Laser Based Digital Pen with Multi-Purpose Mouse Functionality

A Thesis
Submitted to the Department of Electrical and Electronic Engineering
Of
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Declaration

We hereby declare that this thesis paper titled 'Laser Dot Based Digital Pen with 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

Proposition for building a remote wireless computerized pen, which can work similar to a computer mouse, however more exquisitely with the assistance of image processing (on MATLAB). This particular pen can be utilized for composing, painting in classrooms, presentations on meetings and conferences, and so forth. This pen contains two click buttons simply like a mouse, and their operation is executed by utilizing two circuits, one is the transmitting circuit and the other one is the receiver circuit. The pen will work in co-ordination of utilizing both the circuit and the coding of image processing. It also incorporates a webcam which recognizes the red bright dot projected by the Light Radiating Diode placed on the tip of the pen and the red dot is projected within boundary of the webcam.

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Abbreviations:

ASK: Amplitude Shift Keying

BJT: Bipolar Junction Transistor

RF: Radio Frequency

SW: Switch

USB: Universal Serial Bus

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

1.1Motivation:

The study system of Bangladesh is still following traditional way of teaching students. We don't have yet enough resources\money to use the digital technology in school, college or universities. By using digital technology, many other developing countries are going forward in the education sector. Many countries are exploring the possibilities of using electronic devices to aid in teaching, both to make it easier and interesting. Digital teaching aids can add another depth to education systems by making classes interactive and three-dimensional. Our current system has many drawbacks that limit student & teacher efficiency. Much of the class time is spent copying notes & writing lectures, something that lowers concentration and adds the pressure of time to students and teacher alike. In addition the structural layout of the mouse of a computer is at best awkward to be used as a digital substitute for a marker. We have a proposal to hopefully address both these problems with our device, a multipurpose digital pen with the functions of a mouse. In addition to having all the functionalities of a mouse (like Right-Click & Left-Click) and a structural shape of a pen for easy use, it is wireless and mobile meaning you can use it as an interactive pointer instead of being rooted to a particular surface.With the help of Image Processing this device can solve many of the problems an ordinary mouse has in a classroom setting. Also it comes with memory capabilities which will allow the lectures to be stored in the pens and later on be replayed or be shared with others. With these students might not be required to copy a lecture anymore saving a lot of time and effort. Likewise teachers won't be required to write lectures multiple times. Not to mention valuable resources that we waste every time we use up a marker like ink & plastic can be saved. This pen however is not just limited to the classrooms rather it can be used in many settings like a conference meeting or as a substitute for a paint brush for painting.

1.2Background:

Today's lecture system is not only consume too much times but also makes it difficult to concentrate on lecture delivered by teacher besides writing or taking notes. Thus, the students can't write down the lectures in their note books while fully concentrating on the lecture as well as understand it properly. Where other developing countries are going ahead yet here we are still using chalk and duster for class lectures. To save time and make things easy we must act soon and start to use the technology in the proper way. Using digital pen can solve the problem of all problems regarding class lecture, presentation, meeting when comes to writing matters. With the assistance of Image Processing, the pen can be utilized to write or paint simply like we compose like a pen and save the lectures in the computer, sparing the students from writing while listening to lectures. It can also fill in as mouse as it will have normal mouse features. By using this pen, lecture can be digitally composed without additional pressure.

Chapter 2

History and Literature Review

A pen is one of the most mundane things that you use almost everyday. It is the only tool the people use vastly to record information. Though being the most popular tool, this little piece of writing instrument which was used long time ago has not yet evolved much comparatively with other technology. Thus the efficiency of pen still limited due to demanding of modern life. Everything around us is occurring so fast. It is becoming challenging for us to write and at the same time reading or concentrating on a important lecture or presentation. We may able to do both at the same time if it is a small task or lecture or presentation but if it is a long lecture/presentation we may stumble upon many errors as our brain is not like a computer. Up until now all we could do is type and save it to pc.

To resolve the delinquent,a digital multipurpose pen can be a better answer. Generally this pen made up of electric circuits and wireless technology. Presently there are two types of digital pen: one thatallows user to write everywhere using wireless positioning technology and the other type that requires a specialized surface to write on to for tracking the pens movement. The difference between the 1st type pen and the 2nd type is user can use it over any surface on the 1st pen but the 2ndpen does not have the compatibility.The type of pen we made also requires a surface. We can use any surface which has less bright and lower intensity than a laser dot, which will work through image processing technology. [1]

Fig 2.1: Ball Mouse in 1964

Mouse is the most important interactive part of all modern computers but it wasn't so long before computers had no mouse and data was inserted by typing instruction on keyboards. The first mouse was invented by Douglas Engelbart in 1964 and it was consisted of a wooden shell, circuit board and two metal wheels. After that Bill English contributed to the development of the mouse in 1970.Presentlythat mouse is known as 'Ball Mouse'. [2] If a pen can be used instead of mouse is evidently a significantlyenhanced technology. The 2nd type pen, has a very long historical root. For example, Elisha Gray who invented telautograph was the first patent which would allowwould allow a person to transmit his/her writing to a distant point over a two wire circuits[25]. In 1942, somewhere in U.S. researchers have worked on touch screen for handwriting. Around 1950 Tom Dimond demonstrates the electronic tablet with pen for computer input and software for recognition of handwritten text in live-time.

Fig 2.2: Wacom Inkling Digital Sketch Pen

In 1982, Pencept of Waltham, Massachusetts markets a general-purpose computer using a tablet and handwriting recognition instead of a keyboard and mouse(26). Around (27) 1989 Wang Laboratories introduces an application which capture screen from a dos application and give users the opportunity to add voice and writing annotation. It was a complicated predecessor to later note-taking applications for systems like tablet computers. Between 1980 and 1994 there was huge improvement on about pen instead of mouse. We can sense from there, we are always meant to shift to digital pen from mouse. As predicted by people this technology is now challenging general mouse we have used till now.24 years ago Apple also created

(28)Newtonmessage pad which had handwriting based input. Last20-30 years many researches have been done on this digital pen and there were lots of positive output. One of the popular digital pens we can mention is (29)Wacom bamboo spark. This pen can writeon any paper. It achieves this success with high-end sensor array inside the tip of the pen that monitors what user writing is. It can store 100 pages in its memory.

Then also (29) Wacom Inkling Digital Sketch Pen should be mention because this also helps user to draw and transfer this drawing to pc/Mac directly.

Another good digital pen we got is (29) Neosmartpen N2, this is IR camera based and it's slightly bulky but beautiful and metal design. It can store 1000 pages of handwriting in its memory.

(30)Moleskine smart writing set is a digital pen with 1000 pages onboard storage comes with complete set of notebook which can detect different dot pattern each page of the notebook which helps writing software to know which page is user writing on.

Livescribe 3 is additionally advanced smart pen with infrared camera and a built-in microphone, which has the capability of recording what's being said and connects it with what is being composed. This pen is likewise consolidated with numerous android application for different purposes for instance like a calculator. It additionally enables client to get to their composed notes and recorded sounds from cell phones and computers as well[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.

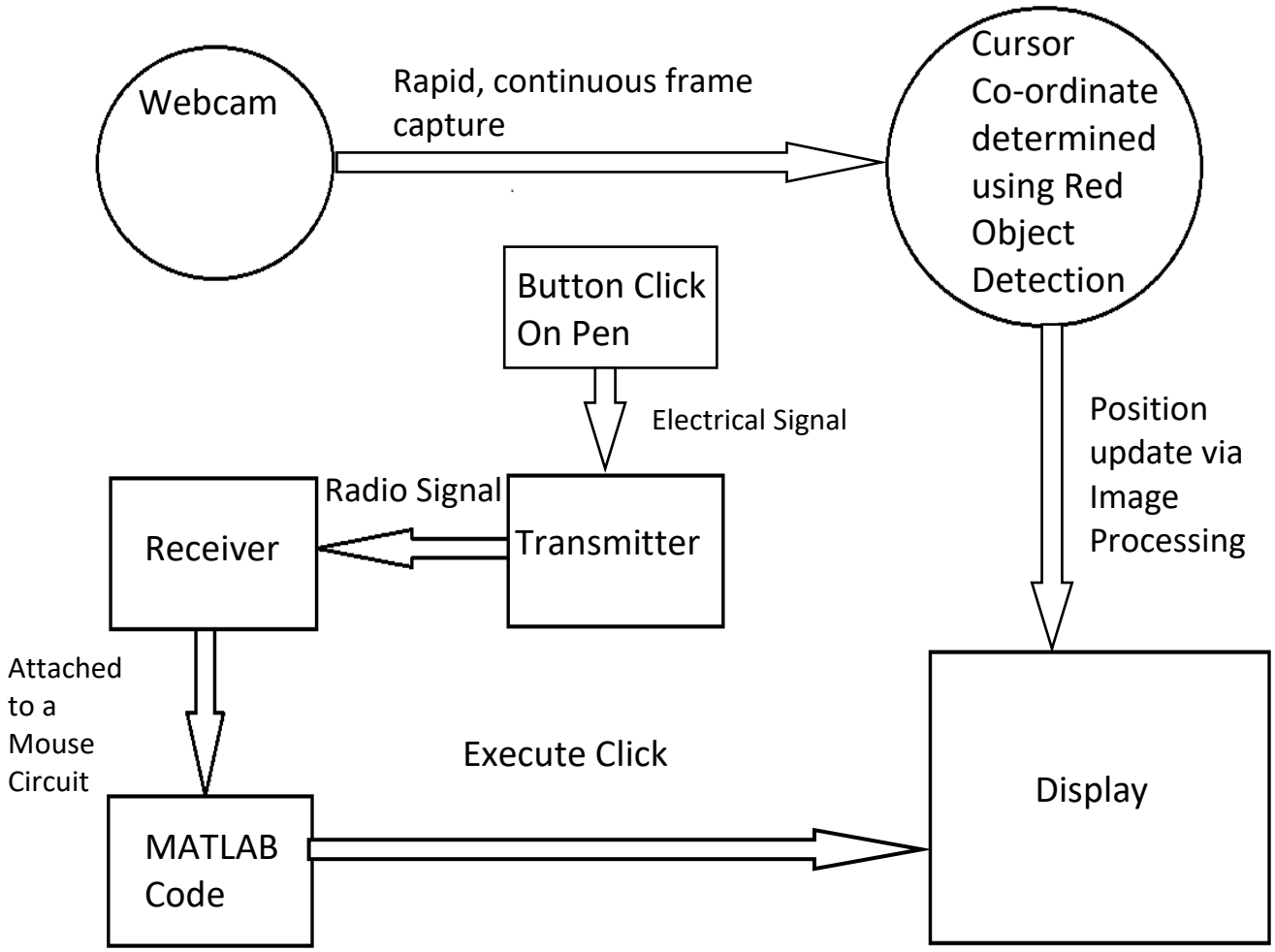

Fig 3.1: Block Diagram of the Whole System

Initially, to detect the movement of the Laser dot, the webcam and the transmitter pen is turned on concurrently. The webcam is placedat a surface facing the wall. Then we perform the desired cursor movement with the laser dot as the marker. The Webcam catches continuous images of the operations. Then, the system is equipped for the following phase.

