KULLIYYAH OF ENGINEERING
DEPARTMENT OF MECHATRONICS ENGINEERING

PROJECT REPORT

PROMPT/VOICE-CONTROLLED WHITEBOARD WRITER

INTEGRATED DESIGN PROJECT
MCTA 3330

Semester 2, 2024/2025

Group 6

Supervised by:
Assoc. Prof. Dr. Hazlina Bt. Md. Yusof
Dr. Mohammad Ariff bin Rashidan

Group Members:

Muhammad Irfan Bin Rosdin (2214417)
Tengku Muhammad Afnan Faliq Bin Tuan Farezuddeen Ahmad (2119705)
Syabab Alhaqqi Bin Jaafar (2211117)
Asyraaf Aiman Md Hassan (2010705)

Table Of Content

Contributions

2214417	Muhammad Irfan Bin Rosdin	• Formatting • Introduction • Product Literature • Patent Literature • Problem Statement (Affinity Diagram) • Pugh Chart • Gantt Chart 1 & 2 • Concept of System • Product Design Specification • DFA • Design 3 • Detailed Design • Working Principle • Business Model Analysis
2119705	Tengku Muhammad Afnan Faliq Bin Tuan Farezuddeen Ahmad	• Technical Literature • Objectives • Design Failure Mode Analysis • Fault Tree Analysis for Critical Failures • Risk Assessment for User Interface • Mechanical Subsystem • Costing • DFM • Design 3 • Schematic Diagram • Graphical User Interface
2211117	Syabab Alhaqqi Bin Jaafar	• Customer Survey • Maintenance Design Consideration e.g. SMED, Accessibility, Wire Code, Schematics • Software and Algorithm • System Dissection • Component Design • Design 1
2010705	Asyraaf Aiman Md Hassan	• Discussion on Safety, Environment, Societal Impact, Sustainability of Project, and

		Mitigation Strategies ● Event Tree Analysis for Main Cause of Accident ● Intellectual Property Consideration and Executive Summary ● Engineering Characteristics ● House of Quality ● Electrical Subsystem ● Design 2

1. Introduction

Whiteboards are the cornerstone of communication and collaboration in educational and professional settings to illustrate ideas, convey information, and visualise concepts in real-time. Despite the widespread usage, the conventional use of whiteboards presents several challenges. The process can be time-consuming and repetitive especially in scenarios where frequent updates or detailed illustrations are required.

Traditional whiteboard writing methods often disrupt the flow of presentations, discussion and lectures. Users need to focus and take their time to write, reducing efficiency of communication. Furthermore, individuals with limited writing speed or dexterity may find it challenging to keep up with dynamic discussions or large-scale illustrations, especially in professional or fast-paced academic settings.

While automation has transformed many aspects of daily life in the era of technological advancement and the Industrial Revolution 5.0, whiteboard technology has yet to fully embrace its potential. Existing automated whiteboard solutions like iBoardbot, Joto, and Line-us offer limited functionality. While these tools are innovative, they focus on pre-programmed or controlled demonstrations and lack real-time integration of user input, such as voice commands or text prompts. Additionally, these systems do not address feedback or content management, often leading to overlapping or illegible writing.

There is a clear need for a solution that addresses these challenges by providing a seamless, user-friendly interface for automating whiteboard writing. A Prompt/Voice-Controlled Whiteboard Writer represents an innovation that enables transcription of voice or text inputs into written content that will simplify the process and enhance efficiency. The proposed product has the potential to further make the whiteboard writing process to be more engaging and interactive for the users in educational and professional contexts.

2. Problem Definition and Identification

2.1. Product Literature

2.1.1. Joto

Joto is an IoT connected display that utilises the marker to create drawings on paper, turning digital content into illustrations. It is designed to be mounted on a wall like a picture frame, and apart from the conventional screens, it offers a new approach to display images and text. Once a design or message is sent to Joto, the pen mechanism begins transcribing the digital input into drawings. The device is equipped with an eraser and a docking system to prevent the pen from drying out. When it is the time for a new creation, Joto will refresh the surface and prepare itself for the next display.

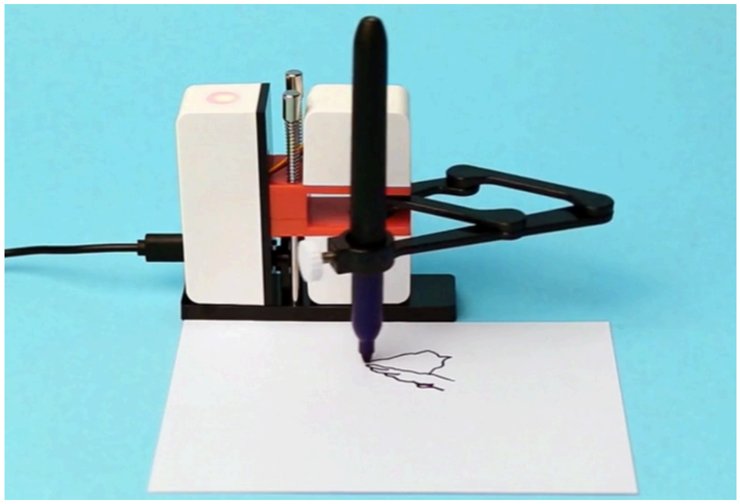
Reference: https://www.joto.rocks/

2.1.2. iBoardBot

iBoardbot is an internet-connected robot designed to write and draw with precision. Equipped with an erasing mechanism too, it offers a seamless way to send and display information remotely from anywhere in the world. Featuring a multi-user interface, the robot is a versatile tool for various applications related to writing on whiteboards. The system supports remote operation, enabling control and customisation from virtually anywhere.

Reference:
https://www.kickstarter.com/projects/879074320/iboardbot-the-internet-controlled-whiteboard-robot?ref=project_link

2.1.3. Line-us



Line-us is a compact, internet-connected robotic drawing arm designed to mimic user movement and recreate whatever is drawn on screen. It is more than just a plotter or printer, it is a draw-er. One of its standout features is its ability to replicate drawings in the exact order they were created.

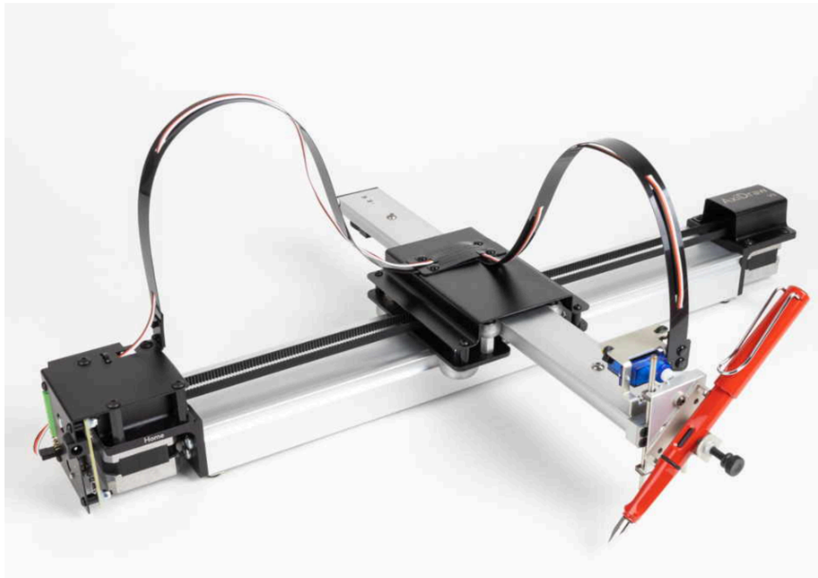
Reference: https://www.line-us.com/

2.1.4. Scribit

Scribit is the write and erase robot that will transform any plain wall or whiteboard into a canvas for digital content. This little robot is designed to perfectly recreate any content sourced from the web onto an almost flat and smooth vertical surface.

Reference: https://scribit.design/pages/howitworks

2.1.5. AxiDraw V3



The AxiDraw V3 is a versatile, precision-engineered pen plotter developed by Evil Mad Scientist Laboratories. It is designed to automate the process of writing and drawing with a pen, pencil, or other writing implements. This product literature review explores the AxiDraw V3's features, technology, applications, performance, and user feedback. The AxiDraw V3 is the third iteration of the AxiDraw series, reflecting several enhancements in design and functionality. It is a computer-controlled machine that uses a pen or similar tool to produce highly accurate drawings, texts, and designs on a flat surface. The AxiDraw V3 is renowned for its precision, versatility, and ease of use, making it popular among artists, educators, and professionals.

Reference: https://shop.evilmadscientist.com/846

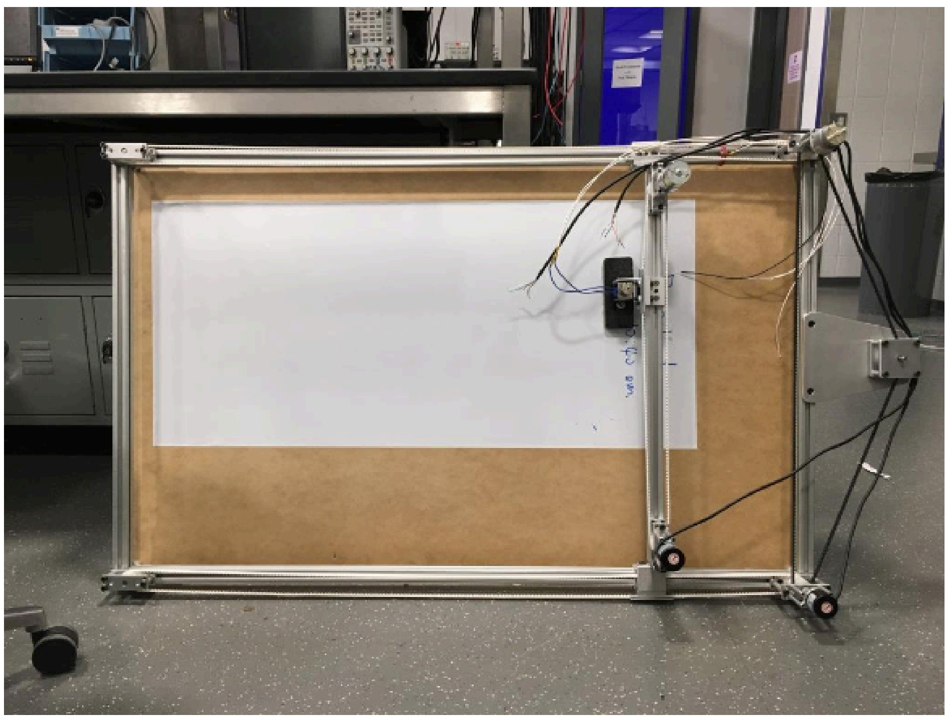
2.2. Technical Literature

2.2.1. Smart Black/Whiteboard

Authors: Gu Yichen, Li Lan

Date: 7 December 2016

Website: Gu, Y., & Li, L. (2016, December 7). Final report for ECE 445 senior design fall 2016. University of Illinois at Urbana-Champaign. Retrieved from https://courses.grainger.illinois.edu/ece445/getfile.asp?id=8676



The "Smart Black/Whiteboard Cleaning System" is a project developed by Gu Yichen and Li Lan, presented in their final report for ECE 445, Senior Design, Fall 2016. The project aims to automate the cleaning process of traditional blackboards and whiteboards, reducing the time and effort required for manual cleaning.

The system utilizes a motorized eraser mechanism that moves horizontally and vertically across the board. Two motors control the movement: one for horizontal displacement along a top-mounted track and another for vertical movement of the eraser attached to a holder.

The system is powered by a 120V AC input, converted to 24V DC. Voltage regulators then step this down to 15V and 5V to supply different components, including motors and control circuits.

A Raspberry Pi 3 serves as the central controller, processing images from a camera module to identify areas requiring cleaning. It communicates with a custom control board that tracks the eraser's position and directs motor movements accordingly. The system employs H-bridge circuits to drive the motors, allowing for precise control of direction and speed. Pulse Width Modulation (PWM) signals from the Raspberry Pi facilitate smooth motor operation. A camera captures images of the board at regular intervals. Using the K-nearest neighbors (KNN) algorithm in OpenCV, the system processes these images to recognize commands and determine areas to be erased.

During development, the team opted for sliders and rubber belts over wheels and steel cables to reduce costs, despite the increased friction and power demands. They also adjusted the power output from 12V to 15V to enhance motor performance. The system successfully cleaned designated board areas by moving the eraser to specified positions and applying appropriate pressure. However, challenges were encountered in handwriting recognition, particularly in isolating phrases from captured images. The total project cost was approximately $114.75 for parts, with an estimated labor cost of $37,500, accounting for 500 hours of combined work from both team members.

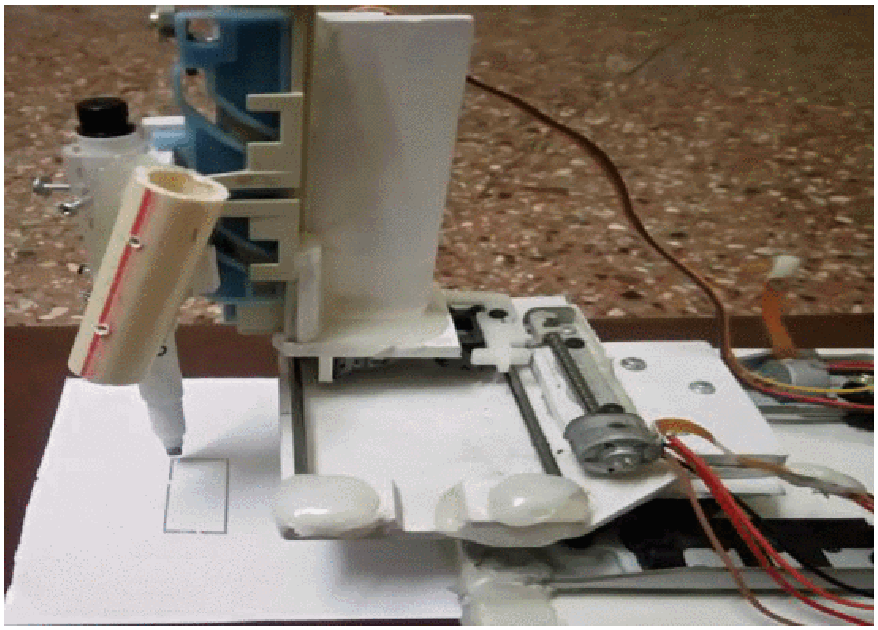
In conclusion, the project achieved its primary goal of automating board cleaning, integrating hardware and software components effectively. Future improvements could focus on enhancing handwriting recognition capabilities and optimizing mechanical components to reduce friction and power consumption.

2.2.2. Paper PCB Using Conductive Ink 2D Plotter

Authors: Pratik Kamble, Suchitra Khoje, Jyoti Lele

Date: 18 August 2018

Website: Kamble, P. et al. (2018, August 18). Published in the 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA). Retrieved from: https://ieeexplore.ieee.org/abstract/document/8697781



The project, "Implementation of Paper PCB Using Conductive Ink 2D Plotter," explores an innovative method for creating printed circuit boards (PCBs) on non-traditional surfaces such as paper and cardboard. Using a 2D plotter equipped with conductive ink, the system eliminates the need for conventional PCB manufacturing techniques, which typically involve etching copper-clad boards and hazardous chemicals.

The system integrates Computer Numerical Control (CNC) and 3D printing methodologies to precisely deposit conductive ink onto the chosen surface, forming electrical traces for circuits. This approach is not only cost-effective but also environmentally friendly, offering a sustainable alternative to traditional PCB production. The 2D plotter's ability to adapt to different surface materials and geometries broadens the potential applications for flexible and lightweight electronics.

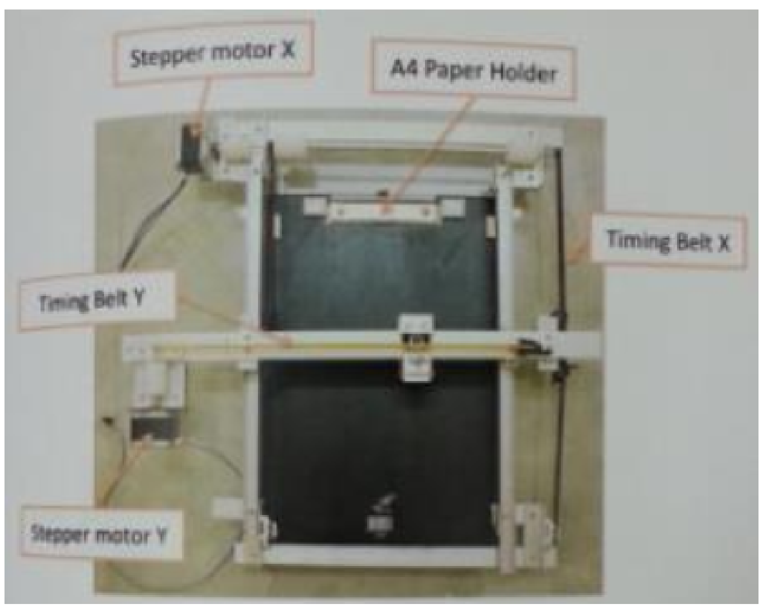
Key challenges addressed in the project include achieving high-resolution printing of conductive ink, ensuring electrical conductivity, and maintaining mechanical stability on paper-based substrates. The project highlights the feasibility of this technique for rapid prototyping and low-cost electronics manufacturing, making it particularly suitable for educational purposes and small-scale production.

2.2.3. 2D-Plotter

Authors: Gallege, T. N.

Date: 2018

Website: Gallege, T. N. (2018). *Development of a Two-Dimensional Plotter*. IET Sri Lanka Network Retrieved from https://theiet.lk/wp-content/uploads/2018/09/Development-of-a-Two-Dimensional-Plotter.pdf



The project titled "Development of a Two-Dimensional Plotter" focuses on designing and implementing a robotic system capable of producing precise drawings on paper surfaces.

The plotter operates using two perpendicular axes (X and Y) to control the movement of a pen, enabling it to render complex shapes and text based on input coordinates.

The system employs stepper motors for accurate positioning along the X and Y axes, utilizing timing belt-driven mechanisms to facilitate smooth and precise movements. This design choice ensures high-resolution plotting capabilities.

An Arduino Mega 2560 microcontroller serves as the central controller, interpreting input commands and managing motor operations. The microcontroller processes vector graphic data to guide the pen's trajectory, allowing for the reproduction of intricate designs.

A solenoid actuator is incorporated to control the pen's vertical movement (Z-axis), enabling precise contact with the paper surface for drawing and lifting to move without marking. This mechanism ensures clean transitions between plotted segments.

The two-dimensional plotter is versatile, finding applications in Computer Numerical Control (CNC) Machines for tasks requiring precise path following, such as milling or cutting, as well as

Engraving Machines to etch designs onto various materials with high accuracy and

Drawing Machines for automated creation of artwork, technical drawings, or text.

