Digital Pen with Multi-purpose Mouse Functionality

A Thesis
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by

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Declaration

We hereby declare that this thesis paper titled 'Digital Pen with multi-purpose mouse functionality' is done only by our research along with the research's implementation results found by us. Any material of research or thesis used from other sources has been mentioned along with their references. This thesis has not been previously submitted for any degree by anyone else. This thesis report is being submitted to the Department of Electrical and Electronic Engineering of BRAC University.

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Abstract

Proposal for building a wireless digital pen, which can work like a computer mouse, but more elegantly with the help of image processing (on MATLAB). This pen can be used for writing, painting in classrooms, conferences, at presentation etc. This pen contains two buttons just like a mouse, which is implemented by using two circuits, one is the transmitting circuit and other one is the receiver circuit. The pen will work in co-ordination using both the hardware and the image processing codes. The project includes a webcam which detects the Light Emitting Diode (LED) of red color which is placed on the tip of the pen within the detectable area of the webcam.

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Abbreviations:

LED: Light Emitting Diode

ASK: Amplitude Shift Keying

BJT: Bipolar Junction Transistor

RF: Radio Frequency

SW: Switch

TE: Transmission Enable

OSC: Oscillator

NO: Normally Open

NC: Normally Closed

COM: Common

TBCF: Threshold Binary Conversion Factor

RGB: Red, Green, Blue.

NTSC: National Television System Committee.

Chapter 1

Introduction

1.1 Motivation:

The study system in Bangladesh is still quite an analog one. Uses of digitalized teaching materials are only seen in universities but that is also not a huge amount of usage. Many countries are using digitalized materials for teaching purposes which is making the life of students as well as teachers easier. The students have to write down lecture in their notebooks and for that they cannot fully pay attention the teacher's lectures as well as cannot fully understand the lectures. This system does not bring a great output. The teacher also has to write and then after sometimes has to mop the board clean again. These are quite wastage of time both for teachers and students. Moreover, the mouse which is used in computers is not that much efficient while it comes to writing or drawing something in the paint or other software. So, to solve the problem with the mouse's efficiency and the problems of writing lecture on board for not only teachers but also students, we came up with the idea of digital pen with multi-purpose mouse functions. This pen has all the general functionalities of a computer mouse like cursor movement, left click and right click. It is also pen shaped which will help to write or draw with it just like a pen. For the problem of teachers and students, with this pen teachers can write the lectures in paint or other software instead of board. The lecture can also be saved in the computer after writing and then the students can take it from there. Thus, the students do not have to write down lectures in their note books and they can fully concentrate on the lecture as well as understand it properly. The teacher's will also be able to write their workings without mopping the board and the pen will also serve the purpose of a mouse. Our multi-purpose functioning mouse will able to solve all these problems with the help of image processing and make lectures digitalized as well as easier for students as well as teachers.

1.2 Background:

Analogous lecture system is not only time consuming but also hard to concentrate on as the students have to take notes of the lectures constantly. Our country is not much efficient while it comes to digitalized classrooms. In school, colleges the teachers still write using chalks and write on blackboards. In universities, classrooms are digital to quite some extent but teachers still have to write on boards while giving lectures. Our country is said to be digitalized within few years but the lecture system is still analogous. Other countries are making their lecture system digitalized. Our country should do the same. Giving up the age old tradition of writing on board has become a must now to save time and make the students concentrate solely on lectures. If a digitalized pen with mouse functionalities is introduced in classrooms, the problems of writing while listening to teacher's lectures will be over. With the help of Image Processing, the pen can be used to write in paint or other software just like we write like a pen and save the lectures in the computer sparing the students from writing while listening to lectures. The pen can also be used as a mouse as it has mouse functionalities. So the use of another extra mouse is not needed. By introducing this pen, lecture can be made digitalized.

Chapter 2

History and Literature Review

Pen has been one of the best inventions in modern civilization, an amazing invention that changed the way of recording information thousand years ago. In the modern world, when the digital technologies around us are getting faster, pen and paper are not competent enough. It is always easy to take short notes but problem occurs when you have to take detail notes and have to understand something at the same time. For instance, in classes, meetings or in seminars, when we have to take note and understand the lecture, it becomes quite difficult to do both at the same time. Until now, what we can do is either we can take note and understand later or we can understand the lecture and miss the notes. Then if we need to save it for further use, till last decade all we can do is to type it to save it in computer.

A digital multipurpose pen can be a better solution to solve the problem. A digital pen, which will be fatter than ordinary pens, will have electric circuits and wireless technology. Normally there are two types of digital pen: one that uses wireless positioning technology allows user to write everywhere and other type that needs a specialized surface or paper to write on to track the pens movement. The benefit of 1st type pen is user can use it over any surface and the 2nd type pen lacks in compatibility. The type of pen we are working on needs a surface. We can use it over a podium or a table in class room or in auditorium, beneath the surface there will be a camera which will work through image processing technology. [1]

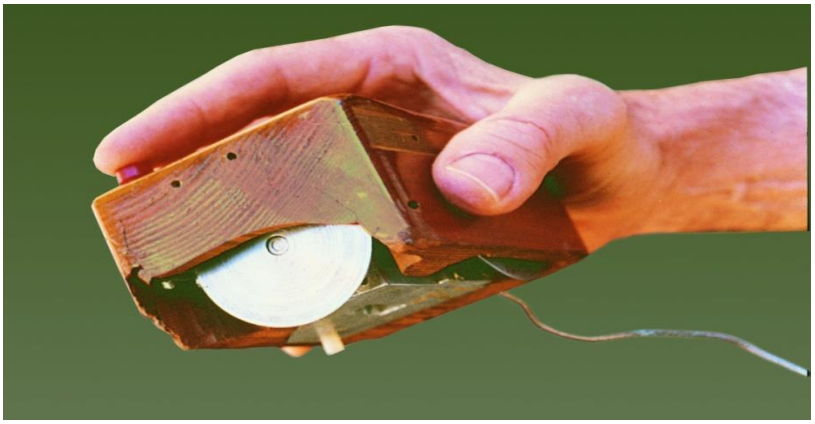

Fig 2.1: Ball Mouse in 1964

It wasn't so long ago when people used keyboard to type a command and to enter data as there was nothing called mouse to give command. It was invented by Douglas Engelbart in 1964 and further developed by Bill English in 1970. Today's optical mouse was known as known as 'Ball Mouse'. [2] Using pen instead of mouse is obviously a much better technology. If we talk about 2nd type pen, the pen and specialized paper combination pen which is known as pen computing then it has very long historical root. For instance, in 1888, the telautography granted their first patient on an electric device used for handwriting. In 1942, somewhere in U.S. researchers have worked on touch screen for handwriting. In the middle of 1950, someone named Tom Dimond exhibited an electric tablet with pen for computer input. In late 1960s, an American computer scientist proposed a notebook using pen input. Between 1989 and 1992, huge progress was there on developing a pen instead of mouse.

Fig 2.2: A pen Computer named ThinkPad Designed by IBM in 1993

People predicted that this technology will challenge the traditional mouse based computers. In the mean time IBM brought ThinkPad, a pen computer slate to run and use PenPoint. In 1993, Apple brought Newton messagePad in the market, having numerous innovations on hand writing recognition technology. In last 20 years, many researchers have been done and drastic improvement has occurred. [3] A group of cadets from United States air force academy also worked on a project of digital pen for taking notes in the classroom.[4]

One of the popular digital pens of this decade is Wacom Bamboo Spark, which can be used on any paper surface and can monitor what user is writing and also can store in its memory up to 100 pages data. Another best digital pen we have got so far is Neo smartpen N2 based on IR camera can detect writing only on standard Anoto dot pattern paper. It can store up to 1000 pages and have 8 interchangeable colors. Though Black ink pen is a bit bulkier than other pens, it helps to draw images on real paper with its accurate sensors and syncs data with connected pc and mobile. Moleskine smart writing set comes with a combination of notebook which enables user access to some extra facilities like detecting different dot patterns which lets writer to know which page he is on. Wacom inkling digital sketch pen is another popular pen that designed aiming to the visual artists. [5]

Livescribe 3 is a digital smart pen that has small infrared camera and built-in microphone. Through this microphone, it records what's being said and links it with what is being written. Besides livescribe also can record sound up to 800 hours and has some app like calculator. Livescrive has recently launched another smart pen named 'Sky wi-fi smartpen' which enables user to take written or audio notes and directly sends them to evernote account. It also lets user to competently access their written notes and recorded audios from smartphones and computers. [6]

Chapter 3

Overview of System

The overview of the whole system is shown below using a proper block diagram and every block are described on later part.

