Visvesvaraya Technological University, Belagavi.

PROJECT REPORT

on

"AUTOMATED WRITING MACHINE"

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CERTIFICATE

This is to Certify that the dissertation work **“Automated Writing Machine”** carried out by Ms. Matam Vyjayanthi, Ms. N Chaitra, Ms. Raksha Ghosh, of USN 1CR16EC078, 1CR16EC088, 1CR16EC127 respectively, bonafide students of **CMRIT** in partial fulfillment for the award of **Bachelor of Engineering** in **Electronics and Communication Engineering** of the **Visvesvaraya Technological University, Belagavi,** during the academic year **2019-20**. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said degree.

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ABSTRACT

Time is a commodity that needs to be managed effectively and efficiently in order to maximize productivity. As the process gets more complex and cumbersome, technology and automation become vital resources for the success and continued growth of a sales organization.

Automation, or labor-saving technology is the technology by which a process or procedure is performed with minimal human assistance. Automation or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention.

Advantages commonly attributed to automation include higher production rates and increased productivity, more efficient use of materials, better product quality, improved safety, shorter workweeks for labor, and reduced factory lead times. Higher output and increased productivity have been two of the biggest reasons in justifying the use of automation. Automated machines are more accurate, versatile & reliable. They reduce the probability of error significantly.

The automated writing machine consists of two motors to achieve movement of the mechanical arm in two dimensions. The system developed aims to reduce the final production cost by 73%. This Automated writing machine is a programmed composing machine used for composing any kind of content and drawing any outline on paper. It works like a CNC machine.

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Chapter 1

INTRODUCTION

1.1 OVERVIEW

As the world is entering the dawn of a new era, manufacturing is undergoing an evolution which has been termed as Industry 4.0 or Smart Manufacturing. The speed with which industries are moving towards digital technologies like industrial robotics, 3D printing, machine learning, optical character recognition, cloud computing, augmented reality and sensors can make the Industry 4.0 revolution more realistic [1].

The human race is turning to robots to do the work and reduce human effort. In this society which is undergoing a rapid change, time and manpower are the major critical constraints in the completion of any tasks on large scales and with efficiency. Therefore automation is playing a significant role in saving a lot of human efforts in most of the regularly carried out works like welding, painting, assembly, container filling, writing, etc. As far as writing is concerned, the time and effort taken in typing the keys on a keyboard which is time consuming and requires a lot of skills and human efforts can be avoided with the help of automation [2] [3].

Some existing technologies such as automated voice to text converters are used to write only the inbuilt fonts like the Roman, Calibri, Arial, Impact, Georgia, etc. The paper aims to design and develop a system which is capable of writing on a page with the help of a pen in the user's specific handwriting or in predefined font if needed.

This initiates the concept of CNC machines which are Computer Numerical Control machines which is a unique and versatile form of soft automation. Initially, it had been advanced to regulate the motion and also the operation of device tools. By using concepts like CNC machines, an automated machine can be implemented for writing purposes also [6][9]. Fig 5 shows the overall hardware setup of the proposed system.

1.2 PROPOSED SYSTEM

The proposed system is an auto composing machine through which one can make their work simpler by programming the venture. According to the title this is a straightforward task utilizing Arduino to make a writing machine at the place of work, which can draw any outline and compose various kinds of fonts. This system is an embedded system whose working principle is based on the Computer Numerical Control machine. It uses an Arduino development board which is connected with other peripherals like motors to provide the necessary pen movement on the paper.

The Arduino board is interfaced with one servo motor and two stepper motors to achieve the pen movement and x-y axis gantry movement respectively based on the input image that is fed into the system. The pen which is fitted in the system is part of the z axis movement. The servo motor helps in the vertical movement of the nib of the pen so that the pen nib will touch the paper only when something needs to be written and is raised above when not needed. This motion of the pen in the z axis coupled with the x and y axis movement achieved through the stepper motors results in a two dimensional sketching on the paper.

This system is a valuable setup and can be utilized in everyday life. As we know, there are many areas in human life which require us to write the matter by ink on a paper in their own handwriting. For example Departments like Administration, Judicial, Municipal, Police, etc. having clerks for writing the matter manually.

Chapter 2

LITERATURE REVIEW

In this chapter , we will discuss how the automated writing concept developed through history. Table 2.1 shows a list of all major automated or mechanical writing systems.

Table 2.1 List of all major automated or mechanical writing systems

Machine	Year
1804	Polygraph
1874	Typewriter
1888	Telautograph
1937	Autopen
2004	Longpen
2014	AxiDraw
2017 - 19	Papers published

2.1 POLYGRAPH

A Polygraph is a duplicating device that produces a copy of a piece of writing simultaneously with the creation of the original, using pens and ink. It was first developed by an Englishman named John Isaac Hawkins. Hawkins received a United States patent for his device in 1803. This early device was known at the time as a polygraph and bears little resemblance to today's autopens in design or operation .

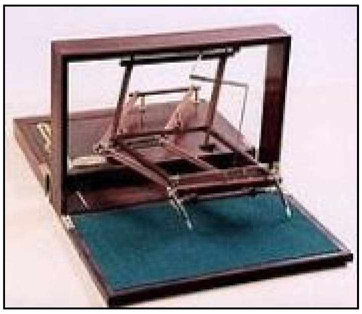

Fig 2.1 Polygraph

2.2 TYPEWRITER

A typewriter is an electromechanical machine for writing characters similar to those produced by a printer's movable type. Typically, a typewriter has an array of keys, and each one causes a different single character to be produced on the paper, by means of a ribbon with dried ink struck against the paper by a type element similar to the sorts used in movable type letterpress printing. The first commercial typewriters were introduced in 1874, but did not become common in offices until after the mid-1880s. The typewriter quickly became an indispensable tool for practically all writing other than personal handwritten correspondence. It was widely used by professional writers, in offices etc.

Fig 2.2 Basic typewriter

2.3 TELAUTOGRAPH

The telautograph, an analog precursor to the modern fax machine, transmits electrical impulses recorded by potentiometers at the sending station to servomechanisms attached to a pen at the receiving station, thus reproducing at the receiving station a drawing or signature made by the sender. It was the first such device to transmit drawings to a stationary sheet of paper. The telautograph's invention is attributed to Elisha Gray, who patented it on July 31, 1888. Gray's patent stated that the telautograph would allow "one to transmit his own handwriting to a distant point over a two-wire circuit".

2.4 AUTOPEN

An autopen or signing machine is a device used for the automatic signing of a signature or autograph. The autopen called the Robot Pen was developed in the 1930s, and became commercially available in 1937. It was used as a storage unit device (similar in principle to how vinyl records store information) to record a signer's signature. A small segment of the record could be removed and stored elsewhere to prevent misuse. The machine would then be able to mass-produce a template signature when needed.

The first commercially successful autopen was developed by Robert M. De Shazo, in 1942. The modern autopen, the Autopen Model 50 was one of the International Autopen Company’s earliest automatic signature machines [20].At top speed, the machine signed about twice as fast as a human.

Fig 2.3 Autopen Model 50

2.5 LONGPEN

The LongPen is a remote signing device conceived of by writer Margaret Atwood in 2004 and debuted in 2006. It allows a person to remotely write in ink anywhere in the world via tablet PC and the Internet and a robotic hand. It also allows for an audio and video conversation between the endpoints, such as a fan and author, while a book is being signed.

2.6 AXIDRAW

The AxiDraw project has been active since 2014, when it was first created by Dr. Lindsay Robert Wilson. In the UK. The AxiDraw is a simple, modern, precise, and versatile pen plotter. AxiDraw machines work with a variety of writing instruments, including permanent markers and fountain pens. The unique writing head extends beyond the base of the machine, making it possible to write or draw on almost any flat surface [18].

The AxiDraw is a pen plotter, which is a type of simple robot. Its sole function is to guide a pen along the set of vector lines, curves, and paths that you ask it to follow. Everything that the machine is ultimately capable of, such as drawing graphics, writing text, or signing documents, are expressions of this basic function. It is capable of drawing essentially anything that can be composed from a set of lines. But there are not many advances made in the machine where the output is in the user's handwriting. Additionally, these machines are really expensive for a common man to buy.

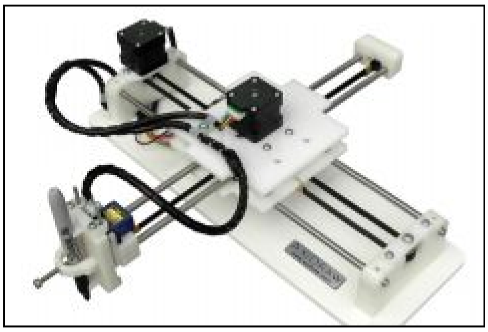

Fig 2.4 AxiDraw

2.7 PAPERS PUBLISHED

All the papers published about pen plotters do not incorporate converting the extracted text from a document into the user's font.

In the paper title “Automated Writing and Drawing Machine“ [2] a robotic arm has been developed which is fitted with a pen and this system is programmed to write down anything that the user pronounces into the microphone. This setup is cost efficient which helps a physically challenged person to write or draw small sketches, draw an outline diagram, and do multiple signatures. This work was based on Java and web applications along with firebase Server.

The paper “Homework Writing Machine” [3] discusses a composing machine which is capable of composing any kind of content and drawing any outline on paper. This instrument could be utilized by the network for the outline and quick composition process. This machine works in three axes whose movement is given by stepper engine and servo engine.

The author in the paper “Design and Development of Arduino Controlled Writing Robot” [7] has focussed on developing a writing robot which incorporates speech recognition using an Arduino microcontroller. This machine is capable of recognizing voice inputs recorded by the user with the help of a microphone and writing the message on paper.

