Ubiquitous Computing – The Future of Computing

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ABSTRACT

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." This statement was written by Mark Weiser – the father of Ubiquitous Computing, in his well-known "The Computer for the Twenty-First Century". Ubiquitous Computing is a concept in computer science where computing is made to appear anytime and everywhere by embedding microprocessors in everyday objects in any location and in any format, so they can communicate information. The development in technologies like ambient intelligence, augmented reality and wearable computing will change the perspective of people towards computing.

This paper deals with ubiquitous computing, the eras of computing, generic features of ubiquitous computing like natural interfaces, context-aware learning and automated capture and access to live experiences, related areas of ubiquitous computing like ambient intelligence, augmented reality, wearable computing, how it has changed the way humans interact with the computers and the future of computing.

Keywords: **Ubiquitous computing, augmented reality, ambient intelligence, wearable computing, future of computing,**

1. INTRODUCTION

Ubiquitous Computing is a technology that interlinks physical and digital world together. It aims to do so by embedding microprocessors in devices of various forms including laptops, tablets and in everyday objects such as fridge, tables, walls, pair of glasses, etc. The basic idea behind Ubiquitous Computing is to embed chips in almost any devices, from clothing to tools to appliances to cars to homes to kitchens to the human body to connect it with an infinite network of other devices. Ubiquitous computing is also known as Pervasive Computing or ambient intelligence or "Unicomp" or "everyware. [3][14][18]

There are various underlying technologies that support ubiquitous computing like advanced middleware, internet, operating system, microprocessors, sensors, mobile codes, new I/O and user interfaces. It touches a wide range of research topics – distributed computing, mobile computing, mobile networking, location computing, context-aware computing, sensor networks, human-computer interaction and artificial intelligence. [18] The goal of ubiquitous computing is to build an environment where the inter-relation of devices is embedded in such a way that the connectivity does not draw attention of the user and is always available. All ubiquitous computing models has a vision of inexpensive, small and robust networked processing devices distributed at all scales throughout everyday life. [5][20]

2. THREE GENERATION OF COMPUTING

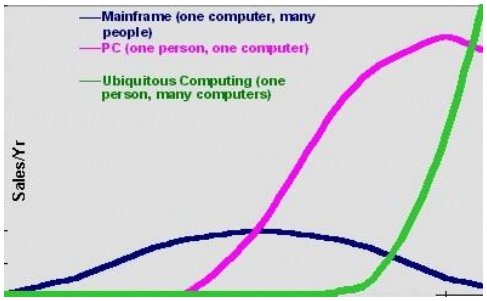
The evolution and development of computing have come a long way which can be divided into following generations of computing.

i. The first era of computing were the mainframes, which were huge, that would occupy a single room and used by large organizations for evaluative applications and scalable data processing. The

relation between the mainframe and the users was many people to one computer.

ii. The second era is the personal computing era, developed for individual use, where one person uses one computer. Personal computers are faster, smaller, cheaper and portable than compared to the mainframes.

iii. The third era is the era of ubiquitous computing, or the age of calm technology, when technology recedes into the background of people's lives. In this, many person uses many computers or one person uses many computers. [17][20]



[17]

3. GENERIC FEATURES

3.1 Natural Interfaces

Unlike desktop computing that requires keyboards, mouse or any other input devices, ubiquitous computing motivates interaction between humans and computers to be more like the way humans interacts with the physical world. Humans speak, write and use gestures in order to communicate with other humans. Similarly, ubiquitous computing also aims to incorporate these natural interactions like speech recognition, gesture recognition, free form pen interaction, computational perception, etc. in its system. These interfaces are admired for their general ease of use, quick learnability and performing tasks without drastically changing the structure of those tasks. [10]

3.2 Context-Aware Learning

Context is the information about the environment with which the application is associated. For example: location and time. Context-awareness is a property of mobile devices which is defined complementarily to location awareness where location determine how certain processes around a contributing devices operate. This concept is associated more with smartphones. A tablet computer that switches the orientation of the screen and adapts the zoom level and orientation according to it, switches on the backlight of the phone when used in the dark and dims the brightness of the screen in sunlight are some examples of computers that are aware of their environment and their context of use. Context-aware learning enables the smart device to learn from its environment and adapt accordingly. [21]

Location is a common context-aware example which is used in the development of application and software. The most popular application have been GPS-based car navigation systems and "tour guide" systems. Another important piece of context is recognizing individual objects by the use of vision-based recognition system for example face recognition system. [4][21]