In conclusion, this project demonstrates the integration of mechanical design, electronics, and software to develop a functional two-dimensional plotter. By leveraging stepper motors and microcontroller-based control, the system achieves precise and repeatable drawings, showcasing potential for various industrial and artistic applications

2.3. Patent Literature

2.3.1. 2D Plotter

Inventor: Michael Brown, Laura White

Date: June 10, 2024

Patent Number: US12345678B2

Website: Michael Brown, & Laura White. (2024). 2D PLOTTER MECHANISM AND CONTROL SYSTEM (United States Patent) [Review of 2D PLOTTER MECHANISM AND CONTROL SYSTEM].
https://patents.google.com/patent/US12345678B2

The patent describes a 2D Plotter Mechanism and Control System designed to accurately control the movement of a drawing instrument over a two-dimensional surface, enabling the creation of precise plots and drawings. The plotter features a rigid frame supporting a dual-axis system controlled by stepper motors, which guide a pen holder along linear rails. The pen holder is adaptable to various writing instruments, maintaining consistent pressure on the drawing surface. The control system includes a microcontroller, motor drivers, and a feedback mechanism using an optical encoder for real-time position monitoring and error correction. The software suite accompanying the plotter allows users to design plots and send instructions via USB, Bluetooth, or Wi-Fi. It supports multiple input formats and provides tools for scaling, rotation, and translation of designs. The system includes safety features such as emergency stop buttons and limit switches, emphasizing ease of maintenance with accessible and modular components. The invention aims to enhance precision, versatility, and user-friendliness in plotting tasks, with innovations in stepper motor control algorithms and a comprehensive feedback mechanism. The patent details the components, their arrangement, and operation methods, highlighting significant advancements in 2D plotting technology.

*Image not provided.

2.3.2. Whiteboard 2D Plotter

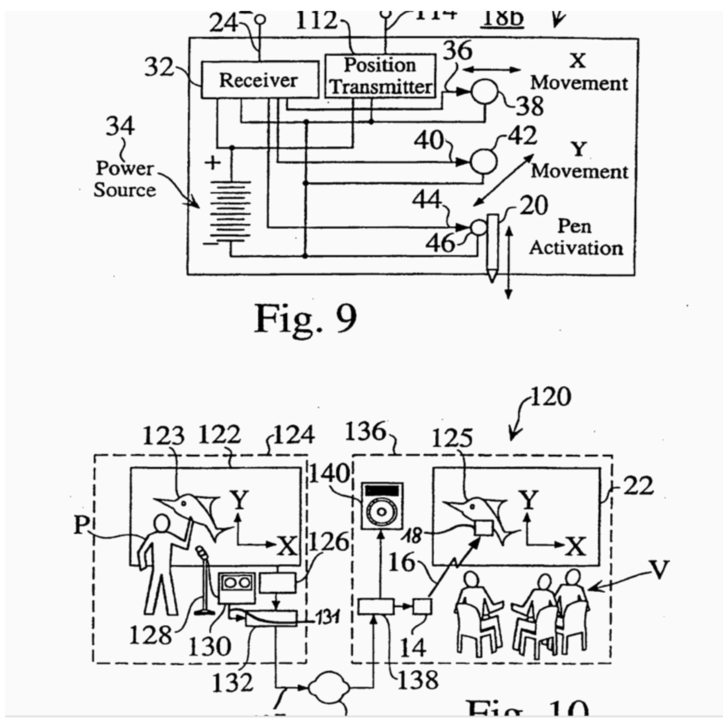
Inventor: Brian Andrew Hicks

Date: May 24, 2006

Patent Number: EP1040320B1

Website: Brian Andrew Hicks. (2006). PLOTTER FOR USE WITH WHITEBOARD (European Patent) [Review of PLOTTER FOR USE WITH WHITEBOARD]. https://patents.google.com/patent/EP1040320B1/en

The patent describes a plotter designed for use with a whiteboard, enabling the precise and automated creation of drawings on whiteboard surfaces. The plotter features a mechanism that supports the movement of a marking instrument across the whiteboard in two dimensions, controlled by a system of motors and guides.This system ensures accurate plotting and ease of use in various settings, including educational and professional environments.



1. Mechanical

Frame and Mounting: The plotter includes a lightweight, durable frame that can be easily mounted onto a whiteboard. The frame supports the entire mechanism, ensuring stability and precision.

Axes and Movement: The device operates on two orthogonal axes (X and Y), utilizing a combination of stepper motors and linear guides. This setup enables smooth and accurate movement of the marking instrument.

2. Control System

Microcontroller: A central microcontroller processes commands and coordinates the movements of the stepper motors. This ensures precise control over the drawing process.

Motor Drivers: The plotter employs motor drivers to convert control signals into movements, enabling fine-tuned control of the marking instrument.

Sensors and Feedback: Position sensors provide real-time feedback to the microcontroller, allowing for continuous adjustment and correction of the plotter's movements to maintain accuracy.

3. Software Interface

Design and Plotting Software: Accompanying software allows users to create and upload designs to the plotter. The software supports various file formats and provides tools for editing and customizing plots.

Connectivity: The plotter can connect to a computer or network via USB, Bluetooth, or Wi-Fi, facilitating easy transfer of designs and remote operation.

4. Versatility and Adaptability

Interchangeable Marking Instruments: The plotter's pen holder can accommodate different types of marking instruments, such as dry-erase markers, pens, and styluses, expanding its functionality.

Scalability: The system can be scaled to different sizes of whiteboards, making it adaptable to various environments and needs.

5. Safety and Maintenance

Safety Features: The plotter includes safety mechanisms such as limit switches to prevent over-travel, emergency stop functions, and protective covers for moving parts.

Maintenance: Designed for easy maintenance, the plotter features accessible components and modular design, allowing for quick replacements and repairs.

2.3.3. Electronic White Board

Inventor: Hidetoshi Kobayashi

Date: May 11, 1999

Patent Number: JPH11127283A

Website: https://www.lens.org/lens/patent/122-480-167-408-93X/

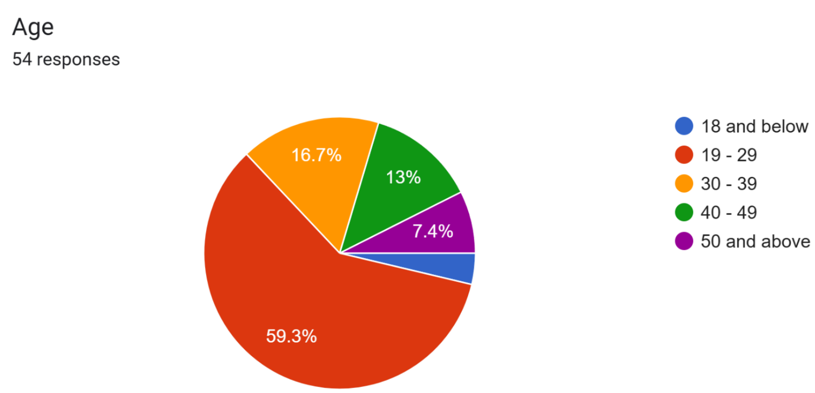
The patent describes an electronic whiteboard system enabling the automated execution of copying, correction, and postscript functions with figures, drawings, and text at specific positions on the whiteboard. The system features a whiteboard scanner and a plotter mechanism, both driven by a drive control unit based on signals processed by a signal processing unit. Input signals from devices such as a keyboard, electronic pen, or other input tools allow the system to write figures, drawings, and text on the whiteboard using the plotter's pen. For corrections or additional content, users can write on a postscript pad with an electronic pen, and the system processes these signals to execute precise updates or additions on the whiteboard via the plotter. The whiteboard scanner reads the described contents on the whiteboard and outputs the data to a printer for hard-copy printing. The scanned content can also be transmitted to external input devices connected to the signal processing unit for recording. This system ensures seamless interaction between input devices, accurate recording and reproduction of content, and flexibility in professional and educational applications.

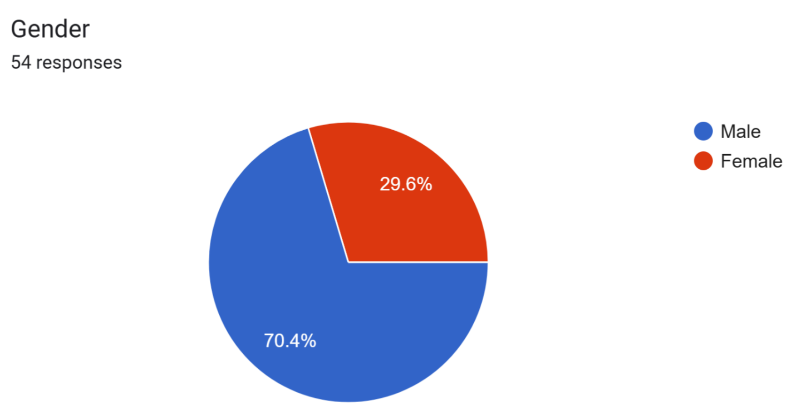
*Image not provide

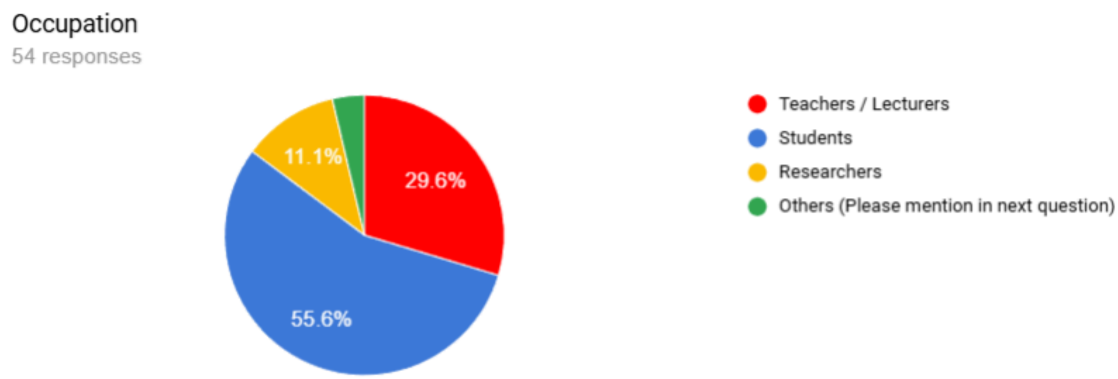
2.4. Customer Survey

The purpose of this survey is to collect insightful comments and viewpoints from important participants in academic and professional contexts. The report aims to offer a comprehensive knowledge of the product's impact on improving efficiency, time management and overall user happiness by exploring user experiences, preferences and potential difficulties. To better satisfy the varied demands of our users, the survey's results will provide the basis for well-informed decision-making, directing future product development and strategic efforts. The survey consists of three different design questions: Demographic details, Agreement questions and Preferences questions.

2.4.1. Demographic Details

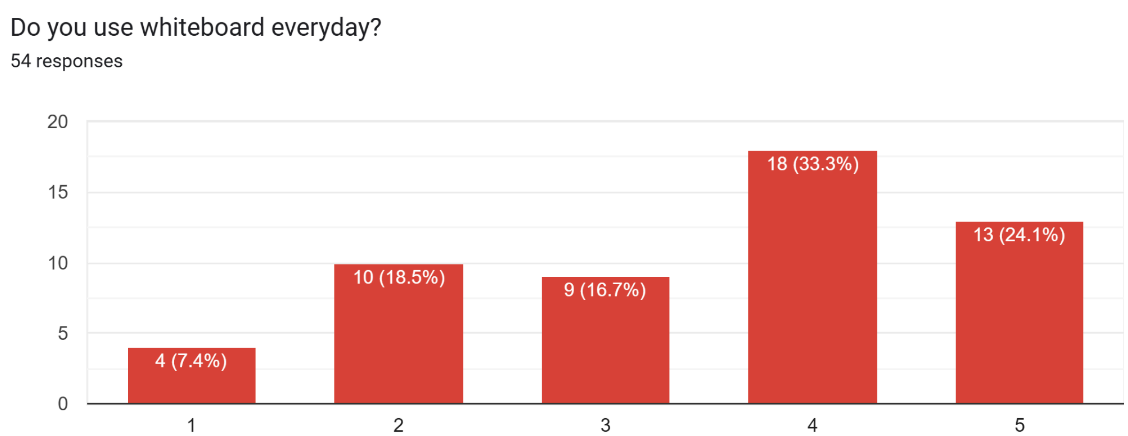






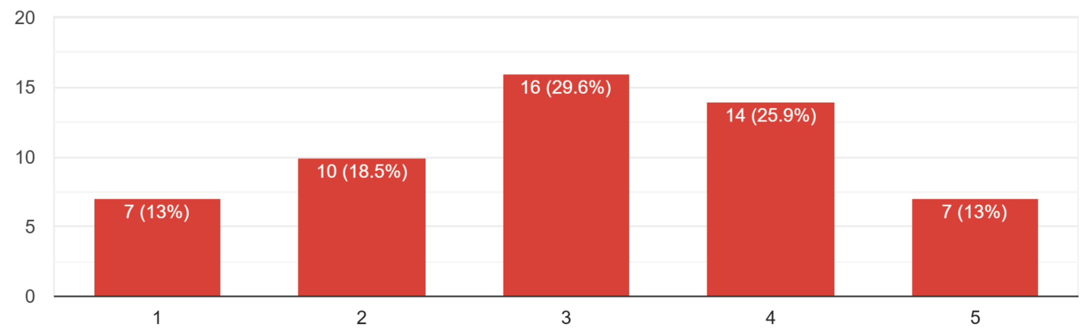
According to this survey, the age group varies but we could see that students in the age group 19-29 is more dominant for about 59.3% in this survey which corresponds to the number of students by 55.6% while some are teachers or lecturers. This shows that our target audience are the majority of this survey which met our objective.

2.4.2. Agreement



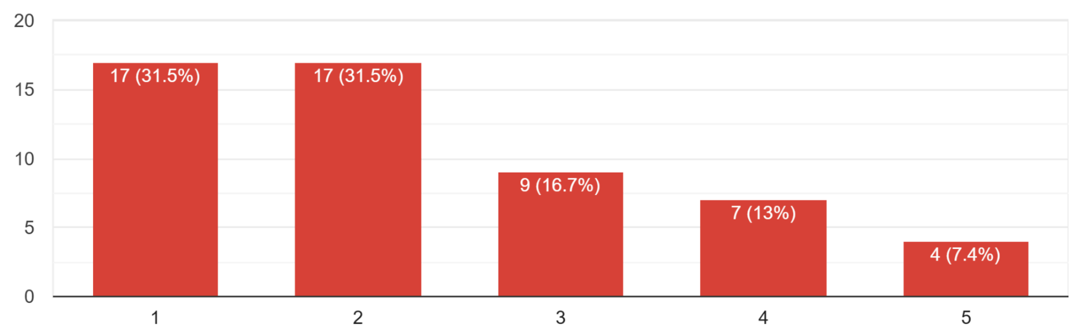
Do you have a hard time writing on whiteboard for a long time?

54 responses



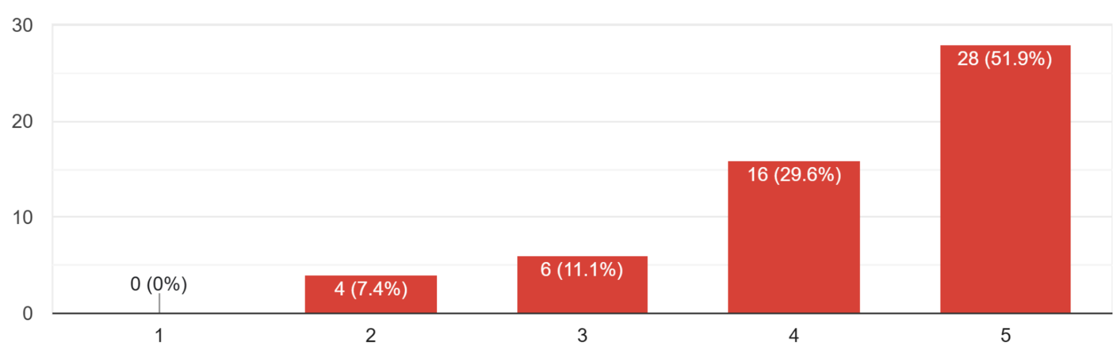
Do you fully use all the space on whiteboard?

54 responses



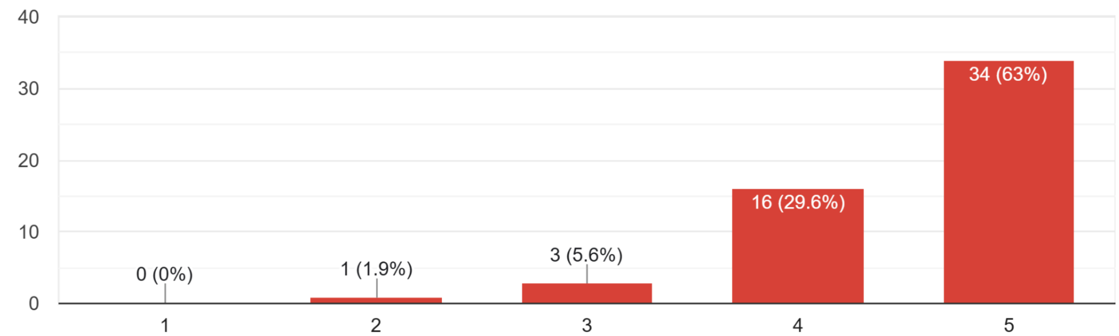
Do you wish you could reach the higher part of the whiteboard?

54 responses



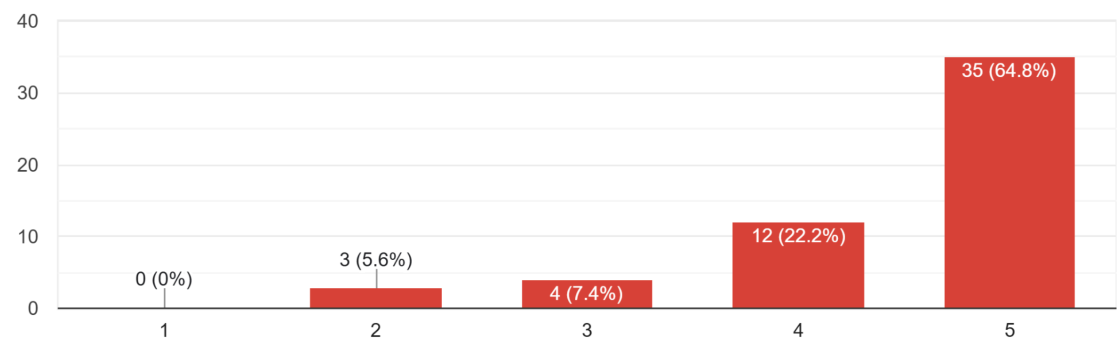
Do you wish you could write faster on whiteboard?

54 responses



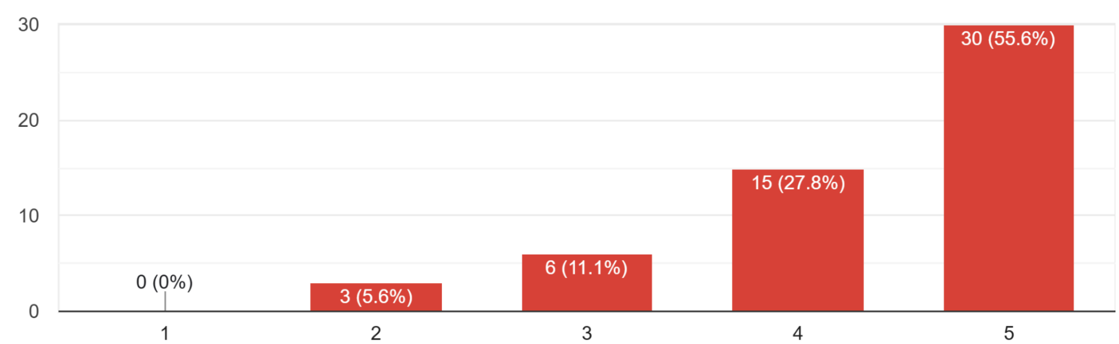
Do you wish you could erase the whiteboard faster?