In this part of the system, the position or movement of the cursor is detected by means of Red Object Detection process. We used a Laser diode which is placed on the tip of the transmitter circuit. With the assistance of Image Processing, the movement of the Red Laser dot is detected. A MATLAB code is used to execute this procedure. This is the most integral part of this project as it associates the detection and execution cycle of the pen.

The transmitter circuit consists of two switches which are used for the Right and Left clicking action of the pen. After a click is executed, the encoder encodes the signal in such a way that the signal frequency is distinct, corresponding to either Right or Left Click, when it is received by the RF circuit. The transmitter circuit sends the encoded signal of the execution of the clicking action, usingthe principles of ASK modulation,to the receiver circuit.

The receiver circuit is connected with the circuit of a mouse, which is connected with the computer via USB.The receiver circuit receives the encoded signal via RF Receiver and sends it through the decoder installed in the circuit which determines whether it is left or right-click signal.
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 mainly responsible for the execution of the clicking action of the pen.

After that the signal is sent to the computer, the desired movement of the pen we want to execute is shown on the display. By implementing the above mentioned steps, the digital pen functions and carries out various operations like execution of clicking action, drawing, or writing, painting on any compatible software.

Chapter- 4

Hardware Components

4.1 Introduction:

The objective of our project is to construct a pen which can be utilized as a mouse pointer hybrid to compose or paint in classrooms, conferences, gatherings etc. with the assistance of MATLAB program. In this segment of the paper, hardware portion of the project is depicted briefly. Essentially, there are three primary parts of the device, one is the transmitter circuit and other is the receiver circuit and the last one is the camera to detect the movement of the red dot. The pen has two push switches utilized as click buttons which are executed withthe help of transmitter andreceiver circuits. With the co-ordination of hardware and MATLAB code both the click happen and the movement of cursor occurs with the help of movement detection from the camera.

A Laser diode is used as the pointer or marker and is placed on the tip of the pen.A webcam is used to track the movement of the red dot to translate it into cursor movements. Two push switches are used to generate the signals for left and right click. Then, the transmitter sends the signal 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 of the clickingconnecting with a 750K resistor for the encoder's protection against voltage overload. The decoder of the same model is used in receiver circuit. A 33k used for the decoder circuit and a9V battery is used for turning on the transmitter circuit. Two relays are used for left and right click execution in the receiver circuit. BJT is used for amplifying the received signal and switching for the relay.A click switch and one push switch is used to power the Laser diode ON and OFF.

4.2 Circuit Description:

In this portion of the chapter, the three parts of the circuit is covered in detail. The description of the transmitter and the receiver circuit of are given in a detailedstructure along with appropriate representation of the two circuits to show how these circuits work. The transmission and receiving circuit fundamentally have to work at the same time to make the click and movement of cursor happen. The role of camera in movement detection is also covered.

The RF transmitter circuit works as the pointer whereas the receiver circuit is connected with the mouse. The receiver circuit is connected to a slightly modifiedworking circuit of a mouse which is connected with the computer or laptop. With the help of the signals generated by the transmitter that are relayed to the receiver, along with the MATLAB code mentioned in later chapters, we are able to get our desired results which are essentially to mimic a computer mouse and to write or to paint on paint software in classroom or conferences.

The crucial part of the project is the coordination of the transmitter and receiver circuit. So, itis clear that these two circuits are the central part of the digital pen as well as indispensablefor the execution of our project. A point by point portrayal of these center parts are specified in the accompanying piece of the section.

Camera:

Out of the three parts, the camera plays the most vital part. Without this, the whole operation of the circuit is obsolete. The camera is a simple webcam with no special specification. It is placed facing the surface where the red dot to be projected which is connected to the MATLAB code in the computer via USB. The main task of the camera is to detect the red dot emitted from the laser diode placed in the transmitter circuit. It also tracks the movement of the red dot projected in the surface. If the movement of cursor is needed, The MATLAB code observes the movement of red laser dotusing the camera. After observing the coordinates of the movement of the laser dot by the camera, the movement of the cursor happens in accordance with the movement of the red coloredlaser dot. If writing or painting to be done by the digital pen, it will also have to be done after tracking the movement coordinates of the red dot.

Another important task of the camera to is to filter out other red object which may distort the result of the tracking. If the camera catches a bright red colored object, it may count it as a point of coordinates which will result in output with error. By physically changing the focal length placed in the camera lens manually, we are also calibrating the filter to detect only the red dot and ignoring other bright red object.

Transmitter Circuit:

The transmitter circuit is one of thethree major components for the execution cycle of the digital pen with multi-purpose mouse functions. This part is responsible for the transmission of the signal of left and right clicks, generated by the push switches, to the receiver circuit to allow implement of right and left click on the computer.

When the push switches are pressed a distinct signal is generated by the transmitter circuit corresponding to the click we want to execute. This signal is then dispatched to the receiver circuit utilizing radio waves. This is important because if the transmitter circuit fails to send the signals then the whole clicking operation fails. So we can say that the transmitter circuit is the starting point for the click operations.

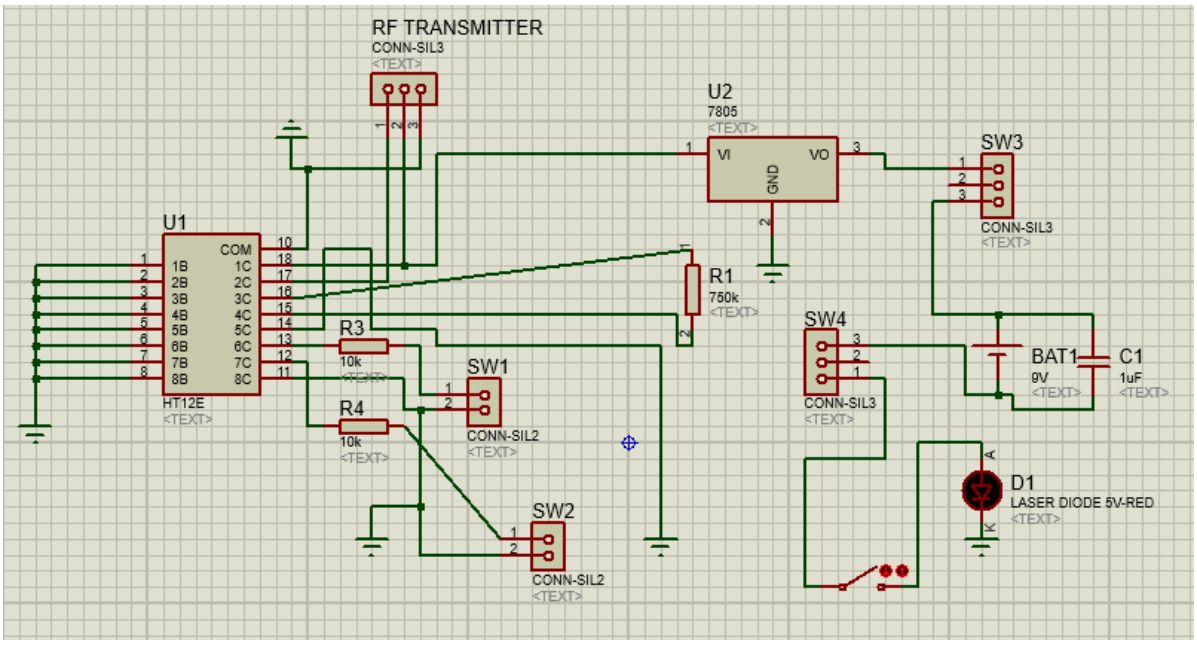

Fig 4.1: Circuit Diagram of the Transmitter Circuit

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 circuitconsists of

- Two Click Switches
- Two Push Switches
- RF Transmitter
- Encoder
- Voltage Regulator
- Two 10K Resistors
- 750 k Resistor
- Capacitor
- Red Laser Diode
- 9V Battery.

There are two switchesto turn ON and OFF the Red LED. One is a click switch (SW4) and the other one is a push switch. The pin3 of the switch (SW4) is connected with the negative side of the 9V battery. Pin2 of the fourth switch (SW4) is grounded (pin2) and the pin1 is connected with the push switch. The other end of that switch is connected with the Laser Diode. The other side of the Laser Diode is grounded.There is a 9V battery connected with a 1uF capacitor to run the whole transmitter circuit. There is a switch(SW3) which is placed for turning the power of the battery to ON or OFF and it is connected with the positive side of the 9V battery (pin3). Pin2 of this switch is grounded (pin2) and the pin1 is connected with the output of a Voltage Regulator which gives a constant 5 volts to the Encoder and the RF transmitter.

So, the input of the Voltage Regulator is connected with the Vcc (pin2) of the RF transmitter. The ground pin of the Voltage Regulator is grounded.Both the ground pin (pin10) of the Encoder and the ground pin (pin3) of RF Transmitter and are grounded together. To send the encoded data from the encoder to the RF transmitter, the DATA pin (pin17) of the HT12E Encoder is connected to the DATA pin (pin1) of the transmitter.

The HT12E Encoder encodes the signal of right/left clicks for sending it to receiver part. Pin 15 and pin 16 are connected with a 750K resistor.Two separate 10K resistorsare both connected with Pin 12 and pin 13.The pin 1 of both the push switches (SW1 and SW2) are connected with the other sides of the 10K resistors separately.The pin 2 of both the push switches (SW1 and SW2) are connected with the Encoders pin 11and then they are allgrounded. Pin1-Pin8 of the HT12E Encoder are all connected together and grounded.We also do not need Pin 14 for any purpose so it is grounded as well.

