The Evolution of Multi Touch Tabletop Systems

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Abstract

Nowadays, multi-touch devices had become accessible to everyone and they are now part of several areas of the social interaction that depend on this technology. One of the most explored fields of this technology is collaborative work, based on multi-touch tables and how the use of these devices can affect society. In this paper we review the evolution of the multi touch table top systems and how those devices haven improved in performance, materials and design.

1 Introduction

Until now, the interaction between a user and a computer has been directly associated to the use of external devices, like keyboards or mice and the results of that interaction were shown on a screen. However, users demand an immediate interaction to enable them to control the computer directly [1]. Because of that, multi touch systems have become the most appropriate alternative to substitute the traditional human-computer interface. These systems allow the possibility of interacting directly with the graphic elements on the screen using dynamic and interactive surfaces capable of identifying multiple contact entry points [2].

This technology has evolved slowly until it reached a level advanced enough to be spread and be able to be part of common devices such as mobile phones, video game consoles, laptops, etc. [3].

In this paper the origin and evolution of the multi touch technology is analysed, specifically focused on the table top devices due to their potential to improve interactive activities, and also for their potential to evolve into massive collaborative interpersonal systems. Some iconic, mainly research-oriented, devices are described as part of the historic evolution in this field. An analysis of the comparative advantages of this technology is shown, including limitations and use challenges. Finally, the perspective of future developments and scenarios of use are reviewed.

2 Origin and evolution of multi touch tabletop devices

The origin of the multi touch technology starts at 1982, when N. Mehta, a researcher at the University of Toronto developed the “Flexible Machine Interface” currently considered the first multi touch system [4]. “The Flexible Machine Interface” consisted of multiple and simultaneous activation points produced by the user interaction by processing images to perform graphic manipulations. Later on, Bell Labs got involved in research in this field, publishing and developing important works, but this field was not recognised properly until 1985, when B. Buxton in collaboration with the “Input Research Group” of the University of Toronto developed the “Multi-Touch Tablet” [5]. The “Multi-Touch Tablet” device (Figure 1) was able to detect an arbitrary number of inputs produced by multiple simultaneous touches performed by the user on a special surface. The device was also able to identify the touch’s coordinates and estimate the degree of pressure in each contact point.

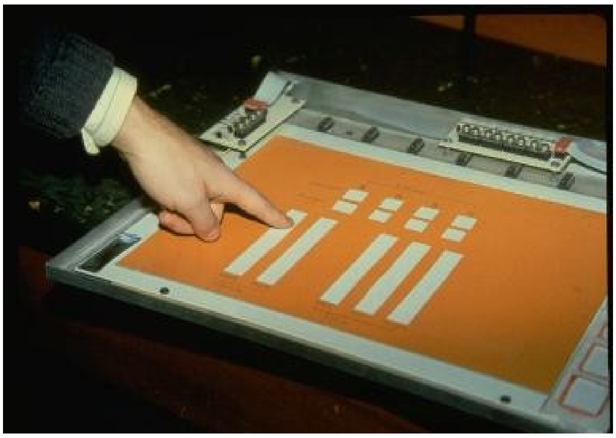

Fig. 1. "Multi-Touch Tablet" [5]

The transcendence of Buxton’s work in the field of the development of multi touch technology lies in the aim of his research, where it showed how this new technology of human-computer interaction could be used in a stress-free and constructive way in the near future.

During the last years, different projects and research have been developed in the field of sensitive surfaces, aiming mainly at improving interaction capabilities, especially related to the contact devices. Some of those developments include interaction by external contact devices, such as pens, gloves, cubes, magnifying glasses, cards, etc., or systems where the interaction is provided by bare hands.

Today, several products are available in the market using an interaction prototype similar to the one analysed previously. The most iconic devices of the evolution in this field are described briefly below:

2.1 HoloWall [6]

In 1997, Matsushita and Rekimoto published "HoloWall: Designing a Finger, Hand, Body, and Object Sensitive Wall". HoloWall is a computer based wall, capable of allowing the user to interact with graphic objects without the use of any external devices. Users can interact using their fingers, hands, body or even an object.