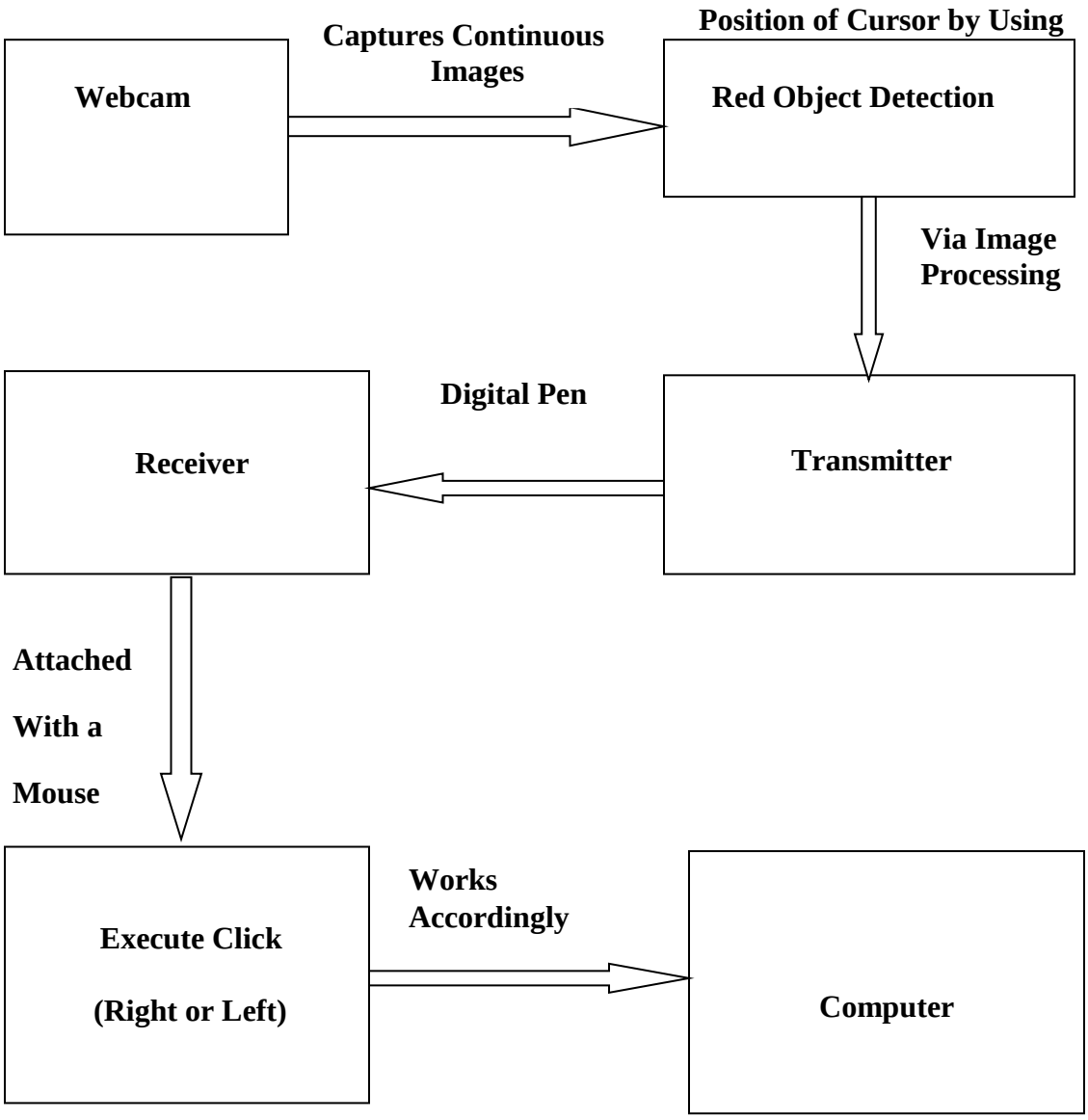

Fig 3.1: Block Diagram of the Whole System

Firstly, the LED of the pen is turned on and the webcam is turned on simultaneously to detect the movement of the LED. The webcam is placed under the glass or transparent surface on which we are going write or draw something. On the surface which is above the Webcam, we have to perform the cursor movement which will be sent via the Transmitter circuit. The Webcam captures continuous images of the operations which are performed on the glass surface above it. Then, the system is ready to be carried out to the next phase.

In this part of the system, the position or movement of the cursor is detected via Red Object Detection process. We used a Red LED which is placed on the tip of the transmitter circuit by which we are focusing on the movement of the curser. With the help of Image Processing, the movement of the Red LED is detected. This portion is solely dependent on Image Processing technique of Red Object detection which is done using MATLAB. Without this part of the system the cursor movement which we want to perform with our digital pen will not be possible.

The execution of left/right click is done by the transmitter circuit when needed. The transmitter circuit consists of two switches which are used for the clicking action of the pen. After a click is executed, the encoder encodes the signal so that any transmitter, transmitting signals of the same frequency does not interfere with the RF receiver. The transmitter circuit sends the encoded signal of the execution of the clicking action via ASK modulation to the receiver circuit.

The receiver circuit receives the signal via RF Receiver and decodes the encoded signal. The receiver circuit is connected with the circuit of a mouse, which is connected with the computer. The RF receiver detects the signal of left and right clicks and sends the signals to the decoder.

After the signal is being decoded, it is sent to the relays through a BJT. The execution of left or right click is mainly done by the relay with the help of a mouse circuit connected to it. So, the relays are responsible for the execution of one of the core operations of the project which is the clicking action of the pen.

After that the signal is sent to the computer, the output can be observed with respect to the input. By implementing the above mentioned steps, the digital pen functions and carries out various operations like execution of clicking action, drawing, or writing on paint or any compatible software.

Chapter- 4

Hardware Components

4.1 Introduction:

The main intention of our project is to make a pen which will have the basic functionalities of a mouse and it can also be used to write or to paint in classrooms, conferences, meetings etc. with the help of MATLAB software. In this section of the paper, hardware part of the project is described briefly specially the hardware components of the project. Basically, the project has two main parts which are the transmitter circuit and the receiver circuit. The pen has two push switches used as click buttons which are implemented by the help of the transmitter and the receiver circuits. The co-ordination of hardware part and the MATLAB code makes both the click and the movement of cursor happen.

A light emitting diode (LED) is used on the tip of the pen for the detection of it by the webcam for the cursor movement. The RF transmitter circuit recognizes click on the push switches which are used as left click and right click button. Then, the transmitter sends the signal which was generated by the click to the receiver circuit by using ASK modulation method. Both left and right clicks are executed in the same way.

An encoder is used in the transmitter circuit to encode the signal with a 750K or 1M resistor for the encoder's smooth running without it being burnt. The decoder of the same model is used in receiver circuit. A 33k used for the decoder circuit to work perfectly. A battery is used for power supply for the transmitter circuit. Two relays are used for left and right click execution in the receiver circuit. BJT is used for switching for the relay. Two click buttons are used for turning the LED ON and OFF.

4.2 Circuit Description:

In this part of the chapter, the representation of the two parts of the circuit is given in detail. The description of the transmitter and the receiver circuit of our project are given in a vivid way along with proper diagrams of the two circuits to show how these two circuits work. The transmission and reception circuit basically have to work at the same time to make the click and movement of cursor happen.

The RF transmitter circuit works as the pen whereas the receiver circuit is connected with the mouse. The receiver circuit has to be connected with a full working circuit of a mouse which will be connected with the computer or laptop for executing the right and left clicking operations of the digital pen. With this signal sending and receiving actions between the transmitter and receiver circuit, we are able get our desired result along with the help of MATLAB which are to give the functionality like a computer mouse and to write or to paint on paint software in classroom or conferences.

The success rate of the project mainly depends on the coordination between the transmitter and receiver circuit. So, this can be understood that these two circuits are the core part of the digital pen as well as essential for the execution of our project. A detailed description of these core parts are given in the following part of the chapter.

Transmitter Circuit:

The transmitter circuit is one of the main parts for the execution of the digital pen with multi-purpose mouse functions. This part is responsible for the transmission of the signal of left and right clicks on the push switches of it to the receiver part by which we implement the operation of right and left click on the computer.

If the movement of cursor is needed, the signal of the movement of transmitter circuit has to be sent to the receiver circuit by the transmitter circuit. Transmitter circuit has to send the signal of the movement of the circuit with the coordinates of the movement. By the coordinates sent by the transmitter circuit, the movement of the cursor happens in accordance with the movement of the transmitter circuit. If write or paint has to be done by the digital pen, it will also have to be done after the transmitter circuit has sent the movement coordinates of the transmitter circuit to the receiver circuit. If the transmitter circuit fails to provide the click signals or the coordinates of the movement of the transmitter circuit via camera or webcam, the click operations or cursor movement do not happen on the computer screen. The movement of the transmitter circuit has to be within the range of the webcam for capturing images of the movement for the image processing part. So, the transmitter circuit can be considered as the initial point and the most important part for the execution of cursor movement, right/left clicking, writing or painting operations.

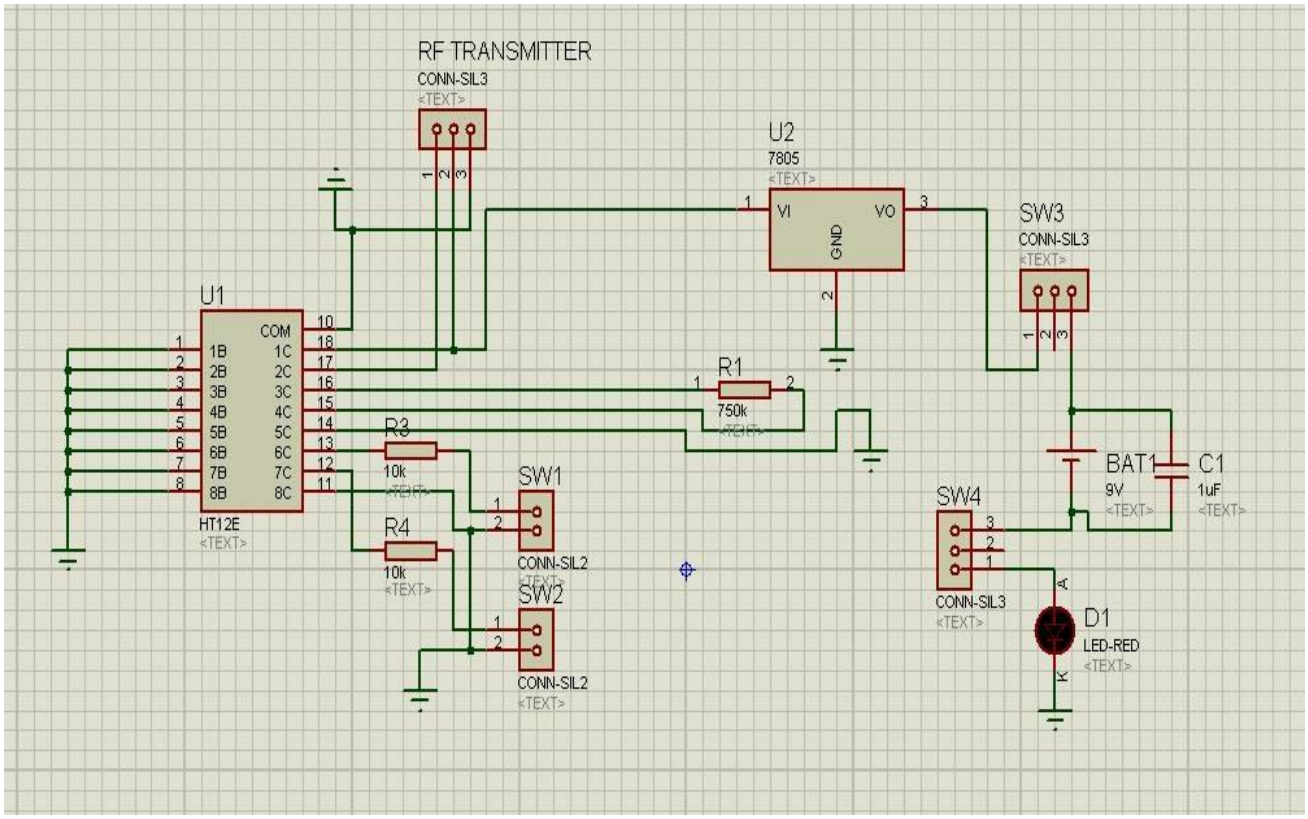

Fig 4.1: Circuit Diagram of the Transmitter Circuit

In the circuit diagram of transmitter circuit, it can be seen how the whole transmitter circuit is constructed. The connection between the components of the transmitter circuit can be understood from the diagram. The transmitter circuit has two Click Switches, two Push Switches, an RF Transmitter, an Encoder, a Voltage Regulator, two 10K Resistors, a 750 k Resistor, a Capacitor, a Red LED and a 9V Battery.

