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Facilitating Information Transfer in Multi Device Environment by Using Augmented Reality and Gestural Interaction

تسهيل نقل المعلومات في بيئة متعددة الأجهزة عن طريق استخدام الواقع
المعزز والتفاعل الإيمائي

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إقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Facilitating Information Transfer in Multi Device Environment by Using Augmented Reality and Gestural Interaction

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Facilitating Information Transfer in Multi Device Environment by Using Augmented Reality and Gestural Interaction

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267

Abstract

Multi-device environments consist of multiple devices, possibly of different types, that are located in the same physical place and connected to each other via the same network. Information transfer between separate devices is an important process that is essential for several tasks but that requires to deal with multiple interfaces, so the current paradigm of user interface design is still device-oriented, meaning that the user interface is traditionally built for and tailored to a single device. Several efforts have explored information transfer in multi-device environments by proposing different techniques.

In this research, we present a new approach that leverages a mix of recent technologies in the field of Human Computer Interaction (HCI) to provide easy to use yet intuitive interaction paradigm. The working approach exploits Augmented Reality (AR), a wearable device and gestural interaction to enable the user to interact with the surrounding devices. Unlike the traditional user interfaces.

Our proposed approach can facilitate and speed up interaction and data transfer between devices. This research can be applied and used in different fields such as schools, workplaces, markets, and lecture rooms.

We evaluated the practical part of our thesis by using an observational study in which users used the application in practice, and their actions were recorded in order to be analyzed. The questions in the questionnaire measured the ease of use of the system and was measured by answering 13 questions where the experiment included 10 users and were supportive that the system is easy to use by 84%

Keywords: *Augmented Reality, Multi Device Environment, Hand Gestural Interaction, Hand Detection, File Facilitating, Hand Pose Estimation.*

الملخص

تتكون البيئات المتعددة للأجهزة من أجهزة مختلفة ، تتواجد هذه الأجهزة في مكان واحد ومتصلة ببعضها البعض عبر شبكة محلية (LAN). تعد عملية نقل المعلومات بين أجهزة مختلفة ومتباعدة مكانياً عملية مهمة جداً لانجاز العديد من المهام ، ولكنها تتطلب التعامل مع واجهات متعددة بحيث لا يزال النموذج الحالي لتصميم واجهة المستخدم يعتمد على الجلوس أمام الجهاز لاستخدامه ، مما يعني أن واجهة المستخدم في النظم التقليدية هي مخصصة لجهاز واحد فقط. لذا كان هنالك العديد من الجهود في تقنية نقل المعلومات في بيئة متعددة الأجهزة عن طريق اقتراح تقنيات مختلفة تخدم هذا الغرض. في هذا البحث ، نقدم بحث جديد يستخدم مزيجاً من التقنيات الحديثة في مجال تفاعل الانسان مع الحاسوب (HCI) لتقديم نظام سهل الاستخدام والتعلم.

يقوم البحث المقترح باستخدام تقنية الواقع المعزز (AR) ، و نظارات الواقع الافتراضي وهي اجهزة قابلة للارتداء بالاضافة الى استخدام تقنية التفاعل الإيمائي للأيدي من تمكين المستخدم من التفاعل مع الأجهزة المحيطة بكل سهولة على عكس واجهات المستخدم التقليدية.

البحث المقدم الذي قمنا بانجازه يقوم بتسهيل وتسريع التفاعل ونقل البيانات بين الأجهزة المختلفة حيث أن هذا البحث قابل للتطبيق والاستخدام في مجالات مختلفة مثل المدارس وأماكن العمل والأسواق وغرف المحاضرات.

قمنا بتقييم الجزء العملي في أطروحتنا وكانت النتائج جيدة جداً وذلك عن طريق استخدام دراسة قائمة على الملاحظة حيث سيستخدم المستخدمون التطبيق في الممارسة ، وتم تسجيل إجراءاتهم من أجل تحليلها. وقد قمنا بسؤال المستخدمين من خلال تقديم استبيان يهدف قياس سهولة استخدام النظام وقد تم سؤال أولئك المستخدمين وعددهم 10 أشخاص 13 سؤال حيث كانت الاجابة تميل الى الايجاب بأن النظام سهل الاستخدام بنسبة 84%.

Dedication

To the soul of my father may Allah have mercy upon him, He would be proud of me if he were alive

To my mother whose love for me knew no bounds, and she gives without expecting anything in return, without her loving I would not have been where I am today and what I am today

To my beloved wife who taught me the value of life, gave me moral and emotional support and encouraged me in difficult times to complete this achievement

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Table of Contents

| | |
|-------------------------------------------------------------------------|-----|
| Declaration | II |
| Abstract | III |
| المخلص | V |
| Dedication | VI |
| Acknowledgment | VII |
| List of Figures | X |
| List of Tables | XI |
| List of Abbreviations | XII |
| Chapter 1 Introduction | 1 |
| 1.1 Introduction | 2 |
| 1.2 Statement of the problem | 4 |
| 1.3 Objectives..... | 4 |
| 1.3.1 Main objective | 4 |
| 1.3.2 Specific objectives | 4 |
| 1.4 Importance of the project | 5 |
| 1.5 Scope and limitations of the project..... | 6 |
| 1.6 Research Contributions | 7 |
| 1.7 Research Methodology..... | 7 |
| 1.8 Overview of Thesis | 8 |
| Chapter 2 State of the art and review of the related works | 9 |
| 2.1 State of the art | 10 |
| 2.2 Related works..... | 12 |
| 2.2.1 Hand gestures detection: | 12 |
| 2.2.2 Augmented reality UI interaction | 13 |
| 2.2.3 Multi-device environment..... | 14 |
| 2.2.4 Related works discussion | 17 |
| Chapter 3 Design | 19 |
| 3.1 Introduction | 20 |
| 3.2 Design principles..... | 20 |

| | | |
|---------------------------------------------------|-------------------------------------------------|-----------|
| 3.3 | Envisioned Design..... | 21 |
| 3.4 | System Design..... | 24 |
| 3.5 | Proposed Model..... | 27 |
| Chapter 4 Implementation..... | | 30 |
| 4.1 | System Usage..... | 31 |
| 4.2 | Software Architecture..... | 38 |
| 4.3 | Tools, equipment and methods..... | 44 |
| 4.3.1 | Software..... | 44 |
| 4.3.1.1 | <i>Tools</i> | 44 |
| 4.3.2 | Hardware..... | 44 |
| Chapter 5 Evaluation..... | | 46 |
| 5.1 | Introduction..... | 47 |
| 5.2 | Usability Test..... | 47 |
| 5.3 | Questionnaire..... | 49 |
| 5.3.1 | Sample Size..... | 49 |
| 5.3.2 | Experimental Tasks..... | 50 |
| 5.3.3 | Questionnaire Results..... | 50 |
| 5.4 | Observations..... | 54 |
| Chapter 6 Conclusion and Future works..... | | 55 |
| 6.1 | Conclusion..... | 56 |
| 6.2 | Future Works..... | 57 |
| Bibliography..... | | 58 |
| Appendices..... | | 62 |
| | Appendix1: System Evaluation Questionnaire..... | 62 |

List of Figures

| | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| FIGURE 1.1 : MULTI-DEVICE COMPUTERS, ENVIRONMENT CONTAINS TWO PRINTER AND SMART BOARD | 2 |
| FIGURE 2.1 : DIFFERENT FORMS AND STYLES OF WEARABLE DEVICES..... | 10 |
| FIGURE 2.2 : TWO METHODS OF HAND GESTURE DETECTION: LEFT ONE SHOWS THE DETECTION USING GLOVES (KIM, ET AL., 2012)AND THE RIGHT IMAGE SHOWS DETECTION USING SKIN COLOR IMAGE PROCESSING TECHNIQUE..... | 11 |
| FIGURE 2.3 : LEFT FIGURE SHOW THE ELECTRONIC REST GLOVES (DAVID KIM1, 2012) AND THE RIGHT ONE SHOW THE FIDUCIALLY MARKER ON FINGER | 12 |
| FIGURE 2.4 : SIX SENSE DEVICE WHICH IS WEARABLE ON HUMAN CHASE WHICH SHOWING THE PROJECTOR AND CAMERA | 13 |
| FIGURE 2.5 : AIRCRAFT WEARABLE USER INTERFACE LAYOUT | 13 |
| FIGURE 2.6 : RESULT OF DESKTOP-MOBILE ADAPTATION OF THE UI INTERFACE IN MULTI-DEVICE ENVIRONMENT..... | 14 |
| FIGURE 2.7 : MULTI-SCREEN SERVICE MIGRATION ARCHITECTURE (GEUN-HYUNG KIM, 2010) | 15 |
| FIGURE 2.8 : IN THIS ILLUSTRATION, THREE STUDENTS ARE DEPICTED INSPECTING REGIONS OF THE MUSHI SIMULATION. THE SIMULATION, RUNNING ON A TABLET PC, WIRELESSLY DELIVERS CONTENT TO THEIR HANDHELDS..... | 15 |
| FIGURE 2.9 : AIRLINK ALLOWS FILE SHARING BETWEEN MULTIPLE DEVICES BY USING IN-AIR GESTURES (KE-YU CHEN, 2014) | 16 |
| FIGURE 2.10 : FACILITATING INFORMATION EXCHANGE BETWEEN DIGITAL DEVICES AS A FUNCTION OF PROXIMITY... .. | 16 |
| FIGURE 2.11 : MULTI FILE IN SAME SURFACE AND A MAN CONTROLLING THEM BY HAND | 17 |
| FIGURE 3.1 : A PHYSICAL ENVIRONMENT CONTAINS 2 COMPUTERS, PRINTER AND SMART BOARD AND THEY ATTACHED BY A QR STICKER | 21 |
| FIGURE 3.2 : SHOWS A SAMPLE QR CODE STICKER WHICH ATTACHED TO A PRINTER, THE QR CODE STORE THE FOLLOWING INFORMATION: IP-ADDRESS: 192.168.1.1 / DEVICE-TYPE: PRINTER..... | 22 |
| FIGURE 3.3 : AUGMENTED REALITY UI FILES APPEARS AROUND THE COMPUTER QR..... | 22 |
| FIGURE 3.4 : A) THE APPLICATION CHECKS THE HAND GESTURE TO START DRAGGING FILES. B) USER START DRAGGING THE FILE TO PRINTER. C) THE DRAGGED FILE REACHED TO THE PRINTER. | 23 |
| FIGURE 3.5 : LOCAL AREA NETWORK WHICH CONTAINS TWO COMPUTERS, SERVER, PRINTER, SCREEN AND ROUTER . | 25 |
| FIGURE 3.6 : RIGHT FIGURE SHOWS GOOGLE CARDBOARD VR GLASSES, AND THE LEFT ONE SHOWS THE DIVIDED VR SCREEN..... | 25 |
| FIGURE 3.7 : MODEL WORKFLOW..... | 27 |
| FIGURE 4.1 : ENVIRONMENT CONTAINS: 2 COMPUTERS, SCREEN, PRINTER AND QR CODE PRINTED ABOVE THEM | 31 |
| FIGURE 4.2 : (A) TOP FIGURE SHOWS THE SECOND COMPUTER FILES WHICH HOLD IP-ADDRESS 192.186.1.3 AND | 32 |
| FIGURE 4.3 : USER WEAR THE VR GLASSES | 33 |
| FIGURE 4.4 : THE GLASSES CONTAIN A TRACK TO PUT THE MOBILE IN | 33 |
| FIGURE 4.5 : SHOWS THE ACTUAL SIMULATION OF AUGMENTED UI | 34 |
| FIGURE 4.6 : FILES TYPES ICONS..... | 34 |
| FIGURE 4.7 : BY FINGERS NUMBER WE CAN CHECK IF THE HAND IS CLOSED OR OPEN | 35 |
| FIGURE 4.8 : CLOSED HAND POSE DETECTED BY OUR SYSTEM, AND AT THE TOP WE CAN SEE FINGERS NUMBERS AND HAND STATUS | 35 |
| FIGURE 4.9 : OPEN HAND DETECTED BY OUR SYSTEM | 36 |
| FIGURE 4.10 : SEQUENCE OF IMAGES SHOW THE DRAG AND DROP PROCESS | 37 |
| FIGURE 4.11 : SHARED FILES IN TWO COMPUTERS | 38 |
| FIGURE 4.12 : SOFTWARE ARCHITECTURE | 38 |
| FIGURE 4.13 : RIGHT FIGURE SHOWS THE HAND AND THE LEFT ONE SHOWS THE COLOR BLOB DETECTOR RESULT | 41 |
| FIGURE 4.14 : HAND CONVEX HULL VERTICES..... | 42 |
| FIGURE 4.15 : A WORK ENVIRONMENT CONTAINS 2 COMPUTERS, PRINTER AND SCREEN | 45 |