Receiver Circuit:

The RF receiver circuit receives right/left click signals as sent by 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 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 executes the operations of right/left clicks in the computer or laptop.The Receiver circuit consists of

- Two Relays
- Full Mouse Circuit
- Two BJTs
- Decoder
- 33K Resistor
- RF receiver.

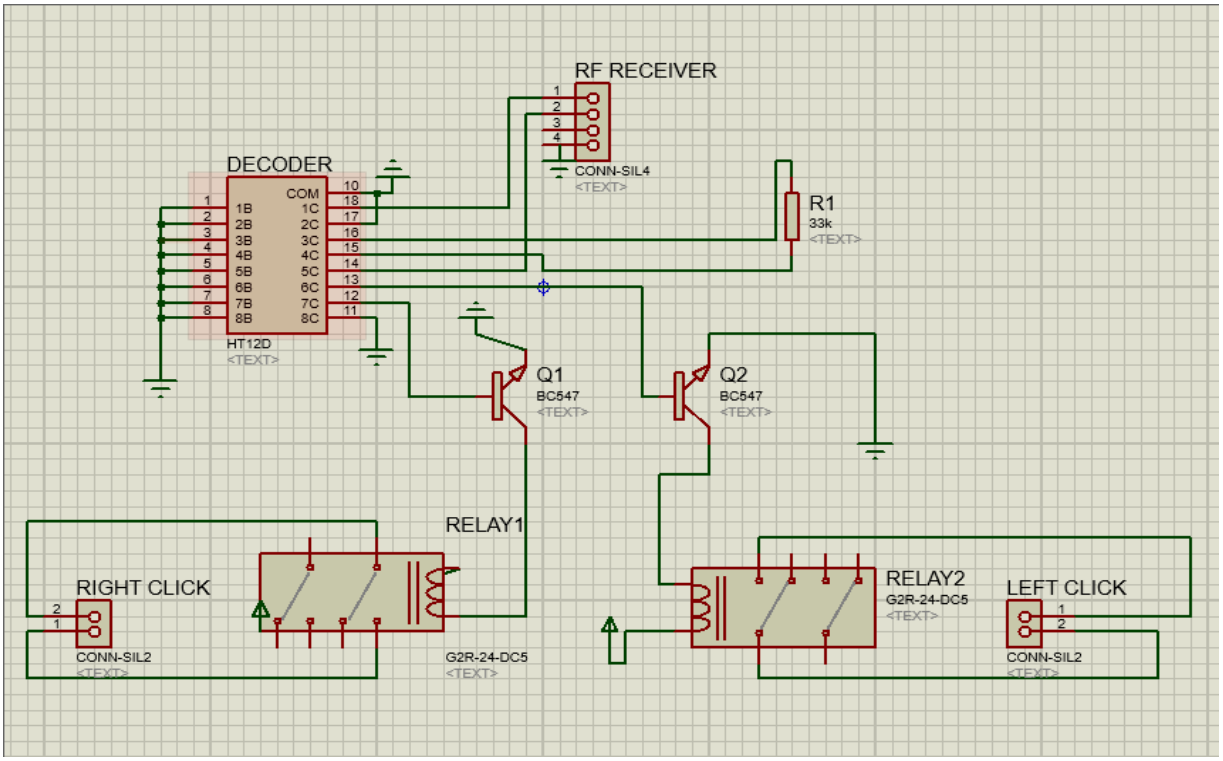

Fig 4.2: Circuit Diagram of the Receiver Circuit

From the circuit, it is shown that to send the received signal to the Decoder, the DATA pin (pin18) of the decoderis connected with the DATA pin (pin1) of the RF receiver. Both the Vcc

The pin (pin2) of the RF transmitter and the decoder's Vcc pin (pin14) is connected together. The receiver's pin 4 is grounded (pin4).

A resistor of 33k is connected with the Pin 15 and pin 16 of the HT12D decoder. Pin 12 and Pin 13 is connected with the base of a BJT (Q1) and the base of BJT (Q2). From Pin1 to pin8 ,Pin 17, pin 10 and pin 11 are all grounded. As the BJTs are NPN transistors, Emitters of both the BJTs are grounded. Collector of Q1 BJT and collector of Q2 BJT is connected to a (RL1) Relay and the RL2 Relay's input respectively. Power is supplied to both of the relay's input pin. Thetwo output of the relay (RL1) are connected withboth the pins of the Right click of the whole mouse circuit. Similarly, the outputs of the other relay (RL2) are connected with both of the pins of the whole mouse circuit's left click.

4.3 Component Description:

In this section, a smallportrayal of the components arespecified and thedepictions of the components aredivided into two parts which are- Transmitter Circuit components and Receiver Circuit components and they are described in the next how these components are important to be related with each other.

Transmitter Circuit Components:

Fig 4.3: Laser Diode

Laser Diode:

It is the most popular type of laser with anextensive range of uses. These are generally used in fiber optic communications, barcode readers, laser pointers, CD/DVD/Blu-ray reading and recording, laser printing, scanning and other directional lighting sources[24].This 5V Laser Diode with a diameter of 6.5mm emits a laser beam similar to a laser pointer when given 5 Volts of power. Max operating current is 40mAand its wavelength is 650nm. The operating Temperature is -10 C to 40C. The working life of the Laser Diode is more than 1000 hours.

750K – 1M Resistor:

To run the HT12E Encoder properly, Resistors from 750K-1M range is needed. These resistors are made out of carbon and metal-oxide films. So, to avoid interruptionswhile running the Encoder, the 750K resistor is required. Because we don't want the encoder to be suffered by the overflow and overvoltage

9V Battery:

This 9V battery is basically appropriate for high voltage devices[7]. In our project, connecting with a capacitor, we used this 9V battery for the whole Transmitter circuit to operate. Because the 9V battery is needed to supply 5V for the laser diode and another 5V for starting the RF Transmitter and Encoder and so balancing the power management with the help of a voltage regulator is essential.

LM-7805 Voltage Regulator:

This IC ensures no fluctuation of output and deliver perfect output.7805 ICs are one of the fixed linear voltage regulators ICs which gives constant 5 Volts. If we do not get the desired output as if the input's value might have fluctuated within the circuit and the resultant output will be with undesired errors.This 7805ICssolves the problemof fluctuation of inputs within the circuit. It provide a constant 5 Volts which we need for theRF Transmitter circuit and the Encoder. Pin 1 is its input pin where 5Vis supplied through[8]. Pin 2 is the ground pin. Pin 3 is the output which delivers the regulated output of 4.8V-5.2V [8]. In our circuit,this regulator is appliedto supplyconstant voltage so that we can get our desired result accurately.

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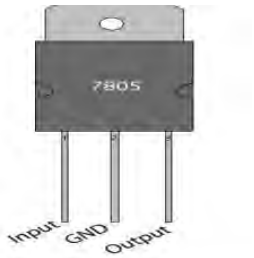


Fig 4.4: 7805 Voltage Regulator

Vero Board:

For hardwiring components, Vero board has the perfect size and gap between hole and tracks for connecting ICs easily [9] as holes and tracks are spaced appropriately. Vero board is a laminated board which made of Copper clad. In this board, all connections are shorted in parallel which is useful for us because we need common signal lines for our design. The boards has a thickness of 1.6 mm with grid of 2.54×2.54 mm and the diameter of the hole is 1.02 mm where thickness of copper is of 35um. In a row all the holes are connected by copper strips and we cut up if continuous holes are not wanted which is also an advantage for us as it is a prototype and the pen cannot be very big in design.

HT12E Encoder:

.In our project this Encoder is used for transmitting through RF Transmitter. HT12E Encoder is a 2^12 series encoders, which means there are 12 bits consists of 8 address and 4 data bits. Forparallel input, we get serial output. It is mostly suitable for RF interfacing This encoder is also paired with 2^12 series Decoders. So when 12 bit parallel data are encoded into serial data and transmitted through RF Transmitter it goes to that paired Decoders.

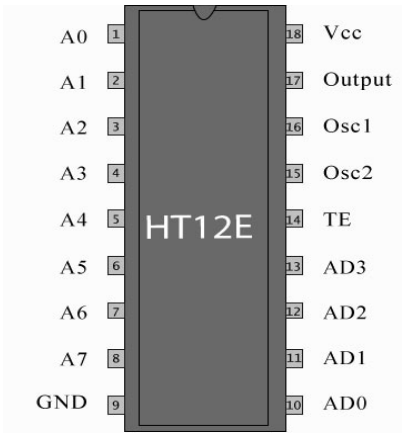


Fig 4.6: HT12E Encoder

From the above diagram of the Encoder, the term TE is denoted as‘transmission enable’ which is the pin kept high until the final transmission cycle is completed.For the initialization of the HT12E Encoder, 4 word transmission cycle is received in TE pin.So, the TE pin needed to be kept low when the whole process of encoding is being executed.

Except the pin 9 which is grounded, the A0-A7 pins are 8 bit address pins for input.4 bit data pins for inputs are AD0-AD3 pins. The OSC1 pin is oscillator output and the OSC2 pin is the oscillator input. The Vccpin is the pin where the constant 5 Volts voltage is supplied coming from the voltage regulator. The Serial Data output pin 17 is the output.[10]

RF Transmitter (Fs1000a):

This transmitter plays most imperative parts of this project because we need to transmit the signal of left/right clicks wirelessly.The size of the transmitter is Its size is 19×19 mm. The input voltage has to be between 3V-12V. There are 3 pins in the RF Transmitter and they arecorrespondingly the Vcc Pin, Ground Pin and a Data Pin. The operating mode of the transmitter is Amplitude Modulation where the transfer rate is 2400bps. To work perfectly the working range of frequency is needed to be close to 433Hz.

Fig 4.7: FS1000a RF Transmitter

If the transmitter data pin is set to high, it will make a radio transmission and in turns it will also enable the data pin of the RF receiver to high.

We chose this transmitter because this RF transmitter transmits the radio transmission based on ASK modulation[11]. We need this ASK modulation because the encoder encodes two types of signal, one is for the right click and the other one is for the left click.ASK stands for Amplitude Shift Keying which is modulation process usesfinites number of discrete signal[22]. That means each finite number of amplitudes are assigned with a unique pattern of binary digits[22].