To run the whole transmitter circuit, there is a 9V battery connected with a 1uF capacitor. To turn ON and OFF the Red LED, there is a click switch (SW4). The other switch is for turning the power of the battery to ON or OFF. One of the two switches (SW3) is connected with the positive side of the 9V battery (pin3) and one of the three switch pins is grounded (pin2) and the other pin (pin1) is connected with the output of a Voltage Regulator which gives constant 5 volts to the RF transmitter. One of the three pins (pin3) of the other switch (SW4) is connected with the negative side of the 9V battery. One of the remaining two pins is grounded (pin2) and the other one (pin1) is connected with the Red LED. The other side of the Red LED is grounded.

So, the output of the Voltage Regulator supplying a constant 5V to the RF transmitter whereas the input of the Voltage Regulator is connected with the Vcc (pin2) of the RF transmitter. The remaining ground pin of the voltage pin is grounded as it should be. The ground pin (pin3) of RF Transmitter and the ground pin (pin10) of the Encoder are grounded together. The DATA pin (pin1) of the transmitter circuit is connected with the DATA pin (pin17) of the Encoder are connected together. Data from the encoder comes to the RF transmitter.

Pin1-Pin8 of the HT12E Encoder are all connected together and grounded. This is the encoder which encodes the signal of the movement and the signal of right/left clicks for sending it to receiver part. Pin 15 and pin 16 are connected with a 750K resistor. Pin 14 is grounded as it is not used for any purpose. Pin 12 and pin 13 are both connected with two individual 10K resistors. The other sides of the 10K resistors are connected with pin 1 of both the push switches (SW1 and SW2) individually. Pin 11 is connected with pin 2 of both the push switches (SW1 and SW2) and then they all are grounded.

Receiver Circuit:

The RF receiver circuit receives right/left click signals as well as the coordinates of the RF transmitter circuit's movement for moving the cursor from the RF transmitter circuit. When RF receiver receives the signals from the RF transmitter, it sends the data which it received to the HT12D decoder for decoding the received signal. The decoder then passes the signal to the relays where the relays make a click sound to confirm that the right or left clicks happened if left click or right click operations are done. The two relays are connected with the left and right click buttons of a whole circuit of a mouse which makes the operations of right/left clicks in the computer or laptop. The movement of mouse cursor also follows the same kind of process. Coordinates of the movement are sent to the receiver circuit from transmitter circuit and then sent to the relays. From relays, they go to the computer or laptop for the cursor movement.

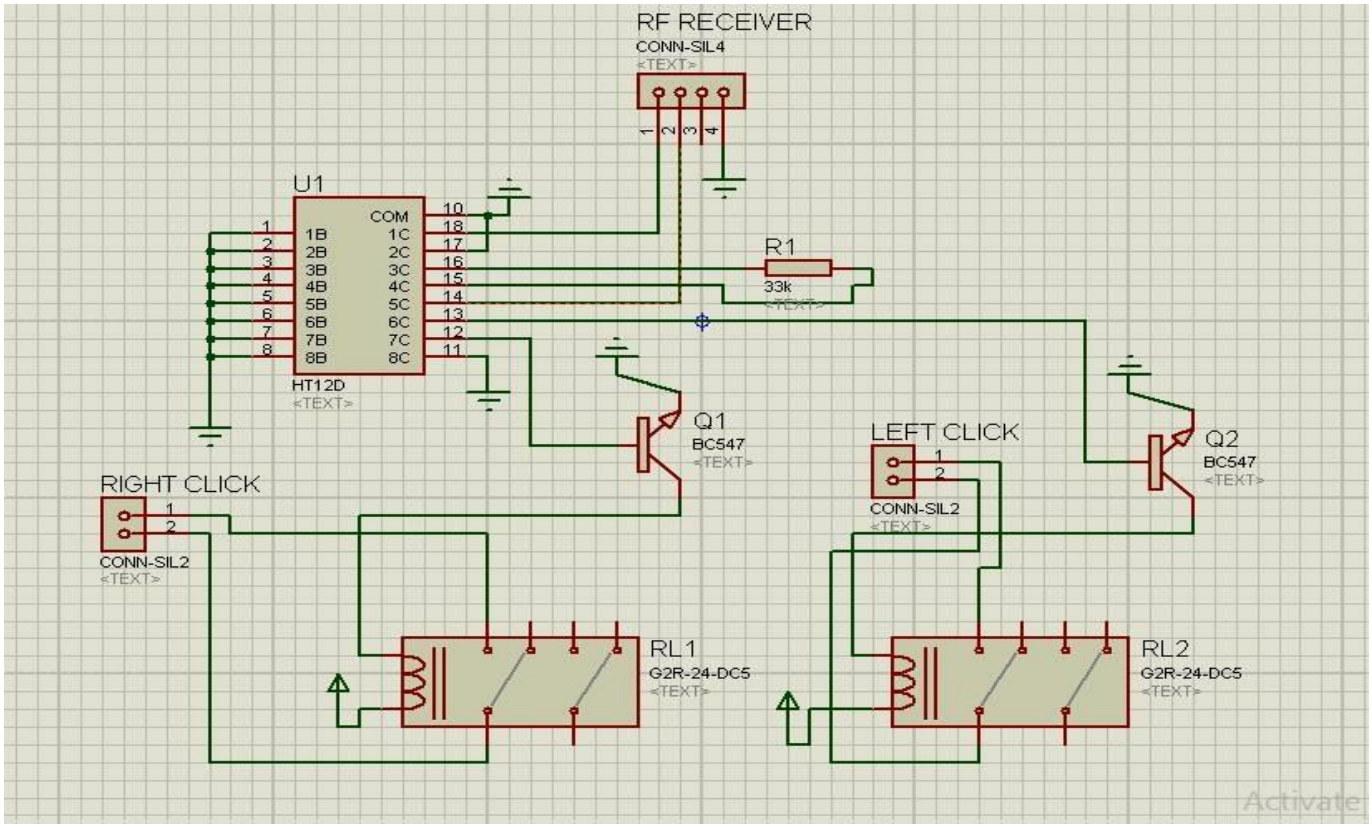

Fig 4.2: Circuit Diagram of the Receiver Circuit

The Receiver circuit has two Relays, a Full Mouse Circuit, two BJTs, a Decoder, a 33K Resistor and an RF receiver. In this circuit, the DATA pin (pin1) of the RF transmitter circuit is connected with the DATA pin (pin18) of the decoder. The Vcc pin (pin2) of the RF transmitter is connected with the decoder's Vcc pin (pin14). One of the receiver's two remaining pins are grounded (pin4) and the other one (pin3) is unused.

A resistor for HT12D decoder is used in the circuit which is connected with pin 15 and pin 16. Pin 17, pin 10 and pin 11 are grounded. Pin 13 is connected with the base of a BJT (Q2). Pin 12 is connected with another BJT (Q1). Pin1 – pin8 is connected all together and then they are grounded. Emitters of both the BJTs are grounded. These two are both NPN transistors. Collector of Q1 BJT is connected a Relay's (RL1) input. Similarly, the collector of Q2 BJT is connected with the other Relay's input which is RL2 Relay. Power is given into both the relay's input pin. Both the pins of the Right click of the whole mouse circuit are connected with two output of the relay (RL1). Likewise, both the pins of the whole mouse circuit's left click are connected with the outputs of the other relay (RL2).

4.3 Component Description:

In this part of the chapter, a short description of the important components will be given along with their works in the project, data sheets and diagrams with pin configurations. Descriptions of the components are given in two parts which are Transmitter Circuit components and Receiver Circuit components. Descriptions of important parts of transmission circuit such as 750K Resistor, HT12E Encoder, FS1000a Transmitter, 9V Battery and Vero board are given along with some important parts of receiver circuit which are BC547 BJT, Relay, HT12D Decoder and Fs1000a RF Receiver.

Transmitter Circuit Components:

750K – 1M Resistor:

These types of resistors are normally made out of carbon, metal or metal-oxide films. Resistors from 750K-1M range has to be used in our circuit with the HT12E Encoder. Without this resistor the Encoder does not work properly. So, for making the Encoder run without any interruptions, the 750K resistor has to be used.

9V Battery:

This 9V battery is suitable for high voltage devices[7]. For our project, we used this 9V battery for providing the desired power for the whole Transmitter circuit to run. However, whole 9V is not needed. This battery supplies 5V for starting the RF Transmitter and Encoder though a voltage regulator. This battery is connected with a capacitor in the transmitter circuit.

LM-7805 Voltage Regulator:

7805 ICs are one of the fixed linear voltage regulators ICs which gives constant 5 Volts. '05' in the IC's name means it can only provide constant 5 Volts. If input is given in a circuit but output of the circuit is not as it was desired, this means the input's value might have fluctuated within the circuit and the output will not be perfect. ICs like 7805 give the solution to this fluctuation of inputs within the circuit. These ICs provide constant 5 Volts for getting the desired output. Pin 1 is its input pin through which 5V-18V can be supplied in the input [8]. Pin 2 is the ground pin. Pin 3 is the output from where we get the regulated output of 4.8V-5.2V [8]. In our circuit, we use this regulator for providing constant 5V for the RF Transmitter circuit and the Encoder. This IC ensures no fluctuation of output and we get the perfect output.