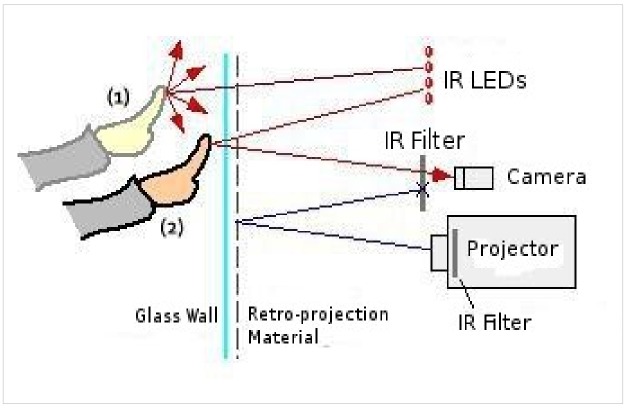

Fig. 2. System configuration of multi-touch HoloWall [6].

The system itself (Figure 2) has a glass panel with a projection material glued to it and in its rear part there are a digital projector, an infrared camera and an infrared projector. When the user or object are near or make contact with the front side of the panel, the infrared light is reflected and, in that way, the interaction is captured by the camera.

2.2 DiamondTouch [7]

In 2001, the Mitsubishi Electrical Research Laboratory (MERL) launched the DiamondTouch (Figure 3), a touch sensitive table created for enhanced collaborative work between several users having visual contact with the information being manipulated.

In the DiamondTouch system the image is projected from the upper part and uses a matrix of embedded antennas in the touch surface, where each antenna broadcasts a unique signal. Also, each user has an individual receptor, connected to them in a capacitive way (normally throw their chair). When the user touches the surface, the antennas closer to the contact point send a signal to the receptor in the chair. This connection indicates to the system where exactly the screen was touched and, in this way, the system can distinguish between several contact points at the same time and by which user, controlling access to specific functions.

2.3 ReacTable [8]

ReacTable was conceived and developed in 2003 by the research team of the University Pompeu Fabra in Barcelona. Jordà et al. presented their creation for the first time during a concert at the International Computer Music Conference 2005 in Barcelona. ReacTable is an electronic collaborative musical instrument with a tangible interface, based on a multi-touch table, capable of identifying and following fiducial markers in the surface of the device, allowing in that way to add, control and combine different musical instruments using movements and spins of these markers. This system uses a digital projector to generate images in the surface of the table. When the user adds an object with a fiducially marker in the surface of the table, the pattern is detected by the camera and is subsequently processed and identified, generating an associated sound. A schematic view of this device appears in Figure 4.

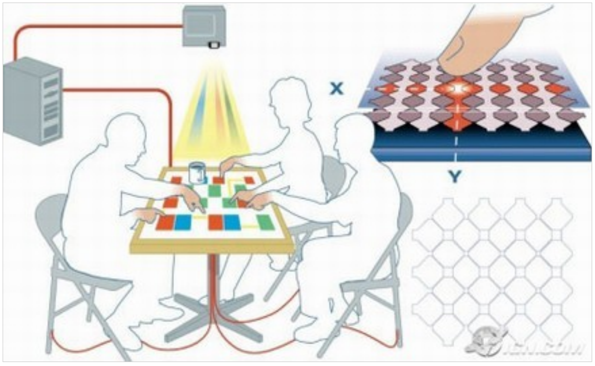

Fig. 3. Configuration of multi-touch DiamondTouch [7].

2.4 Touchlight [9]

TouchLight is a touch screen for visualization and interaction based on gestures with 3D images. It was developed by Andrew D. Wilson, a researcher at Microsoft and presented at the end of 2005. Its EON Reality was authorized on July of 2006. This device uses two cameras sensitive to infrared light, a digital projector and an infrared projector, all placed in the back part of the back projection holographic screen (DNP HoloScreen), which allows the camera to capture the objects placed in front of the screen, including the images generated by the digital projector. The schema of this device can be viewed in Figure 5.

2.5 MS Surface [10]

Microsoft Surface is an interactive table that uses navigation by tactile menu, developed by Microsoft and released during 2007. Microsoft Surface has a transparent surface where images are projected from a digital projector placed inside it. This surface is also illuminated by infrared light. The device has five infrared cameras placed in each corner and in the centre of the table to detect the infrared occlusion in the surface, caused by user's activities. A schematic view of this device is presented in Figure 6, where the interaction surface (1), infrared emitters (2), infrared cameras (3) and digital projector (4) are shown.