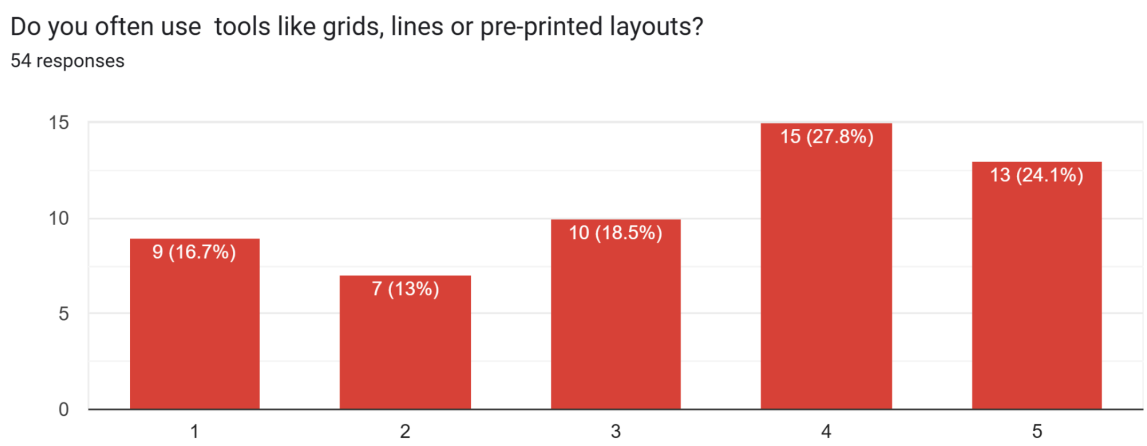
54 responses



Do you wish you could use voice to write on the whiteboard?

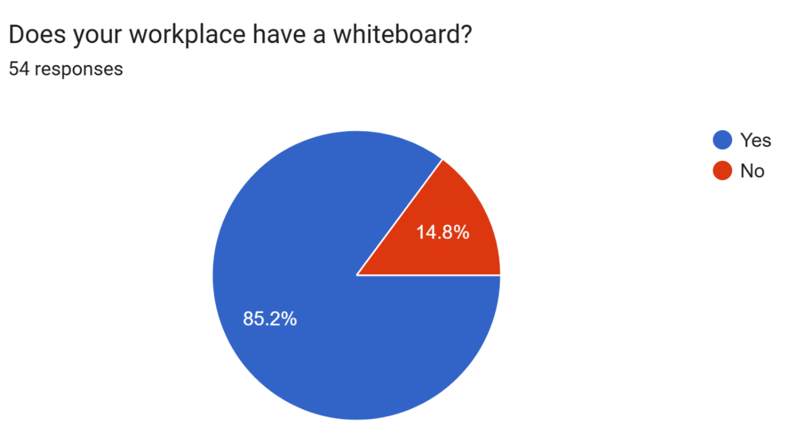
54 responses





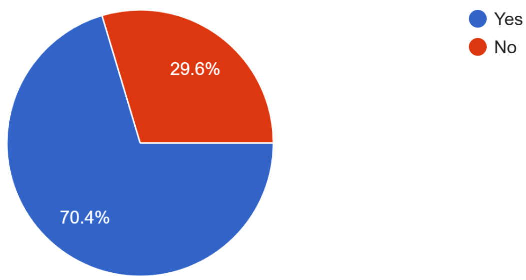
From the findings of their agreement on or proposed questions, many agreed that they use a whiteboard on an everyday basis. While the average don't have any problem writing on a whiteboard for a long time, they do wish that they use all the space on the whiteboard and could reach the higher part of the whiteboard, which they find difficult in reaching the spot. Most of them wished to write and erase faster on the whiteboard, a feature which we could include together. They are also enthusiastic in using voice input to write on the whiteboard and auto draw layouts like a graph or diagram. Therefore, we could conclude the majority of them seems to agree to have this Prompt/Voice-controlled Whiteboard Writer.

2.4.3. Preferences



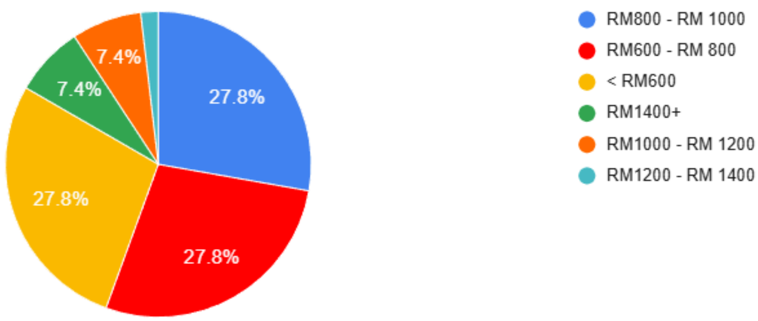
Do you prefer a fixed wall-mounted whiteboard?

54 responses



How much would you pay for an automatic writer whiteboard?

54 responses



What improvements would you suggest for its design or usability?

51 responses

Very high accuracy based on user input

make it easy to use and safe for the user.

make the voice assistant more accurate

Can write just by voice

portable

Movable. I would also prefer that if i can sit at my workspace while my data research to be noted on the whiteboard. For now, I have my research assistant to do it. Would be nice if the whiteboard can help me on that.

can adjust height

i want it to be cheap bcs im high school student

What improvements would you suggest for its design or usability?

51 responses

You can write on the whiteboard using your mind

.

can adjust the height of the whiteboard

Able to write on all the space efficiently

can scan text into pdf or image

Can write quickly

For more space maybe we can make layer whiteboard

Easy to use

use a quality speaker detector to catch the words so the automatic writing on whiteboard will not make any mistake

What improvements would you suggest for its design or usability?

51 responses

Not complicated to use

aesthetic

Not leave stain

Make sure the interface to be PWD-friendly

Quick writing

more white

bigger space of whiteboard

can connect with your device

Can be attached to any whiteboard


What improvements would you suggest for its design or usability?

51 responses

bigger space of whiteboard

can connect with your device

Can be attached to any whiteboard

It would be better if there's additional features to erase the scribbles too.

minimalist for design

integrate with ChatGPT

add auto erase

Write from far away

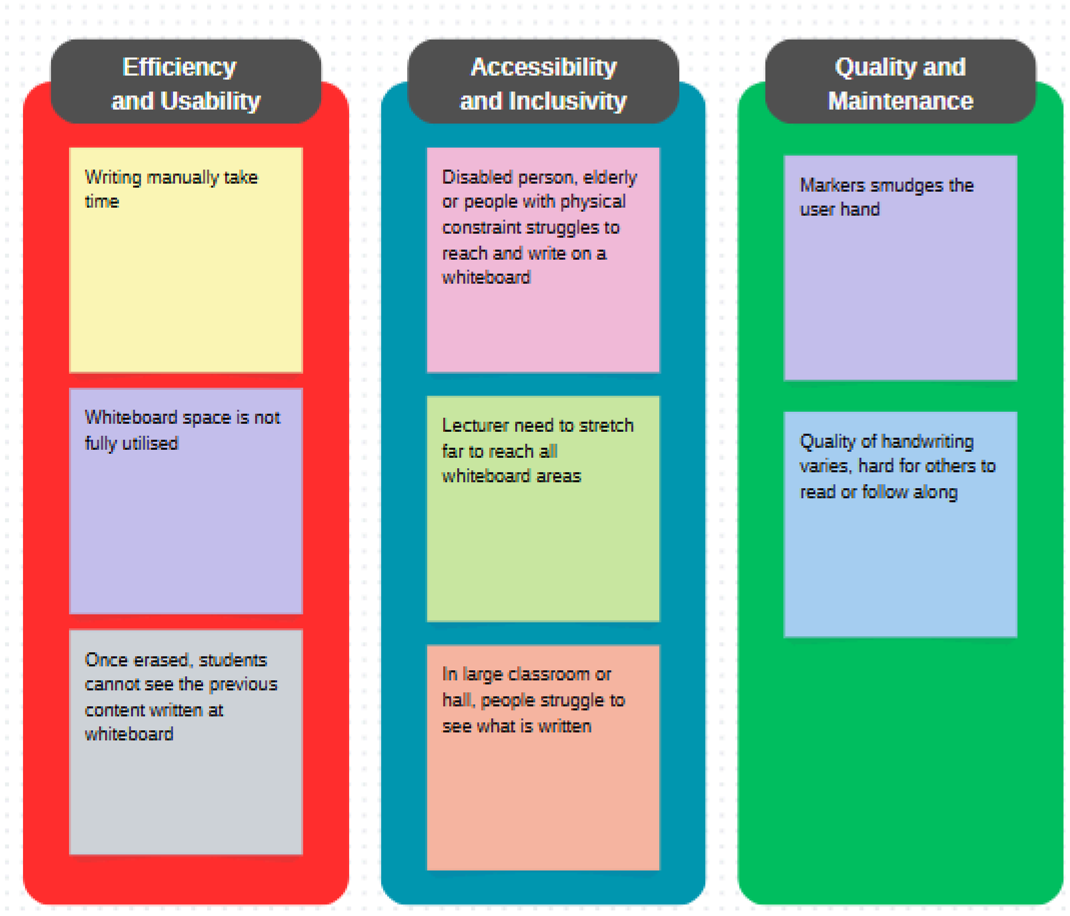
Write graphs and tables

From the data above, most of them have a whiteboard at their workplace which is 85.2% of the respondents. Based on their preferences, the majority of them prefer a fixed wall-mounted whiteboard rather than a moveable whiteboard which. The amount they would pay is varying where below RM600, between RM600 - RM800 and between RM800 - RM1000 came to an even result at 27.8% which we could consider the project to be in a mean of RM800. In a nutshell, this project is very executable based on all the responses.

This survey also gives out a number of very interesting suggestions for its design or usability which we find could be a great feature and also a bit overdesign. While most of it are the features we already have in mind, the features such as ‘integrate with ChatGPT’ and ‘connect with your device’ could be a major improvement in our project. Therefore, these feedbacks from the survey are very helpful in making the best Prompt/Voice-Controlled Whiteboard Writer and will surely satisfy the needs of the people

2.5. Problem Statement

2.5.1. Affinity Diagram



2.5.2. Problem Statement

Whiteboard is a vital tool in classrooms, used to convey information and visualise concepts. Although that, it comes with several limitations that can make communication and interaction more challenging. Lecturers often spend a lot of time writing on the board, which takes away from valuable time that could be used for engaging with students or explaining concepts. For persons with disabilities, using a whiteboard can be especially difficult, further limiting their ability to participate. Additionally, in larger classrooms, lecturers may struggle to reach or fully utilise certain areas of the whiteboard.

One possible solution to these challenges is a Prompt/Voice-Controlled Whiteboard Writer. This system could allow a whiteboard marker to automatically write based on voice commands or text prompts from the user, saving time and improving efficiency. To address visibility issues, a real-time digital display could share the whiteboard content with students, especially those seated at the back of the room or in large lecture halls. This approach could make the classroom experience more accessible, inclusive, and efficient, allowing both teachers and students to focus on what really matters which is learning and interacting.

3. Conceptual Design

3.1. Objectives

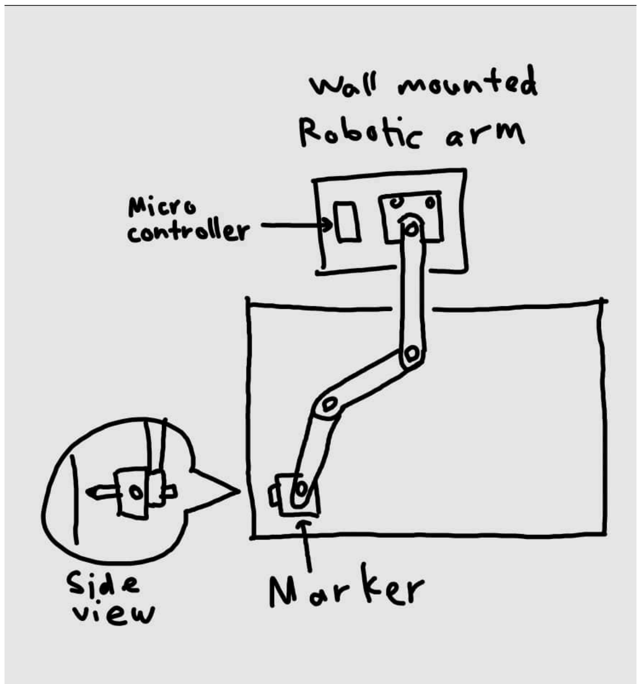
The objectives of this project are:

- To create a fully functional whiteboard writer
- To enable voice and prompt-based control
- To integrate all features into a user-friendly design

3.2. Concept of System

Considering the findings or what the customer needs, we came out with three different designs as per the problem statement:

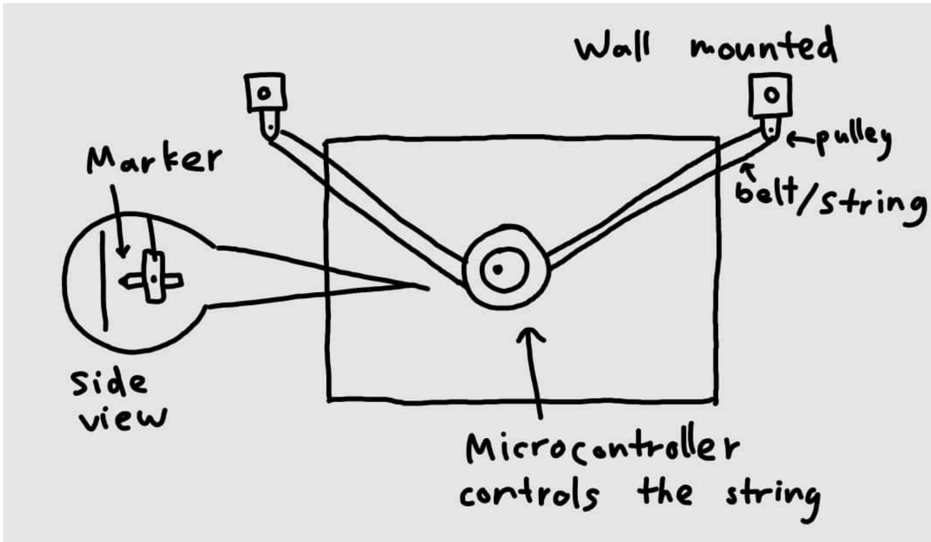
3.2.1. Concept 1: Robot Arm Writer (DATUM)



Working Principle:

The writing is performed by a robotic arm which is mounted to the wall above the whiteboard. Using SCARA (Selective Compliance Assembly Robot Arm)-style plotting with a shoulder and elbow joint for better maneuverability and range of motion. Implementing inverse kinematics and the use of G-Code will allow the end-effector, in this case the marker pen, to move to the desired position.

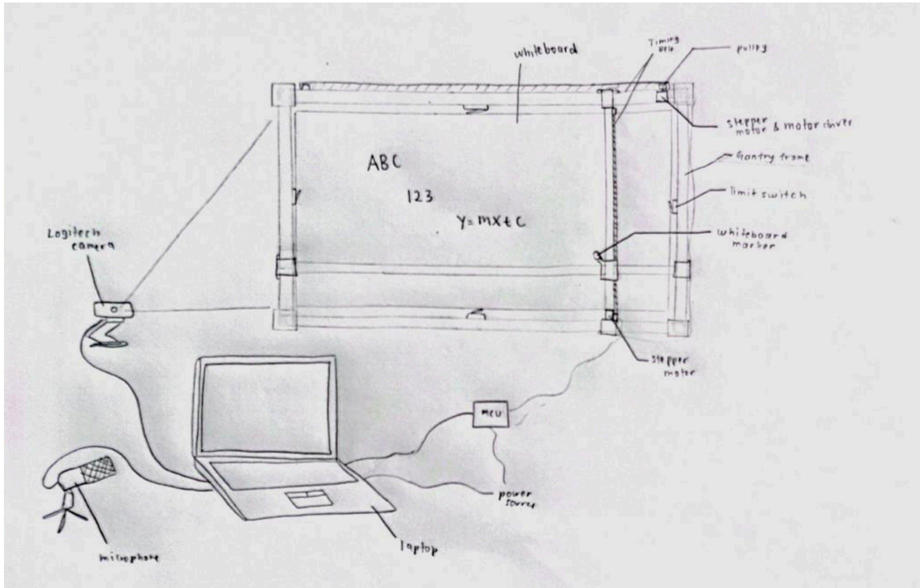
3.2.2. Concept 2: Roomba Writer



Working Principle:

The marker pen is attached to a moving robot which is placed perpendicular to the writing surface. It remains in place with the use of a pulley system which suspends the robot, while still maintaining contact with the writing surface. The microcontroller determines the movement of the robot, which will produce the desired text. This design is adaptable for multiple sizes of whiteboards.

3.2.3. Concept 3: CNC Gantry Writer



Working Principle:

The movements of the marker pen can be precisely controlled by attaching a CNC Gantry to the whiteboard and programming the movement of the marker pen using G-Code, similar to CNC machining. This allows the CNC Gantry to act as the sturdy framework to precisely guide the marker pen, achieving an accuracy similar to plotters and 3D printers. G-Code instructions ensure accurate and reproducible movement operation of the marker pen by defining pacific pathways, speeds and points. Preset text or patterns can also be used due to the automated setup, speeding up processing time.

3.2.4. Pugh Chart

Pugh Matrix - A Decision Matrix

Problem/Situation: Prompt/Voice-Controlled Whiteboard Writer

Criteria	Weights	Concept 1 (DATUM)	Concept 2	Concept 3			Totals	Rank
Accuracy of written text	8	0	0	+			1	5
Maximum usable space on the whiteboard	7	0	+	+			2	1
Average time to write	6	0	0	+			1	5
Jamming Probability	5	0	+	+			2	1
Weight	1	0	+	+			2	1
Noise	5	0	+	0			1	5
Safety	10	0	-	+			0	9
Durability	3	0	+	-			0	9
Assembly Time	3	0	-	0			-1	10
Power Consumption	1	0	+	+			2	1
Writing Force	2	0	-	0			-1	9
Cost	6	0	0	+			1	5
	Totals	0	3	7				
	Rank	2	3	1				

From the Pugh Chart above, it clearly shows that Concept 3: CNC Gantry Writer is the most suitable concept for the project, as it has highest +ve numbers of criteria compared to DATUM and concept 2.