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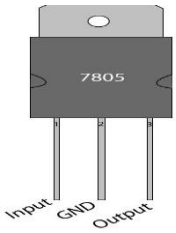

Fig 4.3: 7805 Voltage Regulator

Vero Board:

Vero board is ideal for building a IC based circuit on it. For building a prototype of a system or developing it we need the help of Vero board. Vero board is made of Copper clad laminated board. In Vero board, we get shorted connection in parallel. All Vero boards have a thickness of 1.6 mm with Hole grid of 2.54×2.54 mm and Hole diameter of 1.02 mm. It has a copper thickness of 35um. In every tenth inch of a inch part holes and tracks are spaced. All the holes in a row are connected by copper strips and have to cut up if continuous holes are not wanted. For hardwiring components, common signal lines are required which are provided by the Vero board. It has the perfect size and gap between hole and tracks for connecting ICs easily [9]. Our project is an IC based design, so it was easier for us to construct the circuit on the Vero board because of its connection techniques.

Fig 4.4: Vero Board

HT12E Encoder:

HT12E Encoder is one of the integrated circuits of 2^12 series encoders. It is paired with 2^12 series Decoders. One of its main usages is for RF interfacing. While working with HT12E, we get serial output if we give parallel input. 12 bit parallel data are encoded into serial data and transmitted through RF Transmitter. 12 bits consist of 8 address and 4 data bits. In our project this Encoder is used for transmitting through RF Transmitter. How it is connected with the other parts has been described in the previous part of the chapter.

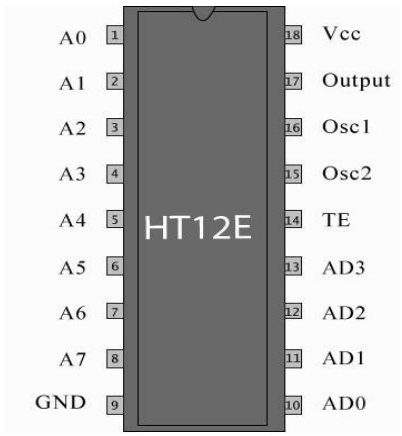

Fig 4.5: HT12E Encoder

TE is transmission enable pin of the encoder which is active low and when a signal is received it transmits the signal over medium. TE is kept high until the final transmission cycle is completed. Before that, TE had to be kept low for transmission cycle. 4 word transmission cycle is received in TE for the initialization of the HT12E Encoder.

A0-A7 pins are 8 bit address pins for input and pin 9 is grounded. AD0-AD3 pins are 4 bit data pins for input. TE is the Transmission Enabler pin which is set to active low during whole process of encoding. There are two pin named oscillator OSC2 and OSC 1. Between those two OSC2 is the oscillator input whereas OSC1 is oscillator output. Vcc pin is the pin where the supply voltage is given which 5 Volts is coming through a voltage regulator constantly. Output is the Serial Data output pin.[10]

RF Transmitter (Fs1000a):

This is one of the most important parts of this project as it is responsible for transmitting the signal of left/right clicks as well as the coordinates of the movement of the mouse cursor. There are 3 pins in the RF Transmitter which are Data Pin, Ground Pin and a Vcc Pin. Its size is 19×19 mm, operating mode is Amplitude Modulation and transfer rate is 2400bps. This transmitter's working range of frequency has to be close to 433Hz to work perfectly. The transmitter input voltage has to be between 3V-12V.

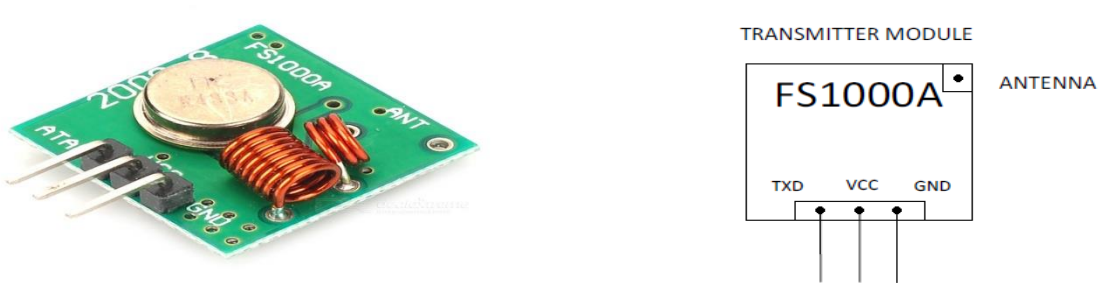

Fig 4.6: FS1000a RF Transmitter

If we set the transmitter data pin to high, it will make a radio transmission which will make the data pin of the RF receiver high. ASK modulation technique has been used for making the radio transmission.[11]

The RF transmitter transmits the radio transmission using ASK modulation. Amplitude Shift Keying is a modulation process which separates a signal to one or more discrete amplitude level. If the sequence is a binary sequence, one level is almost zero whereas the other level is congested burst of sinusoids. Discontinuity is found at the transition points. Some of these signals might have unnecessary wide bandwidths. By band limiting process which is introduced before transmission rounds of the discontinuities.

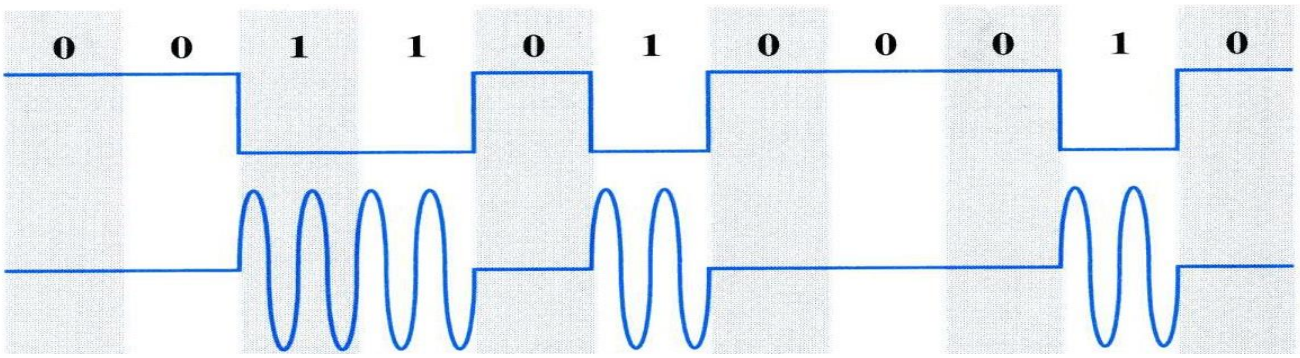

Fig 4.7: ASK Modulation

The data rate is often happens to sub-multiple of the carrier frequency. Not having a constant envelope is one of the disadvantages of ASK modulation. This makes the signal processing more difficult. However, this problem can be solved by the use of envelope detector.[12]

Receiver Circuit Components:

Relay:

In our project, we used double pole double throw relay which has 8 terminal points. COIL, COIL, COM, COM, NO, NO, NC and NC are the 8 terminals of the relay.

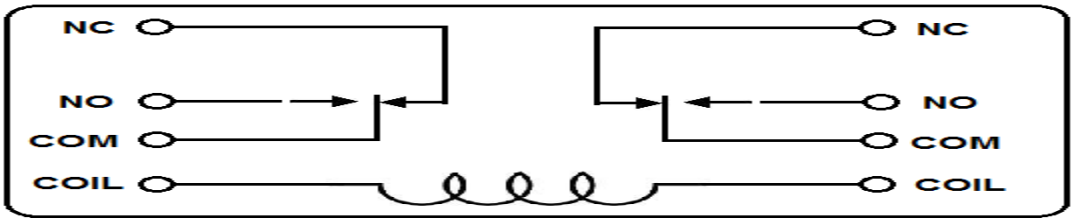

Fig 4.8: Relay Terminals

The COIL terminals can be considered as the input for the relays. In these two terminals, voltage is given to power up the coils. These two terminals are not polarity sensitive unless it's a diode.

The COM is the common terminal of the relay where the first part of the circuit is connected. The COM has continuity if the relay does not have power.

NO is the normally open switch. The device which will receive power from the relay is connected with it. NO is ON if the relay is ON and NO stays OFF if the relay is OFF.

NC is the normally closed terminal. The device connected to it is ON when it is OFF and OFF when it is ON.[13]

HT12D Decoder:

HT12D Decoder is a 2^12 series decoder integrated circuit. It is paired with 2^12 series encoder. It decodes the 12 bit series data to again parallel 12 bit data. In our project, we used the decoder to decode the data which was send by the transmitter circuit's HT12E encoder.

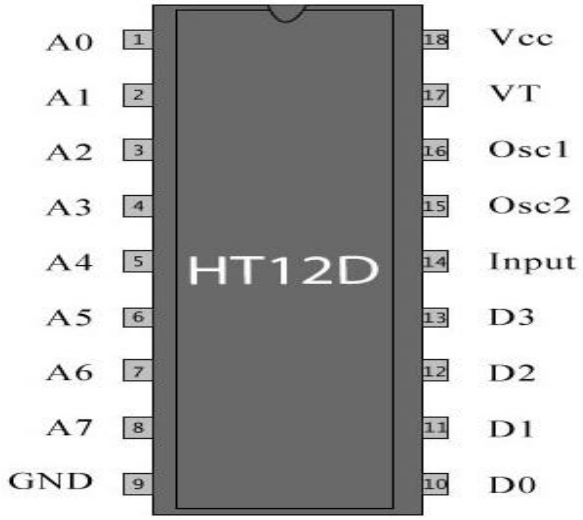

Fig 4.9: HT12D Decoder

A0-A7 pins are the eight address pins and pin 9 is grounded. Pin 18 is the Vcc pin whereas pin 14 is the input pin. D0-D3 pins are four DATA pins. There are two pins which are OSC1 and OSC2 which are pin 16 and pin 15 of the HT12D consecutively.