The activation of the system is determined by the contact performed by the user with the surface or when an object with a specific label is placed over the table, making the light to be reflected and captured by the cameras.

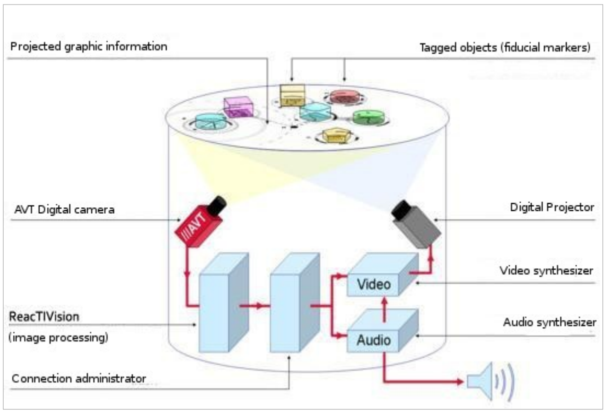

Fig. 4. Multi-touch ReacTable system configuration [8].

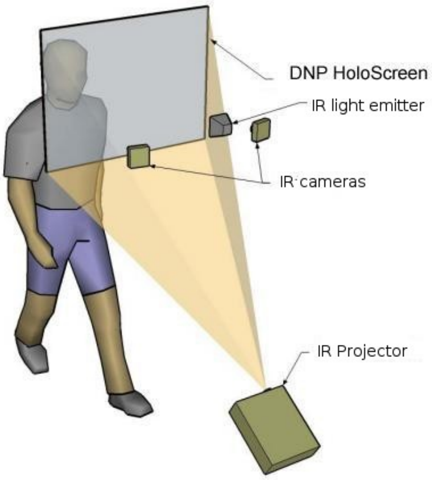

Fig. 5. TouchLight system schema [9].

3 Advantages of multi-touch table tops

Since the beginning of this technology, several advantages over the conventional interaction devices have been proposed [11]. These include their capability of being "self-contained", (i.e. they do not have the need of external interaction devices connected to them to make them operate). Another big advantage is the absence of a limit of interaction points (traditional systems are limited to just one interaction point while multi-touch tabletops can manage 10 or even more) that enables users to perform multiple interactions and manipulation tasks with the graphic elements. Also, due to their monolithic construction, the multi-touch tabletops tend to be more durable in environments of constant use.

Probably the main advantage of the multi-touch tabletop systems is the nature of the interaction with them, more intuitive and natural for the human being, and more similar to the way that humans interact with their environments [12]. These systems enable users to perform tasks with both hands, increasing the usability and efficiency of the systems. Studies about the usability of these systems show that they increase the productivity of their users, making the traditional interaction techniques seem obsolete [3]. Direct interaction with the information representation gives users a better understanding of that interaction and the ability to perform activities more confidently; increasing the speed of performance compared to traditional interaction systems [2]. Also, the speed of learning new configurations is increased allowing users to quickly adapt to new environments that could appear incompatible with the usual activities of the user [13]. The ability to use coordinated movements, allows performing multiple tasks of classification or information manipulation in new software metaphors, giving groups of people the possibility to work together simultaneously, improving the coordination between groups or reinforcing the links between them [1].

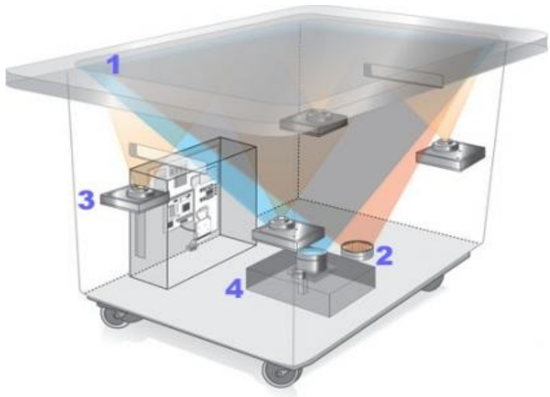

Fig. 6. Multi-Touch MS Surface System [10].

