AN EVALUATION OF VISUAL DESIGN PARAMETERS FOR USER INTERFACES

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Abstract

User interface experience and visual communication design are strictly related with designing daily needs of humans. They both focus on the convergence of functionality with aesthetics; both giving special importance to functionality of the design product. In designing interaction environments for human whereever they live, work and spend time, the designer focuses on the aesthetic, psychological, social and functional concerns. During designing the space and environment, she/he must find the appropriate "interface", so that it can interact and communicate with the user, define itself, its functionality and thus serve its purpose. The accompanying concepts such as sociability, daily needs, comfort, serenity of the environment, etc. are all met when the underlying system has a well designed interface that offers proper interaction to the user, and let him/her socially adapt the environment and survive in it. Therefore, a discussion of design in general is indeed about the interface of a product in question.

Keywords

Keywords about “Interface”

interface, visual perception, Gestalt, affordance, semiotics, cognition, HCI (Human Computer Interaction), GUI (Graphical User Interface), interaction, theory of navigation

Keywords about Home Automation: smart home, home automation, future home, pervasive computing, HVAC (heating, ventilation, air conditioning), OSGi (Open Services Gateway initiative), Bluetooth, X-10, ubiquitous computing,

Keywords about Psychological/Social Perspective

technophobia, technophilia, technological fantasies, future, home and technology, consumption
Introduction

A. Overview

1. User Interfaces: A Visual Design Issue

Deployment of digital medium and its use with varying purposes is closely connected with the practice of visual communication design. Especially with the emergence of the Internet, the digital media began to dominate the way people communicate. Because the Internet, as a revolutionary development in communication, proved to be an unlimited source of information for everyone, its user base developed rapidly and consequently made computers part of our daily life.

This increase in human computer interaction and the enhancement both in the number and profiles of the users called for an accurate and well designed user interfaces which required the collaboration of visual communication, information and software design. Internet and various softwares were designed essentially aiming for information deployment; but failed in offering information in a "comprehensible" and "manageable" way for the nonexpert naive users. The lack of proper presentation of information caused uselessness and unmanageable accumulation of information. Johnson describes this with the following observation: "For the magic of the digital revolution to take place, a computer must also represent itself to the user; in a language that the user understands" (Johnson, 1997, p. 14).

After creating many conflicting and insufficient interface designs and incomprehensible web sites, the need for a visual infrastructure to offer information in a more comprehensible way was finally becoming clear to everyone. In their research about developing design guidelines for user interfaces, Smith and Moiser mentioned this emerging significant need as: "The design of user interface software is not only expensive and time-consuming, but it is also critical for effective system performance. To be sure, users can sometimes compensate for poor design with extra effort. Probably no single user interface design flaw, in itself, will cause system failure. But there is a limit to how well users can adapt to a poorly designed interface. As one deficiency is added to another, the cumulative negative effects may eventually result in system failure, poor performance, and/or user complaints" (Smith, Moiser, 1986).

Following a short period of text based web pages, the Internet, itself, is now a medium of visual design. However, the control of using/manipulating the Internet and the digital medium remained an occupation only for programmers and technically advanced users for a long time; thus, the concept of "visual design" has been ignored during this stage and resulted in many visually insufficient/unappealing examples.

2. Home Automation Systems

The rapid development of the digital universe and the deployment of computers caused the involvement of technology and computers into our lives in an extensive way. Computers became the staple items first in our offices, then in our houses, and now they are a personal belonging, such that the number of people that cannot maintain the day without working on their laptops is very high.

This transformation into a digitalized life caused the emergence of a number of technologies that offer attracting possibilities and convenience in our daily life. So, the "smart home" concept developed in the last three decades rapidly. The term was used for automation systems that control home appliances and utilities. After its emergence in 50s, the concept of home automation developed significantly in the last decades. The use of computers and smart appliances is now a common thing, and today many people are familiar with technologies such as Bluetooth, WiFi, HAVi, X-10 etc., which make up the underlying technologies. Practically, we can say that we already enjoy the benefits of the smart appliances technology; furthermore, the concept of the future smart home that is also connected to the Internet is also here: "A networked home will be connected to an external network, like the Internet, which connects the devices on your local home network with different service providers" (Hansmann et al., 2001, p. 363).
However, the futuristic automation technology is, indeed, more than a promise of the fantastic home environment, as the “Jetsons” cartoon offered. In the beginning, home automation systems were mostly designed and deployed for energy saving purposes, that is they were considered from an economic point of view (Cawson et al., 1995). To give some examples, the early automation of lighting or HVAC systems were mostly serving to reduce energy costs. With the ubiquitous use of computers and easier connectivity options, home automation has evolved into a concept that also offered convenience, flexibility and enhanced security, that is, now promoting the ergonomic issues on top of the economic ones.

Convenience as one of the principle subjects of ergonomics comes along different lines. With extensive customization possibilities systems easily adapt to the minute needs of an individual. Especially the disabled and elderly people and children benefit from these previously unimaginable offerings. Beyond convenience such systems also offer flexibility to accommodate to different conditions and circumstances thanks to the inexpensive availability of digital technology. Similarly enhanced security mechanisms become available which are also facilitated with the proliferation of better, cheaper and easy-to-use auxiliary devices such as cameras, sensors, detectors etc. On top of these, the unified control perspective and a smooth connection to the Cyberspace as offered by OSGi (Open Services Gateway Initiative) opens a new era for humans in their quest for managing their continuously changing complex environments.

The mentioned smart home concept, has always been a challenging, attractive subject for me, that is emerging as a phenomenon for the near future predictions of technological development. Personally, due to its architectural connections, with several experiences during my undergraduate education in architecture, the development of smart homes was already within my interest areas and provided me with a good amount of familiarity with the basics of this field within the last three years.

However, beyond the promise of a grand change and convenience in our lives, the technology of home automation, may also become a nightmare for the naive user if not controlled and structured properly. A common language for the usage of both a seven-year-old child or an expert adult should be provided with optimum conditions. Therefore, the interface of a system emerges as a very important problem, concerning the practice of visual communication design, entailing the collaboration of communication design with information and interaction design.

An average user may be confronted with computers or computer based information systems several times a day. Surfing the Internet, sending and receiving e-mails and messages, using the television, VCR and other devices in the home entertainment system may be some examples. However, such uses of high technology entails the presence of proficient interfacing elements. Because, interacting with the computer and computer based appliances may not always be too simple even for the advanced user. Insufficient interface design may end up with uselessness of the medium, confusion, lack of information and sometimes technophobic reaction. Therefore, if computers are intended to be an extension of man, the need for professionally designed accurate interface is inevitable. Such an interface designed for "smart homes" are expected to offer usability, easy manipulation, aesthetic quality and usefulness.

However, interfaces of the existing systems are still far from being usable, easy to manipulate and intuitive as mentioned by Ziegler and Machate: "Unfortunately, the user interfaces of these different interactive products vary vastly and are often not intuitive. Supplier-specific designs differ from each other and are often not even consistent within the same product line. (...) It is not surprising that the users of such diverse technologies and interfaces are often overwhelmed by the complexity and inconsistency of the user interfaces they are supposed to operate in their home environment” (Ziegler, Machate, 1997, p. 1).

At the edge of a future computerized life style, this need is inevitable and has great importance. Since the technology of smart houses constantly develops, affordability of these systems is also increasing. David Goetz comments on this affordability: “A lot of our business in the early '90s was from ballplayers, celebrities; it moved in the middle '90s to more of the professionals -- lawyers, doctors, executives... As
the prices have come down and the functionality improved, we’re seeing more of the middle market” (Goetz, 1999).

In summary, due to the wide use of this technology, examining graphical user interfaces in the framework of home automation systems is a challenging subject for me.

B. Relevance of User Interfaces from a Visual Communication Design Perspective

Communication has been significantly affected by the emergence of the digital medium in the last decade. Beside the emergence and deployment of technologies such as e-mailing, instant messaging, voice-over systems which already replaced the conventional communication methods (including the telephone), broadcasting has also found a place on the Internet arena which now offers a better instant availability. Television, as the principle medium of communication in the industrial age, occupied a very important place at our homes for years, acted as the box of magic that brings the household together and brings the world into the living room. Now within the rapid domination of computers and digital media, television had to either adapt itself to the online world or leave its place to home computers which now bring the world into home via Internet. The principle difference of the Internet from the conventional communication media is of course interactivity. The interactive nature of the computer enables the user to surf in the ocean of information, access any source of information or entertainment available, virtually exist in the digital world and even customize this world for him/herself, consequently finalizing the inactive spectatorship of the user in front of the medium, providing a revolutionary experience in the virtual world. Thanks to its abundant opportunities and offerings, the Internet is indisputably the principle medium of communication, information and entertainment of our times.

Furthermore, just as the media of photography, cinema and television, the Internet came up also with its own visual language and visual understanding of the digital age, in addition to some attracting offers and services. After the text based and command line interaction stage, graphical user interfaces emerged. Within the increase of computer use with various purposes, visual representation gained importance in the rapid world of 0s and 1s, serving as the common language, with international acceptance and use. After the invention of the revolutionary desktop metaphor, providing a new understanding of the virtual world with the graphical user interfaces, the computer became a new world and a new medium. Johnson mentions this emergence as a new medium especially with the release of Macintosh computers which provided a wide use of graphical interfaces: “There wasn’t a word to describe a computer’s visual sensibility because up to that point, computers hadn’t had visual sensibilities. The Mac changed all that. Staring at that undersized white screen, with its bulging trash can and its twirling windows, you could see for the first time that the interface itself had become a medium” (Johnson, 1997, p. 50).

After the world wide acceptance of the graphical user interfaces and the revolutionary desktop metaphor, uses of the visual language developed in the digital medium. The widely accepted desktop metaphor became the image of the computer’s virtual world in our mind with the presence of informational complex created by the World Wide Web and the deployment of the computerization in almost every aspect of our lives. The practice of interface design gained importance consequently, in order to offer accurate information to users in an intuitive way, and an international language to be used by millions of people around the world who interact with computers or computer based information systems. Johnson, in his book Interface Culture mentioned this situation as: “As our machines are increasingly jacked into global networks of information, it becomes more and more difficult to imagine the dataspace at our fingertips, to picture all that complexity in our mind’s eye -the way city dwellers, in the sociologist Kevin Lynch’s phrase, ‘cognitively map’ their world environs” (Johnson, 1997, p. 18).

In the first chapter, we will examine the home automation technology with respect to automation, the concept of “home”, social aspects of home automation and the scope of the home automation technology with a brief historical study of the development of this technology. In the second chapter, I will focus on the Interface, using the term in a general sense and then evaluate the graphical User Interface for computers and computer based systems with a brief summary of their historical development.
It is now clear that the required accurate interface design should be based on the collaborative work of scientists including the social psychologists, kinesiologists, designers and sociologists. For the virtual world to be understandable for the user, evaluation and study of the interface through cognitive, visual, psychological and sociological aspects is simply indisputable. Chapter III, The Principles of the User Interface, examines all these aspects where cognitive and perceptual theories and factors are explained in detail.

Once the mentioned practices are involved in the design process, all of these fields should also concentrate on a collaborative stage. Therefore, when focusing on the visual design aspects, it is mandatory that cognitive, physiological, sociological and psychological aspects should also be considered by the designer. In summary, this thesis focuses essentially on visual design parameters respecting human perception and cognitive, sociological and psychological aspects from a holistic perspective.

C. Culture

We seem to be waking up to a new culture, where we exchange information in visual terms through the bits and bytes, the world is now pictured with the 0s and 1s of the computer. As soon as we got accustomed -and addicted- to the use of smart technology in the office and at home during each phase of our daily life, we faced problems that were caused by lack of a robust and accurate, easy to use visual substructure. As we try to explore the accurate infrastructure for interfaces that is satisfactory both in terms of aesthetic quality and functionality, the responsibility of the designer emerges not only in making up the fancy dressing but also conveying information in a most functional and understandable way, within an interdisciplinary field of study. From the beginning, various "pragmatic/practical" alternatives of interface design have been suggested by technologists, ignoring the contribution of other practices. However, since the man is a social being with specific cognitive, social, psychological and aesthetical needs, this ignorance of benefiting from other fields resulted in the proposal and use of many models, most of which failed to work properly for everyone. For instance, the inefficient, complex design of some web sites (those that are prepared for being informative, not for visual show-off) are examples causing confusion to users and blocking them from accessing the information; this warned designers about reconsidering the basics of design in digital medium/web site design.

The new medium is inevitable, and communication design has already transformed into this digital medium. The interface as the vital element of the digital medium is a significant part of visual communication design, and is evaluated in aesthetical, psychological, sociological and cognitive aspects.

Due to this emerging need in developing functionally and visually well designed interfaces there is a continuous work on this subject. Therefore I will focus on the application and use of visual design parameters in the digital medium with a particular concentration on the interface for the smart home.
I. A Case Study: User Interfaces in Home Automation

Home environment, and the increasingly popular automation of this environment, offer superb opportunities and challenges for user experience. The term automation emerged and became a popular subject of discussion long before the involvement of computers in our daily lives and the embrace of the various smart technologies of our times. When automation was mentioned for the first time in 40s, it was different from what we understand from the term today and what people were expecting at that time. The only familiar meaning of 'being automatic' was in the automatic washing machine, however, actually the concept of automation contained a rather broad meaning from its use in 'automatic washing machine'.

A definition mentioning this distinction was involved in Erkki Huhtamo's paper with a quotation from Sir Leon Bagrit's book 'The Age of Automation' (1964): "An automatic machine is basically any machine with a sufficient self-regulating (feedback) mechanism to allow it to perform certain functions without human intervention. (...) Automation, however was defined in the preface to Bagrit's book quite precisely as 'a process which substitutes programmed machine-controlled operations for human manipulations. It is the fruit, so to speak, of cybernetics and computers'" (Huhtamo, 1999, p. 99). So was automation differed from the automatic machine technology by the technocrats of the 40s. The concept of automation was promising a totally broad and different mechanism of an artificial system that performs a series of tasks automatically without a requirement of human manipulation.

Automation first emerged in industrial applications as the technology of using machines that are controlled and maintained by a computer based system, reducing the participation and manipulation of humans in the process. It was first used in the Ford Motor Company as Huhtamo stated: "The specific word 'automation' seems to have been coined in 1947 at the Ford Motor Company, and first put into practice in 1949, when the company began to work on its first factories built specifically for automation" (Huhtamo, 1999, p. 100).

After its first use in the Ford Company, automation developed and spread rapidly in industrial applications of various sectors and also in military use. In 60's, automation and cybernetics (which is the theory explaining the functioning and manipulation of information in computer based electronic systems), became popular controversial topics, mentioned as "the markers of technological transformation" (Huhtamo, 1999, p. 97).

Using 'automated' systems in industrial processes stimulated imagination for using robots, replacing man with machine. Therefore it evoked social reaction, resistance against mechanization. Words of Jacques Ellul, one of the resisters, is included in Huhtamo's paper as: "Jacques Ellul, whose influential La Technique (1954) was translated into English as The Technological Society in 1964, warned against the effects of automation: 'Man is reduced to the level of a catalyst. Better still, he resembles a slug inserted to a slot machine: he starts the operation without participating in it'" (Huhtamo, 1999, p. 98). And there were positive approaches to mechanization as Sir Leon Bagrit. His approach, claiming that mechanization may improve man's capacities was reported in Huhtamo's paper as: "In Bagrit's view it 'is not a question of machines replacing men: it is largely a question of extending men's faculties by machines, so that, in fact, they become better men, more competent men'" (Huhtamo, 1999, p. 98). The debates between the rejection of automation or benefiting from it lasted for years, however, concluded in rapid deployment and acceptance of the technology. Today we are embracing extensive forms and uses of automation, not only in industrial applications, but also in our daily life, in the automation of buildings, offices and the home. This study mainly focuses on the automation of the home, places we live and work.

From a Home Automation (HA) related perspective, automation has been first used in the construction sector, specifically in the mechanical infrastructure design of the large scale buildings. The purpose of automating the functions of a building was to design and develop an intelligent infrastructure for large scale buildings which will serve properly, be economic and allow easy management. The early building automation systems focused on developing security systems, central heating, ventilation, air conditioning
systems (HVAC) and centralized control mechanisms for them. Lighting control developed and emerged as a part of the security system. A control panel enabled the management of all lighting, and sensors were used to activate lights in case of motion detection or inactivate them when there is none.

Automation in buildings has been basically used for these purposes in the beginning. Later, the idea of inserting other applications into this system resulted in the development of the concept of "Home Automation" systems.

Home automation is the control of various functions of home appliances and utility services, allowing reconfiguration, preprogramming and remote controlling; with an intended technology of offering these under a single centralized system which is also available through the mediation of the Internet. Today, a complete home automation system further suggests the interconnection of subsystems such as security, HVAC (Heating, Ventilation, Air Conditioning), lighting or domestic electronic appliances so that they can communicate with each other as well as being accessed and controlled through a common control platform. Usually, houses/buildings with interconnected home appliances are called smart houses or smart buildings.

Since 1970’s, a number of home automation control systems have been developed, using various technologies. These models proposed a number of interfacing devices such as a wall mounted control panel for the security system, a remote control device for the lights or a PC based software package that can command the heating system. The concept of developing a common control panel to provide centralized access point to all the systems is still immature. Therefore, put in other words, automation of the home is available as a separate system, with a separate control mechanism.

A centralized control mechanism is possible only when various appliances are connected within a network. The opportunity of networking appeared within the deployment of computer based devices, containing microprocessors in them. Smart electronic appliances with built-in microprocessors are used more and more. Besides the wide use of handheld computers, cellular phones and digital cameras, smart air conditioners, refrigerators and cookers have been introduced. Computer technology has become pervasive, being used almost everywhere, in office machines, in cars, at home and in the kitchen.

Both the pervasiveness of computer based appliances and the deployment of the Internet contributed to the development of new features for home automation control systems. The opportunity of networking basic home appliances allowed communication among each other. This allowed the use of a more integrated system that can work in a more efficient way and in coordination. The above mentioned benefits of the communicative infrastructure may be explained with a very basic example: sensors of some security system may detect motion in the garden, let us say after 2 am in the morning; and besides turning on the alarm, the system can communicate with the lighting system to activate entrance lights, place a telephone call to police or send a message to the home user to report the situation. Reengineering home automation systems in the context of connectivity provided the development of more advanced systems with big improvements.

In the following sections the scope of an average home automation system will be explained in detail. However, it should be noted that in an average household, the basic members of the home automation system may be grouped as follows: communication members (Intercom, telephone/videophone, TV and the Internet) and core members (lighting, security system, heating, ventilation, air-conditioning (HVAC), fire sprinkler; and electronic appliances used in kitchen, bathroom and etc.). Optional members may include the music system and additional audio and video entertainment appliances.

A. A Social/Cultural Approach to the Home Automation Technology

1. Domesticity and Involvement of Technology in Domestic Life
The concept of home and things related to the home occupy an important place in human life based on social and cultural mechanisms. Home, being more than just a shelter to protect humans from threatening conditions of outer world, is accompanied by other concepts such as belonging to a place, a physical but mostly psychological sense of comfort, a place of retreat offering privacy and security. The sense of owning the living place and protecting it from the outside factors are related with the concept of domesticity, which signifies the situation of belonging, pertaining to the home environment.

In the presentation paper of their research on the integration of computer into the domestic life, Habib and Cornford use the term ‘domestic sphere’ for the social and physical environment of homelife and define it as follows: "The domestic sphere is a multigenerational world where people seek security, intimacy, support and protection. The domestic is often seen as a sanctuary not only for family life, but for all the values associated with civilization" (Habib, Cornford, 2001, p.130). The mentioned humane senses of need for security, intimacy, support and protection mostly appear as a result of the increase in the opposing threatening situations. Domesticity, though, emerged with the changes appeared in social life after the industrial revolution. The term domesticity was not used widely in the 16th century. As stated in a paper of Charles Leadbeater, the term domestic was not even used for pets in the 16th century, before the industrialization. "Take the burgeoning cult of domesticity. As an antidote to innovation and change it is far from new. In the 16th century, animals were an unsentimental part of the working household for most people. They became pets only in the 19th and 20th centuries — objects of sentiment — when agriculture became more industrialized" (Leadbeater, 2002, p. 1).

Domesticity, prominently, polarized with the push of technological transformation and its effects on social culture. Beginning with the industrial revolution, the cycle continued with mechanization, automation and reached a peak with the involvement of computers in our lives. Habib and Cornford mention the origins of domesticity as follows: "It has thus been argued (Davidoff and Hall, 1987; Ellis, 1975; Easton, 1976) that the development of an idealised image of the domestic was closely linked to the spread of industrialization. Because the public world of business evoked images of immorality and misery, the private world of the home came to be understood as a shelter for security and moral values (Clark, 1976; Zaretsky, 1976)" (Habib, Cornford, 2001, p.131). The impact of industrialization to the rise of domesticity was apparent. The routine and quiet world of production transformed into a challenging place of race and ambition, which increased continuously in time. The transformation in the world of work production reflected to the social life as the extended nine-to-five working hours, invading the time spent at home, and taking work to home accompanied with the stress attached to it. The strict style of the business world evoked the need for retrieval and domesticity. In this period of transformation, technology and all its offerings showed up and spread rapidly first at the workplace, and then at home.

The early symbols of the technology appeared at the work place with telephones, fax machines and then inevitably, with computers. Meanwhile, the marvels of technology began to penetrate into the daily life in the form of ‘harmless products that really make things easier’. White and brown goods of the household, like automatic washing machines, cookers with timers, vacuum cleaners or such devices that do not seem to be threatening the domesticity of the home, were presented to the society in a successful way through television and press. The major fields of consumption, became the major targets of deploying the technology and consequently, the term "automatic" gradually became a more familiar thing. Huhtamo states this deployment as such: The fashion for 'things automatic' spread, however, to other, more accessible fields, such as household machinery and education (teaching machines) that, at least nominally, 'brought automation to people’" (Huhtamo, 1999, p. 101). This popularization of technology, of course, reduced and gradually removed the cold, alien image of technological devices and accelerated their acceptance into our lives.

The television contributed to this familiarization process significantly. Commercials on television or in the press worked as excellent propagandists the 'things automatic'. As Huhtamo also stated with a quotation from Lupton's "Mechanical Brides: Women and Machines from Home to Office (1993): The media including the press, the cinema and the novelty of the time, television (itself a piece of semiautomatic technology), played a major role in this dissemination. A case in point is an advertisement for the Bendix washing machine from 1946: 'It's Wonderful!-how my Bendix does all the work of washing! because it
washes, rinses, damp-dries—even cleans itself, empties and shuts off— all automatically!” (Huhtamo, 1999, p. 102). Television was of course the most popular and attracting offer by technology. Emerging as the enchanting magic box, television became the main medium of communication and entertainment and influenced the society in various controversial ways.

Consequently, television and other kinds of electronic/automatic devices succeeded in making technology a part of the domestic life, leading to major changes in it, but mostly increasing/altering the meaning of the term “domesticity” itself. People reacted and resisted against technological products for a long time claiming that it terminates the peaceful domestic life, bringing in the chaotic mechanization of the work place. Especially the emergence of the computer and its involvement into the home has been a significant milestone in the technological transformation.

