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ಬೆಳಗಾವಿ, ಕರ್ನಾಟಕ

# *"AI-Powered Automatic Board Cleaner"*

Submitted to Visvesvaraya Technological University in partial fulfillment of the requirement for the award of Bachelor of Engineering degree in Artificial Intelligence and Machine Learning.

**Submitted by**


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**National Education Society ®**

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## CERTIFICATE

Certified that the project work entitled **"AI-Powered Automatic Board Cleaner"** carried out by **Mr. Arqam Zakriya (4JN21AI010), Mr. Puneeth A S (4JN21AI038), Mr. Sathwik P (4JN21AI043) and Mr. Tarun K Hillodi (4JN21AI055),** bonafide students of **J N N College of Engineering**. In partial fulfilment for the award of Bachelor of Engineering in **Artificial Intelligence and Machine Learning** of the Visvesvaraya Technological University, Belagavi during the year **2024-25**. 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

Maintaining clean whiteboards is crucial for effective communication in educational, corporate, and collaborative settings, yet traditional manual cleaning methods are often labor-intensive, time-consuming, and inconsistent, leaving streaks or residue that compromise visual clarity. Accessibility challenges, such as cleaning boards at varying heights or hard-to-reach locations, further exacerbate the issue, causing physical strain and potential health risks. This project aims to develop an AI-powered automated whiteboard cleaner that employs advanced path optimization algorithms to deliver efficient, consistent, and streak-free cleaning with full surface coverage. Designed for ease of use, the system overcomes accessibility barriers, reduces physical effort, and enhances safety. By integrating cutting-edge technology with practical design, this solution provides a reliable, ergonomic, and time-saving alternative to traditional methods, significantly improving productivity in environments where whiteboard cleaning is essential.

# ACKNOWLEDGMENTS

On the very outset of this project report on **“AI-POWERED AUTOMATIC BOARD CLEANER”,** we would like to extend our sincere & heartfelt obligation towards all the persons who have helped us in this endeavor. Without their active guidance, help, co-operation & encouragement, we would not have made headway in the project.

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Thanking you all,

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# Chapter 1

# INTRODUCTION

## 1.1 Overview

In educational institutions, corporate offices, and collaborative environments, whiteboards play a crucial role in facilitating effective communication and idea sharing. However, the traditional method of cleaning whiteboards manually is time-consuming, labor-intensive, and often results in inconsistent cleaning quality, leaving streaks or residues that compromise their usability. Additionally, manual cleaning poses accessibility challenges for users who find it difficult to reach whiteboards positioned at varying heights or in hard-to-reach locations, leading to physical strain and potential health risks. Frequent cleaning can further cause repetitive stress injuries, especially in environments with high whiteboard usage. To address these challenges, this project introduces an AI-powered Automatic Board Cleaner, designed to automate the cleaning process with precision and efficiency. By incorporating artificial intelligence and advanced machine learning algorithms, the device optimizes the cleaning path to ensure complete surface coverage while eliminating redundant efforts. The system is inclusive, user-friendly, and reduces the physical effort required for maintenance. The solution is ideal for schools, offices, training centers, and shared workspaces, offering consistent, streak-free cleaning that enhances productivity and convenience. Leveraging technologies like Python, Arduino, Raspberry Pi, Flutter the project aims to revolutionize whiteboard cleaning, making it smarter, faster, and more ergonomic for all users.

## 1.2 Importance

The salient points emphasizing the importance of this project work are:

- This AI-powered Automatic Board Cleaner automates the cleaning process, saving time and effort in frequently used spaces such as classrooms and offices.
- It ensures consistent, streak-free cleaning quality, improving the appearance and usability of whiteboards, which enhances overall communication efficiency.
- The system eliminates accessibility barriers, allowing users of all physical abilities to benefit from clean whiteboards without manual effort or strain.

- By using AI to optimize cleaning paths, the device maximizes efficiency, ensuring complete surface coverage while minimizing redundant efforts.
- It reduces physical strain and prevents repetitive stress injuries caused by frequent manual cleaning, promoting ergonomic safety for users.
- The automated solution eliminates the need for manual intervention, reducing dependence on human resources and lowering maintenance costs.
- Applicable across various environments such as schools, offices, training centers, and research labs, the device ensures a professional and ready-to-use whiteboard at all times.