4 Limitations

Despite the expectation of significant results of multi-touch systems, (specially referred to table and tabletops systems) there are several issues that have to be addressed when software is designed for these devices [14], [15]:

- The graphic context is critical in order to use software that operates using a multi-touch surface, because the design of the application must be created to resemble reality as much as possible.
- The gestures to interact with the graphic elements must be natural, providing an abstraction of natural process, such as touching, to select a specific graphic object.
- The interpretation model or system metaphor must be able to use all the degrees of freedom provided by the system, which are not necessarily the ones in the real world. In that way, users can perform tasks intuitively according to their work area (e.g. making things float in the air placed before them).
- The possibility to use both hands allows adding new actions and commands to the system, increasing the possibility of generating "collisions" between commands. However, with an appropriate conceptual definition, this problem can become easily an advantage.

- The structure of the systems must be flexible, giving the possibility to extend and modify their functionality for different surfaces, improving the level of interaction.

Another aspect to consider about the development of these systems is related to design techniques and how to prevent certain environmental factors that could interfere with the performance of the system, such as occlusion, user identification, ergonometric aspects of systems/environments, relative position of the light source and image/video capture techniques to interpret gestures [16].

5 Future perspective

The impact of touch technologies nowadays cannot be denied. Their use is becoming part of everyday activities and slowly becomes part of many areas in human daily activity. Considering the future perspective of these technologies, including tabletops, is related to the integration with other media and devices that could be of the same type (multi-touch) or totally different ones (traditional interfaces), reaching a higher potential of use, functionality and efficiency [17].

A clear example of that is research work related to mobile devices, using an integrated work with multi-touch tabletops able to increase their functionality, creating heterogeneous systems, capable of sharing information and, at the same time, keeping some specific data available just for some specific users [18], making new ways of user to user interaction.

Another field of exploration is the development of software and tabletop systems able to manage not just a multi-touch interface, but also other ways of interaction, such as natural language. This integration of multimodal interaction in a collaborative environment increases notably the capability of interaction and the usability of these devices, giving users a more natural working environment [19].

A new research area tries to provide these systems an "extra" dimension to operate. Today, the multi-touch tabletops systems work with 2D gesture interaction, just with the contact with the detection surfaces. There are several studies to design systems able to work with 3D interaction; which will show a notable increase in interaction capabilities including more natural gesturing and giving the users more confidence and comfort when they interact with the devices. As a result, learning and efficiency will improve related to new challenges ([20], [21], [22]).

Additionally, the possibility of making the traditional interaction devices evolve and improve their performance combining traditional information representations will increase. The evolution process of multi-touch systems is progressive and less invasive in different work places [23].

Today, one of the main limitations of multi-touch tabletops devices is referred to their portability, because generally they are big in comparison with their traditional counterparts. Advances in size reduction of the components of these devices (such as processing systems, cameras, digital projectors, etc) should in future enable the creation of portable multi-touch table-tops, improving in that way their massive use [24] and hence leading to lower costs.

In reference to the use of this technology, it seems clear that a key aspect of their future evolution is related to the possibility of integrated collaborative group work. This will allow collaboration between both professionals of the same or different areas [25]. Since the interaction is simple to understand, this type of devices will be able to improve interaction between professionals and common people, providing new developing lines for these devices such as education ([26], [27], [28]), house and kitchen hardware components/environments ([29], [30], [31]), environment design for neighbourhoods and buildings[32], etc.

6 Conclusions

In this work, an analysis of the evolution and functionality of multi-touch tabletop systems have been presented, showing their historic evolution along recent years. The advances in hardware were shown and their contribution in this evolution, improving their performance and decreasing their costs. Also, advances in software algorithms, such as tracking, image processing, and graphic manipulation have clearly improved clearly these devices, allowing developers to create more and better applications and multimedia environments making multi-touch devices part of several fields of work.

Another important issue is referred to the possibility of using this technology instead of traditional technologies, because of the intuitive interaction methods and the possibility of having multiple users at the same time.

However, it is necessary to consider several aspects related to the design of applications and use environments when their use is decided, issues that probably in the future will be overcome.

In the near future, one can expect that multi-touch tabletop technology will be part of the daily life in society and will get more social relevance, even without an actual surface.

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