A cost-effective pen touchscreen overlay

# Abstract

Touch interfaces are becoming increasingly popular as tangible user interfaces (TUIs) in the modern era of technology but they prove to be so expensive and inapplicable to cover larger area such as classroom writing board. Another problem with these technologies is the durability. A little damage in the traditional capacitive touchscreen may result into permanent damage of the whole touch interface. This paper introduces technology that is cost effective, less prone to damage and provides much similar look and feel of a traditional board marker.

# Introduction

## Background

When a person uses a computing machine, he expects it to be fast and convenient to use. The contemporary computing machines are fast and have techniques and algorithms implemented to handle errors and failures once an input is received at the user-end. Computing machines are definite. This means that they will produce a discrete and finite output that is heavily dependent upon the input entered. So, it is highly important to make sure that correct input is entered to in the computing machine.

Making it convenient for a user to input his command is equally important as getting the correct command. There have been the input devices that stood well in the evaluation criteria of input but are difficult to use. The more convenient to use the device, the more likely to have accurate data input. Some user interfaces are so friendly that a user can interact with computer just as he is interacting with the physical environment. These interfaces are formally known as tangible user interfaces.

Touch surfaces are more popular than any other human-interface-device because of their intuitive design. They could be found on ATMs, smartphones, laptop computers and machine touch-panels. The user interaction is much more similar to the physical environment. Gestures such as zoom, pinch and roll are much easier to learn. Touch surfaces are easy to use when they are fast enough to make the input processed instantaneously.

## Motivation

More general the device is, more commonly it can be used. The current trend is of reusability and recycling. Once a fully developed hardware device comes to the market, it is rigorously tested in common. If a hardware device could be used in the applications not mentioned by the manufacturer, then it can be bought in bulk by original-equipment-manufacturers or OEMs and can be sold as a separate product.

The market prices of sensor modules are high and also, they are not tested as a product from brand is tested. This ready-made hardware is available in market at relatively cheap price. There is number of projects and research papers that explain how the ready-made hardware can be used to perform much useful tasks.

Being a researcher and a student, I observed that students want to record the lecture. On the other hand, class instructor wants to use the traditional board marker to write on the board. It is not comfortable for him to write on touchpad. Large touch frames are expensive, not easy to use because they involve a specialized hardware for input and a person who only knows how to use the board marker will have difficulties to use that touch hardware. These hardware devices are more liable to error especially when bare-hand input is acceptable. This is due to the convention of using a writing board. Instructor may come in contact with touch hardware with his hand or arm which will result in occlusion causing error.

## Objectives

The aim of this research is to provide a touch interface which is cost effective, more user friendly, more accurate, flexible and reliable.

The corresponding objectives of the aim are

* To use the cheap yet rigorously tested gaming hardware which is available in the market to make the overall hardware cost effective.
* To use the inked stylus similar to actual marker which will be more user friendly
* To use custom made stylus-only as input in the hardware, hand input and gestures are avoided to maximize accuracy.
* To provide a mechanism to calibrate the hardware in a specific range of dimensions of touch surface which will make sure the flexibility.
* To minimize the size of the hardware by using more adjustable and portable hardware components.

## Scope

The system provides a tangible user interface which is specially designed for medium to large surfaces typically 400 square inches to 1000 square inches. There are many areas according in terms of scope to where the system can be implemented.

Education institutions where it is a challenge yet very useful to provide a user-friendly touch interface to record the lecture animations. By using the touch system, a lecture animation can be recorded with no overhead of latency because stylus is inked and user do not have to write on digital screen rather than he has to write on the conventional white board.

In industrial presentations and meetings, a typical touchpad can be helpful while writing in digital media but when using the conventional board for writing, it can be challenging because of large surface area of board.

In fact, the system can be used where there needs a large touch interface and environment is of varying dimensions and where the user needs to record the writings of inked board marker.

## Summary of existing work

There are many virtual interfaces introduced and available in the market such as DiamondTouch[1], HoloWall[2] which are projector based touch-screen interfaces. Touch interfaces such as The design of infrared touch screen based on MCU[3] and SmartTouch[4] uses infrared illuminators and infrared cameras. Another technique is Turn Any Display into a Touch Screen Using Infrared Optical Technique [5]. In this technique the fingertip is extracted using color filtration matching to the skin. The biggest contour is the touch surface.

## Problems faced

There were several problems faced during the development of the system.

### Selection of technology

There were two major problems of this domain

#### Choice of software technology

There were several application frameworks available in languages majorly C++, C# and python. Choice between the frameworks and libraries of the same language was also difficult. The purpose behind the software choice was to make the code more portable and efficient and to exploit the features the modern computing hardware available such as utilizing multi-core using multi-threading.

#### Choice of hardware technology

The system was aimed to have less hardware latency. For this, highspeed cameras i.e., higher framerate cameras needed to be implemented in order to get position of contact area after very short intervals of time. The available hardware in the market was expensive and not tested significantly.

### Range of marker hardware

Marker hardware did not need to have large range because mostly it will be close to the writing surface. The data transfer rate of marker transceiver needed to be high to achieve less latency.

### Hardware calibration

While setting up and calibrating the hardware in the environment of varying dimensions, two major problems occurred.

#### Gimbal lock

Gimbal lock is the loss of one degree of freedom in a three-dimensional, three-gimbal mechanism that occurs when the axes of two of the three gimbals are driven into a parallel configuration [6]. After calibration, the system may lead to a situation where marker tip is logically not in contact to the touch surface where it is supposed to be.

#### Order of axes in calibration

While calibrating the marker hardware, the order in which offset is given to the axes is much significant. Even if the same amount of offset is given in different order of axes, the resulting rotation will be different. For instance, 30° X-axis first then 30° Y-axis offset will result in different rotation as compared to 30° Y-axis first then 30° X-axis.

## Solution to the problems faced

The problems were solved by narrowing down the problem area and understanding the problem well.

### Selection of technology

There were two major problems of this domain

#### Choice of software technology

C# Windows form application was appropriate due to following reasons

* Different libraries for hardware and computer vision were readily available and plugin packages were freely available on plugin store.
* Windows from application takes less memory and hence faster response can be observed. Also, it is much easier to modify the control’s attributes. Hardware support for RS-232 [7] USB to serial is available as separate control.

#### Choice of hardware technology

PlayStation eye [8] camera was used as marker hardware position tracking camera because of the following characteristics

* It can capture video at fairly high frame rate i.e., 120fps.
* It is mainly used to track the moving game controller and that is what it is going to do in the system.
* It is available at fairly low price as compared to other cameras of equivalent specifications.

### Range of marker hardware

The range of the marker hardware was also made it challenging in choosing the transceiver hardware. The hardware needed to be relatively small, cheap, have higher speed of transfer rates and a few meters of range. The nRF24l01 transceiver module was appropriate because it had all the features that were required.

### Hardware calibration

While setting up and calibrating the hardware in the environment of varying dimensions, two major problems occurred.

#### Gimbal lock

This problem was solved by using the Quaternions [9] while calibration. The interconversion of Quaternions to Euler angles [10] made it possible to avoid the gimble lock.

#### Order of axes in calibration

This problem was solved by using the Quaternions mathematical formula to model the orientation. Unlike Euler angles, Quaternions do not include explicit angles to represent rotation

# References

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