The system proposed in this paper is an automated writing machine which is capable of performing optical character recognition. The aim is to give the output on paper with the help of a pen controlled by motors in the user's handwriting or in a predefined font, provided the user's font is built and installed which can be done through web applications.

Chapter 3

PROJECT DESCRIPTION

3.1 OVERVIEW

This chapter describes the fundamental concepts based on which the project is designed and implemented. This includes a brief introduction on the overall software and hardware working.

3.2 SOFTWARE

Computer software, or simply software, is that part of a computer system that consists of encoded information or computer instructions, in contrast to the physical hardware from which the system is built. All the softwares used in this project comes under the open source category.

Open-source software (OSS) is computer software with its source code made available with a license in which the copyright holder provides the rights to study, change, and distribute the software to anyone and for any purpose. Open-source software may be developed in a collaborative public manner. Open-source software is the most prominent example of open-source development.

The role of software in this project is to mainly extract text from the image. This is called Optical Character Recognition (OCR). Optical Character recognition (OCR) is a process of detecting text regions inside a digital image and recognizing the text. It is mostly used in text detection and extraction from scanned documents. The processing of images in OCR comprise of detecting and recognizing various characters like numbers, symbols, and alphabets. It's also possible to integrate several programs which will result in OCR. For example one program can detect text regions and send the output to a second program, which in turn can recognize the characters in text and convert them to editable form [5][10].

3.3 HARDWARE

Electronic hardware consists of interconnected electronic components which perform analog or logic operations on received and locally stored information to produce as output, resulting in new information or to provide control for output actuator mechanisms.

Electronic hardware can range from individual chips/circuits to distributed information processing systems. Well designed electronic hardware is composed of hierarchies of functional modules which inter-communicate via precisely defined interfaces.

The proposed system’s hardware mainly consists of two axes operating orthogonally to each other and a third axis, with limited motion capability, which is used to actuate the write head. Additionally, the hardware is controlled by the software through a development board.

Chapter 4

SOFTWARE

4.1 OVERVIEW

All the softwares and libraries used to implement this project is exhaustively discussed in this chapter. The softwares and libraries used are: Python, Open CV, Pytesseract, PIL, Benbox.

4.2 PYTHON

The basic programming language used in this project is python. More precisely Python version 3.8. Python is a general-purpose programming language that can be used on any modern computer operating system. It can be used for processing text, numbers, images, scientific data and just about anything else you might save on a computer. It is used daily in the operations of the Google search engine, the video-sharing website YouTube, NASA and the New York Stock Exchange. These are but a few of the places where Python plays important roles in the success of the business, government, and non-profit organizations; there are many others.

Python is a dynamic language, built for speed. Python is a high-level, interpreted and general-purpose dynamic programming language that focuses on code readability. The syntax in Python helps the programmers to do coding in fewer steps as compared to

Java or C++. Python has topped the charts in recent years over other programming languages like C, C++ and Java and is widely used by programmers.

One of the main reasons to choose this language was because it provides large standard libraries that include the areas like string operations, Internet, web service tools, operating system interfaces and protocols. Most of the highly used programming tasks are already scripted into it that limits the length of the codes to be written in Python. Secondly, python is relatively very easy to write and understand.

4.3 OPEN CV

The CV in OpenCV stands for Computer Vision. Humans are capable of perceiving the three-dimensional structure of the world around with apparent ease. Computer vision (CV) tries to describe the world that humans see in one or more images and to reconstruct its properties [22]. Being a very matured and well supported programming language in the area of machine learning, Python is used for computer vision programming. Practically computer vision applications contain a mix of programming, modeling, and mathematics [22].

Computer vision is a field of computer science that works on enabling computers to see, identify and process images in the same way that human vision does, and then provide appropriate output. It is like imparting human intelligence and instincts to a computer. In reality though, it is a difficult task to enable computers to recognize images of different objects. When a human who is driving a car sees someone suddenly move into the path of the car, the driver must react instantly. In a split second, human vision has completed a complex task, that of identifying the object, processing data and deciding what to do. Computer vision's aim is to enable computers to perform the same kind of tasks as humans with the same efficiency.

An important point to note is that computer vision is not like image processing. Image processing only deals with enhancing the contents of the image but it is not concerned with understanding the content of the image. One of the problems solved with computer vision is Optical Character Recognition (OCR).

OpenCV stands for open source computer vision. OpenCV is an open source computer vision and machine learning library. OpenCV is a library of programming functions mainly aimed at real-time computer vision. In simple language it is a library used for Image Processing. It is mainly used to do all the operations related to images. It is really great for research papers or projects that are built on top of the work of other developers. OpenCV is capable of working with any operating system [11]. OpenCV also supplies functions to read images from files. It supports the most common image formats [19]. OpenCV and Tesseract can together be combined and used to achieve OCR [15].

In the proposed system, OpenCV performs text detection using OpenCV's EAST text detector, a highly accurate deep learning text detector used to detect text in natural scene images [15].

4.4 TESSERACT

OCR (Optical Character Recognition) is a widespread technology to recognise text inside images, such as scanned documents and photos. OCR technology is used to convert virtually any kind of images containing written text (typed, handwritten or printed) into machine-readable text data. Probably the most well known use case for OCR is converting printed paper documents into machine-readable text documents. Once a scanned paper document goes through OCR processing, the text of the document can be edited with word processors like Microsoft Word or Google Docs. Before OCR technology was available, the only option to digitise printed paper documents was to manually re-typing the text. Not only was it massively time consuming, it also came with inaccuracy and typing errors.

Tesseract is an optical character recognition engine which can recognize characters from images by using Python. It was initially developed by Hewlett-Packard. The recognition of characters in fonts that are available on computers are much more accurate than human handwriting recognition, based on the training dataset of Tesseract. [8][12][17]. It mounts the machine and deep learning technologies to achieve optimal accuracy. Tesseract works best when there is a (very) clean segmentation of the foreground text from the background. In practice, it can be extremely challenging to guarantee these types of segmentations. Hence, we tend to train domain-specific image classifiers and detectors. Hence it’s important to understand how to access Tesseract OCR via the Python programming language to apply OCR to personal projects .

Python-tesseract, also called Pytesseract, is an optical character recognition (OCR) tool for python. That is, it will recognize and "read" the text embedded in images. Pytesseract is a wrapper for Google's Tesseract-OCR Engine. Wrapper is basically a software that contains other software so that the contained elements can exist in the newer system or domain. Pytesseract is also useful as a stand-alone invocation script to tesseract, as it can read all image types supported by the Pillow (PIL) and Leptonica imaging libraries, including jpeg, png, gif, bmp, tiff, and others. Pytesseract is just a more secure version of actual tesseract software which can be easily accessed using python.

Once the text regions are detected with OpenCV, we'll then extract each of the text ROIs and pass them into Tesseract, enabling us to build an entire OpenCV OCR pipeline.

4.5 PIL

Python Imaging Library (abbreviated as PIL) (in newer versions known as Pillow) is a free and open-source additional library for the Python programming language that adds support for opening, manipulating, and saving many different image file formats [13]. It is available for Windows, Mac OS X and Linux. It is one of the core libraries for image manipulation in Python. Unfortunately, its development has stagnated, with its last release in 2009. Luckily, there's an actively-developed fork of PIL called Pillow. Forking refers to development of different versions of a program. It's easier to install, runs on all major operating systems, and supports Python 3.

Some of the file formats supported are PPM, PNG, JPEG, GIF, TIFF, and BMP. It is also possible to create new file decoders to expand the library of file formats accessible.

Fig 4.1 shows the entire process flow of optical character recognition including tesseract and imaging libraries. Here API is an abbreviation for Application Programming Interface and it is a way to communicate between applications. Every time a call is made to a server in the name of an application using an API, it counts as an API request. Logins, saves, queries are examples of operations counted as API requests among other types of operations. For better understanding, consider you downloaded an application to your smartphone, you opened it and the application asked your Email and

Password. At the moment you press Register and send your data to the API it is counted as one API request.

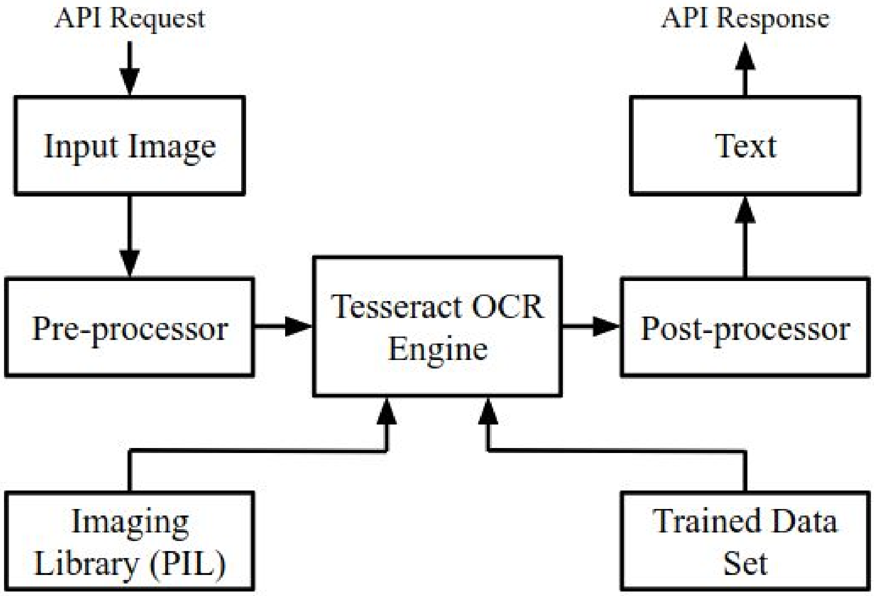

Fig 4.1 Process flow of OCR

4.6 BENBOX

The Benbox Laser Engraver as a CNC-platform for laser engraving. In this project, benbox is used to achieve precise control. When a firmware code is uploaded into the software, after pressing run in Benbox, the hardware moves according to the firmware.