Meanwhile, we mostly agree that we live in a world where extreme marketing drives consumption beyond reasonable limits. The home automation market surely is not an exception to this. Here, the marketing mechanisms especially target the soft spots of potential users by concentrating on convenience, social status and aesthetical factors. As of today, many such technologies are widely used at home—such as the remote control, preprogrammable video players, etc., and a life without the remote control technology, personal computers or printers and many others would simply be not bearable even if they were thought of as unessential options in the not very distant past. The comfort offered by them has already become part of our life, and most of them transferred into addictions; or perhaps a need beyond simply being an addiction.

The argument is also made for aesthetical considerations other than convenience. But again, marketing motivations may sometimes exaggerate an innocuous starting point and end up in excess; hence the flood of kitsch optional skins for cell phones and media players of the newly introduced operating systems. A similar situation occurs when the introduction of a new technology is hastily embraced by avant-garde users even if only for the sake of acquiring another new social status symbol. The home automation technology/market is not exempt from this tendency.

2. Transformation of the Home with the Involvement of the Personal Computer

In ancient examples of homes, or those that might be called shelters, the central place used to be the fireplace. The fireplace had symbolic connotations other than its functional importance of providing fire to cook, to heat and to enlighten the place. It was the central point at home where the family or the household came together at dinner or to benefit from the light and heat. Times spent together around the fireplace provided the interaction between family members and cultivated communication with each other, since there was no other point of interest.

In time, the fireplace transformed into the kitchen, as a separated room in the house. It was the room that women used to spend most of their time while cooking and dealing with house chores. Throughout all ages, in the absence of the television, the gathering places at home always stimulated the communication of the family. However, things started to change with the emergence of the television. Becoming a point of interest for everyone, television was also bringing them together in the living room, but totally removing their interaction with each other since television itself was the only point of interest. The room with the TV replaced the kitchen consequently. Thus started the asocial way of living together among the household, though, encouraging the resistance against the penetration of technological devices into home.

After the dominance of television at home, and the involvement of other technological automatic devices, computers entered the home. It was a well-known marketing tactic to let the computer into the house, of course, and it was the most efficient way to broaden its market. After its sanctioning as a home electronic device, its market share reached unexpected levels. In the beginning, personal computers were commonly used as office machines for simple tasks such as text editing, account management and such things that would not appeal much to everyone. After its introduction to the home electronics market, it preserved its alien attitude for a long time as stated in the paper of Habib and Cornford, “We also saw the
home computer represented in other terms, as a symbol of the world of work and conjuring up images of 'corporate culture' invading the domestic space, quite literally bringing work home, which sometimes result in some family members developing ambivalent attitudes. The home computer was also seen as symbolizing the 'cold' and impersonal aspects of technology. In particular, the computer was seen as an inferior mode of communication when compared with other means such as the telephone” (Habib, Cornford, 2001, p.132).

However, the rapid acceptance and developing abilities of personal computers resulted in the successful replacement of the television, since the computer was offering almost everything and more than what the television could, including the interaction. Especially with the emergence of the Internet, the computer became the principle medium of communication and created a mass of computer addicted people which includes men, women, children, anyone else at any age or occupation. Personal computers became our microcosms without which we would be worse off. This has been the second stroke that hit the borders of domestic life and this time, the change occurred in a fatal way. As though the kitchen or the living room still pursues its function of bringing the family together, the social interaction is minimized, that they mostly prefer to stay alone with the computer and the world it offers.

Several concerns emerged towards the computer during this social process of its embracement. One of the most specific concern was the thought that it is a surrealistic machine and can take the control from humans any time. Habib and Cornford reported this fear in their paper as : “It may be noted, although this is a rather judgmental statement, that a number of the fears and anxieties that surround the home computer, although they are grounded in reality, may easily turn into irrational beliefs. The computer is thus seen as able to incapacitate its users, to take control over their mind, to turn them into different persons. The power of the computer is then seen as a force of destruction, playing tricks on the mind of individual users, thereby bringing turmoil within the house, and ultimately the disintegration of the family as an institution” (Habib, Cornford, 2001, p.133). Actually as computers turned into a more attractive means of entertainment, especially with the help of computer games, the time spent in front of a computer reached hours, nights and sometimes days. The virtual world of entertainment especially attracted men and children, causing the emergence of concerns in the family that computers take most of their times, limit their social activities and communication with other people.

This problem about the time spent in front of the screen developed into some kind of fear as reported: "Another fear concerning the quasi-magical powers of computers resides in the beliefs that they may possess or acquire human characteristics. The literature offers many interpretations of such a phenomenon. Seeing the computer as possessing human characteristics has been seen as an expression of one’s affinity or even intimacy with the computer (Turkle, 1984) and such affinity has been presented as one of the dangers associated with spending too much time with the computer” (Habib, Cornford, 2001, p.134). Today, this problem continues especially with the advance of the Internet. Computers are used at workplace, education and as a means of entertainment. A very prominent tendency is towards adapting the person-to-person communication to the medium of Internet instead of having face to face interactions. Therefore, social relationships are now mostly transferred to the digital medium.

Meanwhile, as we are preparing ourselves to the involvement of technology in our daily lives and at home, the existence of two social groups, that is, technophobes and technophiles -as polar opposites- cannot be neglected. Technophilia is a human behavior of showing great interest in the development and use of technological innovations and/or improvements. Technophilic people are followers of technological innovations and are always eager to purchase and use them whether useful or useless, enjoy dealing with devices containing high technology and having quite optimistic expectations from the future offerings of technological improvements. Unfortunately, however, the majority of the population (as of 1995, according to a survey made in USA) was technophobic: “For 85-90 percent of the population, it’s not fun, and it’s not easy, and they’re not sure that the solutions exist” (Bollentin, 1995, p. 6).

Technophobia is a term used to describe a human reaction of fear, discomfort or anxiety towards one or more forms of technology, resulting in avoidance from it and a strong reaction. “Overall, given that
technophobes make up anywhere from 30 to 50 percent of the population worldwide, the answer is really no” (Bollentin, 1995, p. 6). At a very extreme end, we may mention the luddites, a term that signifies people who fear changes brought by technology and react to the use of technology under any circumstances (it was coined after the name of Ned Ludd who was the first one to start such a reaction against textile machines in the late 18th century, suggesting that they would take away the weaver’s livelihood) (Mokyr, 1998). In this paper, both technophobia and technophilia will be reconsidered within the framework of computer technology.

Today's technology directly addresses human activities and social life. This thesis will focus in particular on the technological redefinition of domestic life at home. Therefore, in this context, improvements in human computer interaction and graphical user interfaces are particularly important. Technology at any level can be handled by anyone with a basic computer knowledge as long as the interface is designed in an appropriate way.

Since its emergence, the computer and its domination in our lives proposed a number of social problems and, in turn, resistances, for years. However, an increasing number of people are accustomed to it now, and most of them became addicted users. Especially the advent of the Internet brought unimaginable opportunities of access to the sources of information, entertainment, communication, etc.. Today, computers are the principle electronic tools in offices, homes and in education sector and any other type of occupation. The number of computer based smart devices are already in our lives, and we are at the edge of embracing many more. It is possible to say that we have already got accustomed to live with computers and smart devices. Therefore the home automation is not that alien to us as it offers the automated life style with various kinds of smart devices, gadgets and sensors, at our homes, in domestic life and in the personal spaces.

3. Women, Home and Technology

Through this period of technological transformation in the social life, the term domesticity have usually been thought as related to women more than men. Throughout the historical development of the social life, women appeared to be managing the home, taking their responsibilities as the care of home, children and husband, cookery and protection of the comfort at domestic homeplace. Therefore they were known to be ‘working at home’ as devoted housewives in conventional societies for ages.

The age of industrialization, significantly contributed to the tendency of reserving the term domesticity for women. In the developing world of production and mechanization women have stayed at home, dealing with the domestic chores and avoiding from the automation invading the life. Habib and Cornford comment on this: “Authors such as Easton (1976) and Hareven (1991) have contrasted the prominent economic role of women in pre-industrial times with their retreat towards domesticity and consequent loss of social status during and after the industrial revolution. In their analysis, the move from farming villages to industrializing towns and suburbia had a direct effect on the redistribution of economic roles within the household and the confinement of women within the home, thereby redefining and narrowing both their role within the family and their social status” (Habib, Cornford, 2001, p.131).

The socio-economical structure of the society also transformed in the years of change. Today women are also involved in the world of production, and are proficient in dealing with technology almost as much as men. We cannot mention the superiority of either men or women in using and benefiting from technology. However, the field of home automation, still concerns women in a different way. Since women pursue their dominancy in maintaining the housework, the home technologies address them specifically. Women from various cultural or educational backgrounds are already dealing with various technological appliances and gadgets and somehow manage to comeover the complicated user interfaces of the oven, multifunctional programs of the washing machine and the drier and various small gadgets for mixing, blending, chopping and else. So they constitute the significant part of the home autoomation technology users and the most important part of the technology is being developed to meet their needs.
Therefore, it might be said that women are dealing with most of the home technology. However, one of the main purposes of home automation systems of today intend to address men, women, children and people at any age, from any cultural or educational background. Providing the most 'domestic' automation systems and the most user friendly interface for them stands as a main principle in the design of these systems since the opposite will result in the technophobic reaction against the concept of the automated home.

4. The Development of the 'Future Home' Imagery

There has been various futuristic images of the home containing utopian and/or dystopian approaches. These futuristic images have been mentioned either in architecture, in literature or in cinema. For example, the history of architecture contains a number of utopian designs for the future living, made by the famous architects as Le Corbusier, Frank Lloyd Wright and others. Peter Cook and his group Archigram were also a significant example, concentrating on the concepts of utopian designs for the future life. These projects contained political and social ideals of their designers, and depicted the future architecture for the idealized lifestyle. However, as utopian projects were specifically pointing out to the future prospects of architectural design, they were mostly concentrating on the development of futuristic homes with flexible architectural forms.

Imagining the future home has been a major subject of both cinema and literature during various times. And the predictions and aspirations articulated in them have been usually adopted by the society and become part of the vision for the foreseeable future. A number of cult movies have been made approaching the future imagery in both pessimistic and optimistic manner, either mentioning the fascinating future technologies and comfortable lives surrounded with smart gadgets, or the catastrophe resulting from the social breakdown and technological entrapment. Especially during the last quarter of the 20th century the general course of technology/man relations in fiction was rather set, for example, by the cult phenomena such as the well known novel "1984" ("Big Brother") and the film "2001 A Space Odyssey". They created popular benchmarks for the years 1984 and 2001 (both were conceived in 60's and portrayed a future founded on the use of artificial intelligence, presence of robots and other high technological advances -but there was a disappointment when the predicted technologies could not be achieved neither in 1984 nor in 2001, even if in both cases the implications were rather negative in nature).

The TV series "Star Trek" (1966-1969) is a milestone for the depiction of life in the future. Portraying the future in an optimistic way, Star Trek portrayed the advanced lifestyle with robots and various intelligent gadgets. In the movie versions, there wasn't an obvious home environment portrayed, and the sociological aspects of living with high technology was not mentioned in detail. However, kinds of smart devices used in the series, and its futuristic environment inspired a generation's expectations from the future in a very significant way.

A more mundane depiction of the home environment came from the popular cartoon series "Jetsons" of 1960's. Presenting a colorful picture of the life with high technology, Jetsons imposed the early images of future with flying cars, moving walkways and the presence of the robots. The animation shows the life of an American family, Jetsons, living in the year 2062. Jetsons live in an apartment with 2000 tenants. Their house is equipped with high-tech devices which are the robotic versions of the usual home devices, such as the robotic cleaner. The future environment is described in a very soft manner, skillfully avoiding from destroying the sense of domesticity and conventional structure of the family life. Therefore, the characters of the cartoon is determined as a standard American family of 1960s. Even though the story takes place in 2062, the mother of the family is a devoted housewife, the father is the only member responsible for earning the living. The children are typical teenagers at school age, like those in 1960s. So the cultural and traditional attributes of the family and the domestic lifestyle is protected in Jetsons. In spite of various technological devices and the robots used at home, there is no sign of technological degeneration and mechanization. William Mitchell comments on the depiction of future home environment in Jetsons in an interview conducted by Joe Gelonesi as: "The thing that's really funny about the Jetsons, well it's the past now in fact, it takes a mid-century, suburban American family and transports it literally into a kind of..."
gadget-filled future and the whole humour comes out of the fact that the family, the life, hardly changes at all" (Gelonesi, 1999, http://abc.net.au/future/citytext.htm).

However, set almost in the same period of future time with the Jetsons, Bladerunner, one of the very significant cult movies in the history of cinema was made in 1983. Bladerunner depicted the Los Angeles of 2019 as the abandoned decaying place with no fascinating technological toys. Andrew Benjamin comments on the future environment depicted through the pessimistic viewpoint of Bladerunner as: "Deckard's apartment is standard. (...) As a work of architecture, his apartment's only concession to the future--and here would be a putative concession--is the voice-activated lift and the location of his apartment on the 97th floor. (...) The architecture as well as interior design within Bladerunner is more straightforward. The police station to which Deckard is taken has an entrance area reminiscent of large rail stations--places in the American context that are already marked by a certain redundancy--while within the office the filing cabinets are wooden. The desk is conventional. The presence of fans indicates the absence or failure of air conditioning. Here, technology is only partly at work. The office indicates a continuity with a certain image of the present" (Benjamin).

Meanwhile in 1968, "2001: A Space Odyssey" has been made. The star character of the movie was the computer named HAL that has been a symbol of artificial intelligence at that time. Although use of artificial intelligence is still not possible to such an extent, 2001: A Space Odyssey and HAL have always preserved their place in people's mind, reflecting the fear from the future life and artificial intelligence.

5th Element (1997) is another example, presenting the chaotic life in a future American city, 250 years from present. The most significant attribute of the city is its cramped look, with skyscrapers everywhere. In the movie, the home environment is depicted in an extreme style. Houses are for individuals only and are quite small. For example, due to the lack of space, the high tech architectural design of the home allows the shower cabinet (it is hard to name it as a bathroom) to rise up when not in use. 5th element mostly presents the future life as a technologically degenerated, as a chaotic environment with no specific benefit of high technology.

In many films and novels, stories and fictions for the future, robots have been some of the most attracting future icons, occupying an important place as a symbol of automation. A robot is the perfect convergence of man with machine, possessing an improved intelligence and extended capabilities, but being produced, programmed and controlled by the human beings. Robots have mainly been imagined to serve men and to undertake the daily chores and works. However the image of this perfect machine that possesses improved human capabilities was also related to the controversial subject of artificial intelligence, which is both an appealing future technology and a scary threat against the dominance of human beings on earth.

In Huhtamo's paper, the imagery around the robot and the intended uses of it is exemplified with a quotation from O.O. Binder as: "In a typical 1950s fantasy, the cover story 'Amazing Marvels of Tomorrow', published in Mechanix Illustrated in 1955, the robot has two roles. First there are the 'Robot Factories that are completely automatized without a single human workman inside.' Second there is the 'Robot Kit, Make Your Own Robot': 'The kit has complete tools and parts for building your own metal robot, with an atomic battery guaranteed a century. Hearing and obeying all orders, the robot can be your servant. Or lonely people can train them to play checkers and cards, and even dance'" (Huhtamo, 1999, p. 102).

In Binder's story, both uses of the robot recalls the emergence of robots as the agents of artificial intelligence. Programmed to automatically undertake the work in a factory or to accompany human beings, behave like them and meet their needs, they were both appealing harmless technologic dreams and the phantasies for the emergence of artificial intelligence.

The concept of artificial intelligence has usually been dealt as a threat against the humanity by the cinema. Many samples from the history of cinema contain the instances of being captured by artificial intelligence and the loss of humanity against the development of the semi-human machines, robots.
However, the actual technological advancements simply took a different course and pace offering a more digitalized world for both today and the futuristic projects such as intelligent devices and environments, and defined the "home" as an information center. Therefore, beyond the previous expectations that hastily included a robotized lifestyle, today we have a more realistic agenda for the "home" of tomorrow as offered by a more cautious technology. Practically, the center of attention has shifted to the management of information that floods us from every direction.

B. Historical Development of the Home Automation Technology

The concept of a smart house has been a well known subject almost since 50's. As mentioned in the previous sections, in the beginning, the ideal house of the future was described somewhat in a different way. This idealized version was expected to make use of flexible architectural forms that would allow, for example, the interior walls to be movable thus offering a vast freedom and a broad range of options to the users (Cawson et al., 1995). And the robot was an important figure of the future home. In order to offer ultimate comfort and freedom to us, robots were thought as agents that would take over all kinds of boring chores that today we have to carry out ourselves. Surprisingly, however, the technological developments have proceeded in a different way and changed what we had expected from the future.

Practically, the (building) automation concept has been first conceived as a control function of HVAC (Heating, Ventilation, Air Conditioning) and security systems. Such automation systems were planned for economic considerations in mind, that is, to reduce the consumption and/or use of energy in large buildings. The automation technology developed especially in these two domains (HVAC and security) until the emergence of the automated home concept.

Automation of the home took a different route at that time. Based on the emerging technologies, concept houses with various functions have been designed both in Europe and US. Such houses were built by wealthy individuals or computer experts and most of them were for demonstration purposes. However beyond the tricky functions of these conceptual models, almost no practical solutions became available for the associated problems caused by the cumbersome cabling requirements and unaffordable costs (Cawson et al., 1995). Home automation was not considered as a functional technology that might become a part of daily life in the future, but rather thought as some kind of unnecessary show of technology.

In 70's, with the deployment of remote controlled and preprogrammable brown goods, automation of electronic appliances became a popular subject. It was quite impressing for the consumer to tinker with the infrared remote controls to operate their TV set and other equipments later, or to have the video recorder preprogrammed to record their favorite TV show when s/he should be working late. The remote control was a significant innovation that spread over to many other devices such as the stereo system or air conditioner and now it has become an addiction for everyone. The use of timers in home appliances has also brought the concept of preprogrammability that has started to be widely used in ovens, washing machines, heating systems or the security systems after a while. The two technologies of infrared remote control devices and programmable timers composed the basis of the home automation technology as they are deployed to many devices and appliances at home. Meanwhile, the use of these technologies in consumer electronics and white/brown goods has significantly marked the penetration of automation technology into the home, the domestic life.

Consequently, a lucrative market of home automation technologies emerged. And the emergence of home computers cultivated the market, proposing the PC's as the heart of the automation or as the control point. The first attempts happened in Japan and this has been followed by United States and then Europe, as Cawson reported: "Designs and prototypes using home micros appeared in Japan as early as 1978, and by 1983, a number of companies, especially in the US, were offering products to link X-10 systems with various home microcomputers such as the Commodore VIC 20 and 64, the Apple, and the IBM PC" (Cawson et al., 1995).
However, although the renowned PC was already in the consumer electronics market since mid 80's, the leading companies were trying to avoid using the PC as the control device. There was a common opinion suggesting that the use of personal computers for home automation purposes might give the unwanted impression that home automation is only for those interested in and capable of using computers (Cawson et al., 1995). Various solutions and approaches were designed and applied in the following decade suggesting the interconnection of audio-video devices and control through various handheld devices. However, the market was developing in an unorganized way containing various alternatives and solutions offered by various companies. These companies were interested in as diverse fields as the automation of brown goods, security systems, HVAC systems, white goods and many more.

X-10 appeared as one of the earliest systems in US during 80's. It is a home automation technology that uses the existing power line networking of the home to convey automation commands from the control center to the lighting points or appliances being controlled. This technology developed rapidly thanks to its low cost, ease of use and widespread marketing efforts. Since X-10 uses the existing wiring system of the house, the incurred costs are quite low. The low cost and easy application of the X-10 system also cultivated the deployment of home automation technology significantly. Today, such systems are easily purchased via the Web and a wide range of appliances are offered that are compatible with each other (Cawson et al., 1995). Unqualified users can order these products and use them easily. In spite of its broad market, easy use and low cost, X-10 technology offers a slow data transmission rate of 10Kbps, using the electrical wiring system. This rate of data transmission allows the basic functions as turning on/off the lights or the heating system (Hansmann et al., 2001).

A more advanced alternative, the CEBus initiative developed a power line carrier standard using the existing electrical wiring different from the X-10 technology; it uses the spread spectrum technology and defines a more general purpose method for sending information through power line wiring.

C. Scope of The Home Automation Technology

Scope of the home automation technology developed significantly since its emergence as a simple control system that switches on/off the lights and the heating system automatically. The early applications of the 'smart homes' were those mostly built by wealthy individuals or computer experts and were based on the wiring of the home to provide an electricity based automation system. An example to those houses was the "All Electric House" built in 1953. It offered "A remote-control switch in the master bedroom turned off the coffee maker in the kitchen, and 'moonglow' lights in the hallways came on at dusk" (MIT Architecture Department, Homes of the Future of the Past).

In the beginning, the main concept of the home automation system originated from the two main technologies: pre-programmability and remote control. So the early smart home systems were composed of remote control devices for the lights, television, central heating system or the coffee-maker, and timers for the cooker, VCR and television that would enable programmability. The automatic home of the time included various technologic/automatic appliances, some of which can be controlled with remote control devices and some can be pre-programmed. Therefore, there was not actually a system of automated devices, but a number of devices that can be controlled individually.

After the early applications in 50s and later, the rapid, unexpected development of technology changed the direction of the home automation concept in a significant way, especially with the advent of the information age and the deployment of the personal computers. The new understanding of home automation emerged with the home networking technology. The purpose of automation changed from separate control solutions to the connection of the appliances into systems and building common centralized control mechanisms. The capabilities of the subsystems and devices increased as they could be able to ‘talk’ to each other and co-operate when necessary.

Scope of the automation system also developed based on the new concept of home automation and its offerings. Computerization of many of the devices we use daily and their convergence into a system also
improved the capability of these systems. The restricted scope of the early systems covering the lights, heating system, remote control for television and music system developed into a network of the subsystems and home appliances that can be controlled through a centralized PC based control platform, which is accessible through home computers, PDA's (Personal Digital Assistant), web enabled telephones and the Internet.

In his article on home networking, Erick Glick mentions the scope of the home automation system of today as follows: "the home networking market is broken into five major categories: lighting and window treatments, security and access control, voice and data communications, environmental and energy management and finally, audio and video entertainment" (Glick, 1999). In this thesis, the mentioned five major categories will be examined in three groups which are the communication members, core members and optional members of the home automation system that probably exist in an average home.

1. **Communicating Members of The Home Automation System**

This group corresponds to the voice and data communications category of Glick. It includes the basic devices as the Intercom, telephone/videophone and the TV/Internet.

   **a. Intercom**

The intercom devices are prevalently in use today, providing aural communication inside the home environment. Intercom has a widespread functionality that covers the aural communication of the household with each other while residing in different rooms and identification of the person at the gateway. Today's technology enabled the visual data transmission through the intercom devices. This especially achieved a wide use in watching the children's room or the room of the elderly that are in need of care from anywhere at home.