3.3. Engineering Characteristics

No	Engineering Characteristics	Unit	Improvement Direction	Explanation
1	Accuracy of written text	%	↑	Text written should match the desired text with little to no errors.
2	Maximum usable space on the whiteboard	m^2	↑	The area on the whiteboard that can be utilised for writing
3	Average time to write	s	↓	Time taken to write the text can affect efficiency.
4	Jamming probability	%	↓	Likelihood of operational

				issues or blockages which can affect uninterrupted functionality.
5	Weight	kg	↓	Affects portability and ease of use.
6	Noise	dB	↓	Noisy operation will affect user comfort
7	Safety	-	↑	User safety during and between operations is an important factor
8	Durability	-	↑	Use of strong and resilient materials reduces need for repairs and replacements
9	Assembly Time	n/a	↓	Duration needed to assemble, influencing manufacturing efficiency.
10	Power Consumption	W	↓	Amount of energy used during operation, affecting sustainability and cost
11	Writing Force	N	↑	Pressure applied during operation for effective and visible writing
12	Cost	MYR	↓	Expenses associated with manufacturing, including material and labour costs

3.4. Quality Function Deployment - House of Quality (HOQ)

		Engineering Characteristics												
Improvement Direction		↑	↑	↓	↓	↓	↓	↑	↑	↓	↓	↑	↓	
Unit		%	m^2	s	%	kg	dB	-	-	n/a	W	N	MYR	
Customer Requirements	Importance Weight Factor	Accuracy of written text	Maximum usable space on the whiteboard	Average time to write	Jamming probability	Weight	Noise	Safety	Durability	Assembly Time	Power Consumption	Writing Force	Cost	
Low Cost	4		1	3		3			5		9	3	9	
Durable	3				9	3		9	9			1	3	
Fast Writing Speed	5	9	3	9	9		3				9	9	9	
Portable	3					9		3	3	9			3	
Safety Features	3				1			9	9	1	3		3	
Adjustable Writing/Drawing Area & Size	4	9	9	9	9						3	1		
Low Noise	1		1	3			9				3	3	3	
Compatible to Different Whiteboard Sizes	4	3	9		3	1		1	3	9	1			
User Friendly	4	9	9	9		1	3	9		9			3	
Bigger Writer Size for Bigger Whiteboard	3	3	9	9	3	9			3	9	9	3	9	
Aesthetic	2					1				3	3		9	Total
Raw Score		138	155	159	132	85	36	103	104	135	142	76	168	1433
Relative Weight(%)		9.63	10.82	11.1	9.21	5.93	2.51	7.19	7.26	9.42	9.91	5.3	11.72	100
Rank Order		5	3	2	7	10	12	9	8	6	4	11	1	

The figure above illustrates house of Quality (HOQ) analysis for our Prompt/Voice-Controlled Whiteboard Writer. Based on the analysis above, it has been proven that the cost to produce is the most crucial part in the design and the development of our product, followed by average time to write and maximum usable space on the whiteboard. This emphasizes the need for a product that is economically feasible to manufacture and affordable to consumers while prioritizing its performance on writing speed and maximum usability space to write on the whiteboard. The customer requirements that have the least of importance is the writing force and the noise level produced.

3.5. Product Design Specification

Product Name	Prompt/Voice-Controlled Whiteboard Writer
Function	Writes on the whiteboard based on user voice or prompt input
Features	● Hands-free writing on the whiteboard ● Writing on the whiteboard from a remote distance via text prompt or voice ● Screenshots of whiteboard screen via Cloud
Duration of Product Completion	1 year (2 semesters)
Service Environment	● Raises the Efficacy of Teaching - Educators can focus on teaching the students instead of writing on the whiteboard, allowing teaching to be more effective. ● Less Physical Strain - Eliminates the physical exertion required to write on the whiteboard, increasing comfort and ease during educational or professional environments. ● Accommodating for Disabled People - Persons with disabilities and physical constraints who struggle to stand up and write on the whiteboard can now utilise the whiteboard with little issues. ● Interactive for Children Early Learning - Children learning how to speak can use the product Voice Prompt features interactively
Target Market	All individuals and organisations that use whiteboards regularly, including educators, students, professionals, businesses, hobbyists and early learning & kindergarten education
Dimensions	45cm x 30cm
Material	Aluminium and Plastic

3.6. Gantt Chart 1

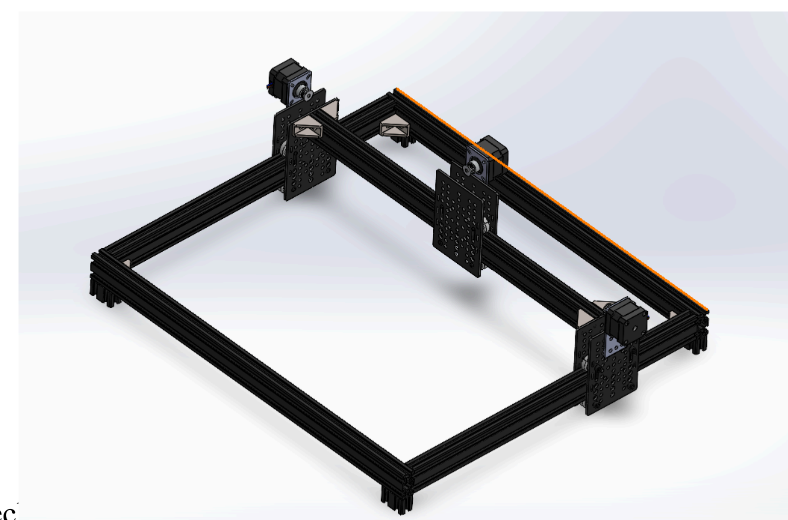
Gantt Chart 1 **Prompt/Voice-controlled Whiteboard Writer**													
	Week												
Process	2	3	4	5	6	7	8	9	10	11	12	13	14
Problem Statement													
Project Selection													
Data Collection													
Conceptual Design													
Embodiment Design													
Detail Design													
Reporting & Submission													

4. Modelling of the System

4.1. Mechanical Subsystem

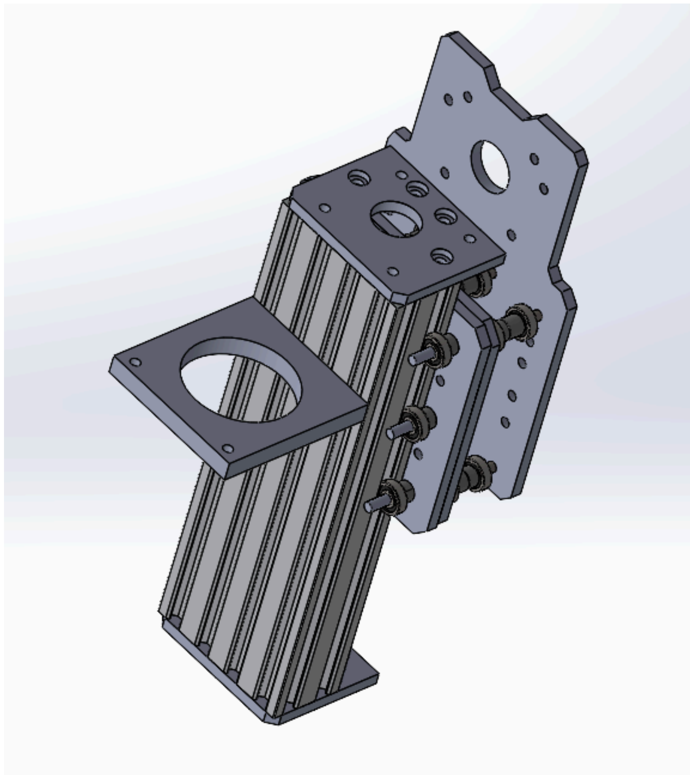
4.1.1. Gantry System

The primary structural element that supports and moves the tool (such as a writing or cutting tool) in the X and Y directions is the gantry system. It is made up of a carriage that holds the tool, rails, and bearings. The principle movement of the tool across the plotting surface is accomplished by the gantry, which is typically mounted on a frame.



4.1.2.

This mechanism's function is to hold the whiteboard marker pen. It moves along the tool arm (the moving vertical bar) due to being attached to the v-slot.



Size of the whiteboard: 0.47 m x 0.32 m x 0.02 m

Size of the frame: 0.57 m x 0.71 m x 0.54 m

Calculation for Nema 17 Stepper Motors:

- Holding torque is 0.4Nm-0.7Nm
- Weight of piece with whiteboard marker is 0.5kg = 4.9N
- Distance between motor and piece is 4 cm = 0.04 m
- 4.9 N x 0.04 m = 0.96 Nm

The holding torque of the motor is sufficient

4.2. Electrical Subsystem

4.2.1. Determining Power Supply Required

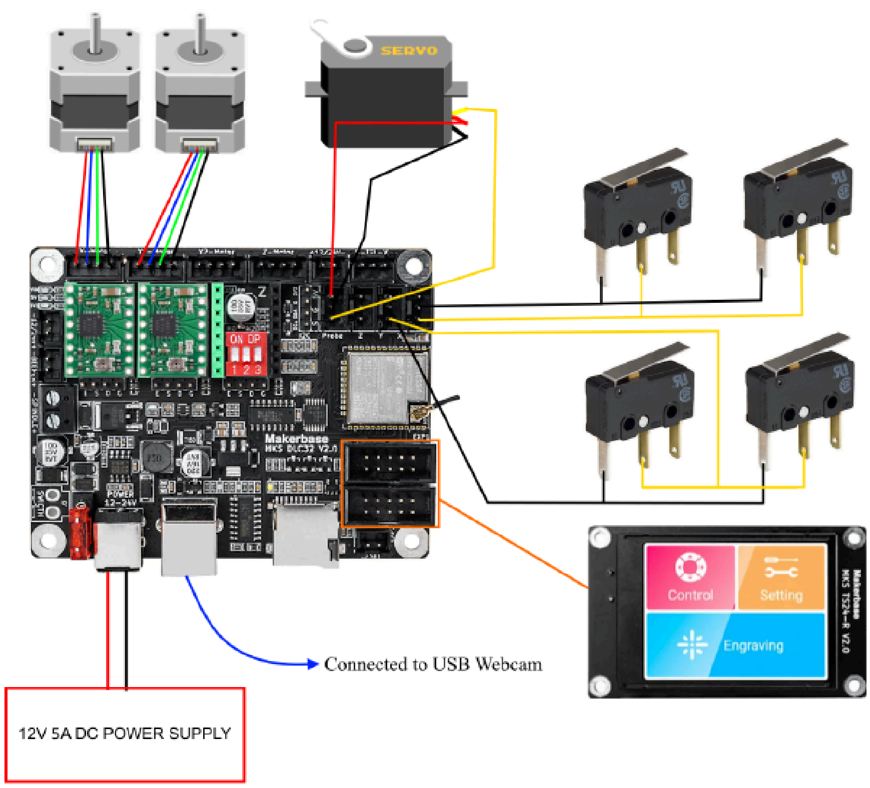
Firstly, we determine the maximum current draw for each electrical component:

- Nema 17 Stepper Motor has a rated current of 0.7 A x 2 = 1.4 A

- MG996r Servo Motor uses 2.5 A when stalled, running current is between 0.5 – 0.9 A.
- A4988 Motor driver uses 8mA x 2 = 0.016 A
- Total Max A = 1.4 + 2.5 + 0.9 + 0.016 = 4.816 A

From the calculations, we decided to choose a 12V 5A power adapter as the power supply.

4.2.2. Circuit Diagram

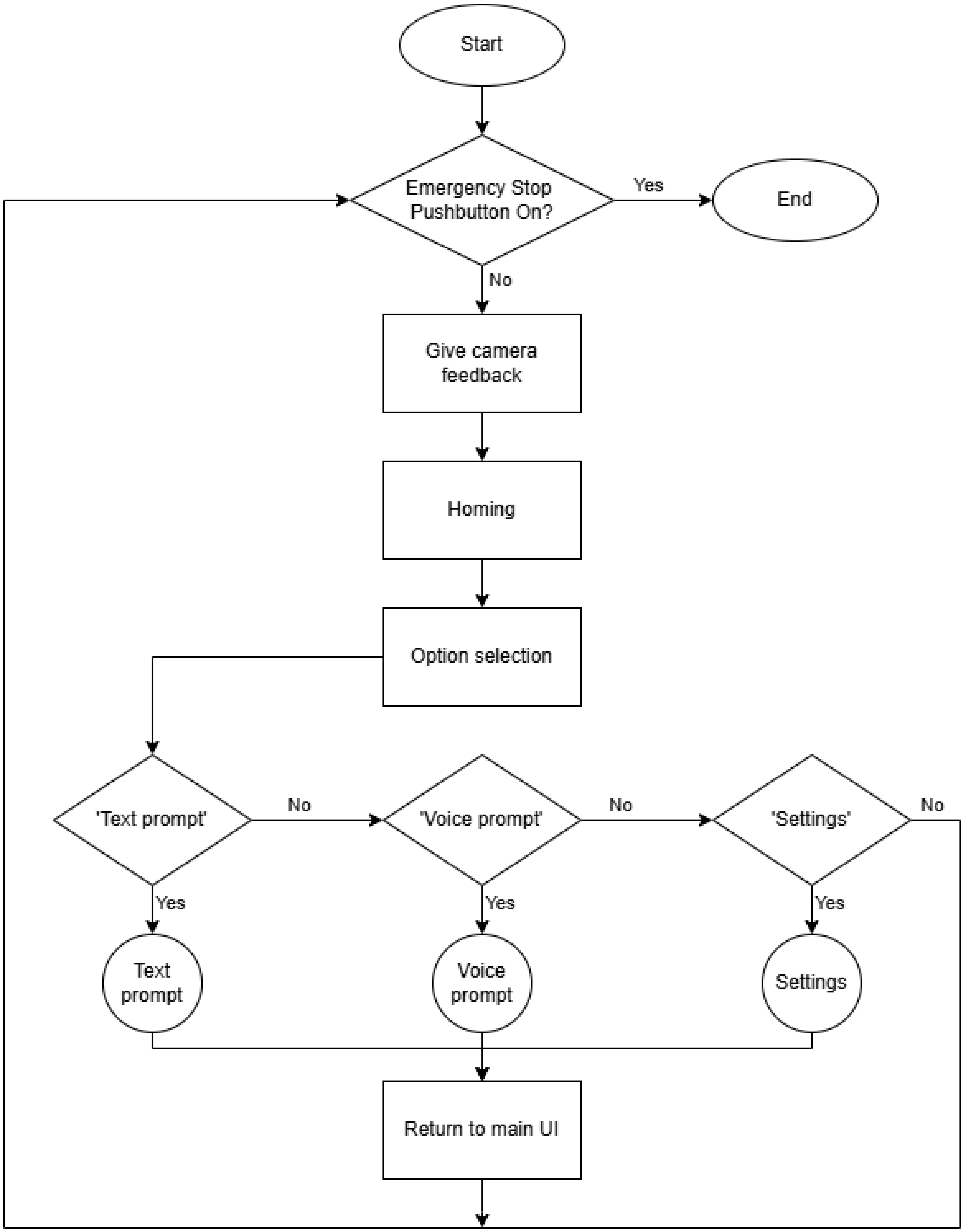


Above is the circuit diagram, which we designed with minimal components without sacrificing the necessary functions. The reason being to increase reliability by reducing points of potential failure. The brain of the circuit diagram is MakerBase MKS DLC V2.0 motherboard kit, which is an offline engraving master control kit developed for desktop engraving machines. Several components are connected, which are the two NEMA 17 Stepper Motors, MG996r Servo Motor, 4 limit switches, 2.4 inch TFT touch screen, and the USB Webcam. Powering the whole thing is a 12V 5A DC Power Supply using an AC/DC power adapter that is connected to the outlet.