Benbox has a number of various parameters that can be manipulated and changed to get the required precise control [14]. Fig 4.2 shows the view of Benbox software with changaeble parameters on the right hand side.

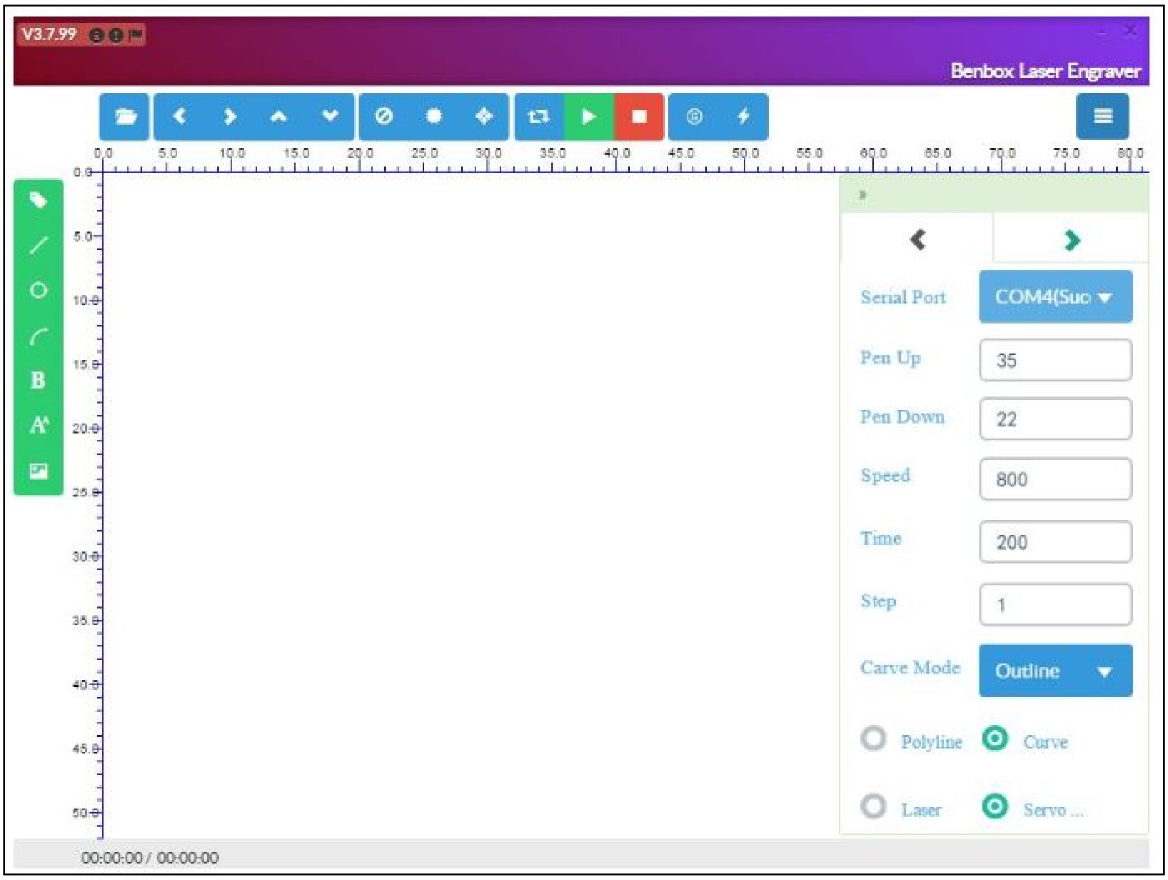

Fig 4.2 Benbox software

Chapter 5

HARDWARE

5.1 OVERVIEW

The hardware components, and the rationale behind the selection of different components is discussed in detail in this chapter. The overview of the components used is shown in Fig 5.1 and these components are discussed in detail in this chapter. Additionally, the

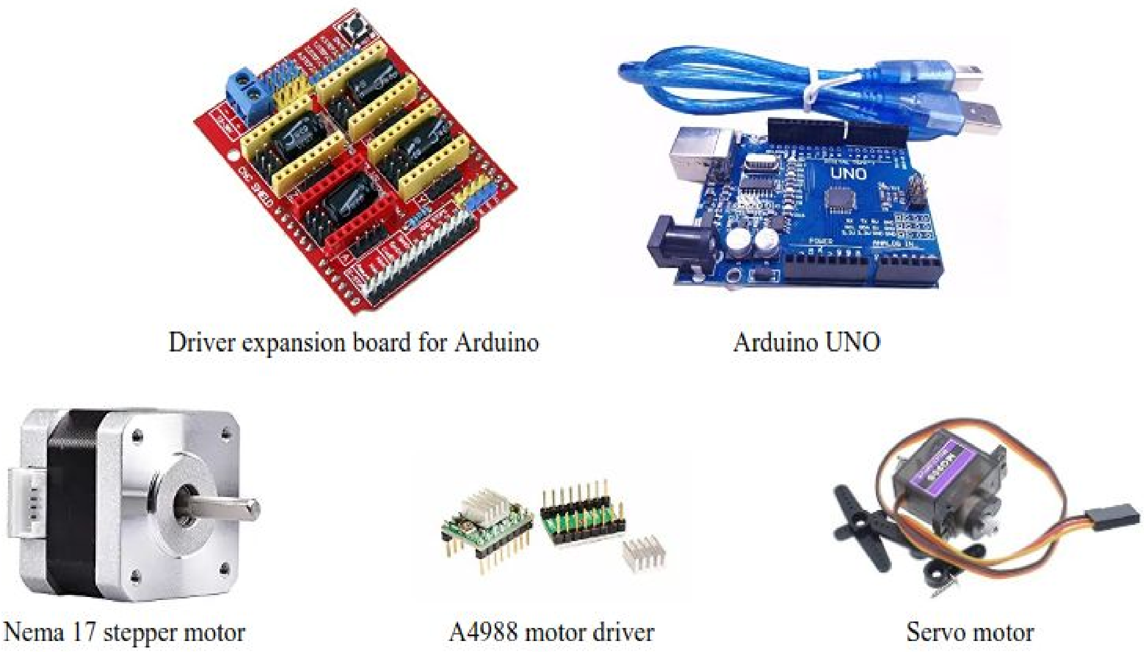

Fig 5.1 Overview of hardware components

5.2 STEPPER MOTOR

Stepper motors are DC motors that move in discrete steps. They have multiple coils that are organized in groups called "phases". By energizing each phase in sequence, the motor will rotate, one step at a time. With a computer controlled, very precise positioning and/or speed control can be achieved. For this reason, stepper motors are the motor of choice for many precision motion control applications.

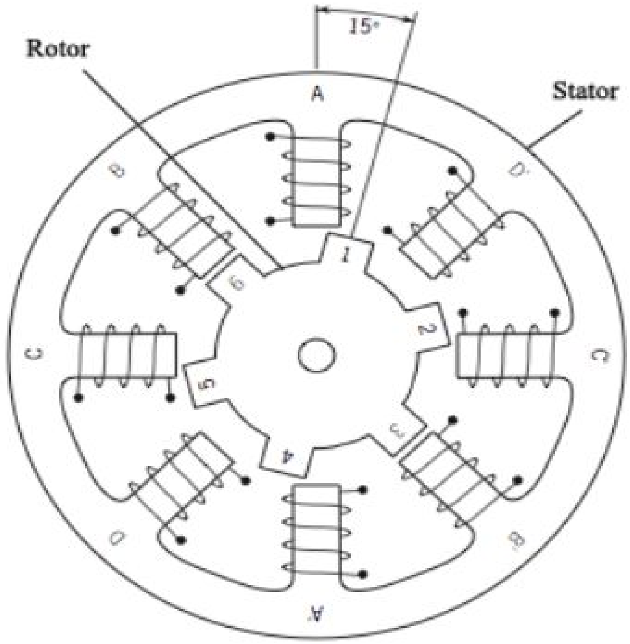

Fig 5.2 Schematic view of a general stepper motor

Stepper motors have a permanent magnetic rotating shaft called a rotor and stationary electromagnets surrounding the rotor called the stator. If you look at the coils on the stator in Fig 5.2, they are arranged in terms of coil pairs, like A and A' forms a pair, B and B' forms a pair and so on. So each of these coil pairs form an electromagnet and they can be energised individually using a driver circuitry. When a coil gets energised it acts as a magnet and the rotor pole gets aligned to it, when the rotor rotates to adjust itself to align with the stator it is called as one step. Similarly by energising the coils in a sequence we can rotate the motor in small steps to make a complete rotation.

Stepper motors basically are electromagnetic devices which convert digital pulses into mechanical shaft rotation. Many advantages are achieved using these motors such as: high simplicity, low cost, high reliability, high torque and high accuracy.

Fig 5.3 Nema 17 stepper motor

This project involves usage of two Nema 17 stepper motors (Fig 5.3). One motor to control the X-axis motion and another motor to control the Y-axis motion. Additionally, a driver is used to drive the motors. Stepper motors are categorized by frame size, such as "size 11" or "size 23". The National Electrical Manufacturers Association (NEMA) sets standards for many electrical products, including step motors. Generally speaking, "size 11" means the mounting face of the motor is 1.1 inches square. The Nema17 stepper motor is a stepper motor with an end face size of 1.7 inches x 1.7 inches. The driving voltage is 12-24V. The maximum speed can be as high as 2000 rpm. It is widely used in 3D printers, engraving machines, film cutting machines and other occasions.

Stepper motors are rated by their holding torque in oz/in (ounces per inch) or N m or N cm. For example Nema 23 is rated as 175 oz/in, which means it can hold 175 ounces on an arm of 1 inch in length attached to the motor shaft. Similarly, Nema 17 stepper motor is rated 50 to 80 oz/in, which is approximately 1.4 to 2.2 kgs. Hence that is why Nema 17 is used in this project.

