Modern User Input Methods

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Abstract — *The main objective of this research paper is to identify the modern technologies which are used to interact with computing devices and securing those input methods. Here, we mainly focus on modern aspects of the user input methods such as gestures, multi-sensors and motion detections devices rather than obsolete methods.*

Index Terms — modern input methods, mobile user input, gestures, facial expressions, eye tracking

I. Introduction

Today, most of the computing devices including tablet PCs, laptops and smart phones use the mentioned highly sophisticated user input methods in order to give a user friendly experience for their work, including typing, gaming and browsing. Each of these input methods have their own characteristics. The convenience given to the users is a dependent of those inherited characteristics. The main problem of those modern user input method is that how to make the optimal choice which provides maximum efficiency, user friendliness with minimum cost and complexity.

Content of this paper mainly based on several user input methods types.

1. User input methods in mobile devices
2. Gestures and facial expressions
3. Thumb based user input method for automobile applications
4. Viewing conditions and rotation methods in a collaborative tabletop AR environment

The rest of the research paper will contain threats and vulnerabilities in user input methods. Threats are categorized under following sections.

1. Eye tracking system for password entering
2. Eye tracking
3. Errors in user inputs in mobile
4. Identified other problems in input method

We will finally discuss the solutions for the above mentioned threats.

II. User Input Methods in Mobile Devices

A. Multi Sensors in Mobile Devices

The multi-sensors in mobile devices have become very interested field for researchers and this technology is still emerging. It covers mobile application interfaces; mobile to mobile interaction and mobile to house hold appliance interaction.

"Five components are built in the handheld sensible interface device: distance measurement component, acceleration measure component, main processing component, haptic generation component, and wireless communication component."[16, page 1]

The interactions which are done by using the keyboard, mouse or joystick has become obsolete ways of communicating with digital devices. The technology has developed to a large extend of user input methods including touch screens, motion detection systems and multi-sensors in mobile devices.

The mobile application controlling can be done without even touching its screen or the key pad. The distance meter and accelerator meter is used to implement this technology. The user can navigate, zoom and scroll the web pages or images using the distance measurement sensors. [16] Our intention is to discuss of this technology with more details in our paper. Therefore this section will be highly significant as a reference.

B. Accelerometer Based User Input Methods

The accelerometer based user input devices can be used to detect the motions of the users and it allows the user to get the real time experience of interaction. The user experience of this kind of input method is more sophisticated than that of the touch screen device. Therefore the accelerometer technology is very interested field among researchers.

Thus we have chosen a research paper which mainly describes of the improvements which can be done to the accelerometer based user input methods. It was written by Jonghun Baek and Byoung-Ju Yun and published by IEEE. This article has been written on the topic of "A Sequence-Action Recognition Applying State Machine for User Interface".

"The user interface in accelerometer-enable mobile devices requires more advanced action recognition technology than that of the traditional input method due to its awkward handling (e.g., limited computational capability, miniaturized input/output controls, and so on)."[5, page 1]

The paper [5] introduces more advanced way to recognize user's gestures and postures using a state machine. This design enables the identification of user's sequence action by using a two axis accelerometer. The paper [5] introduces the state machine algorithm which is used to identify the user's gestures. The interesting scenario of this extended accelerometer feature is that it facilitates the game developers to develop games using its amazing capabilities. For example, a cricket game can be implemented where the user can bat and bowl in real time to give the inputs to the game. The gamer does not need to click, press or touch on a screen to interact with the game. He can be a virtual cricketer and imitate a real player's actions. The mobile device recognizes the sequence of his actions and generates appropriate inputs. The game engine then decides the further actions according to those inputs. Another example of using this technology in gaming is the implementation of the fishing game. A user can catch fishes even without seeing a single drop of water. He only needs to imitate the actions of a fisherman and catch as much as he can. [5]

The way of implementation of this user input method by using the state machine algorithm allows the application developers to develop their application in convenient or traditional way. They can be adhere to the design and coding practices which they are used to do with convenient user input technologies such as mouse and key boards. Since the accelerometer implementation is decoupled with the underlined applications, the program developers can use the same API (Application Programmer Interface) which they used to build apps with older input methods. The only difference is the user input capturing and interpretation method. This article [5] describes how this can be done using the accelerometer.

C. *Accelerometer Scrolling*

Next we referred a research paper on the development a new method of input method other than touching something to give inputs [4]. It was published by J.F. Buttler. The article outlines the development of the Rock 'n' Scroll input method which lets users gesture to scroll, select, and command an application without resorting to buttons, touch screens, spoken commands, or other input methods.