   **b. Telephone/Videophone**

Telephone, the fundamental means of communication is a part of the voice and data communication system of Glick. Enabling aural communication with the outer world, it stood in the middle of the communication medium for years. The mobile phone technology pushed the market with an improved network making everyone accessible anywhere and anytime. The emerging technologies of the day enable even the transfer of visual data with the emergence of the videophones, and there is a wide use of web enabled telephones that give access to the source of information. Consequently, telephone is a part of our lives. The videophone technology is developing rapidly, becoming a part of our digital life.

   **c. TV/Internet**

TV and the Internet can be included in the voice and (audio/video) data communication. Internet serves as the basic fundamental source of information, communication and entertainment. The bandwidth problem, which seems to be blocking its extended use, limiting the speed of data transfer, is disappearing with recent improvements in its infrastructure. The status of the Internet in the future daily life and the future technologies of many devices is indisputable.

However, even it gives access to kinds of audio and video broadcast, Internet acts different than the television due to its interactive nature. Yet, a possible convergence of the television and the source of Internet is mentioned as a future technology.

2. **Core Members of The Home Automation System**

The core members of an average home may include the lighting system, security system which includes the control of the doors and windows also, fire sprinkler system and the HVAC system.
a. Lighting:

Lighting control exists as a part of the home automation system since the emergence of this technology. Previously mentioned "All Electric House" of 1953 included the lighting control with 'moonglow lights that came on at dusk'. Sensors that can perceive the change in the amount of light have been used as the base of lighting automation. This allowed the activation of the lighting appliances when necessary. Later, this improved into the use of motion sensors to perceive the movement and activate the lighting system. A number of useful functions of the lighting automation can be thought with the possibilities offered by this technology.

The lighting control developed to offer more with the improvement of home networking technology that proposed a centralized control point for all the systems at home. Through the control panel, each lighting appliance can be reached and controlled separately, allowing the manipulation of light intensity. The manipulation is possible either from the control panel at home, through the screen of a computer and through the Internet. Meanwhile, in a networked home, lighting system can even cooperate with other systems. In a case of a security breach, the doorway cameras may perceive a motion in the garden at night. All the lights can be activated as a precaution incase of such a situation, conducted by the sensors of the security cameras.

b. Heating, Ventilation, Air Conditioning (HVAC):

The basic mechanical infrastructure of the home is the heating, ventilation and air-conditioning system. A convergence of them into a common system forms the mechanical infrastructure of the building which is called the HVAC system. HVAC systems are widely used in 'building automation' for the purpose of energy saving in large-scale industrial and office buildings. A centralized control point that can command the heating, ventilation and air conditioning system provides easy management of the energy use that provides significant cost-saving.

The networked HVAC systems are widely accepted and applied in the field of construction and architecture today. And the emergence of 'smart' state-of-the-art appliances contributed to the development of this technology. A number of smart devices are already in the market with capabilities of controlling the energy use by setting a working schedule that can benefit from the discounted tariffs and communicating with each other to cooperate. As they can communicate, the appliances can work in coordination with each other. Such as, if the sensors of the heating system receive a message of overheating, the system can inactivate itself and send a message to the air conditioning system to turn on, or warn the fire alarm system if the heating results from an unexpected cause.

Hansmann mentions the benefits of using smart systems in HVAC installations as: "Current heating, ventilation and air conditioning (HVAC) installations use dedicated wiring between the thermostat and the heating and airconditioning unit. This means that wires have to be run to each room in which a thermostat is installed. Due to the cost and complexity of such an installation, this usually limits the number of thermostats per home to one.

By allowing communication through home wiring, for example, thermostats could easily be installed in any room of the house. The heater could find its thermostats through appropriate broadcast messages, and the thermostats would report their settings and temperatures" (Hansmann et al., 2001, p. 78).

c. Fire Sprinkler System:

Mostly considered as a part of the security system, fire sprinklers are prevalently used in non-residential buildings for years and are now deployed in home use. The fire sprinkler system works on the basis of receiving smoke through its sensors that will turn on the sprinklers placed in the house.
The automated fire sprinkler can act through an intelligent procedure to decrease the damage in case of a fire alarm. As it receives the amount of smoke to activate the alarm, fire system can turn on the sprinklers, 'talk' with other elements of the entire system to shut the electronic appliances at home, send an emergency message to the fire department and alert the neighborhood with flashing lights.

d. Security:

Security management is a fundamental task that is included as a part of the home automation system. Different gadgets and devices are already in use and purchased in the market today, including cameras, sensors and types of control mechanisms. Comprehensive security systems with interconnected sensors and cameras are used in large scale buildings for a years. Now these systems are appearing at home as a a part of the automation system. In the smart home network, the security system is composed of cameras, sensors of various types as motion sensors. At any required time the cameras and sensors report the data to the central control point. Security reports can be sent to the user through the Internet to the control point at home, to his/her cellular phone or PDA. The centralized control of the security system network facilitates instant indication of the user and manipulation to the situation.

e. Appliances:

In the history of automation, the control of electronic appliances at home began with the invention of the miraculous infra red remote control technology. Remotely operating the television, VCR or the stereo is a very ubiquitous technology today that its absence is unimaginable. Besides the remote control, the timers are a part of the consumer electronics, allowing preprogramming of the cookers, VCRs and many other appliances.

However, the ubiquitous use of computer technology, today mentions the emergence and use of the smart appliances. The term 'smart appliance' is described by Hansmann as: "...devices used to increase comfort or convenience that are endowed with a certain computer intelligence and networking capability" (Hansmann et al., 2001, p. 77). The smart devices are now able to act in the most efficient way, as they can talk with each other thanks to the networking technology. Home entertainment systems are the most popular products of this smart technology. Moreover, the smart refrigerators, ovens, dishwashers, washing machines and similar devices are also in the market, offering the smart technology for home usage.

In their article "appliances to be Linked to Internet", Koncius and Haggerty report a few of these emerging appliances: "At the International Builders Show in Dallas a few days ago, General Electric Co. demonstrated a concept Internet-connected refrigerator, with its ability to read bar codes as you put the groceries away and reorder when the cupboard is bare. This was obviously more than an ice box. It was a "command center," wired with "home gateway" technology for a home where all appliances are on the Internet, sharing information that goes well beyond reminders to take out the trash.

Only yards away on the exhibition floor, competitor Whirlpool Corp. showed off its command-center fridge, complete with food-tracking capability and a wireless pad to let consumers download recipes from the Net.

Far from Dallas but not wanting to miss the moment, Sunbeam Corp. let word leak out early about its own interconnected appliances – the bedside alarm clock that turns off the electric blanket and turns on the coffeemaker; the bathroom scale that transmits your weight to the gym. Sunbeam's introduction had been planned for the International Housewares Show in Chicago over the weekend" (Koncius, Hagerty, 2000).

Similar products are emerging in the market everyday. The Screenfridge is another example from the real world. In their web site, the electronics company Electrolux announces the production of their smart refrigerator Screenfridge. Besides functioning as a smart refrigerator, Screenfridge promises a combination of a number of functions accessible through its screen as internal and external...
communication, food management, news and radio broadcasting, home security and surfing the Internet (Official Web Site of Electrolux).

The scope of the appliances that can be included in the automation system can go further. However, we may mention the basic appliances in an average home and categorize them three groups. **Kitchen appliances** are the basic electronic appliances in an average house kitchen such as the refrigerator, oven, and the dishwasher. Coffee maker and the toaster can be added to the list in most kitchens. **Bathroom appliances** include mainly the water temperature control. Washing machine and dryer are two of the other basic devices that may be included. The third category includes **other appliances** that might be included in this system as the central vacuum cleaner, humidifier/dehumidifier, aquarium and etc.

### 3. **Optional Members of The Home Automation System**

The optional members of the home automation system include the home entertainment with any other additional system. Actually, this has been one of the most rapidly developing branch of the home automation systems. Today, the home entertainment systems and various high technology music systems are already in use and available. The existing systems enable the high quality audio and video access with both visually attracting and intelligent designs. However, this field develops in itself, mostly separated from the integrated home automation system. The intended home automation system promises additional connectivity and control of these existing audio and video technologies, making it a part of the entire home system.

### D. **Today and Future Prospects**

In today's technology, networking of electronic appliances at home are possible in three different technological infrastructures. These are based on existing power and phone line networks and the new radio frequency networks. Today, the widely used X-10 and CEBus technologies use the power line networking, however, various advanced technologies are developing into the market using the radio frequency networks, which allows a significant increase in the data transmission rate and a more spread use.

Use of existing power line structure of the home is one of the prevalent options due to its low cost for basic functional controls at home. However, since it uses existing electrical wiring for data transmission, it offers a relatively slower data transmission rate of 10Kbps due to the high amount of noise on the line and various types of materials used for wiring (Hansmann et al., 2001). Still it is a widely used technology for the control of simple functions such as lighting or heating systems. X-10 and CEBus systems are two well known technologies providing control over the power line. CEBus is a more developed technology. Different from the X-10 which uses a narrow band, CEBus introduces the spread spectrum carrier technology. This means a larger frequency area is used for sending information reducing the risk of failure. The spread spectrum carrier technology of CEBus is also called (EIA-600) of The Electronic Industry Association. Besides providing a physical layer for signal carrying, CEBus makes use of a special language known as CAL-Common Application Language for application development (Hansmann et al., 2001, p.296).

Phone Line Networking is built on the existing phone line wiring systems for data transmissions with a 1 Mbps rate.

Use of the radio frequency networking is another technology which offers a data transmission rate of 1-2 Mbps allowing a much faster transmission compared to the first two technologies. Due to its advantages, use of radio frequency networking seems to be the most appropriate technology for the purpose of widespread connectivity in the future (Hansmann et al., 2001).

A well known technology using the radio frequency networking is **Bluetooth** which was first offered in 1994 but essentially gained a significant momentum in 1998. Hansmann defines Bluetooth technology as:
".... a technology for short-range wireless connections between devices" (Hansmann et al., 2001, p. 279). It provides the wireless communication and connection of the appliances within a periphery of 100m. Bluetooth technology was initiated by Ericsson in 1994, developing with the participation of IBM, Toshiba, Nokia and Intel in 1998. Today, it is already being used widely, with various compatible devices existing in the market. It has a data transmission rate of 1Mbps which allows communication between personal computers, printers, mobile phones and other devices. It enables this connectivity by establishing piconets, which are ad hoc networks, where each appliance can communicate with up to seven other units. Since it uses the 2.4 GHz public band of the radio frequency spectrum for data transmission, the communication of Bluetooth compatible devices has no cost. This availability of wireless connection provides low complexity, and the reduction of the costs makes Bluetooth technology a preferrable option for connectivity (Miller, 2000).

1. OSGi, The Open Services Gateway initiative

Networking enables the communication of devices within a subsystem such as a camera and an alarm set that are part of a security subsystem. However, the future projects on the smart home suggest a complete connectivity between different subsystems. For example, the communication of the security system with the heating system or the kitchen appliances. Therefore, a new understanding of connectivity has been defined following the conventional deployment of networked subsystems. Thus, this new approach leads to a holistic perspective of the distinct but coordinated home automation subsystems.

Therefore, this systematic view of home automation has become a cornerstore for the perception of the future of these systems. Besides other standardization suggestions, the foundation of OSGi (OSGi-Open Services Gateway initiative) also rests on the same principles.

“The Open Services Gateway Initiative (OSGi), established in 1999, is a independent, non-profit corporation working to define and promote open specifications for the delivery of managed broadband services to networks in homes, cars and other environments” (OSGi Official Site).

The conventional approach suggests a separate gateway for each service such as telephony, cable or data networking, thus requiring a coordination among them. However, this causes a redundant complexity. On the other hand, OSGi defines a common services gateway that replaces the array of separate dedicated gateways and serves as a single and principle gateway, thus reducing cost of service deployment.

The standards specified by OSGi define how a service that operates through a service gateway can

- be managed,
- communicate with the OSGi platform and other services on the same platform,
- be presented to users and administrators through a Web interface, and
- detect and communicate with devices on a local network.
The OSGi specification is designed to complement and enhance virtually all residential networking standards and initiatives, such as Bluetooth™, CAL, CEBus, Convergence, emNET, HAVi™, HomePNA™, HomePlug™, HomeRF™, Jini™ technology, LonWorks, UPnP, 802.11B and VESA. In the same way, the specification leverages the value of existing wire line and wireless networks while providing flexibility toward cable, WCDMA, xDSL and other high-speed access technologies.

The OSGi Framework and Specifications facilitate the installation and operation of multiple services on a single Open Services Gateway (set-top box, cable or DSL modem, PC, Web phone, automotive, multimedia gateway or dedicated residential gateway)” (OSGi Specifications Overview).

The presence of the OSGi specifications contribute to the market in various ways. In technical aspects, it helps end the complexity for service providers, and makes possible to access high value services via a single services gateway. OSGi has provided strong benefits to related communities in the following ways (OSGi Web Site).

- By means of OSGi specifications, there has been a reduction in the cost of service deployment and new recurring revenue streams have been created for the service and content providers.
- For the network operators, there has been an increase in the use of networks where the customers will be more dependant and permanent.
- Using a common API and framework and the extension in the application of devices has been a benefit for the manufacturers.
- The reduction in the costs and complexity and access to many services in a secure way was a benefit for the end users.
The future plans for home automation seem to go beyond what has been foreseen until today. The presence of OSGi and the cooperation of relevant companies in this field will provide a solid concept of connectivity and subsequently a complete automation.

2. Convergence/Pervasiveness

We can say that all these developments come from both the technology push and market pull kind of factors. In a parallel course, for example, with the introduction of many smart appliances, it is apparent that we are going towards a new era of computing that pervades everywhere. As computers become part of our daily life, many devices that can process and enable access to information, at anytime and anywhere, are emerging with at accelerating rate. Also, these smart devices are getting smaller in size and are being embedded in other devices. This phenomenon is called pervasive computing.

Still another modern phenomenon is the emergence and spreading of the Cyberspace. The OSGi vision of home automation also facilitates a smooth convergence to Cyberspace, the extension of both the environment and self of Homo Sapiens.

From an economic perspective, these developments create new opportunities. As the market of home automation develops and the need for prevalent connectivity increases, a new question arises as how the accompanying complexity due to this increased connectivity should be managed. On the other hand, due to the nature of the breadth of such systems, this market is composed of specialized subsegments such as equipment/device makers, Internet Service Providers (ISP), standard organizations, platform developers, service system providers (SSP), and the end users. Therefore, in order to extend the scope of the service capabilities of home automation systems, a coordination is inevitable between all these subsegments in a way that the above mentioned complexity is properly managed.

The future projections about the home automation technology is based on the communication of the subsystems such as the security cameras and the videophone. All these subsystems are fed up with different service gateways. Telephony, data networking, cable services are instances for the existing gateways. In the future, to provide networking and a communication gateway, a “Services Gateway” is proposed to serve all the subsystems in the home automation system. OSGi, Open Services Gateway initiative is founded in 1999 to define the specifications of this services gateway. The official web site of OSGi foundation defines the available services in the home as: "Information/Entertainment, communication, energy management and metering appliance, diagnostics and servicing, safety adn security monitoring, telemedicine and healthcare monitoring."
II. The Interface

Everyday, we push, pull or twist some door handles to open or close them, turn some light switches on and off, press some buttons on the television’s remote control to command it and carry out a number of other similar things, to control the tools and devices we use. When using a knife or a palmpad computer, be it the simplest tool or an advanced electronic appliance, we interact with them through their interfaces.

What should be understood by the word interface varies; it can be examined through a vast literature, and brings along some philosophical connotations. A generalizing description of the term was made by Raskin, who is well known for his studies in human-computer interaction: “The way that you accomplish tasks with a product - what you do and how it responds - that’s the interface” (Raskin, 2000, p. 2).

Raskin’s definition of the interface brings up the term in its general sense. The interface is anything that serves as the means of interaction with a tool, object or device. In different media, the interface can be examined in various connotations. We may mention the interface of a screwdriver, a telephone machine, the digital display screen of a cellular phone or the operating system of a personal computer. Or to consider the word in its broadest sense, human body may be thought as the interface of the biological formation of human beings, specializing in a number of organs that undertake different tasks and actions. Or the human face may also be considered as an interface, expressing the thoughts, feelings and reactions of the human brain. There is a vast literature on the philosophical understandings and considerations of the interface. However, this thesis rather concentrates on the use of the visual language in the interface of concrete tools and devices with an emphasis on the user interface for the human-computer interaction.

The interface of a tool or an object, is usually a combination of the visual clues, signs and messages existing in its physical formation. To give an example, scissors has holes at the handle side, for the user to put his/her fingers through them. There are various buttons on the remote control device, each serving for a different function to turn on and off the TV set, increasing or decreasing the volume, etc. Or each button placed on the keyboard of the computer corresponds to a letter of the alphabet, and thus serve typing. Many different interfacing elements may be mentioned that are on a variety of tools. The field of product design mainly concentrates on designing their interface. However, the interface for human computer interaction differs in some respects. Designing an interface for the screen concerns the collaboration of different fields such as industrial, graphical, communication, interaction and information design disciplines.

A generalizing classification for the interface of tools, objects and devices may be considered in three groups: simple daily tools, modern mechanical tools/appliances and high technology computer based media/appliances of today. In this chapter, the term interface will be examined in the three contexts mentioned above: interface of the simple/daily objects; interface of the modern information systems and interface for human computer interaction. Before the introduction of computers or even electronical/mechanical appliances in our life, the term interface was still mentioned for the simple tools we use. The history of interface design starts with the invention of the early simple tools used in basic daily activities, as mentioned by Alan Kay: "Of course the practice of user interface design has been around at least since humans invented tools. The unknown designer who first put a haft on a hand axe was trying not just to increase leverage but also make it an extension of the arm, not just the fist" (Kay, 2001, p. 123). The ancient man created the axe, the knife, the spear and many other tools and developed them through his emerging needs. In the beginning, the axe was composed of a piece of rock, one side of which is sharpened for cutting and tearing. A handle was added later, both to protect the hand and to facilitate its functioning. The handle became a round shaped piece of wooden stick to prevent the hand being hurt while clutching it. Throughout the development stages of these tools, men added every piece to serve a purpose, for an ease of use. Actually, today, the design and development of tools and objects, their functionality and ease of use, generally concerns the practice of industrial product design, founded on functionality, ergonomy and also aesthetics. And these three main subjects compose the basis of interface design, in tools, objects and even interface for computer screen.
The interface of the daily objects are composed of various interaction elements, pieces and signs conveyed by their **appearance**. Usually we do not notice these pieces and signs consciously, however, we perceive the way these tools are supposed to be used, handled or managed. The knife is a basic example. It is composed of two parts: The handle and the sharp cutting blade. The handle is mostly designed of wood or plastic and has rounded edges, obviously to prevent the hand to be hurt while using it. The metal part is only for cutting. However it has a cutting edge and an unsharpened back. This is for protecting the fingers that push the blade while cutting.

The mechanical telephone machine is a device that can exemplify a more developed interfacing structure. The average mechanical telephone machine is composed of the body and the receiver. The buttons that contain the numbers are placed on the body of the telephone machine and are mostly made of plastic material, placed in a nest, carved on the surface of the body. Therefore, the press of the fingers push the button into its nest, providing the user with the sense that he already pressed it. Besides helping the user to perceive his action of pressing a button, dialing a number, the bumpy appearance of the button also gives the user a message that it is a button created for pressing. Meanwhile, it should be mentioned that the button and its functioning has a significant place in the practice of interface design. Buttons have quite a prevalent use either in telephones, keyboards, electric switches, and even in the design of graphical user interface for the screen, which will be examined in detail in the following chapter.

As exemplified with the knife and the telephone machine, the visual and physical clues in the appearance of the tools provide the basic messages that either facilitate the use of these tools or help the user to grasp how and in what way, for what purpose it can be used. This type of information, that is available from the appearance of the objects is based on the Theory of Affordances which was offered by J.J. Gibson in 1979. In his book, 'The Ecological Approach to Visual Perception', J.J. Gibson defined affordances briefly as follows: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" (Gibson, 1979, p. 127). The theory of affordances has become a foundation for designing functional user interfaces for both every day objects and the GUI's that are used in computer interactions, especially upon their reinterpretation of user interface issues by Donald Norman, a well-known psychologist, who is especially famous with his book 'The Psychology of Everyday Things' where he studies the theory of affordances for objects we use in daily life. In his book, Norman defines affordances in a more explanatory way: "The term affordance refers to the perceived and actual properties of the thing, primarily, those fundamental properties that determine just how the thing could possibly be used. Affordances of simple tools provide clues of usage, so things do not require explanations" (Norman, 1998, p. 9). Affordances are actually what is meant to be the visual information perceived through the appearance of the objects. A bumpy button on the control panel of the washing machine affords to be pressed. The theory of affordances will be explained in more detail in the succeeding chapters. But briefly, we may classify the information extracted from objects' physical appearance into three main categories: structural appearance, material and color.

The **structural form** of an object is the main clue to identify the object and its function. Objects which are familiar to us, already have usual accepted shapes in our visual memory. Therefore, although they may be designed in various forms, sometimes even not serving up to their designated functionality, the existing knowledge in our visual memory can identify the object and its function. As an example, we may contemplate a number of available chair designs. However, we have a visual knowledge of a standard chair, that is, it has a surface with a slight curve available for sitting and some kind of base or legs to provide support to it. Actually, throughout the design process, usually the functioning of the object determines the design form of it. Therefore, the functional definition of objects also shapes the physical design, which provides the user to recognize the object more easily.
A door is also an example for the objects that provide information from their appearance. Different types of doors exist, such as sliding doors, swinging doors or folding doors. Swinging doors afford to be pushed or pulled; sliding doors afford only being slid to the right or left side. When a person confronts with a door, s/he may be able to distinguish the door type and how it should be treated, for instance through the appearance of the door handle. In daily routine, we mostly don't have the time to receive this visual information from objects, evaluate this knowledge and determine our actions towards it. Rather, we receive the information from the visual appearance of the doorknob and then use the existing knowledge from our previous experiences of how to deal with different door types. For instance, the doorknob in Fig. 2a affords to be twisted and the doorknob in Fig. 2b afford to be pressed down. Differing types of doorknobs may state rather the door should be pushed or pulled to be opened or closed.

Choosing the accurate material for an object depends on many factors such as aesthetic appearance, pricing, etc.; but it mainly serves to define the functionality of the tool. To meet functional requirements, a soft, hard, refined, rough, plastic looking or rigid material can be preferred. These parameters affect not only the functionality, physical appearance and design of the objects but also provides the sense to the user about how it should be treated.

The use of texture also serves the interface of an object. For instance, the plastic cover of the screwdriver is mostly textured at the handle, in order to prevent the slip of the hand that may result in a significant injury. Sometimes textured areas may be also be conducting messages as how should the hands be placed. Such as the handles of the saucepan and its cover are covered with a plastic of different color, that both indicate where it should be held and prevents the transformation of the heat to the hand.

Although it is generally mentioned as a matter of aesthetic quality, actually, the choice of color may also contribute to the affordances of the object significantly. Color is a strong sign that may contain a number of connotations depending on cultural understandings, traditions, standards and aesthetics. Zakia notes on the use of color and its connotations as follows: “Colors also serve as signifiers and are culture-as well as context-dependent. (...) Color is symbolic in its millions of hues, chromas, and lightnesses, feeds our emotions with various connotations that are culturally agreed upon” (Zakia, 1997, p. 89). Color coding is analyzed in detail in the proceeding chapters from a semiotic perspective.