RF Receiver (FS1000a):

The RF Receiver circuit receives the radio transmission sent by the RF transmitter circuit then sends it to the decoder for decoding the signal. The Receiver circuit the left or right click signals and the coordinates of the transmitter circuit's movements for sending it to the computer for executing the operation ultimately. The receiver has three pins like the transmitter circuit. It has a Vcc, a ground and a data pin. This receiver operates at 5 Volts and use only 4mA current. The receiver's size is 30*14*7mm and it has a sensitivity of -105 dB.[11]

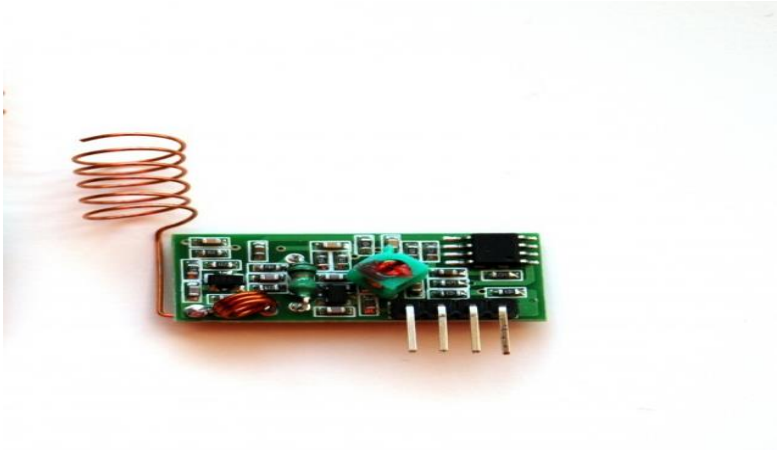

Fig 4.10: FS1000a RF Receiver

The data pin of the RF receiver is set to high by the Radio Frequency transmission by the RF transmitter circuit as the data pin of the FS1000a RF transmitter's data pin is also high.

B547 BJT:

B547 BJT is a Bipolar Junction Resistor which is used to amplify current and it's an NPN transistor. It has three pins which are Emitter, Base and Collector. Larger currents at collector and emitter are controlled by a merely smaller current at the base. In our project this transistor is used for amplification of current and switching. Fixed DC voltage is required for the terminals to be in the specific regions according to its characteristic curve. This is known as Biasing. The BJT is common Emitter configuration. The input signal is given at the base and amplified. The output is taken at emitter side of the BJT.

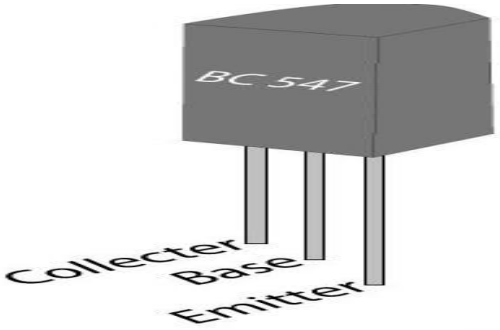

Fig 4.11: BC547 BJT

The transistor is biased for all input conditions. For switching purpose, the transistor has to remain biased for a digital signal being at the base of the BJT. If there is no base signal, the BJT is completely OFF.[14]

Chapter 5:
Software

5.1 Introduction:

The Mouse pen that we are making consists of two parts combined together. The movement of the mouse cursor and the red detection of the LED of the pen is determined by using two separate codes which is processed in MATLAB. The two codes are combined together to get the full output of the pen.

5.2 Algorithm:

The whole process requires an algorithm to run in a systematic manner. Figure 4.1 shows the complete flowchart of the overall mechanism of the MATLAB codes used. As the code starts, the camera begins to take continuous frames of [n] number which can be varied according to our necessities. Then the red object is detected which is described in chapter 5 and also the flowchart of the whole procedure is given in figure 4.2. As the red object is detected then the position is showed on the screen according to the coordinates. All users might not use a specific size monitor to use the digital pen and so the algorithm is made in such a way so that the resolution of the monitor is detected firstly and then the camera resolution is converted to screen resolution. The video is then showed and the mouse curser movement detection is observed as the system continues to run. As soon as [n] number of frames are taken then the camera stops to take more frames and clears all existing variable.

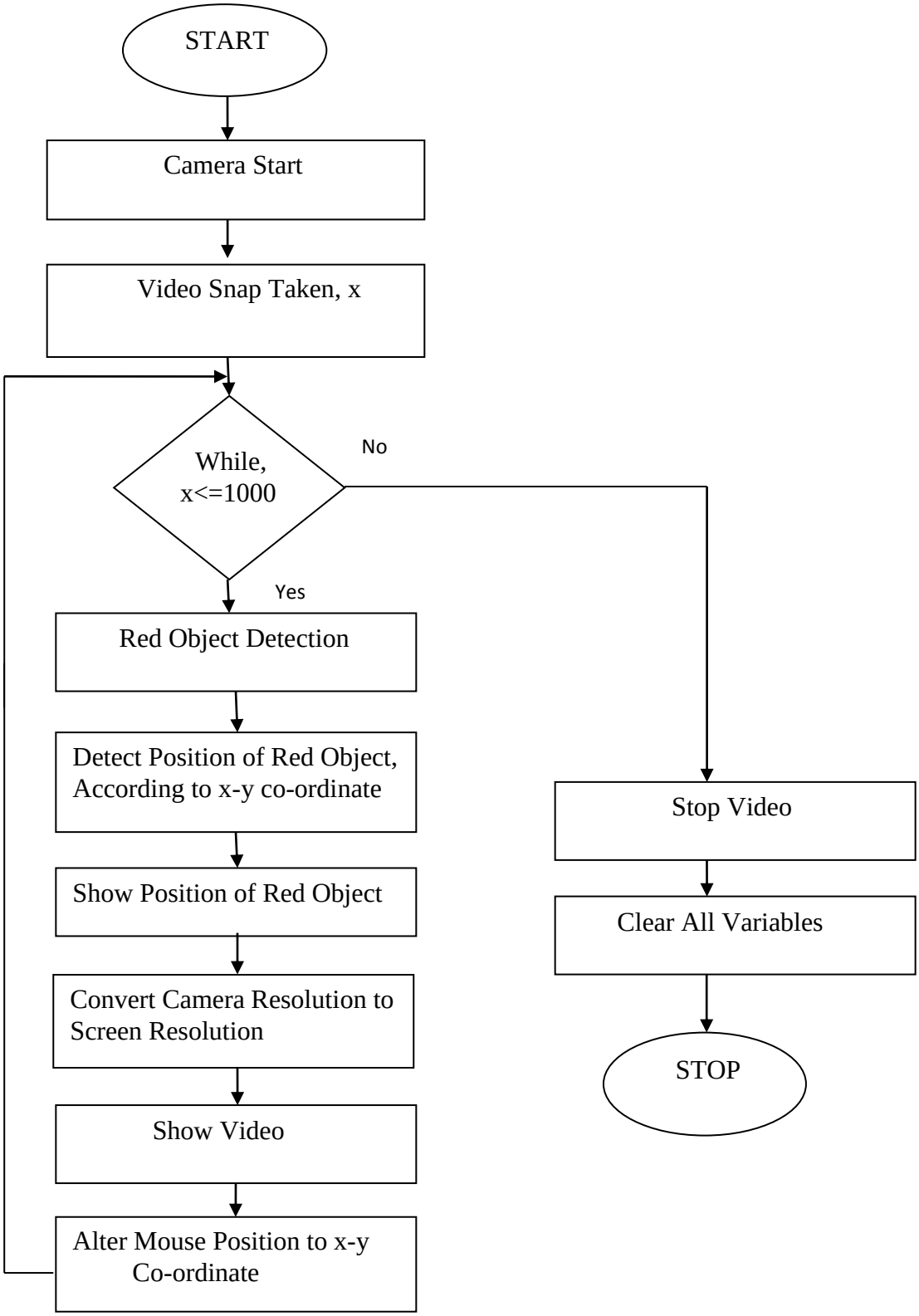

Figure 5.1: Red Image Detection and Moving the Cursor Code

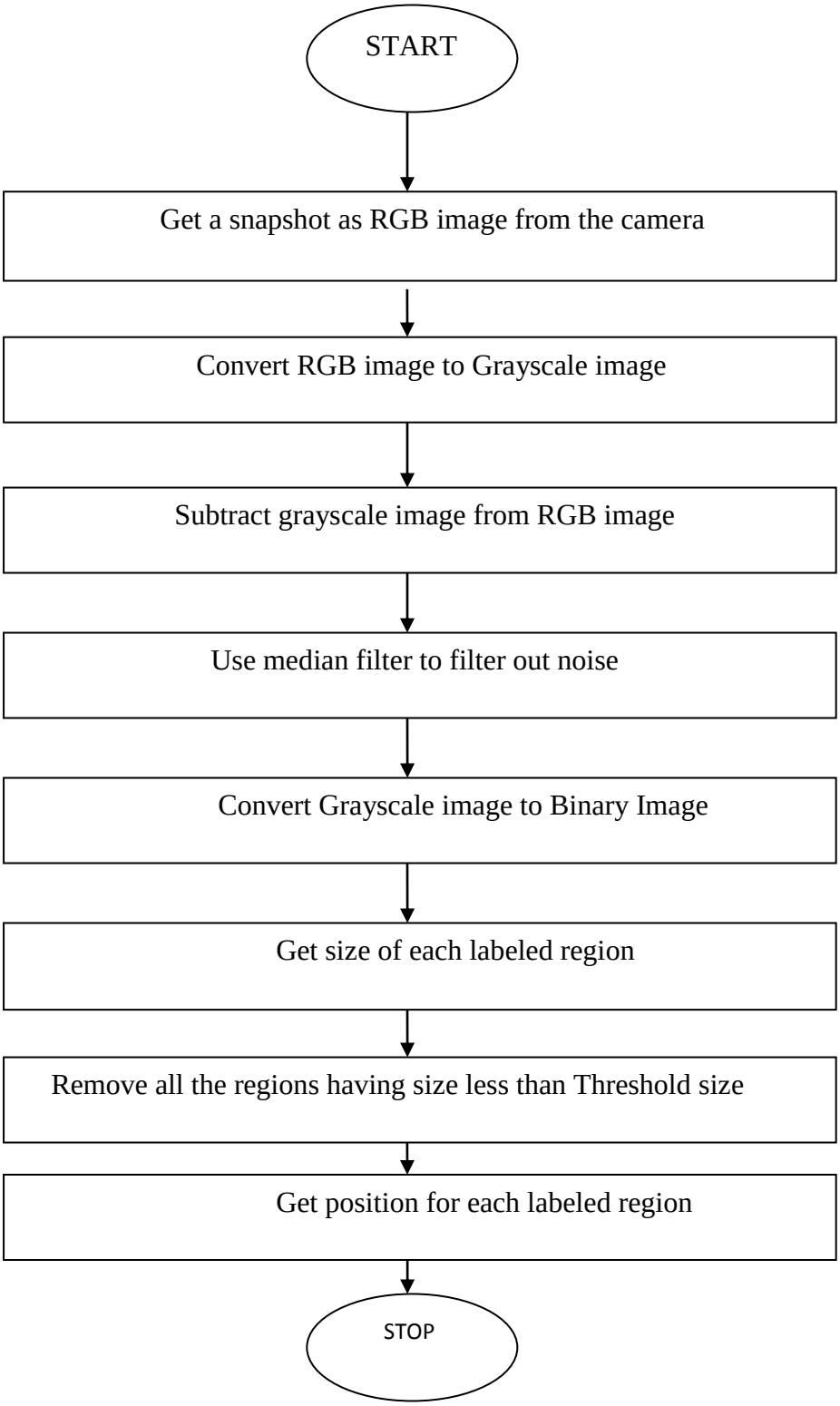

Figure 5.2: Red Object Detection Code

Chapter: 6

Image Processing

6.1 Introduction:

Image processing is basically a method to convert an image into a digital format so that alterations can be done for a better outcome [15]. This may be by enhancing the quality of the image or to get some useful information from it. It is a type of signal dispensation in which the input is an image, video or of any type and the output is also an image or the characteristics associated with it. The use of image processing is vast in this modern world and each and everywhere it is playing a crucial part in modern technology and also for medical purposes.