"The Rock 'n' Scroll user interface shows how in built sensors in handheld devices can provide additional function beyond "tilt-to-scroll". By also using them to recognize gestures, a significantly richer vocabulary for controlling the device is available that implements an electronic photo album, pager, or other limited function digital appliance without any additional input methods. The examples presented offer a glimpse at the freedom for both device designers and users inherent in devices that can be held in either hand, at any orientation, operated with mittens on, or not in the hand at"[4,page1].

The problem of this document is that this some old technical thing when consider about the newer technology. But the thing is this research was the base of motion sensing and rotation detecting and multi touch concept in modern mobile devices.

This paper contains the features of the image gallery scrolling using the device rotation and motion sensing. Image gallery is sensing the multi gestures to control the device. This is the method of accelerometer and the multi touch screen based technology using in the modern mobile devices and most of the other devices like ATM machines. This is the modern trend of give user inputs to a device.

When we consider the user input methods, having devices with the accelerometer and the devices with multi gesture sensing is more important today than the day's writer researched this. If the user has the ability to provide inputs with friendlier manner then they will use such devices more than now. In this document they talk about a new method of providing inputs to a system, so it is very much related to our topic user input methods.

D. *Comparing Model Prediction to Actual Performance*

Mobile phones play a very important part in human life nowadays. So when we are talking about user input methods this topic is a really important topic that need to be discuss about.

The article is by Christina L. James and Kelly M. Reischel. Both are researches of the user interface & usability group, Tegic Communications, AOL Wireless. And the article was published on the SIGCHI conference on Human factors in computing systems in 2001.

This paper talks about the two major currently available text input methods used in mobile devices. Those are T9 text input and multi tap method. This research is done to compare the performances of those two methods. That means to check the faster method from these two methods.

The result of the research is the predictive input method is faster than the multi input method. "In addition, in order to help shape future models, additional results are presented for both input methods to show how both accuracy and speed performance varies based on user experience and text subject matter."[6]

E. *Using Voice Input for SMS Composition*

This section is on using voice input for SMS composition. The previous paper talks about the currently available text input methods in mobile devices. But this method is still on experimental level. Some newest phones have this feature. But it needs some development.

This article is written by Anna L. Cox, Paul A. Cairns, Alison Walton and Sasha Lee. All are from University College London. And it was published in the journal 'Personal and Ubiquitous Computing' Volume 12 Issue 8, November 2008.

The currently available text input method has lots of drawbacks. While driving a vehicle or doing some other work we can't type a text message. But we can give voice commands while doing some other work. This paper [??] reports a series of investigations, which aim to test the appropriateness of voice recognition as an interaction method for mobile phone use.

A KLM model was used in order to compare the speed of using voice recognition against using multi-tap and predictive text to interact with the phone menus and compose a text message. According to the research results speech is faster than the other two methods and that a combination of input methods provides the quickest task completion times.

To select a faster method to input text, the researchers are using some experiments. The document gives a descriptive idea about those experiments. When talking about input methods, the other thing we need to talk about is the accuracy. The article discusses about the accuracy levels of the currently available method and the newly suggested voice input method. "These experiments not only indicate the usefulness of voice in SMS input but also that users could also be satisfied with voice input in hands-busy, eyes-busy situations."[3]

III. Gestures and Facial Expressions

A. Gesture Sensing by Mobile Phone Camera

Camera based motion sensing is a developing section among user interaction methods used in modern world. When considering about the camera based motion sensing, basically it is basically about the gesture identification. Therefore using gestures user can give various inputs to many devices and fulfill his needs. This is a newly emerging method in 21st century and lot of researches and implementations are going on this area. Nowadays significant amount of innovations can be identified in gesture based controlled devices and technologies.

The research paper, "Camera Phone Based Motion Sensing: Interaction Techniques, Applications and Performance Study", by Jingtao Wang, Shumin Zhai, John Canny has given important content on gesture based user interactions which is a modern technology emerging in 21st century. The research paper has described a new technology called TinyMotion.

"We have developed a technique called TinyMotion (figure1) for camera phones. TinyMotion detects the movements of a cell phone in real time by analyzing image sequences captured by its built-in camera. Typical movements that TinyMotion detects include horizontal and vertical movements, rotational movements and tilt movements." [9, page 2]

This is the definition given in the research paper for the TinyMotion. TinyMotion can process the gestures. The images are taken from the camera and some processing done to the images taken and convert them to data. Colour space conversion, grid sampling, Motion estimation and Post processing are done according to a mathematical method. An algorithm called "The TinyMotion Algorithm" is used in this process. TinyMotion method can be used in gesture recognition, face tracking, body tracking in mobile phones.