## 1.3 Problem Statement

In today's educational and professional environments, maintaining clean whiteboards is a frequent necessity but remains a tedious and labor-intensive task. Existing manual cleaning methods are time-consuming, inconsistent, and prone to leaving streaks or residues that compromise the usability and appearance of whiteboards. Accessibility challenges further exacerbate the issue, as whiteboards positioned at varying heights or hard-to-reach locations can be difficult to clean for all users, particularly those with physical limitations. Frequent manual cleaning also leads to repetitive strain and physical fatigue, making the task cumbersome over time.

With the growing adoption of automation and AI-driven solutions, there is a need for an innovative approach to simplify and improve the whiteboard cleaning process. This project proposes the development of an AI-powered Automatic Board Cleaner to address these challenges. By leveraging artificial intelligence and advanced path optimization, this system automates the cleaning process, ensuring efficiency, consistency, and accessibility while eliminating physical strain and reducing dependence on manual intervention.

## 1.4 Objectives

The major objective of this project is to design an AI-powered Automatic Board Cleaner that automates the whiteboard cleaning process, ensuring consistent, efficient, and streak-free cleaning. The other key objectives of this project are:

- Automate the entire cleaning process, eliminating the need for manual effort and saving time in frequently used environments such as classrooms and offices.
- Optimize cleaning paths using AI and machine learning algorithms to ensure complete surface coverage while minimizing redundant efforts.
- Provide a user-friendly system that overcomes accessibility barriers, enabling users of all physical abilities to benefit from a clean whiteboard.
- Ensure consistent cleaning quality by delivering uniform, streak-free results every time, improving the board's usability and appearance.
- Reduce physical strain and prevent repetitive stress injuries caused by frequent manual cleaning, enhancing user safety and convenience.
- Utilize advanced hardware components such as Raspberry Pi and Arduino, along with programming in Python and C/C++ for efficient system operation.
- Implement the device in diverse environments such as schools, offices, training centers, and shared workspaces to improve productivity and professionalism.

## 1.5 Organization of the report

The rest of the report is organized as follows: Literature Survey is explored in Chapter 2. System Requirements are put in chapter 3. Later in chapter 4, discusses and explains the design and implementation of the project. Chapter 5 provides the result and snapshot of the project. Finally, chapter 6 concludes the report along with possible future enhancement of this project.

# Chapter 2

# LITERATURE SURVEY

## 2.1 Automatic White Board Cleaner

**Methodology**:

The system is designed to automate whiteboard cleaning using an integrated approach comprising a cleaning mechanism, control system, remote operation, and power management. The cleaning mechanism involves a horizontally moving duster mounted on pulley chains that span the width of the board. Powered by a DC motor, the duster moves back and forth to ensure complete cleaning of the board. This motion is driven by a mechanical shaft connected to the motor, which is controlled through a precise sequence programmed in Arduino. The mechanism eliminates manual effort, providing consistent and efficient cleaning.

The control system is built around the NodeMCU microcontroller, which processes user commands received via a Wi-Fi-connected mobile application. The L298N motor driver regulates the DC motor's speed and direction based on the commands. The mobile application serves as a user-friendly interface, allowing remote control of the cleaner's operations, such as starting, stopping, and reversing the duster’s motion. A regulated power supply ensures energy-efficient operation of the entire system, with all components optimized for minimal power consumption.

The system operates seamlessly, beginning with a start command sent from the mobile application to the microcontroller. This activates the motor, initiating the duster's motion across the whiteboard to erase its content before returning to its original position. The remote-controlled automation reduces time and effort, avoids interruptions during lectures, and addresses health concerns by eliminating dust-related issues. The design is cost-effective, user-friendly, and highly efficient, making it suitable for educational environments like classrooms and lecture halls.