List of Tables

| | |
|-----------------------------------------------------------------------------------|----|
| TABLE 4.1 : DRAG AND DROP FILE CASES AND RESULTS | 37 |
| TABLE 4.2 : SYSTEM MAIN FUNCTIONS | 39 |
| TABLE 4.3 : MOBIE DEVICE SPECIFICATIONS | 45 |
| TABLE 5.1 : COMPERISON OF THE PREVIOUS USABILITY EVALUATION METHODS | 48 |
| TABLE 5.2 : SHOWS THE NUMBER OF PARTICIPANTS AND THE PERCENTAGE OF PROBLEM FOUNDS | 49 |
| TABLE 5.3 : QUESTIONNAIRE RESULTS | 52 |

List of Abbreviations

| | |
|-----|-------------------------------|
| IP | Internet Protocol |
| UI | User Interface |
| AR | Augmented Reality |
| VR | Virtual Reality |
| HCI | Human-Computer Interaction |
| PDF | Portable Document Format |
| QR | Quick Response |
| HUD | Heads Up Display |
| API | Application Program Interface |

Chapter 1

Introduction

1.1 Introduction

In a few years ago, the computers have brought the ease to our daily life and they have transformed our lives to be easier and effort-less. However, with the complexity of our works and needing to work with multiple devices such as PCs, handheld devices, printers and monitors, things have become more complicated. The difficulty of interaction with multiple devices, the fact that tasks can be often distributed over multiple PCs, and the need to transfer data between devices are examples of different challenges that can be encountered in multi-device environments. These challenges trigger the need for novel interaction paradigms that facilitate the user interaction with multiple devices simultaneously and easily

To illustrate the interaction needs in multi-device environments, look at Figure 1.1, which depicts our perception of multi-device environments. Several devices of different types are used in the same room and are connected together through the same network. Similar environments are common in corporates, schools, universities and laboratories. A user in such an environment may need to interact with multiple devices to carry out some tasks. For example, he/she may need to transfer files between PCs, send a file from a PC to the printer for printing, show the content of a file stored in a PC on the board.

PCs are often equipped with operating systems that can facilitate interaction with devices on the network. For example, a user can simply send print command to print a file on PC. Despite the intuitiveness and simplicity offered by operating systems, the current paradigm of interaction allows the user to interact with devices remotely through one PC. We think that accessing and interacting devices remotely provides limited scope of interaction and awareness of the surrounding environment. We think that it can be more appropriate and intuitive if the user can use and interact with all devices in the room at the same time by using hand gestures.



Figure 1.1 : Multi-Device computers, environment contains two printer and smart board

Suppose that you deal with multiple devices such as PCs, handheld devices, printers or monitors in the same time, and you need to transfer files from a computer to mobile or from a PC that not connected to the printer, what you will act in this situation? You have to interact with multiple devices with its different interfaces or Operating Systems and transfer the files by using the portable mass storage or through the internet which makes the file transfer or printing is a complicated process while dealing in multiple environment devices.

Through the listed above challenges, this research proposes a new interaction approach based a wearable device to offer an intermediate user interface. The proposed interaction approaches use both Augmented Reality (AR) and hand gestures to facilitate interaction and data transfer in multi-devices environments. The ultimate goal is to support rich, comprehensive and intuitive interaction in multi-device environments.

Our research uses a variety of technologies from different research areas such as gestural interaction, augmented reality, wearable devices and image processing. Unlike traditional user interfaces, the user will interact with one interface. The proposed research can be applied and used in different fields such schools, work places, markets and lecture rooms.

Many of previous works proposed researches that aim to enhance file transferring between devices such as Geun and Shughwan (Guen & Shughwan, 2010) have proposed a media synchronization between multi device environment by using 3rd parity server to do that. Another work (Leilah Lyons, 2006) used the data transferring between devices to make school science experiments on one device, these works are different in methodology and purpose that aims to make centralization. Other solutions such as Light Space team (LightSpace-Microsoft research, 2010) used sophisticated and costly equipment to transfer data between surfaces and devices. Several other efforts aimed to exploit gestural interaction for a variety of tasks such as information transfer (James, 2015), pointing (Daniel Vogel, 2005) and interaction with 3D models (Mahfuz Rahman, 2009). This work build on previous efforts and proposes a novel interaction paradigm particularly for multi-display devices. Our solution exploits a variety of techniques including augmented reality, wearable devices and image processing to facilitate interaction and information transfer through gestural interaction.

Our methodology contains three main steps: Environment setup, which is to make the physical environment ready by create QR codes using online generators and make them as stickers in the devices of that environment. The second step is called Augmented reality UI Representing: in this step we shall talk how we display the shared files around each device to make the interaction in the last step which called Hand UI interaction, in this step we checked the hand movement changes and perform some actions drag , drop and events such as file transferring or printing.

In following chapters we will talk in details about the problem statement, the objectives, importance of the project, scope and limitation, state of the art and related works, design, implementation, evaluation, and future works for this research.

1.2 Statement of the problem

This research considers the problem of facilitating information transfer in multi-device environments. Multi-device environments have become common in everyday life: They exist in a variety of places such as universities, schools, and corporations. Multi-device environments often consist of devices of different types such as PCs, handheld devices, printers and monitors. These devices are often connected together through a network to enable for data transfer and service sharing. Each device in a multi-device environment is often equipped with a user interface that enables to interact with the device's functions and contents. The user interface may also enables to connect to other devices in the environment(e.g. other PCs or printers) to access shared services or resources. However, the current paradigm of user interface design is still device-oriented, meaning that the user interface is traditionally built for and tailored to a single device. Using a device –driven user interface, a user will not only be able to control a single device, but will not perceive the actions taking place in the surrounding environment or realize the services and resources available in nearby devices. In many cases, it is important for some users to gain an inclusive overview of the multi-device environment by being aware of the various resources available around him/her.

1.3 Objectives

1.3.1 Main objective

This research proposes a new approach based on Augmented Reality (AR) and gestural interaction to facilitate data transfer in multi-devices environments. The proposed approach exploits a variety of techniques from computer science such as hand detection, gestural interaction and augmented reality to support rich, comprehensive and intuitive interaction in multi-device environment.

1.3.2 Specific objectives

The specific objectives of the project are:

- Explore the pros and cons of existing interaction techniques and their suitability for multi-device environments.
- Using augmented reality techniques in wearable device application.
- Propose a new interactive interface for a multi-device environment.

- Exploits the computer science techniques such hand detection, gestural interaction and augmented reality to support rich, comprehensive and intuitive interaction in multi-device environments.
- Explore image processing techniques required for the detection of hand gestures.

1.4 Importance of the project

The proposed research introduces a new approach to transfer data between multi-device environments based on hand detection, gestural interaction and augmented reality techniques without needing to change your place or to deal with multiple interfaces of another environment unlike the traditional controlling of a single device and taking out of place to reach multi-device to preform files transferring.

The proposed research has several benefits that include:

1. This research is consistent with the recent advances in user interface design as it investigates the use of natural interaction for data transfer in multi-device environments.
2. Unlike traditional user interfaces, the proposed approach can facilitate and speed up interaction and data transfer between devices.
3. The proposed approach can be applied and used in different fields such schools, work places, markets and lecture rooms.

1.5 Scope and limitations of the project

- 1- The augmented reality UI will show the text files like doc, docx, pdf (printable files) not including audio or video files because we focus on transfer files between devices themselves and between them and networked peripherals such as printer and these type of files can't be printed.
- 2- The main objective of our research is to transfer files easily between two or more devices, but any other process like file browsing, file editing or even deleting it, etc. are not included in our research. The latter activities can be performed on single devices, and thus are out of scope of our research which focuses on multi-device environments.
- 3- The hand gestural poses will be just the closed to drag file and opened pose to drop it down, and any other poses are not included.
- 4- Our proposed solution will focus on using drag event to copy files, or to show them on the projector, or even print them; are not be use the drag event to sort the files in the space or surfaces.
- 5- All devices must be connected to the same network, and are physically present in the same place because our research requires using multi-device in the same time and place.
- 6- Since the proposed interaction paradigm can't be compared with traditional interaction techniques, we will evaluate our approach by running an observational study: Users will be asked to use the approach in a real environment, and the actions will be recorded, analyzed and discussed.
- 7- The QR reading distance is tied by this equation (Minimum QR Code Size = Scanning Distance / 10) (What Size Should A Printed QR Code Be?, 2018).
- 8- The evaluation will be limited to number of users that are don't belong to any field like educational, medical etc.

1.6 Research Contributions

In light of existing efforts, this research proposes the following research contributions:

1. It proposes an interaction paradigm by integrating multiple techniques that have rarely combined together in previous research to facilitate information transfer in multi-device environments.
2. It proposes a preliminary evaluation of using our approach of interaction in a realistic environment. The evaluation results will be informative for designers and HCI researchers who are interested in using or investigating the use of augmented reality in similar configurations.

1.7 Research Methodology

Our research methodology depends on 5 stages that are: Exploring existing research efforts and similar systems, Identifying requirements and design principles, designing the physical environment and the integration of devices, Implementation and Evaluation, in the following points we will discuss them in detail:

1- Exploring existing research efforts and similar systems:

At this stage we exploring the related works to this research which made us institutes our ideas correctly by taking the positive points and go away from the disadvantages, from this stage we can get the knowledge of what will exist within our system and what does not suitable to the presence and this is the first stages of analysis.

2- Identifying requirements and design principles:

After looking at the related works, we can know what the requirements are required to achieve our goal by collecting the necessary tools and requirements. At this stage we also can start with the actual design so this stage considered the first step of implementation and all of that can be done through the design principles which are general instructions we put in order to comply with them, without these principle achieved the system will be useless.

3- Designing the physical environment and the integration of devices:

At this stage we designed the actual environment that make the system working, which consisting of computers, printer, screen and the network ,in this stage we determine the components of the physical environment and knowing how its elements will work together with each other in a consistent and without any problems.

4- Implementation:

It is the actual stage of the completion of the system and make it alive, it starts by detailing the structure of the system to components and then elaborating these components into

modules ,which would be communicate with each other to make the system work. The system contains 3 components which are server, mobile and other devices and we will talk about these modules in detail in the Implementation chapter.

5- Evaluation:

In this stage we evaluated the system services and function, present how our solution answer the research questionnaire, then we present the study we conduct to evaluate the system and discuss the results.

1.8 Overview of Thesis

This thesis consists of six chapters as following:

- **Chapter 1: Introduction:** This chapter presents an overview of the research, main problem, objectives, importance of the project, the scope and limitation of this research.
- **Chapter 2: State of the art and related works:** This chapter focuses on related works that use the same technologies of our research and we discuss the pros and cons of each.
- **Chapter 3: Methodology and Design:** This chapter explains in detail the proposed methodology, design principles and software architecture with diagrams to clear our ideas and concept.
- **Chapter 4: Implementation:** In this chapter we explain how we worked in detail step by step , we start to explain the system and its possible scenarios after that we talked about the technical issues which talk in deep about algorithms , tools and techniques.
- **Chapter 5: Evaluation:** This chapter explains the assessing process of our approach, we used questionnaires to make system assessments after that we wrote our results and concluded that with the percentage of acceptable usage for our system.
- **Chapter 6: Conclusion and Future work:** This chapter conclude the research thesis, explaining the results and its limitations and discussing how to develop it in the future.

Chapter 2

State of the art and review of related works

2.1 State of the art

The rapid development of modern devices has been growing over the world, such we started from the desktop device to laptops, through the handheld devices revolution, but in more recent the humanity looks for the ease to use techniques and devices. Among these improvements the wearable devices have been developed, which combines the power of computers and handheld with more usability and accessibility. A wearable device is another style of small computer that is classified into the personal space of a user, controlled by the user, and has both operational and interactional constancy (i.e., is always on and always accessible). Wearable devices have the same computing abilities as mobile phones and tablet computers. In some cases, however, wearable devices are more competent for tasks such as calculation, navigation, and remote picture than handheld devices due to their portability and characteristics (He Jiang, 2015). Wearable technology has different styles and forms as shown in Figure 2.1 including head-mounted such as helmet and glasses, body-dressed such as coat, and pants, hand-wrist such as hand strap, gloves, and watch, and foot belts such as socks and shoes. In our research we will use the google glass because of the power of its built-in camera , and it is so useful of interaction at distance to show the augmented UI on its screen and get the hand gesture on front of it.