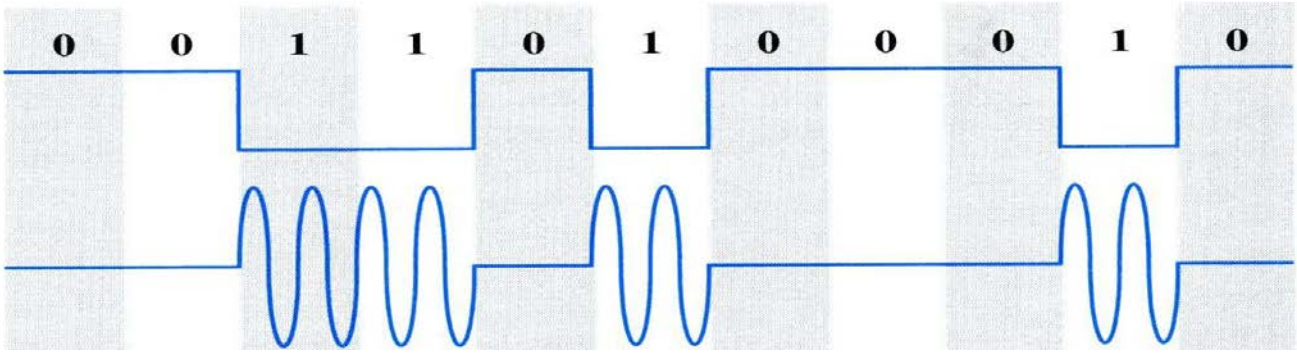


Fig 4.8: ASK Modulation

There are some disadvantages of ASK modulation Sometimes some of these signals have wide bandwidths which is unnecessary. As the data rate is often happens to sub-multiple of the carrier frequency there is no constant envelope, which makes the signal processing more complicated. However, this challenge can be overcome by using the envelope detector.[12]

Receiver Circuit Components:

Relay:

In our receiver circuit, we used a relay which has a characteristic of double pole double throw and it is of 8 terminal points which are 2 COIL, 2 COM, 2 NO and 2 NC on each side as shown image.

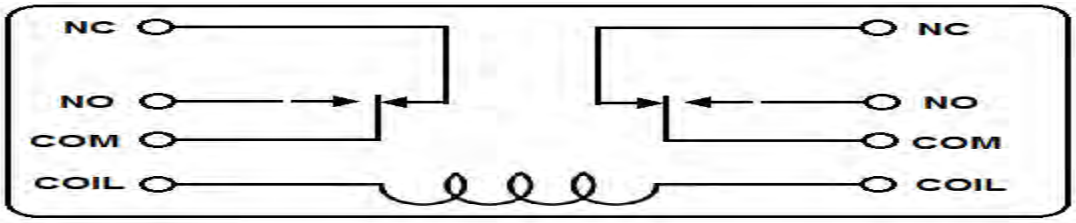


Fig 4.9: Relay Terminals

The COIL terminals are the input for the relays where voltages is supplied to power up the coils. These two terminals are not sensitive polarity.

The first part of the circuit is connected The COM which is the common terminal of the relay.

NO acts as the open switch. It determines if the device which is connected with it, will receive power from the relay or not.If the relay is ON, then NO terminal is ON and if the relay is OFFthen NO terminal stays OFF.

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

HT12D Decoder:

HT12D Decoder is paired with HT12E Encoder. Like the Encoder it is also a 2^12 series decoder which decodes the 12 bit series data to parallel 12 bit data. This decoder is used in the receiver circuit because this particular Decodercan decode the encoded data which was send by the transmitter circuit's HT12E encoder.

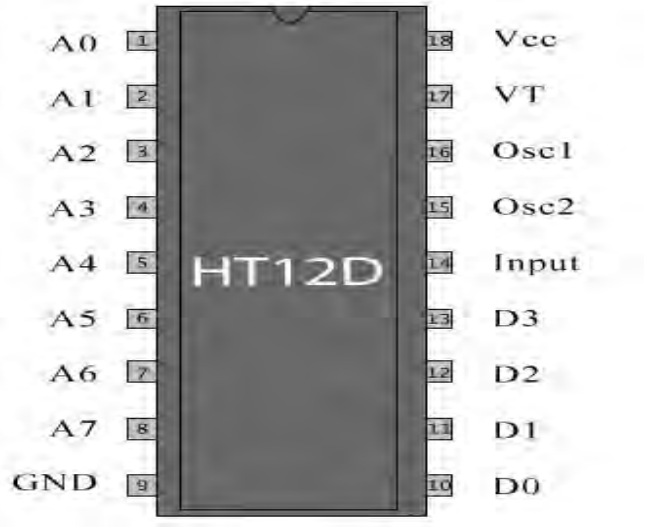


Fig 4.10: HT12D Decoder

From the diagram it is observed that the pin 9 is for ground and the A0-A7 pins are the eight address pins. The Vcc pin is in pin 18. The DATA pins D0-D3 pins. The input is pin 14. The rest two pins are OSC1 and OSC2 of the HT12D Decoder respectively.

RF Receiver (FS1000a):

The RF receiver has a size of 30*14*7mm and it has a sensitivity of -105 dB[11]. It operates at 5 Volts and use 4mA current. The receiver has three pins similar to the transmitter circuit. It has a Vcc, a Ground and a Data pin respectively.

The main objective of the RF Receiver is to circuit receive the radio transmission sent by the RF transmitter circuit and then sends the signal to the decoder for decoding because the radio transmission consists of the left or right click signals to executing the operation of the mouse.

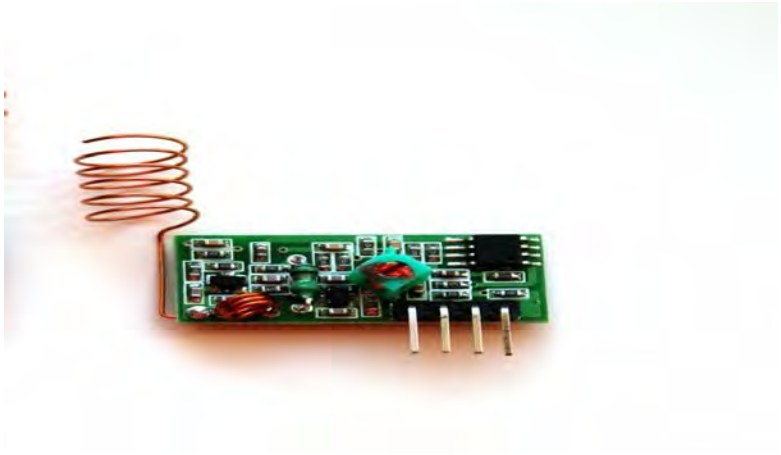


Fig 4.11: FS1000a RF Receiver

When the data pin of the FS1000a RF transmitter's data pin is high, and the Radio Frequency is transmittedby the RF transmitter circuit, the signal in turn set the data pin of the RF receiver to high.

BC547 BJT:

BC547 BJT is a Bipolar Junction Resistor which is an NPN transistor withthree pins and they are Emitter, Base and Collector respectively. The BJT is Common Emitter configuration[23]. This BJT is essential because it has the characteristics amplifying current which we need for switching.At collector and emitter, larger currents are controlled and the smaller currentsare controlled at the base. Which is why the input signal is considered to be supplied at the base and after the input signal is being amplified, the output comes from the emitter side of the BJT. The DC voltage is fixed which is required for biasing[23].For switching purpose, the transistor is biased for all input conditions as the digital signal is being fed at the base. But If there is no presence of signal at the base, the BJT will be completelyturnedOFF[14].

Fig 4.12: BC547 BJT

Chapter 5:
Software

5.1 Introduction:

The pen that we would making comprises about two parts. The movement of the mouse cursor and the tracking of the laser dot of the pen which is resolved by utilizing two differentiate codes which is executed in MATLAB. To get the full yield of the pen, These two codes need to be joined together.

5.2 Algorithm:

The entire procedure requires an algorithm to keep running in a deliberate way. Figure 5.1 demonstrates the entire flowchart of the general component of the MATLAB codes utilized. As the code begins, the camera starts to take continuous frames of [n] number which can be varied by our necessities. At that point the red spot is identified, which is clarified later on in part 6, and the flowchart of the entire system is given in figure 5.2. As the red dot is recognized, the position is appeared on the screen as per the coordinates (x,y). The display being may not have the similar resolutions as the webcam thus the code is made such that the determination of the screen is identified first and afterward the camera resolution is aligned to coordinate screen resolution automatically. The video is then appeared and the mouse cursor movement location is detected as the system keeps on running. When [n] number of frames are captured in the loop then the camera stops recording and clears all current variable.