They have shown that it is also possible to build higher level interactive applications, such as gaming and gesture recognition, based on our sensing method. Therefore this is an important detail related to the new technologies developed for the user input methods. According the TinyMotion, users can control devises or give input to the software applications through their mobile phones.

B. User Input by Gestures

Two approaches have approved high potential for interacting with services in the environment of the user: The use of a mobile or handheld device, or performing gestures in the air, with the head, finger or other part of the body, or simply by moving around. The inputs given through the handheld devices are mainly generated by pressing keys. But gesture base inputs are more advance and complex in implementing as described above.

The research paper, "The Ambient Media Player - A Media Application Remotely Operated by the Use of Mobile Devices and Gestures", by Andreas Lorenz and Marc Jentsch describes also about the gesture based user input method given to control the media player. The user inputs given in public and private environments for advertisement, entertainment and user guidance are discussed in this research paper.

"For controlling the behavior of a computer system, users require methods to express input to the system. Whether a control device is suitable for an intended interaction depends on the capabilities, personal preferences, situation and task of the user. The design and implementation of interaction in ambient computing environments cannot rely on traditional input devices like mouse and keyboard". [2, page 1]

Because people were familiar with the use of the buttons, they quickly adopted its usage to the task. The use of the hardware buttons was fast and satisfactory to the test persons. It is narrowed to simple controls and low number of commands, which have a comprehensible mapping to the four directions. Because the use of rather simple gestures, it was intuitively used, but limited in the provided functionality. Techniques of deriving user input from observing the direction and length of movements in the air or on the display of a mobile phone were slower and less satisfactory.

C. Facial Expression Recognition Using Facial Movement Features

Facial expression recognition methods are considered as an evolving field in nowadays. It can be used for human communication and it has so many other applications as image processing, machine learning and human cognition. FER (Facial expression recognition) have been growing in a wide range of applications, including human-computer interaction, robot control, and driver state surveillance. Main obstacle for the rapid development of this field is difficulty in accurate extracting the useful emotional features.

Facial expression recognition is done based on the facial movement features – feature position and shape changes. For an example, as a person laughs the facial elements and muscles change. Detecting those facial muscles movements and positions, do some process, resulting actions can be taken. Changes in above features may different from one person to other. Therefore recognizing the facial expressions is a crucial process. Some efforts have been made in capturing and utilizing facial expression. Most of them are based on video. These efforts try to adopt either geometric features of the tracked facial points, facial animation parameters, distance and angular, trajectories, or appearance difference between holistic facial regions in consequent frames, or texture and motion changes in local facial regions, motion units, spatiotemporal descriptors, animation units, and pixel differences.

This section mainly focuses on improving the performance of FER by automatically capturing facial movement features in static images based on distance features. The distances are obtained by extracting "salient" patch-based Gabor features and then performing patch matching operations. Building the distance feature can be divided in to two phases.

1. Patch based feature extraction.
2. Patch matching operation.
3. Distance metric definition.

IV. Thumb Based User Input Method for Automobile Applications

Most of the mechanical machines including vehicles are becoming automotive in nowadays. For example, a car which is manufactured after year 2000 having built-in navigation and information systems, satellite radios, multimedia systems, and complex air conditioning and heating systems. Other than that drivers are also bringing complex devices in to vehicle such as cellular, mp3 players, PDA etc. This paper reveals that BMW iDrive system controls over 700 functions. Because of this trend user or the driver need to have his visual attention to configure or operate these devices.

As a solution for this, some suggested solutions are speech based control devices, thumb based control devices. Most of the devices have already been designed for the speech based control. But scientists are still searching more accurate way to communicate with these devices. This paper present multiple thumb-based input techniques for destination entry using a small touchpad called a StampPad which is a single input device that can be used for both built-in and brought-in devices mounted where the right-hand thumb naturally grips the steering wheel. This use of the thumb keeps the driver in the preferred position with both hands on the steering wheel. They adapted popular interaction techniques from computers and consumer electronic devices for the thumb-based interaction techniques, which they evaluated in both stationary and simulated driving conditions. Techniques include "dialing," which is found on the Apple iPod, "clutching," which is common to laptop touchpads, "displacement," which is similar to how joysticks operate, and the EdgeWrite text entry method.

According to the author, dialing a phone number and selection while driving have been tested in a simulated environment. Dialing an unfamiliar 10-digit phone number on average took approximately 28 seconds, and tuning a radio using a seek function took on average 22 seconds. Therefore this kind of situations makes risks. Therefore the solution should be implemented in a way that user's thumb should not be taken from the steering wheel.