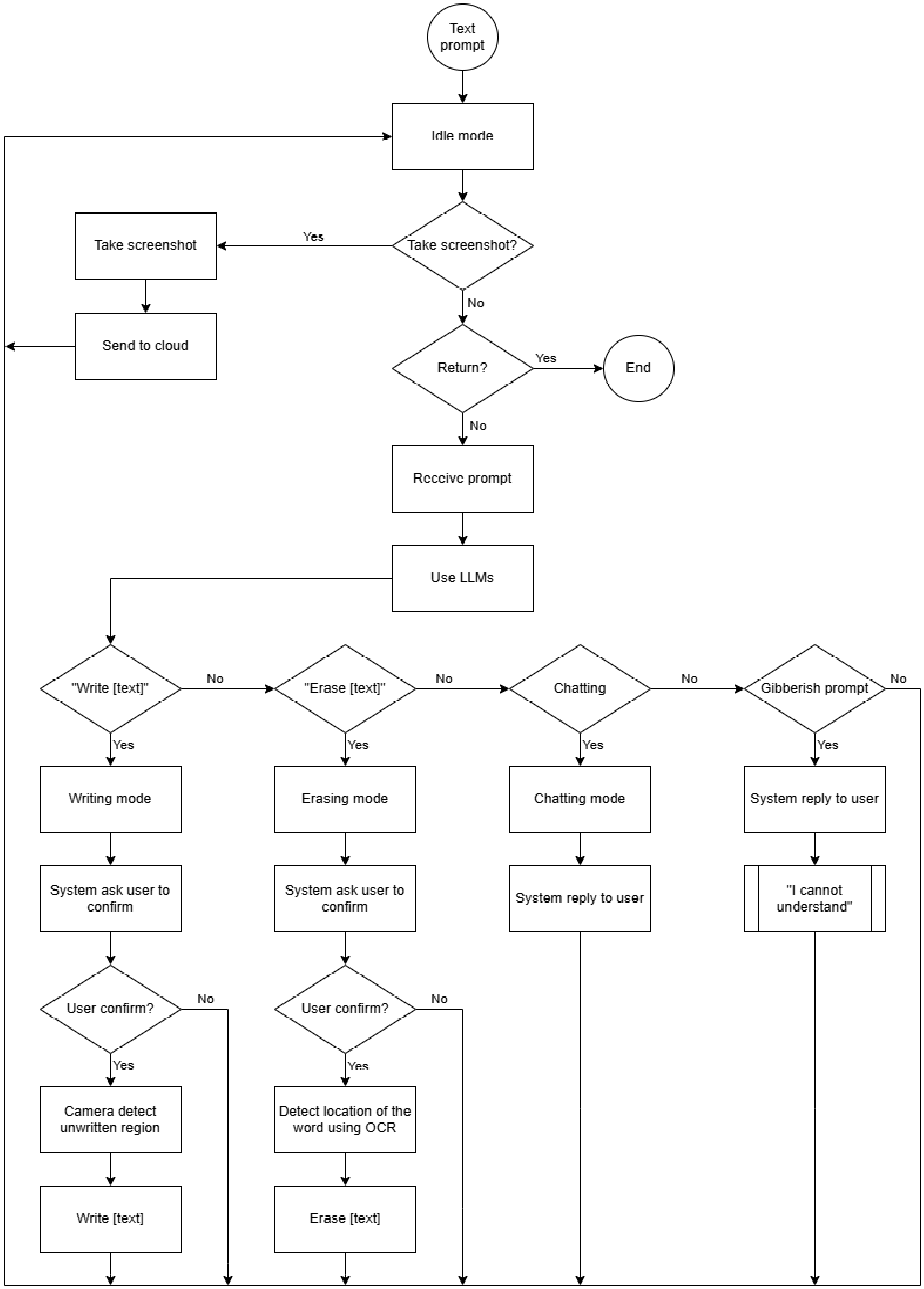
4.3. Software and Algorithm

4.3.1. Flowchart

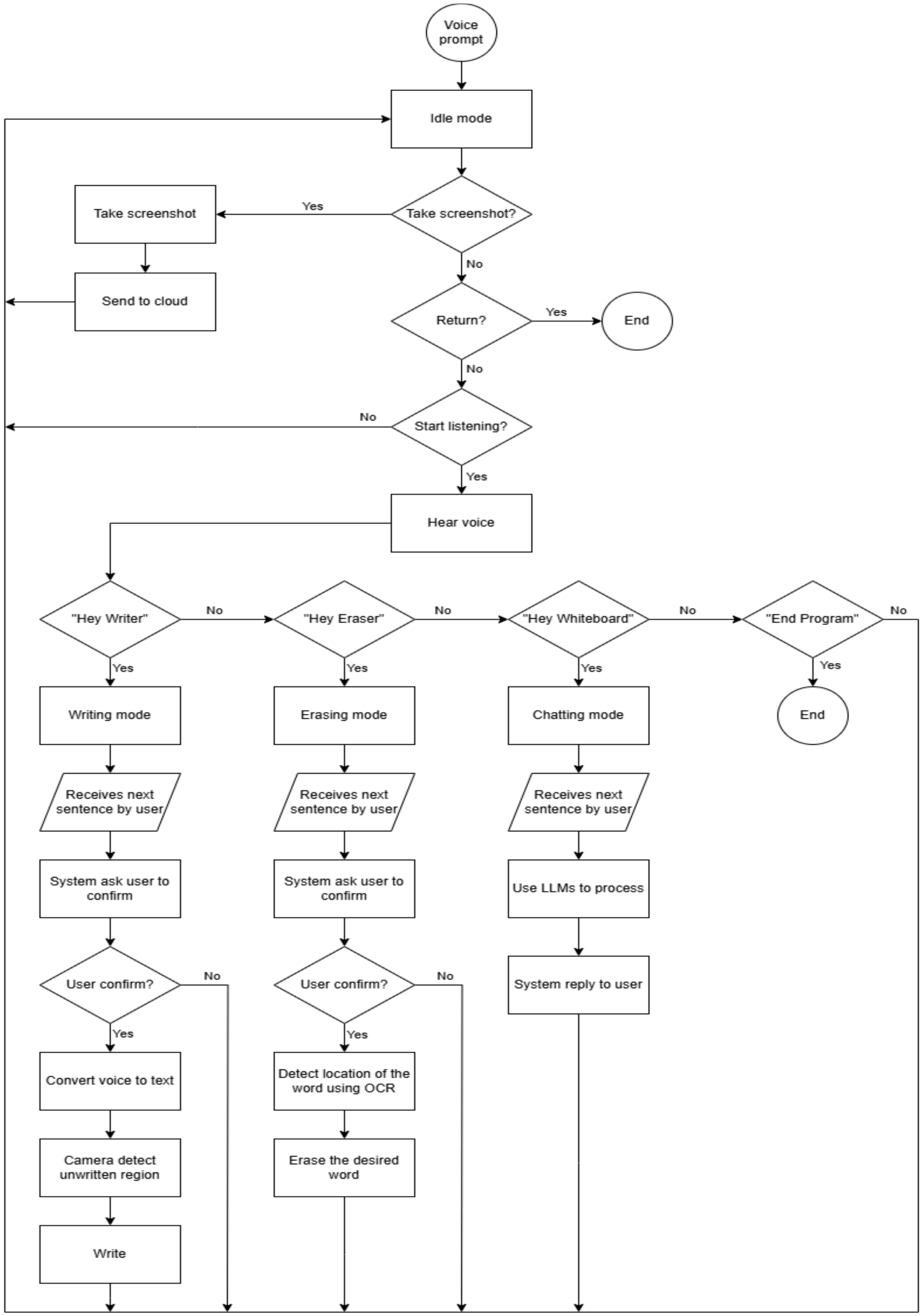
4.3.1.1. Main flowchart



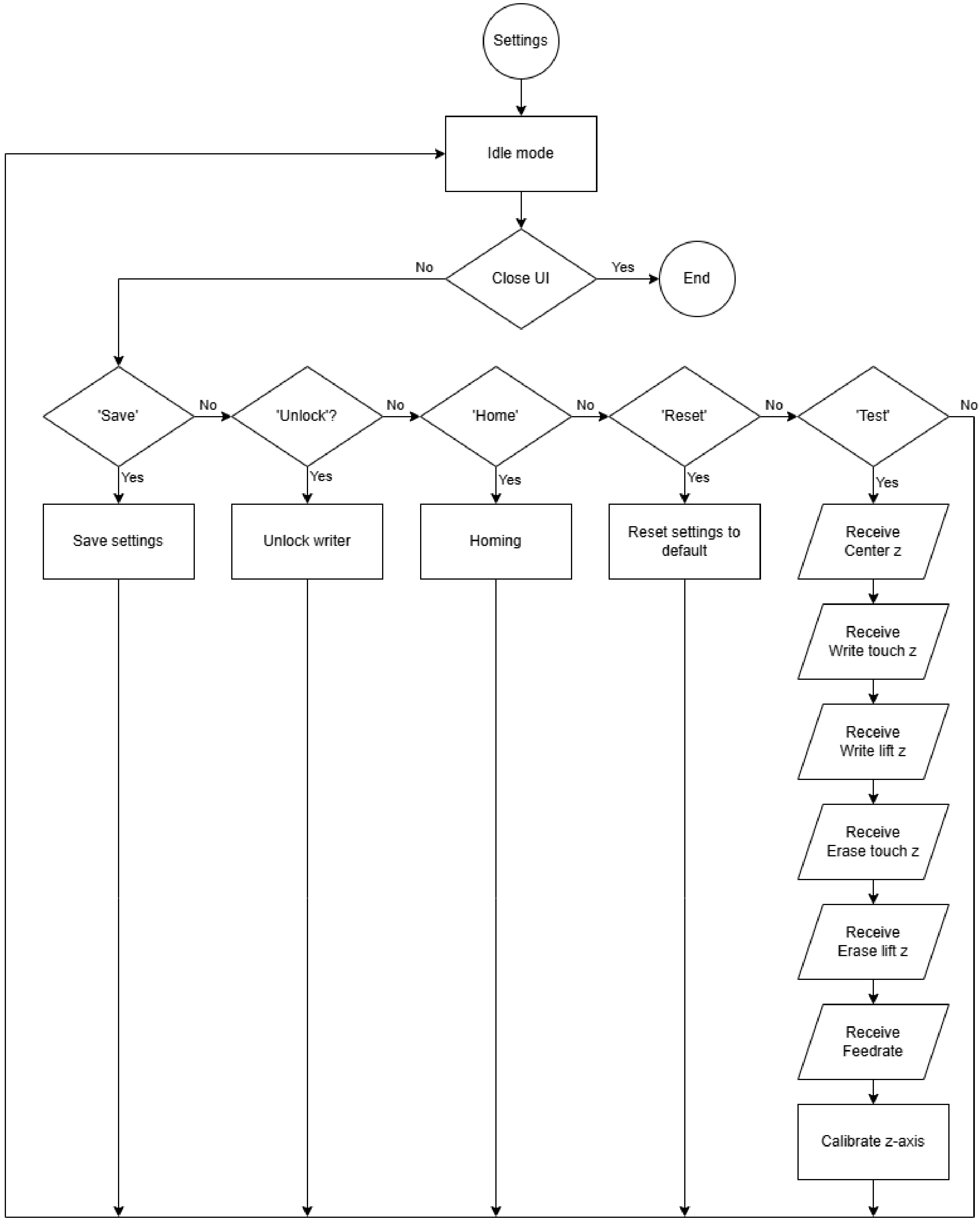
4.3.1.2. Text Prompt flowchart



4.3.1.3. Voice Prompt flowchart

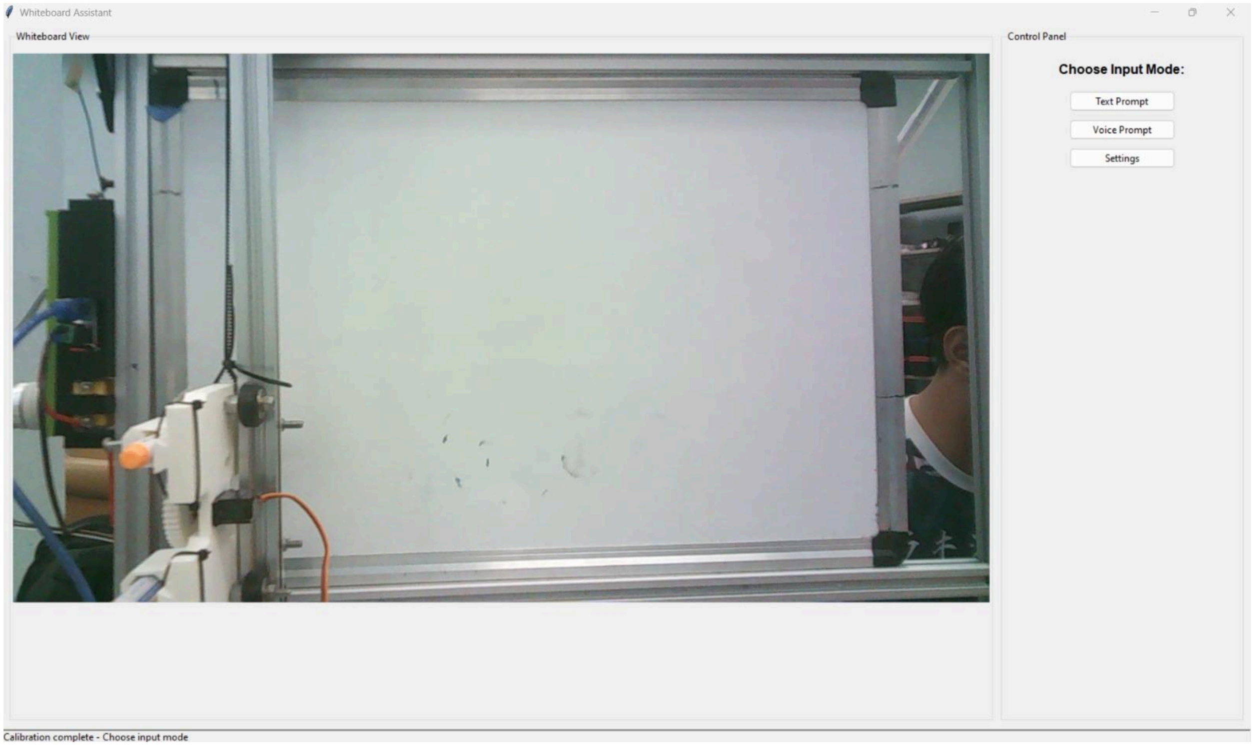


4.3.1.4. Settings flowchart

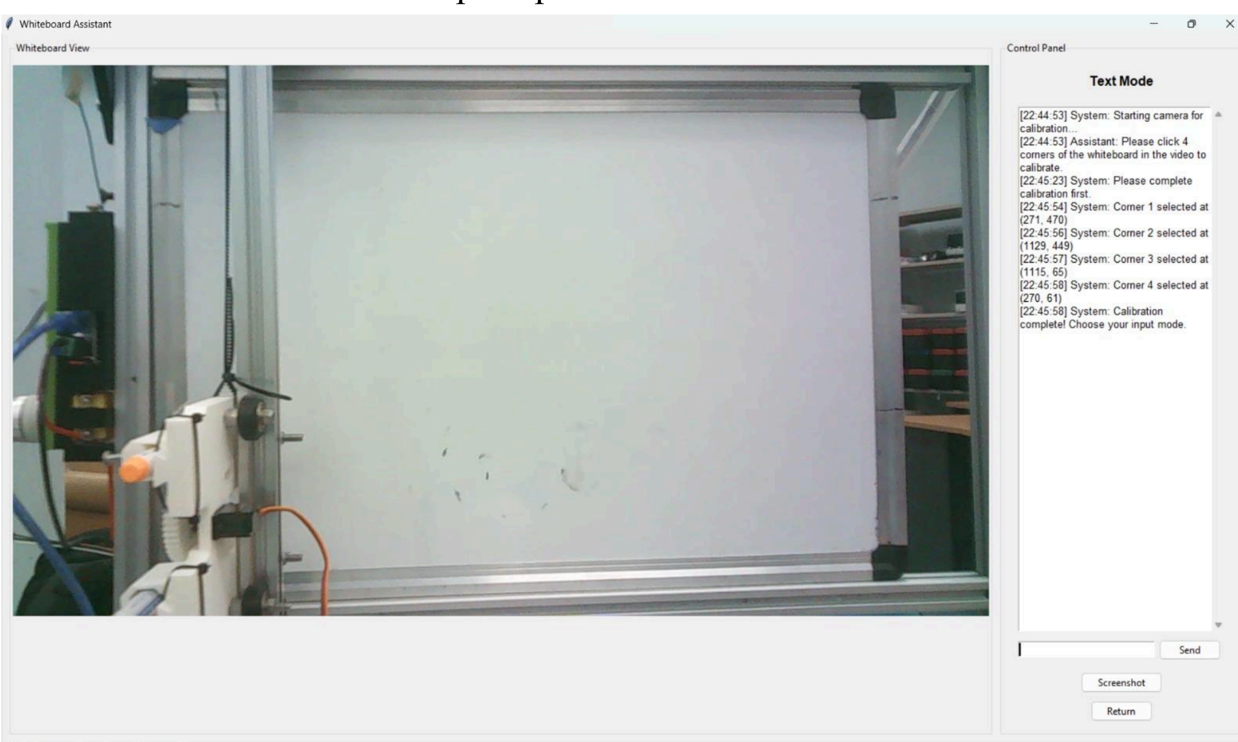

Settings
Idle mode
Close UI
No
Yes
End
'Save'
No
'Unlock'?
No
'Home'
No
'Reset'
No
'Test'
No
Yes
Yes
Yes
Yes
Yes
Save settings
Unlock writer
Homing
Reset settings to default
Receive Center z
Receive Write touch z
Receive Write lift z
Receive Erase touch z
Receive Erase lift z
Receive Feedrate
Calibrate z-axis

4.3.2. Graphical User Interface (GUI)

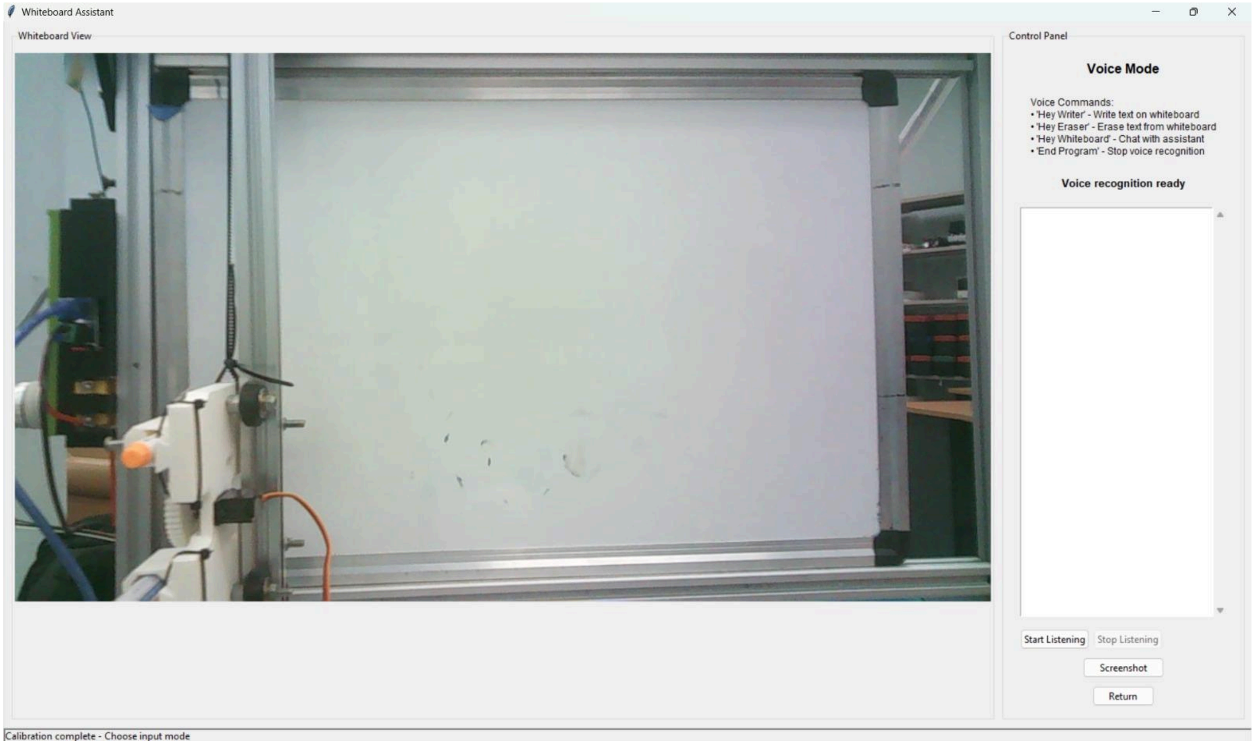
4.3.2.1. Main interface



4.3.2.2. Text prompt

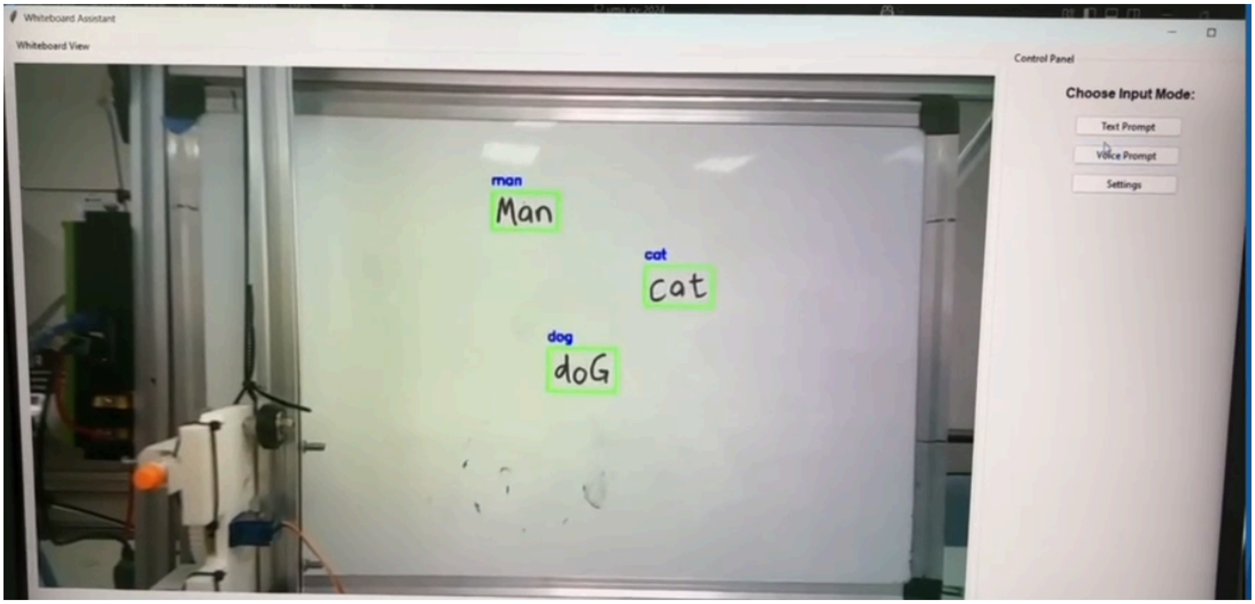


4.3.2.3. Voice prompt



4.3.2.4. Settings

4.3.2.5. OCR



4.3.3. The full code may be found in the Github link. Refer Appendix

5. Design of the System

5.1. Component Design

Component	**Specifications**
Aluminium Frame (5 pieces)	• Dimension(Length): 914.4mm±0.3 (3ft) 609.6mm±0.3 (2ft) 127mm±0.2 (5 inches) (2 units) 457.2mm±0.3 (1.5ft) • Weight: 144g (Main frame) • Thickness: 1.5mm±0.05
V-Slot (with holder)	• Responsible for moving the tool arm horizontally and tool head vertically • Size (length x width): 40mm x 40mm
Stepper Motor	• Type: Nema 17 • Voltage(rated): 12V DC