Figure 2.1 : different forms and styles of wearable devices

(He Jiang, 2015)

The computer human interaction is one of the important fields of recent researches that refers to the relation between the human and the computers, and this relationship expressed by the functionality and usability. One of the most usable interaction between human and computer is to interact with human body without saying anything like the motion of his/her face morphs, body, or hands. Among a variety of gestures, hand gesture is the most expressive and the most frequently used. Gestures have been used as an alternative form to communicate with computers in an easy way. This kind of human-machine interfaces would allow a user to control a wide variety of devices through hand gestures. Hand gesture recognition is one of the growing fields of research today, which provides a natural way of human-machine interaction. Gestures are some forms of actions that a person expresses in order to express information to others without saying it. Gestures can be static (pose) picture which need less computational complexity and the other type is the dynamic which is a sequence of poses that can be as a video or in the real time and that make the process of recognition more complex but it is suitable for real time environments. Different methods have been proposed to make recognition as shown in Figure 2.2 such as the methods that need a hardware electronics or devices such as gloves and color markers to make the extract easily comprehensive description of hand features. The second method is with a less cost and easy to implement which is based on the image processing techniques to illustrate the hand and then extract the main features.

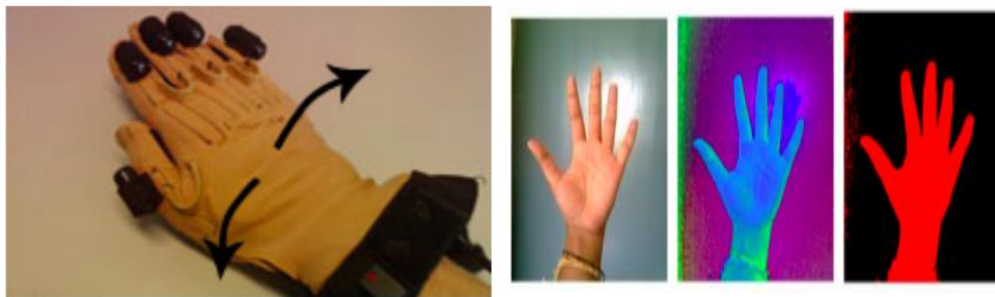


Figure 2.2 : two methods of hand gesture detection: left one shows the detection using gloves (Kim, et al., 2012)and the right image shows detection using skin color image processing technique

(Benko, 2009)

2.2 Related works

The proposed research built on a variety of techniques from computer science such as hand gestures detection, augmented reality user interface and multi-device environment:

2.2.1 Hand gestures detection:

David Kim et al. (David Kim1, 2012) proposed a new technique of hand gesturing using electronic rest gloves sensor to simulate a 3D hand model, however Wolfgang and Joris (Wolfgang Hürst, 2013) proposed an application which requires fiducially markers to detect hand gestures as shown in Figure 2.3. Other work (F. Guimbretiere, 2012) uses Microsoft Kinect to detect hand gesture to make menu selections.

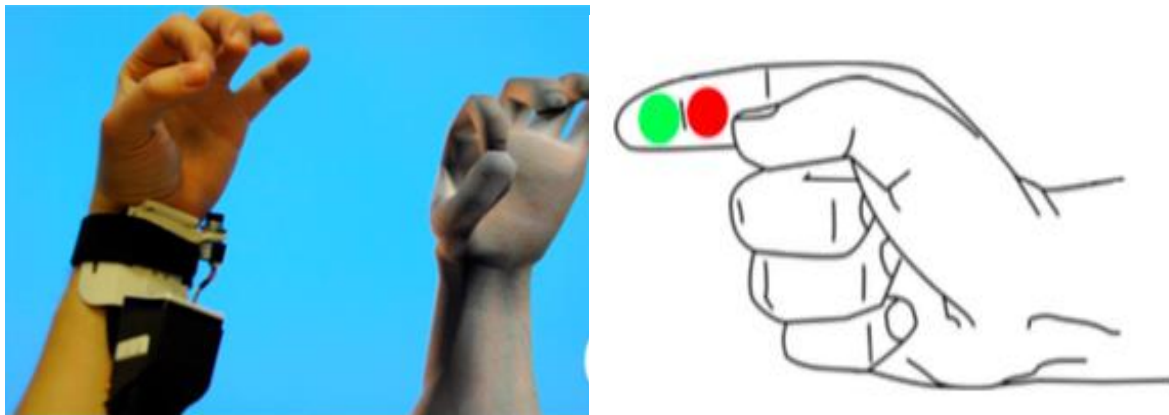


Figure 2.3 : Left Figure show the electronic rest gloves (David Kim1, 2012) and the right one show the fiducially marker on finger

(Wolfgang Hürst, 2013) .

Rakesh and Vandana (A Study on Wearable Gestural Interface – A SixthSense Technology, 2013) proposed a SixSense technology which is a wearable interface that allow the human to communicate the digital data by using the hand natural gestures, This technology made as a device containing camera and projector which attached to cell phone that acts as a computer which is

connected to cloud . This research aimed to enhance data transferring between surfaces using hand gestures as shown in Figure 2.4.



Figure 2.4 : six sense device which is wearable on human chase which showing the projector and camera

(A Study on Wearable Gestural Interface – A SixthSense Technology, 2013)

2.2.2 Augmented reality UI interaction

Augmented reality technique based on how to create three-dimensional objects on a marker or marker less physical world, however other works suppose how to deal with ring menu (J. Liang, 1993) and tile menu (Mahfuz Rahman, 2009) in the 3D space.

In the past the peripherals mouse, keyboard and joystick were perfect solutions to make interaction with GUI by selecting, clicking and dragging, Soren Lenman et al. (Sören Lenman, 2002) developed a prototype for remote control of home devices by using hand gestures , another work (Hendrik Witt, 2006) designed a wearable user interface in maintenance application called aircraft as shown in Figure 2.5.



Figure 2.5 : aircraft wearable user interface layout

(Hendrik Witt, 2006)

2.2.3 Multi-device environment

A multi-device environment is an environment that contains more which used to solve one or more tasks. These devices have different in Operating system, system interfaces, size, form, and portability. Other works (Fabio Paternò) (Jarle Petter Kasbo) have been proposed a solutions of how to make an UI design to be cross-platform for a multi device environment as shown in Figure 2.6. These works use the multi-device environment to make a cross platform design for mobile and desktop devices and we focus on file transferring between these devices so the purpose are definitely different.

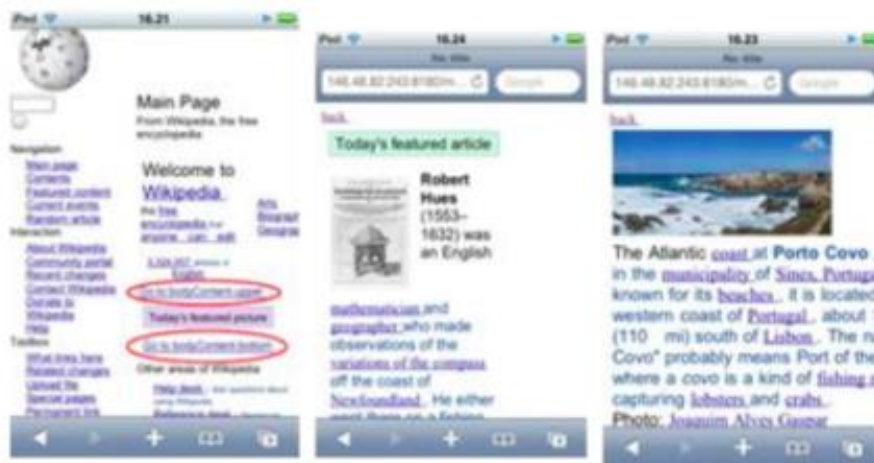


Figure 2.6 : Result of desktop-mobile adaptation of the UI interface in multi-device environment

(Fabio Paternò)

Geun and Shughwan (Geun-Hyung Kim, 2010) proposed a research to make media synchronization between more than device by using one mobile interface to connect them at one device screen as shown in Figure 2.7. This work unifies the multi-device interfaces to be managed by one device, so our proposed research is different in interacting technique which is by using the hand gestures.

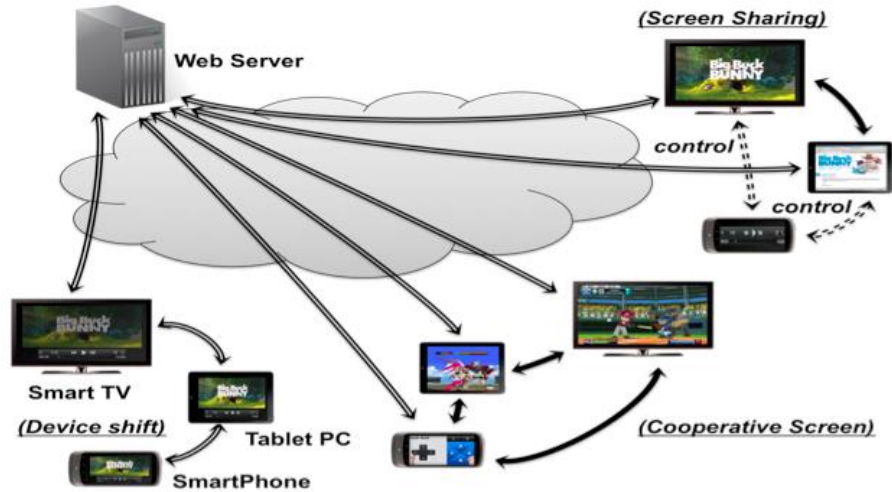


Figure 2.7 : Multi-Screen Service Migration Architecture (Geun-Hyung Kim, 2010)

Leilah et.al (Leilah Lyons, 2006) present a MUSHI which is a multi-user system to support middle and high school students by using multi device environment to share their experiments through the same laboratory or screen as show in Figure 2.8.



Figure 2.8 : In this illustration, three students are depicted inspecting regions of the MUSHI simulation. The simulation, running on a tablet PC, wirelessly delivers content to their handhelds

(Leilah Lyons, 2006)

AirLink (Ke-Yu Chen, 2014) is project that proposed a new way to move files between multi mobile devices using hand waving on the air as shown in Figure 2.9.

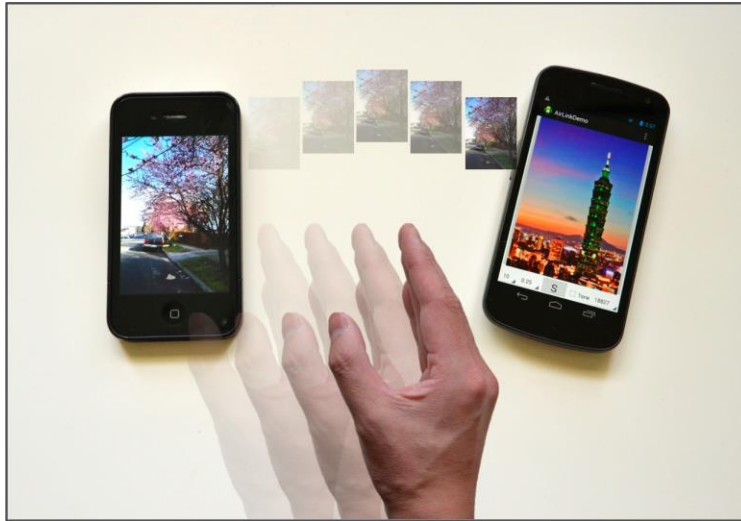


Figure 2.9 : AirLink allows file sharing between multiple devices by using in-air gestures (Ke-Yu Chen, 2014)

Nicolai et.al (Nicolai Marquardt, 2012) introduced a technique for handheld devices to share data between them by detecting the nearby devices as icons on the border of the screen to share their data between each other as shown in Figure 2.10, which means that we can share data on such device when it's nearby graphically without needing to permissions, knowing the type of data or even how to transfer data. However our research used a wearable device to deal with all shared files in multi-device environment using hand gesture to communicate, and the files must be shared to be shown.