A. Interface of Modern Information Systems

"From the earliest use of interactive computing in the fifties -mostly for air traffic control and defense-there have been attempts at user interface design and application of ergonomic principles" (Kay, 2001, p. 123).

After the emergence of modern information systems with the development of technology and before the involvement of computers as a daily used tool in our lives, the term interface was mentioned regarding to the control panels of developed machines and information systems. The cockpit design of an airplane or the control panel of a sound mixing system can be given as examples.

Distinct from simple tool interfaces, user interface systems in modern information feedback systems are more complex in nature. The steering wheel of the car is a good example. When the user turns the steering wheel, the car turns to the same direction simultaneously giving a real time feedback. A still more complicated system is the control desk of a sound editing/mixing machine. In such devices, there is a distinct interfacing panel, the so called control panel, which is composed of buttons, indicators, sliders and lights, offering an interaction platform to the user for accessing the control mechanisms of the appliance.
B. Interface for Human-Computer Interaction

In an interview, Aaron Marcus described the user interface as follows: "A user interface is a means for human beings to interact with computer-based 'tools' and 'messages'" (Rhodes, 1999, p. 1). His description, implying especially human computer interaction, briefly states the meaning of the term properly. Since the invention of the simplest tools, humans intuitively designed the interface for these tools in order to use/interact with them. The interface of concrete tools and objects make use of messages that are perceived with our five senses. However, today we are facing an almost completely new understanding of the term interface, which enables our interaction with the cyber world, with the "tools" and "messages" of this new environment. And the interaction with the cyberworld is only related to visual and aural communication, eliminating the remaining senses: touch, smell and taste. This restriction in perception requires the existence of a strong graphical interface, supported with aural feedback.

Today, computers are a must in our daily activities, and this requires them to be functional in communicational terms. The computerized lifestyle does not require each person to become a computer expert, of course; rather, computers are becoming more easy-to-use machines with smart user-friendly graphical interfaces. Yet, the transformation to the computerized lifestyle is in progress, promising more interactive, easy to use systems, that recall lifestyles depicted in futuristic fantasies.

Johnson, in his book "Interface Culture", examines the interface both as a software and as a part of the society, including the cultural aspects. He defines the term interface as flows: "... In it's simplest sense, the word refers to the software that shapes the interaction between user and computer. The interface serves as a kind of translator, mediating between the two parties, making one sensible to the other" (Johnson, 1997, p. 14).

The user-friendliness of this mediator cannot be ignored. Even writing a single word on a text editor requires the user to interact with the computer, open a text editor software, type it, format it, save his document and finally perhaps, to have a printout of it. This might completely become a scaring process for an unqualified user since s/he will have to interact with the computer "world", composed of graphics, symbols, texts and a series of commands that really make no sense in the beginning.

Yet, other than creating text documents, many of us use the computer even for further different purposes. Becoming more complex as it serves more purposes, the language we use to communicate with the computer becomes more important. Johnson notes on the importance of this communication: "Representing all that information is going to require a new visual language, as complex and meaningful as the great metropolitan narratives of the nineteenth century novel. (....) As the infosphere continues its exponential growth, the metaphors used to describe it will also grow in both scale and complexity. The agora of the twenty-first century may very well relocate to cyberspace, but it won't get very far without interface architects to draw up the blueprints." (Johnson, 1997, p. 18).

The interface for the human-computer interaction has a long historical background, starting from the early 1950s, after the invention of the first computer. In the fifties, the computer emerged as room-size machine, used and controlled by scientists only, and therefore there existed a different interface. It was a text based language composed of commands containing mathematical functions. However, the studies for graphical user interfaces for human interaction methods have been developed shortly after the invention of the computers. As mentioned here, the history of the interface may and should be examined in two main epochs: that is, the "text based" interfaces and the GUs (Graphical User Interfaces). This study mainly focuses on the Graphical User Interfaces, and the long way from the textual command based interfaces to the user-friendly graphical and colorful interfaces of our age is very significant.

1. Text based user interfaces

The computer emerged as a functionally developed huge machine that could calculate and served basically scientists in the beginning. The room-sized machines were controlled with punch cards
containing plenty of complicated commands. Later more humanized computers emerged that were also controlled and used by experts, enabling interaction through the keyboard and the text based mathematical languages. Although it served the advanced user only, the early interface for human computer interaction was the text based languages, composed of plenty of complicated command sets. Johnson mentioned the text based languages as: “In its original usage, in fact, 'interface' was just another word for text: input entered with keystrokes, output delivered studiously to the printer or the monitor. All the great languages that governed the relationship between the computer and user were text driven: BASIC, COBOL, Unix, DOS” (Johnson, 1997, p. 150).

The “text” dominated the computer world for decades, especially for the advanced users. Whereas the graphical interface facilitated use of computers for others, advanced users still preferred to use the text driven ancestors of the interface. However, the subject of this thesis focuses on the design of graphical user interfaces, therefore there will be a detailed examination of the development of graphical user interfaces in the following chapters.

2. Graphical User interfaces

The history of graphical user interface (GUI) is usually mentioned as having emerged with the release of the famous Apple Macintosh interface. However, actually, the need for a visual representation of the computer world was realized long before the development and release of Apple Macintosh computer. The early studies intending to design a visual language, a graphical user interface for human computer interaction actually started at Xerox Palo Alto Research Center (PARC) during the 70’s. But this work itself was based, in turn, on the research and studies at Stanford Research Institute (SRI) in 60’s, where the technology of bitmapping and the concept of direct manipulation were developed.

This attempt of representing the mathematical world of computers in a visual way was developed based on the fact that the visual memory and capability of the human brain is far beyond the textual memory. However, since the interaction with the computer was available through a textual language, containing a number of mathematical functions that are really complex and nonsense for casual user profile, the computer addressed the advanced users, that were the scientists of the time. Meanwhile, even for the advanced users, the textual language of the computer was not so efficient as it caused plenty of mental load for the brain. The visual representation of the computer would certainly facilitate the learning and using processes significantly, even for everyone. In his paper, Weiser also mentioned the difference between visual memory and textual memory in the sense of human computer interaction: “A well designed system makes everything relevant to a task visible on the screen. It doesn't hide things under CODE+key combinations or force you to remember conventions. That burdens your memory. (.....) When everything being dealt with in a computer system is visible, the display screen relieves the load on the short term memory by acting as a sort of visual cache. Thinking becomes easier and more productive. A well designed computer system can actually improve the quality of your thinking. (...) In addition, visual communication is often more efficient than linear communication; a picture is worth a thousand words” (Weiser, 1991, p. 102).

After the invention of the bitmapping technology, research at the PARC mostly turned toward the development of a visual interface, that would provide computer accessibility to casual users and even children. The research and emergence of GUIs significantly affected human computer interaction and changed the user profile from scientists and computer experts to unqualified users, even to children. Johnson mentions the effects of the appearance of the GUIs as follows: “The widespread adoption of the GUI has dramatically changed the way in which humans and computers interact, and has greatly expanded computer literacy among people once alienated by the arcane syntax of the older ‘command line’ interfaces” (Johnson, 1997, p. 16). This transformation followed a long path since its beginning at the PARC, as a software developed to facilitate the children's interaction with the computer, and then developed into the GUIs of our time, that are used by everyone.
C. Historical Development of The Graphical User Interfaces

The ancestors of today's GUIs first appeared in the software SketchPad, developed by the computer scientist Ivan Sutherland in 1962. The Sketchpad was mainly a kind of an early drawing software which pioneered the late MacPaint and Photoshop drawing softwares. Sutherland introduced the use of a virtual drawing page in Sketchpad and thus brought a new understanding to the virtual world provided by the computer screen. The virtual page also contained buttons used for entering commands, which may be known as the early examples of interactive graphics; therefore Sutherland is usually mentioned being the inventor of the first interactive graphical applications. However, beyond the the concept of a virtual drawing page and interactive graphics, Sketchpad introduced the "light-pen" that may be used for manipulating the screen. The lightpen was the first input device after the keyboard, however, it required the arm to be kept in a vertical position while using it, therefore, it has been discovered to be inefficient, causing the blood run out of the hand when it is used for a long time. As a sum of all, the SketchPad was a pioneering study and it proposed a number of innovations. However, in essence, the software was not dealing with the problem of visually representing the data, but rather aiming to use the computer as a drawing tool.

Later, in 1968, at the Stanford Research Institute (SRI), Douglas Engelbart, a computer scientist, presented his inventions where he proposed a number of new technologies and concepts, that are known to be the basics of the modern interface design. The bitmapping technology, the concept of direct manipulation, the use of a pointer and representation of information in tiling windows have been mentioned by Engelbart, all of which is accepted as being revolutionary today.

The bitmapping technology proposed the use of the computer screen as a two dimensional space, allowing active and inactive pixels, thus creating an image on the screen. The technical definition of the term was made by Johnson as: "Each pixel on the computer screen was assigned to a small chunk of the computer's memory: on a simple, black-and-white screen, that chunk would be a single bit, either a zero or a one. If the pixel was lit up, the value of the bit would be 'one'; if the pixel went dark, its value was 'zero'. The computer, in other words, imagined the screen as a grid of pixels, a two-dimensional space" (Johnson, 1997, p. 20). Briefly, the bitmapping technology allowed the visual representation of data on the spatial computer screen, and thus paved the way for the future technology of graphical interfaces.

Besides bitmapping, the concept of direct manipulation was another revolutionary invention in the history of graphical interfaces. Briefly, the direct manipulation was aiming to provide interaction of the user with the computer through the screen, icons and objects seen on it, thus making her/him a part of the operation of controlling the computer. Thanks to this approach, the incomprehensible hocus-pocus process of the computer with some awkward command sets changed into a more understandable process since it allowed the user to manipulate what s/he sees on the screen, or as Johnson said: "Instead of telling the computer to execute a particular task - 'open this file' - users appeared to do it themselves" (Johnson, 1997, p. 21). The technology of direct manipulation is the basis of graphical interface design, since it allows the user to interact with what s/he can see on the screen real time.

Later, in 70s, the studies founded on the inventions of Engelbart has been pursued by the scientists at Xerox PARC. PARC is known to be the heart of studies made on user interface design and is founded by scientists, most of which were veterans of SRI. Alan Kay is one of those scientists. He studied electronic engineering and he started his studies on user interface at the college by designing a user interface for a personal computer model project. In his project, he included the virtual window concept and the tiled windows of Sutherland.

Later, he joined Xerox PARC to pursue his studies on interface design. Focusing on the breathtaking inventions of Engelbart, the tiling windows on the screen, Kay pointed to the problematic implementation of windows that caused lack of enough space on the screen. Since the windows of Engelbart were not able to overlap, there was a real problem of fitting them in the screen area. Kay proposed the overlapping of the windows on the screen so that many of them could be opened simultaneously and managed more
easily without lack of enough space. Johnson reports the words of Levy (Levy, 1994, p.61) about the revolutionary invention of Kay as: "Not only was it difficult to keep straight which window one was working in, but the windows wound up competing for the extremely limited real estate on the screen. Kay's solution to this was to regard the screen as a desk and each project, or a piece of a project, as paper on the desk. It was the original desktop metaphor. As if working with real paper, the one you were looking on at a given moment was on top of the pile" (Johnson, 1997, p. 47). The legendary desktop metaphor came into being with Kay's solution. Now there was a virtual world with depth, that one can move things in and out. Plenty of well-known objects, icons and actions pertaining to the desktop metaphor had originated from Kay's inventions.

In 1971, Kay founded the Learning Research Group (LRG) in Xerox PARC and started his project named Dynabook. Dynabook was originally a personal computer model which was intended to be at notebook size with flat panel high resolution graphics display. Kay pursued a hard work on the project, however, the technology suggested with the Dynabook project was so farfetched at the moment that the project had not been very noticeable.

However, some parts of the Dynabook project lead to the initiation of the first genuine desktop interface by Alan Kay and his team at Xerox PARC. The interface was developed for the operating system Smalltalk which was also developed by Alan Kay. Actually Warfield comments on the Smalltalk as such: "Although hardware limitations prevented commercial production of Dynabook, many of the features of the new interface technology can be traced directly to the prototyping efforts behind it. One of the most important products to come out of the Dynabook project was the Smalltalk language" (Warfield, 1983, p. 218). Smalltalk also was the first widely used object oriented language.

The Dynabook project also caused the development of the Xerox Alto computer in 1972. The project was basically intended as a prototype for Dynabook system. The Xerox Alto computer was quite a large machine and didn't have a GUI in real meaning, and consequently, Xerox Alto has never been commercialized. However it had been mentioned for featuring a bit-mapping display that is essential for displaying graphics and the first WYSIWYG text editor, Bravo, which has later been used in Xerox Star computer.

The use of icons and iconic representations have been mentioned by David Canfield in 1975, at Stanford University, in his doctoral thesis. With the cooperation of Alan Kay, Smith and Bill Verplank, iconic representations have been developed for the Xerox Alto computer; however, later, the icons have been popularized by Smith, during the design of Xerox Star computer. The computer was revealed in April 1981. Although it aimed to be a commercial product, it never became a success in financial terms. However, it became the predecessor of many well-known ideas we use today as making an extensive use of Direct Manipulation, featuring the desktop metaphor and WIMP (Windows, Icons, Menus, Pointer). Especially, Xerox Star was released to target offices and business people that deal extensively with information management.

Steve Jobs, the co-founder of the Apple Company also was interested in the Xerox PARC. He had contacts with the PARC scientists and asked for cooperation of Alan Kay and his colleagues. The group transferred to the Apple company, and soon released the Apple Lisa computer. The Apple Lisa was striking with its powerful microprocessor and graphical interface, however, it had also been a commercial failure. The research lead the team to the development of a second project, the Apple Macintosh, a milestone in the history of user interface design.
Apple released the legendary **Macintosh** computer in 1984. The machine included an attached mouse and keyboard, a 9 inch monochrome screen and a single floppy disk drive. The real big difference was its interface. The interface borrowed similarities from the Lisa computer, but also contained the menu bar with File, Edit, Search, Format, Font, Style, pull-down menus. The Macintosh provided the extended use of all the graphical interface concepts and technologies. The desktop metaphor, WIMP (windows, menus, icons and pointers) and the interaction methods with the computer had been accepted and soon became the standard of the graphical user interface. "... Apple released the Macintosh -the 'computer for the rest of us'- with an inventive, mesmerizing desktop metaphor; one that introduced almost every modern interface element to the popular imagination: menus, icons, folders, trash cans. More than a decade later, it remains the standard by which all interfaces are judged. You can safely say that all interface enhancements since are merely variations on that original theme" (Johnson, 1997, p. 49).

The Apple Macintosh, as a predecessor, inspired the following releases of emerging user interface designs. During the release of the Mac Apple, the MS-DOS was widely used, as a text based operating system. The Windows interface has emerged almost at the same time, also featuring the use of desktop metaphor and the WIMP paradigm. The story of the development of Microsoft Windows -which was named as Interface Manager at the beginning- started actually in September 1981. The first version developed included word-like menus that were placed at the bottom of the screen, but this has been changed before the release of **Windows 1.0** which was released in November 1983, just before Apple Macintosh. It could be named a commercial success by the November of 1985. In this first version, there was: MS-DOS Executive, Calendar, Cardfile, Notepad, Terminal, Calculator, Clock, Reversi, Control Panel, PIF Editor, Print Spooler, Clipboard, RAM Drive, Windows Writer and Windows Paint included. Meanwhile, Mac Page Maker has been released by Apple as the first desktop publishing program. Subsequently in 1987, Windows compatible desktop publishing program Aldus Page Maker has been released (the first WYSIWYG PC program). Later, Microsoft released Excel, a Windows compatible spreadsheet. Then came Corel Draw and Microsoft Word.
In 1987, December, Windows 2.0 appeared in the market. In Windows 2.0, there were icons to represent programs and files and overlapping windows. Windows 3.0 came after in May 1990 with an improved program manager and icon system, a new file manager, support for 16 colors. It has been the best-selling graphical user interface ever in the history. Windows 3.1 was released in April, 1992. True type scalable font support was available in Windows 3.1.

The Windows releases continued in the following years, and soon started its domination in the market. Windows 95 had been released in August 1995. In 1996, Windows CE had been released as the operating system for handheld devices and palmpads. The interface was similar to the interface of Windows 95 and NT. This has been followed by Windows CE 2.0 in 1998 and Windows CE 3.0 in 2000. CE 2.0 was mostly bringing solutions to the problems surfaced in CE 1.0. And Windows CE 3.0 offered an embedded platform with the power of Windows and the Internet. Windows 98 had been released in 1998. In this version, there was the desktop browser-like interface of Windows. Internet Explorer 4.0 supporting HTML 4.0 was also included. The Windows NT 5.0 released in November 1998 and later became Windows 2000. MS Windows reached a more different and advanced point at user interface design with the release of Windows XP in October 2001.

III. The Principles of User Interfaces

In this thesis study, user interfaces (of appliances) will be studied from a "general systems theory" perspective. This defines a "system" by its boundaries, its internal working (supersystem, system proper, user, interaction) and its interactions with the environment (culture). Eventually, the fine distinction
between the "supersystem" (the network where the "system proper", that is the "device", is connected to a web of other interconnected devices, for example, the Internet) and the "system proper" emphasizes the fact that they are, indeed, inseparable organic parts of a single entity. For all practical purposes, however, as the complex relationship between the "supersystem" and the "system proper" are beyond the scope of this study, in the remaining part of this chapter the "system proper" will be called simply as the "system".

![Diagram of system: supersystem, system proper, user, interaction.]

**A. The Cultural Environment**

The cultural environment that give us the fundamental matrix of the system related concepts depicted in Fig. 7 is predominantly determined by production relationships; furthermore, the modern phenomenon of technology penetration into our lives is also a strong factor to reckon with. Finally, conventions that give indeed rise to culture (language, logic, communication, etc.) are the subject matter of semiotics; this paper will mainly focus on the latter two aspects.

**1. Production Relationships**

Beyond offering simply a fundamental Marxist perspective to the subject at hand, production relationships are extremely important for the proper analysis of user interactions, because the latter are directly determined by the nature of the environmental conditions that are offered when the user is, indeed, in action (more on this later when discussing "affordances" given by the ecological psychology of J.J. Gibson). Homo sapiens is homo faber (man at work). And all work always comprises senses on the input side, and hands on the output side (indeed, hands are equally active on the input side, too). And the way hands operate, determine the whole nature of the interactions. These issues are handled by a special subdiscipline of user interface studies' which is usually simply called input; since this requires considering alternative input devices and methodologies (see Zhai, 1995, for a field survey), this thesis will ignore this aspect, and target only the other subdiscipline, that is, perception/cognition issues, assuming thus the commercially available UI platforms as "given" for the input issues.

**2. Technology Penetration**

Within the rapid development and deployment of technology, computers and computer based devices/appliances are getting involved more and more in our daily life. At home, work or school, people require the use of these devices while performing their daily activities. The cellular phone is a clear example for an everyday technology. Besides the phones, we use personal computers, portable/handheld computers at home or office to manage and process information. The Internet is now a widely accessible
domain though providing instant accessibility to information. Personal computers, handheld computers and even the cellular phones offer Internet accessibility. And finally at home, we confront the state of the art devices as a part of the home theatre system, or similar home entertainment systems that we use everyday.

The need for using technology products in daily life forced us to be more familiar with the technology. While people get accustomed how to interact with these devices, their number increased, becoming an indisputable part of daily activities. About the increasing use, Myers reports the number of cellular phones within a quotation from the article "Is Your Cell Really Safe?" by Kalb, C. and Springen, K., Newsweek, 07.08.2000, p. 63 as: "A whopping 100 million Americans now use mobile phones, and tens of thousands of new customers wire up every day. There will be as many as 1.6 billion cell phone users worldwide by 2005" (Myers, 1996). And besides the cellular phones, the use of Internet also increased significantly, as again Myers reported from the "The White House, Office of the Press Secretary, January 21, 2000, IT Research and Development: IT for the 21st Century": "During the past seven years, computers, high-speed communication systems, and computer software have become more powerful and more useful to people at home and work. Nearly half of all American households now use the Internet, with more than 700 new households being connected every hour. More than half of U.S. classrooms are connected to the Internet today, compared to less than three percent in 1993. It allows Americans to shop, do homework, and get health care advice online, and it has enabled businesses of all sizes to join the international economy. Since 1995, more than a third of all U.S. economic growth has resulted from IT enterprises. Today, more than 13 million Americans hold IT-related jobs, and the rate of growth is six times as fast as overall job growth" (Myers).

This significant increase in the use of computers and computer based devices in daily life forces individuals to become more advanced users, to carry out their daily interactions. Especially in the last decade, the most common way of technology learning occurred while maintaining routine daily activities such as checking/sending e-mails, finding out the timeline schedules of flights on the Internet, making money transactions via the ATM machines, etc.. However, computer literacy is now a part of our education system. For the evolving generation, interaction with computer begins at the primary school, continues throughout the high school and college education. The basic programming courses are already included as a preliminary core course in the curricula of universities, to provide students with basic skills of computer literacy. Consequently, today, as Myers also mentioned, most schools have Internet connection that facilitates and cultivates students' access to information resources.

Besides the academic environment, the professional world has been included in the digital revolution; many professions today require computers. The qualified employees, therefore, are expected to have computer skills and improve themselves along with the development of technology. Most companies offer supplementary courses to their employees, to help them get acquainted with the computer and follow the developments in technology, specific to their field of occupation. Internet connection is provided ubiquitously at the office, and thus, the communication structure is based primarily on the Internet.

Computers have been part of the home entertainment for years since the emergence of the computer games market. The Internet enhanced the entertainment and offered alternate social activities as virtual chatting, online computer games. In the last years, state of the art home entertainment systems also introduced high technology products which offer comfort of watching movies at home in high quality digital formats. These offerings enhanced the interaction with technology at home and acquaintance of using these high technology devices. Actually the Internet is a medium that teaches itself, containing tutorials for softwares and any other information.

3. Semiotics (The Theory of Signs)

Although the origin of semiotics may be traced back to Aristotle, in modern times, there are "... two main directions in semiotic research projects: interpretative semiotics inspired by the works of Charles Sanders Peirce, and structural semiotics, sometimes referred to as "semiology" following the terminology introduced by the Swiss linguist Ferdinand de Saussure" (MITECS, 2001, p. 744). Stated vaguely,
semiotics is the study of how humans use signs.

a. A Lot of Triads (Peirce's Approach)

Peirce's semiotics is based on a triad of sign relations: the sign itself, its object, that is what the sign stands for, and an interpretant which gives the "meaning" of the sign by indicating how the sign represents the object.

Furthermore, Peirce offered three divisions for the sign, based on the character of the sign, on the relation between sign and its object, and the way in which the interpretant represents the object; and he calls these divisions Firstness, Secondness and Thirdness.