5.3 SERVO MOTOR

A servo motor is an electrical device which can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use a servo motor. It is just made up of a simple motor which runs through a servo mechanism. If a motor is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in small and lightweight packages. Due to these features they are being used in many applications like toy cars, Robotics, Machine etc.

It consists of three parts: Controlled device, Output sensor, Feedback system. It is a closed loop system where it uses a positive feedback system to control motion and final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal.

Here the reference input signal is compared to the reference output signal and the third signal is produced by the feedback system. And this third signal acts as input signal to control devices. This signal is present as long as a feedback signal is generated or there is a difference between reference input signal and reference output signal. So the main task of servomechanism is to maintain output of a system at desired value at presence of noises.

Servo motor works on PWM (Pulse width modulation) principle, meaning its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically a servo motor is made up of a DC motor which is controlled by a variable resistor (potentiometer) and some gears. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if the pulse is shorter than 1.5ms, the shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180° as shown in Fig 5.5. All servo motors work directly with your +5V supply rails but we have to be careful on the amount of current the motor would consume, if you are planning to use more than two servo motors a proper servo shield should be designed.

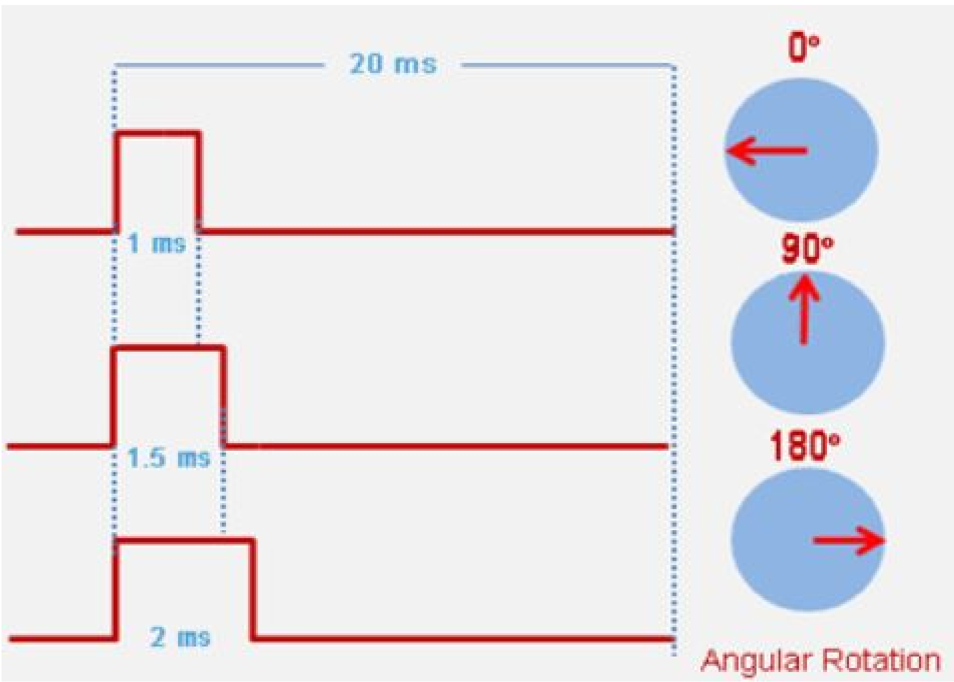

Fig 5.5 Controlling of servo motor using PWM

In this project, a servo motor is used for the movement of the pen in the Z-axis. More specifically MG90S-Metal Gear Micro Servo Motor is used (Fig 5.6). This small and lightweight servo comes with high output power, thus ideal for Robotic Arms.

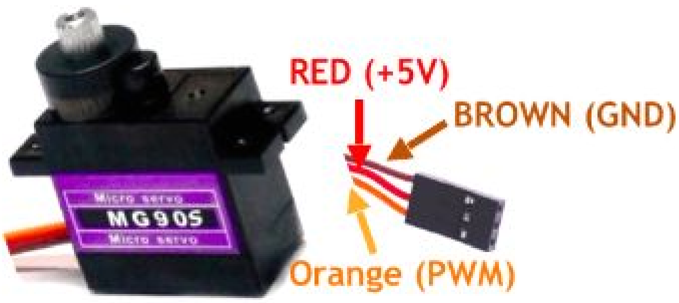

Fig 5.6 MG90S servo motor

5.4 MOTOR DRIVER

A stepper motor driver is an electronic device that is used to drive the stepper motor. By itself it usually does nothing and must be used together with a controller. Stepper motors require voltages and/or currents that the controller simply can't produce. Therefore we need to use a stepper motor driver. This electronic device will transform our movement instructions from a controller into a sequence where the winding in the stepper motor will be turned on or off while still providing enough power to it.

Basically a motor driver acts as an interface between the motor and the control circuits. Motors require a high amount of current whereas the controller circuit works on low current signals. So, the function of motor drivers is to take a low current control signal and then turn it into a higher current signal that can drive a motor.

Having only one Arduino control all of the stepper motors can take up a lot of the processing and not leave a lot of room to do anything else; unless a self-contained dedicated stepper motor driver is used. Therefore, the stepper motor driver used in this project is A4988. Fig 5.7 shows A4988 motor driver with heat sink, heat sink is used as a passive heat exchanger that transfers the heat generated by an electronic device to air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature at optimal levels. Motor drivers can control both speed and spinning direction of a bipolar stepper motor like NEMA 17 with just two pins. The A4988 stepper motor driver has output drive capacity of up to 35 V and ±2A and lets you control one bipolar stepper motor at up to 2A output current per coil like NEMA 17.

Fig 5.7 A4988 motor driver with heat sink

The driver has a built-in translator for easy operation. This reduces the number of control pins to just 2, one for controlling the steps and other for controlling spinning direction. The driver offers 5 different step resolutions viz. full-step, half-step, quarter-step, eighth-step, and sixteenth-step. STEP input controls the mirosteps of the motor. Each HIGH pulse sent to this pin steps the motor by number of microsteps set by Microstep Selection Pins. The faster the pulses, the faster the motor will rotate. DIR input controls the spinning direction of the motor. Pulling it HIGH drives the motor clockwise and pulling it LOW drives the motor counterclockwise (Fig 5.8).

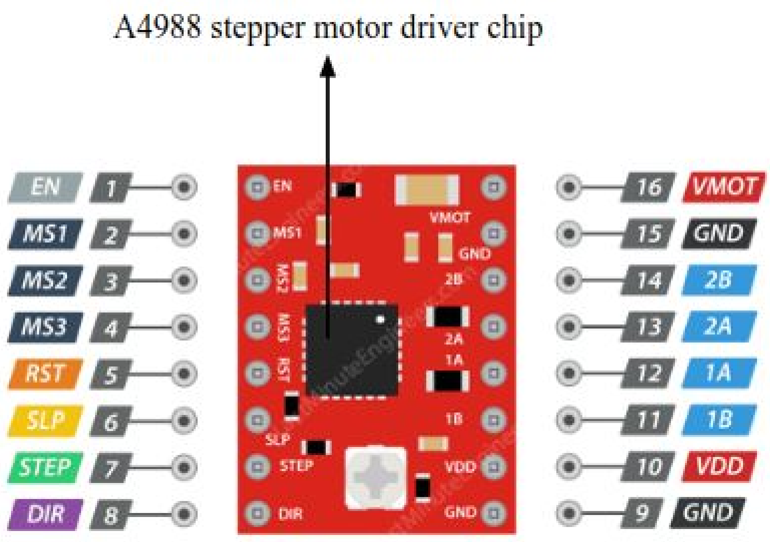

Fig 5.8 A4988 Motor Driver Pinout

5.5 EXPANSION BOARD

A microcontroller has a limited number of pins, and hence a limited number of interfaces with the outside world. An expansion board takes a few of those pins and fans them out to even more pins. Expansion boards are also called shields. A shield is basically a board that can be plugged on top of the Arduino PCB extending its capabilities. Shields are pieces of hardware that sit on top of your Arduino, often to give it a specific purpose. For example, you can use a shield to make it easier to connect and control motors. Fig 5.9 shows A4988 driver expansion board for Arduino.

In this project, A4988 driver CNC shield expansion board for Arduino is used. It is an Arduino shield which has the capability to control four stepper motors by using four A4988 stepper motor driver boards. Another good feature of this is that one of the motors can clone the movement of another motor on the same board. In our case, the expansion board is used so that two stepper motors and a servo motor can be controlled easily. Fig 5.10 shows the expansion board with A4988 motor driver and Arduino board connected to it.