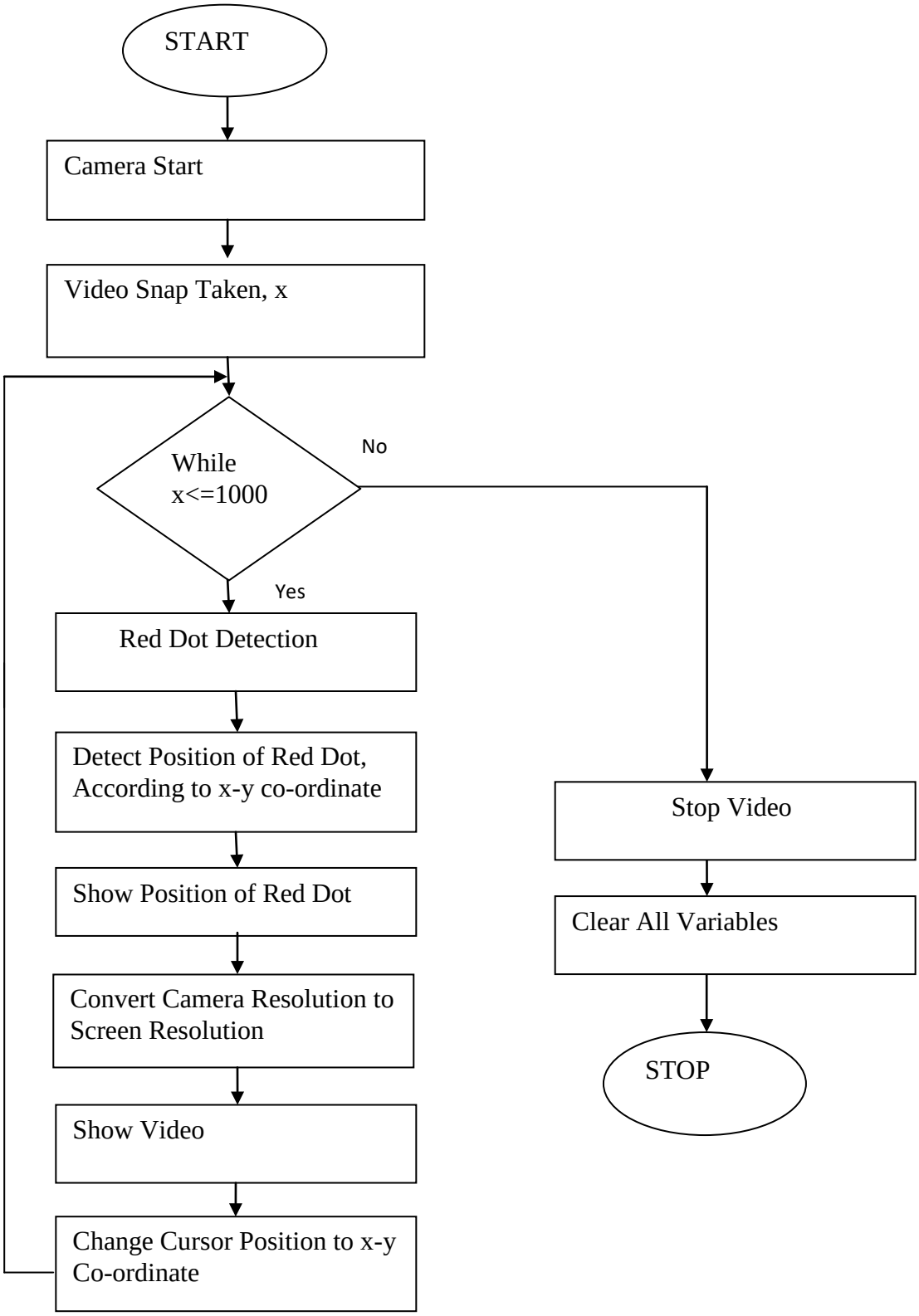


Figure 5.1: Red Dot Detection and Moving the Cursor Code

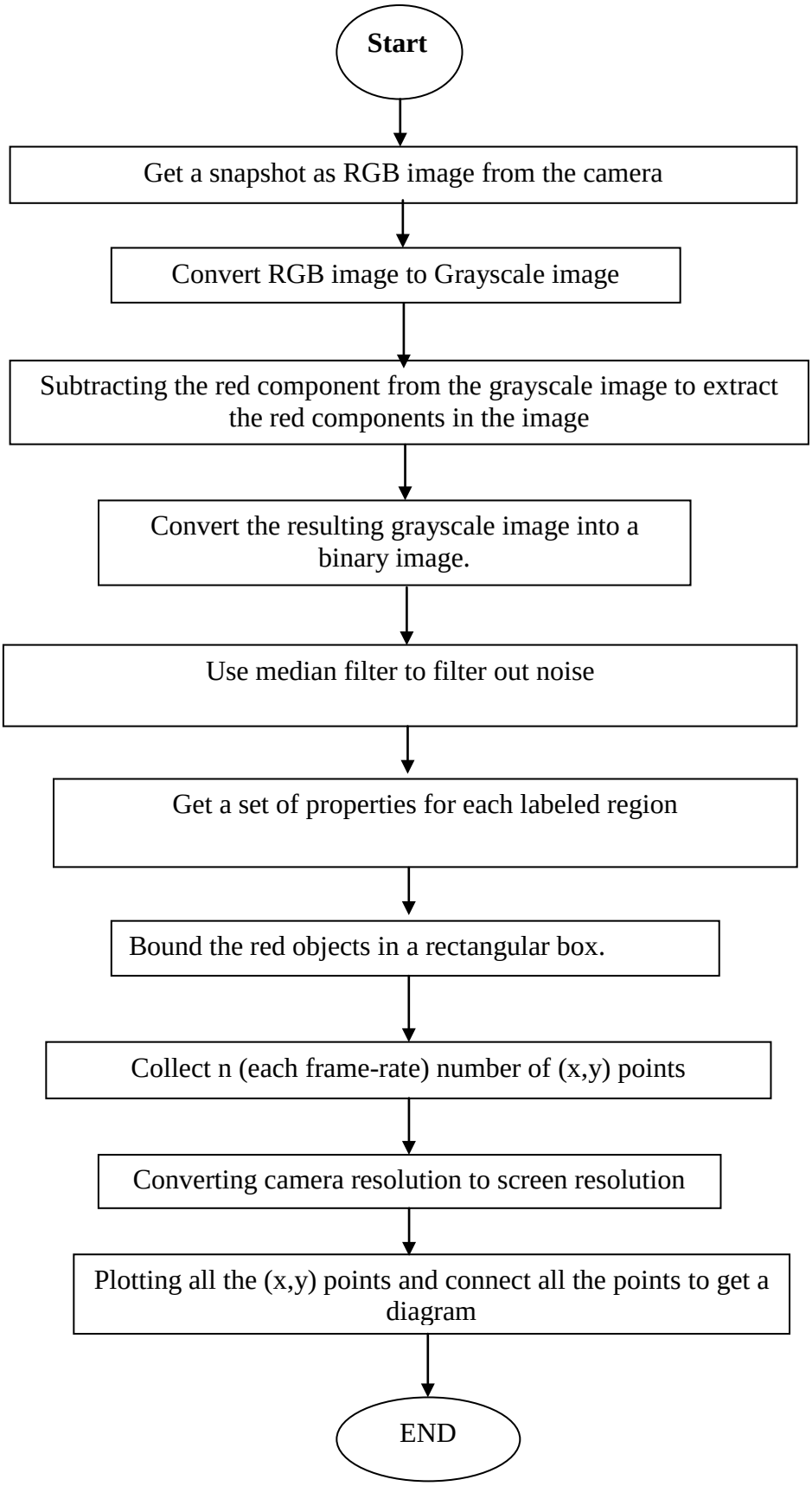


Figure 5.2: Red Dot Detection Code

Chapter: 6

Image Processing

6.1 Introduction:

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it[15]. It is a form of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Digital Image processing employs the use of algorithms to scan and manipulate an image or a video to get desired results. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science and medicinal disciplines too.

6.2 Description:

Image processing is central and the most crucial part of our project as it is the basis on which our device starts, detecting the laser dot or pointer. In our project the image processing is done by a series of codes to make sure that the webcam that is used to track the laser dot only reads the red dot and filters out everything else. Through this we are able to get an accurate reading of the laser dot's movement. The whole process is done in several steps which will be discussed in elaborately in sequence later on. From the beginning to the end the steps or stages in sequence are

I. Getting snapshot as RGB image from the camera.
II. Convert RGB image to grayscale image.
III. Subtract grayscale image from RGB image.
IV. Apply 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.

IX. Connects all the (x,y) points and forms an image.

Capturing snapshot as RGB image from the camera:

To begin the camera is placed on a surface facing the surface on which the laser will be projected i.e facing the laser dot. The camera captures frames in rapid succession and stores them in RGB format. Although a high quality camera can capture higher number of frames per second, it affects the overall processing speed therefore a relatively good camera with modest frame rate is used and recommended for smooth running. Alternatively a better processor in the computer being used will allow more frames to be processed per second thereby granting smoother and faster processing. As the pen is designed for common everyday use the values are set to a standard level for optimum performance and execution time in personal computer rather than high performance ones.

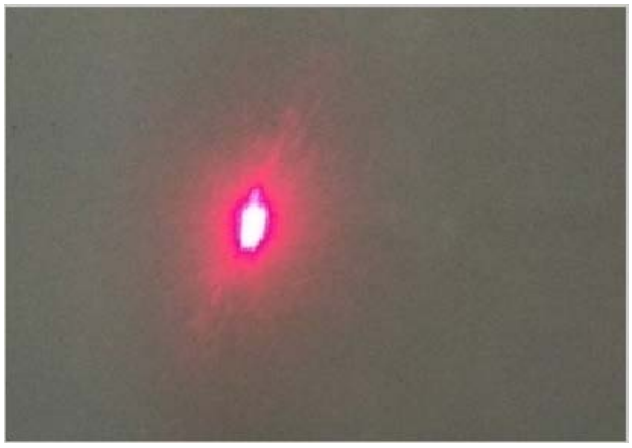


Fig 6.1:Capturing snapshot as RGB image from the camera

Convert RGB Image to Gray-scale Image:

The image is initially recorded in RGB format which is a three dimensional format and therefore takes up a lot of space. In order to reduce the amount of space to speed up execution time the image which is in RGB format is converted to Grayscale, a format which only has intensity as its pixel variable, which is much simpler. The equation used to convert RGB color space to Grayscale value is given below. The converted image will be in NTSC format [16].

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

Where,

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

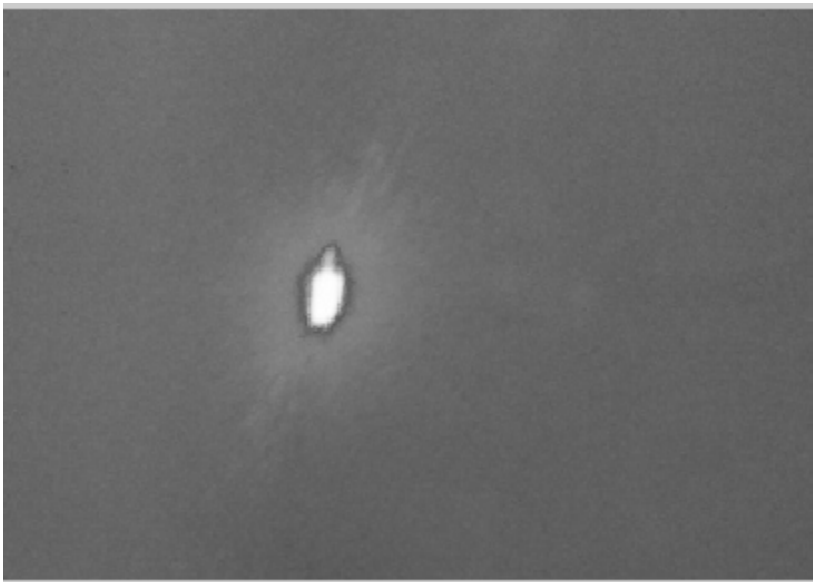


Fig 6.2: Converting RGB Image to Gray-Scale Image

Subtracting gray-scale image from RGB image:

The RGB image consists of 24 bits with 8 bits representing the Red, Green & Blue components of the color and each component has a value in the range between 0-255. A white pixel has a combination of (0,0,0) while a black has (255,255,255). Considering equation 1 we can see that the red component of the pixel is now represented by Luminance (Y). If we were to subtract this grayscale value from a white pixel background then we can see that the regions with high luminescent red pixels appear brighter in stark contrast to a black background that all the other surrounding pixels with non-red color represent. Therefore the red pointer appears as cluster of white in a background of black. As a direct result of this process the variable in consideration is reduced to one which is red luminescence.