Firstness (quality), based on the character of the sign itself, is mostly of philosophical interest and is divided into three elements:

- a sign can be a qualisign (a mere quality or appearance)
- a sign can be a sinsign or token (an individual object or event)
- a sign can be a legisign or a general type

Secondness (relation), based on the relation between the sign and its object, and as such it is frequently used both in modern theoretical and practical disciplines including those that are visuality-oriented. Secondness is also divided into three elements:

- Icons represent an object by virtue of a character which it possesses regardless of whether or not the object exists ((Greenlee, 1973:701) Edmondson, 2002). As to give an example, here is an icon representing my cat "Badem".

![Icon of a cat](image)

- Indices represent an object by virtue of 'being really effected' by it, that is, by being in a dynamical or causal relation to it ((Greenlee, 1973:701) Edmondson, 2002). Here, you can "see" Badem when he has finished his meal and walks around in my room:

![Footprints](image)

- and, a symbol is a sign without either similarity or contiguity, but only with a conventional link between its signifier and its denotata, and with an intensional class for its designatum ((Sebeak, 1976:1341) Edmondson). A word/sound symbol for my cat is his name:

**BADEM**

Thirdness (representation) is based on the way in which the interpretant represents the object and is beyond the scope of our investigation as it is more a proper subject matter for logic; it is also given in three subdivisions:

- rhemes (predicative signs)
• propositional signs (propositions)

We should also add that Peirce's semiotics has strongly influenced Umberto Eco’s semiotic theory of signs and interpretational processes (MITECS, 2001, p. 744).

In the preparation of the model, the general consensus that "visual elements" convey a superior cognition over linguistic elements is followed. Therefore either icons or indices will be used as visual signs, extensively; however, to avoid ambiguities, “linguistic symbols” that is “label words” should accompany the visual elements. And when considered from the home automation aspect, visual elements help building a common denominator for several cultures and languages and thus promote a wider user acceptance, which at the end, increases availability and minimize learning problems.

Furthermore, in compliance with general design criteria, to achieve "consistency", only a certain category of visual signs will be used; “icons” are more appropriate over indices to offer an immediate recognition. Especially when considered through the home automation aspect, since indices offer an indirect referencing, their use might cause recognition problems for the naive household audience. Furthermore, house appliances are widely "standard" in appearance and thus allow a clear communication with iconic representation.

Additionally, from an abstraction point of view, icons can be given in two ways: pictorially or graphically (mouseworks.com); we prefer the graphical variety to offer a better textual integration with the rest of the visual scene. When considered through home automation aspect, graphical elements are preferred because the proposed UI should not change over long periods of time to support habituation; therefore abstracted visualizations of house appliances are used instead of some actual pictorial elements as the latter are subject to frequent changes from one generation to other or even between different models of a brand.

Below, the major GUI platforms are given to elaborate on their icon choice regarding the "graphical/pictorial" criterion.

graphical representation: Yahoo

![Yahoo graphical interface](image)

quasi-pictorial representation: Microsoft Internet Explorer

![Microsoft Internet Explorer interface](image)

quasi-pictorial representation: Groove

![Groove interface](image)
Apart from the infrastructural visual elements such as windows and panes, which are not subject to semiotic mechanisms but rather applied directly, we have action and navigational buttons that should be designed with semiotic considerations in mind; this fact should be emphasized to offer the user a better cognitive framework. A cognitively correct design should make this distinction explicit; to achieve this goal, visual parameters such as color, size, shape, texture, complexity, etc. can be used in a contrasting manner. Specifically, the infrastructural elements' colors are generally neutral; their size is comparatively larger, their shapes much simpler; they have rich texture (interestingly, existing GUI's seem to forget this); and their overall complexity is very low. In contrast, action and navigational buttons' colors may be more attractive to underline some salient features; their size smaller (indeed, it should be minimized as much as Fitt Law allows); they may come in a variety of shapes and also they should not be bound by complexity concerns as long as they convey the message in a proper and economical way.

Also color coding used for some elements falls under this topic; used as such, they are symbols based on universal and/or local (intelligible to their target audience) conventions.
In addition to the criteria explained above for buttons, graphical representation of especially the "action (icon) buttons" should include sufficient information to allow easy recognition; also, cultural dimension of this should be considered carefully. Especially the Saussurian "code" perspective of a signifier, that is the holistic approach is critical. Buttons, designed by technologically oriented people for naive users usually miss this point, and usually the result may be ambiguous if not catastrophic all the time; for example, the widely used Lotus Notes platform employs a "rocket" icon designating the "launch" of a subprogram: an improper (mis)representation that is harshly criticized at user platforms.

Furthermore, visual tokens used for actions buttons make up a different category than the visual tokens used for navigational buttons; therefore, an additional mechanism emphasizing this distinction would definitely enhance user’s cognitive capabilities (see Fig. 11. below).

In the proposed model, actions buttons are kept at a minimum to allow easy navigation and thus prevent errors which might be critical otherwise; also button sizes are kept larger than usual by applying the "standard" Fitt's Law (i.e. not the derivative "corner" interpretation).

Navigational (icon) buttons are differentiated as "signs" by Passini (Chien, Flemming, 1997, p. 5). Actually, whatever the general appearance of navigational buttons should be, the main criterion for them should be distinguishability from action buttons (the criterion applies mutually). To meet this goal, we will prefer "simpler" forms -as compared to action button graphics. Furthermore, as stated by Raskin, navigational buttons should not make use of "label" symbols, to avoid redundant screen congestion (Raskin, 2000). Contrary to established convention, it is also suggested not to put them on button bases, both to be able to distinguish them from action buttons which usually come with such button bases because they are more frequent and thus can be easily confused with the underlying context material; and also because of fact that due to their nature they usually convey their message strong enough and do need such button bases which usually increase the visual congestion of the screen. To give a negative example, beyond using the button base without further elaboration, the toolbar of the Microsoft Windows XP improperly incorporates action icons based on the "arrow" metaphor -which strongly suggests a navigational message- for some trivial action tasks such as "refresh" and "history" (see Fig. 23 above).

Navigational buttons do not call for a special consideration from a Home Automation perspective, except, as explained for action buttons above, the standard Fitt's Law is applied with much tolerance, that is button sizes are kept conveniently large.

b. The Other Thread (Saussure's Approach)

The other thread in the semiotics research gives us the staple repertoire of modern sign studies: the signifier and the signified, as propounded by Ferdinand de Saussure, a linguist and also the founder of Structuralist linguist school. "For Saussure, the system of language is a 'treasury' or 'depository' of signs,
and the basic unit of the linguistic sign is itself two-sided, having both a phonemic component ("the signifier") and a semantic component ("the signified")" (Cambridge Dictionary of Philosophy, 1999, p.815).

Here we must emphasize that the depository/treasure (i.e. language) is a holistic matrix for these two elements: "... the sign ultimately derives its linguistic value (its precise descriptive determination) from its position in the system of language as a whole, i.e. within the paradigmatic and syntagmatic relations that structurally and functionally differentiate it" (Cambridge Dictionary of Philosophy, 1999, p. 816).

Indeed, the dichotomy of the signifier/signified is part of a series of other structuralist dichotomies, such as synchronic/diachronic, syntagmatic/paradigmatic, and langue/parole and thus became the subject matter, criticism target of structuralism/post-structuralism and gave way, among others, to Roland Barthes’ semiology with its rich "interpretations of visual, tactile and aural sign systems, culminating in the publication of several books and essays on photography, advertising, film and cuisine" (Cambridge Dictionary of Philosophy, 1999, p. 72).

The use of color and its cultural connotations may also be examined related to Saussure's approach of codes, where the color may be thought as a conventional code. There are conventionally standardized meanings that are interwoven with the use of some colors. These connotations may also have universal acceptances. Marcus exemplifies the common Western denotations of some colors as: "Red: Stop, danger, hot, fire; Yellow: Caution, slow, test; Green: Go, Okay, clear, vegetation, safety; Blue: Cold, water, calm, sky; Warm colors: action, response required, proximity; Cold colors: status background information, distance; Grays, white and blue: neutrality" (Marcus, 1992, p. 84). Zakia notes the Saussurian perspective as follows: "Colors also serve as signifiers and are culture-as well as context-dependent" (Zakia, 1997, p. 89).

Color coding is widely used in the design of the interface for the computer screen. For instance, as in Fig. 13, the use of color red may exemplify a world wide signification. Due to the international usage of color red in traffic lights related to the message 'stop', use of color red in other mediums may also carry the message 'stop'. Therefore, the red button on the remote control of the television or the air conditioner also signifies that pressing this button will stop the machine. In the remote controls or the control panels of washing machines, the color red signifies the message "stop the action". Conversely, the color green is mostly preferred to be used in the buttons to start an action, that is in parallel to the acceptance of color green as "go" in the traffic lights. Therefore, the start buttons in the stereo or in the control panel of the washing machine are preferred to be green. Meanwhile, the color red as the signifier and the message 'stop the action' as the signified are transformed into a more common use, the sign of emergency. Red is also used as the color of emergency buttons. This, actually, originates from its accepted meaning of halting the action, therefore the emergency button should serve as stopping the dangerous action.

![Fig. 13. Windows XP: amber, red, green: transition, stop, go.](image1)

![Fig. 14. Proposed model: red, green: emergency, active.](image2)

Finally, color coding should not be confused with "color perception" or "color perception cues" which are also proper subjects of the graphical design discipline.

Through the home automation aspect, color coding should be used with greatest care; as explained above, the Saussurian "code" perspective of the signifier becomes even more important here. Since universal color conventions are not established on a wide scale, in order to address as large as possible a naive user audience typical of a household, color coding has not been much used in this model. The exceptional uses include the red color of the emergency button, and the greenish color of the "active"
items and the "marching ants" for mouseovers, which I think are fairly established.

B. The Supersystem

1. The Web of Public Information and Connectivity (The Internet)

We live in the age of information with a series of technology products around us. We use computers and computer based devices in our daily actions which we are all, to some degree, familiar how to use. As the technology penetrates with many different devices to serve different purposes, the web of technology and the web of information develops rapidly, bringing out the significant concept of connectivity.

Hansmann examines the term connectivity in three technical categories as: "The topic of connectivity can be divided into three major themes. Wireless Wide Area Networking allows long distance communication through cellular radio. Short-range Wireless technology allows communication through radio or infrared beams up to a distance of a five or ten meters. Finally Home Networking deals with communication between appliances and controls in a residential or small business environment" (Hansmann et al., 2001, p. 243). His categorization explains how connectivity may be possible technologically. However, connectivity as a concept from a home automation perspective is also about connectivity of home appliances with each other.

Furthermore, OSGi, for example, promises connectivity of these appliances with the outer world; thus the (future) home automation system (the "system proper") emerges as a part of a “supersystem”, the Internet to which it is inseparable connected. Therefore, the smart home concept targets a more developed connectivity. The outward oriented connectivity offers communication between remote systems. To give an example, in the simple case, the front door camera is a member of a security system, and may talk to other members of the security system. However, a complete connectivity enables the security camera to talk in emergency situations via communication networks to remote systems and to ask for appropriate actions.

OSGi is an important technology standard that promises connectivity of home appliances and systems with the outer world. This connectivity can enable the refrigerator doing some shopping, based on its depleted stocks, and place orders to replenish them via Internet.

The concept of connectivity is important for making systems work in cooperation. The Internet provides a universal web for all computers around the world. And now it is enabling the connectivity of computer based devices to this web of information resources. The connectivity at the home environment enables the complete communication of the home automation system with the greater web of communication as it becomes a part of the Internet. Offering this complete communication and the concept of universal connectivity, the conception of the home automation system as a part of the superstructure is important. The user interface of the system should be designed with this concept in mind so that it should provide the user with the complete conception of the automation system and its place in the superstructure.

C. The User Interface

The user interface system has two components: the appliance itself, and the user interface. In this thesis study, the underlying appliance will not be examined. In the subsections of this chapter, alternative manipulation modes, interaction objects and some design disciplines will be examined. Manipulation modes briefly explain the ways how humans interact with the computer interface: direct, remote and voice control. Interaction objects examine the elements of the user interface which the user is assumed to manipulate during interactions: graphical, textual, navigational interaction objects and signs. The final section explains the relevance of master and stylistic designs.
1. Manipulation Modes

a. Direct Control

Whenever an appliance receives input and displays output through one of its parts, we speak of direct control. The desktop computer is a good example offering direct control. It receives input through the keyboard and the pointer (mouse), both of which are attached to the body of the computer. Therefore the user can manipulate the system only through these devices that are essentially part of the computer.

Direct control offers both advantages and disadvantages to the user. Among its advantages is being free from size restrictions. In conventional systems that have direct control, such as the desktop computer and the touchscreens, essentially, size restriction is not a major issue because the device does not need to be portable. Additionally, there is this cognitive advantage where the user controls the system and receives feedback on the same device, s/he may not be easily distracted by peripheral events. The user may focus on the input apparatus and the output display, and therefore, can be more involved in the control of the system.

On the other hand, a number of disadvantages can also be mentioned. Systems with direct control do not offer a remote control mechanism which would offer some mobility to the user. Therefore, the user is bound to be in the vicinity of the system, such that s/he can access the input/output devices to be able to interact with the system.

However, direct control has a wide use in different areas, and will probably be not abandoned.

b. Remote Control

Remote control has quite a wide spread use that already exists in the technological appliances we use daily. The concept of remote control entered into our life, as the portable apparatus that enable the user to command the television without going near to it. The remote control later has been used for many other systems as the music set, the VCR, computer and even for the air conditioner.

A remote control offers the advantage of mobility to users, thus offering a large flexibility of use: the user may command the system in sitting or standing position, and also probably do this with one hand free. The major disadvantage of remote control devices stems from the limitation in size and weight that immediately affect their mobility and the portability. And in addition to size restrictions, the remote control devices may get lost or damaged due to their portability and small size.

Consequently, the design criteria for remote control devices is defined by the use of minimum space for multiple functions. Designing the optimum size device for portability but also providing easy use is challenging. Other ergonomic properties can be also mentioned and considered such as the optimum hand size of the users, right or left hand usage, etc..

c. Voice Control

Using voice control for giving directions to a system is relatively a new technology that is usually considered as the basis of future control technologies. It provides the use of oral dictation through a microphone to command or control the computer.

As a new technology, voice control also shows a number of advantages and disadvantages. Among its advantages comes freeing the user from use of hands. Users can command the system with both hands free. But a more significant factor is that it is quite intuitive to interact with the computer through speech in spoken language. Besides the factor of intuition, saving time is also significant as the user doesn't have to write anything or click on anything.
However a number of disadvantages may be mentioned. First, voice control technology has not been matured yet, thus cannot be used widely for computers or computer based systems. Voice control is mostly used in cellular phones today to take a few basic actions. However, computers appear as more complicated systems, and are used for a number of different tasks. Therefore a misunderstanding may cause unpleasant results for the user. Even if the technology matures in the very near future, the social aspects come forward. Voice control may be not available or useful in crowded environments due to privacy reasons. The level of noise may be irritating in a place like offices or the classroom, where each user would talk to her/his own computer. Besides this, from a psychological perspective, it is inconvenient that the user speaks to him/herself. In any case, it is inevitable to use supplementary visual feedback, even if voice control technology advance further and will be widely used. As Schneiderman stated, “The bandwidth of the visual media is far greater than sound or other media and the perceptual skills of the human brain are keenly turned to the visual” (Schneiderman, 1989, p. 10).

2. Interaction Objects

Human interaction with the computer may occur in several ways: content creation, content signification, or navigation through the existing content. Both the graphical user interface and the presented content are composed of interaction objects. These interaction objects are categorized as graphical, textual, navigational objects and signs. They may either serve a single function/action or be multifunctional such as the visual containers that also serve navigational purposes.

a. Graphical Interaction Objects

The graphical interaction objects are windows, images, icons and visual panes that present the data in a structured way. In the case of functionality, graphical elements may serve as visual containers for textual and visual material, or themselves may constitute the content. To give an example, windows in the conventional GUIs based on the desktop metaphor act as containers for all kinds of contents. Icons or images, on the other hand, may constitute the content such as thumbnail images of larger photographs in a folder, presented in a window.

There is a hierarchical use of graphical elements. This means, in a typical desktop interface, icons representing files or folders stand together, in the form of a list, or as thumbnails, where they form a visual pane, a visual group of content in the window. The visual pane may be visible or not, but it serves its purpose for the proper perception of the elements it contains.

There is a widely accepted standardization in the use and design of windows and icons: windows appear with scalable sides, with a "close" button at the upper edge, the title bar at the top giving the name of the file presented. Icons may appear in small or large sizes. A folder icon is used to represent folders, and files are represented with icons of representative applications which they are created in.

b. Textual Interaction Objects
Text is the principle element of interaction with the computer, in spite of the developing graphical user interfaces. Johnson mentioned its importance in the GUIs as: “Even the most conventional modern interface uses text in many different ways. Words appear in the content of documents, of course- in word processors, and presentation software and page layout programs. They also continue to have an important role as commands, the tools we use to get the computer to do something” (Johnson, 1997, p. 151).

Textual elements usually serve as the content or they describe or name visual objects. Also, textual interaction elements have been redefined with the emergence of the hypertext, where some part of the text may now serve as a navigational element.

Textual elements show up in a hierarchical structure: words compose lines, and lines compose paragraphs. Beyond a regular text content, words are also used in menus, file or folder names and commands. Text lines are used in displaying short descriptions as the content of the folder, messages that show up in dialog boxes. And paragraphs may be used as the main element of content in all kinds of textual content.

Consequently, text is still part of the modern graphical user interface. Even if it is not supposed to be as intuitive as visual representation, textual data may be more effective, brief and accurate in some cases.

c. Navigational Interaction Objects

The navigational interaction objects serve user’s navigation through a content. The cursor, the pointer, orientators and locators are the basic navigational objects. The cursor shows the point of action in the textual environment, continuously blinking to inform the user about the last point of action. The pointer serves the same purpose in graphical environments. The user controls and moves the pointer with the mouse to travel all around the screen, clicking on icons, selecting or deselecting things etc. Counters appear as locators, where they display the virtual location in an aural and visual media (e.g. page/line counters). The right, left, up, down arrows are some widely used orientators; they orientate the user in the spatial or temporal navigational space.

Functionally, the objects of interaction serve only for navigation, and do not have multifunctions. They do not have any hierarchical structure, each serves a different purpose for navigation.
In the widely used user interfaces, standardizations have occurred in the representation of navigational elements. These standards are mostly borrowed from established graphical symbols; therefore they are commonly used in GUI designs. An arrow is mostly used as a pointer, for it is an accurate form that points the user's attention to a specific thing through its sharp edge. Different forms of arrows are also used for spatial navigation (e.g. right-left-up-down arrows). The use of standardized symbols indicate "universal" meanings, and they are usually recognized internationally. Beside being universal or at least multicultural, symbols are chosen to be simple and easily perceived.

d. Signals

Signals are visual elements that signify, enrich or help annotation of the content. Graphical user interfaces employ markers, signals, highlights or status indicators as signaling purposes. A list item can be "marked" by an appropriate action/icon pair for later deletion or some other purpose. A flashing green light may "signal" active communication via the modem. The reader of a text may "highlight" some parts with a "florescent" market for later referencing. A status indicator may give the amount of the part just in the process being installed on the system.

3. Design Discipline

a. Master Designs

The GUI design is based on structured paradigms and standards that have been put forward since the emergence of the early GUI models. There has been milestones in the history, that come up with the basics of GUI design. Today, GUI design is primarily based on the desktop paradigm -that has been developed at the Xerox PARC in 70s- that is commonly agreed upon. The desktop metaphor is based on the perception of the computer screen as a desktop, containing papers, documents and folders stacked upon each other, with a trashbin put aside for discarded documents. The papers, documents and folders are represented by stacking windows, and a trashbin icon is included for the user to drag and drop the unnecessary documents into it, similar to the real world action. The desktop metaphor has been used and popularized mainly by the Apple Macintosh computer in 80s. Later the Windows operating system and others used and developed it.

Using master designs bring up a number of advantages. First, master designs are widely accepted models which are already used and grasped by most of the users. Therefore, using a common denominator, a common language with minor design changes provides significant ease to the users in the learning process. The existence of a familiar common language prevents the inconvenience of getting used to various design approaches. This significantly increases users' capability of grasping the GUI completely, thus enhancing the efficiency of the system. Besides these many advantages that are provided to the users, master designs provide the GUI designers with the opportunity of developing existing paradigms into more efficient models, instead of starting from scratch every time.

b. Stylistic Designs

While the use of master designs facilitates the understanding of the GUI, stylistic designs help the development of the existing master paradigm, and create new design approaches that enhance design choices offered to the user, or provide the distinguishability of the brands and companies from each other.
Stylization also provides designers with a robust agreed upon base which they can develop throughout their own design approach.

To give an example, the desktop metaphor is used by a number of GUI designers, especially popularized by Macintosh and Windows. However, the different stylistic designs used provide a clear difference between these two. New releases also propose new design approaches. The latest versions of the Macintosh UI, the Mac OS, is stylized through a more three dimensional approach where essentially mechanical buttons are represented as three dimensional water droplets.

Also a stylistic design provides development of different strategies, offers diversity to the user, meets aesthetic needs. the fact that companies work on the same master design but create their own stylistic designs may contribute to the user accepting one of the stylistic design through his/her aesthetic choice and personal taste. The distinguishability of the brands and offering novice design alternatives also contributes to the emergence of qualified aesthetic options in the market.

D. The User

1. Physiologic Parameters

There are straightforward design guidelines for the tools and devices we interact physically. Designing a chair, a bicycle, a wardrobe follows the rigid physiological guidelines that are determined in ergonomic studies according to the average physiologic attributes and needs of human beings.

In user interface design, too, there are basically two components: the machine and the human. Furthermore, we have two different cases regarding the phase of the interaction: the interface of the physical input devices such as the mouse, keyboard, on one hand, and the graphical user interface design for the screen, on the other. The design of input devices are also based on rigid principles presented by ergonomic studies focusing on the physiology of the hand (Guiard, 1987). However, as stated before, the study of input mechanisms is beyond the scope of this study.

Meanwhile, the graphical design of the screen concerns only the physiology of the eye. The visual design parameters include the accurate use of color, text, images and objects depending on the visual design guidelines and perceptual theories, the Gestalt Principles and design issues such as legibility, color sensitivity, color blindness etc. While making use of visual elements, the designer should consider the accurate font size for the person with average sight, should provide solutions for people with visual impairments, color blindness, etc.; therefore, the interface will not only look good but must also fit the performance of the eye.

a. Fitt's Law

Since this thesis is mostly focused on graphical user interface design for the screen, the physiologic parameters governing the practice of interface design include the physiology of the eye and the related motor actions of the hands that controls the input device(s). Fitt's Law is one of the basic theories developed in 1954 to examine the relationship between the size and placement of the interaction element and the time spent for the user to reach and interact with this element.

Raskin, in his book The Humane Interface, briefly defines the Fitt's Law as: "Fitt's Law quantifies the fact that the farther a target is from your current cursor position or the smaller the target is, the longer it will take you to move the cursor to the target" (Raskin, 2000, p. 93). In other words, the theory is a functional definition that calculates the time spent for hitting a target on the screen, using the parameters of the distance of the target

\[ T = k \times \frac{D}{S} + A \]

\[ T \] is the time to hit the target, \[ D \] is the distance of the target, \[ S \] is the size of the target, \[ k \] and \[ A \] are constants.