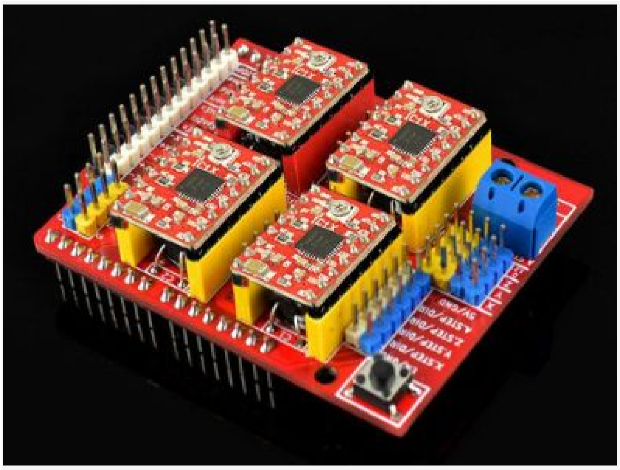

Fig 5.9 A4988 driver expansion board for Arduino

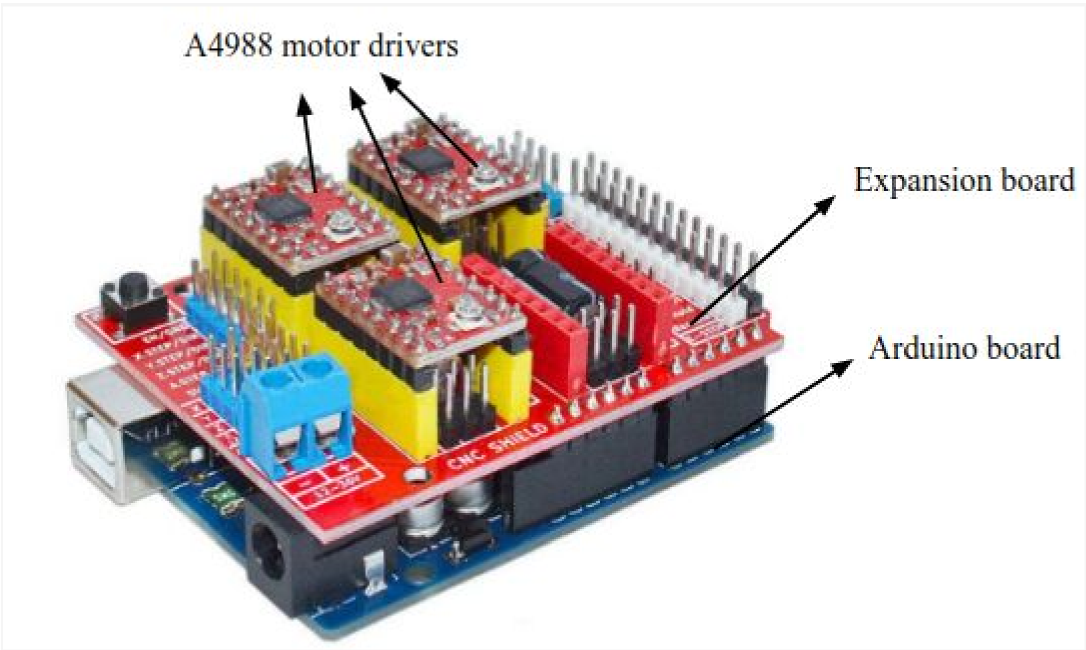

Fig 5.10 Expansion board connected to A4988 motor driver and Arduino

5.6 ARDUINO

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. The Arduino board is a printed circuit board (PCB) designed to use a microcontroller chip as well as other input and outputs. A microcontroller is a small computer contained in a single, integrated circuit or computer chip. Microcontrollers are an excellent way to program and control electronics. Microcontroller boards have a microcontroller chip and other useful connectors and components that allow a user to attach inputs and outputs.

You write code in the Arduino software to tell the microcontroller what to to-do. For example, by writing a line of code, you can tell a light-emitting diode (LED) to blink on and off. If you connect a push button and add another line of code, you can tell the LED to turn on only when the button is pressed. Next, you may want to tell the LED to blink only when the pushbutton is held down. In this way, you can quickly build a behavior for a system that would be difficult to achieve without a microcontroller.

In this project, Arduino UNO R3 is used, shown in Fig 5.11. The Arduino UNO is the best board to get started with electronics and coding. The UNO is the most used and documented board of the whole Arduino family. Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator , a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0.

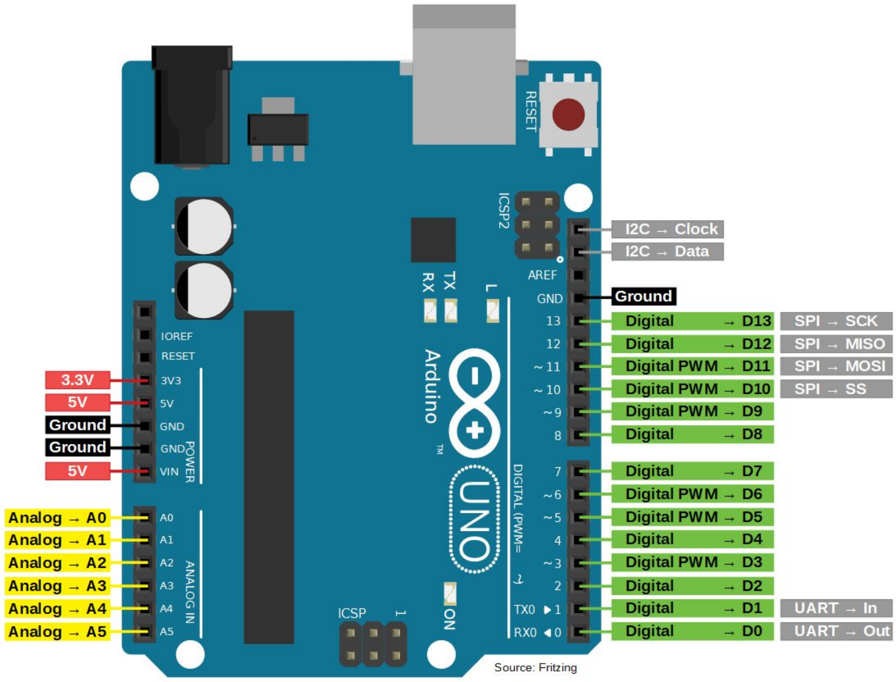

Fig 5.11 Arduino UNO R3 pinout

5.7 WOODEN FRAME

Selection of frame is an essential part for system designing. The main material used to make up the X and Y gantry is Medium Density Fiberboard (MDF). Medium-density fiberboard is the most versatile building material because it’s inexpensive and fairly durable. MDF is a good choice for practical projects. This MDF is fitted with 3D printing rods which are in turn connected to the Nema 17 stepper motors. These rods help in achieving the two dimensional movement because these rods are threaded.

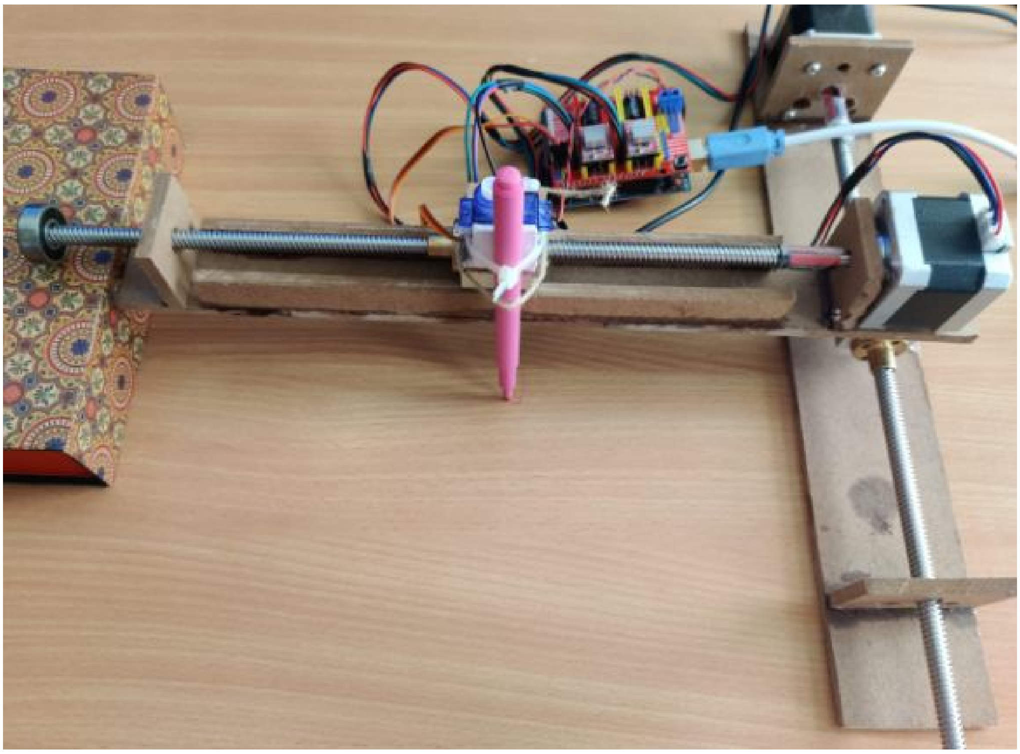

Fig 5.12 Frame of the project

Chapter 6

METHODOLOGY
OF IMPLEMENTATION

6.1 OVERVIEW

The methodology of implementation was structured and carried out after a detailed analysis. To achieve the automated writing, a detailed study and analysis was made before executing the full mission.

An analysis was made to select a programming platform for easy and faster processing which is also compatible with most systems with minimum configuration required. This resulted in converging to use the python programming platform.

In this chapter, firstly the flowchart of the entire process is shown and then the overall process of implementation is discussed in detail.