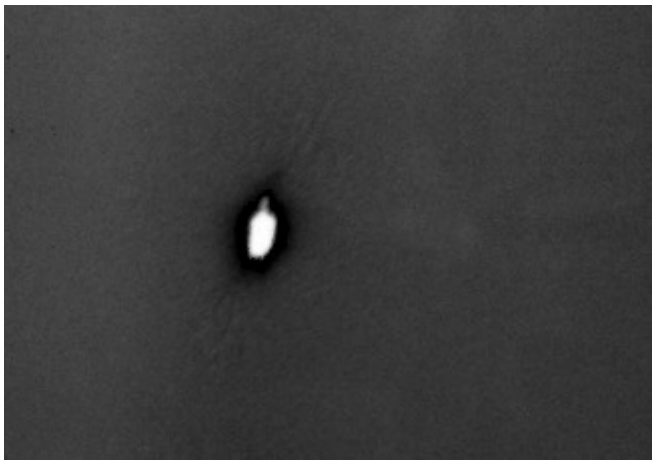


Fig 6.3: Subtracting gray-scale image from RGB image

Use Median filter to filter out Noise:

The image we get at this stage is not accurate. Environment disturbances, like dust particles, as well as electrical device irregularities produce deviance in the values we get. These deviances are called “salt and pepper” noise due to the characteristics black and white spots they create in the image map[17]. These pixels cause significant error in the reading of the data and therefore it is important to compensate for them. A median filter is used to replace the noisy pixels with the median value of the surrounding pixels to reduce the error[19]. The equation used to achieve this is given in the next,

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

Where ω represents a clusterwhose location (m,n) is centered in the image. As a result, the value of the center pixel is calibrated to be closer to its surrounding values. A window of 3x3 matrix of pixels (that is one pixel surrounded by 8 pixels in each direction) is used to ensure that the whole area of the image is swept through and calibrated. This results in a drastic reduction in noise while still maintaining the sharpness of the image.

Converting Gray-scale Image to Binary Image:

The next step is to convert the grayscale image we have until now to a binary image. However before that we must consider the surrounding ambient lights which may interfere with our red dot. To fix this problem a technique known as "Thresholding" is used. In this technique a range of pixel values that we want is assigned the number '1' while all the other values are given '0'. This is done so that we can completely separate the pixels we want from the other values. There is a pre-existing condition for the process to be effective namely, the contrast between the luminescence, or intensity, of our desired pixels and the background must be significant. The contrast between target pixels and background influences the "Threshold Binary Conversion Factor" [TBCF]. Usually the value of TBCF lies within the range [0, 1]. However as mentioned earlier the ambient lights causes disturbances to the intensities of the target and background pixels so to compensate a modified range of TBCF is used, since ambient light intensity is directly proportional to TBCF. A range of [0.10, 0.30] was found to give the most optimum results. The value of TBCF is varied gradually from 0.10 to 0.30 until the red dot is detected, upon which a value of '1' is assigned to all the pixels detected in this range and all the others '0'.

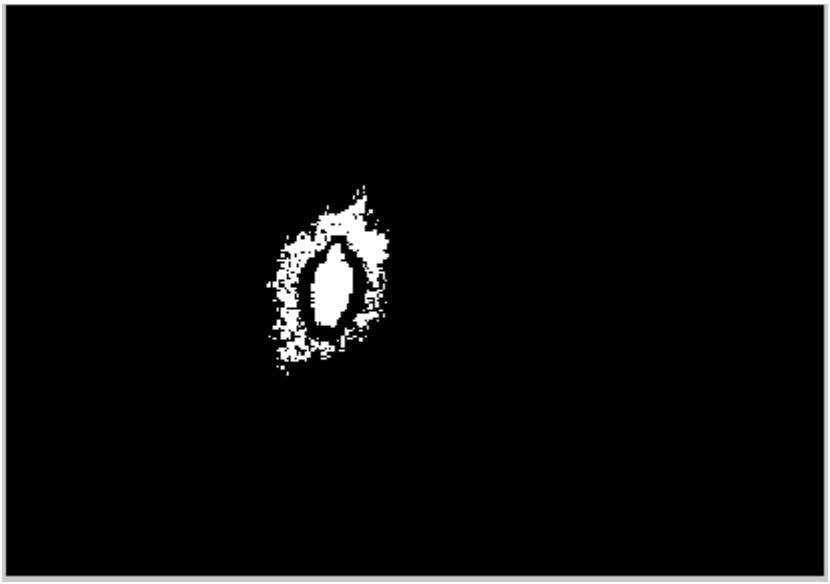


Fig 6.4: Conversion of Grayscale Image to Binary Image

Selection ofDesired Red Mark and Position Identification:

The next step is to isolate the red dot and remove everything else with precision. This is done by first connecting all the white pixels to the surrounding black pixels resulting in another binary image. A Threshold size is pre-determinedand the values of the connected pixels are compared with it. The pairs which are above the threshold size are removed leaving us with the red dot. This is done to remove the slight possibility of any other similar red objects.To summarize the entire process is

- Connect white pixels to nearby black pixels
- Compare each pair size
- Remove pixel pairs greater than threshold size

If we consider the pixel pairs that are connected as a single unit then a few conditions must be met namely, the pixel sizes must be same and their values must also be same. Although Grayscale and RGB images have a wide range a binary image does not have any range, it is 1 or

0. And there is also the matter of how many dots are connected to consider so two equations are used for both cases to provide similar values of V in order to provide continuity [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) }

Where N_x denotes the number of dots connected, N_4 being 4 connected and N_8 being 8 connected. Two pixels are 4-connected or 8-connected to each other if there is a path between them.

After all the connected pixels of the binary image is found and analyzed, they are each component labeled with unique labels using Sequential Algorithm [20]. Then they are compared against a Threshold size, T_0, and the components that cross the threshold size is removed or turned dark by changing the pixel values to 0. Centre co-ordinates from the remaining components are calculated and the position of the red dot is derived from it.

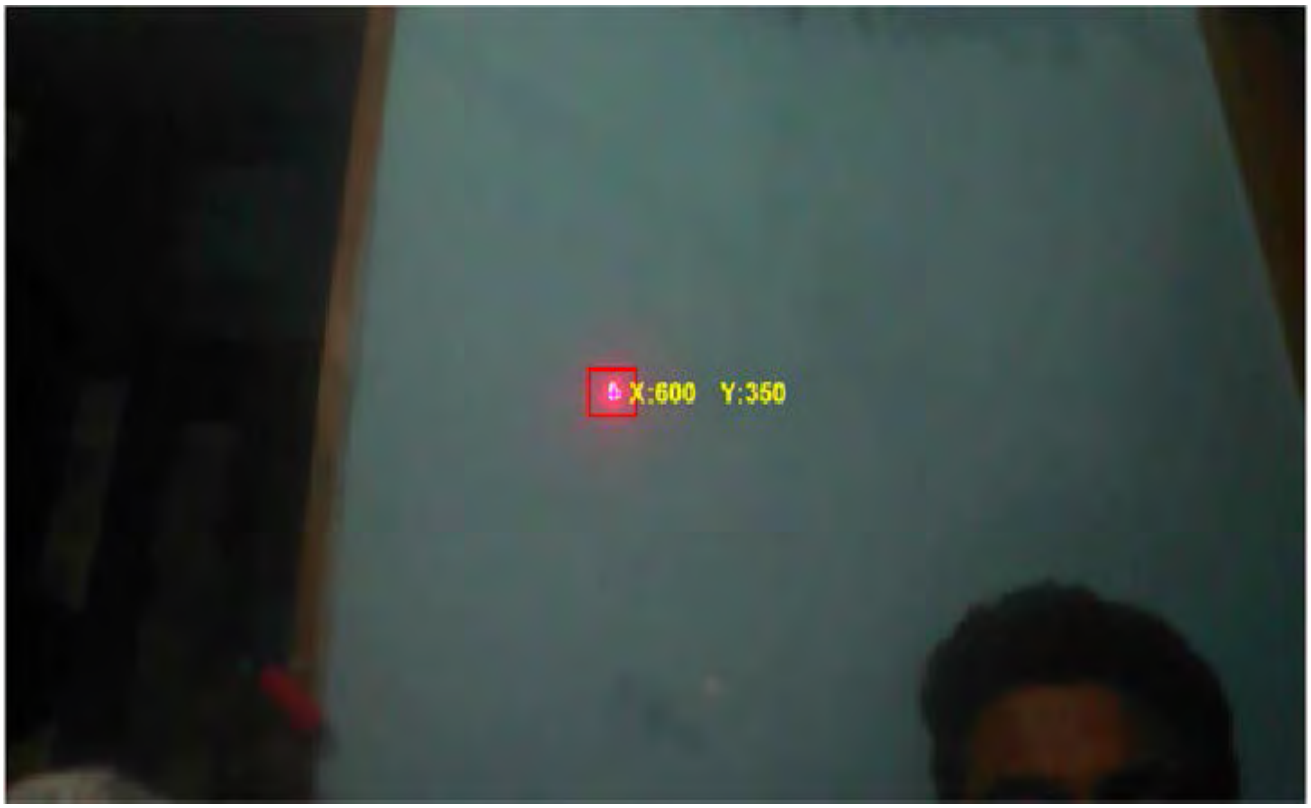


Fig 6.5: Desired Red Dot Detection

Colored Background Subtraction:

As the camera records successive frames there, is a possibility of more than one red object being detected in all other stages. Based on the assumption that the other red objects are stationary while our red dot is dynamic, we can find out the positional background matrix of the image. At each frame the position matrix of the red dot is also detected. Then the position matrix of the red dot in each frame is compared to the positional background matrix and this process is repeated for each frames. By comparing the matrixes we can find the position of the moving red object i.e. the red dot.