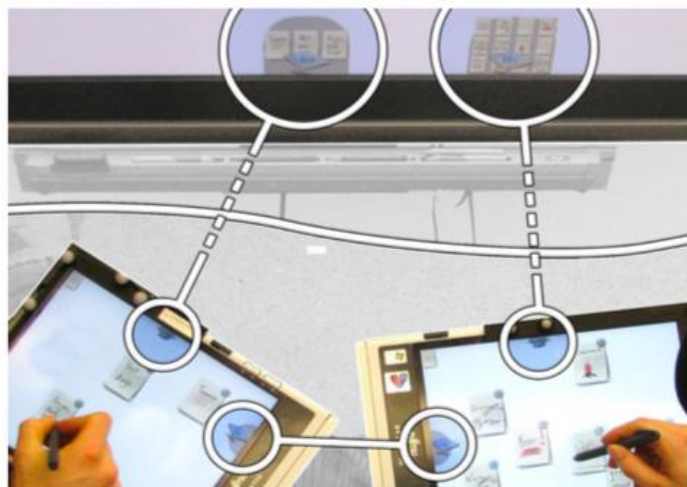


Figure 2.10 : facilitating information exchange between digital devices as a function of proximity.

(Nicolai Marquardt, 2012)

LightSpace (LightSpace-Microsoft research, 2010) is combines elements of surface computing and augmented reality research to transfer data between surfaces, which is fully physical interactive as shown in the Figure 2.11.



Figure 2.11 : Multi file in same surface and a man controlling them by hand

(LightSpace-Microsoft research, 2010)

2.2.4 Related works discussion

After looking at related works, we can summarize the differences between our research and previous researches through this discussion:

(David Kim¹, 2012), (Wolfgang Hürst, 2013) and (F. Guimbretiere, 2012) researchs rely on a hardware like a Kinect, markers and electrical sensors, which make these applications suffer from some drawbacks like needing a pre hardware setup and calibrations. Another method is introduced which is Image processing based solutions (Benko, 2009) (Wilson, 2006), with a powerful smart phones and wearable devices like a google glass we can use their built-in camera to detect hand poses using image processing API like OPENCV (openCV Library, 2018).

However, (J. Liang, 1993) (Mahfuz Rahman, 2009) focused on menu designing in the 3D virtual environment not in augmented reality applications, however the other works (Sören Lenman, 2002) (Hendrik Witt, 2006) use hand gesture detection to control application menus like a pinch in remote controlling and maintenance application which are a way of our domain and usage.

(Leilah Lyons, 2006) Allows the users to make the content of the server device by sending data to it, our work make one client controls the all connected devices.

(Ke-Yu Chen, 2014) Used a technique for multi mobile device with the same operating system and interface, the hand must be shown in each mobile cameras and this make file transferring at distance not worked as our research.

(LightSpace-Microsoft research, 2010) Has a drawback of depending on special hardware to transfer data between multi surfaces, in our work there is no needing to use special hardware, just the wearable device.

Chapter 3

Design

3.1 Introduction

In this chapter, we talked about the first stage of starting the implementation for the proposed research, where we will address three sections, the principles of design, which are the principles we formulated to reflect the conditions necessary to exist in the system ,the system without them determined useless, in addition, talking about envisioned design with some Figures, which is the vision of the system and its components, In addition to talking about the proposed model and we talked about these points in detail.

3.2 Design principles

Based on the review of the related works and the objectives of the project, we consider these design principles:

1. The system shall be able to interact with the existing environment by using hands and understanding its movements which are innate things that do not need to be learned or trained.
2. The system shall be integrated with the physical environment, which makes the interaction easier and can deal with the physical environment through the virtual environment that settles on the mobile device.
3. The system capable to execute orders without any problems or complications and the system's order response should be automotive and quick.
4. The system capable to understand the hand gestures by analysing the hand shape and differentiate whether the hand is closed or open, which will make us do the drag and drop actions.
5. The system shall support different events such as files transfer, viewing files on a particular device, or even printing those files.
6. The system shall facilitate the process of communication between the devices and make them understand each other to facilitate the process of transferring orders to and from the devices.
7. The system shall be able to see the shared files in each device, so we can view them to execute commands (Transfer, View, and Print) on them.
8. The system capable to contain a fault-handling module that can handle user errors occur, such as rejecting the file transfer process because it exists or a network problem.
9. The system shall contain a feedback module to indicate errors or to confirm the occurrence of a particular operation.

10. The system shall be easy to install and run by ordinary people.

3.3 Envisioned Design

The proposed research aims to use a wearable device, to make file transferring mechanism easier in a multi device environment, which will be done through a sequence of steps as the following:

- 1- **Environment Setup:** the needed physical environment should contain multiple devices such as computers, handheld devices, projector and printer, which are all connected to the same local area network (LAN). Each device must have a sticker of QR code as shown in Figure 3.1. The QR code associated with each device will be used for identification. The user is supposed to watch the environment through a wearable device and interact with it by using hand gestures.



Figure 3.1 : a physical environment contains 2 computers, printer and smart board and they attached by a QR sticker

The QR code refers to Quick Response Code, which is a trademark for a type of matrix barcode that used to encode the text to black squares arranged in a square grid on a white background as shown in Figure 3.2, which can be read by an imaging device such as a camera, and processed using Reed–Solomon error correction until the image can be appropriately interpreted. The required data are then extracted from patterns which presented in both horizontal and vertical components of the image, these QRs have multiple online generators like (Owen, n.d.), and there are multiple applications and APIs to decode these QRs and convert them into the original text. By using the QR generator, we will generate the QR that holding a plain text contains the device IP address and the device type.



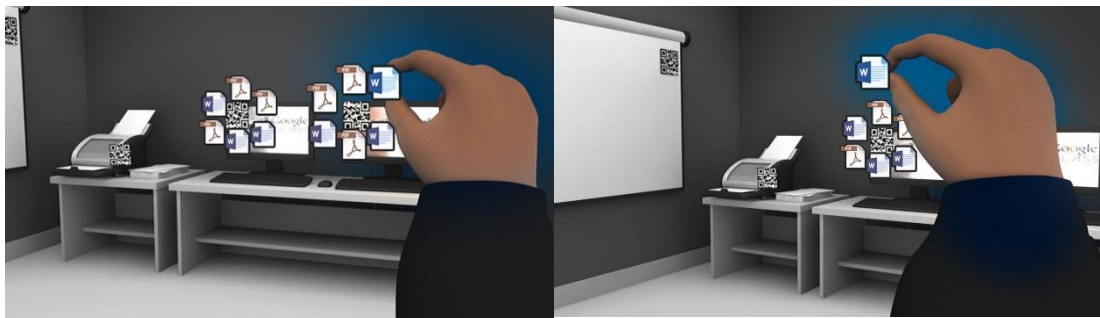
Figure 3.2 : Shows a sample QR code sticker which attached to a printer, the QR code store the following information: IP-address: 192.168.1.1 / device-type: printer

- 2- **Augmented Reality UI Representing:** By implementing the application on a wearable glasses device such as google glass, user will be able to see the augmented user interface (UI), this UI will be appeared just when you wear the glass as augmented reality objects, these objects represent the shared files on this device through the LAN as shown in Figure 3.3. Only devices that have a storage like PCs, handheld or Laptops will show these UI file elements, and the other devices like printer, smart boards and projectors will be used just for dragging files on them to perform a task like printing or viewing.



Figure 3.3 : Augmented reality UI files appears around the computer QR

- 3- **Hand UI Interaction:** By using the appropriate image processing techniques we can detect the hand and its poses. In our research, we need to detect the closed and flat poses, when the user makes his/her hand on the closed pose it means that he/she wants to drag the file, and the dragging event depends on the drop event, which can be detected on the flat hand pose. i.e. When the user drags the file as shown in Figure 3.4-A. The system will store the dragged file position , file name , file source and it will be tied to the closed hand position as shown in Figure 3.4-B until the hand changes to be flatten ,which means that the drop state begins , so here the system should decide to take the suitable event like : if the drop pose in the space the file will be return to the stored position of the source, else if the dropped file was on another QR , the system must read the QR to know the device type and take the suitable event such if the device is the printer as shown in Figure 3.4-C, the system will print the file ,however if it is a PC , the file will be transferred to the destination PC.



A

B



C

Figure 3.4 : A) The application checks the hand gesture to start dragging files. B) User start dragging the file to printer. C) The dragged file reached to the printer.

3.4 System Design

In this section we will talk about all the issues and components should the system has to run correctly with no problems, so the system should contain:

1- Physical Environment:

Our system based on the physical environment and dealing with multi-device existing in this environment, so it should has a variety of devices such as computers, handheld devices, printers, and smart boards. In the practical part, we use three computers, one printer and one smart board, These devices should have a physical marker to make them different for the system, we used a sticky QR as a marker with the size of 20*20cm to make view clear to detect the QR marker, the QR marker can be read from within 2 meters depending on the equation (What Size Should A Printed QR Code Be?, 2018):

| | |
|----------|--------------------------------------------|
| Equation | $QR\ Code\ Size = Scanning\ Distance / 10$ |
| Usage | $QR\ Size = 200\ cm / 10 = 20cm$ |

2- Local Area Network (LAN):

All the physical environment devices (computers, handheld devices, printers, and smart boards), server and users glasses should be connected to the same wireless network, we use wireless network because of the variety of devices some of them could not use Ethernet cables such as mobiles and tablets. We made one of the three computers as a server to handle the orders given from the user glasses interaction and devices that connected to the same network as shown in Figure 3.5.

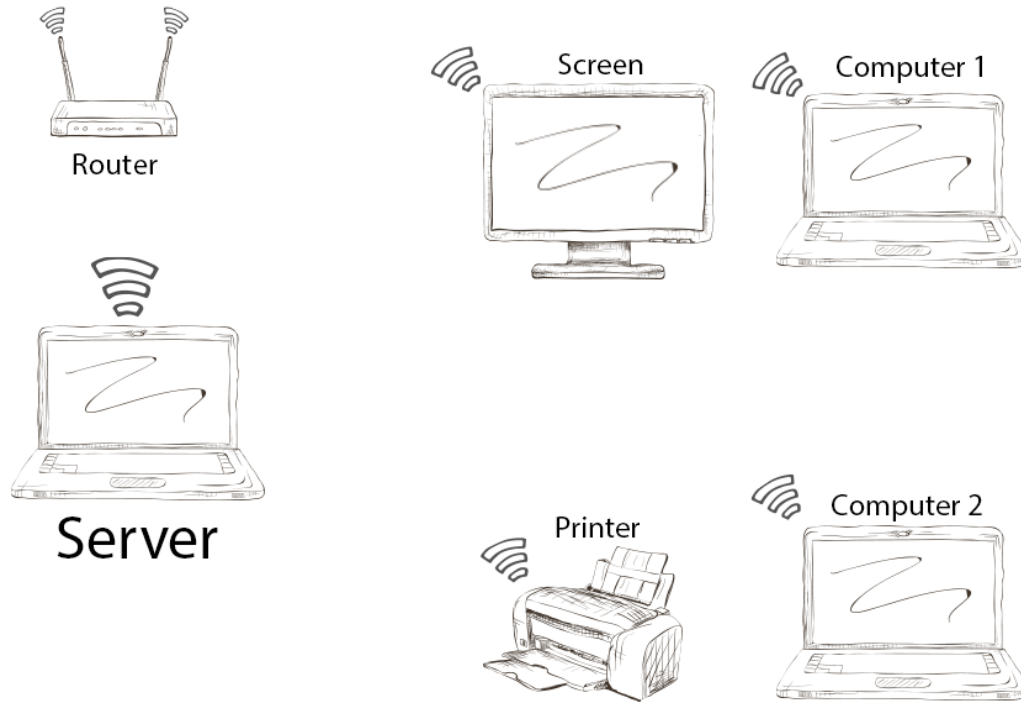


Figure 3.5 : Local Area Network which contains two computers, server, printer, screen and router

3- Wearable Device:

We used Google Cardboard glasses (Google Cardboard – Google VR, 2018) which is shown in Figure 3.6 Right. Because of its popularity and its low price, The mobile dividing the screen into two parts left and right, through this technology we can see the elements as one view virtual reality as shown in Figure 3.6 Left, using mobile devices presents many challenges due to lack of processing speed which can effect on using image processing techniques to make hand detection and analysis, compared to the computer. This device is the main component of my work environment where the mobile device connects to the server mentioned in the previous point and then through hand gestures, the mobile analyze the movement of hands and status then it will send the appropriate event to go through.



Figure 3.6 : Right Figure shows google cardboard VR glasses, and the left one shows the divided VR screen

4- **User:**

In my system, the user is the main player who uses the virtual reality glasses referred to in the previous point and using his\her hands to transfer files through drag and drop process, User can drag the files on a specific device and drop it on another device within the environment that we explained in the first point and all of this done using bare hands.

Previous Figure 3.1 shows a user wearing glasses and standing in the environment made up of two computers and a display screen. And then the user sees in the virtual reality glasses where we see the computer and its files around it as seen in Figure 3.3. System Hands detection and drag/drop actions that we explained earlier.