**Contributions:**

The contributions of this project include the development of a cost-effective and efficient automated whiteboard cleaner that significantly reduces cleaning time compared to manual methods, achieving an average cleaning time of 5.975 seconds. The system incorporates innovative features, such as a mobile application developed using MIT App

Inventor, which provides remote control through forward, backward, and stop commands. It ensures effective cleaning through optimal pressure applied by the brush mechanism and enables easy maintenance with a straightforward brush replacement process. The integration of Arduino microcontroller technology and simple tool-based construction makes the system user-friendly and accessible. This project highlights advancements in automating classroom utilities, reducing human effort, minimizing noise, and offering potential for further enhancements, such as Bluetooth or infrared sensors, for a fully smart whiteboard system.

**Advantages:**

- The automated whiteboard cleaner reduces the cleaning time to approximately 5.975 seconds, significantly faster than the manual cleaning process, which takes about 25 seconds. This helps improve classroom productivity.
- The system eliminates the need for manual cleaning, saving time and effort for teachers, allowing them to focus more on teaching rather than cleaning the board.
- The system is built using inexpensive and readily available materials, making it cost-effective to construct. Additionally, the brush replacement is simple and does not impact other components, ensuring easy maintenance.

**Limitations:**

The system is limited to full-board cleaning, as partial cleaning of specific areas is not possible. Tensioning issues with the chains and sprockets may affect cleaning performance. There is a slight delay in starting the motor, causing minor inconsistencies in initial operation. Additionally, further improvements are needed for the gear mechanism and motor control.

## 2.2 Design and Fabrication of Automated Board Cleaner

**Methodology**:

The methodology for the design and fabrication of the Automated Board Cleaner involves several phases, including system design, component selection, fabrication, and testing. The initial step in the process was to conceptualize the system, with the primary goal being to automate the manual process of cleaning a whiteboard in educational settings. The system design was carried out using AutoCAD software, which allowed for the detailed modeling of the components and ensured dimensional accuracy during fabrication.

For the system, a DC wiper motor was selected to provide the necessary movement for cleaning the board. This motor was connected to a lead screw mechanism that enabled the reciprocating motion required for the cleaning action. The lead screw was powered by a 12V battery, which supplied the necessary energy to rotate both the lead screw and wiper motor. A two-way switch was used to control the forward and reverse motion of the motor, thus enabling back-and-forth cleaning. The duster was attached to a frame, positioned centrally on the whiteboard, where it could move across the entire board area for effective cleaning.

During fabrication, various components such as the whiteboard, frame, duster, lead screw, and motor were assembled into a functioning model. The fabricated components were then tested to ensure the system's functionality, efficiency, and durability. The system was evaluated for its cleaning time, noise levels, and ease of operation. Testing revealed that the automated cleaner was able to clean the board significantly faster than manual methods, making it a valuable addition to smart classrooms and educational environments.

In the future, the system could be further enhanced by integrating remote control features, such as app control or gesture-based systems, to offer even more convenient and efficient cleaning solutions. The design of the system ensures that it is lightweight, cost-effective, and easy to operate, providing an innovative solution to everyday board cleaning tasks.

**Contributions:**

The contributions of this project lie in the design, development, and fabrication of an automated whiteboard cleaner that enhances the efficiency of the cleaning process while reducing the time and manual effort involved. The system introduces a mechanism powered by a DC wiper motor and a lead screw for reciprocating motion, which allows the duster to effectively clean the entire surface of the whiteboard in a fraction of the time compared to manual cleaning. The use of a 12V battery and a simple two-way switch makes the system easy to operate and control, providing a low-cost solution that requires minimal maintenance. Additionally, the project contributes to the broader application of automation in educational settings, offering a practical alternative to traditional cleaning methods and contributing to the advancement of smart classroom technologies. The fabricated model demonstrated a reduction in cleaning time from 25-30 seconds to 7-10 seconds, making it a highly efficient tool for classrooms, meeting rooms, and other educational environments.

**Advantages:**

- The automated board cleaner significantly reduces the cleaning time, completing the task in just 7-10 seconds compared to the 25-30 seconds required for manual cleaning, allowing for more efficient use of class time.
- The system is built with simple components that are inexpensive and easy to maintain, providing a practical solution without high operational costs.
- The automated cleaner minimizes the need for manual labor, improving convenience and ensuring a consistent and effective cleaning process with minimal human intervention.