6.2 FLOWCHART

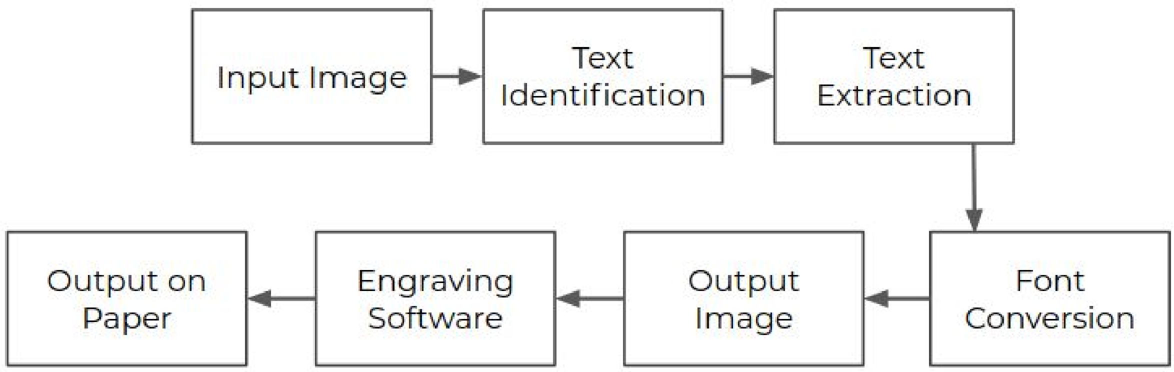

Fig 6.1 Flowchart of the overall process

6.3 BLOCK DIAGRAM

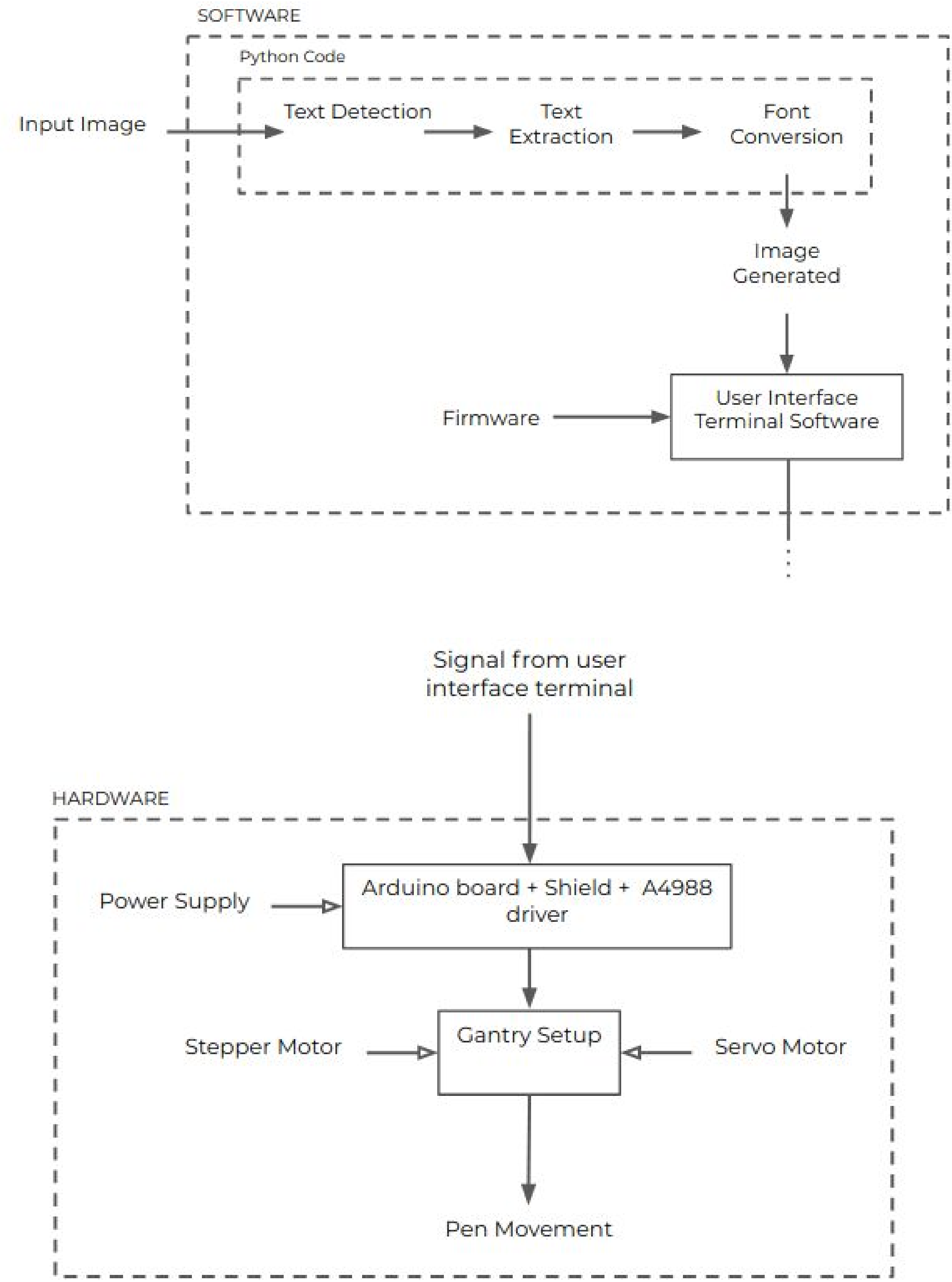

Fig 6.2 Block diagram of the complete process

6.4 IMPLEMENTATION STEPS

STEP 1 : Input the image of the text document which can be in predefined text or in a human's handwriting. We will consider predefined text for the sample implementation as shown in Fig 6.3.

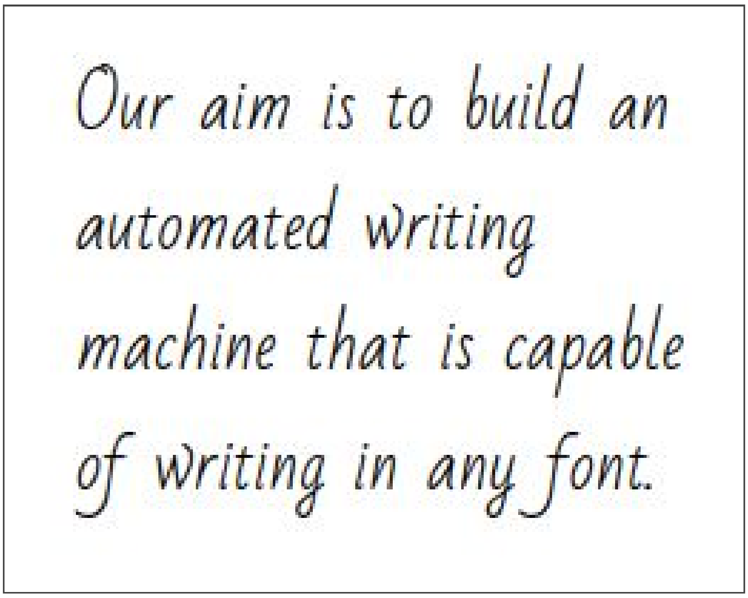
Our aim is to build an
automated writing
machine that is capable
of writing in any font.

Fig 6.3 Sample input image in predefined font

STEP 2 : Through the python code, the text region is detected using OpenCV and these text ROIs (Region of Interest) are passed into Tesseract which will extract the text. This extracted text is shown on the python terminal (Fig 6.4) and also written into a text file (Fig 6.5).

Fig 6.4 Extracted text shown on the terminal

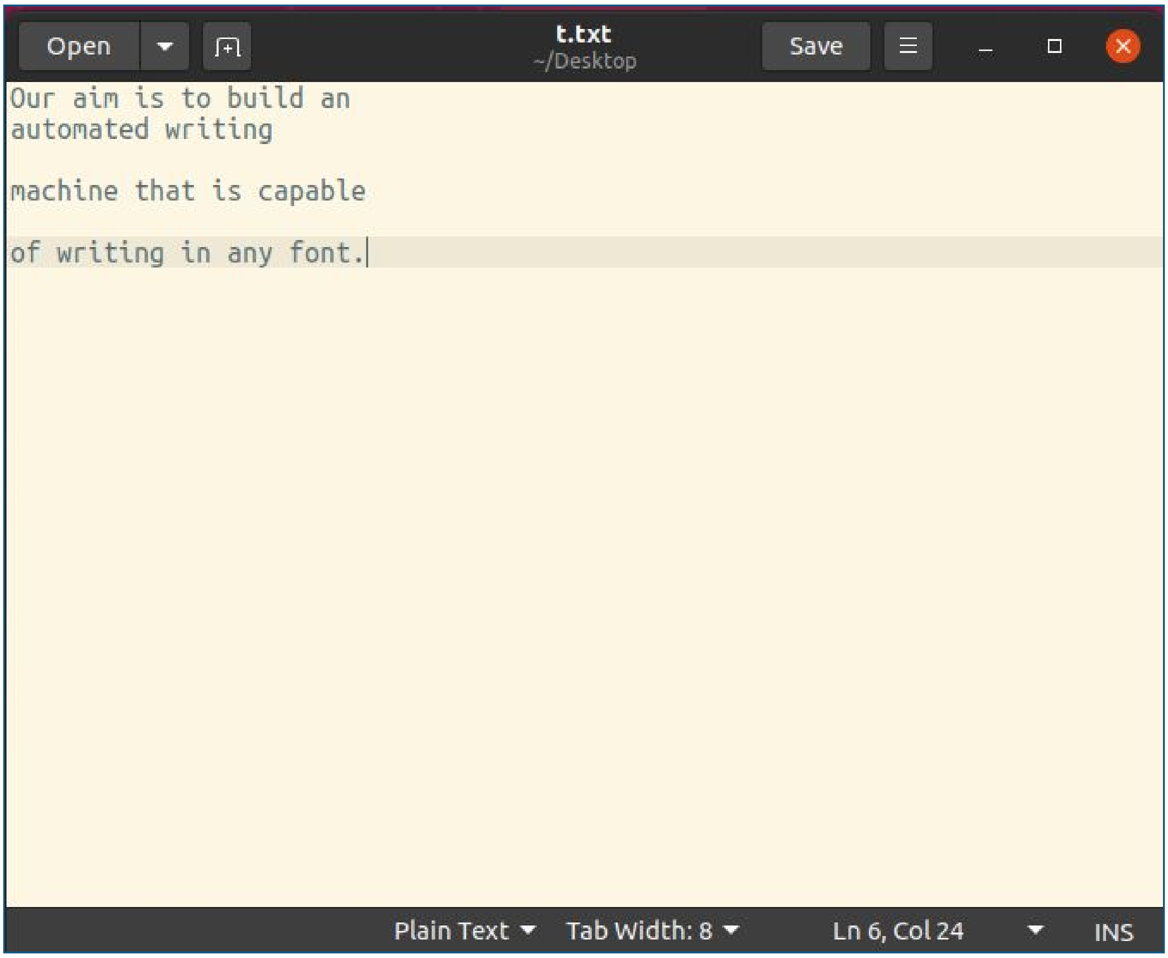

Fig 6.5 Extracted text written into a text file

STEP 3 : The font of text from the text file in the previous step is converted into the user's font which in turn is converted into an image as shown in Fig 6.6. Here the user's font template is obtained with the help of a web application.