3.5 Proposed Model

In the research's practical side, we built a Virtual Reality (VR) application that using a google cardboard which is a wearable glasses and cheap technology. Figure 3.7 shows the proposed research implementation workflow. By encoding the QR code stickers on the devices, the system will read the IP-address and device type for each one, after that the augmented reality module will show the files as UI in ring form. When the user's hand appears on the camera view, the system will use the hand recognition module to check the hand poses and make the suitable event.

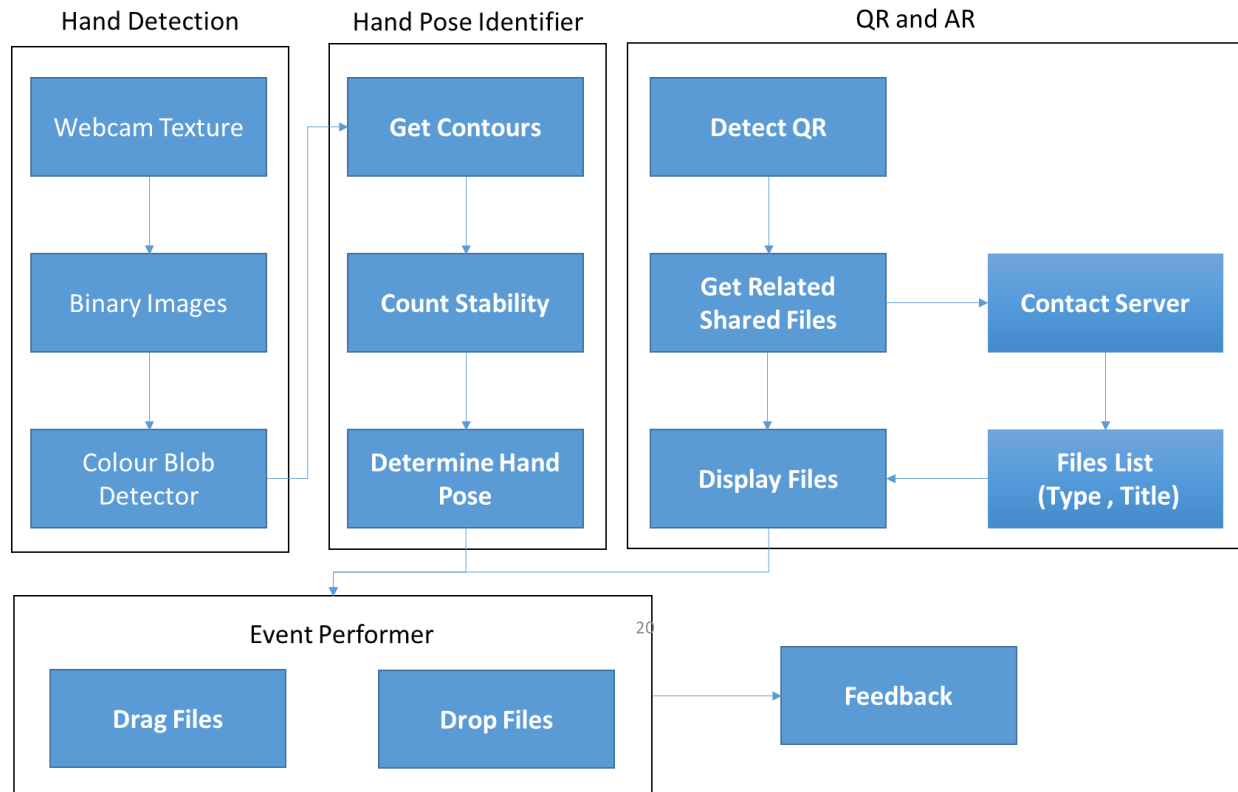


Figure 3.7 : Model workflow

1. Hand Detection and Pose Identifier :

In this step we detect the hand based on skin color appeared in front of the camera , we collect the related color groups and get final contours of hand, after that we judge the hand if it is opened or closed by counting the fingers if it is less than 3 it considered closed ,but if it is equal or greater than 3 it is considered to be opened.

2. Detect QR and offline encoding:

By using the built-in Camera and programming APIs, we can detect the QR value and its position that will be benefit in step 5. after that we will use XING (Owen, n.d.) Programming API to encode the QR value without needing to use internet.

3. Extract IP and device type:

The encoded QR images for each device like a computer, printer and smart boards will contain the private IP address for this device and the device type, which can be benefit to give the event trigger in step 10.

4. Get shared files:

After the IP address got from the previous step, we can get the shared files such as word and PDF files on the same local network.

5. Display files around QR:

After getting the shared files, we displayed the files using augmented reality techniques on the screen as Heads Up Display (HUD) . It can be in multiple shapes like square, hexagon or ring one. The displayed files will take the position of the QR detected for every device as we proposed in step 1. The device type will be a key point in this step so we can decide if the device can view shared files or not like a printer.

6. Hand recognition:

By using image processing based techniques such as color blob detector and canny edge extraction classes, we can recognize the hand skin to know where the hand is and check its poses to do some events.

7. Hand pose detection:

In our application we need a closed pose to express the dragging process of the UI elements that displayed in the step 5.

8. Drag file:

When the hand on closed pose and in the same position of any displayed file, the user can drag the file on the space by his hand.

9. Drop file:

By doing closed pose, the application will check if the closed pose changed to flat one which will notify the application that (end drag) state is started. Then the system will obtain the data of last dragged file and its position in the space.

10. Event Performer:

The end dragged file will be drag to a device or resource, we mean by resource is anything that not connected to the network and has not any electrical consumption. So if the end dragged position equals the position of any device, the application should have an event to do for example printing the file if the device is a printer, and if the device is a computer the system will copy the file from the dragged device to end dragged one.

Chapter 4

Implementation

4.1 System Usage

As mentioned previously in the design chapter, the system consists of three modules: the server and other devices that we want to deal with, and finally the mobile device which has the main role in the process of transferring files through the understanding of hands gestures, below we will explain the mechanism of using the system in addition to multiple scenarios that will be happened to the user and how our system will react to these actions.

1- Hardware and Software Setup:

We connected all devices that we want to deal with on the same local network using Tplink router (TP-Link: WiFi Networking Equipment for Home & Business, 2018). These devices are two computers, a printer and a smart board and then we installed the client program for the transfer of data from and to those devices, In addition to using one of these devices to be as a server through the installation of the server program, which we previously programmed to transmit the signals from the wearable device to the connected devices on the same network ; As shown in Figure 4.1, we can see the connected devices in the same physical Place. After that, we share some files that located on the computer which shown in Figure 4.2-a for the first computer and Figure 4.2-b for the second one.



Figure 4.1 : Environment Contains: 2 computers, screen, printer and QR code printed above them

| Name | Date modified | Type |
|--------|------------------|---------------------|
| File21 | 8/4/2018 2:35 PM | Text Document |
| File22 | 8/4/2018 2:35 PM | Microsoft Word D... |
| File23 | 8/4/2018 2:36 PM | WinRAR archive |
| File24 | 8/4/2018 2:36 PM | Adobe Photoshop ... |
| File25 | 8/4/2018 2:36 PM | PNG File |

| Name | Date modified | Type |
|-------|------------------|---------------------|
| File1 | 8/4/2018 2:00 PM | Microsoft Word D... |
| File2 | 8/4/2018 2:00 PM | WinRAR archive |

Figure 4.2 : (A) Top Figure shows the second computer files which hold IP-address 192.186.1.3 and

(B)Bottom one shows the first computer files which hold IP-address 192.186.1.2

2- Wearing the glasses:

Through this step, user will wear a Google Cardboard glasses, which is a virtual reality glasses where you can see virtual reality by your near vision through mobile device. As we show in Figures 4.3 and 4.4 the user puts the mobile in these glasses and then wear them to be able to see the augmented UI and the surrounding environment through his/her eyes.



Figure 4.3 : User wear the VR glasses



Figure 4.4 : The glasses contain a track to put the mobile in

3- Showing Augmented UI:

The user should direct the mobile device to the QR markers which affixed on the devices inside the surrounding environment where the system will recognize these markers, and then the wearable mobile device will show the simulated files displaying as a ring around these markers. The simulated displaying for the files will show an image that express the type of the files (you can check the images type in Figure 4.5) , Figure 4.6 shows the actual simulation of Augmented UI appeared in mobile screen.



Figure 4.6 : Files Types Icons



Figure 4.5 : shows the actual simulation of Augmented UI

4- Hand Detection and Pose Identification:

The user will direct his/her hand against the mobile camera, which in turn analyses the colour of the skin and recognize the hand, then the system counts the fingers in the hand to be able to determine whether it is open or closed, by checking the number of open fingers, if they are three or greater the hand will be considered as open but if it is two or less than two it will be considered closed as shown in Figure 4.7 and Figures 4.8, 4.9 for real captured images, The hand will be surrounded by a red selection and we notice fingers number and hand status (Open, Close) at the top of the screen as shown in Figure 4.6.

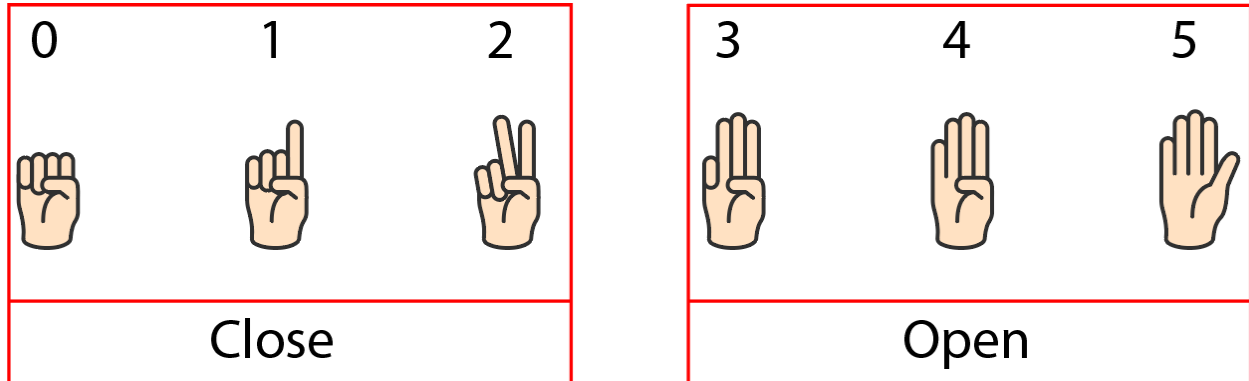


Figure 4.7 : By fingers number we can check if the hand is closed or open



Figure 4.8 : Closed Hand Pose Detected by our system, and at the top we can see fingers numbers and hand status



Figure 4.9 : Open Hand detected by our system

5- File Selection:

Before user start dragging and dropping files he must be able to select this file, then he can move this file by hand, File selection process done by stop the hand on the file and be stable open pose and then close the hand, then the file will move to the hand center, we can move it unless the hand converted to be opened.