**Limitations:**

The system is designed for full board cleaning only, making partial cleaning unfeasible. Additionally, some lag may occur in the switch section, though it remains generally optimal.

## 2.3 Design and development of smart whiteboard cleaner in classroom Application

**Methodology:**

This tool operate on principles of mechanical and electronics combination. The main objective of Smart Whiteboard Cleaner is to prepare an attachment for whiteboard which can operate automatically by pressing the button thus get rid of the drudgery of manually cleaning whiteboards. The duster can move up and down to clean the whiteboards by pressing Double Pole Double Throw (DPDT) button and powered with the help of DC Motor 12V. Double Pole Double Throw (DPDT) button is refer to electrical configuration of switch. Smart Whiteboard Cleaner uses the mechanism of DC Motor for cleaning the whiteboard. The motor will support the rail which will convert into linear motion carrying the connecting duster attached to the whiteboard.

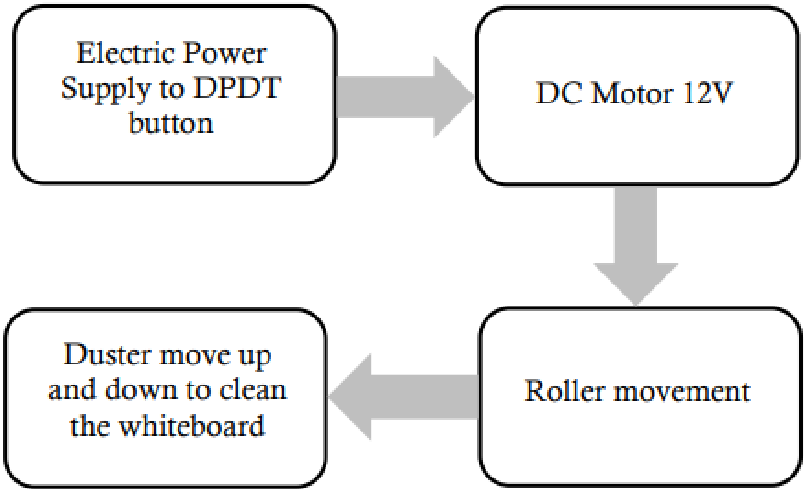


**Fig. 2.1. Flow Process of Smart Whiteboard Cleaner**

**Contributions:**

The Smart Whiteboard Cleaner contributes significantly to enhancing the efficiency of classroom housekeeping by automating the traditionally manual process of whiteboard cleaning. This innovation eliminates the need for manual effort, saving time and energy for teachers and students. By integrating mechanical and electronic components, such as a 12V DC motor and DPDT button, the system provides a user-friendly solution for quick and efficient cleaning. The reduced cleaning time, as demonstrated by experimental results, ensures that classroom activities can proceed without unnecessary interruptions, thereby improving the overall teaching and learning experience.

Moreover, the Smart Whiteboard Cleaner serves as an example of how automation can address everyday challenges in educational environments. It not only streamlines routine tasks but also promotes the adoption of technology in schools and higher educational institutions. By designing a system that is simple to operate, cost-effective, and adaptable to various settings, this project highlights the potential for broader applications of automation in education. The cleaner's efficient design and performance pave the way for future advancements, such as integrating sensors to detect dirty surfaces and further automating the cleaning process.

**Advantages:**

- The Smart Whiteboard Cleaner significantly reduces the time required for cleaning,
- allowing teachers to focus more on teaching rather than housekeeping.
- With its simple design and operation using a DPDT button, the cleaner offers an easy and hassle-free method for cleaning whiteboards, eliminating the need for manual effort.

- By automating the cleaning process, the system saves energy and reduces physical strain, making it an ideal solution for improving classroom management in schools and higher education institutions.


**Fig. 2.2. Graph time comparison between manual whiteboard cleaning and using Smart Cleaner Duster**

**Limitations:**

The Smart Whiteboard Cleaner, while efficient, has certain limitations. It relies on manual activation through the DPDT button, lacking full automation to detect and clean dirty whiteboards independently. Additionally, its design may not accommodate variations in whiteboard sizes or mounting styles, limiting its versatility for widespread adoption across different educational settings.