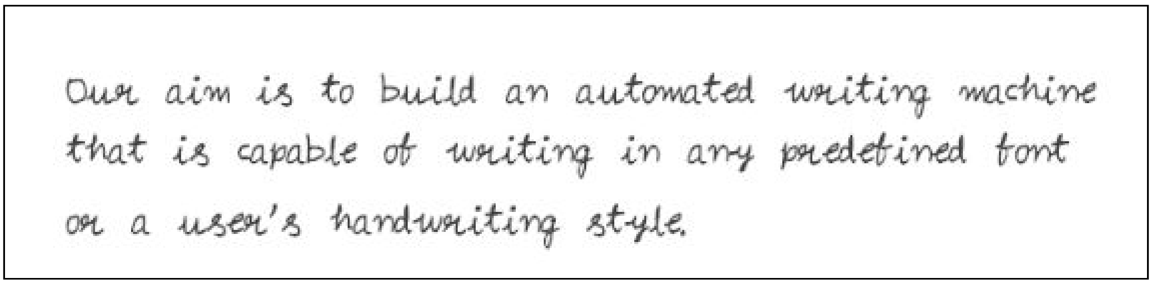
Our aim is to build an automated writing machine that is capable of writing in any predefined font or a user's handwriting style.

Fig 6.6 Document image in user's font

STEP 4 : Finally the image obtained in the previous step is uploaded into the user interface terminal software, which is Benbox in this case. With the help of the firmware code, the image that is uploaded is written onto the paper with the help of hardware motion that is achieved through motors and power supply. Fig 6.7 shows how the image can be uploaded into benbox. Fig 6.8 shows the parameter configuration in Benbox.

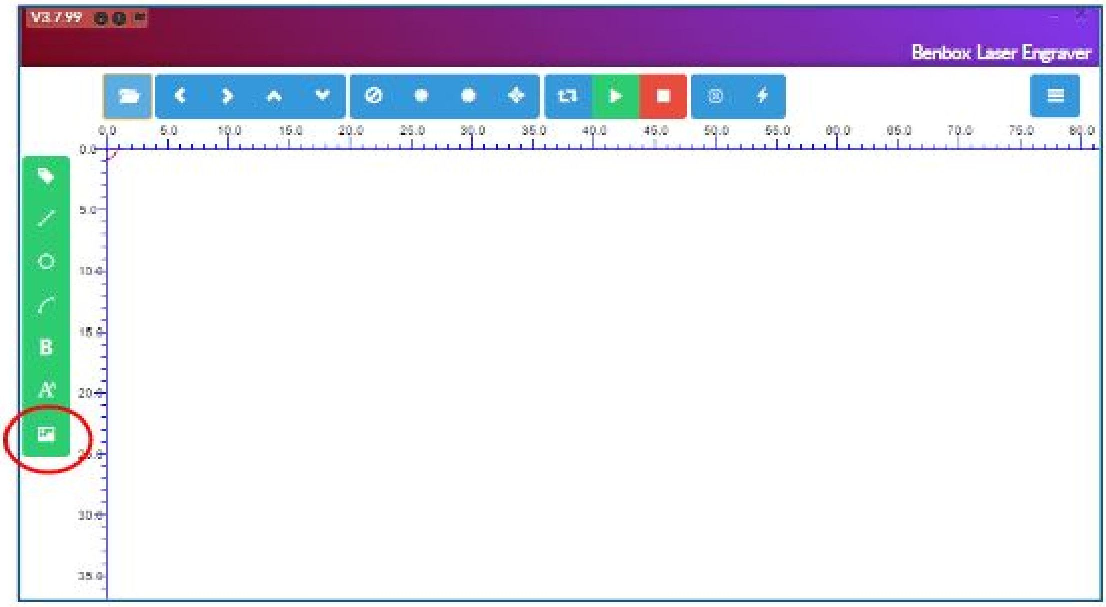

Fig 6.7 Image uploading in Benbox software

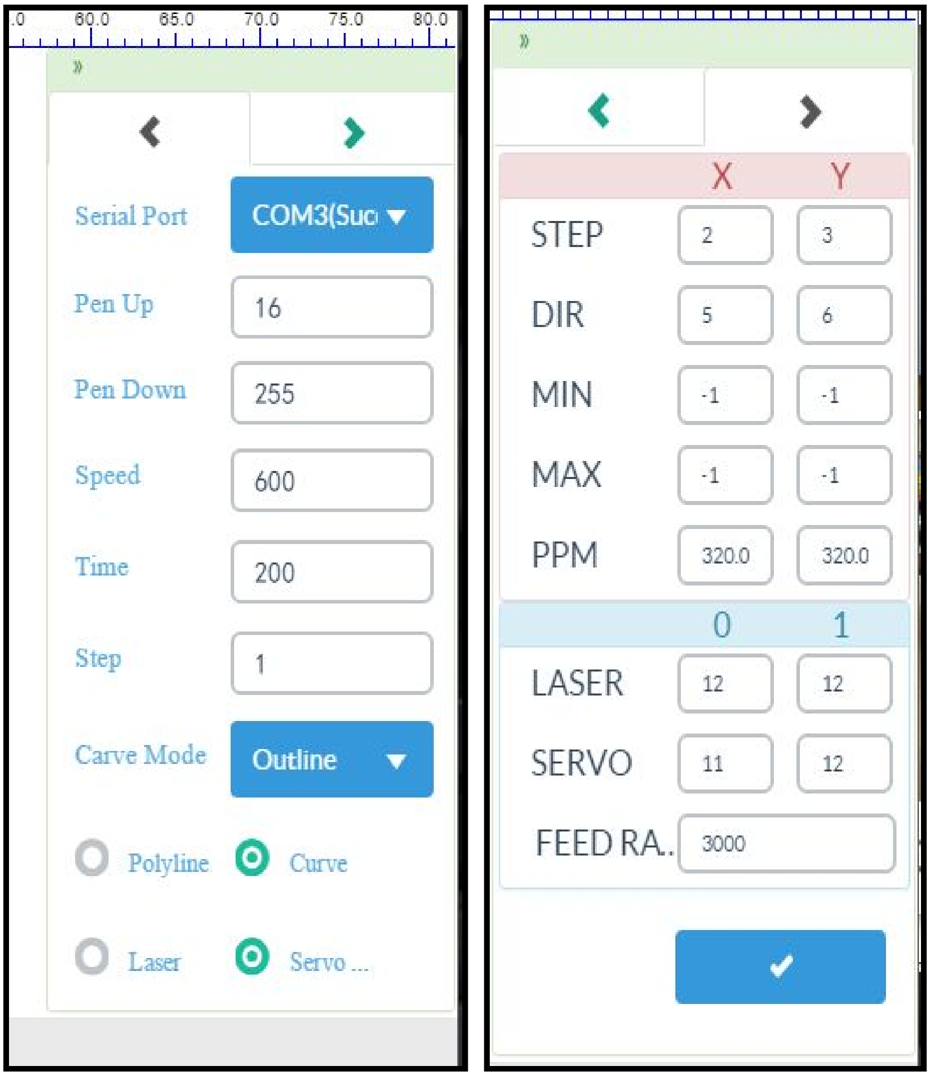

Fig 6.8 Parameter configuration for Benbox

Chapter 7

RESULTS AND DISCUSSION

This proposed system is a new kind of automated writing machine which incorporates optical character recognition. The source code will first extract the text from the input image and this extracted text is converted into any of the predefined fonts stored in the computer or to the user's handwriting. Fig 7.1 shows the input image which is a snippet of scanned document in predefined font - "Arial" and Fig 7.2 shows the extracted text converted to user's font. The font conversion is done with the help of a web application. Here the user's alphabetical data is uploaded and using this the font is built.

Fig 7.1 Input in predefined font

Fig 7.2 Font converted text

This font converted image or image in predefined text is uploaded and executed in Benbox software, the output is written on the paper as shown in Fig 7.3.