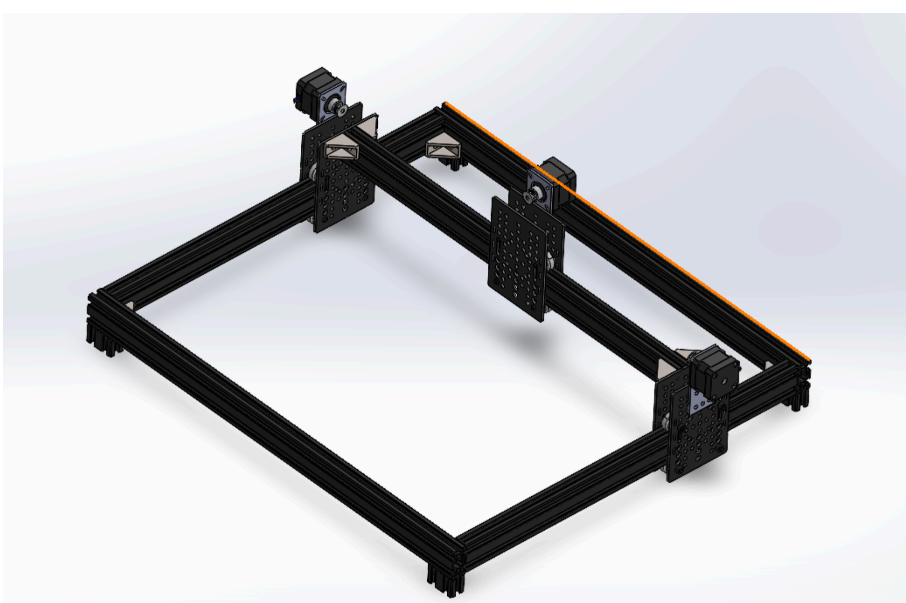
	● Current: 1.2A at 4V ● 200 steps/revolution ● Shaft diameter: 5mm ● Step Angle: 1.8° ± 5% / STEP ● Holding torque: 3.2 kg-cm ● Responsible for the motion of tool arm
Stepper Motor Driver	● Type: A4988 ● Motor Voltage Input Range : 8V- 35V ● Convert pulse signals from the controller into motor motion to achieve precise positioning for the stepper motor
Makerbase	● Type: MKS DLC32 ● The "brain" of the machine ● Contains ESP32 module (microcontrollers)
GT2 Timing Belt	● Type: Closed-loop timing belt ● Length: - 1220mm - 610mm ● Width: 6mm ● Pitch: 2mm ● Tooth Height: 0.76mm ● Belt Height: 1.52mm ● Responsible for moving the tool arm horizontally and tool head vertically
Limit Switch	● Type: KW12-C ● Power: 5A125VAC /3A250VAC ● Mechanical Life: 400,000 times ● Used to stop the marker when it reached maximum position
Servo Motor	● Type: servo mg996r (360 degrees) ● Purpose: to control the pen's Z axis
Nylon Sleeve	● Length: 2 m ± 0.5 m ● Width: 6mm ● Used for cable protection ● Light ● Flexible
Camera	● Logitech USB camera ● Scans the board for pre-existing text to determine the allowable writing region

Whiteboard Marker	● A standard whiteboard marker ● Writing Width: 2.0mm
USB Microphone	● Will receive user voice input ● Plug Type: USB/3.5mm ● Impedance: 2.2kΩ ● Sensitivity: -42dB ● Frequency Response: 100 Hz - 10000 Hz ● Power Rating: 3V
Belt Pulley GT2	● Responsible for moving the tool arm horizontally and tool head vertically ● Bore Size (Diameter): 5 mm ● Teeth Num: 16 teeth
AC/DC Power Adapter	● Voltage: 12V ● Current: 5A ● The main power source of the machine
Castor Wheels	● Allows for easy transportation and movement
Handle	● Gives the option to carry it around
Emergency Stop Button	● Responsible for immediately halting all operations of the device

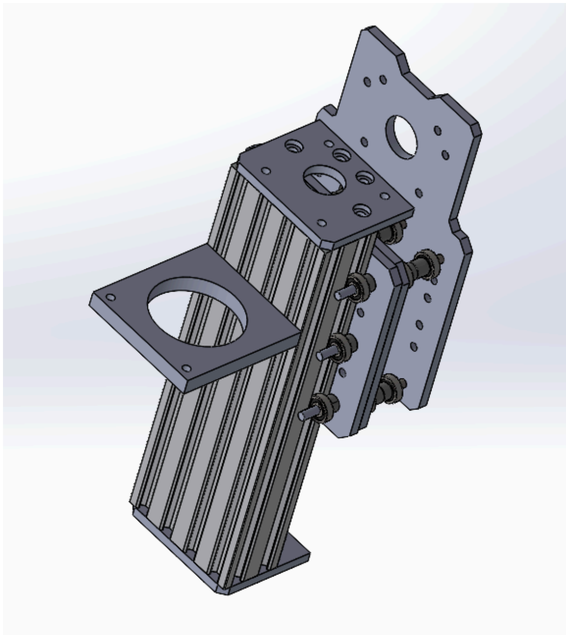
5.2. Embodiment Design

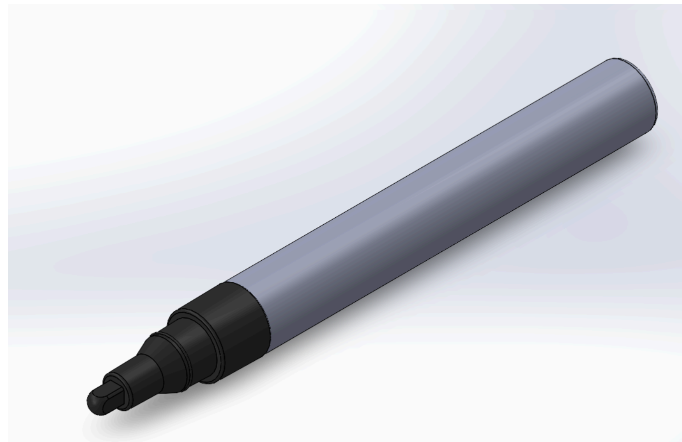
5.2.1. Detailed Design

Gantry Design

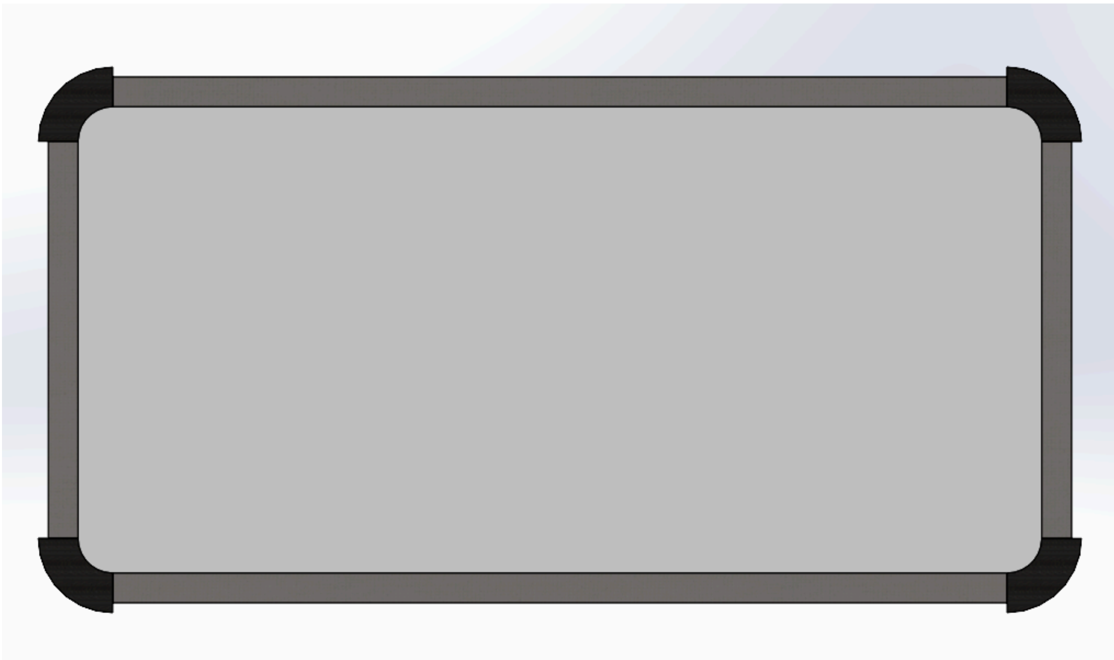


Tool Head: Marker Holder + Marker



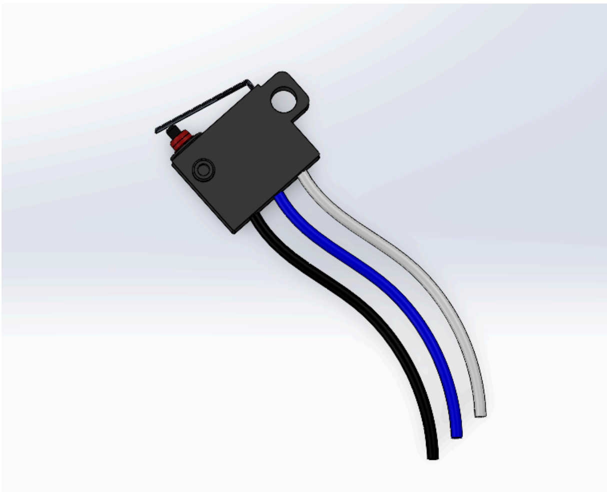


Frame System: Aluminium Gantry Frame + Whiteboard

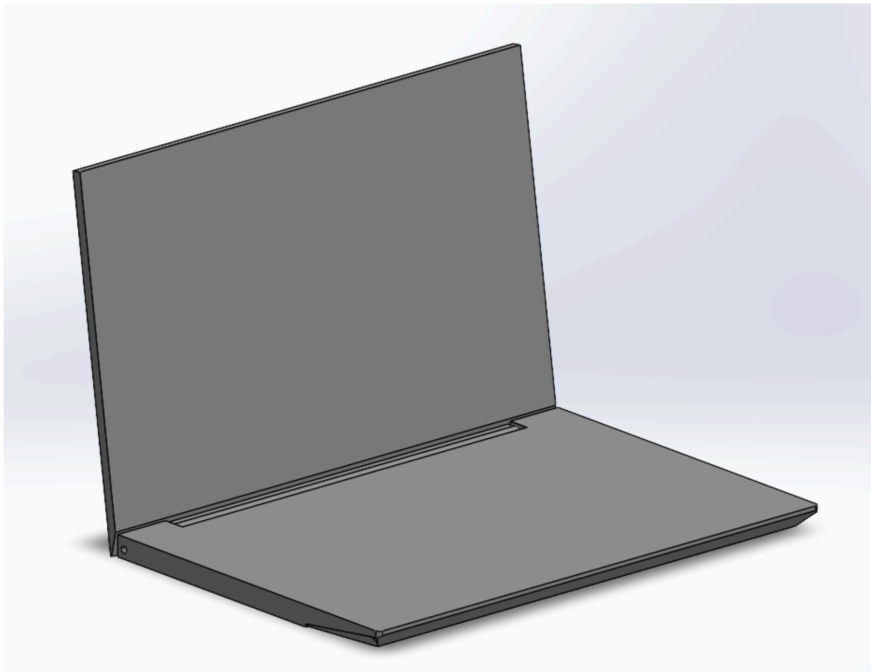


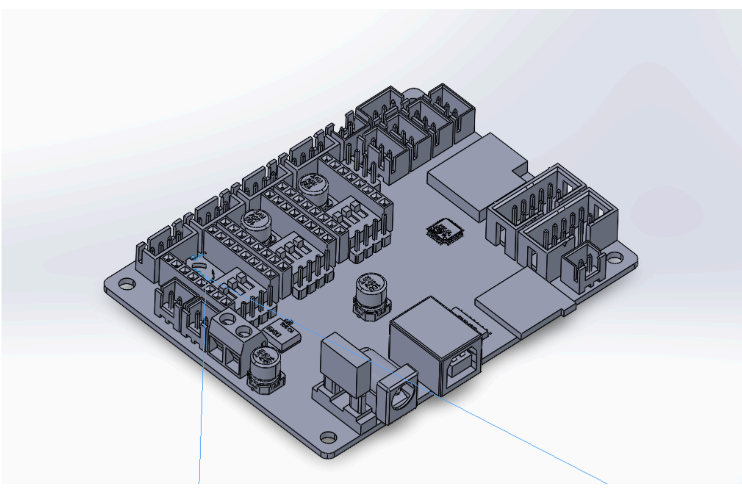
Motion System: V-Slot with Roller + Stepper Motor

Feedback System: Limit Switch + USB Camera



Processing System: Laptop + Makerbase(MKS DLC32) + Microphone



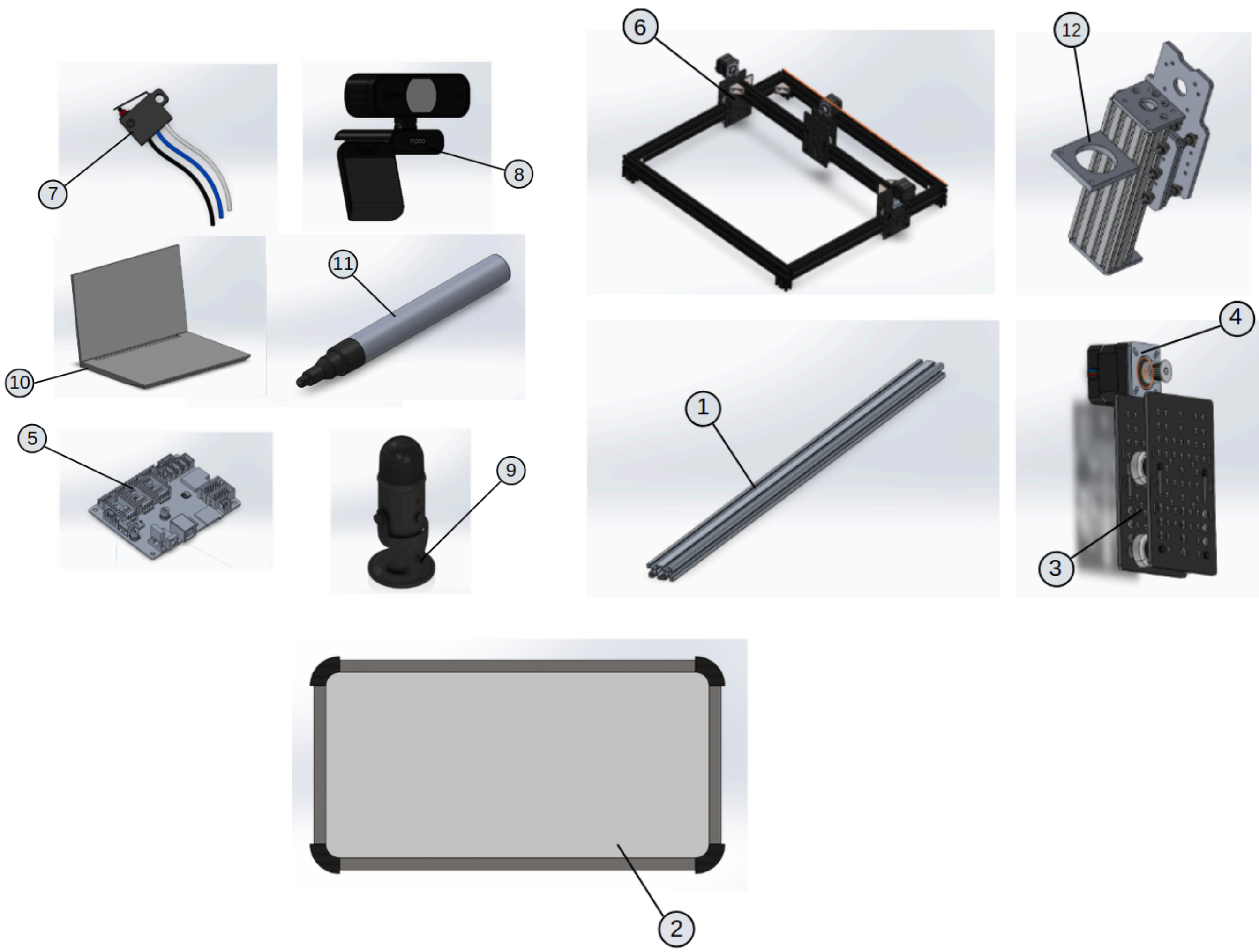


5.2.2. Updated Detailed Design - Design Changes

We have incorporated **lockable wheels** and a **handle** into the design to significantly improve the mobility and usability of the product. The lockable wheels allow the system to be easily transported and securely positioned during operation, ensuring both convenience and safety. The handle further facilitates movement, especially in confined or shared spaces, making the setup more user-friendly and adaptable to various environments.

In addition, we have reinforced the top frame by installing an additional **metal bracket** and **internal T-connectors.** These enhancements were implemented to increase the structural rigidity and stability of the gantry system, particularly during high-speed or prolonged operation. This reinforcement minimises frame flex and ensures more consistent writing precision, thereby improving overall performance and durability.

5.2.3. Working Principle



Label	Components
1	Aluminium Gantry Frame
2	Whiteboard
3	V-Slot with Roller
4	Stepper Motor

5	Makerbase Controller (MKS DLC32)
6	GT2 Timing Belt
7	Limit Switches
8	Camera
9	Microphone
10	Laptop
11	Whiteboard Marker
12	Whiteboard Marker Holder

The **Prompt/Voice-Controlled Whiteboard Writer** operates as an automated system for writing on a whiteboard based on user input. The system is built around an aluminium gantry frame (1), which provides structural stability and serves as the base for mounting the components. A traditional whiteboard (2) is securely attached to the frame as the writing surface.

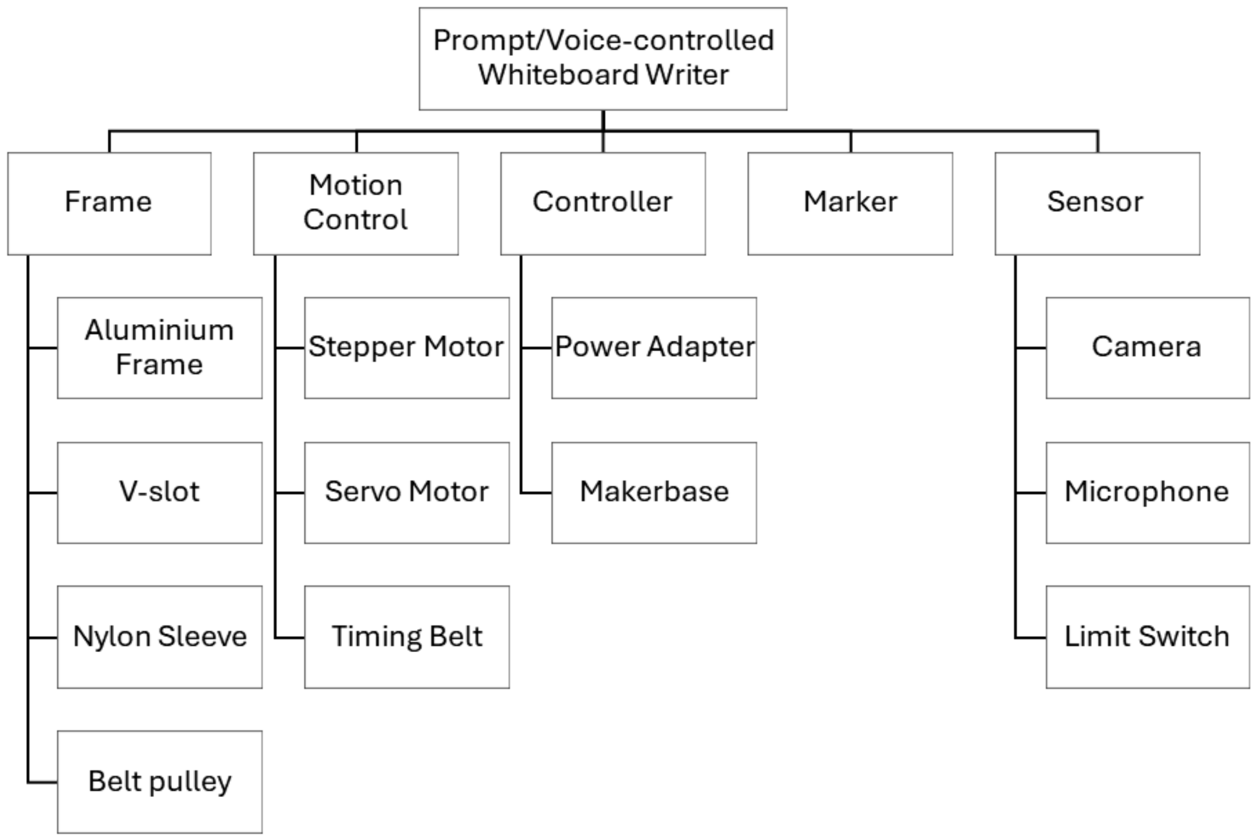
The movement of the writing mechanism is guided by a V-slot with Roller (3), ensuring smooth and precise linear motion along the X and Y axes. Two stepper motors (4) drive this motion by moving the writing head, which holds the whiteboard marker (11) in place within a whiteboard marker holder (12). The movement is transmitted using a GT2 timing belt (6) connected to the motors, ensuring accurate positioning of the marker.