**Figure 4.6.** Distances used in Fitt's Law to determine the time to move a cursor to a target.
from the pointer, and the size of the target:

\[
\text{time} = a + b \log_2 \left( \frac{D}{S} + 1 \right)
\]

where \(D\) is the distance travelled, \(S\) is the size of the button, and \(a\) and \(b\) are experimental coefficients.

Although it sounds to be quite a mathematical explanation that does not seem to be concerning the designer, Fitt's Law is quite important in practice, especially in the visual design process. It is applicable in the design of any interactive medium graphics and is directly related with the performance of the user, reflecting the efficiency of the interface. Calculating the time for reaching the interaction element, using the distance of the pointer to the target and the size of the target reveals that the interaction elements such as the buttons, menu bars, icons should be designed with great care respecting all these factors.

There are two common uses that are completely explained by the Fitt's Law. One is about the placement of interaction points that have significant importance. In the most popular two GUI designs, the Mac interface and the Windows interface, there is a brief difference in the ease of using the menu bars: in the Mac interface, the menu items are always placed at the top edge of the screen, whereas in Windows the "current" menu bar may be placed a few levels further down from the top edge of the window. Users mostly report that they are more comfortable with the placement of the menu at the top of the screen as preferred in the Mac interface. Actually this is not a statistical report but is a fact that can be explained with the Fitt's Law. The explanation is, when the menu is placed at the edge of the screen, there is no cognitive and physiologic load for the user to target the menu items, to place the pointer on the interaction element. Since the pointer will not get out of the screen area, the interaction area of the menu bar is actually infinite.

To optimize this parameter in the design of the implemented model, two initiatives are taken: first, related buttons are grouped close to each other. Second, the emergency button is placed at the upper right-hand corner, for easy access, and the most frequently used interaction elements, i.e. the master navigational buttons, are placed at the upper left-hand corner, since the four edges and four corners of the screen are the most easily clickable places as a practical consequence of the Fitt's Law (at these particular locations the clickable areas are effectively infinite, making the spent "time" approach to the experimental constant \(a\), which is the practical minimum value).
However, the placement of the emergency button to an "infinite area" has not been generalized where all actions buttons would be lined up on the edges and corners of the screen and this would leave the central area mostly unoccupied, an organization that would not allow proper grouping of related buttons (see Gestalt Principles of Grouping below); it is also aesthetically not pleasing. Furthermore, especially the assignment of the emergency button to a privileged location is of great importance; in that respect, to further increase the effect of Fitt's Law, the periphery of the emergency button is also kept free of other activation purposes.

The second common use of the Fitt's Law is about the size of the interaction element since it matters for the process of reaching the element. This can be summarized practically as "the larger the icon, the easier for the user to click". Therefore, in the model, the icon and button sizes have been designed large enough to make it easier for the user to identify and click on them. To further enhance this effect, they are also placed on larger elliptical button bases that both increases the effective size and provides an affordance.

Fig. 21. Icon: standalone and on a button.

2. Cognitive Parameters

The emerging discipline of cognitive science and hence our recent knowledge of the "cognitive" faculties is commonly investigated under the broad headings of perception, conception, attention, consciousness, memory, learning, association, language and reading, and finally reasoning and problem solving; since not all of these divisions are of equal importance to our study, some of them will be omitted and the emphasis will be given to the relevant ones.

a. Perception

Perception is the fundamental cognitive parameter, that is effective on the design process. However, before the evaluation of the basics of perception such as the Gestalt Principles of Grouping and the Figure-Ground Relationship, it is important to mention the Levels of Visual Processing and Faculties of Perception.

i. Levels of Visual Processing

The visual processing of the percept in human beings occurs in three levels which are defined to be Low-Level Vision, Mid-Level Vision and High-Level Vision. Previously, these levels of processing were mentioned in a hierarchical order. However, as of today, rather an interactive hierarchical model is accepted where the distinction between the levels is somewhat blurred and the levels may not follow this hierarchical order.

Low-Level Vision is known as the simplest level where the image is basically analysed. Memory is not involved in the evaluation of the image and its meaning, and the image is simply perceived by finding the edges of the object, detecting the colors and locating it in space.

The mid-level vision is assumed to be somewhere between the basic analysis of the object in low-level vision, and recognition of the object in high level vision. What separates it from high-level vision is defined in MITECS as : “Yet, in distinction to high-level vision, mid-level vision represents the world only in a most general way, dealing primarily with surfaces and objects and the fact that they can appear at different orientations, can be variously illuminated and can be partially occluded" (MITECS, 2001, p. 545). The memory is not involved in this level either and the perceived object does not go through a recognition process. Rather objects are simply perceived by determining their features and their segregation from the background.
In MITECS, **high-level vision** is defined as: "Aspects of vision that reflect influences from memory, context, or intention are considered 'high-level vision', ..." (MITECS, 2001, p. 374). In high-level vision, the memory is involved in the process and the perceived object is recognized on the basis of some existing knowledge in the memory. There are three theories that investigate the recognition and categorization process of human cognition; however they are mostly involved with the field of cognitive science and their detailed examination is beyond the scope of this study. These three theories are basically known as object recognition, face recognition and scene recognition.

**ii. Faculties of Perception**

It is also important to understand how humans perceive various environmental information through different types of perception faculties. Three principle faculties of perception are Shape, Surface and Depth Perception.

**Shape perception** provides the basic important clues about an object's identity, its functional properties and affordances. Shape perception occurs in the mid-level vision as stated in MITECS: "Although clearly related to high-level vision phenomena such as object recognition, shape perception is better classified as an aspect of mid-level vision because the perception of shape does not require recognition" (MITECS, 2001, p. 753). The basic cues for shape perception are the internal geometry of the object which helps the basic shape perception; the silhouette and the contours that segregate it from the background; the shading of the object that reveal its 3D formation, and finally occlusion, that is, the state of an object being covered by another one.

We perceive the visual information from the object by the reflection of the light off the object to the eye; therefore, the **surface perception** is important as it provides basic information of color, material, shape and opacity about the object. Also, surface perception occurs at mid-level vision since recognition and memory are still not involved in this process. Surface perception uses the basic cues of lightness perception, where the material's reflection of light and its luminosity help to grasp of the surface; the surface curvature that provides information about the texture and the structure of the surface; segregation from the background that helps the perception of the shape; and the color of the surface that is already a basic clue of information. The perception of transparency is also examined under the surface perception. Transparency is perceived when the light projected to the eye originates from two or more surfaces that are at different depth levels.

**Depth perception** is about an object's situation in the three dimensional space and also belongs to the mid-level vision because the memory is still not involved. The basic cues for depth perception are obtained either with binocular vision, which is the perception of visual information with the use of two eyes; or monocular vision, which is the perception of visual information with one eye. In binocular vision, the convergence and disparity of the eye provide depth clues, where convergence is "the inward/outward turning of the eyes stimulated by a change in the distance of the object or regard" (MITECS, 2001, p. 227); and disparity, the difference in the position of the images formed on the retina from each eye. The perspective sight is also perceived only with binocular vision.

Various cues are perceived with monocular vision like the **relative size** factor, that the more closer the object, the larger it is in size; **motion perspective** which explains the perception of distant objects moving slower, closer ones moving faster when the viewpoint is in motion; **occlusion** which explains the observation that when two objects are at different depth levels, the closer one blocks the distant object; **shadow** where objects casting a shadow have more depth than those that do not, and the **color**: "There is a tendency for warm colors such as reds to be seen as advancing and cold colors such as blues, receding" (Zakia, 1997, p. 100).

In the proposed model, as a stylistic approach, all visual elements are placed into a 3D scene to make use of depth perception (and other Gestalt mechanisms). To that effect, especially color perspective is used: the hierarchy of panes and popup windows always obey the color perspective rule, that is, element
further back are darker, whereas the nearer and/or recently popping up elements are always brighter. To further help depth perception, both the infrastructural panes and action buttons are given in high-relief. However, this is applied with great care not to overdo the effect of the underlying phenomenon; therefore, height of the secondary panes are kept at a minimum whereas that of the buttons, which occupy the topmost layer, is more emphasized.

iii. (Gestalt) Principles of Grouping

Before the introduction of Gestalt Perception, perceptual theory was based on a structural approach which claimed that "...complex perceptions were constructed from atoms of elementary color sensations and unified by associations due to spatial and temporal contiguity" (MITECS, 2001, p. 344).

Later, Gestalt Perception was offered, explaining the perception through a holistic approach, which means that the whole is more than the sum of its parts. Gestalt perceptionists proposed a number of factors that occur in mid-level vision and are effective in the perception of simple elements when organized in distinguishable groups. These factors are simply known as proximity, similarity of color, similarity of size, common fate, good continuation, closure, common region and element connectedness.

The "proximity principle" may be defined with the words of Zakia as: "The closer two or more visual elements are, the greater is the possibility that they will be seen as a group or pattern" (Zakia, 1997, p. 32). The proximity principle also applies to the figure ground relationship as we have a tendency of perceiving smaller shapes as the figure and the large surrounding as the ground. This is explained by proximity: the greater the proximity of the edges of a shape, the more probable that we perceive it as a group. In the model, the infrastructure design of the main screen well exemplifies the use of "proximity". As shown in Fig. 22, the appliance icons are placed on base panels such as the oven, refrigerator, dishwasher, microwave and coffee maker panels are placed on the kitchen base. Besides the kitchen base that provides common region, proximity principle also shows up to provide grouping of the kitchen appliance panels.

In an analogous way, the "similarity of color" principle suggests that two or more elements that have the same color are perceived as a group.

The "similarity of size" principle suggests that as long as two or more elements are similar in size, we tend to perceive them as a group.

When designing the icons, as regards to "similarity", all icon sizes are made equal to relax mental loading, that is to help the user's comprehension of them as members at the same functional level (consistency); e.g. the appliance icons: the fridge, oven, dishwasher, etc.. Furthermore they all have the same shape, color, texture, etc. Their content is also monochromatic, except some minor colorizations.

The "common region" principle says that visual elements that are surrounded by a boundary are naturally perceived as a group. "Common region" was the most critical design principle used in the design of the visual infrastructure of the model. The main screen design of the proposed model is segmented into three main panes, that are the functional, communicational and utility panels. Therefore, the sub panes placed in the same bases are perceived to be grouped through the principle of common region. The use of this principle is explained in detail below, within the Gestalt Ridden Conceptualization, Visual Paragraphs.

The "common fate" principle is described by Zakia as: "...visual elements that function, move, or change in unison will tend to be grouped and seen as a pattern or movement (similarity of movement)" (Zakia, 1997, p. 254). The generalized use of the elliptical form for all buttons indicate their "common fate" and allows easier recognition as active action spots.
The use of these principles may be exemplified with too many design implementations, however, the principles proximity, similarity, common fate and common region are rather more significantly used than the others.

Zakia describes "continuity" as follows: "Visual elements that require the fewest number of interruptions will be grouped to form continuous straight or curved lines" (Zakia, 1997, p. 50). In other words, elements that tend to form a continuity are perceived as a group.

The "closure" principle is described as: "Nearly complete familiar lines and shapes are more readily seen as complete (closed) than incomplete lines and shapes" (Zakia, 1997, p. 56).

The elements that have a physical connection with each other are perceived as a single unit, which is known as "element connectedness" principle. The rules of proximity and similarity may also be effective on this perception.

As explained with these examples, Gestalt perception is widely used in each and every design phase of the model. Proximity, similarity, common fate, continuity, closure, common region and connectedness principles are all used individually or together in designing the infrastructure layout of the screen, the icons and the button bases that contain the icons, their labels and related status information. Especially, the master design of the infrastructure layout of the screen is based on these principles; however, this topic will be examined in the following section entitled "Gestalt Ridden Conceptualization".

The principles of continuity, closure and connectedness are not exemplified with apparent uses, however, both have significant use in interface design as the design process is examined in detail.
The use of grouping principles does not call for special treatment from a Home Automation perspective; their consideration is fundamental for all kinds of applications.

iv. Figure Ground Organization

Figure ground relationship and organization is the second basic phenomenon of Gestalt Perception, first mentioned in 1921 by Rubin. "The crucial feature of figure ground organization is that the boundary is perceived as belonging to the figural region" (MITECS, 2001, p. 344). Basic factors that are effective on figure ground relationship are surroundedness, size, contrast, convexity and symmetry.
**Surroundedness** claims that any element that is surrounded by a boundary is perceived as the figure, as seen in Fig. 23J.

**Size** is effective on figure ground organization where the visual element that is smaller in size tends to be perceived as the figure; this is shown in Fig. 23K.

**Contrast** is rather effective on the enhancement of figure ground perception, where with more contrast, it becomes easier to distinguish the figure and the ground.

As seen in Fig. 23M, **convexity and concavity** also offer figure ground organization, where the concave element usually tends to be perceived as the figure.

According to the principle of similarity, elements that stand together to form a **symmetry** are perceived as a group and thus the figure, as shown in Fig. 23N.

Figure-ground relationship is an important design issue in graphical user interfaces. The importance of figure-ground relationship appears apparently when textures, structures, messages and many more need to be presented through a two-dimensional environment of the computer screen. The use of figure ground relationship in interface design is explained by Chalmers as: “The button has to be perceivable for this potential functionality to be easily accessible. The graphical design in particular features such as being distinct from the background and having the shading around its edge. This shading mimics a raised surface that would allow localised pressure, linking or referring through to buttons made from wood, metal etc. Therefore the design of the electronic button makes use of skills in physical media” (Chalmers, 2001, p. 1).

All figure-ground principles such as surroundedness, size, contrast, convexity and symmetry are used implicitly during the design of various visual elements. Moreover, the design process was not limited to rely on such elementary perception principles only, but rather it was supported with other techniques such as contour, texture, plasticity, depth perception, etc. Furthermore, the choice of the elliptical shape for action buttons emphasizing convexity especially in the presence of a crowded rectangular pane environment was a conscious move. Also use of “visual paragraphs” called for delicate consideration of all these principles.

When considered through the Home Automation Aspect, again, the fundamental character of figure-ground principles are so universal that a special consideration from a Home Automation perspective was not necessary.

**v. Frame of Reference**

Frame of reference is the third phenomenon of gestalt perception examining the perception of visual elements. Motion and orientation provide two examples for understanding frame of reference.

**Induced motion** is explained in MITECS as: “... a slowly moving larger object surrounds a smaller stationary object in an otherwise dark environment. Surprisingly, observers perceive the frame as still and the dot as moving in the opposite direction” (MITECS, 2001, p. 345). This is also exemplified with the perception of the moon as moving behind the clouds rather than perceiving the clouds moving in front of the moon by the wind.
Related with the motion and orientation, an upright rod in a tilted rectangle is perceived as a tilted rod standing in an upright rectangle. This is known as the **rod and frame effect**.

Since they do not call a special importance from home automation aspect, neither *induced motion* nor *rod and frame effect* were used significantly in the proposed model.

### vi. Other Organizational Phenomena

There are several other organizational phenomena that may be included in the Gestalt perception. Three of them are amodal completion, illusory contours and color scission.

**Amodal completion** is the perception of an element that is partly visible as a whole as if it is occluded by another object. In Fig. 25 (Q), the circle with three quarters are perceived as a complete circle of which a quarter is occluded by an object. In the modern interface designs, the overlapping layout of the windows may as well exemplify Amodal completion. On the desktop screen layout, if more than one windows are opened, they are placed on the screen, overlapping each other. Although these windows are not visible completely, we perceive them as complete rectangular windows occluded by another. In the model, beyond the motivation to comply with the principle of depth perception, all popping up windows are forced into a color hierarchy (the darkest being at the background level) such that overlapping windows would still allow proper perception to maintain their integrity.

**Color scission** is explained in MITECS as: “Color scission refers to the splitting of perceived color into one component due to a translucent figure through which the farther figure is seen” (MITECS, 2001, p. 345). Color scission is exemplified in Fig. 25 (S), where the translucent figure is perceived in front of the rectangle, that is, seen through the transparency of the translucent figure. Unfortunately, this principle could not be used because transparent windows were not available; however, since transparent windows are powerful tools allowing various opportunities for a better interaction, they should be incorporated in advanced models.
In the model, these effects have been carefully used for popup windows; indeed, to offer a better perceptional material they are deployed in combination: in Fig. 24 above, both amodal completion and color scission work in synergy to distinguish the popup window.

Similar to the amodal completion, an illusory object may be perceived by its edges that do not physically exist but perceived as existing. Briefly, this is explained by the Fig. 25 (R), where a triangle is perceived by its edges that occlude the three circles standing behind. This is known as **illusory contours effect**. However, actually no use has been made of this principle in the proposed model.

![Fig. 25 Q-R-S. Amodal completion, illusory object and color scission.](image)

These issues do not call for a special consideration from a Home Automation perspective; except perhaps the fact that they might be useful, when done properly, to manage screen congestion problems which cannot be tolerated due to the high frequency usage and critical nature of Home Automation applications.

**vii. Pragnanz**

Gestalt perception is based on a holistic approach; this is explained by Pragnanz as “...the claim that percept will be as good as the stimulus conditions allow. This means that the preferred organization should be the simplest, most regular possibility compatible with the constraints imposed by the retinal image” (MITECS, 2001, p. 345). Pragnanz is also explained by Zakia as: “The tendency of a process to realize the most regular, ordered, stable, balanced state possible in a given situation” (Zakia, 1997, p. 65). However, another approach, the likelihood principle of Helmholtz is offered by those who do not prefer the Gestalt approach. Helmholtz claims that “...the perceptual system is biased toward the most likely (rather than the simplest) interpretation” (MITECS, 2001, p. 345).

**b. Affordance**

The term "affordance" was invented by JJ. Gibson where he defined it in his own words as: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" (Gibson, 1979, p. 127). Gibson proposed the theory of affordances as related to the world of physical environment.

In terms of visual design, Norman interpreted affordance as such: “The term affordance refers to the perceived and actual properties of the thing, primarily, those fundamental properties that determine just how the thing could possibly be used. Affordances of simple tools provide clues of usage, so things do not require explanations” (Norman, 1988, p. 9). Norman specifically talked about the affordance of physical everyday objects like the chair affording support, knobs affording turning or the slots affording putting things in, actually he examined it in terms of psychology of the objects.

Chalmers also mentioned the affordances of physical objects: "An affordance is an ecological property of the relationship between an agent and the environment. For example, we hold the pencil in such a way that it fits comfortably in the hand, ignoring the myriad less appropriate ways that it might be grasped. The pencil affords being held in this way as a result of its length, width, weight, and texture, all with respect to the size, configuration, and musculature of our hand. Further, we can see most of these properties and relationships; we can often tell how to interact with an object or environmental feature simply by looking at it, with little or no thought involved" (Chalmers, 2001, p. 1). Applicable to a number of examples, we may
talk about the affordance of the fork, how it intuitively affords to be grasped by the handle and to be stuck into the piece of food by the prongs.

However, the theory is also mentioned in terms of graphical user interface design. The visual representation of an object on the screen is also accepted to provide some affordance. The exact example is the use of buttons in the GUI, for performing various actions. Related to the physical appearance of the button, how it affords to be hit, pushed in by the user, the button graphics on the screen also appear as raised surfaces with a shading below that provide a plastic bumpy appearance. Similar to the action of hitting the button in physical world, we click the buttons on the screen. Or a different clue of affordance is the grey shading of the inactive menu items - which makes it almost indistinguishable from the background - and that do not afford to be chosen, the active menu items are conversely in highlighted with bright colors.

In Fig. 27a and 27b below, the comparison between QuickTime 4 and QuickTime 5 briefly shows the effect of affordance over the perception of the buttons.

In the proposed model, affordances have been considered in each design phase. Especially, design of the buttons and the base panes they have been placed onto are intended to offer a reasonable affordance to the user, being easily recognizable and indicative. Such that the bumpy three dimensional buttons afford to be hit/clicked since they appear as real buttons.

Affordance may not call for a specific attention from home automation aspect, rather it is quite significant in the practice of user interface design. However, as the home automation system has a multi-purpose use, offering a number of different functions, affordance is a significant design issue that should be considered to design a functional interface to such systems.

c. Hick's Law

The Hick' Law states that, when the user confronts a number of choices, alternatives to decide upon one, the time s/he will spend to choose one is related to the number of alternatives s/he has. In mathematical terms, it is calculated with the formula:

$$t = a + b \log_2(n + 1)$$

where a and b are experimental coefficients, t is time, n is the number of choices and b gives the effect of habituation

and Raskin explains it as: "...when you have to choose to take one among n alternative actions and when the probabilities of taking each alternative are equal, the time to choose one of them is proportional to the
logarithm to the base 2 of the number of choices, plus 1" (Raskin, 2000, p. 96). However, in other words, the more alternatives exist, the longer it would take the user to decide. The Hick's Law can be exemplified in terms of web design, that the more crowded the site menu, the longer it will take to choose a target. And Raskin also notes that it would take less time for the user to choose from a menu of eight items rather than two menus of four items each.

Fig. 28. Internet Explorer: a simple menu.  
Fig. 29. Windows XP: "All programs" menu - where is the magic number?

Hick's Law cannot be used directly as a design tool; it is rather a warning, a principled reminder for not placing too many alternatives within a close region; beyond a perceptual difficulty that may arise due to the screen congestion, it is a cognitive problem to recognize and identify a particular target among options that are offered on some equal basis.

In the proposed model, Hick's law does not play a significant role as the options are first categorized into visual paragraphs and their number thus reduced.

When considered from the home automation aspect, the habituation component in the equation gives a positive outlook because Home Automation applications enjoy a high frequency usage, and thus the habituation factor decreases as users get acquainted with the application and accumulate experience over long periods of time.

d. Attention

Harrison defines attention as: "Attention is the selection, processing and consciousness of specific sensations" (Harrison, 2002, p. 3). We receive too many sensory input from our environment. However, since human cognition has a limited capacity, we cannot focus our attention to each and every thing we perceive. Therefore we rather focus on a specific body of stimulus, as we do while reading an article on a specific subject; or divide our attention between a few different stimuli as the typist does both for typing and attending a conversation.

Visual attention is an important subject to be considered in the design of visual interfaces for the screen. Particularly, as mentioned by Rauterberg and Cachin, the "visual attention" depends on and is affected by both the organization of the visual field and positioning of the visual feedbacks (on a computer screen): "What is an optimal screen layout is till now the open and unanswered question. Where is the best place to put messages on the screen? How far away from the primary attention focus should the message be?" (Rauterberg, Cachin, 1993, p.130).
i. Organization of the Visual Field

The organization of the visual field should be examined from two different perspectives, that are the presence of the quadrants on a screen and the visual field regions.

Before proceeding further to explain the quadrants, it should be stated that "the central 30° of the field is focal vision" (Visual Expert, 2001).

Within this central field of focal vision, "... the main area of expectation (40%) is in the left upper quadrant I of a dark and unstructured screen. The visual focus is further on shared by quadrant III (25%) and quadrant II (20%). In 15% of observation time the attention focus is in quadrant IV (see Figure 30). First, we carried out a signal detection experiment to estimate the maximal distance between the primary attention focus of users and the screen position of visual feedback (e.g. messages) regarding to the four screen quadrants. Second, we investigated the eye movements to pinpoint the actual location of the primary attention focus of the user on the screen regarding to different task's types" (Rauterberg, Cachin, 1993, p.130).