## 2.4 DESIGN AND FABRICATION OF AN AUTOMATIC BLACK BOARD CLEANER

**Methodology:**

The automatic blackboard duster operates based on a combination of mechanical and electrical components designed for efficient and automated cleaning of blackboards. The key components of the system include a motor, a duster, and a drive assembly. The motor drives the movement of the duster across the blackboard, ensuring even cleaning of the surface. The duster is mounted on a track structure that allows lateral movement along the length of the blackboard. The motor is connected to a drive assembly, which produces the movement required to erase the chalk marks on the blackboard.

The system operates by activating a switch, which controls the motor's movement. This activation prompts the duster to move back and forth along the blackboard, erasing the chalk marks. Additionally, the system incorporates a vacuum mechanism to reduce dust accumulation during the cleaning process, providing a cleaner environment. The duster is designed to be easily replaceable, and the system is constructed to allow for simple maintenance and repairs. The methodology focuses on minimizing manual intervention and maximizing efficiency, reducing the time and energy required for traditional hand erasing. The design ensures that the device is simple to operate and maintain, with minimal human effort required to keep the blackboard clean.

**Contributions:**

The development of the automatic blackboard duster brings significant advancements to the classroom environment by automating the board cleaning process. This device saves valuable time and energy for teachers by eliminating the need for manual cleaning, thus allowing teachers to focus more on teaching and less on housekeeping tasks. The mechanism is designed to move laterally across the board, powered by a motor, and ensures efficient cleaning by detecting chalk stains automatically. With easy-to-operate controls, the system makes the classroom environment cleaner, more convenient, and more hygienic, benefitting both teachers and students.

Additionally, the design of the automatic blackboard duster contributes to reducing the exposure to dust and chalk particles, which can pose health risks. The use of a vacuum system further minimizes dust in the air, enhancing air quality in the classroom. The system's simple structure and ease of maintenance make it an ideal solution for schools of all sizes. Furthermore, the device can be programmed to perform optimally at different wiping speeds, providing versatility to suit various classroom needs. This innovation not only improves efficiency but also promotes a cleaner, healthier learning environment.

**Advantages:**

- The vacuum cleaner integrated into the system minimizes the dust produced during cleaning, improving air quality in the classroom and reducing health risks associated with chalk dust.

- By automating the cleaning process, the device saves human energy and eliminates the need for manual labor, making it a more efficient solution for classroom maintenance.
- The system is simple to operate and maintain, with a straightforward design that ensures reliability and low maintenance costs, making it suitable for various educational institutions.
- The automatic blackboard duster ensures consistent and thorough cleaning, maintaining a cleaner and more hygienic board compared to manual wiping, which can leave residue or streaks.
- With reduced labour costs and minimal maintenance requirements, the automatic system offers a cost-effective solution over time, making it a practical investment for schools and educational institutions.

**Limitations:**

The automatic blackboard cleaner, while offering several advantages, also has certain limitations. The initial cost of implementing the system is higher compared to traditional cleaning methods, which may deter some institutions from adopting it. Additionally, the system relies on electricity, making it vulnerable to power outages, which could interrupt its functioning. The complexity of maintenance and repair might require specialized knowledge, limiting on-site repair capabilities. The device may also be unsuitable for certain types of blackboards or irregularly shaped boards. Moreover, frequent use can lead to wear and tear on the motors and other components, leading to potential malfunctions. The size of the device might restrict its ability to clean large or unusually shaped blackboards. Lastly, the ongoing operational cost for maintenance and parts replacement adds overhead.

## 2.5 Development of an Automatic Board Cleaning system using Microcontroller

**Methodology:**

The automatic whiteboard cleaning system is designed around an **Arduino UNO microcontroller**, which controls the movement of **DC motors** via an **L293D motor driver**. The system utilizes four 6V DC motors that drive a wiper bar across the whiteboard. The L293D motor driver allows the motors to be controlled in both directions, enabling the wiper to move back and forth for effective cleaning. The motors are powered by a 9V DC supply, and the Arduino sends signals to the motor driver, managing the motor direction and speed through **Pulse Width Modulation (PWM)**. A **push-button switch** initiates the cleaning process, triggering the motorized wiper to clear the whiteboard.