6.2 Description:

In our experiment we also used image processing to carry out one of the most important feature of our project and that is detecting then red LED which is done by the webcam. This is very precisely done as only red object/image will be taken in considerations and all other will be discarded out. All these can be done with the help of various steps which needs to be followed in order to get the complete outcome. To carry out all these steps smoothly a sequence is needed to be followed which will be given in hierarchy shortly. All these are done using codes and the image processing codes are executed in MATLAB software to get the results. Starting from detecting the red object/image from the surrounding and all the other steps that are carried out in the procedure to get the final output is listed in brief points below which is explained in later portions.

I. Get snapshot as RGB image from the camera.
II. Convert RGB image to grayscale image.
III. Subtract grayscale image from RGB image.

IV. Use median filter to filter out noise.

V. Convert Grayscale image to Binary Image (TBCF).

VI. Get size of each labeled region.

VII. Remove all the regions having size less than Threshold size.

VIII. Get position for each labeled region.

Get snapshot as RGB image from the camera:

After placing the camera in the correct position which will be preferred by the user as per necessity. The camera will be capturing continuous frames and the frames are saved in RGB color space. Certain things play an important role while taking the images. One is the frame rate the camera can capture. The better the camera used the more the frame can be captured per second. Thinking for the purpose of mass use frames are skipped in a certain number during the frame saving process so that a camera of low frame rate does not cause any problem. The second important fact that plays an important role is the speed of the process of the computer that is being used. The more the processing speed available the more smooth performance can be observed. All of these things are taken in consideration to avoid excess execution time and also the processing of every frame does not decrease the smoothness of the movement of the curser of the mouse. We set the values to a standard level so that a personal computer of performance below standard level can still access the benefits from this.

Fig 6.1: Get snapshot as RGB image from the camera

Convert RGB Image to Gray-scale Image:

The format of the images that are captured from the camera is RGB. RGB is a format consisting of three dimensions. As performance is one of the things that we are taking in consideration so our aim is to make the whole process as simple as possible for it to work faster. As the RGB images are of three dimensions in format so it takes a lot of computation space. So we came to a solution of converting the RGB images to gray-scale image whose pixel values specify intensity values. The conversion process includes each of the value of RGB color space is converted to gray-scale value in NTSC format [16] using the equation below.

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} [Equation: 1]$$

The letters means the following:

Y= Luminance. I= Hue. Q= saturation.

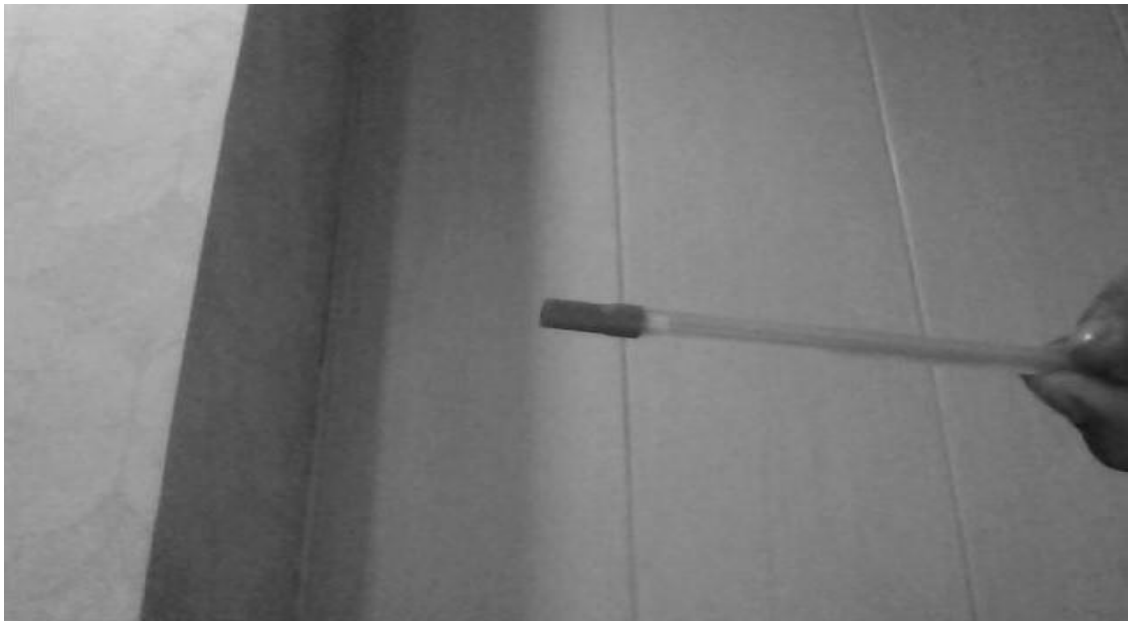

Fig 6.2: Convert RGB Image to Gray-scale Image

Subtract gray-scale image from RGB image:

The RGB image which is stored as 24bit image where the Red, Green and Blue image are of 8 bits each. The image can be stored in m×n×3 arrays which are for red, green and blue color component and for each pixel having m×n resolution. Each color component in an RGB array is in the range of $\{0,255\}$. The color component (0,0,0) of a pixel tells us that it is black and the color component of (255,255,255) of a pixel tells us that the color is white. An example will help us to understand the situation better. For example the RGB component of a pixel (10,5) are stored in RGB(10,5,1), RGB(10,5,2) and RGB(10,5,3) positions and let us consider that they contain pixels of 144, 197 and 152 respectively. If we consider equation 1 from above and suppose we are taking only Luminance (Y), the gray-scale value of that pixel is 176. In the RGB image the value of that pixel is 176 for red color component. Now the value of that pixel component (10, 5) position of the output gray scale image is the absolute difference between 144 and 176. Using this method every pixel value of gray-scale image is subtracted from every pixel value of RGB image of red color component. As a result it can be seen that the gray scale image where red color component from the previous RGB image gets a much higher pixel than the regions of other colors. So the Red region looks much brighter which can be considered as white and the other regions are much darker which is considered as black.

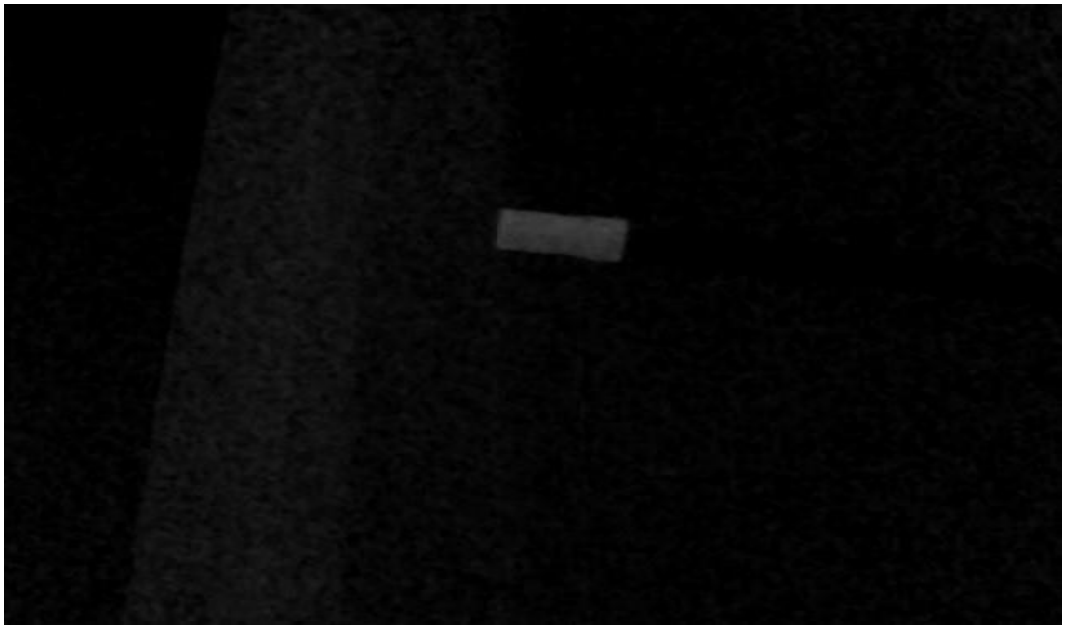

Fig 6.3: Subtract gray-scale image from RGB image

Use Median filter to filter out Noise:

Dust particles inside the camera and faulty charge-coupled device produces "salt and pepper noise" [17]. The name is given salt and pepper because due to this there are white and dark dots present in the image. Due to salt and pepper the pixels in the image is different in both intensity and color than the other pixels surrounding it. Noisy pixels have no relation with the surrounding pixels color. So reducing noise is an important issue. So we can diminish the noise by using a median filter [19]. The filter replaces the pixel by the median of all the filters in the neighborhood which is done by the equation given below.

$$y[m,n] = median\{x[i,j],(i,j) \in \omega\} \quad \text{[Equation 2]}$$

Here ω represents a neighborhood centered its location (m,n) in the image. Therefore the median of all the values of the pixels replaces the pixel at the center. The window used over here is a 3×3 matrix of pixels. This way the filter examines each pixel by pixel throughout the image. This method is very effective as it can diminish the noise without blurring the sharp edge of the image. By this way we can use this filter effectively to suppress the noise inside an image.

