TOUCHLESS 3D CONTROLLER USING CAPACITIVE SENSING METHOD

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This thesis is dedicated to my family, Adibah bt Ali and Aminuddin bin Abdul Rahman who are my parents and also my siblings, Nur Syamimi, Nur Sabryna, Danial Syahmi and Danish Syazani.

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ABSTRACT

This project is to improve the existing technology into the next level needs where it will implement a touch-less interaction by hand movements in the air for human computer interactions. This project will cover about gestural control and interface technology by using capacitive sensor as the major component for sensing the gesture movement. Capacitive sensing function depends upon how long it takes a capacitor to charge (known as the time constant). Placing an object within the electric field of a capacitor will affect the capacitance value and the corresponding time constant. The main idea is to build a low cost 3D controller for gesture detection and implement it for human computer interactions. The functionality of it is to allow a run time user control by simply using microcontroller as a bridge for interface connection between the hardware and computer. In this project the microcontroller used is Arduino UNO. The technology has the potential to change the way users interact with computers by eliminating input devices (e.g. mouse, keyboard) and allows gestural movement to take control of the computer. Movements of hand gesture will be an input to be manipulated so that it can take over the computer cursor to control applications at computers. With the use of MATLAB software the input received can be calculated and the functionality of the capacitive changes will be substitutes to the gestural input created by the user.

ABSTRAK

Projek ini dijalankan bertujuan untuk meningkatkan mutu teknologi yang sudah sedia ada kepada satu peringkat yang lebih tinggi menggunakan interaksi tanpa sentuh melalui pergerakan tangan di udara sebagai medium komunikasi antara manusia dan computer. Oleh itu, projek ini meliputi megenai pergerakan gestur dan kawalannya serta teknologi antara muka menggunakan konsep sensor kapasitif sebagai komponen utama untuk mengenal pasti pergerakan gestur. Kapasitif sensor ini bergantung kepada masa yang diambil untuk kapasitor mengecas(dikenali juga sebagai masa tetap). Dengan meletakkan sesuatu objek didalam medan elektrik yang terhasil daripada kapasitor, nilai kapasitor tersebut dan masa tetapnya akan terkesan. Idea utamanya adalah untuk membina kawalan 3D tanpa sentuh yang dimana kos untuk membinanya adalah murah. Selain itu, untuk di aplikasikan sebagai iteraksi antara manusia dan komputer. Projek ini berfungsi dengan menggunakan mikropengawal sebagai jambatan komunikasi antara perkakas elektronik dengan komputer supaya pengguna dapat mengawalnya secara langsung. Mikro pengawal yang digunakan untuk projek ini adalah Arduino UNO. Teknologi yang ingin dijalankan ini berupaya untuk menyingkirkan peranti input yang tradisional seperti tetikus dan juga papan kekunci. Oleh itu, peranti ini akan dignatikan denganinteraksi tanpa sentuh yang menggunakan pergerakan tangan di udara. Akhir sekali, dengan menggunakan perisian MATLAB input daripada mikropengawal akan diterima dan dikira seterusnya fungsi kepada perubahan nilai kapasitif akan dijadikan sebagai rujukan kepada data daripada pergerakan tangan yang dilakukan oleh pengguna.

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LIST OF ABBREVIATION

2D	-	Two dimensional
3D	-	Three dimensional
E-FIELD	-	Electric field
HCI	-	Human-computer interactions
IDE	-	Integrated development environment
RFID	-	Radio-frequency identification
DOF	-	Depth of field
DC	-	Direct current
AC	-	Alternating current
RX	-	Receiver
COM	-	Communication port
USB	-	Universal Serial Bus
UART	-	Universal asynchronous receiver/transmitter
IR	-	Infrared
IC	-	Integrated circuit

CHAPTER 1

INTRODUCTION

1.1 Background

Human Computer interactions nowadays are in various forms. The act to transfer data between the user and computer uses a lot of different type of peripheral devices. Since computers are nowadays having been so integrated with everyday life, new technologies and applications are introduced from time to time in order to improve the user interactions with computers. This aims to improve the usability of the computer making it user friendly and easy to use. However, the existing technology nowadays for user interaction with computers at the moment are limited to the device systems such as keyboards, mice, touch screen, trackball, and keypads. This entire device requires a full interaction which requires a contact with the device so that it can read the input data of interactions to control the computer [1].

The purpose of this project is to develop a touchless control device in three dimensional areas of interactions by gestural movement in the air for interaction with computers. The method used to develop the 3D controller is by using capacitive sensing. Capacitive sensing method uses electrodes as sensor input. The electrodes act to detect the E-field variations at different positions in order to measure the origin of the electric field distortion from the varying signals received due to the conductivity of the human body itself that shunted to ground [2]. Then the information is used to calculate the position, track movements and to classify movement patterns (gestures).