The Makerbase controller (5) acts as the brain of the system, receiving input from the user and translating it into precise movement instructions for the stepper motors. It also processes feedback from the limit switches (7), which are placed at the edges of the whiteboard to define operational boundaries and prevent the writing head or the marker from exceeding the physical limits of the whiteboard surface.

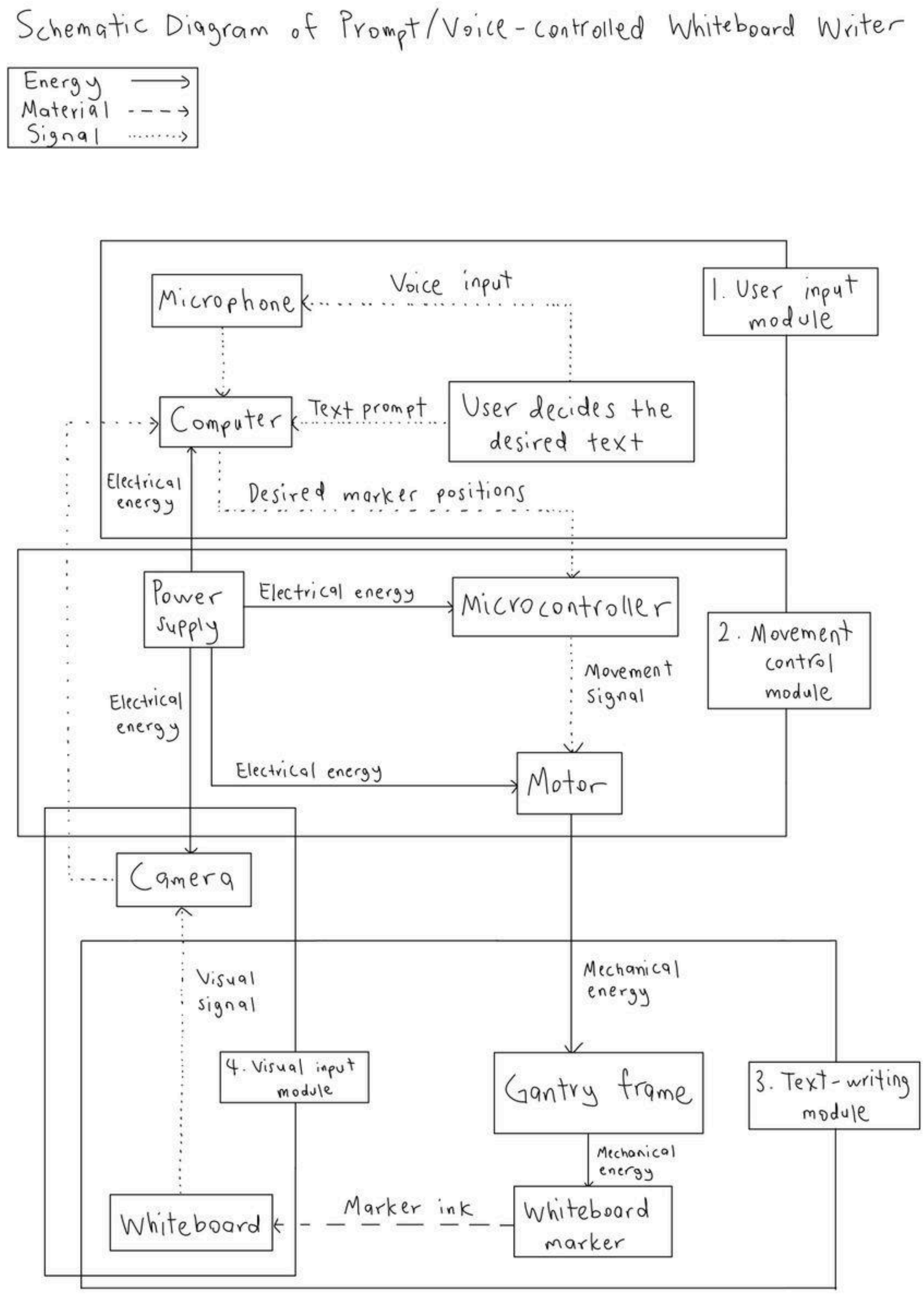
Input to the system is provided either through voice commands captured by a microphone (9) or text commands entered on a laptop (10). The laptop serves as the primary user interface, enabling configuration, monitoring, and adjustment of the system. The microphone captures spoken instructions, which are processed by the Makerbase controller to determine the content to be written on the whiteboard.

During operation, the camera (8) monitors the writing process in real time, providing visual feedback to ensure the accuracy and alignment of the text or illustrations. Users can view this feedback on the laptop and make adjustments if necessary. The combination of real-time monitoring and precise motion control is to make sure the system delivers consistent and reliable results.

5.2.4. System Dissection



5.2.5. Schematic Diagram



5.3. DFM (Design For Manufacturing)

Design for Manufacturing or DFM is the process of designing components, parts or products for ease of production with the final goal of producing a better product at a cheaper cost. By simplifying, optimising and improving the product design, this goal can be achieved. In essence, this can be done by using parts and components that fit conventional dimensions and are readily available in the market

In this project, the selection of readily available materials which can be easily machined, such as aluminium for the gantry frame, is crucial. The parts should be designed with simple geometry to reduce the complexity in manufacturing and to avoid the need for detailed and intricate machining processes.

Tolerances must be specified within the limit of standard manufacturing processes to reduce the cost of unnecessary precision work. By using ready-to-use components such as motors, camera modules and bearings, the need for custom manufacturing can be reduced. The overall part count should also be minimised by including parts with multiple functions or combining certain components together.

The manufacturing process that is chosen should be appropriate and cost-effective for the required production volume, such as using CNC milling or laser cutting. To ease fabrication, parts should also be designed with features like threaded inserts for components that are frequently assembled and disassembled. In addition, the system should allow for easy testing and calibration to ensure that both assembly and maintenance are straightforward processes.

5.4. DFA (Design For Assembly)

Design for Assembly for the product should emphasize using modular components, to allow for easy assembly and disassembly. By using a modular mechanism, certain parts can be exchanged or switched out in cases where they are unavailable or damaged, making this process much easier.

Standardizing the use of fasteners should also be used to reduce the variety of screws, nuts and bolts, further simplifying the assembly process. Furthermore, by incorporating snap-fit and quick-connect components, the need for tools can be reduced which even further speeds up assembly.

Pre-assembled subcomponents, such as the motor mounts and wiring harnesses, can streamline final assembly, while making clear markings and comprehensive instructions can minimize the errors. By ensuring that all parts are readily available and easily accessible, as well as the assembly steps being simple, logical and in order will also enhance the assembly process.

5.5. Costing

Item No.	Item	Quantity	Unit Cost (RM)	Total Cost (RM)
1	Aluminium Profile	500mm (3 units)	RM 26.65	RM79.95
		600mm (1 unit)	RM 34.79	RM34.79
		300mm (1 unit)	RM 16.04	RM16.04
2	V-Slot (with holder)	2	RM19.95	RM39.90
3	Stepper Motor	2	RM35.00	RM70.00
4	Stepper Motor Driver	2	RM5.00	RM10.00
5	Makerbase	1	RM77.45	RM77.45
6	GT2 Timing Belt	1220mm (1 unit)	RM16.00	RM16.00
		610mm (1 unit)	RM11.00	RM11.00
7	Limit Switch	4	RM1.20	RM4.80
8	Servo Motor	1	RM16.90	RM16.90
9	USB camera	1	RM0.00	RM0.00
10	USB Microphone	1	RM0.00	RM0.00
11	Whiteboard Marker	1	RM0.00	RM0.00
12	AC/DC Power Adapter	1	RM15.90	RM15.90
13	Belt Pulley GT2	4	RM4.00	RM16.00
14	Castor Wheel	4	RM16.00	RM64.00
15	Hinges	4	RM13.94	RM55.76
16	Bracket	2	RM4.50	RM9.00
17	End Cover	1	RM22.00	RM22.00
18	Handle	1	RM5.10	RM5.10

19	Whiteboard (30*45cm)	1	RM69.00	RM69.00
20	Screw and Nut	1	RM16.00	RM16.00
			Sum of total cost:	RM649.59

5.6. Discussion on Safety, Environment, Societal Impact and Sustainability of Product

5.6.1. Safety

Ensuring user safety is paramount in the design of the Prompt/Voice-Controlled Whiteboard Writer. Multiple safety features have been integrated to protect users from potential harm and ensure reliable operation of the device. To prevent the marker head and marker from exceeding the boundaries of the whiteboard surface, the system is equipped with limit switches. These switches act as boundary sensors, ensuring the writing mechanism operates strictly within the designated space. This feature prevents potential damage to the whiteboard, marker, and internal components, enhancing the overall reliability and safety of the system. An automated shut-off feature is included to deactivate the device after a predetermined period of inactivity. This not only conserves energy but also minimizes the risk of overheating or prolonged mechanical stress.

The system undergoes electrical safety inspections to comply with safety standards. Precise calculations and evaluations ensure that the power supply meets the requirements of all components while maintaining efficient performance. Safety safeguards, such as overheating protection and electrical fault detection, are integrated to reduce risks associated with electrical hazards, such as shocks or fire. Comprehensive instructional manuals and safety labels are provided to guide users in operating the device correctly and safely. These resources aim to reduce misuse and enhance the overall safety of the system. Together, these features ensure a reliable and secure user experience, giving users peace of mind during operation.

5.6.2. Environmental Impact

Wherever possible, our Prompt/Voice-Controlled Whiteboard Writer uses sustainable materials to lessen its impact on the environment. In order to reduce production waste and encourage a more environmentally responsible approach to manufacturing, we concentrate on recyclable and eco-friendly materials. The Prompt/Voice-Controlled Whiteboard Writer uses very little power when in use because it is made to be energy-efficient. To lessen the product's total environmental impact, we plan to optimize its power consumption and include energy-saving technologies. The whiteboard writer's design incorporates recyclability to address end-of-life disposal. In order to reduce its impact on landfills, we have worked to ensure that it is simple to disassemble and facilitate appropriate disposal or recycling procedures.

5.6.3. Societal Impact

The whiteboard writer that operates automatically greatly improves accessibility, especially for people with limited mobility or disabilities. Its automated capabilities make writing simple and encourage inclusivity in both professional and educational contexts. This invention promotes efficiency in workplaces and educational institutions. Time is saved, a neater and more orderly environment is promoted, and user productivity is increased by automating the writing process. This Prompt/Voice-Controlled Whiteboard Writer is designed to be affordable and available in a range of socioeconomic contexts. In order to increase the technology's societal impact, we want to make it available to a wide range of consumers at a fair price.

5.6.4. Sustainability

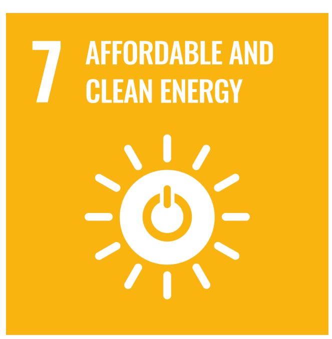
The Prompt/Voice-Controlled Whiteboard Writer is designed with sustainability at its core, ensuring durability, energy efficiency, and environmental responsibility. Its modular design allows for easy repairs and component replacements, extending its lifespan and minimizing electronic waste. Prioritizing recyclable materials and designing for easy disassembly enable efficient recycling or disposal, reducing its environmental footprint. The product also incorporates energy-efficient technology, operating on minimal power to lower user costs and environmental impact. Features like idle and standby modes optimize energy consumption further, making it an eco-friendly choice for modern educational and professional settings.

The Prompt/Voice-Controlled Whiteboard Writer aligns with several United Nations Sustainable Development Goals (SDGs), reinforcing its role in promoting sustainable progress:

1. SDG 4: Quality Education

Targeted primarily for educational institutions, the product enhances the teaching and learning experience, enabling educators to focus on delivering high-quality education. By simplifying and streamlining whiteboard usage, it supports better engagement and learning outcomes for students.

2. SDG 7: Affordable and Clean Energy



The whiteboard writer utilizes electrical energy, a clean and sustainable energy source to operate. This lessens pollution and waste compared to traditional alternatives, therefore prioritising adoption of cleaner technology.

By addressing the SDGs of Quality Education and Affordable and Clean Energy, the Prompt/Voice-Controlled Whiteboard Writer contributes to global sustainable development efforts. Its design enhances educational experiences, promotes clean energy use, and aligns with sustainability goals, advancing the quality of life for individuals and communities worldwide.

5.6.5. Mitigation Strategies

The Prompt/Voice-Controlled Whiteboard Writer has been thoughtfully designed to minimise environmental impact while promoting sustainable usage throughout its entire lifecycle. From material selection to energy use and end-of-life considerations, the system integrates a comprehensive range of strategies to reduce its ecological footprint. The frame is constructed from durable, recyclable aluminium, and internal components are carefully chosen to avoid over-specification. This helps reduce material waste and supports responsible manufacturing practices.

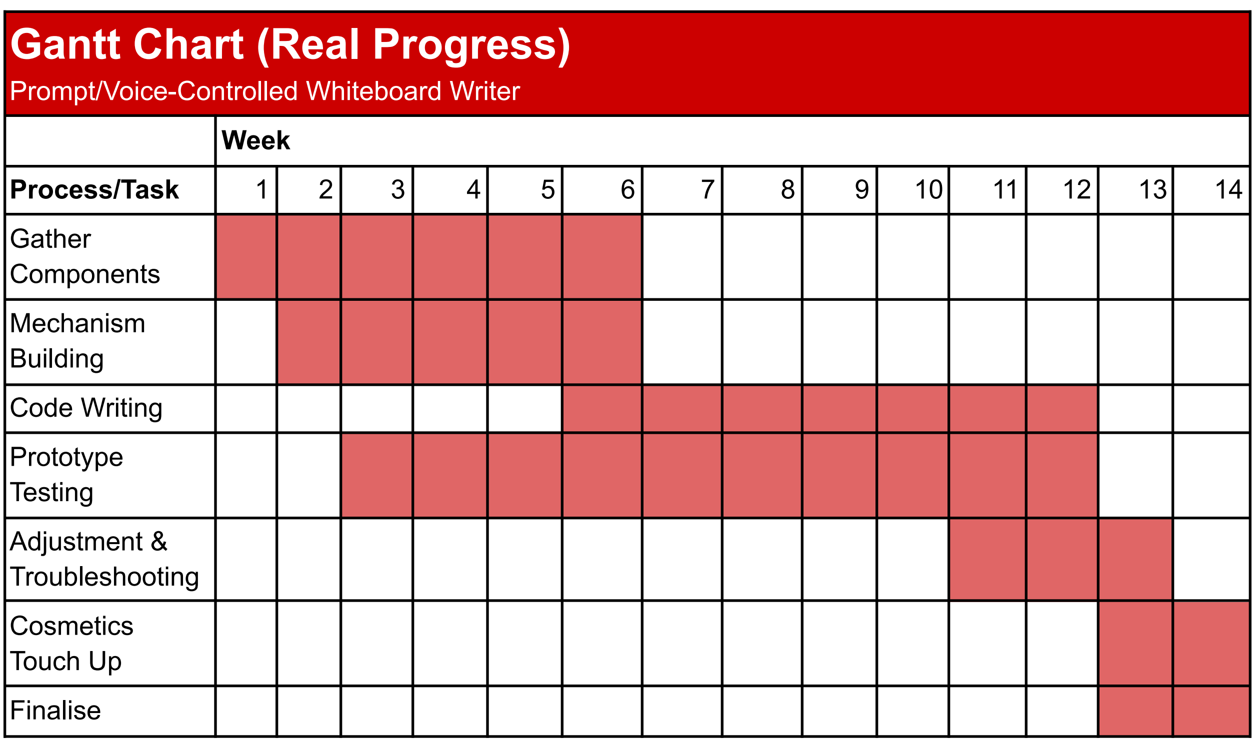
The system operates efficiently using low-power stepper motors and consumes minimal energy during use. It runs on a safe, low-voltage 24V power supply, eliminating the need for high-voltage infrastructure and making it accessible across various settings, including rural or off-grid locations. Additionally, it is compatible with rechargeable lithium polymer (LiPo) batteries and solar power, offering clean and renewable energy options that further reduce environmental impact and support energy independence. Features such as idle and standby modes help optimise power consumption, while its ability to function offline makes it suitable for low-resource environments.

Designed with modularity in mind, the whiteboard writer allows for easy disassembly, repair and upgrades. This extends the product's lifespan, reduces electronic waste and enables components like the gantry system to be reused for other hardware projects. The integration of cloud-based storage promotes paperless workflows by allowing users to save and retrieve content digitally, which reduces reliance on printed materials in educational and professional contexts.

In addition to its environmental features, the system is also inclusive by design. It supports hands-free interaction through voice prompts, enhancing accessibility for persons with disabilities, toddlers and speech learners. This inclusive functionality ensures that the product is not only sustainable but also equitable in use.

Altogether, the Prompt/Voice-Controlled Whiteboard Writer reflects a strong commitment to environmental responsibility, energy efficiency and inclusive design. It offers a sustainable, forward-thinking solution that supports modern education, collaborative work and environmentally conscious innovation.