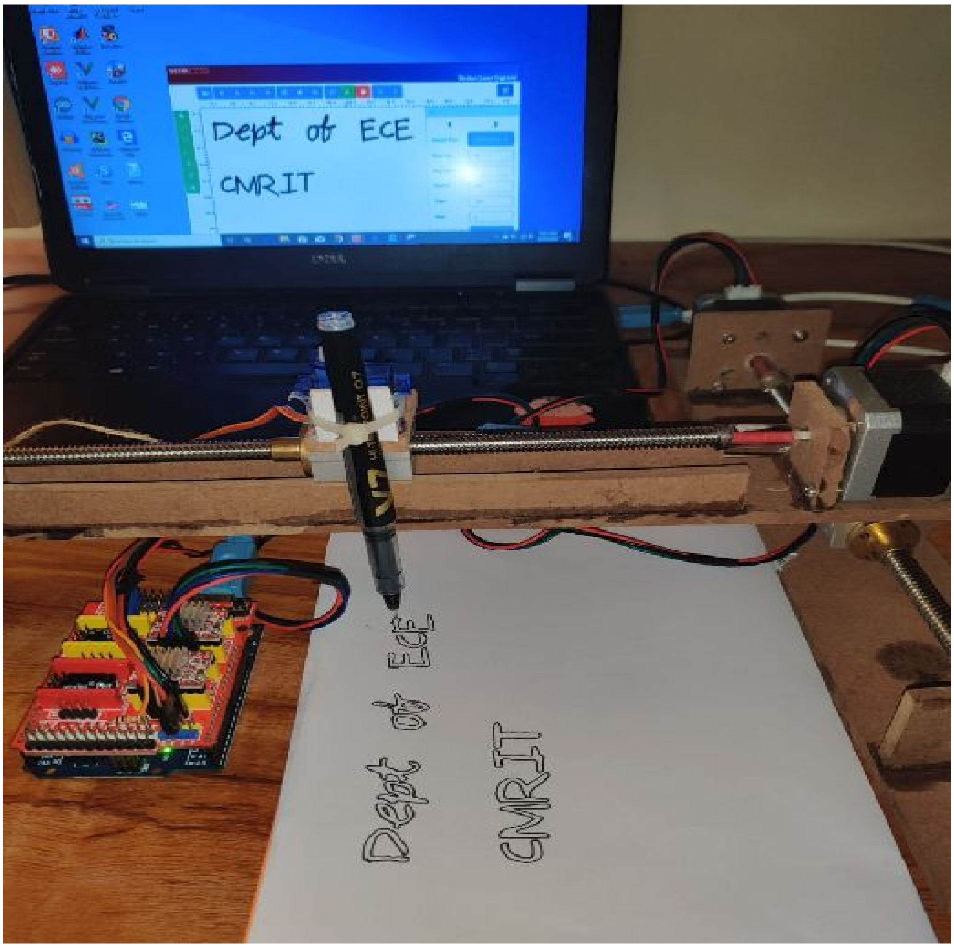

Fig 7.3 Final setup and output on paper

The main advantage of this system lies in the cost of production. Considering two commercially available similar systems for the purpose of comparison as shown in below.

Table 7.1 Comparison of proposed system with others

Parameters	System A (2D Plotter)	System B (AxiDraw)	Proposed System
Cost (Rupees)	15,000 - 20,000	45,000 - 75,000	4000 - 6000
OCR	Not present	Not present	Present
Font Conversion	Not possible	Not possible	Possible
Weight (Kg)	2	2.2	1
Speed (wpm)	13 - 20	13 - 20	5 -15
Origin	India	India	USA

Another important point to keep in mind is the accuracy of optical character recognition. OCR of text in predefined fonts is relatively more accurate than that in human handwriting, approximately above 95% most of the time depending on which font is used. Accuracy of OCR in case of human handwriting recognition is dependent on how shabby or neat the person's handwriting is. The writing speed of the machine is almost the same as that of an average human which is 13wpm (words per minute).

One of the limitations in this project is that the output can only be written in block letters due to the laser engraving software used. This problem can possibly be solved by using a different software.

Chapter 8

FUTURE SCOPE AND APPLICATIONS

The proposed system can be used as a baseline setup for many future modifications. One such modification can be inclusion of voice to text modules in the already proposed system [16], which will be beneficial for specially abled people.

Another modification can be to make a real time system, where the user can send the text to be written remotely and the machine should be capable of writing it down. This can be achieved by incorporating the use of the internet and cloud services into the process. This particular application can be useful to notify a family member whose phone battery might have run out and hence the phone would have switched off.

Currently, the optical character recognition of the proposed system is not as accurate for shabby handwriting than it is for predefined handwriting style. Hence, by achieving better text recognition [4], the system can be extended to read doctors' prescriptions which in turn can be converted to the user’s language using a language translation model.

To summarize, the automated writing machine is user friendly, cost efficient and aims to improve the quality of life & reduce human efforts.

Chapter 9

CONCLUSION

In these developing times, humans are turning towards robots to do their work to save time and manpower and to have an efficient output. The basic problem with the already existing technologies like automated speech writing machines, speech to text converter, printers, scanners, is that they only write in predefined fonts present in the computer. The proposed system works as an automated writing machine that is capable of writing in any predefined font or in the user's handwriting style.

After integrating the software with hardware, the resultant mechanical system makes up an user friendly and cost effective automated writing machine with minimum human interruption, reducing the requirement of manual effort and time. To summarize, the automated writing machine will be able to contribute to our daily life challenges and hence improve the quality of life.

It has been a great pleasure for us to work on this exciting and challenging project. This project proved good for us as it provided practical knowledge of not only programming in python and working with embedded systems, but also about all the handling procedures related with "Automated Writing Machine". It also provides knowledge about the latest technology used in developing web enabled application technology that will be in great demand in future. This will provide better opportunities and guidance in future in developing projects independently.

To summarize, the automated writing machine will be able to contribute to our daily life challenges and hence improve the quality of life.

Chapter 10

REFERENCES

[1] P. Novák, J. Vyskočil, P. Kadera, L. Kathrein, K. Meixner, D. Winkler, S. Biffl, "Engineering Roles and Information Modeling for Industry 4.0 Production System Engineering", 2019 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), DOI: 10.1109/ETFA.2019.8869141, Sept, 2019.

[2] M. Aditi, S. Karpagam, B. Nandini, B. S. Murugan, "Automated Writing and Drawing Machine," International Journal of Engineering Research & Technology, ISSN: 2278-0181, ETEDM - 2019 Conference Proceedings, 2019.

[3] Mr.R.Augustian Isaac, Amit Kumar Singh, Prateekshit Tamta, Gaurav Singh, "Homework Writing Machine," IJARIIE, Vol-4 Issue-5 2018.

[4] T. C. Wei, U. U. Sheikh and A. A. A. Rahman, "Improved optical character recognition with deep neural network," 2018 IEEE 14th International Colloquium on Signal Processing & Its Applications (CSPA), Batu Feringghi, 2018, pp. 245-249, doi: 10.1109/CSPA.2018.8368720.

[5] A. M. Sabu and A. S. Das, "A Survey on various Optical Character Recognition Techniques," 2018 Conference on Emerging Devices and Smart Systems (ICEDSS), Tiruchengode, 2018, pp. 152-155, doi: 10.1109/ICEDSS.2018.8544323.

[6] Shani Ranjan, Mani Rani, Shweta Ranjan, Dr. Manmohan Singh, "Design and Implementation of low-cost 2D plotter Computer Numeric Control (CNC) Machine," International Journal of Engineering Research & Technology, Vol. 7 Issue 05, May-2018.

[7] R. Balathangam, P. Mathipriya, R.Pavithra, G. Prithiviraj, U.Poornima, "Design and Development of Arduino Controlled Writing Robot," International Research Journal of Engineering and Technology, Volume: 04 Issue: 04, Apr -2017.

[8] Q. Li, W. An, A. Zhou and L. Ma, "Recognition of Offline Handwritten Chinese Characters Using the Tesseract Open Source OCR Engine," 2016 8th International Conference on Intelligent Human-Machine Systems and Cybernetics (IHMSC), Hangzhou, 2016, pp. 452-456, doi: 10.1109/IHMSC.2016.239.

[9] Kajal J.Madekar, Kranti R. Nanaware, Pooja R. Phadtare, Vikas S. Mane, "Automatic mini CNC machine for PCB drawing and drilling," International Research Journal of Engineering and Technology, Volume: 03 Issue: 02, Feb-2016.

[10] D. Berchmans and S. S. Kumar, "Optical character recognition: An overview and an insight," 2014 International Conference on Control, Instrumentation,

Communication and Computational Technologies (ICCICCT), Kanyakumari, 2014, pp. 1361-1365, DOI: 10.1109/ICCICCT.2014.6993174.

[11] "The OpenCV Tutorials," Release 2.4.13.7, December 31, 2019.

[12] Ng Wai Foong, "A Beginner's Guide to Tesseract OCR," Jun 3, 2019.

[13] Kenneth Reitz, "Python Guide Documentation Release 0.0.1", 21st December, 2018.

[14] Endurance, "The Benbox Laser Engraver as a CNC-platform for laser engraving", 2018.

[15] Adrian Rosebrock, "OpenCV OCR and text recognition with Tesseract," 17th September, 2018.

[16] Rajat Nitin Shah, "Voice Based Writing Machine," MyGov Innovation, August 18, 2018.

[17] George Livingston, "Optical Character Recognition in PDF Using Tesseract Open-Source Engine," July 25, 2018.

[18] "AxiDraw User Guide", Evil Mad Scientist, 2016.

[19] Gloria Bueno García, Oscar Deniz Suarez, José Luis Espinosa Aranda, Jesus Salido Tercero, Ismael Serrano Gracia, Noelia Vállez Enano, "Learning Image Processing with OpenCV," March 2015.

[20] "The Autopen: We've Been At It Since The Very Beginning", Automated Signature Technology, December 11, 2013.

[21] Jan Erik Solem, "Programming Computer Vision with Python," 2012.

[22] Richard Szeliski, "Computer Vision: Algorithms and Applications," September 3, 2010.

APPENDIX - A

List of Acronyms

2D	:	Two Dimensional
3D	:	Three Dimensional
AC	:	Alternating Current
API	:	Application Programming Interface
CNC	:	Computer Numerical Control
CV	:	Computer Vision
DC	:	Direct Current
ICSP	:	In-Circuit Serial Programming
IDE	:	Integrated Development Environment
LED	:	Light Emitting Diode
MDF	:	Medium Density Fiberboard
MG	:	Metal Gear
NASA	:	National Aeronautics and Space Administration
NEMA	:	National Electrical Manufacturers Association
OCR	:	Optical Character Recognition
OpenCV	:	Open-source Computer Vision
OSS	:	Open Source Software
PC	:	Personal Computer
PCB	:	Printed Circuit Board
PIL	:	Python Imaging Library
PWM	:	Pulse Width Modulation
ROI	:	Region of Interest
USB	:	Universal Serial Bus