The use of quadrants is important in interface design and can be exemplified with the commonly used interfaces. Such as, the Windows interface remains faithful to this fact, using the quadrants in an accurate way in applications. For instance, in the Internet Explorer window, the menus are located at the top left of the screen, starting with the File, Edit an View menu items. When clicked, a drop down menu appears, significantly situated in the first quadrant. The fundamental icons/buttons are also located at the top left of the window, right below the File, Edit, View menu. Again, informative web sites prefer to place the menu items in the first quadrant, so that the user may easily notice, access and use them.

The quadrants are used with careful attention through the preparation of the model. While designing the general layout of the main screen, the most frequently used action buttons and links are placed mainly in quadrant I, and to a lesser degree in quadrant II. Indeed, the first decision to be made was about the alternative placement of the communication and functional master panes; there were a lot of factors to be considered and some of them would conflict with each other. However, once it was clear that the functional pane had priority over the communication pane, respecting the visual field organizations automatically favored it to be located on the left (Fig. 31a), and not on the right hand side (Fig. 31b).
The visual field regions are also to be considered while examining the visual attention of the user. To have an understanding of the relevance of visual field regions, first the concepts of egocentric spaces should be exposed. Ecologic psychology differentiates several regions of space from the perspective of a human agent: "In general, the space that surrounds the user can be meaningfully segmented into a number of ranges, usually three or four, based on principles of human perception and action. Several models have been proposed (e.g. Grusser, 1983; Rizzolatti & Camarda, 1985; Cutting & Vishton, 1995), all of which distinguish between a peripersonal space (the immediate behavioural space surrounding the person) and a far or extrapolonal space. For instance, Cutting and Vishton (1995) divided the spatial layout surrounding the perceiver into three egocentric regions that grade into one another: personal space, action space and vista space. Personal space refers to the zone that falls within arm's reach of the observer, thus having a diameter of around 2 meters. Beyond the range of personal space, action space refers to the space of an individual's public actions. Within this space we can move quickly, speak easily and toss or throw objects. Cutting and Vishton (1995) suggest this space is limited to about 30m ... Beyond this range, vista space stretches out until the visual horizon" (Ijsselsteijn, 2002, p.6).

As far as visual perception/attention is concerned, "... the visual field has other functional divisions. One is left/right, corresponding to a difference in spatial and verbal specialization. The other is upper/lower. The upper is is "extrapersonal" and is used for searching and viewing the world. The lower is "peri-personal," possibly specialized for to aid grasping and manual control. This specialization developed because objects in the upper visual field are usually far away while objects in the lower field are close" (Visual Expert, 2001).

Indeed, the importance of the peripersonal space would force the placement of the most frequently used action buttons horizontally on the lower visual field (in the quadrants III and IV); however, this would violate the previously made decision to place them into quadrants I and II, which seems to be a more effective criterion. Furthermore, such a move would leave the central area mostly unoccupied which is certainly aesthetically not much pleasing (see also the refusal of this criterion when Fitt's Law was considered above).
ii. Positioning of Visual Feedbacks

Rautenberg and Cachin report that "the results indicate that the maximal distance between the primary attention focus (of users) and the screen position of visual feedback (i.e. messages) should not exceed 3". They also note that "... the position of visual feedback on the screen must be very close to the primary attention focus of the user. A distance over 3" should be avoided" (Rauterberg, Cachin, 1993, p.129).

"... to pinpoint the location of the primary attention focus ... the results indicate that if the task solving process requires mouse operations and the visual feedback of the results of these mouse operations appears close to the mouse cursor, then the visual focus and the mouse cursor position on the screen are highly correlated: between 76% and 95% correspondence" (Rauterberg, Cachin, 1993, p.129).

In the case of the main screen of the model, the "feedback" is the popping up of an auxiliary window activated by its button. Therefore, in the model, the distance between the primary attention focus and the screen position of visual feedback is always kept under 1", well below 3" suggested by Rauterberg and Cachin.

iii. Color

Color is significantly effective on the locus of attention as Marcus also stated in his words: "We react strongly to color in the natural environment, in graphic communication, in architecture and in industrial design" (Marcus, 1992, p. 77). Especially use of high value and high chroma colors attract user’s attention to the specified elements in graphical/communication design. As soon as...
color can be used for calling attention, it may also cause overattraction especially to unnecessary, unfunctional points, causing confusion for the user.

In the practice of interface design, the use of color is quite important. In Windows interface, may again exemplify the use of color in order to avoid overattraction of irrelevant elements on the screen. Such as in the status bar of an application window, toolbar and the borders of the window appear as grey, as a default setting, unless the user changes. Thus, the user's visual attention may easily focus on the material presented in the window.

This issue has been considered while designing the proposed model. In the background of the model, the use of grey as the dominant color is preferred deliberately. The infrastructure of the model should be simple and unimposing to prevent stealing unwanted attention from other functional elements.

Meanwhile, the existing interface designs allow the user to customize the color settings through his/her visual preference. A home automation system is also expected to allow customization of color settings and similar things. However, since Home Automation applications can be categorized as critical, careful organization of interaction material to support attention related cognitive capacities is especially important in emergency situations. Therefore, the vital design settings should either be preserved by the system, or the offered alternatives should be considered through this aspect in order to preserve the functionality of the interface.

e. Consciousness

The notion of "consciousness" is very challenging and therefore it is one of the central problems in "cognitive science". After exploring some views on consciousness in the literature, Raskin decides that they do not specifically target UI issues and offers his own perspective; here, his approach is adopted.

Raskin defines unconsciousness as: "Unconscious mental processes are those of which you are not aware at the time they occur" (Raskin, 2000, p. 11).

Cognitive consciousness and cognitive unconsciousness are briefly explained with a simple example by Raskin: "What is the final character in your first name? Until you read the previous sentence, you were probably not thinking about this alphabetic character and its relation to your name. You know -and have long known- what that character is and where in your first name it lies, but you were not paying attention to that knowledge. You were not thinking of it; you were not considering it. Or to use our preferred terminology, you were not conscious of it" (Raskin, 2000, p. 13). As an existing knowledge, it was situated in cognitive unconscious, and is called to the surface by the cognitive conscious with the articulation of the question.

Among a series of differing properties of the cognitive conscious and unconscious, Raskin lists "volition" vs. "habit" (Raskin, 2000, p. 16); we will concentrate on habits, or better "habituations" from a UI perspective. There is a close relationship between the cognitive unconscious and habituation. And habituation itself has positive (as we saw above when interpreting Hick's Law) as well as negative sides; for example, sometimes, habituation may invite a mechanical attitude and the user may forget some recent actions that were performed under the cognitive unconscious or may even perform some of them incorrectly. Therefore, s/he must be ensured that there is always a way to go back and check what was done and correct it if necessary.
Actually, while designing an interface for home automation systems, "resilience" is an important property needed in HA applications. The lack of "undo/cancel" options is not acceptable in HA applications. Therefore, to meet this need, the "history" and "undo/cancel" buttons are introduced into the model, which seemed to be a luxury in the beginning. Furthermore, the "undo/cancel" action can be taken both locally at a particular hierarchy level of popup windows and/or at the "history" window, in a more generalized way. And because of its importance and generality, the history "button" will be placed both on the quadrant I and at the edge for easy accessibility, and also designed not as a button but rather as a mouseover "no-click trigger" (occasional unwanted triggering will not do any harm because its first stage does not include an action but only the display of the last ones).

Fig. 34. History button.

f. Memory

We continuously receive a number of percepts from our environment as a result of our experiences regarding vision, sound, smell, taste, touch, movement and balance. As we have those experiences, we gather and consciously try to fix some of them in our mind. All the material we receive through our experiences are situated in our mind as memories.

"Short Term Memory (STM) and Long Term Memory (LTM) are the two major classes of memory distinguished by psychologists" (Norman, 1988, p. 66). And Zakia describes these two as: "The memories we remember for a long time are called long term memories and are contrasted with short term memories (STM) that we remember just long enough to use and then forget" (Zakia, 1997, p. 82). In other words, the memories we keep for a short time and then forget are STM which is, for example, a telephone number that one would dial for once and then forget immediately; and the memories we keep in mind and sometimes recall for later use are the LTM, which may be exemplified with one’s own telephone number.

Understanding the memory, LTM and STM is important for design process of the interface. The visual memory is used significantly through the interaction with the interface. While interacting with the computer through the visual and textual elements and the semiotic meanings they convey, the user would come up with a number of different messages, either visual or textual. Some of these are kept in the LTM, but actually most of them are stored in the STM. Whether the issues about LTM and STM are ignored, it may cause to the appearance of mental load to the user that will certainly decrease the efficiency and the usability of the interface.

The Magical Number should also be mentioned as it stands closely related to the subject of memory. The number seven is mentioned as the magical number since it represents the range of different items that a person can remember at once. As it is concerned with the capacity of short term memory and the cognitive properties of human brain, the magic of number seven is mostly mentioned in relation to memory issues. In their paper, Larson and Czerwinski state that the rule of thumb was offered by G. Miller, explaining with examples supporting the relation of seven with STM: "When people are asked to distinguish between different tones, if the number of tones presented is over about 5, their accuracy at this task decreases rapidly. When asked to recall a series of unrelated words or numbers, people fail when the size of the series increases to 6 or 7. In other words, the span of immediate memory imposes
severe limitations on the number of items we are able to receive, process and remember” (Larson, Czerwinski, 1998).

Zakia also mentions the magical number related to the STM. He notes that: "There is a limit to the amount of unrelated information a person can hold in STM, from five to nine items, averaging seven" (Zakia, 1997, p. 82).

Since Home Automation is a commonplace (as compared to expert applications) and sometimes also a critical application, sticking to the Principle of the Magic Number has been a required design goal. In the prepared model, the number of visual elements are usually kept under the control such that they are not in conflict with the Principle of the Magic Number (that is, 7±2) by splitting them into visual paragraphs. The only exception occurs with the number of action button elements in the functional pane, however, their number are designed safely at the lower limit. Even if it was merely by coincidence that this set size was dictated by the nature of the problem at hand, were it not the case, this could be still controlled by further splitting the set into subpanes such that the Principle of the Magic Number would not be violated.

g. Association

We keep an acquired information either in LTM or STM, and sometimes transfer those in STM to LTM by different techniques. The methods that we remember and fix the information in our memory are significant. Association is simply the way through which we remember things by finding relationships between objects, ideas and concepts and connecting them with each other for later recall. Zakia, in his book "Perception and Imaging" explains making associations with the following example: "When I was first introduced to a gentleman named Lothar, I could not remember his name on later occasions since it was strange to me. He advised me to remember it as 'Low tar, more taste', a slogan for a cigarette at that time. I have never forgotten it" (Zakia, 1997, p. 85).

Mnemonics is an association technique that helps remembering things. Zakia mentions a well known one as: "Spring forward, fall back" (Zakia, 1997, p. 83), one that helps remembering whether to set a clock one hour ahead in spring or fall for daylight savings time.

h. Gestalt Ridden Conceptualization (based on Gestalt Riding)

Gestalt Principles are used individually in different design phases of the interface. However, there are also design issues that may be explained with the use of more than one Gestalt principles. Making use of some Gestalt principles which he calls Gestalt riding, Sener offers standard visual infrastructure elements similar to those used in textual environments and calls them, in analogy, visual paragraph and visual lineup. Visual paragraphs are based on the principles common region, proximity, closure and continuity. Visual lineups are based on inferred continuity.

Sener explains these visual infrastructure elements as follows: "Visual paragraphs may host a set of any heterogeneous elements, whereas visual lineups contain either syntagmatic ('sentence') or paradigmatic ('list') elements. Furthermore, for 2D planar presentations, visual paragraphs have a 2D, and visual sentences 1D linear organization" (Sener, 2000). And relates the visual paragraphs and visual lineups with the use of Gestalt Principles as: "Both visual paragraphs and sentences are explicit manifestations for functional interrelations of some visual elements; they ride on Gestalt grouping principles and facilitate better conceptualization, that is, they are design/communication approaches where both perception is managed to assist conceptualization, and the "synthesized" concept is offered as a visual whole. Also, the explicitness defeats the ceteris paribus nature that undermines the Gestalt principles when these coexist in a conflictary manner" (Sener, 2000).
The overall visual infrastructure is thus built with "visual paragraphs" to give a firm cognitive foundation to the design. Occasionally, as another cognition-friendly mechanism, "visual lineups" are also used to further support it; the lack of such mechanisms led to disastrous consequences in the US presidential elections in 2000 (Selker, 2001).

Therefore, visual paragraphs are extensively used in the model; they are easily recognizable on the main control page. For example, the three conceptual/functional divisions of the application, i.e. communication, functionality and information sections are explicitly designated by three separate visual paragraphs. Furthermore, the "functional" paragraph is further divided visually into kitchen, bathroom and garage "paragraphs". At still a higher level, the smaller high-relief rectangles that contain the action buttons and related indicator information can be regarded as "smaller" visual paragraphs.

It seems that the mechanism of visual lineups is especially valuable for categorization purposes (paradigmatic sets); they offer a neat and compact grouping without much visual congestion; however, as it can be experienced when working with feature-rich tool palettes (such as in Photoshop) which use this same mechanism excessively and thus become overcrowded, the recognition and targeting of individual buttons may be problematic. Long visual lineups may be good for tabulation purposes, but for interactions only a small set should be used; the size of this set is given by the "magic number" 7±2 which seems to
govern the short term memory (see magic number above). Only the number of action buttons in the functional pane seem to be an issue in that regard, but they are kept safely at the lower limit.

These issues sound as they do not call for a special consideration from a Home Automation perspective, but rather they are mostly related with the basics of interface design. However, actually, the design of the visual infrastructure is a fundamental issue and calls for special importance in home automation systems. Since the home automation system interface is quite comprehensive, including numbers of different tasks, functions and controls, the visual structure should be handled with care in order to avoid a confusion on the basic design.

3. Psychological Parameters

Technophobia/Technophilia

While we are transforming our lifestyle and culture into digital, there are two specific social groups that should be mentioned within this thesis. Technophobia and technophilia are the social behaviour types where the first describes the fear from technology and the latter describes the extreme interest in the technological product. Technophobia is the fear of dealing with the technological products. The technophobic person believes that s/he cannot manage to overcome the perceived difficulties and may cause an unexpected situation when performing an incorrect action. The sense “What if I make a mistake” causes a strong rejection of dealing with technology. Technophilia is an opposite term that describes human behaviour of showing extreme interest in the technological product, an extensive will of using or purchasing the items that involve high technology. Technophilia is also related with consumption; technophils tend to make good consumers since they fall in love for innovation and latest products of technology (Campbell, 1992).

Campbell evaluates the social tendency to technophilia as: “Research suggest that this category of lovers of the new is more likely to comprise young males rather than females or the elderly” (Campbell, 1992, p. 56). This is already a common opinion shared, however it is mostly based on the technologic culture of 70s where women deal with domestic technologies that make their life easier and men work out and deal with the technology in production. Probably today the social grouping of men and women’s interest in technology is similar. Therefore both men and women at any age can be technophobes or technophiles depending on their life experiences and how they have been introduced to technology. Another view defines women as potentially technophobic. At least in the context of home automation, this sounds like a baseless claim because a special relationship exists between women and life inside the house due to their social positioning. Therefore, if housekeeping and maintenance chores of their home is somehow facilitated by advanced technologic offerings and ergonomic considerations, this would be only welcome and appreciated by them.

As stated many times before, this thesis focuses on the interface for the computer screen. However for any technological product, the interface stands at the most strategic point of creating technophobes from casual users, or inversely making them advanced users that can accomplish the required tasks. The interface of the computer may either facilitate the use of the computer, provide the user with the sense of safety and ease of use and prevent any technophobic reaction. Or an interface with insufficient design may conversely result in the formation of technophobic reaction, that may be permanent especially if the user cannot manage to overcome it.

The interface first aims to increase usability, by representing the mathematical world and language of the computer in a humane visual language, transforming the 0’s and 1’s into simple understandable and familiar messages. The most important interface design guidelines of incomplexity, consistency, simplicity basically serve for the easy use of the computer by nonexpert users. The unnecessary complexity of an interface when interacting with a high technology device serving simple functions may be very frustrating,
or the inconsistent messages may force the user to make mistakes. This situation alone can cause a technophobic reaction even if the user had been neutral before having such a bad experience.

Simplicity and consistency are quite effective making the interface easy to use and less scaring for the unqualified. However, besides these visual issues, there is a conversation between the human and the computer, where each of them perform specific tasks. In order to prevent irreversible vital mistakes, the interface should have forgiveness, that means it should allow returning back from mistakes, therefore assuring the user that s/he still has the control and won’t possibly cause any unexpected situation by mistake (see consciousness/resilience below)

The interface becomes more significant in a smart home environment, where it acts as an integrated system that controls a number of various actions. And the potential users of the home automation system may be children, teenagers, adults and elderly. Therefore the simplicity and the consistency of the interface is of great importance.

4. Sociological Parameters

a. Aesthetical

The aesthetic concerns regarding the computer appeared within the invention and deployment of graphical user interfaces. Today, as we are moving towards a digital culture, to make the computer look fancy and thus promote its market share or remove its alienating image and make it a domestic appliance, the aesthetics of the screen through which we interact with the computer is a serious design matter; as David Gelernter notes: "Most computer technologists don't like to discuss it, but the importance of beauty is a consistent (if sometimes inconspicuous) thread in the software literature. Beauty is more important in computing than anywhere else in technology.. Beauty is important in engineering terms because the software is so complicated... " (Gelernter, 1998. p. 22).

There have been debates on the importance of aesthetic concerns in GUI design, that the fancy dressing-up is not necessary and the adornment may even prevent the functionality of the interface. However, aesthetic design of GUI's is effective both for marketing computers and user's acceptance of the system personally. Ong observes that: "What has aesthetics got to do with GUI design? Everything. Aesthetics are what people are willing to pay for in this world - designer clothing, designer cars, designer goods, designer houses. Image is what many companies and corporations set out to create. A good-looking GUI will entice the user. It would drive some obsessed users to put up with it no matter how painfully slow the system is" (Ong, 2002).

For the marketing purposes, the graphical user interface is significantly effective on the promotion of the computer with the appealing aesthetical design, presenting the mathematical world of the computer around the desktop metaphor, recalling the casual home or office environment, decorated with colorful, eyecatching icons and animations. The aesthetic appeal helped the acceptance of the computer with customizable menus, changeable wallpapers, many alternatives for the color palette of the menu backgrounds and borders, a number of things to play with, all persuading reasons to purchase a home computer. Besides the marketing purposes, there was a social and psychological need for aesthetic quality. Today there is a significant increase in the time we spend in front of the computer due to the enhanced capabilities of the technology as information processing, image processing, entertainment and more. The computer, and the interface itself became a medium and here is the aesthetics of this new medium.

The emerging technologies of automation are pushing the walls of the home place now. The home automation concept emerged and developed rapidly in the last decade, bringing up the image of the future home where the computer based systems and devices are integrated with the house as the information center. Technology brought its own aesthetic to the home, representing and identifying the
user just like the decorative furniture of the living room. The physical appearance of computers or computer based appliances turned toward a design approach exemplified by the stylistic i-Mac desktop and laptop computers with different colored monitors and boxes and rounded design, or the TV and music sets with high tech or minimalist design that follows the trend of decoration.

As we speak of home as an automated computerized environment, the interface of this technology is actually a design matter. We are already accustomed to live with computers and the aesthetics of the digital media we have been exposed. Since the home is a private personal space identifying the user, the interface for a home automation system is expected to offer proficient aesthetic quality besides many other requirements as a functional, easy to use human interface. As an access and control point for all actions conveyed at home, the interface is expected to represent the user's aesthetic needs and requirements, offering diversity in design and allowing user's manipulation and customization.

b. Fashion

As we are facing the new era where we are computerizing our offices, homes and lives, and navigating through the emerging digital medium and its emerging dominant aesthetic understandings, it should be also discussed how fashion is related with this medium.

The nature of fashion is based on the formation of styles and patterns in aesthetic taste. However, it serves specifically to the concept of consumption because fashion is what has been determined and suggested in aesthetic taste, what is new and in continuous change. As a consumed visual product, the user interface design is also effected by trends of fashion. The design alternatives address specific visual tastes and do follow the trends in fashion to capture the user's attention to the product, appeal to the user with fancy clothing that accurately fits the current trends.

Since the emergence of the graphical user interface practice, each new release of the MAC, Windows or any other operating system/software, the design is renewed in accordance with current fashion expectations and offerings of the technology. As a marketing tactic, new releases of softwares or operating systems are accompanied by renewed appearances, such as the use of animations (the animated paper clip of Office 97), file transfer animations and changes in the mode of representation (the move from the two-dimensional to three-dimensional in the Aqua interface). The three dimensionality in the Aqua interface has been followed by the release of the Windows XP, and the new releases of various softwares that also use the three dimensional interface. This is a well known marketing tactic that promotes the product and makes it sold, appearing each time in the market with a new face in order to attract the user.

Moreover, the fashion of the interface is significantly effective in the user's acception and internalization of the computer and its operating system. People make up aesthetical choices with their personality, social environment they have been grown up and environmental effects of the trends and fashion in the market. We choose any product for ourselves in parallel to our discriminations, and personalize these choices. People identify themselves with their aesthetic choices and the things that are imposed by the current fashion idiom, which is a strong environmental condition. Mostly, with the products we choose we identify ourselves and this psychology can be exemplified by the motto of "being a Mac user" that has been mentioned by Johnson as such: "But despite the totalitarian imagery of their opening salvo, the first interface wars were basically cultural in nature, more about 'lifestyle choices' than anything else. PCs, with their arcane codes and hideous green-on-black monitors, belonged to the suits, to Organization Man. The Mac's playful interface spoke to a different demographic; jazzier, creative types, new thinkers and iconoclasts. Buying a Mac was an expression of individual identity, like Steve Jobs wearing T-shirts to board meetings-more of a fashion statement than a party affiliation" (Johnson, 1997, p. 51).

When we consider the home and fashion, there is a huge market to be mentioned. The home market is already affected and driven by fashion trends. Any visual product at home is a symbol that identifies the user's taste of aesthetics. This might include decoration materials, preferred color palettes for wall
paintings, kitchenware or technologic appliances, which are all strictly related with fashion and current trends. When we consider technology at home, we may already exemplify this with the trendy home entertainment devices with high-tech or minimalistic design as mentioned in the previous section. And we already use the minimalistic interface designs for the players or applications we have in computers, download or purchase various different skins that either reflect our own taste or represent the ambiance of the latest movie such as *Lord of the Rings* or *Spiderman*. Moreover, the design of physical appearance for the interface of the home automation system is strictly related with the user’s identification of aesthetic taste, as it is the info centre of the home where everything is controlled.

**Fig. 37. Windows Media Player Skins.**

c. Consumption

Consumption is the most effective social parameter dominating the market. In the age of consumption, the field of advertising is completely based on this social parameter, the business of driving the sense of consumption.