5.7. Gantt Chart 2



Prototype													
Presentation													

6. Reliability Analysis of the Designed System

6.1. Design Failure Mode Effect Analysis

Product Name: Whiteboard Writer Group 6

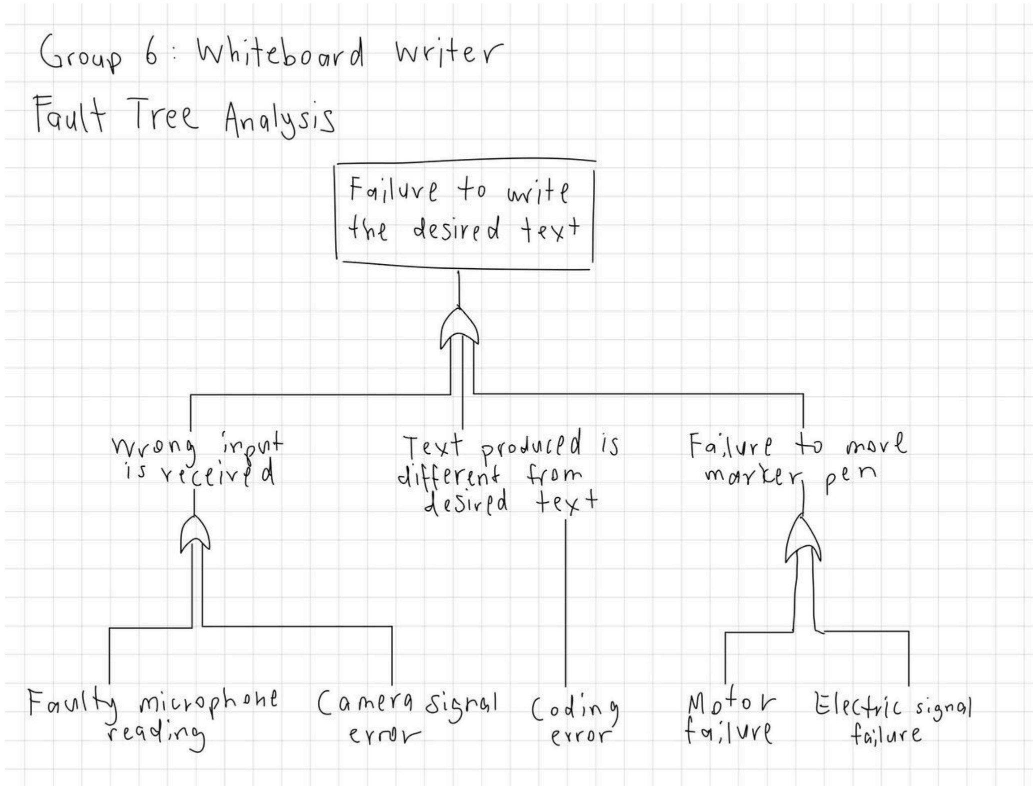
Process Step/Input What is the process step or feature under investigation?	Potential Failure Mode In what ways could the step or feature go wrong?	Potential Failure Effects What is the impact on the customer if the failure is not prevented or corrected?	SEVERITY (1-10)	Potential Causes What causes the step or feature to go wrong? (how could it occur?)	OCCURRE (1-10)	Current Controls What controls exist that either prevent or detect the failure?	DETECTIC (1-10)	RPN
Motor	Motor fails to turn on	The marker pen does not move	8	Mechanical failure	4	Observing the motor operat	8	256
Electrical wires	Improper electrical signal/ Insufficient power	The marker pen does not move or it moves inaccurately	8	Damaged wiring or faulty wiring	5	Use of current sensors to observe current flow	8	320
Deciding the path for the desired text	The wrong coordinates are calculated	The desired text is not written	7	Wrong computation of the necessary coordinates	5	System will display the desired text before writing	3	105
Text detection	System fails to detect the text already on whiteboard	Desired text is written on pre-existing text	6	Camera signal is not clear	3	Display new text alongside existing text before writing	4	72

Action Recommended What are the recommended actions for reducing the occurrence of the cause or improving detection?	Responsibility Who is responsible for making sure the actions are completed?	Actions Taken What actions were completed (and when) with respect to the RPN?	SEVERITY (1-10)	OCCURRE (1-10)	DETECTIC (1-10)	RPN
Use a functioning motor	Part inspector	Test the motor to ensure it works	8	4	8	256
Assemble the wiring using new wires in a neat and functional manner	Wiring	Inspect the wiring and ensure proper connections	8	5	8	320
Ensure the coordinates can be determined accurately and consistently	Coding developer	Test and troubleshoot the coding	7	5	3	105
Use a high quality camera with clear images	Camera supplier	Maintenance of the camera	6	3	4	72

The process inputs that were identified were the motor and electrical wires with the potential failure modes being the motor failing to turn on and there being improper electrical signals or insufficient power, respectively.. The potential failure effects are that the marker pen does not move, or the marker pen moves inaccurately, with both having a severity of 8. The potential causes are mechanical failure and damaged wiring or faulty wiring with an occurrence of 4 and 5 respectively. The current controls are by observing the motor operation and the use of current sensors to observe the current flow, with both having a detection of 8. The Risk Priority Number (RPN) assigned to the Motor and the Electrical wires are 256 and 320, respectively. The recommended action to reduce the RPN of the motor is to use a functioning motor, which should be done by the part inspector who will test the motor to ensure it works. Meanwhile, for the electrical wires, the wiring should be assembled using new wires in a neat and functional manner, which should be done by the person in charge of the wiring, who should also inspect the wiring and ensure the proper connections were made.

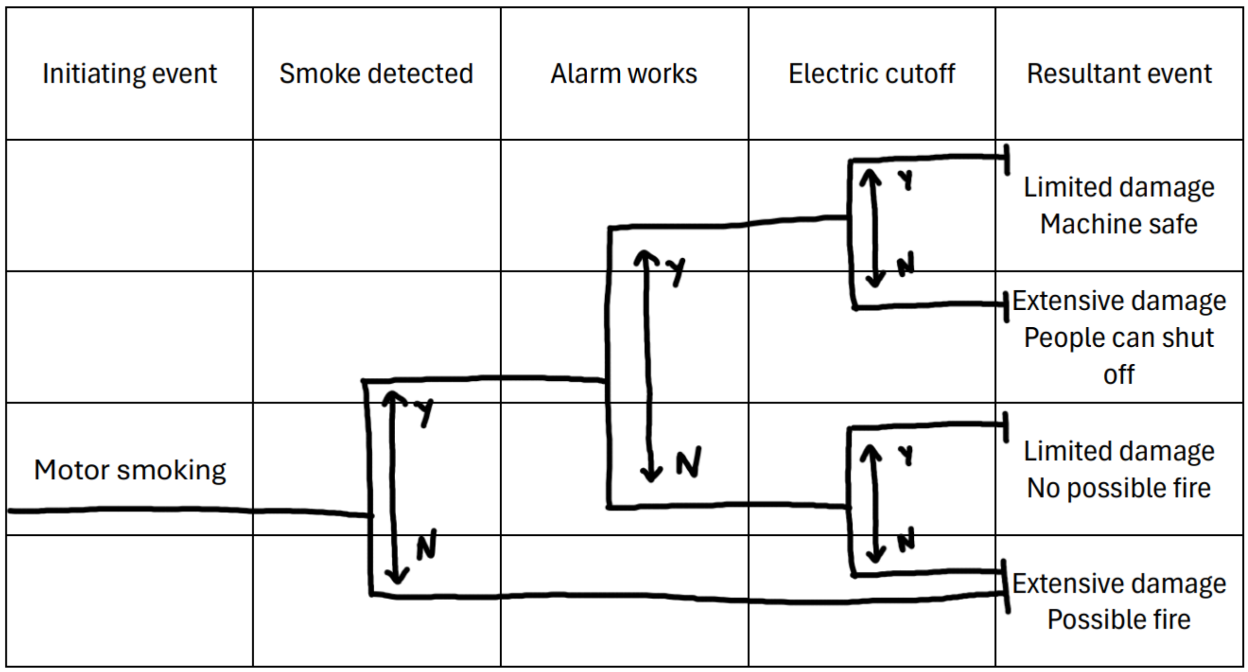
The process steps that were identified were deciding the path for the desired text and the text detection. The potential failure modes were that the wrong coordinates were calculated and the system fails to detect the text already on the whiteboard, with the resulting potential failure effects being the desired text is not written and the desired text being written on pre-existing text, with the resulting severity being 7 and 6, respectively. The potential causes are wrong computation of the necessary coordinates and the camera signal is not clear, with occurrences of 5 and 3, respectively. The current controls are that the system will display the desired text before writing, and it will display the new text alongside the existing text before writing, with current controls of 3 and 4, respectively. The RPN assigned to the process steps are 105 and 72, respectively. The recommended actions are to ensure the coordinates can be determined accurately and consistently and to use a high quality camera with clear images. These should be done by the coding developer, who needs to test and troubleshoot the coding, and the camera supplier, who is in charge of also maintaining the camera.

6.2. Fault Tree Analysis for Critical Analysis



A critical failure of the design can occur in the form of failure to write the desired text. This failure can occur when either the wrong input is received, the text produced is different from the desired text, or failure to move the marker pen. The wrong input can be received if there is a faulty microphone reading, due to signal disturbance or it can also occur due to camera signal error, where the data from the camera is not sent to the system. If there is an error in the coding, then the text produced can be different from the desired text. Also, if the motor fails or there is a failure to send electrical signal, due to either faulty wiring or damaged wires, then the marker pen will fail to move.

6.3. Event Tree Analysis for Main Cause of Accident



Possible outcome and damage severity can generally be predicted and evaluated from Event Tree Analysis (ETA). One of the possible events that may arise from our product is motor smoking which can cause a range of damage from limited damage and the machine is safe to extensive damage with possible fire occurrence based on a series of events.

From the figure of event tree analysis above, the initiating event that might occur to our product is motor smoking. In the case where no smoke is detected, there will be extensive damage and possible fire occurs. If the smoke is detected, it will lead to another event which is the alarm.

In both cases where the alarm might work or not, it will lead to another event which is the electric cut-off which results in a total of four different outcomes with two outcomes from each Yes and No. Firstly, in the case if the alarm works (Yes), then if the next event which is electric cut-off does work (Yes), the resultant event that will happen is limited damage and the machine is safe. If the electric cut-off does not work, there will be extensive damage but people or the user can shut off the power supply manually.

Secondly, in the case where the alarm does not work (No), if the electric cut-off is activated (Yes), then there will be limited damage with no possible fire occurrence. Instead, there will be extensive damage and possible fire occurrence if the electric cut-off does not work (No).

In summary, undoubtedly it's best that all of the sensors are working as intended to make sure the damage is kept to as low as possible. But in the event of faulty sensors, the damage is still possible to be kept at minimum with no fire occurrence given that the electric cut-off works (Yes). Therefore, the fuse and the sensor for the electric cut-off should be kept working at all times by making preventive maintenance on the product, especially on its safety features.

6.4. Maintenance Design Consideration (SMED, Accessibility, Wire Code, Schematics)

Aspect	**Design Considerations**	**Implementation Ideas**
SMED (Single Minute Exchange of Die)	- Minimize component replacement time. - Enable tool-free marker replacement. - Modular subsystems.	- Use spring-loaded or magnetic clamps for markers. - Design modular motor and belt assemblies. - Automated calibration
Accessibility	- Ensure easy access to components. - Simplify marker cleaning. - Provide service points.	- Use hinged/removable panels. - Position motors and wiring in open, accessible areas. - Marker holder with easy-release design.
Wire Coding	- Clearly identify wires and connections. - Prevent tangling or accidental disconnection.	- Use color-coded wires (e.g., red for power, black for ground). - Heat-shrink labels for identification. - Use cable ties and detachable connectors.
Durability	- Use robust materials. - Reduce wear and tear.	- Aluminum or acrylic for frames. - Ensure moving parts are durable and wear-resistant.

6.5. Risk Assessment for User Interface

6.5.1. Hazard and Risk

The primary hazard in the user interface (UI) of the Prompt/Voice-Controlled Whiteboard Writer lies in the potential for user errors, miscommunication, or system malfunctions that could compromise the system's safety or functionality. Examples of such hazards include misinterpreted voice commands leading to incorrect writing or drawing, delayed or unresponsive system behavior, and overly complex prompts that make it challenging for users to operate the system effectively. These hazards pose risks such as operational failures, user dissatisfaction, or safety concerns, including unintended motor movements that could result in physical harm.

6.5.2. Risk Management Process

The risk management process for the UI involves several key steps. First, hazards are identified by evaluating user interaction scenarios and identifying potential risks. These risks are then assessed by considering their likelihood and severity. Once assessed, strategies are developed to mitigate these risks by minimizing their probability and impact. Finally, the process includes regular monitoring and review to ensure the effectiveness of the implemented measures and to adapt to any emerging issues.

6.5.3. HAZOP (Hazard and Operability Study)

A HAZOP study systematically identifies and analyzes potential hazards by examining deviations from normal operations. For example, common deviations include a lack of system response due to poor voice recognition, commands being executed with excessive intensity (e.g., overly fast or large writing), and incorrect or unintended actions such as the marker moving in the opposite direction of the intended command. Safeguards such as error notifications, limits on speed and range, and robust input validation can mitigate these risks. Actions like improving the speech recognition engine, fine-tuning command processing logic, and implementing better signal processing algorithms are essential to address these issues effectively.

Deviation	**Cause**	**Consequence**	**Safeguards**	**Action**
No response	Poor voice recognition	User frustration	Error notification system	Improve speech recognition engine
More movement	Misinterpretation of command	Inaccurate output	Limit speed and range	Fine-tune command processing logic
Reverse action	Signal processing error	Marker movement hazard	Safety stops	Robust input validation algorithms

6.5.4. Criticality Analysis

Criticality analysis helps prioritize risks based on their severity and likelihood. Risks are categorized into severity levels such as catastrophic, critical, marginal, or negligible, and likelihood levels such as frequent, probable, occasional, remote, or improbable. High-risk issues, such as misinterpreted commands causing potential injury or system damage, are addressed with top priority. Medium-risk issues, like incorrect outputs causing user dissatisfaction, and low-risk issues, such as minor UI glitches or delays, are also considered to ensure a comprehensive risk management strategy.

6.5.5. Risk Control Measures

Several measures can be implemented to control the identified risks. From a design perspective, simplifying the UI ensures users can interact with the system without confusion. Integrating noise-canceling microphones and advanced Natural Language Processing (NLP) improves voice recognition accuracy. Software safeguards include fail-safe mechanisms that halt motor functions in the event of critical errors and command validation to prevent unintended actions. Physical safety measures, such as limiting marker speed and range, reduce the likelihood of injury. Regular usability testing, incorporating diverse user groups and scenarios, further ensures the system's reliability.

6.5.6. Maintenance Strategies

To maintain the system’s safety and reliability, routine checks should be conducted to update software, improve NLP, and address any bugs. Regular hardware testing, including stepper motors and microphones, ensures optimal performance. A robust user feedback mechanism helps identify and resolve recurring issues. Additionally, providing comprehensive user manuals, training videos, and troubleshooting guides enhances user familiarity and reduces operational risks. A dedicated support system is essential to address any technical difficulties promptly, ensuring continued reliability and user satisfaction.

Overall, by employing a structured risk assessment, including HAZOP, criticality analysis, risk control, and maintenance strategies, the Prompt/Voice-Controlled Whiteboard Writer's UI can be optimized for safety, functionality, and user satisfaction. These measures ensure a reliable, user-friendly interface that minimizes risks and enhances the overall experience.

6.6. Intellectual Property Consideration

The development of the Prompt/Voice-Controlled Whiteboard Writer involves integrating various hardware and software components, including a small gantry frame, stepper motor, a microcontroller, a laptop, a camera, and a microphone. For intellectual property (IP) considerations, the following aspects were evaluated:

1. Patentability:
The unique combination of features and functionality in our design, specifically the integration of voice prompts with a whiteboard writing mechanism, could potentially qualify for a patent. However, the individual components (e.g., stepper motors, microcontroller, etc.) are widely available and not novel, so the focus would be on the innovative system-level integration and algorithms developed for this project.

2. Copyrights:
The software developed for controlling the whiteboard writer, including any code for voice recognition, camera processing, and motion control, is original and thus protected under copyright law. The authorship and ownership of this software belong to the project team.

3. Open-Source Components:
Open-source tools and libraries may be used for certain functionalities, such as voice recognition or camera processing. The licensing terms of these components will be strictly adhered to, ensuring compliance with attribution and usage requirements.

4. Trademarks:
If the whiteboard writer is to be commercialized in the future, a unique brand name and logo may be considered for trademark registration to protect its identity in the market.

5. Infringement Risks:
Prior art and existing patents will be reviewed to ensure our design does not infringe on any existing intellectual property. Any identified risks will be mitigated through redesign or licensing agreements, if necessary.

6.7. Business Model Analysis

6.7.1. Pricing Strategy

Pricing Strategy Prompt/Voice-Controlled Whiteboard Writer							
No	**Variation**	**Component Cost***	**Engineering + Misc Cost**	**Total Cost**	**Selling Price**	**Profit Per Unit**	**Profit Margin**
1	Without Whiteboard 30cm*45cm	RM580.59	RM150.00	RM730.59	RM999.00	RM268.41	26.87%
2	With Whiteboard 30cm*45cm (RM69)	RM649.59	RM150.00	RM799.59	RM1,099.00	RM299.41	27.24%
3	Without Whiteboard 45cm*60cm	RM620.59	RM150.00	RM770.59	RM1,129.00	RM358.41	31.75%
4	With Whiteboard 45cm*60cm (RM99)	RM679.59	RM150.00	RM829.59	RM1,199.00	RM369.41	30.81%
5	Without Whiteboard 60cm*90cm	RM660.59	RM150.00	RM810.59	RM1,249.00	RM438.41	35.10%
6	With Whiteboard 60cm*90cm (RM139)	RM719.59	RM150.00	RM869.59	RM1,399.00	RM529.41	37.84%

Price Tier				Base Price:	
1	Without Whiteboard 30cm*45cm	RM999.00		30*45	RM999
2	With Whiteboard 30cm*45cm (RM69)	RM1,099.00		45*60	RM1129
3	Without Whiteboard 45cm*60cm	RM1,129.00		60*90	RM1249
4	With Whiteboard 45cm*60cm (RM99)	RM1,199.00		Whiteboard add on	RM90-RM150
5	Without Whiteboard 60cm*90cm	RM1,249.00			
6	With Whiteboard 60cm*90cm (RM139)	RM1,399.00			

6.7.2. Market Trend

Our product sets a new market trend by introducing an **AI-powered interactive whiteboard system** that blends intelligent software with functional hardware. Unlike traditional setups that rely on ipads or projectors, where educators must manually write or draw content during class, our system allows for hands-free, pre-class preparation. Educators can simply use voice or text prompts as early as 10 minutes before class, even while in transit, to generate and schedule the content to be physically written on the whiteboard. By the time they arrive, the material is ready, eliminating setup delays and allowing them to focus fully on teaching.

This innovation is made possible through the integration of Large Language Models (LLMs) and voice-to-text features, enabling a more seamless and interactive teaching experience. Especially for early childhood education, the system transforms learning by letting children speak and see their words written in real time, enhancing both speech development and literacy skills. In doing so, we are not just following existing educational technology trends; we are creating a new standard in how content is delivered, experienced, and personalised in the classroom.

6.8. Executive Summary

This project presents the design and development of a **Prompt/Voice-Controlled Whiteboard Writer**, an innovative solution that automates writing or drawing on whiteboards using voice commands or textual prompts. The system is built on a gantry frame, with marker motion actuated by stepper motors and guided by a microcontroller. It incorporates a computer, camera, and microphone to process inputs and translate them into precise movements of the writing tool.

The core innovation of this system lies in its ability to seamlessly convert verbal or text-based instructions into written or graphical outputs, significantly enhance accessibility, efficiency, and engagement in various applications such as classrooms, corporate settings, and presentations.

The design emphasizes modularity, affordability, and user-friendliness, leveraging widely available components and open-source technologies. Key features of the system include:

- **Voice Recognition:** Enabling prompt-based control for intuitive operation.
- **Automated Motion Control:** Ensuring precise and consistent writing or drawing on the whiteboard.
- **Real-Time Feedback:** A camera provides live monitoring, allowing adjustments for improved accuracy and performance.

The **Prompt/Voice-Controlled Whiteboard Writer** aims to redefine traditional whiteboard usage by integrating cutting-edge technology, fostering greater inclusivity, and driving enhanced communication in educational and professional environments.

Appendix

GitHub repository link for this project:
https://github.com/DefNotIrf/Text-Voice-Prompt-Controlled-Whiteboard-Writer

All our files and codes can be found in our GitHub repository.