In the matrix given below, we have 3 frames each containing red objects and the position matrix 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].

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

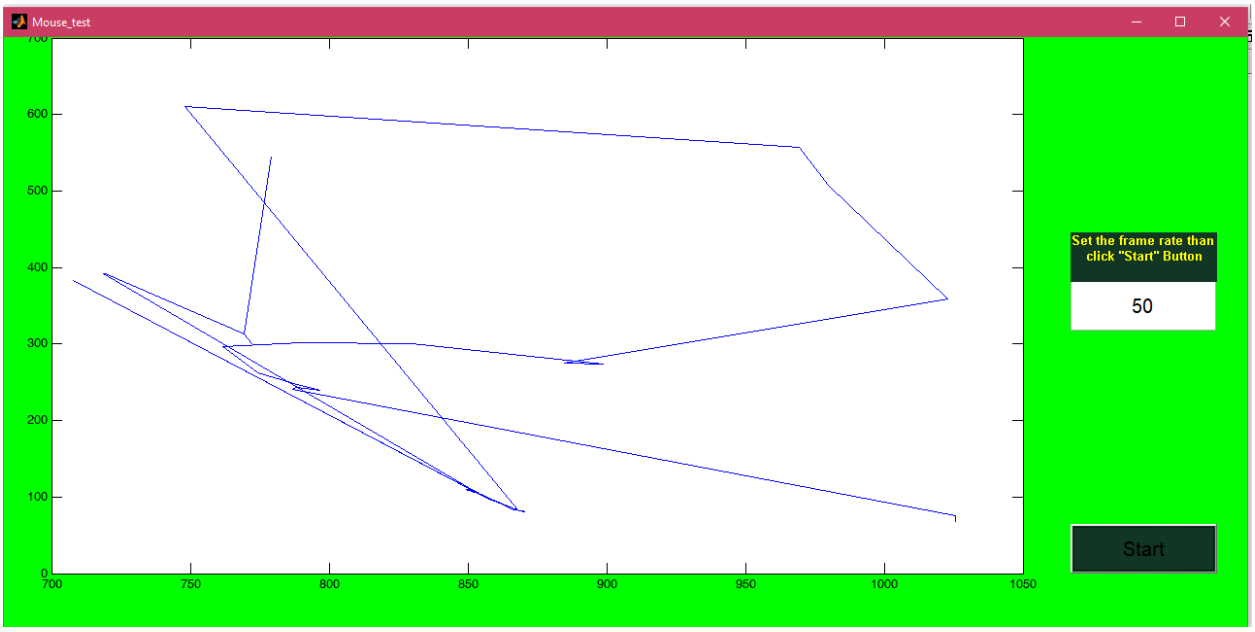
In the above example if we consider that (p1, q1) ≈ (p1', q1') and (p2, q2) ≈ (p2', q2'), then the background matrix is

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

We can determine the position difference of the same object in the position matrix and we can denote it by the term ∈. The values vary depending on the quality of the camera. Every time a new frames is recorded a new position matrix is formed and is compared to the background image. If it contains all the rows then we can conclude that the position of the red dot is in the row that does not satisfy the equation. This process is repeated each time a frames is taken continuously.

Connecting all the (x,y) points and forms an image:

After collecting n number of frames, at the end the code connects all the positions of the red dot coordinates and forms an image similar to the given below-



Chapter 7:

System design and Result

7.1 System Design

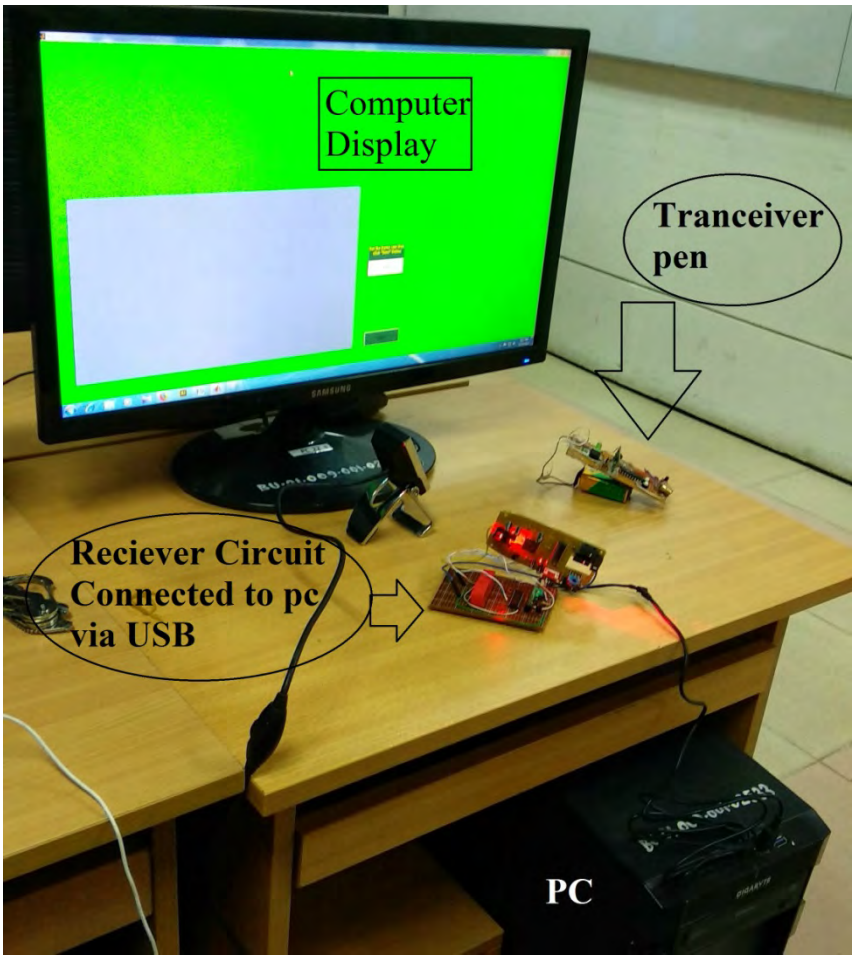


Fig 7.1: Design of Full System

As we have shownearlier, our full system of digital pen has three mainparts. These are respectively a pen that has the transmitting circuit, a camera facing the surface where the laser will be projected at and a receiving circuit that is being connected with amodified mouse circuit, which is connected to the software section of the computer. The pen has a Laser diode on the tip of it. When the power button is pressed, the laser projects a red dot on the surface it is pointed towards. The camera detects the red dot and sends the pictures to the processing MATLAB code which is running to identify the position vector of the red dot. If we move or change the position of the red laser dot by moving the pen, its position vectors change and the cursor on the display changes appropriately.

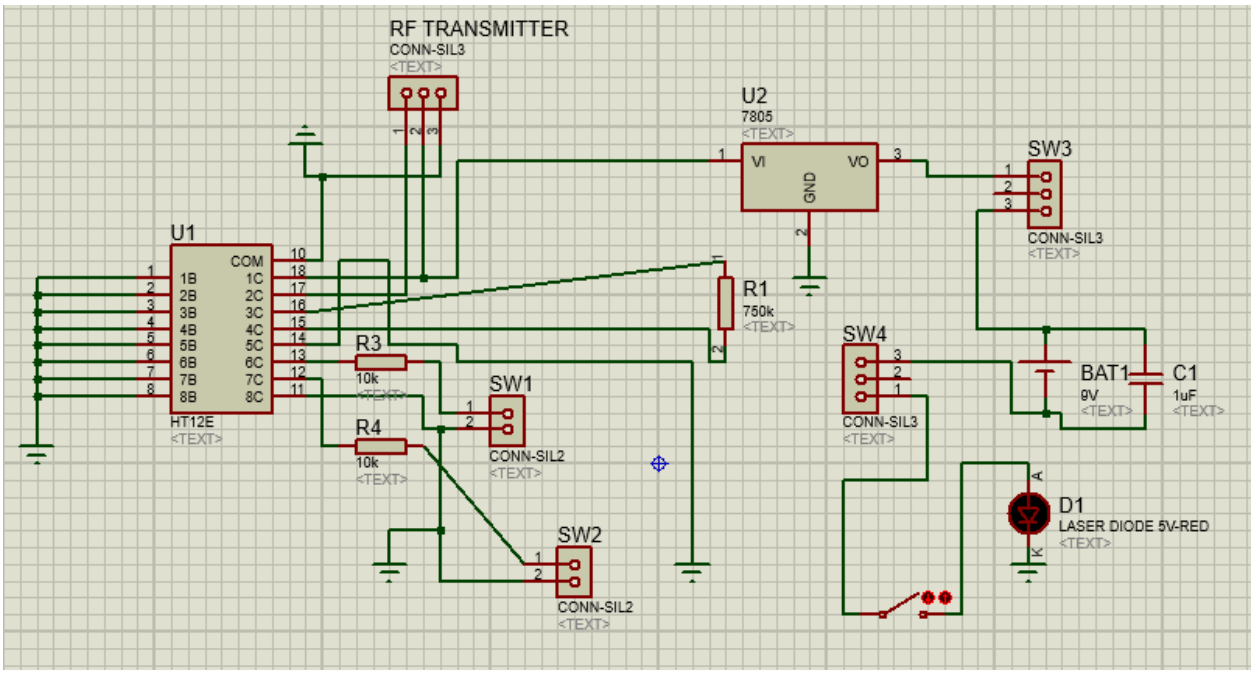


Fig 7.2: Transmitting Circuit

After the detection of the red marker is completed the execution part begins. When we proceed clicking the left-click button of the pen, it sends the instruction signal to the encoder where the signal is being encoded by the encoder and pass the encoded signal to the RF transmitter. Transmitter transmits the signal to the RF receiver of the receiving circuit, which is associated with the mouse circuit.