The wiping mechanism is designed to wipe the whiteboard in approximately **8.04 seconds**, significantly reducing the time compared to manual cleaning, which can take around 25 seconds. The wiper moves horizontally across the board twice to ensure all markings are erased, and the visual quality of the board is maintained. Capacitors and resistors are used in the circuit to stabilize power and prevent spikes. The system is simple to construct with readily available materials, and the Arduino-based controller allows easy customization and control. The implementation of this system automates the cleaning process, reducing human effort and introducing a form of automation into classroom environments.

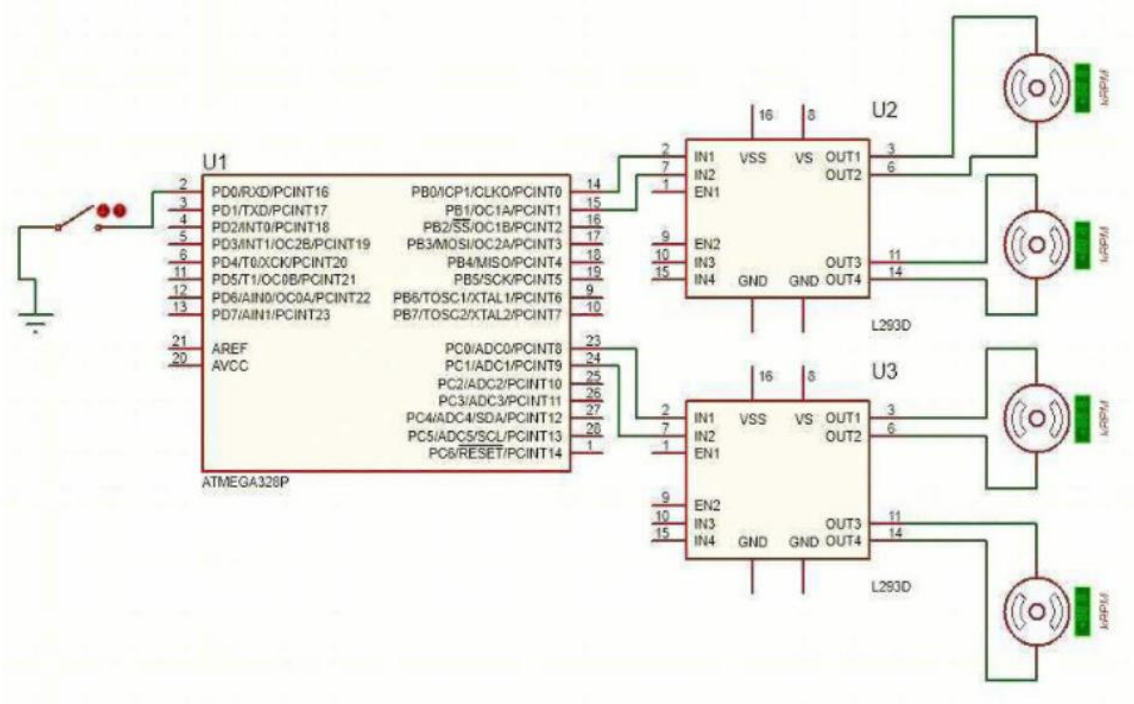


**Fig. 2.3 Circuit diagram of the whole system for the board cleaner**

**Contributions:**

The contributions of this project are primarily centered around automating the whiteboard cleaning process in classrooms, significantly reducing the time and effort required for manual cleaning. The system uses an **Arduino UNO**, **DC motors**, and **motor drivers** to automate the wiping mechanism, ensuring that the board is cleaned efficiently within approximately 8 seconds, compared to 25 seconds using traditional methods. This not only saves time but also minimizes the physical effort involved in cleaning the whiteboard, allowing teachers to focus more on teaching.