3.3 Automated Capture and Access to Live Experience

Automatic capturing of data is the method that automatically identifies objects, collects data about them, and enters that data directly into the computer systems automatically, i.e. without the involvement of human and also saving it in the database for future use. Automated capture is a very important feature of ubiquitous computing that captures the everyday experiences and makes that information available for later use. A huge amount of time is spent to listen to and record, that the information may or may not be recorded accurately, and the piece of information may not be available when needed the most. This problem is solved by the automated capture feature. But one challenge in ubiquitous computing is to provide automated tools that support capture, integration and future access of information. [22]

The technologies that automatically identifies and captures data include bar codes, Radio Frequency Identification, biometrics, magnetic stripes, smart cards, voice recognition and Optical Character Recognition (OCR). [22]

4. RELATED AREAS

4.1 Ambient Intelligence

Ambient Intelligence is an emerging discipline that holds a great vision on the future of consumer electronics, telecommunications and computing. The Advisory Group to the European Community's Information Society Technology defines the term Ambient Intelligence as "the convergence of ubiquitous

computing, ubiquitous communication and interface adapting to the user." The intention of ambient intelligence is to expand the interaction between human beings and digital information technology by the use of ubiquitous computing devices. Ambient Intelligence largely depends on the technology like sensors and devices interconnected through networks. Similarly, it also depends on the intelligence of the software. Ambient Intelligence is aligned with the concept of disappearing computing (users will not be aware that they are using the computer but in fact they will be) and the disappearing computing is directly linked with ubiquitous computing. [8][9]

One of the key factor in ambient intelligence is the presence of intelligence. Ambient intelligence is based on sensing, reasoning and acting. Sensing relies on sensory data which perceives the environment and uses that information to reason about the environment and to take actions to change the state of the environment. Sensors are small and can be integrated into any ambient intelligent environment. In order to make sensor and acting responsive and adaptive, number of reasoning must take place like user modeling, decision making, activity prediction and recognition and spatial-temporal reasoning. After sensing and reasoning, ambient intelligent systems can execute actions through the intelligent and assistive devices. [9][13]

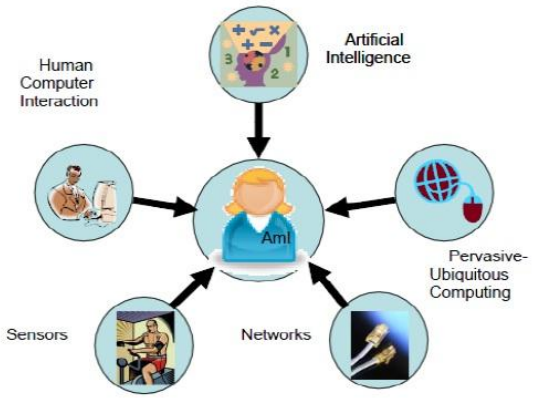


Figure 2: Ambient Intelligence [27]

4.2 Augmented Reality

Augmented reality is the combination of digital information with the natural environment in real time. It is a live view of physical real-world environment but adds graphics, sound, videos and haptic feedback to the natural world as it exist. Augmented reality is different than virtual reality. [15] Virtual reality creates a total artificial environment whereas augmented reality uses the existing natural environment and masks new information on top of it. Augmented reality can make the real world interactive and digitally manipulative. Special 3D program is used to develop augmented reality applications. Global Positioning System (GPS) is used to pinpoint the location of the user and also to detect the orientation of the device if augmented reality is to be used in smartphones or tablet computers. Other hardware components that are used in augmented reality are processor, display, sensors and input devices. [15][16]

The basic idea behind augmented reality is to mask audio, graphics and other sensory augmentations over real-world environment in real time. The most famous example of augmented reality is Google Glass, a pair of eyeglasses which is an optical head-mounted display connected to the internet and displayed information in a smartphone-like hands-free format and controlled via natural language voice commands. [16]

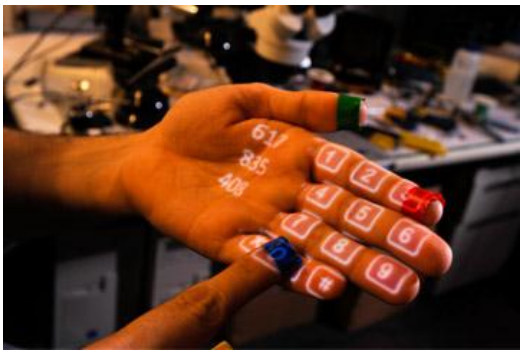


Figure 3: Augmented reality [16]

