Tangible User Interface

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INTRODUCTION

Tangible User Interface is a technology that has been gaining popularity over the past two decades. A Tangible User Interface (TUI) is defined as the type of user interface in which the user interacts with the device through a physical medium. The initial name for this technology was Graspable User Interface, which is now replaced by Tangible User Interface [1]. A user interface is classified as a tangible user interface when it possess a space multiplex for input and output and it has concurrent access and manipulation of interface components. Along with these, it should be a strong, specific and especially aware computational device which is capable of the re-configuring spatiality of the devices [3]. The introduction of the tangible user interface has changed the conventional methods of the user interface which was limited to using a mouse and a keyboard to interact with the computer and using the keypad for the mobile phones and various other devices [2]. There are many advantages for tangible user interfaces over other conventionally used interface methods. One such advantage is that it is easy to use and understand and can be helpful for people with disabilities. Also, tangibility can play an important role in problem solving by observing logistic apprentices who are using the device with a tangible interface. However, there are many other possibilities of the tangible user interface which remains unexploited. The tangible user interface has relevance in non digital world as well. This is getting more important in real, normal world in terms of touch surfaces. The scope of study for the tangible user interface is very vast since the design space of TUIs is constantly evolving and there are implications in highly technical digital devices as well as normally used devices such as wi-fi, remote etc. But, this does not mean that the interaction with the tangible user interface is limited to touch, but includes visual and aural senses as well. So, it deals with both 2 dimensional and 3 dimensional interactions [2].

SYNOPSIS OF KEY RESEARCHERS

As mentioned before, there have been many previous pieces of research in studying the applications and advantages of tangible user interfaces. The notable personalities who conducted the study on tangible user interfaces are Hiroshi Ishii, Brygg Ullmer and Orit Shaer.

Hiroshi Ishii is a Japanese computer scientist and professor at the Massachusetts Institute of Technology. He was the founder of Tangible Media Group and started the Tangible Bits project in 1995 which is still ongoing. He had made his mark in Human Computer Interaction (HCI) and Computer-Supported Cooperative Work (CSCW) in the early 1990s [6].

Brygg Ullmer is the assistant professor in division of computer science in LSU. His research group is named Tangible Visualization. "Brygg Ullmer received his Ph.D. in Media Arts and Sciences in August 2002 for research based on “tangible interfaces” — user interfaces employing physical objects, surfaces, and spaces as representations and controls for computationally mediated information. His projects have focused on ways these interfaces can be used to manipulate networked content." [6].

Orit Shaer is the Associate Professor of Computer Science and co-director of the Media Arts and Sciences Program at Wellesley College. Her research focuses on next generation user interfaces including virtual and augmented reality, tangible, gestural, tactile, and multi touch interaction. The current project she is working on involves the design and evaluation of smart environments for collaborative decision-making, the design and evaluation of novel interactive visualizations for personal genomics, and the development of computational tools for enhancing learning. [7]

Apart from them, there are many other researchers and studies conducted on this emerging technology and its design space is constantly evolving. The key researches of these researchers are,

- "Tangible bits: towards seamless interfaces between people, bits and atoms" by H Ishii and B Ullmer.
- "Emerging frameworks for tangible user interfaces" by B Ullmer and H Ishii.
- "Tangible user interfaces: past, present and future directions" by O Shaer and E Hornecker.

The first paper "Tangible bits: towards seamless interfaces between people, bits and atoms" by H Ishii

and B Ullmer are presented with the vision of human computer interaction in the form of tangible bits. The paper "Emerging frameworks for tangible user interfaces" by B Ullmer and H Ishii is discussing the introduction of the tangible user interface as a new beginning to the human computer interaction. This paper considers the tangible user interface as a growing space for the human computer interaction, in which a change is implied from the usual visual paradigm of the human computer interaction and changing it to the physical representation and controls to the system. The paper "Tangible user interfaces: past, present and future directions" by O Shaer and E Hornecker discuss about the history, current and future trends of the tangible user interfaces.