"Many automobiles have an option to control the entertainment devices using a controller which is attached to the steering wheel. Following this trend, they embedded a small Synaptic StampPad (2.8×3.2 cm) beneath the thumb's natural position on a Logitech Driving Force steering wheel for investigating thumb based interaction techniques".

Driving guidelines suggest that hands should be placed at the 2 o'clock and 10 o'clock positions when gripping a steering wheel. Furthermore, the natural position of the thumb when grasping a device is often the best location for thumb-controlled input areas. Accordingly, we placed the touch sensitive area at the 2 o'clock position for use by a right-handed user.

V. Conditions and Rotation Methods in a Collaborative Tabletop AR Environment

This section is on effects of viewing conditions and rotation methods in a collaborative tabletop AR environment. When we are talking about user input methods it is important to talk about the effects of viewing conditions and rotation methods to users. It gives a clear idea on how the input methods have to be organized.

This article is by Sangyoon Lee and Hong Hua. Both are from university of Arizona, USA. They have prepared this research paper after doing lots of experiments using people. This article talks about the different experiences done by them to do their research on this topic.

"The viewing condition means how the manipulation of a tabletop world by one user is shown in the other users' views and the rotation method means what type of input devices is used to rotate the tabletop world for alternative orientations."[14]

The paper talks about two viewing conditions (consistent view and inconsistent view), two rotation methods (direct turn and indirect turn), and two task types (synchronous and referring-strong type, and asynchronous and orientation-strong type).

VI. Threats in User Input Methods

A. *Eye Tracking System for Password Entering*

This section is about the different ways to enter password to get authentication of a system that allows you to do some stuff when you logged in or get inside that premises. This article research is done by Alexander De Luca, Martin Denzel and Heinrich Hussmann from university of Munich Munich [1].

Today world has many systems that the users have to login or grant permission to some work. Today almost every websites which have has critical information has that authentication mechanism. Some government or private organizations have password mechanism to enter their buildings. So the persons have to provide their password anyway to access the facility. Most of these systems work with a keyboard inputs. Huge threat on this authentication systems are, when we give the input from a keyboard or a mouse others can see that over our shoulders. So this research group provides other kind of way to prevent such kind of attack. This document explains why this kind of attacks taken place and what are the mechanism that are existing there to prevent such attacks and they provide a solution to that problem do test about what they implemented on how the users can use such kind of systems.

Today there are some authentication systems available there to control the login and logout systems. Some of them are keyboard, fingerprint scanners, smart card readers etc. when we consider them the keyboard is a not secure thing due to the attackers can see above your shoulder. Consider When considering about fingerprint scanners it is still very error prone. For instance, fingerprint scanners are very sensitive to changes in the humidity of the air. If you lost your smart card what would happen? A thief can take your smart card and do some bad stuff in your office. If he takes s some critical information from the office then what kind of situation you have to face? These kinds of problems are there in the currently available system.

Here the system is implemented that the user has to give the input from their eye, and a camera will capture your eye movements and the shape of your eye. In this application they used two different ways of aye eye involved authentication mechanism. One is that it takes the shape of the eye and its component. And it is there implemented in the world today. But other method is save your eye movements and compare when you try to login. User has to give input numbers from their eye movements. This movement will compare with previously saved items and do authentication. This is some new method of give giving user inputs to the systems.

The contents of this paper are very much related to our topic; user input methods. The input methods of the computing devices are evolved lot with time and in this paper we are looking for the new trends of these technologies. To authentication systems gestures and the biomedical scanning is combined and using newer way. This will provide more security to the systems that has critical data. This paper is well suited for the research topic of ours since it includes the modern approach to the user input methods. Our research paper will cover some area of modern user input methods including touch gestures and biomedical scanned prints as an input to the computing devices.

B. Eye Tracking

Our paper discuss about a way of eye tracking system for authentication purpose. It was published by Zhiwei Zhu and Qiang Ji[20]. This article is about a system that takes pictures of human eye and takes that thing as an input for the device or to a security system. So this is a pretty good input method when we consider about the user input methods.

This document explains eye tracing system which completely differs from the previous one. This takes the input as an image of human eye. Human eye is differing from person to person. So system developers use this as a mirror and take an image of a lighting device and compare with previously taken picture. This is a good method of providing inputs to a system. But the problem in this document is that it is more theoretical and full of mathematics which cannot understand by an ordinary person.

In this document they are proposing two techniques for tracking eye. The first techniques proposed to estimate the 3D eye gaze directly.