This method uses three aluminium foil board and building it in cube form with each plate act as x, y and z coordinates. The cubes are conductive so that it can store capacitive charge with current and voltage supplied by the Arduino UNO. The Processing software is used to display the tracking interface of the sensor when it detects our hands within the sensor region. MATLAB software used to build a serial connection between Arduino and the software so that the cube sensor can establish a mouse control for user computer interface control.

1.2 Objectives of project

This project is mainly about using gestural control as input for computer user interactions. Therefore, the objectives are:

i. To develop a 3D interface for gesture control by using capacitive sensing
ii. To construct a low cost 3D gesture controlling device.
iii. To implement the 3D gesture controller by using MATLAB for human computer interactions.

1.3 Problem Statement

There has been a surge interest for a touchless human computer interactions system. The HCI (human-computer interactions) can be defined as the study, planning, design and the uses of human interface between the users and computers. Most developer wants to have the best fit in the designing of HCI. The important is to know the activity those are to be done for HCI. For example the material that are being used needs to be durable, the development of the hardware needs to be cost effective and also the important is for it to fit among users, computers and all the task it will corresponding. Therefore, the main objective for HCI is to get feedback from users about their experience with the available prototype and the developer will refine the design based on the comments and suggestion given by the user [3]. Thus the HCI designed by using a touchless system has taken its place in the market with best possible performance to fit the user. For an example, Microsoft Kinect which uses gestural input movement for gaming purposes. The technologies are based on infrared projector and camera to track the gesture. However there are drawbacks from using camera as gestural input such that:

i. The product device for 3D camera is very expensive with estimated value nowadays in the market is more than RM200.
ii. By using camera the 3D gestural input are impacted by ambient influences such as light or sound, which are a negative impact for gestural recognition accuracy.

1.4 Scope of Project

The scope of this project is to develop a gesture controller interface with 3D coordinates. The method chosen is by using capacitive sensing which will recognize the gesture by using the principles of capacitive sensing. It will have 3-axis of conductive foil to store charge and to detect any hand gesture approach. The 3D sensing block was built by designing the sensor in cubic form with three sensors attached together. The cube sensor will be connected to Arduino to read the time taken for capacitance value to change over interactions of the hand within the sensor cube with a reference value given. The device can recognize hand gestures input and implement it for an interaction with computers for which this project is for the control of mouse cursor on the computer. This interface is by using Processing software for display the interface of the hand movement as the electric field is distorted by grounded object (hands). Then, for the application of this project is by using MATLAB software to control google earth program by using the hand movement at the sensor cube. The priority of making this system device is for it to be simple and cost effective.

1.5 Report Structure

In this thesis, there are five total chapters that consist of introduction, literature review, methodology, results and discussions and for the last chapter is the conclusion and recommendations for the project.

For Chapter 1, the introduction for project is explained. The contents of the first chapter are the background and objectives for the project. Furthermore, the problem statement that inspired for making this project was thoroughly explained and lastly in this chapter is the scope of work for overall overview of the 3D Gesture Controller Using Capacitive Sensing method development project.

Chapter 2 discusses about the literature review of the capacitive sensing method in gestural movement and its comparisons with other methods based upon previous research and also from multiple sources (internet, magazine and data sheet).

Chapter 3 will explain the methodologies used in the project. It will explain the steps and flow of the project for design and develop the 3D gesture controller. The specification and the layout circuit design and software implementation are explained in this chapter.

Chapter 4 describes the results and analysis obtained upon developing the project and justifies its performance in making sure it meets the objective of the development of the project.

Finally, in Chapter 5 concludes the whole project and make recommendations for future development of it.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Human and computer interactions have recently gaining attentions by developers in making it more intuitive and having a more natural interaction between them [4]. Human-computer interaction (HCI) is defined as the disciplined that is concerned with the design, evaluation, and implementation for an interactive computing system in human use and the phenomena around them [5]. There are many studies about the interaction in global computing environments that have been introduced. Previous studies are the Things That Think, which consists of various researches for smart objects and human computer interactions performed by MIT Media Lab, the studies about mobile and context-awareness HCI platform which is WatchMe, [6]. Another one is a vision-based human computer interaction system which uses RFID reader and motion sensor called MouseField [7].

Figure 2.1 shows the different type of gesture controller method that can be used to develop a touchless controller. Based on the figure, capacitive sensing method is chosen in this for project in order to develop a touchless 3D controller.