KEY RESEARCH RESULTS

The paper "Tangible bits: towards seamless interfaces between people, bits and atoms" by H Ishii and B Ullmer is presented with the vision of human computer interaction in the form of tangible bits. They have mentioned that "the tangible bits allow the users to grasp and manipulate the bits in the center of the users' attention by coupling the bits with everyday physical objects and architectural services." [4]. This will help the user to understand what is in the background of the bits and it undertakes a human perception of using the visual and aural senses such as light, sound, air flow, water and also other aerial factors whose movement is in the augmented space [4]. In this paper they have presented the idea to reduce the gap between the cyberspace and the physical environment by introducing tangible bits and this can be used in every human activity. The main inspiration behind this research was to incorporate the physical world into the human computer interaction. The authors believed that this will reduce the boundary between the physical world where every human being is living and the cyber world. "We are now almost constantly "wired" so that we can be here (physical space) and there (cyberspace) simultaneously" [4], states the authors. The research introduces the design projects including the metaDESK, transBOARD and ambientROOM systems. The whole world itself will be considered as the interface when tangible user interface is implemented. The tangible bits were developed to work as an interactive surface which converts any surface to an interface and to couple the bits and atoms. It also uses the ambient media such as sound, light, airflow, and water movement for background interfaces with cyberspace at the periphery of human perception [4]. The research was based on three applications which uses tangible user interface which is a metaDESK, transBOARD and ambientROOM. The metaDESK uses the tangible interfaces such as lens, phicon, tray, phandle and instrument to connect between the virtual and real world. "The transBOARD is a networked digitally-enhanced physical whiteboard designed to explore the concept of interactive surfaces which absorb information from the physical world, transforming this data into bits and distributing it into cyberspace" [4], where as the ambientROOM uses the ambient light, shadow, sound, airflow and water flow as a means of interaction [4].

The paper "Emerging frameworks for tangible user interfaces" by B Ullmer and H Ishii is discussing the introduction of the tangible user interface as a new beginning to the human computer interaction. The authors have stated that "their goal is to identify a distinct and cohesive stream of research including both recent and decades-old examples, and to provide conceptual tools for characterizing an1d relating these systems under the common umbrella of “tangible user interfaces.” [5]. This paper considers the tangible user interface as a growing space for the human computer interaction, in which a change is implied from the usual visual paradigm of the human computer interaction and changing it to the physical representation and controls to the system. The paper has presented with the interaction model and the key characteristics for a tangible user interface and the model has been explained with different interface examples. The paper has put forward a newly integrated view of human computer interaction and it has been molded seamlessly to the physical and digital world [5]. They have taken steps towards a conceptual framework for tangible user interfaces. The research considers various examples such as URP, which is a tangible interface for urban planning built around a workbench that allows the direct manipulation of physical building models to configure and control an underlying urban simulation, and MediaBlocks, which are small, digitally tagged blocks, which are dynamically bound to lists of online media elements and acts as a tangible interface for manipulating collections of physically embodied videos, images, and other media elements [5].

The paper "Tangible user interfaces: past, present and future directions" by O Shaer and E Hornecker discuss the history, current and future trends of the tangible user interfaces. The author states that the tangible user interfaces have been in the technology for the past two decades. The research carries forward from the beginning of Graspable User Interface through the tangible bits and various

application domains. The author states various applications for tangible user interface such as for learning, problem solving and planning, information visualization, programming, entertainment etc. The tangible user interface has significantly increased the potential to enhance the way in which the users interact with a digital or a non digital system. However, the paper also mentions that the technology of tangible user interface is still under research and there a variety of applications and advancements which are still unexplored. The paper starts of by sketching the history of the tangible user interface and examining the intellectual origins and also presents the current development in the tangible user interface in a broader context. There is also discussion based on the perspective of cognitive science, psychology, and philosophy. Apart from these, the research have found the tangible user interface can be used in implementation technologies such as RFID, computer vision, microcontrollers, sensors and actuators. As the name suggests, this research gives us a complete idea of tangible user interfaces from its history to the future trends. The final discussion shows the future trends of tangible user interfaces and also the limitations which we need to overcome to acquire the full out of this technology [2].

DISCUSSION

As mentioned earlier, there are many pieces of research and studies conducted on different aspects and applications of tangible user interfaces. The researchers were able to find and develop many integrated models utilizing tangible user interfaces. However, the finding is not limited to those which are in the researches. The research paper by H Ishii and B Ullmer presented the vision of Tangible Bits which bridges the gap between the worlds of bits and atoms through graspable objects and ambient media in physical environments. The research was successfully able to transform the painted bits which are used in normal graphical user interfaces into tangible bits by incorporating the senses and modality of the real world of human into the cyber world. This methodology can be very useful in easing human computer interaction. This research breaks the conventional methods of the user interface and also changes the concept of only using touch or visual medium for the user interface. This paper actually provides a great source of inspiration for future research and work on tangible user interface [4].

Another research paper which was considered here was the "Emerging frameworks for tangible user interfaces" by B Ullmer and H Ishii which provides a conceptual framework for tangible user interfaces. The paper presented an interaction model and key characteristics which were applied to a number of examples. However, the examples considered in this research does not use tangible user interface explicitly, but alongside numerous past and contemporary systems. But these systems can be considered in terms of tangible interface characteristics. The research has done an excellent job in terms of providing a conceptual framework for tangible user interfaces. Apart from providing the conceptual framework, the research paper also consolidates a few application domains where tangible interfaces can be used. But there are no specifications on how this can be implemented, the technologies needs to be used or any further details on this context. As mentioned before, there are many issues of cognitive engagement and distance, general vs. special purpose approaches etc which remains untouched in this research. The framework will need further consideration in terms of engineering practices, software and hardware updates, tools and techniques, prototypes and more [5].