4.3 Wearable Computing

Wearable computing refers to the computer powered electronic devices that can be worn by a user, with or on top of clothing. [24] Such devices are miniature electronic devices whose application can range from general to special use like smartphone or smartwatch to heart monitoring and pedometer capabilities. Wearable computers are also known as wearables or body-borne computers. [26] Wearables are usually integrated into the user's clothing or can be attached to the body itself through some means like wristband or wristwatch. Wearable technology is portable and wearable devices are always with the users, so the user is able to execute instruction while walking around or doing any other work. [25]

Unlike other computing, in wearable computing, user's body is actively involved as the device's interface which usually includes the hand, skin, voice, eyes and arms. Wearable computing has been implemented in sensory integration, health care monitoring, system service management, behavioral modeling, mobile phones, smartphones, smart watch, fashion design and

so on. Some challenges of wearable computing are how to reduce the size, weight and bulkiness of the device, how and where to locate the display, etc. Wearable computing is still a topic of active research with other areas of study including augmented reality, pattern recognition and user interface design. [25]

Figure 4: Wearable computers

5. FUTURE OF COMPUTING

As we look to the future of computing, we can see the vision and use of ubiquitous computing emerging rapidly. If we are to look back at the evolution of computer, we can see that the computer have become smaller, cheaper, powerful and abundant. So this continuing trend means that the computer will become even smaller, cheaper, powerful and more abundant. [4] The computer will become ubiquitous and they will find their way into everyday objects. This will result in the creation of "smart" objects, which can access the internet, communicate and exchange information with other smart devices. At the present time, the smartphones are the popular computer that will later develop into a control center for a multitude of other personal auxiliary devices. Eventually, ubiquitous computing will take a great economic significance. [5][6]

The effects of rapid progress, growth and development in microelectronics and information technology can be demonstrated using the example of mobile phone. Few years ago, mobile phones were so big, expensive and limited in their functionality that they didn't sell very well. But now, the same mobile phone has become a device that offers beyond its pure functionality of voice transmission. It has now become smartphone, with internet connection, camera, radio, calculator, calendar, etc. in one single device and is one powerful computing device. This rapidly growing technical progress clearly indicates that we are standing at the edge of a new era of computer applications that will influence the lives of people in a great deal. [19][23]

5.1 Invisible and Ubiquitous Computing

Continuous technical progress in ubiquitous computing and communication will lead to the trend of invisible computing technology, where the computer as a dedicated device will disappear, while at the same time make its information processing capabilities available throughout the surroundings. [1] The invisibility of computer can happen in different way. Disappearing can take different forms as described by Streitz (2001) – the physical disappearance that refers to the miniaturization of devices and their integration in everyday objects and the mental disappearance that refers to the situation that the objects can still be large but they are not perceived as computers because the people perceive them as, e.g., interactive tables or interactive walls. The technology moves mentally into the background. [1][19]

5.2 Everyday objects become "smart" and network themselves

Because of the technologies like ubiquitous computing, ambient intelligence, augmented reality and wearables, the everyday objects become "smart" having internet connection that enables them to communicate and exchange information with other smart objects. [17] Many types of smart devices are conceivable. Wearable computing devices will be used to keep people informed, updated, connected and entertained. The smart objects will not only be portable but should become a part of clothing and be worn more or less directly on the bodies. Not only wearables but other objects like for example, the kitchen will become smart, refrigerators, tables, walls, vehicles, etc. will also be smart. [23][17]

5.3 Perspective

The technology trend is clearly pointing towards continued informatization of the world. We are gradually moving towards the ultimate vision of ubiquitous computing where everyday objects communicate and become wearable. If technical progress means more and more everyday objects becoming "smart", it will ultimately lead to a different world. People will not look at the objects as they look now.

6. CONCLUSION

Ubiquitous computing, including areas like ambient intelligence, augmented reality and wearable computing are the bricks that will build the house of

future computing. The future of computing is all about smart and intelligent computing, where everyday objects become “smart” with internet connection so that they can communicate and network with other smart objects around them. [23]

This is possible through pervasive computing or ubiquitous computing that embeds microprocessor in everyday objects. The smart new world will accept input through the human body, unlike previous input devices - keyboard or mouse. The interaction between computer and human become natural through more natural interactions like speech recognition, gesture recognition, free form pen interaction, computational perception, etc. [23] Computing becomes invisible, i.e. it disappears either physically where the devices becomes small and integrates into everyday objects or mentally where the objects can still be large but the user perceive them as normal objects, the computer hides in the background. [19] Hence, ubiquitous computing is the future of computing.

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