Visuality is a significant factor in the promotion and marketing of a product. Besides the realistic functions promised, actually, consumers are mostly impressed by the visual attractiveness, aesthetic quality and the fashionability of the product. In the marketing of technology, especially computers and computer based products, visual appeal calims more importance due to the fact that only a small percent of users may appreciate the technologic capabilities of the product. Thus, whatever exists inside the cover may not matter that much as long as it works. Or, even if such buyers are expert users, they can be still impressed by the visual aspects as soon as they have the basic required functionality, because visual appeal is very concrete.

Considering the home automation market, there is a significant point that the home concept and consumption are strictly connected to each other, just as a result of the specific nature of 'home' in our life. Home identifies the user(s) with its structure, decoration, style, technologic equipment, etc.. Since it is the private personal place where we seek comfort, peace and joy, we show the utmost interest and sensibility to anything regarding the home. Thus, technologic or not, a product may increase its market share when it addresses the home. Furlong, in her article “There's No Place Like Home”, mentions the technology-market-home relationship as: “As public markets become saturated with a new technology, home becomes the prime site where fortunes can be made as long as we can be persuaded that the particular item in question is an indispensible piece of household equipment. As electronic information becomes increasingly powerful and its constituent elements increasingly integrated, the home is perceived as the center for enjoying an ever more sophisticated range of services and experiences via the screen rather than the street. (...) A consistent way to sell a new technology to the public, whether it is electricity, the radio, television, the computer or virtual reality has been to domesticate it” *(Furlong, 1995, p.172)*.

Therefore, home automation technology naturally contributes to the sense of consumption for promising more comfort, convenience and enjoyment at home. In parallel to the drive of buying a refrigerator with a larger base, a faster car, a television set with a larger screen area, the home automation market also
contributes to the consumption with the promised technologies of smartest refrigerators, faster Internet access, etc..

Another special point about home automation is that it offers high technology that may not be comprehended by the unqualified user, it may even cause a technophobic reaction. Therefore the interface of the system should be designed with utmost care, providing ease of use, but also presenting sufficient visual aesthetics to attract the user. It is not rational to expect the majority of users to be fairly aware of technologic specifications, therefore it is the user interface, the visual showoff contact surface of the system is what actually presents and sells the system. It is a usual tendency of computer companies when they stuff each new product release with eye-catching features or with some fancy new interface design, even if it is only a new microprocessor that they actually want to promote.

d. Privacy

Privacy, a cultural convention as Donald Norman notes, is an important social and psychological need that we expect to have in our social environment but especially at home. The concept of privacy may vary in different cultures; however it either exists rarely, or at the extreme case, privacy is becoming a current issue in our age that runs throughout the stream of information. It is based on a series of complicated social mechanisms related with the cultural values and conventions.

As we are living in the age of information where computers keep and process information about everything, there is a significant increase in the way we feel under control. Norman mentions the loss of privacy with a quotation from Paul Saffo where he states: "Daily life is nothing but a string of transactions from credit card purchases to phone calls... Each action adds to a spreading electronic wake that we leave behind us as we go through life. A few bits of matched data can tell volumes about us all, a conclusion implicit in the informal motto of the marketing industry: 'We know more about you than your mother.' " (Norman, 1993, p. 184).

Concerns about the loss of privacy increases as technology becomes more domestic, integrates the home. Home is the specific concept where we remove our personal space which we preserve continuously in every social environment, because home itself becomes the personal private space. However, problems may occur when we consider the automated home concept where the home is completely automatized to control the domestic actions with the appliances connected to each other and to the Internet.

The automation system becomes the digital agent as the center of information at home; this might also be assumed as artificial intelligence. Socially, privacy is damaged with the involvement of the third party agents and this causes the main social problem of human beings concerning the computer based systems. Privacy is mostly damaged by concerns of unreliability of the agent, possibilities of access to personal records, financial activities, personal codes and passwords. Besides this unreliability, users may be socially disturbed with the sense of being watched all the time, having all the actions recorded and kept by the system, even it serves a number of beneficial purposes. In extention, there may even be technophobic reactions and fears that the agent may take the control of the home. The privacy at home is naturally destroyed due to the mentioned reasons.

However, since we are almost addicted to live within this ocean of information with the computer as the servant, it is not much probable that technology would be abandoned due to privacy concerns. A social transformation will probably occur as it did before that we got accustomed to the use of automatic teller machines to perform money transactions, talking to robotic reply machines on the phone, submitting personal data such as the credit card number. As Norman again quotes from Saffo: "We will never slow, much less reverse the growth of this electronic marketplace, because our society cannot function without it. The most that privacy watchdogs can hope to accomplish is to ensure accuracy and confidentiality for certain kinds of information" (Norman, 1993, p. 184).
Consequently, the automation system to rule the home activities should be sensitive to these issues. The interface of the system is critical in preserving the privacy. Not visually but the information design of the interface should be smart enough considering the privacy structure, allowing users to set up their own privacy structure. The privacy issues at home may be categorized in three groups: protecting the home/family privacy against outer factors; protecting the personal privacy of the household against each other; and special customizable restrictions that may be manipulated by the user.

5. The Interaction

a. Navigation Theory

Navigation is a basic human activity of the determination of a path to follow to go from one place to another in an environment. Navigable spaces are those that enable the user to successfully move from one point to another intended point, without knowing the precise location of the target point. Navigation has been a subject of many different disciplines such as cognitive studies, psychology, information design, architecture and urban design.

As Modjeska reports, a fundamental poster at CHI '97 (CHI - Computer Human Interaction) defined navigation in electronic information environments as "locomotion+wayfinding"; "**locomotion is the activity of moving from one location to another**". Surprisingly, locomotion is supported by the proposed model, with the inclusion of a VRML model of the house directly on the main page. And "**wayfinding is primarily a cognitive process**" (Modjeska, 1997, p.2).

![Navigation Theories exposed](image)

Passini also later worked on the theory of navigation based on the works of Lynch, but he further examined it in terms of human information processing, environmental design and information design. As Modjeska stated, "**Passini sought to describe the way finding mechanism and to explore the information processing that relates to a person to his environment**" (Modjeska, 1997, p.11). He mentioned the existence of three categories in environmental design, which are, **signs**, that provide communicative information as directions to places, identification of places; **organizational elements**, those that are the five elements mentioned by Lynch; and **maps**, those that provide information for survey.

"**Signs**" have been already examined above, therefore the next sections will concentrate on organizational elements and cognitive maps/metaphors.

Passini examined the "**Organizational Elements**" basing on the studies of the urban designer Kevin Lynch, who was the originator of the studies in navigational theory. He proposed an effective theory of navigation throughout his investigations, where he focused basically on the physical and spatial characteristics of the environment. Lynch mentioned two criteria, legibility and imageability, that would be effective in creating navigable spaces. Chien and Flemming explain legibility as following: "**Legibility**
refers to the ease with which a city’s parts can be reorganized and organized into a coherent pattern” (Chien, Flemming, 1997, p. 4). And Lynch defines Imageability as: “that quality in a physical object which gives it a high probability of evoking a strong image in any given observer. It is that shape, color, or arrangement which facilitates the making of vividly identified, powerfully structured, highly useful mental images of the environment” (Lynch, 1960).

Lynch proposed five key components, that are paths, edges, districts, nodes and landmarks that are effective for the imageability of the environment. Briefly, paths are channels for movement, as roads, sidewalks, canals, from which the travelers observe the environment; edges are boundaries defining discontinuities or borders between adjacent regions - as seaside, rivers, fences; districts are areas with a clear common factor as the shopping zones, business zones, military zones; nodes are the places where paths and borders meet and are often focal points as meeting locations, city squares (as exemplified in Fig. 28.) ; landmarks are specific memorable objects in an environment as statues, landmark buildings, towers and else. He added that for the legibility of each of these elements, singularity or figure-background clarity and form simplicity for the design of districts; continuity and clarity of joint for designing edges and paths; and dominance for landmark design are significant (Chien, Flemming, 1997, p. 5).

Especially, paths are of special importance and studies carried out by Canter et al. as reported by Modjeska, show that shorter they are, the better: “Overall, users tended to remain in a small area within a site; their navigational paths resembled a hub with spokes, on account of frequent backtracking” (Modjeska, 1997, p.20). There are some special paths: Parunak's study reveals some clues, as reported, again, by Modjeska, “Two types of tool are common - “beaten path” mechanisms and typed links. “Beaten path” mechanisms include back-up stacks (e.g., history lists), path macros, and bookmarks” (Modjeska, 1997, p.22)

In the preparation of the model, to be in accordance with observations, one of the principle design goals was to keep paths as short as possible; in this case no more sublevels than the ones activated by buttons on the popup windows (thus, pathlength=2) are used. This approach makes the whole system extremely easy to use and time-saving. The latter criterion is especially critical for HA applications; the control of house appliances occur so frequently, and their physical counterparts have been optimized over decades, or sometimes over centuries, so less than optimum solutions are simply not acceptable. Also the mechanism of “beaten paths” could not be ignored; however, only the “history” item has been utilized in the proposed model among the three suggested alternatives.

In the model, the main screen is, as it is the case in every application, the main plaza (a node) to go to other places (i.e. taking “paths”); a special care is taken to use the “star pattern” which seems to be the most efficient for master “nodes”. Intermediate popup windows could also serve as distribution centers; they are nodes that direct in an understandable, recognizable and memorizable way to sublevel functions.

As in real life (i.e. city metaphor), districts may have a distinctive texture; this is their only property that can be applied to hypermedia. However, the web of hyperlinks must reach a certain complexity such that “districts” can be ever constructed. The required compactness of HA applications does not allow such complexities; therefore, districts could not be used in in the model.
Edges limit districts; since there are no districts, there are no edges in the model implementation. However, in deeply layered hypermedia usually another limiting property, the "dead end", is used if not consciously. A more careful design would make use of some special indicators, though: no action buttons any more, the sparsity of the displayed material, the nature of the content material, etc. Since the proposed model employs a shallow hierarchy of popups, no use of "dead ends" was made, either.

Of Lynch’s five city elements, Passini found that wayfinding requires mostly paths and landmarks. Given the appropriate consideration to paths, the animated house simulation is also designed to serve as a landmark (even if it is on the first page of the system), to differentiate its immediate environment from others.

When mentioning the "Cognitive (Mental) Maps" it is important to understand the structure of information environments. Modjeska includes his observation as: "... information seeking in large-scale information environments ... tend to be either document-based hypermedia such as the World-Wide Web (WWW or Web) or continuous, spatial worlds such as virtual Reality (VR)" (Modjeska, 1997, p.1). During navigation, spatial imagery is of great importance, and according to Shum it can be given in two different formats: "One can conclude from this example that care needs to be taken in the use of spatial imagery: at the level of cluster organisation, use of a euclidean spatial interface proved not only unnecessary, but intrusive. Virtual space was more appropriate as a medium. At the level of within-cluster work (windows and icons in individual Rooms) local euclidean organisation was ideal, offering a number of useful properties inherent in the physical world" (Shum, 1990, p.10).

Furthermore, Modjeska also states that "through the power of similarity, UI metaphors can help users to understand and predict the behavior of an information system. A metaphor is a type of mental model" (Modjeska, 1997, p.4). Mental models, one of the basic notions in cognitive engineering, help navigational activities. However, the synergy mentioned above at least partially supplies a successful model (it helps show the relationships both between the components of the HA system and to the house itself): no metaphor is needed here to show the relationships between the components of the HA system and to the house itself. The 3D VRML model does this automatically. Once the user arrives at a particular popup window for a component, however, mental mapping is unavoidable. Indeed, the problem of offering a "correct" mental map cannot be separated from the creation of a "correct" navigational infrastructure. And again, to eliminate the need for a "mapping", there are approaches that simulate several "real" things such as a telephone (IBM, Exploratory UI: RealThings).
In the model, apart from the natural implementation of euclidean space in the VRML model, also the organization of the main page follows a euclidean approach for the grouping of several functions based on their physical locations (i.e., kitchen, bathroom, garage; or the whole of the house: lighting, heating, air/conditioning, sprinklers). Virtual space considerations come into play when the popup windows are activated: their subfunctions call for a rather "abstract" organization.

Repeating a passage from the theoretical section, "... information seeking in large-scale information environments ... tend to be either document-based hypermedia such as the World-Wide Web (WWW or Web) or continuous, spatial worlds such as virtual Reality (VR)" (Modjeska, 1997, p.1). An HA application is both a hypermedia and virtual reality (VR) implementation and thus benefits from the synergy of their simultaneous usage; furthermore, it is, on the one hand, the simplest case to be so (the other cases that utilize them both would be imaginably a "city management" and "planet management" system), and on the other hand, an architectural implementation (and this is the main reason for its selection as the subject matter of this thesis). Indeed, a quick look at this section would immediately reveal the importance of an accompanying navigable 3D model along the more functional organization of the control system.

6. General Design Criteria

Due to the design problems in graphical user interfaces, a number of design guidelines, which are also known as heuristics, have been developed by designers and researchers. The heuristics make up long lists, where a few of them have been useful for some occasions; usually most of them are critics of unproficient design cases. However, Jacob Nielsen and Rolf Molich proposed a short and brief list of heuristics which they have identified as a result of a long research in which they evaluated different designs with different users:

The nine heuristics of Nielsen and Molich (Lewis, Rieman, 1993-94) is given below:

a. Simple and natural dialog - Simple means no irrelevant or rarely used information. Natural means an order that matches the task.

b. Speak the user's language - Use words and concepts from the user's world. Don't use system-specific engineering terms.

c. Minimize user memory load - Don't make the user remember things from one action to the next. Leave information on the screen until it's not needed.

d. Be consistent - Users should be able to learn an action sequence in one part of the system and apply it again to get similar results in other places.

e. Provide feedback - Let users know what effect their actions have on the system.

f. Provide clearly marked exits - If users get into part of the system that doesn't interest them, they should always be able to get out quickly without damaging anything.
g. Provide shortcuts - Shortcuts can help experienced users avoid lengthy dialogs and informational messages that they don't need.

h. Good error messages - Good error messages let the user know what the problem is and how to correct it.

i. Prevent errors - Whenever you write an error message you should also ask, can this error be avoided?

Other than Nielsen and Rolf, Ben Schneiderman also proposed the following list of some design guidelines that mostly corresponded to the heuristics of Nielsen and Rolf ([Cognitive Issues in UI Design](#)).

a. Strive for Consistency
b. Enable Frequent Users to use shortcuts
c. Offer Informative Feedback
d. Design Dialogues to yield closure
e. Offer simple error handling
f. Permit easy reversal of actions
g. Support internal locus of control
h. Reduce Short term memory load

7. The Implementation

Finally, the proposed model can be evaluated from a holistic perspective.

a. Proposed Model  
   (activate demo)
b. A Commercial HA User Interface Example

And again, as far as home automation is concerned, it is extremely clear from the comparison of the proposed model with an "above average" commercial example given above that HA user interfaces should be created from scratch respecting all design criteria examined in this thesis, and by no means based on the toolkits provided by the underlying operating system, and by no means designed by technology oriented engineers who are not trained in visual communication and UI related disciplines.

IV. Recommendations and Conclusion

This thesis examines design parameters for graphical user interfaces, especially focusing on how they would effect user interfaces of home automation systems.

Since home automation technology is still an emerging field, a brief exposition is given in the first chapter as what home automation is and its effects on our daily life. A healthy understanding of related user interface issues rests on a firm understanding of home automation in the first place. After these two introductory chapters, the third chapter entitled "The Principles of User Interfaces" explains the perceptual, cognitive and physiologic theories concerning GUI design giving short definitions, and then, examples are offered with their uses in interface design. Later, the same issues are given in the context and preparation of the model, and their relevance in home automation user interfaces is emphasized.
Furthermore, this chapter was a compilation of some theories and factors from related practices. Recognizing the fact that this is an interdisciplinary field, the first stage literature survey for user interface design is made with different keywords and paths. Beside the focus on the subject from different approaches (such as cognitive, social aspects, etc.) visual design parameters were also examined thoroughly, however, because of the lack of a common theory of user interfaces, they were mostly compilations of design guidelines, or put in other terms, rules of thumb. Since these guidelines are mostly practical suggestions to designers, the theoretical chapter is not developed over these guidelines. Instead, as stated above, a detailed literature survey is made in order to examine each and every factor and design parameter in terms of the field it was based on. However, all these aspects and theories embody deep issues which should be studied separately and in detail, a big task well beyond the scope of this study. To repeat it once again, in this study the emphasis was given especially to theories that were related more with visual design aspects.

The study was also intended to propose a model, to visually expose the mentioned design issues over a home automation system interface. Throughout this phase, a more complete and proficient model has been not pursued; on the contrary, a simple model deploying basic actions and meeting elementary needs have been designed where the content of the system was used as a tool to provide visual feedback. In fact, the model could not be developed up to a realistic finishing phase since parts of the system were based on promised technologies that are not realized yet (for example, the 3D VRML model can be only activated within a plug-in browser which has its own control buttons and interfaces; two different interfaces with completely different user interface philosophies would certainly confuse users). However, the overall approach was still helpful for the purpose of the study and did not effect the evaluation of a visual user interface. Consequently, the material examined in theoretical chapters have been used in the implementation phase; therefore, the main target of evaluating these theories in terms of a home automation system has been achieved, and the model has provided a sufficient and useful basis to study the conclusions of the thesis.

Some of the theories are examined even if they do not have a direct bearing for home automation issues. However, this should not mean that these theories are irrelevant and, therefore, should be neglected. The proposed model may not give proper examples for them immediately, however, if a design issue is related with graphical user interface design, it is definitely important for home automation interface design. Besides, it has been stated before that the proposed model is prepared as a basic model to include the basic actions and elementary needs. However, the future promises of home automation technology mention a large scope that would surely require the use or consideration of all these mentioned issues.

As soon as the study is completed, first of all, the examination of the mentioned theories show that the design of the graphical user interfaces is a serious process that absolutely requires the consideration of various theories from different practices. The revelation of these critical design issues also clearly shows how most of the existing user interface designs suffer due to the negligence of these issues and the lack of professional designers’ involvement in the design process. However, it is also clearly put forward that a designer, intending to be involved in the practice on user interface design, should be well aware of the cognitive, perceptual, social and psychological aspects of the subject.

The examined design parameters also show that the accurate interface design is neither a "visually appealing" nor a "completely functional" one. In the absence of the other, both are insufficient; rather, an accurate design should satisfy both aesthetic and functional needs, and this is only possible with a collaborative work of all related practices.
Bibliography

A. User Interface

HISTORY, DEFINITION, GENERAL etc.

- Myers, B. A. "Computer Almanac- Numbers About Computers" (WEB)

VISUAL DESIGN

- Chalmers, M. (2001) "Affordances and Interpretation" (WEB?)
- Chalmers, M. (2002) "Planning and User Interface Affordances" Lecture notes on HCI (WEB?)
- Lewis, C., Rieman, J., 1993-94 (WEB)
- IBM, Exploratory UI: Real Things, Design Guide. (WEB)
- Smith, S. L., Moiser, J.N. (1986) Guidelines For Designing User Interface Software. The MITRE Corporation Bedford, Massachusetts, USA
- Ong, D. (2001) "Designing a Dream OS or GUI", Article published in OSnews.com (WEB)
- Rhodes, J.S. (1999) "Improving the User Interface." An interview with Aaron Marcus. (WEB)

SEMIOTICS

- Harrison, J. (2002) "Lecture Notes on HCI" (WEB)

KINESIOLOGY

INFORMATION RESOURCES ON THE WEB

• Cognitive Issues in User Interface Design
• MouseWorks.com
• "Visual Field Location is ImportantPerception" in Visual Expert, and Human Factors

Home Automation

HA INTERFACE

• Ziegler, J., Machate, J. (1997) "Integrated User Interfaces for the Home Environment" (WEB)

SMART HOUSES

• Benjamin, A. (19xx) "At Home With Replicants" in AD journal. (WEB)
• Glick, E. (1999 September/October) "Home Networking The Time is Now", Vision. (WEB)
• Koncius, J., Haggerty, M. (2000) "Appliances to be Linked to Internet" Washington Post Staff Writers, Tuesday, January 18, 2000; A1
• Gelonesi, J. (1999 September 20) "Program recorded live at Kultur in Fremantle on September 20 1999" (WEB)

INFO RESOURCES ON THE WEB

• OSGi (WEB)
• OSGi Specifications Overview (WEB)
• MIT Home of The Future Consortium (WEB)
• Home of the Future Consortium, Papers (WEB)
• SmartHome.com (WEB)
• Official Web Site of Screenfridge by Electrolux (WEB)

UNDERLYING TECHNOLOGIES


CULTURAL, SOCIAL


UNDERLYING DISCIPLINES

• Rauterberg, M., Cachin, C. (1993) "Locating the Primary Attention Focus of the User" in T. Grechenig & M. Tscheligi (eds.) Human Computer Interaction. (Lecture Notes in Computer Science 733, pp. 129-140), Berlin: Springer. (WEB)

Footnotes

Palo Alto Research Center (PARC): PARC, The Palo Alto Research Center, has a significant place in the history of graphical user interface design, focusing on interdisciplinary research in physical, computational and social sciences. As stated in this chapter, the leading research and inventions on the user interface design was maintained at PARC, by a group of scientists that are the veterans of SRI. Besides the Xerox Alto and Xerox Star computers and a number of significant inventions, the legendary desktop metaphor was also developed at PARC.

Erkki Huhtamo: Erkki Huhtamo is a researcher, writer and curator, who is specialized on media studies, audiovisual culture including the relationship between art and technology. He has numerous articles, edited books and works focusing on media culture, virtuality and media art.
Suggested Readings

A. User Interface

HISTORY, DEFINITION, GENERAL etc.

- Every, K. David, "Microsoft, Apple and Xerox, the History of the Graphical User Interface", 1999 [WEB]
- Rivero, Victor,"Interface With Meaning (Interview with Alan Kay)" [WEB]

VISUAL DESIGN

- Nielsen, Jakob, Gentner, Don, "The Anti-Mac Interface", ACM Inc. [WEB]
- Yale Style Manual Graphic User Interface Manual [WEB]

SEMIOTICS

- "Semiotics and Interface Design". The Rowezone Layer

INFORMATION RESOURCES ON THE WEB

- HCI Lab in University of Stanford
Home Automation

HA INTERFACE


SMART HOUSES

- Taylor, B. J. (xx) Frankenstein Homes: Would you want to live in one? (WEB)

INFO RESOURCES ON THE WEB

- Home Automation and Networking Association (WEB)
- Microsoft's Easy Living Project, Papers (WEB)
- OSGi, history, importance etc. (WEB)

UNDERLYING TECHNOLOGIES

- "Open Service Gateways-Building Bridges to the Connected Lifestyle", A white paper by Gatespace AB (WEB)

CULTURAL, SOCIAL

- Santana, Beatriz, "Introducing the Technophobia/Technophilia Debate: Some Comments on the Information Age", June, 1997 (WEB)

UNDERLYING DISCIPLINES

- Dobson, J., Martin, M., "Conversation Theory: Reasoning about significance and mutuality", Centre for Software Reliability, University of Newcastle. (WEB)
- Paul Pangaro, Speaker (1993) "The Conversation of Theories: Von Foerster, Maturana, Pask," Antioch University Seattle 7 - 9 PM Room T203 (WEB)