Gray-scale Image to Binary Image Conversion:

After implementing the above steps we need the binary image of the gray-scale image and for that a technique is followed which is known as 'Thresholding', This is a technique in which the interested gray level pixels are assigned with '1' and the rest are assigned with '0'. By using this the background can be separated from the object of interest. For this to be effective both the background and the object must have sufficient contrast and the intensity level of either the background or the object is known. The intensity characteristic in a fixed thersholding scheme gives the value of threshold which is known as "Threshold Binary Conversion Factor" [TBCF]. The ambient light intensity of surrounding environment affects the intensity characteristics of both the desired object and the background. The value of TBCF lies within the range [0, 1]. As ambient light intensity changes the value of TBCF also changes and it is found that there is a direct relationship between the ambient light intensity and the value of TBCF. So TBCF is

directly proportional to ambient light intensity. Therefore a modified range is found which is sufficient for red mark detection and the modified range is [0.04, 0.20]. If no red mark detected at first then the value of TBCF is increased gradually between the ranges of 0.04-0.20 until the red mark is detected.

Fig 6.4: Grayscale Image to Binary Conversion

Desired Red Mark selection and Position Identification:

As your motive is to get the red mark only for our purpose so the binary image components which have size less than the "Threshold size" is removed and this is done by converting the connected white pixels to black pixels, this results in another binary image. We can summarize the methods in short in the points given below.

Step1: To determine the connected components in the binary image.

Step2: To compare the size of each connected component.

Step3: Remove the objects that are less than the threshold size.

Now if we want to consider the two pixels are connected as one then the size of both the pixel values must be same and so they must have the same set of values of V for connectivity. Any gray scale or RGB image has a range of value. For example a gray-scale image has a range of V= {32, 33, 34…….50} but the binary image has no range. It is simply V= {1}. We can relate such type of cases with two equations where both 4-connected and 8-connected are considered and according to it the equation is taken[18].

$N_4(p)$= { *(x+1 , y), (x-1, y), (x,y+1), (x, y-1) }*

$N_8(p)$= N_4 ∪ { (x+1, y+1), (x+1, y-1), (x-1, y+1), (x-1, y-1) }

The two pixels which have the set of values of V are 4-connected if q is from the N_4 (p) set and 8-connected if q is from the N_8 (p) set. Two pixels are 4-connected or 8-connected to each other if there is a path between them.

Then all the components are that are in binary image is found and are connected via connected component labeling [20] using Sequential Algorithm and marking each of them with a distinctive label. After all the labeling is done if the object of interest have size upper than the threshold size (T_0) then the entire component below T_0 in size is discarded by changing the corresponding pixel to zero(0). Centroid for each remaining region is detected and from that the position the red object image is detected.

Fig 6.5: Desired Red Mark Detection

Colored Background Subtraction:

As our main aim to focus on the LED of the digital pen and so any object outside which is outside of the desired requirement is discarded. As continuous image is being taken from the camera so there are chances that there are more than one red object in the frame. So are assuming that the background object (red) is stationary in all frames and only our red object is moving. So all the red objects in the background are stationary and so we can find the position background

matrix of the background image. Also the position matrix of our desired red object is made. As this process is done in a continuous manner, position matrix of both the desired and the background is formed. Comparing the two matrixes we can find the position matrix of the desired red object. In the matrix given below, each frame contains three red objects and the position matrix of the first and second are as shown below[18].

$$A=\begin{bmatrix} p1 & q1 \\ p2 & q2 \\ p3 & q3 \end{bmatrix} \qquad B=\begin{bmatrix} p'1 & q'1 \\ p'2 & q'2 \\ p'3 & q'3 \end{bmatrix}$$

Each row in A is compared with each row in B and the rows which fulfill the condition of equation form the background matrix C[18].

$$\sum |A(row) - B(row)| \leq \in$$

In the above example if we consider that (p1, q1) ≈ (p1', q1') and (p2, q2) ≈ (p2', q2'), then the background matrix is

$$C=\begin{bmatrix} p1 & q1 \\ p2 & q2 \end{bmatrix}$$

Background matrix consists of all common rows and column of A and B. We can determine the position difference of the same object in the position matrix and we can denote it by the term €. This can vary depending on the performance of the camera. Now for every upcoming frame, a new position matrix is formed and it is checked whether it contains all the rows of the background image or not. If it contains all the rows then the row which does not satisfy equation determines the position of the desired red object. This procedure is continued as each frame is being taken from the camera and the position of the desired red object is found each time.

Chapter 7:

System design and Result

7.1 System Design

Fig 7.1: Demo Design of Full System

As we have showed previously, our whole system of digital pen has three major parts. Basically, our digital pen is made up with a pen that has transmitting circuit, podium having camera underneath, a receiving circuit that is being connected with mouse and the software section. The pen has a red LED light on tip of it. When the power button gets on, the red light turns on. The camera underneath the podium detects the red light through the grass placed on the podium and sends the pictures to the software section. Software identifies the position vector of the pen on

the podium. If we move or change the position of the pen, its position vector changes and the cursor on the monitor also changes its position.

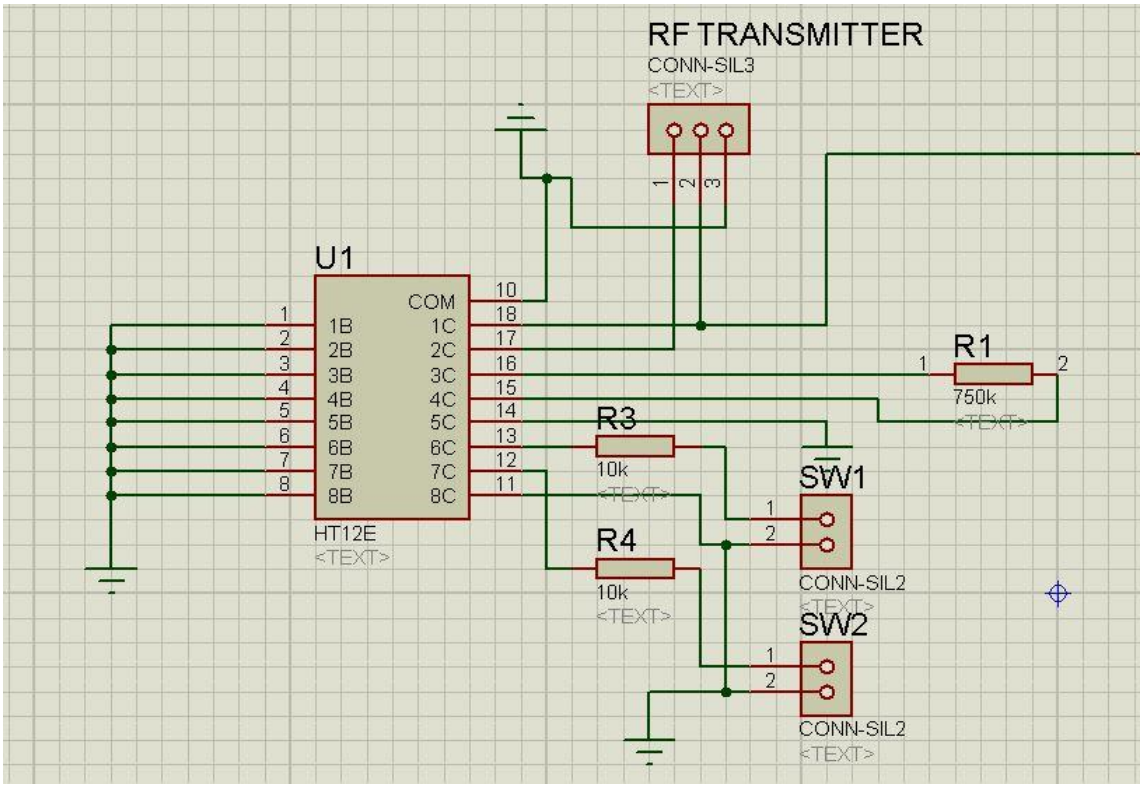

Fig 7.2: Transmitting Circuit

Soon the identification of the cursor is done the execution part swing into action. When we press on the right button of the pen, it sends the information signal to the encoder and encoder sends the signal to the RF transmitter. Transmitter transmits the signal and the RF receiver of the receiving circuit, which is connected with mouse at computer, receives the signal.