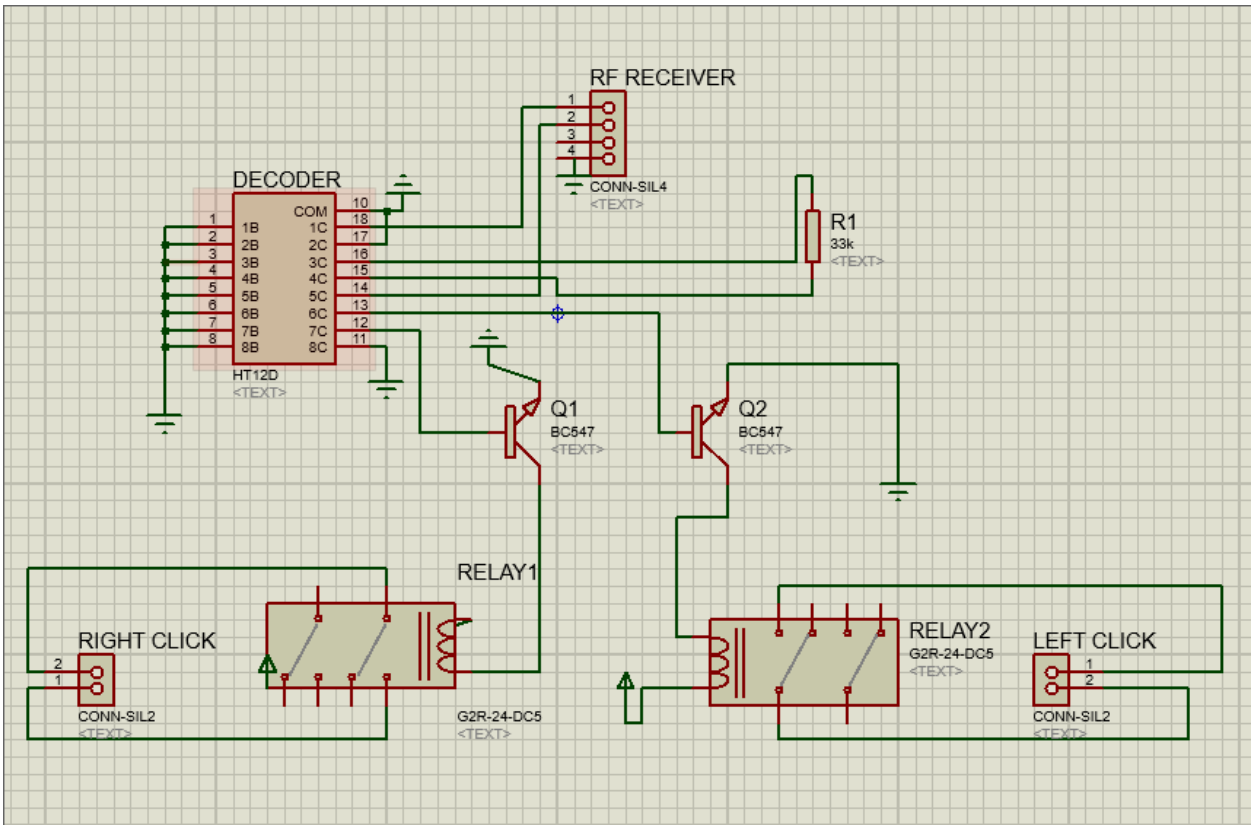


Fig 7.3: Receiving Circuit

After getting the signal, RF receiver sends the encoded data to the decoder. The Decoder decodes the received signal and pass the signal to BJT which will amplify the signal and then passed it to the relay for switching. By default, this particular relay usually stays in NC position. After getting the signal, relay switches its position to the NO position sends the signal to the left button of the mouse and the pen executes the left click. The execution of right click works vice versa.

7.2 Implementation of the system

We cannot imagine a computer without a mouse as it is the most crucial interactive device for the computer. Invention of mouse made it so much easier to operate computers than it was before. As mouse has brought a revolution in the field of technology and computing, any further improvement of it will also open new doors of various opportunities in technology. A digital pen with multipurpose mouse function has many implementations which could be beyond our imagination. Combining both the tasks of drawing as a pen and operating exactly like a mouse, would be more helpful for both instructors and students insome places like classrooms, workshops and seminars where instructor needs to write things for the audiences. It is more effective in delivering lectures at an art or architectural class. An instructor does not have to write on board and blocking the lecture partially while walking around and make changes from anywhere in the class. Students will get more advantage from a digital pen mouse if used in classrooms because unlike the traditional way, the pen is able to provide more visualization regarding the lecture giving the students the advantage offocusing and understanding the entire lecture without any usual distraction. As a result they do not have to do both writing the class notes and understanding the lecture at the same time. After understanding the lecture, they can get the image created by the pen saved in the computer for further studying. As it is saved in the computer memory, it also saves time to redraw or rewrite the same lecture again. And giving access to both students and teachers, it also saves from more unnecessary consuming time to carry on.

7.3 Limitation and Further improvement

Not everything is perfect on earth. There is always a flaw. As such, we too have some limitations in our project. Our objective was to create a system which is not dependent on working in a podium. We overcome the challenge but it created a new limitation to the surface. The projected surface should not be a bright surface. The surrounding environment has to be dim similar to the condition where the room is made less bright to operate a projector to see well.So the should not be very bright otherwise the webcam will fail to detect the red laser dot.The fundamental confinement we have in our project is it can't work without a stationary camera wired with the computer facing the surface where the red laser marker will be projected. At that point another constraint is that it has a receiving circuit connected with the mouse which is also wired with the computer. As the pen needs MATLAB code to work, our device won't work on a computer that does not have MATLAB platform software installed.Without the physical filter of the camera it cannot detect the red laser dot because the laser intensity profile is Gaussian with no clean circular edge and very small so the filter needs to blur out all the colors[21]. The entire system depends upon the specification of the computer and the webcam we use. The higher the configuration of both the computer and the mouse, the better and smoother performance output of our system.

There's lot more options in our system to work with. It is possible to work without the receiving circuit which is connected with mouse. We can make software to avoid MATLAB code so that we can install that software in any computer without worrying to install MATLAB. We can add a scroll wheel button and connect it with the available pin in the encoder of the transmitting circuit but it would mean to re-design the whole logic system of the transmitter circuit. Instead of MATLAB platform we can implement this project on PYTHON platform which would make our system faster. We can redesign the system which is independent of the computer and also the webcam's configuration.

Instead of taking frames in a video loop we can implement real-time imaging systems. As operating MATLAB can be complicated for the lecturers and also for teachers, a friendly user interface can be applied to run the system easily without any complications. If we use ARDUINO UNO it would open many other interesting options of improvement.

Chapter 8
Conclusion and Future Research

8.1 Summary

In our thesis project, what we have been attempting to do is to make an advanced digital multipurpose pen that will work remotely however more productively than a common mouse. To make it conceivable, we needed to consolidate couple of components alongside the pen. A camera is utilized to track the laser dot marker produced from the pen and it is set facing the anticipated marker. Working technique is exceptionally straight forward. Camera recognizes the Red Laser dot of the pen with the assistance of MATLAB code which is running on the computer responsible for the changing the cursor's position in the display. At the point when a button is clicked on the pen, a signal is produced. That signal is being sent by the transmitter circuit on the pen and to the receiver circuit,upon receiving the signal, the circuit execute the click. Principally that is all about the pen which we hope will replace the mouse in digital classroom settings so that we can use it in presentations, classrooms, workshops, seminars and in other educational affairs. It will be an effective tool for delivering lectures or explaining graphical & complicated image which are hard to comprehend.

8.2 Future Research

In not so distant future it is conceivable to make a pen that could go past the creative ability.We can write on any surface with that smart pen and Bluetooth connectivity will allow it to be used as plug and play. It can even be used with a projector. A built in infra-red camera can be used so that the pen becomes a single independent device.A visual sensor can be incorporated so that it can scan any color and generate that color in the monitor so that it can be used in artwork. An interface can be added after developing increased memory and function for better user experience. Also filters can be added to the laser to manipulate the shape of the pointer to make different shapes or, in case of artwork, brush sizes. It will have the ability to record voice command in its memory and execute accordingly. It can also be made to mimic a projector by adding some of the components so that it can project the lectures or art it has recorded. Real time imaging system is possible to implement in this project and it would open doors of revolutionary discoveries. Instead of MATLAB there could be other faster and more efficient platform for the system.

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25.https://en.wikipedia.org/wiki/Telautograph
26.https://wiki2.org/en/Pen_computing
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Appendix:

Codes Used for the Digital Pen:

```
clearall;
closeall;
clc;

Robot=java.awt.Robot;


%  x=10;
%  y=10;
%  for i=1:100
%     x=x+5;
%     y=y+5;
%  Robot.mouseMove(x,y);
%  pause(0.2);
%  end



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);


vid = videoinput('winvideo',1);

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

%for getingscrenresulation;
resulation_screen = get(0,'screensize');
x_screen = resulation_screen(3);
y_screen = resulation_screen(4);
```

```
%for geting camera resulation;
% x_cam=str2double(format(6:8));
% y_cam=str2double(format(10:12));

x_cam=960;
y_cam=720;


%start the video aquisition here
start(vid)

% Set a loop that stop after 100 frames of aquisition
while(vid.FramesAcquired<=150)

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

% 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));
    b=diff_im;
%Use a median filter to filter out noise
diff_im = medfilt2(diff_im, [3 3]);
    c=diff_im;

% Convert the resulting grayscale image into a binary image.
diff_im = im2bw(diff_im,0.18);
    d=diff_im;

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


% 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);

holdon

%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');

        a=vid.FramesAcquired;

xxx = round(bc(1));
yyy = round(bc(2));
        x= bc(1);
        y = bc(2);
%converting camera res to screen res
%         x = MAP_Two(xxx,0,x_cam,x_screen,0);
%         y = MAP_Two(yyy,0,y_cam,0,y_screen);

%         Robot.mouseMove(bc(1),bc(2));
Robot.mouseMove(x,y);

xx(a) = x;
yy(a) = y;

end
%
%    x= uint16(bc(1));
%    y= uint16(bc(2));
% %      % mouse movement


holdoff
end
imshow(a);
imshow(b);
imshow(c);
imshow(d);
imshow(e);
%imshow(f);

% 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',The End :) ')

aa = nonzeros(xx);
bb = nonzeros(yy);
plot(aa,bb);
```