6- Drag and Drop Files:

At this stage, we will drag the files and drop it through the use of hand fist in both cases either be closed to express the drag pose or open to drop the files, we have here some possible scenarios in the next table 4.1, as show in Figure 4.10 we can see the sequence of images that display how the drag and drop for files can be done.

| # | Case | Result |
|----|----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| 1- | The user closes his hand in a place where there are no files | Nothing will happen |
| 2- | The user closes his hand and that hand is on one of the files and then he moved his hand | The file will move with the user's hand gesture unless he opens his hand |
| 3- | The user opens his hand somewhere in the space without intersecting with any element in the screen | The file will return to its original location immediately |

| | |
|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>4- The user holds a file and then opens his hand as it intersect the marker of one of the existing devices.</p> | <p>The file will take the appropriate event ,if the user leaves the file on the printer, the system will print the file and if he leaves it on another computer the system will copy it to that device</p> |
|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Table 4.1 : Drag and Drop File Cases and Results

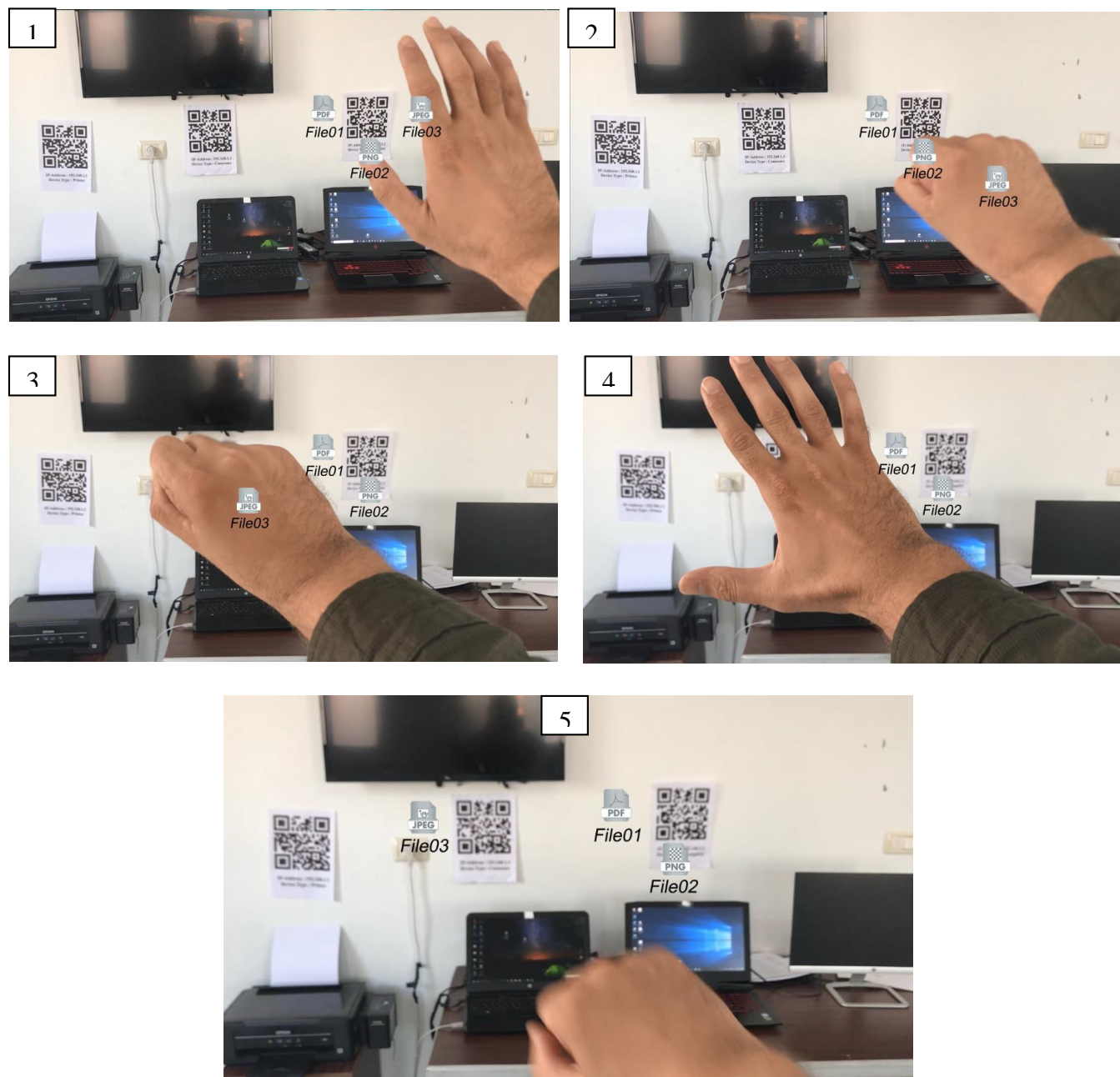


Figure 4.10 : sequence of images show the drag and drop process

6- Ensure the taken action:

In this step, we will check the events that were performed during the previous step to check the files transfer process, if it is done correctly or as the case mentioned in point 4 in the previous table and we notice here that the files copied correctly without any problems. In previous Figure 4.2, we showed the files on both devices we dealt with while Figure 4.11 shows the additional files in the second device where these files copied from the first device to the second one.

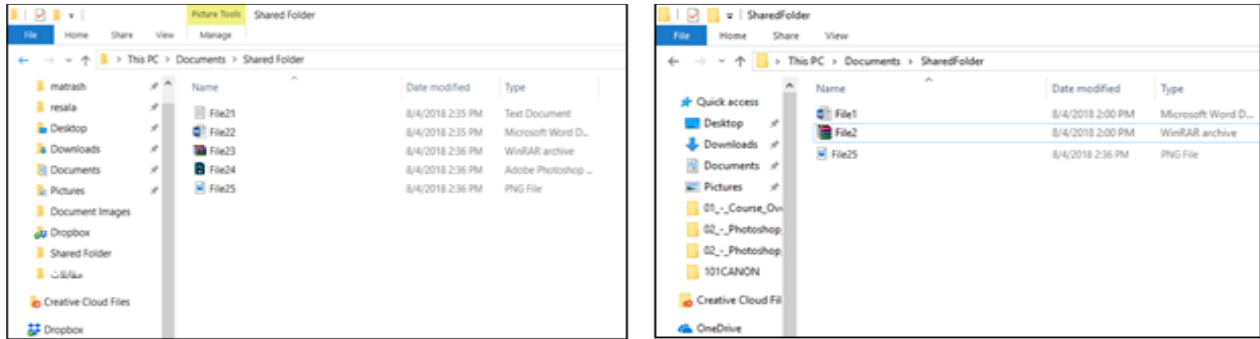


Figure 4.11 : Shared files in two computers

4.2 Software Architecture

Software architecture refers to the high-level structures of a software system, the discipline of creating such structures and systems. Each structure comprises software elements, its properties and the relations among them (Bass, et al., 2010). As shown in Figure 4.12 software architecture device divided into three main components: mobile, server and device component:

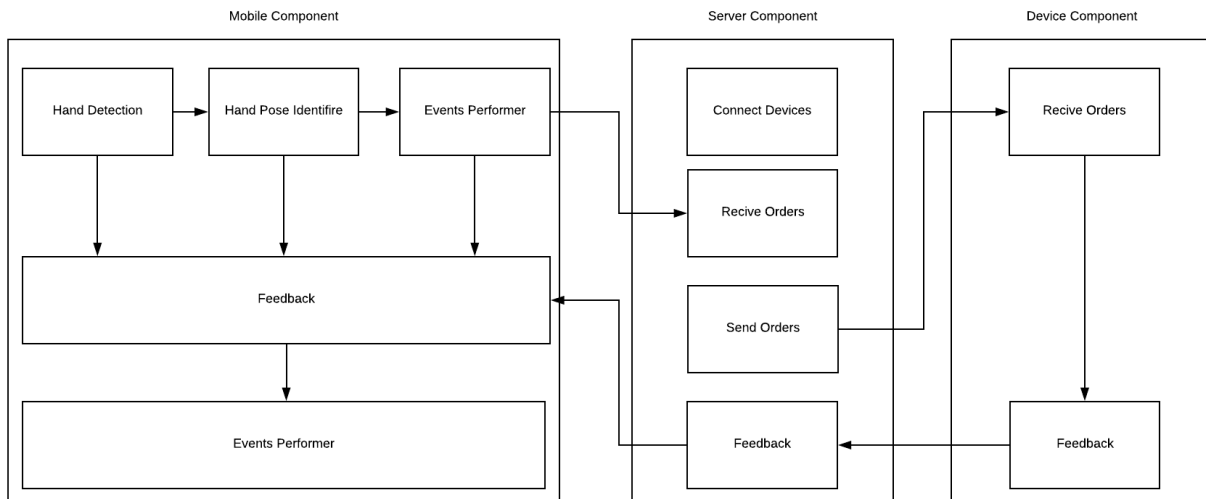


Figure 4.12 : Software Architecture

1- Server Component:

It is the coordinator component which works as a CPU in the computer so it takes the orders from the wearable device, analyses it and then gives orders to all connected devices, these orders can be:

- A- Copy File form device to another.
- B- Print File.
- C- Show File.

We programmed this desktop application using C# programming language, this server software contains three main functions which are shown in table 4.2:

| Method Signature | Example | Explain |
|--------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| CopyFile(Source, Destination) | CopyFile("//192.168.1.2/sharedFiles/file.txt" , "//192.168.1.3/sharedFiles/file.txt") | File called (file.txt) will be copied from computer hold IP address(192.168.1.2) to another device which holds the IP-address(192.168.1.3) |
| PrintFile(Source, Destenation) | PrintFile("//192.168.1.2/sharedFiles/file.txt" , "//192.168.1.3") | File called (file.txt) will be printed on a default printer that connected to device that holds the IP-address(192.168.1.3) |
| GetFilesList(Source) | GetFilesList("//192.168.1.3/sharedFiles/") | The server will get a list of files names and extensions from a computer that holds the IP-address(192.168.1.3) |

Table 4.2 : System Main Functions

2- Other Devices Component:

These devices are the actual action receivers which receive the orders from the server and then perform these orders, we mean by orders: transfer files from/to device, using the connected printer to print file or using the attached screen to view the file.

3- Mobile Component:

This is the main component which plays the main role in the system, we used Unity game engine (unity3d, 2018) as a platform to build this component for several reasons:

- a. We are working on a project using image processing to detect hand and its poses so we used the most famous library in this area which is openCV (OpenCV, n.d.) library , this library is based on the C++ language , and because the programming language of unit3d is C# which is in the same family of C++ invented by Microsoft, we used a high compatibility wrapper called OpenCVforUnity, After having this wrapper we can perform any image processing functions exist in the original C++ openCV library.

- b. Since we are dealing with images and elements that need to have a depth of three-dimensional, we prefer to use this tool to facilitate the process of rendering and processing those images easily and quickly (we mean by these images, the augmented images of files that will appear on the computers).
- c. Since we will deal with virtual reality glasses (Google Cardboard), we prefer to use unity3d because it supports this feature through a Google plug-in which makes the VR vision done easily without any efforts.
- d. As we will deal with Augmented Reality technology, we have searched for several libraries in this field. We found the best and most accurate library in this area is Vuforia (vuforia augmented reality, 2018) library. We have used it in a free version. The library supports three platforms: Android, IOS and Unity.
- e. We have also used the Unity3d because it helps us to use some ready-made functions for collisions to check the collision between the hand and one of the files or check the collision of the file with another device. Without Collision functions, we will start working on the location of the element and its bounds and compare these bounds with other elements.
- f. Since we need to connect to the server that we pre-programmed through C# programming language, so we must make the mobile software and the server using the same programming language and because the Unity3d already using C# as a programming language we used it, Unless that, we will have to create an adapter to convert the orders transporting through mobile server from different language to C# language. We used the network connections to connect to the server and call the appropriate function at the appropriate event.

- Mobile component divided into 5 modules that are:

1) Hand Detection Module :

This module responsible for making the detection process of the hand and differentiates it from all the environmental elements. We used a unity3d WebCamTexture class (WebCamTexture, 2018) to take video streaming of hands from the mobile camera and then convert these images to textures so we can be working on them as a sequence of images after converting them to binary images. After that, we used an OpenCV library to detect hand skin colour by using the colour blob detector (SimpleBlobDetector Class Reference, 2018) . A Blob is a group of connected pixels in an image that shares some common property. The goal of blob detection is to identify and mark these regions which can be filtered by colour, area, circularity, ratio, and convexity, we use filtering by colours to make the system detects the hand by the skin colour, in Figure. The algorithm is controlled by the following parameters:

- A. **Thresholding :** Convert the source images to *several* binary images by thresholding the source image with thresholds with two parameters (minimum threshold and maximum threshold)
- B. **Grouping:** In each binary image, The goal of blob detection is to identify and mark these regions which can be filtered by colour, area, circularity, ratio, and convexity, we use filtering by colours to make the system detects the hand by the skin colour. Connected white pixels are grouped together. Let's call these binary blobs.
- C. **Merging:** The centers of the binary blobs in the binary images are computed, and blobs located closer will be merged.