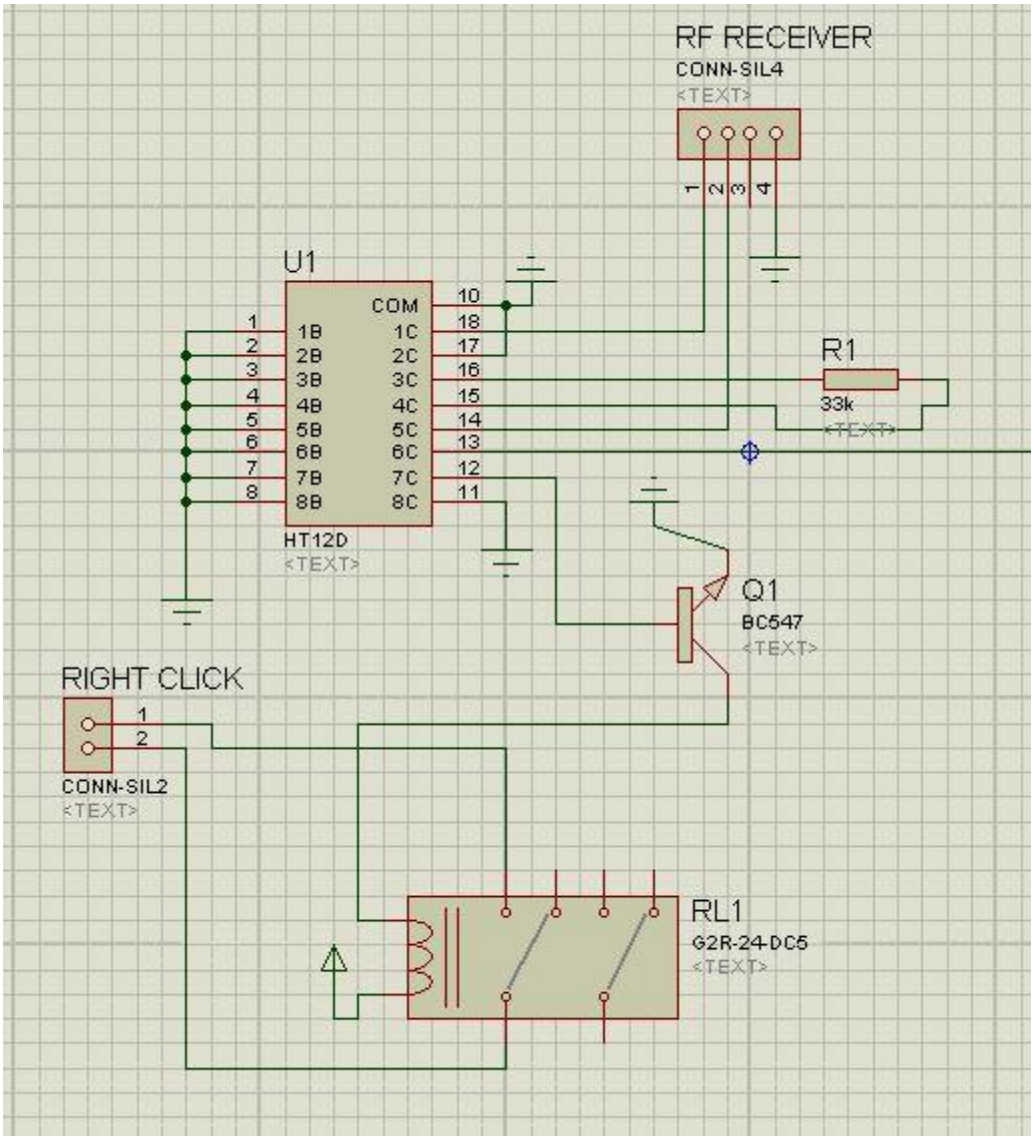

Fig 7.3: Receiving Circuit

After receiving the signal, RF receiver ends the value to the decoder. Decoder decodes the received signal and sends the value to the relay through a BJT. BJT passes the value straight to the relay when it gets value from decoder. As we know relay normally stays in NC position. After getting the value, relay changes its position and gets shorted with No and sends the value to the right button of the mouse and the pen executes the right click. The execution of left click works exactly the same way as right click.

7.2 Implementation of the system

Like mouse has brought a revolution in the field of technology and computing, any further improvement of it will also brought huge difference. A digital pen with multipurpose mouse function has many implementations which could not be imagined. We can now do the tasks of a mouse more efficiently with it. It will be more helpful for both instructors and students in some places like classrooms, workshops and seminars where instructor needs to write things for the audiences. An instructor does not have to write on board instead they can write on podium. That can save the time which can be wasted by erasing the board, rewrite the content etc. Students will get more advantage from a digital pen mouse if used in classrooms. They do not have to do both writing the class note and understanding the lecture, now they can only focus on understanding the lecture.

7.3 Limitation and Further improvement

Nothing is completely perfect on earth. Everything has some flaws. Likewise, we too have some limitations in our system. The main limitation we have in our system is it cannot work without a surface with a camera underneath. Then another limitation is it has a receiving circuit connected with the mouse. The pen needs MATLAB code to operate. Our system will not work on a computer that does not have MATLAB software installed. Our digital pen is a bit fat which is a limitation in some extent is.

There's lot more thing in our system to work with. It is possible to work with receiving circuit so that it will not need a receiving circuit connected with mouse. We can make software to avoid MATLAB code so that we can install that software in any computer. We can upgrade it to a with memory system which will have a memory to store or record data.

Chapter 8
Conclusion and Future Research

8.1 Summary

In our thesis what we have trying to do is to design a digital multipurpose pen that will work wirelessly but more efficiently than an ordinary mouse. To make it we had to combine few components along with the pen. There is a camera underneath a podium and the receiving circuit attached to the mother computer's mouse. Working procedure is simple. Camera identifies the Red LED of the pen with the help of MATLAB code running on the computer which helps to move the cursor on the monitor. Clicking on the switch which is on the pen, generates a signal. That signal is being sent by the transmitter in the pen and receiving circuit connected to the mouse receives the signal to execute the click. That was all about the pen which can work just like a mouse as well as a pen so that we can use it to various aspect of our life as in presentations, classrooms, workshops, seminars etc.

8.2 Future Research

In near future it is possible to make a pen that could go beyond the imagination and we can call it a smart pen. We can write on any surface with that smart pen and it does not have to be connected with a computer or smart phone. At the same time we can use it over normal paper and on touch screen. It can even be used with projector. It will have the power to draw as well with different colors. It will have the capacity to store the writing and record audio in its memory. Though some of the features already exist in current smart pen, it has not reached to the mass people due to high expense. In future the price will fall drastically and who ever have a smart phone or computer will also be able to buy it.

References:

1. http://www.explainthatstuff.com/digitalpens.html
2. http://www.computinghistory.org.uk/det/613/the-history-of-the-computer-mouse/
3. http://pencomputing.com/PenWindows/
4. http://www.usafa.edu/df/iita/Technical%20Reports/Rewriting%20history.pdf
5. http://www.historyofpencils.com/writing-instruments-history/digital-pen/
6. https://www.livescribe.com/en-us/
7. http://newleaderbattery.en.ec21.com/9V_6F22_Carbon_Zinc_Battery--6250039_6256253.html
8. http://www.engineersgarage.com/electronic-components/7805-voltage-regulator-ic
9. http://www.lion.co.il/d?id=3590466
10. http://www.engineersgarage.com/electronic-components/ht12e
11. http://wiki.seeedstudio.com/wiki/433Mhz_RF_link_kit
12.https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=15&ved=0ahUKEwiQl6CmO3QAhVJO48KHagcDv8QFghaMA4&url=http%3A%2F%2Fwww.ele.uri.edu%2FCourses%2Fele436%2Flabs%2FASKnFSK.pdf&usg=AFQjCNGuyCMcTQQVP6i1zpLGhOQwxF6nQ&sig2=vqg50w-iWrA7c3jd-KgTPg
13. http://www.learningaboutelectronics.com/Articles/How-to-connect-a-double-pole-double-throw-relay-in-a-circuit
14. http://www.engineersgarage.com/electronic-components/transistor-bc547-datasheet
15. http://www.engineersgarage.com/articles/image-processing-tutorial-applications
16. R.C Gonzalez and R.E Woods, Digital Image Processing, 2nd edition, Pearson Education.
17. Raymond H. Chan, Chung-Wa Ho, and Mila Nikolova, Salt and Pepper Noise Removal by Median-Type Noise Detectors and Detail-Preserving Regularization," IEEE Transactions on Image Processing.
18. Multimedia Touch System with Color Detection Based Gesture Recognition Technology," IEEE Transactions on Image Processing
19. Huang, T.S., G.J.Yang, and G.Y.Tang. "A fast two dimensional median filtering algorithm," IEEE transactions on Acoustics, Speech and Signal Processing, vol. ASSP 27, no. 1,Feb.1979.
20. Linda G.S hapiro and George C. Stockman, Computer Vision, Prentice Hall.

Appendix:

Codes Used for the Digital Pen:

```
clear all;
close all;
clc;

Robot=java.awt.Robot;

a = imaqhwinfo;
[camera_name, camera_id, format] = getCameraInfo(a);



% Capture the video frames using the videoinput function
% You have to replace the resolution & your installed adaptor name.
vid = videoinput(camera_name, camera_id, format);

% Set the properties of the video object
set(vid, 'FramesPerTrigger', Inf);
set(vid, 'ReturnedColorspace', 'rgb')
vid.FrameGrabInterval = .5;

%for geting scren resulation;
resulation_screen = get(0,'screensize');
x_scren = resulation_screen(3);
y_scren = resulation_screen(4);

%for geting camera resulation;
x_cam=str2num(format(6:8));
y_cam=str2num(format(10:12));


%start the video aquisition here
start(vid)

% Set a loop that stop after 100 frames of aquisition
while(x<=1000) %%Can be varied
  while(vid.FramesAcquired<=1000)

    % Get the snapshot of the current frame
    data = getsnapshot(vid);

    % Now to track red objects in real time
    % we have to subtract the red component
    % from the grayscale image to extract the red components in the image.
    diff_im = imsubtract(data(:,:,1), rgb2gray(data));
    %Use a median filter to filter out noise
    diff_im = medfilt2(diff_im, [3 3]);
    % Convert the resulting grayscale image into a binary image.
    diff_im = im2bw(diff_im,0.18);
```

```
    % Remove all those pixels less than 300px
    diff_im = bwareaopen(diff_im,300);
%     size(diff_im)
    % Label all the connected components in the image.
    bw = bwconncomp(diff_im, 8);


    % Here we do the image blob analysis.
    % We get a set of properties for each labeled region.
    stats = regionprops(bw, 'BoundingBox', 'Centroid');

    % Display the image
    imshow(data);

    hold on

    %This is a loop to bound the red objects in a rectangular box.
    for object = 1:length(stats)
        bb = stats(object).BoundingBox;
        bc = stats(object).Centroid;
        rectangle('Position',bb,'EdgeColor','r','LineWidth',2)

        plot(bc(1),bc(2), '-m+')
        a=text(bc(1)+15,bc(2), strcat('X: ', num2str(round(bc(1))), '    Y: ', num2str(round(bc(2)))));
        set(a, 'FontName', 'Arial', 'FontWeight', 'bold', 'FontSize', 12, 'Color', 'yellow');

        %converting camera res to screen res
        x = Map(bc(1),0,x_cam,x_scren,0);
        y = Map(bc(2),0,y_cam,0,y_scren);

%         Robot.mouseMove(bc(1),bc(2));
        Robot.mouseMove(x,y);
    end
%
%    x= uint16(bc(1));
%    y= uint16(bc(2));
% %      % mouse movement


    hold off
    x= x+1
end
end
% Both the loops end here.

% Stop the video aquisition.
stop(vid);

% Flush all the image data stored in the memory buffer.
flushdata(vid);


 %Clear all variables
 clear all
sprintf('%s','That was all about Image tracking ')
```

```
function [camera_name, camera_id, resolution] = getCameraInfo(a)
camera_name = char(a.InstalledAdaptors(end));
camera_info = imaqhwinfo(camera_name);
camera_id = camera_info.DeviceInfo.DeviceID(end);
resolution = char(camera_info.DeviceInfo.SupportedFormats(end));



% Arduino map() function source code
% long map(long x, long in_min, long in_max, long out_min, long out_max)
% {
%   return (x - in_min) * (out_max - out_min) / (in_max - in_min) + out_min;
% }


function [x] = Map(x, in_min, in_max, out_min, out_max)
x = (x - in_min) * (out_max - out_min) / (in_max - in_min) + out_min;
```