The research paper by O Shaer and E Hornecker provides the complete history, present situation and future trends of tangible user interface. Apart from providing the complete context, this research paper have a dominant advantage over the other research papers is that this paper provides all the necessary context of tangible user interfaces along with its advantages and disadvantages. Better collaboration with familiarity and affordances known from everyday interaction with the real world lower the threshold for engaging with a system and thus increase the likelihood of users to actively contribute. Similarly, other advantages are its situatedness where the tangible user interface can inhabit the same world as we, thus enhancing the interaction design, tangible thinking for better interaction and cognitive skills, gestures, epistemic actions and thinking props. The advantages of tangible user interface are presented separately for each of the application specified. The author also mentioned the limitations which are the scalability and the risk of losing objects, its versatility, and malleability and a fatigue user may experience. Also, the paper provides a complete context of how to implement a tangible user interface to the mentioned applications [2].

OPEN AREAS OF RESEARCH

There are many open areas to continue research in tangible user interface. One such identified research idea is the design of a touch screen mouse. There is a lot of comparison happening between using a mouse

or a touch screen for a computer. Both of these methods have advantages and limitations. Hence the idea of this mouse is to combine both the technologies and implement it using the specifications of a tangible user interface. A tangible user interface is when we use the physical medium for interacting with the computer. Hence we are planning to convert part on the table (preferably the laptop table or the computer table) as a mouse with the facilities of a touchscreen.

The idea is to cover the top part of a mouse with a touch screen. One technology needed is similar to the working of the home button of iPhone 8. Unlike other home buttons on different versions of iPhone, the iPhone 8 home button detects the presence and pressure of the finger. Similarly, the tap part of the mouse will be configured to respond to the touch of the user. This will have a great advantage over the conventional mouse since it allows direct contact with the object on the screen. Its default tap part is the same as a conventional mouse. However, the user can use an exclusive app to change the tap parts and even set up new tap parts with various functions on the touch screen mouse. Additionally, the color or style of a touch screen mouse can be easily changed using the app. There can also be an added advantage on the touch screen monitor as there will be only a small amount if hand and wrist movement required which will be more comfortable for the users. Also, this can provide better sensitivity. Also, this will have more accurate accelerated movements and accessibility support. This type of mouse can be used for any system (large or small) and will be more engaging to interact with the system. The touchscreen mouse will also be compatible to use with the mobile phones. Below diagram shows the basic representation of a touchscreen mouse.

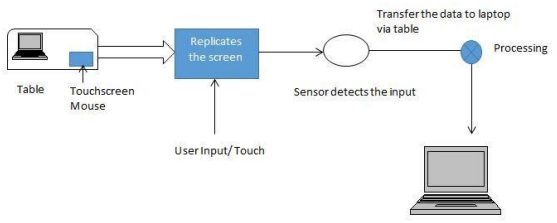

Figure 1: Outline of touchscreen mouse interface.

While comparing it with the normal mouse, the touchscreen mouse has a lot of added advantages. It allows the user to interact directly with the system and will be more efficient. The user can personalize the mouse's functions and aesthetic appearance using an exclusive app. In addition, the user can utilize the mouse with a device which does not offer a touchscreen and can be more interactive with the system. It is easy to use especially for gaming options. Other than different hand and eye movement, both can be concentrated at the same point for more accuracy. Touchscreen mouse will have the added advantage while the user has time restrictions or is working under pressure. The study can be conducted by allowing online games to use the touchscreen mouse and the normal conventional mouse and their feedback can be gathered.

Another idea of research implementing the tangible user interface system is the design of a gaming system which detects the body movements and gestures and allows us to play accordingly. Instead of using regular keypad, mouse or joystick controls, the user will be able to use their own body movements, hand and leg gestures etc. to control the game. This can be utilized with variety of gaming options such as football, boxing, tennis etc. This can provide the user with a virtual reality experience and will be better to any available conventional methods.

CONCLUSION

The tangible user interface is a technical advancement which can provide a good human computer interaction. There have been many researchers conducted on different ideas and applications where tangible user interfaces can be implemented. The applications are not limited to technical but also to simple and day to day non-technical activities as well. This model of human computer interaction was started as early as from the 1990s and many renovated scholars and research persons have conducted studies on the subject. However, there are still many open areas to be considered for the study where tangible user interface can be applied. Also, there are many limitations for this technology which has been identified in the previous researches and needs to overcome to get the best out of this technology.

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