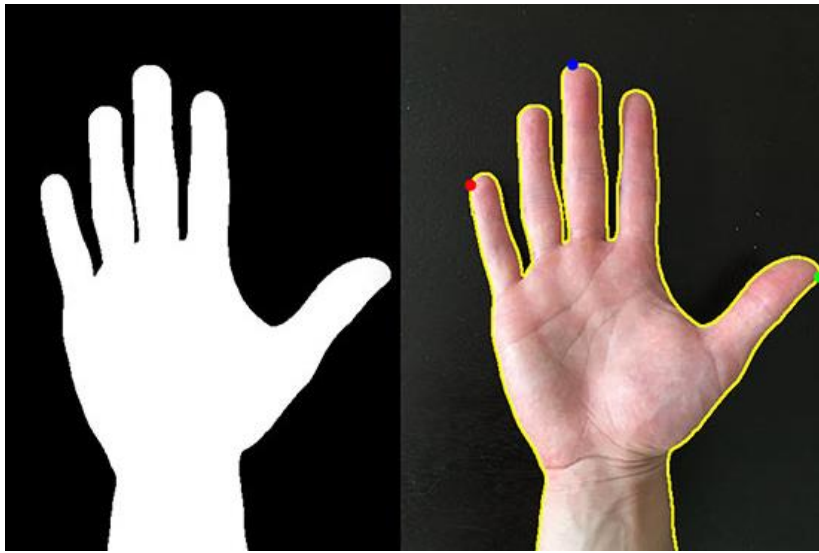


Figure 4.13 : Right Figure shows the hand and the Left one shows the color blob detector result

2) Hand Pose Identifier Module :

In this Module the mobile should identify the hand pose by count the number of folded fingers and then it will determine if the hand is closed or open, this is done by the following steps:

A. Contours Detection:

"Contours can be explained simply as a curve joining all the continuous points (along the boundary), having same color or intensity. The contours are a useful tool for shape analysis and object detection and recognition." (contours, 2018) , We used the binary images from the previous step to make this process more accurate and we used Canny edge detection algorithm which is is an edge detection technique that uses a multi-stage algorithm to detect a wide range of edges in binary images. (Canny edge detection, 2018)

B. Fingers Count:

After selecting the contours, we draw a red rectangle on the border of the hand to determine the location, length, and width of that hand. And then we draw lines at the highest points in the contours to form the hand hull, finally, we get outside hand shape by drawing lines between hull vertices, these vertices represent the fingers count as shown in Figure 4.14.



Figure 4.14 : Hand convex hull vertices

C. Count Stability:

To improve our algorithm of counting fingers, we read the fingers count if changed after one second, because of the immediate and fast difference in reading, which makes the counting process more difficult. So the system can determine whether the read number of fingers is true or not, if the change was fast, the system would not count the number of fingers. If the count did not change for a second, the system would count the number.

D. Determine Hand Pose:

When reading the number of fingers we can distinguish whether the hand is open or closed, and to make the algorithm more accurate we have adopted whether the number of fingers is equal to 3 or greater system will consider the hand as open, else if the count is equal to or less than two, the hand will be considered as closed. Figure 4.8 and 4.9 shows the hand in a closed and open pose.

3) Event Performer Module:

Depending on the previous module the system determines what the action to take and these actions are drag and drop when the hand is closed and it collides any of viewed files, the system makes this files drags and follows the closed hand. When the user

changes his/her hand pose to open, the drop event will be triggered. This module connected to the server software and it is invoking the suitable method to perform the right actions to get files, copy and print files.

4) Feedback Module:

This module is responsible for making messages through the events triggered e.g. if the user drags the file and drop it on another device, the feedback module informs the system that there is a copy file process from device holding specific IP address to another, unless if the user drops the file on the space without colliding any other device this module informs the system to return files to its original position.

5) Update Module:

In this module we check the messages from the feedback module and make updates to the changed devices, we mean by these updates in the UI e.g. if the user succeeded to drop a file from device to another, this module will update the view to make this file appeared on the identified device.

4.3 Tools, equipment and methods

4.3.1 Software

4.3.1.1 Tools

- **Unity3D 5.6:** Unity is the ultimate game development platform which is used to build a high-quality 3D and 2D games, deploy them across mobile (unity3d, 2018) . We used Unity to build the wearable mobile interaction system.
- **Android SDK Manager v.24.4.1:** is an application that contains a composed of modular packages that you can download separately and notify the developers if a new version of the Android platform is released, you can use the SDK Manager to quickly download them to your environment (GOOGLE, n.d.) .

4.3.1.2 APIs and Libraries

- **OpenCVforUnity v2.3:** It is an opencv wrapper that written in c# programming language and programmed to be used in unity games and interactive applications.
- **ZXING:** “is an open-source, multi-format 1D/2D barcode image processing library implemented in Java, with ports to other languages” (Owen, n.d.)

4.3.2 Hardware

- **Google cardboard Glasses:** a virtual reality (VR) glasses developed by Google for use with a head mount for a smartphone. Named for its fold-out cardboard viewer, the platform is intended as a low-cost system to encourage interest and development in VR applications. Users can either build their own viewer from simple, low-cost components using specifications published by Google, or purchase a pre-manufactured one. To use the platform, users run Cardboard-compatible applications on their phone, place the phone into the back of the viewer, and view content through the lenses.
- **Mobile Device:** We used the mobile device because we used a virtual reality glasses (Google Cardboard) that do not work independently but rely on a mobile phone existing inside it, and we used that mobile to setup the module that controls all the devices in the surrounding environment. In table 4.3 we can see the used mobile specifications:

| | |
|---------------------------|-------------------|
| Mobile Model | Samsung Galaxy J7 |
| Display Size | 5.50 inch |
| Display Dimensions | 720*1280 |

| | |
|--------------------|-------------------|
| RAM | 1.5 GB |
| Processor | 1.5 GHz octa-core |
| OS | Android 6.0 |
| Rear Camera | 13 megapixel |
| Storage | 16 GB |

Table 4.3 : Mobile Device Specifications

- Multi-Device environment: is a room 4*4 m² that contains two computers, printer and screen which is suitable to make experiments our research implementation as shown in Figure 4.15.



Figure 4.15 : A work environment contains 2 computers, printer and screen

Chapter 5

Evaluation

5.1 Introduction

In this chapter, we evaluated the system of this research by allowing a group of users to use the system and after the completion of their usage, they fill out a questionnaire which results are used to conclude the quality of the system and its ease of use. In the second part of this chapter, we analyzed the behavior of users when using the system by recording a video for each one of them to observe the general practices and evaluate them.

5.2 Usability Test

Usability evaluation is an essential component of user-centered systems and core competency for human resource professionals working in the software domain. The most important thing we need in this research is to evaluate the ease of use of this system because the problem is based on the difficulty of dealing with the different operating systems devices that require to deal with them, which needs to sit in front of them and deal with each of them separately to make simple actions between these devices such as copying files, viewing or even printing them. The biggest dilemma is to test the ease of use of this system and evaluate it to make the user satisfied with its performance and therefore can use it easily to gain our objective of solving the previous problem.

To evaluate these type of system, we can use one of these three evaluation methods (Andre, Williges, & Hartson, 1999) :

1- User-based:

The system is tested by a group of users by ordering a set of tasks to be executed on the system so the examiner evaluates the ease of use through the results obtained from this usage. Through this test we can measure the actual result we can get if the system reaches to the end users with an effective and reliable way. This method relies on the mechanism of empirical evaluation through the use of human factors in the analysis of tasks, observation, and trial and error depending on their ways of thinking and dealing with similar systems or their expectations of events through the form of some elements of the system.

2- Expert-based:

In this method an HCI expert involved, so he can use the system and evaluate it by his/her experience. the users will be not involved to estimate the system ease of use so we should not make a survey or interview them to conclude the results, the expert examiner can tell us the result based on his/her experience with dealing with similar systems, this method will be faster than the user-based one but its results may be not accurate if we want to know the ease of use for the end users.

3- Model-based:

The model-based evaluation techniques are the least common evaluation methods but it relies on several models or methods to evaluate the system like the difficulty of learning a task and the time that user spending to accomplish these tasks. In this method the examiner focus on a sequence of tasks that the user accomplish, and analyze that sequence and the degree of correctness by filling an analytical model to this sequence to conclude the usability results.

- **Comparison of the previous usability evaluation methods:**

| Usability Method /Indicator | User-based | Expert-based | Model-based |
|-----------------------------|------------|--------------|-------------|
| Accuracy | High | Moderate | Moderate |
| Time Cost | High | Low | High |
| Errors Detecting | Moderate | High | Moderate |
| Require Practical Prototype | Yes | No | Yes |

Table 5.1 : Comparison of the previous usability evaluation methods

We used the user-based evaluation method because we are interested in the end user in our research and the user is a key part of the research problem, so we produced an application pilot with using all setup steps that we discussed in implementation chapter of this research.

We evaluated the practical research by using two practices based on an explanation of user-based method:

5.3 Questionnaire

After the user used the practical system pilot, he/she had to fill out a questionnaire includes multiple questions in our research fields such as usability, gestures detection, Augmented reality UI and file transferring accuracy, we can conclude the usability of the proposed HCI research and make notes for future works. The questionnaire can be found in Appendix (A) which contains sixteen choose questions and another two editorial questions, the questions divide into 3 parts:

- 1- Asking the users about their ages, computer and augmented reality knowledge background.
- 2- Asking the users about the system usability if the system is ease to use or not and the functionalities correctness.
- 3- Inquiring about what things that they like or dislike in the system.

5.3.1 Sample Size

Nielsen's (Nielsen, 2000) states that five participants are enough was clearly based on simple studies, and he has more recently stated that the number of participants must increase with the complexity and criticality of a study. Faulkner (Faulkner, 2003) argued that ten participants would probably find a minimum of 82% of problems. Turner believes seven participants may be ideal, even for complex studies. When setting up a questionnaire for usability study for such system, the main factor we interest on it is the minimal level of problems discovery. As Table 5.2 shows, the most percentage of problem discovery will be discovered by users from 5 to 10, we can also see that this impact will be far less if it is going more than 10 users. So we can have fewer participants in a study if undiscovered problems would have a small impact on users as it is in our research. Because we have the same indicator to evaluate the usability of the system we selected a sample of 10 users from different fields and knowledge to evaluate the system by answering the questionnaire which you can find it in Appendix (A).

| Number of Participants | Percentage of problems found % |
|------------------------|--------------------------------|
| 5 | 55 |
| 10 | 82 |
| 15 | 90 |
| 20 | 95 |
| 30 | 97 |
| 40 | 98 |
| 50 | 98 |

Table 5.2 : Shows the number of participants and the percentage of problem founds

5.3.2 Experimental Tasks

To ensure that users will test the system properly, we have requested some tasks from them as the following:

- Open Application, put the mobile in google cardboard glasses, and wear these glasses.
- Check Augmented Reality UI when aiming the glasses to QR codes.
- Check the hand fingers counter at the left top corner by changing the opened finger count.
- Check the hand status change when the user changes his fingers status (open, close).
- Try to drag a file and drop it before collided the target device.
- Try to drag a file and drop it on the target device.
- Check the files Changes.

After users completed the previous tasks, we asked them to fill out the questionnaire in Appendix A in order to conclude how much they were impressed with the system and evaluated it.

5.3.3 Questionnaire Results

As shown in table 5.3 we can conclude the number of users which was 10 users that filled the questionnaire by answering the questions using (X) answer for the suitable answer, We used a 5-likert scale which converted to numerical values as the following:

(Strongly disagree : 1, Disagree:2,Natural:3, Agree:4, strongly agree:5)

The table also shows the answers frequency, percentage for each answer, and the answers mean in percentage scale.

| # | Question | 10 Users | | | | | | | | | | Mean |
|----|---------------------------------------------------------------------------------------------------------|----------------------|----------|---------|-------|-------------------|----------------------|----------|---------|-------|-------------------|------|
| | | Frequency | | | | | Users Percentage | | | | | |
| | | Strongly Disagree | Disagree | Natural | Agree | Strongly Agree | Strongly Disagree | Disagree | Natural | Agree | Strongly Agree | |
| 1 | 2 | 3 | 4 | 5 | % | % | % | % | % | % | | |
| 1 | The system made you stratified | 1 | 0 | 0 | 3 | 6 | 10 | 0 | 0 | 30 | 60 | 86 |
| 2 | The system can be used with minimal guidance | 1 | 1 | 0 | 4 | 4 | 10 | 10 | 0 | 40 | 40 | 72 |
| 3 | The given guidance and feedback messages are understandable and relevant | 0 | 1 | 1 | 1 | 7 | 0 | 10 | 10 | 10 | 70 | 88 |
| 4 | The system responds to user interaction in a timely and appropriate manner | 1 | 1 | 0 | 2 | 5 | 10 | 10 | 0 | 20 | 50 | 72 |
| 5 | Detecting Hand and showing the Red Rectangle | 0 | 0 | 0 | 1 | 9 | 0 | 0 | 0 | 20 | 80 | 98 |
| 6 | Recognize Hand Gestures (Open , Close) poses | 1 | 0 | 0 | 2 | 7 | 10 | 0 | 0 | 20 | 70 | 88 |
| 7 | Showing the files when Detecting a QR | 1 | 2 | 0 | 0 | 8 | 10 | 20 | 0 | 0 | 80 | 80 |
| 8 | Showing shared files in each device | 0 | 0 | 0 | 3 | 7 | 0 | 0 | 0 | 30 | 70 | 94 |
| 9 | Supporting multi device (Different devices) in the same environment | 1 | 3 | 0 | 5 | 2 | 10 | 30 | 0 | 50 | 20 | 74 |
| 10 | Dragging Files when Hand is Closed | 0 | 2 | 0 | 2 | 6 | 0 | 20 | 0 | 20 | 60 | 84 |
| 11 | Dropping the same dragged Files | 0 | 2 | 0 | 2 | 6 | 0 | 20 | 0 | 20 | 60 | 84 |
| 12 | If one of the shown files dragged and the user opens his hand away from the target (Another Device) the | 0 | 1 | 0 | 2 | 7 | 0 | 10 | 0 | 20 | 70 | 90 |

| | | | | | | | | | | | | |
|----|------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|----|---|----|----|----|
| | file will be returned to the same initial position | | | | | | | | | | | |
| 13 | If one of the shown files dragged and the user opens his hand above the target (Another Device) , the file will be copied to the target device | 0 | 2 | 0 | 3 | 5 | 0 | 20 | 0 | 30 | 50 | 82 |

Table 5.3 : Questionnaire Results

After filling out 10 users for this questionnaire, we collected their results in the previous table 5.3. The questions varied from ease of use and use of the system without guidance or errors. The user response rate is that the system is the easy to use, equivalent to 84%, which is a very good percentage in this type of system.