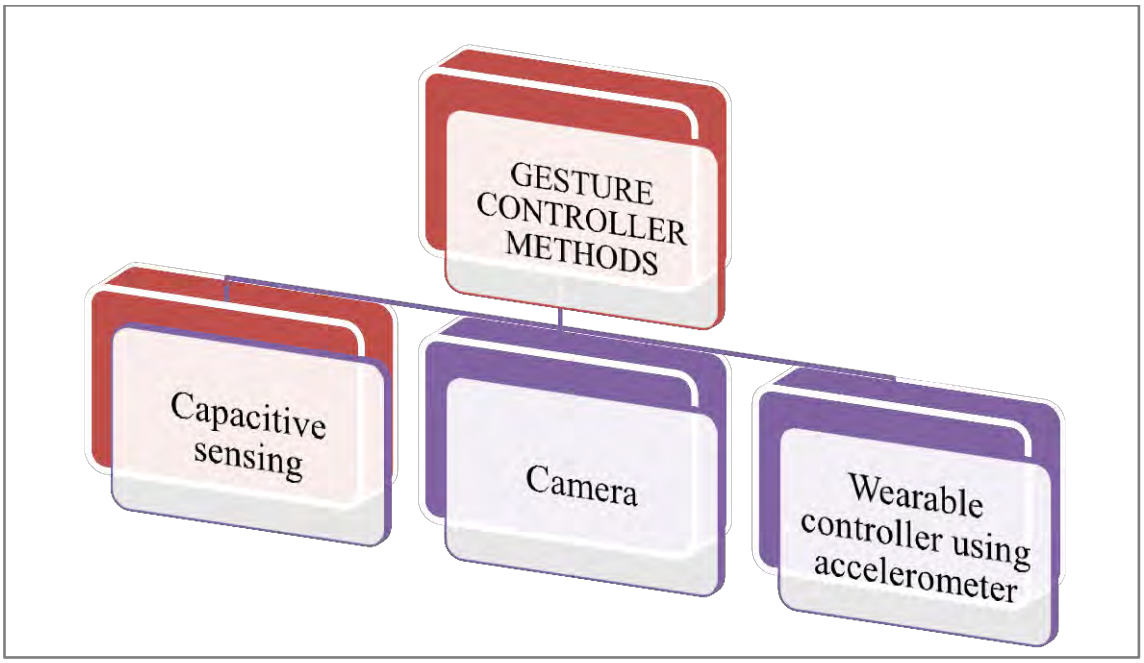

Figure 2.1: Types of gesture control methods

2.2 Hand Gesture Controller

The approach for human computer interactions has made many researchers trying to make the operating methods became more commercially product friendly. The control methods that are available nowadays are keyboard, remote controller, voice and speech recognition and hand gesture recognition [8] [9]. For hand gesture recognition, there are some commercial product that adopts the gesture recognition technique for such areas in gesture language service, intelligent human-machine interface, interfaces of virtual reality navigation, digital art and entertainment. The example of the product is the Kinect for xbox360. It is a very important product which is invented by Microsoft Company. The Kinect camera was able to obtain 3D

depth data by projecting a grid of infrared dots and observing the shift in pixels with respect to a known pattern. This allowed for games to be controlled entirely through gestures and without the requirement of a physical controller [10]. It is common methods that were actually used to develop gestural recognition are by using a camera. By this method it must follow these three steps; segmentation, representation and recognition.

Furthermore, in the gaming industry motion-based interface that mostly uses gesture movement as input has shifted in its market. The Nintendo's Wiimote controller uses three-axis accelerometer where various movements using that controller are used as input to video games. Take a look at tennis game as an example; the player can swing the Wiimote as like they were holding a real racket but actually it is just a virtual racket. The controller accelerometer recognizes the pattern as the player swings the Wiimote and defined it for an in-game animation. The defined concept can be used to build a controller for which it can determine the corresponding movements for a specific task.

2.2.1 Comparison between methods

There are many methods and approaches used in making a touchless interface. The methods are different in the form of type of hardware used in making a system. The comparisons between methods are listed based on their strengths and weaknesses as shown in table 2.1 below.

Table 2.1: Comparisons between methods

Method	Strength	Weakness
Ultrasonic signal [11]	1. Able to operate two modes 3D and 2D modes. 2. Does not need any direct contact surface to move the transmitter.	The user has to control the transmitter by holding the transmitter sensor inside the spatial coordinates.
3D camera [12]	1. The sensing range is between 0.5 meters and 3 meters. 2. Includes RGB camera, infra projector and infra cam to measure object distance to the camera.	1. Static hand gesture detection. 2. Computational complexity is big. 3. One Kinect sensor only ensures depth information, which often does not provide sufficient information to a 3D model fitting.

Driven by a depth sensor, to a virtual camera manipulator, allowing for direct control of 4 DOFs of navigation [13]	1. Body-driven 3D navigation interface for large displays and immersive scenarios. 2. Operates with simple pose recognition scheme.	1. NuNav3D was on average 79.9% slower than the joypad controller. 2. Over translate the virtual 3. Camera when using Nunav3D, which resulted in corrective manoeuvres when exiting the tight constraints of the path-following task.
Kinect sensor [14]	The average accuracy for gesture classification is 93%, and the total time required to cover all controls of 3D medical viewer is about 2.25 minutes on average	1. Have some limitations on finger tracking algorithm and design. 2. Slice selection to the selection to a specific slice is quite difficult thus slowing it. 3. The system might be unstable if the hand stays too close to the body or crosses another hand.