"In this technique, the cornea of the eyeball is modeled as a convex mirror. Via the properties of convex mirror, a simple method is proposed to estimate the 3D optic axis of the eye. The visual axis, which is the true 3D gaze direction of the user, can be determined subsequently after knowing the angle deviation between the visual axis and optic axis by a simple calibration procedure. Therefore, the gaze point on an object in the scene can be obtained by simply intersecting the estimated 3D gaze direction with the object". [20, page 1]

Our second technique does not need to estimate the 3D eye gaze directly, and the gaze point on an object is estimated from a gaze mapping function implicitly. In addition, a dynamic computational head compensation model is developed to automatically update the gaze mapping function whenever the head moves. Hence, the eye gaze can be estimated under natural head movement.

In the security providing environment, it is important that the user provide there their authenticating inputs. To provide it in more secure way is to use biomedical scanners. In that eye tracking systems are more important. So this provides two ways of providing that functionality. So this document is very much related to our topic that is modern user input methods.

C. Errors in User Inputs in Mobile

When considering about the user interaction methods, errors in those methods are also significant. In user input methods like key board inputs and mouse clicks can have errors. In using those user input methods user has to face many problems because of various reasons. The research paper," What input errors do you experience? Typing and pointing errors of mobile Web users" by Tianyi Chen et al. describes some types of errors in user input errors.

"The keyboard on small devices is physically small and compact, which makes it difficult to locate a target key without pressing the neighboring ones. Further, a typical numeric keypad has 12 keys and there are usually three letters on each key. Therefore, a user has to distinguish different letters on a key either by pressing the key several times or using another functional key, which makes typing slow and error-prone."[17, page 1]

There are huge number of errors that user does in accessing the World Wide Web from mobile devices in anywhere and anytime. We can be categorized them as Typing and Pointing Errors. Long key press error, bounce error, missing key error, transposition error, additional key error, and key ambiguity error can be shown as typing errors. Clicking error, multi clicking error and dragging error can be shown as pointing errors.

These errors take place frequently when the users user small devices such as mobile phones and small key pads in browsing the internet. So the solutions must be given to encourage the mobile users in order to minimize these errors.

Dynamic keyboard and TrueKeys are some techniques that can be used to minimize the typing errors. On the other hand to minimize the pointing errors Target expansion, Steady Click, SUPPLE and SUPP LE++ and Sticky Icons with Adaptive Gain Control can be used. [17, page 17]

Those six strategies will be good solutions for the mobile web users and considering about user input methods it is very important to make notice about the weak points of those user input methods. That will make using new technologies more beneficial to the users to fulfill their needs.

D. Identified Other Problems in Input Methods

There are many modern input methods which are described in this section. There are gesture based input methods, inputs given by hand-held devices like mobile phones and various other methods. When a user wants to give some inputs to fulfill his needs, there are many issues which affect his choices in using above methods. Efficiency, usability and performance are some of those key issues. So one should consider about these facts and select the appropriate user input methods to satisfy the requirements.

This section explains several user input methods in both technological and usability perspectives. It gives some opinion to the users about the properties of the user input methods. This section describes the facts such as usability, efficiency and other significant properties. For example giving inputs using buttons is very user friendly and the users adopt it very quickly. On the other hand gesture based inputs can be used as an efficient method. But there are some issues regarding this technology such as complexity, cost and resistance of users for using this. Therefore a trade-off is always necessary when selecting an appropriate user input methods for particular application. We have to consider the type of the application, targeted users and cost when taking the decision. Our paper will provide solutions for this problem by giving some relevant technical aspects of those user input methods.

VII. Solutions for Threats in User Input Methods

A. Securing User Inputs for the Web

When we consider the user input methods, only having a user interface with more user friendly components and sophisticated elements is not sufficient. It should provide the sufficient security for the input data provide by the users. The input data security is very critical in using the web applications. If the user input data is not properly secured, the sensitive data which is transferred through the internet will be captured by other parties and it will be a great threat for the owners of that data. Most of the cyber-attack in the web is done by the hackers through insecure web interfaces. Therefore our research is also focused on this aspect and we discuss the approaches for the user input data security and the pros and cons of these approaches.

We referred to a research paper on securing user inputs for the web. The contributors for this paper are Jan Camenisch, Abhi Shelat, Dieter Sommer and Roger Zimmermann and it has done on behalf of the IBM Research, Zurich Laboratory.

"Three principles define security for us: certification, awareness, and privacy. Four principles define usability: contextual awareness, semantic awareness, prodigious use of screen space, and the availability of recommended choices."[8, page 1]

We will refer to the section of username password based authentication which covers the HTTP and HTTPS authentications mechanisms. Those are more generic and can be extended according to the requirements of the specific security model for user interfaces.

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