We also measured the learnability of the system by made the users try the system with minimal guidance, we let the user to try the tasks without tell him how to do these tasks by hand, it was 72% and, Because of the weakness background of some users in the augmented reality applications or of their usage of various computer applications.

At the following points we discussed on detail some important points related to the background of users and their ages and discuss the question of admiration and disrespect in the system they have tested.

These users were asked 3 questions to determine the appropriate age and to know the scientific background of these users and the result was as follows:

- The category of users ranges between 20-40 years, which is the effective category for this type of systems. It is the category of technology and computer literacy. This is what served the result.
- 9 users of 10 which is 90% of the users have experience in dealing with the computer and its various applications.
- 4 users of 10, which is 40% of the sample have experience in dealing with the enhanced reality systems. This required us to guide them with some guidance and observations after their mistakes in using this system.

After completing these questions, we asked the users two questions: What did you like in this system and what you did not like about it and we were able to summarize these answers in the following points:

1. What are the things that you liked in system?

- A. Sharing the files without standing in front of computer.
- B. Distance controlling of the devices.
- C. Using a cheap device like google cardboard to achieve this goal.
- D. Use the resources which exist in each home or organization to make system settings and make it works like an internal network containing multi-devices in the same place.

2. What are the things that you disliked in system?

- A. The Complexities in the first preparation process before the experiment begins.
- B. Forcing users to wear long sleeve T shirt, and avoid wearing the colors that similar to the body color.
- C. The system usage was in one place is pre-equipped and required to be in daylight.
- D. Users predict that the system performs more operations than copying, displaying, and printing, such as cut and deleting files.

By looking at these previous answers, we can state them as follows:

- A. The complexities mentioned in the first are really necessary for the success of the interaction of the system with each other. We need to install an agent on each device, in addition to printing QR code for each device so we can recognize it, and these procedures are normal and not complicated in such types of systems. These procedures will be configured just once in system installation, not every time when the users will use it.
- B. As mentioned in the point of wearing long sleeve t-shirts are really necessary to recognize only the hand and not the different parts of the body. We are working in the Algorithm previously explained in Implementation Chapter on the technique of hand recognition through the color of the skin, so if there is another part of the body appeared, this will make the system works incorrectly and the same thing will happen if the user wears the color Close to skin color such as yellow and brown t-shirts.
- C. The place was pre-equipped to avoid any problem such as the similarity of the color of the wall or devices and the hands and this will, of course, makes the system reads these parts as part of the hands. In addition to that, lighting, we wanted to make that the experiments in the day, not night so that makes system reads the hand color well and clearly.
- D. In the future works we will include more operations such as cut, display, navigate and delete files.

5.4 Observations

By taking a group of 10 users with a different computer, and observe their usage of our practical research pilot and by recording their dealing with the application, we can conclude how much our system is usable. We recorded a summary of the 10 users in the form of points as follows:

- A. There was a problem with one user who did not have a background to deal with mobile and computer applications. This type of system needs people with a good background to deal with this kind of technology.
- B. The system was a fantasy for people who had not previously dealt with augmented reality applications when they saw the creation of UI files automatically in the front of the camera as well as the ability to move these UI files in the space. The system was a good factor to identify this great technique for them.
- C. The direction of the hand in front of the camera was sometimes hiding some fingers, so the fingers number read was incorrect and thus the judgment on the hand , if it is open or closed, will be not clear. The user must pass the hand in parallel to the camera without hand wrapping.
- D. User's clothing and its similarity to the color of the hands was a problem in reading the hand properly.
- E. If another part of the hand, such as the arm, appears, this causes a wrong reading of the hand. We have addressed this problem by making the user wears a long-sleeved shirt.
- F. When we experimented with the system in dim or night lighting, there was a problem in recognizing the hands because of their color change. We set the experiment to be in strong daylight.
- G. Users used different hands gestures with the open and closed ones, believing that there were other processes such as hand swipe and pinch.

Chapter 6

Conclusion and Future works

6.1 Conclusion

Due to the development of technology and the emergence of different devices that the user can deal with at the same time, the most important problems we face is how to deal with these devices at the same time without the need to use each device separately, so we have achieved the main objective of this research to establish a system that can deal with these devices remotely Through the use of the internal network that connects each of these devices and using the augmented reality technology with the hand gestural interaction.

The thesis went through several stages starting from the problem and finding the solution, then reviewing the related works and criticize them and the statement of what is our idea characterized, then we start the design phase where we have developed a structure of the system and how the parts will deal between each other, then we started with the implementation process through which we used the software needed to create the work And finally we made an evaluation of the system.

We developed a practical solution for our problem which contains three main components: Server, mobile and device component, the server side program is a program designed to coordinate orders by receiving orders from mobile component and execute them in the device, As for the mobile component it contains 5 modules (hand detection, hand pose estimation, QR code detection, feedback and event performer module), and it is the representative side of the user view that can deal with.

We selected a sample of 10 users to carry out the system evaluation by conducting an observational study and questionnaire, where we put 17 questions, three of them related to age and the user's computer and augmented reality background and 13 questions related to the system ease of use, system response and correctness. The remaining two questions were talking about what you like and dislike things founded in this system, after that the user will answer 13 questions with scale from 1 to 5 we made an average based on number of users, the questions varied from ease of use and use of the system without guidance or errors. The user response rate is that the system is the easy to use, equivalent to 84%, which is a very good percentage in this type of system. As for the study of observation, we recorded some points about the actions of users and comment.

6.2 Future Works

As a future work we recommend:

- Hand recognition in a non-color dependency, so we can avoid the similarity of clothes colors, body parts or even the environment.
- Make the system use other operations on files such as cut, navigate and delete them.
- Addressing the problem of hand recognition in the case of dark or night illumination.
- Navigating files in 3D view, not just a 2D user interface.
- Open files in the camera view not just viewing them in another device.

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Appendices

Appendix1: System Evaluation Questionnaire

يقوم الباحث باعداد دراسة كمتطلب تكميلي لنيل درجة الماجستير في تكنولوجيا المعلومات من الجامعة الاسلامية بغزة بعنوان " تسهيل نقل المعلومات في بيئات متعددة الأجهزة عن طريق استخدام الواقع المعزز والتفاعل الإيمائي "

حيث تتناول فكرة البحث تسهيل نقل المعلومات الى أجهزة متعددة في نفس البيئة وذلك من خلال استخدام تقنية الواقع المعزز والتفاعل من خلال حركة اليد حيث يقوم المستخدم بارتداء نظارة الواقع الافتراضي التي تحتوي على برنامج يقوم بالتعرف على اليدين ومن ثم التعرف على وضعية اليدين ما اذا كانت مفتوحة أو مغلقة ومن خلال العلامات المعروفة باسم QR code التي ستوضع على الاجهزة يقوم النظام بالتعرف على هذه العلامات وبالتالي سيظهر قائمة من الملفات بشكل دائري حول الجهاز المعني حيث سيقوم المستخدم بتمرير يده والوقوف فوق الملف الذي يريد نسخه ومن ثم اغلاق يده ليقوم بامسك الملف وافلاته على الجهاز الذي يريد النسخ اليه وبهذا تتم العملية بنجاح.

كما و تهدف هذه الفكرة الى تسهيل التواصل مع اجهزة متعددة في نفس المساحة المغلقة كغرفة مثلا حيث يقوم المستخدم بالتواصل مع الاجهزة المتعددة من خلال النظام المطروح أمامكم وهذا ما سيسهل عليكم كمستخدمين بدلا من الجلوس امام كل جهاز واستخدامه وهذه عملية صعبة حينما تحتاج للجلوس امام عدة اجهزة لنقل الملفات بينها من خلال الشبكة او اجهزة التخزين المؤقت.

يمثل هذا الاستبيان أحد الجوانب الهامة في البحث , ويهدف إلى تحليل آراء المستخدمين الذين تم اختيارهم لتجربة هذا النظام العملي الذي تقوم عليه المشكلة البحثية في رسالة الماجستير , لذا نرجو التكرم والإجابة على الأسئلة المطروحة وتزويد الباحث بأرائكم القيمة من خلال وضع إشارة (X) على الإجابة التي ترونها ملائمة . كما يأمل الباحث أن تغني إجاباتكم وترفع من المستوى العلمي لهذا البحث.

يرجى العلم أن جميع الأسئلة المطروحة ضمن هذا الاستبيان لأغراض البحث العلمي وأن إجاباتكم ستكون محاطة بالسرية الكاملة والعناية العلمية الفائقة.

شكرا لتعاونكم وحسن استجابتكم....

الباحث

أحمد جهاد العف

1- الى أي مرحلة عمرية تنتمي؟

| | | | | |
|---------------|-----------|-----------|-----------|--------------|
| أقل من 20 سنة | 20-30 سنة | 30-40 سنة | 40-50 سنة | 50 سنة فأكثر |
| | | | | |

2- هل لديك خبرة في التعامل مع الحاسوب وتطبيقاته المختلفة؟

| | |
|----|-----|
| لا | نعم |
| | |

3- هل لديك خبرة في التعامل مع أنظمة تعتمد على الواقع المعزز.

| | |
|----|-----|
| لا | نعم |
| | |

| # | السؤال | موافق بشدة | موافق | لا أعلم | غير موافق | غير موافق بشدة |
|----|--------------------------------------------------------------------------------------------------------------------------|------------|-------|---------|-----------|----------------|
| 4 | ما مدى رضاك عن النظام | | | | | |
| 5 | هل استطعت استخدام النظام بدون ارشادات | | | | | |
| 6 | هل رسائل التغذية الراجعة من النظام سهلة الفهم ولها علاقة بالحدث | | | | | |
| 7 | هل النظام يستجيب بشكل فوري وصحيح | | | | | |
| 8 | عند تمرير اليد هل يستطيع النظام اكتشافها واحاطتها باللون الاحمر | | | | | |
| 9 | هل يستطيع النظام معرفة ما اذا كانت اليد مفتوحة ام مغلقة | | | | | |
| 10 | عند توجيه النظارة الى احد الاجهزة هل يظهر النظام الملفات الموجودة على هذا الجهاز بشكل صحيح | | | | | |
| 11 | في حال ظهور الملفات الموجودة في أي جهاز هل كانت الملفات هي نفسها ملفات المشاركة على نفس الجهاز | | | | | |
| 12 | هل يدعم النظام أجهزة مختلفة الأشكال مثل طابعة وحاسوب وشاشة | | | | | |
| 13 | عند اغلاق اليد هل تستطيع امسك احدى الملفات | | | | | |
| 14 | في حالة ترك الملف هل يتم اسقاط الملفات المسحوبة | | | | | |
| 15 | في حال كانت احدى الملفات مسحوبة وقام المستخدم بفتح يده بعيدا عن الهدف (جهاز آخر) سيعود الملف الى مكانه الأصلي قبل السحب. | | | | | |
| 16 | في حال كانت احدى الملفات مسحوبة وقام المستخدم بفتح يده فوق الهدف (جهاز اخر) سيقوم الجهاز الهدف بالاحتفاظ بنسخة من الملف | | | | | |

17- ما الامور التي أعجبتك في النظام

18- ما الأمور التي لم تعجبك بالنظام

تمت