Additionally, the project contributes to the development of a low-cost, easy-to-build automation system that is both effective and practical for educational institutions. The materials and components used are readily available and affordable, making it a cost-effective solution for schools. The design also ensures that the visual quality of the whiteboard is maintained, as the automated system provides gentle cleaning. Moreover, - the potential for further enhancement, such as the integration of **Bluetooth remote control** or **infrared sensors**, could make the system even more user-friendly and adaptable, bringing automation to modern classrooms.

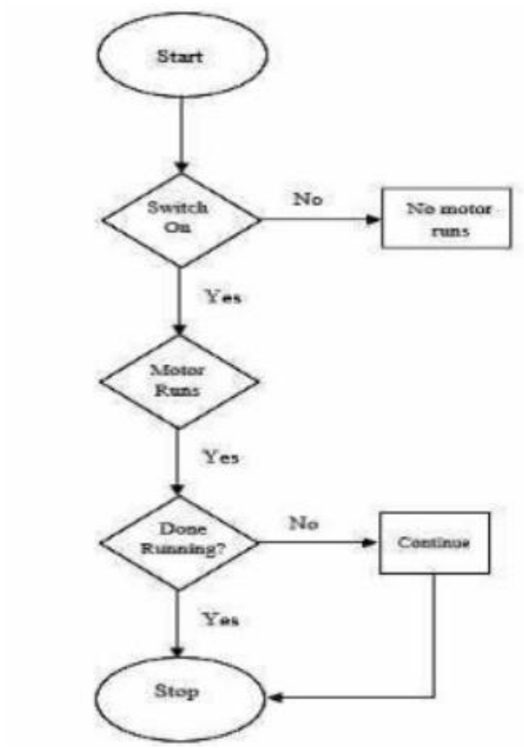


**Fig. 2.4 Flow diagram of control system**

**Advantages:**

- The automated board wiper significantly reduces the time required to clean the whiteboard, completing the task in approximately 8 seconds compared to the 25 seconds needed with traditional manual cleaning. This allows teachers to focus more on their lessons.

- By automating the cleaning process, the system eliminates the need for teachers or students to manually wipe the board, thus reducing physical strain and promoting a more comfortable teaching environment.
- The system is built using inexpensive and readily available components, making it an affordable solution for schools and educational institutions. This allows schools with limited budgets to implement the automation without significant financial investment.
- The automated cleaning system ensures gentle wiping, which helps in preserving the visual quality of the whiteboard. This reduces the wear and tear that can occur with manual cleaning methods, maintaining a clearer and more durable surface.

**Limitations:**

The automated whiteboard cleaning system, while innovative, has certain limitations that must be addressed. Its reliance on a consistent power supply makes it challenging to operate in areas with frequent outages or limited electricity access. Additionally, the mechanical components, such as motors and pulleys, are susceptible to wear and tear, leading to increased maintenance costs and potential downtime. The system's adaptability is another concern, as the current design may not accommodate non-standard or oversized boards without significant modifications. Furthermore, the reliance on a switch or remote for activation restricts its integration into advanced smart classroom setups. Features like automatic activation using sensors or infrared detection could enhance functionality, but such additions would increase the system's complexity and overall cost.

## 2.6 Development of New Design of Automatic Blackboard Cleaning System

**Methodology**:

The development of the Automatic Blackboard Cleaning System began with conceptualizing a mechanism to automate blackboard cleaning, inspired by the sliding door's motion. The design incorporated a DC motor-driven erasing module connected via a relay module for control. Assembly language was utilized for interfacing the motor with a computer's parallel port to manipulate movement. The system's mechanical structure was designed to be lightweight yet durable, ensuring smooth operation across the blackboard surface. Detailed calculations were conducted to select components such as motors, screws, and nylon strings, ensuring they could handle the required torque, force, and stress during operation.

Prototyping and testing played a significant role in refining the design. The prototype was evaluated for its ability to clean efficiently, the smoothness of its motion, and its reliability in long-term use. Adjustments to motor speed, mechanical alignment, and chalk dust collection mechanisms were made to optimize performance. The final implementation emphasized user-friendliness, with a single-button operation and a robust yet simple structure. The system successfully combined ease of use with cost-effectiveness, making it suitable for adoption in educational institutions of various scales.

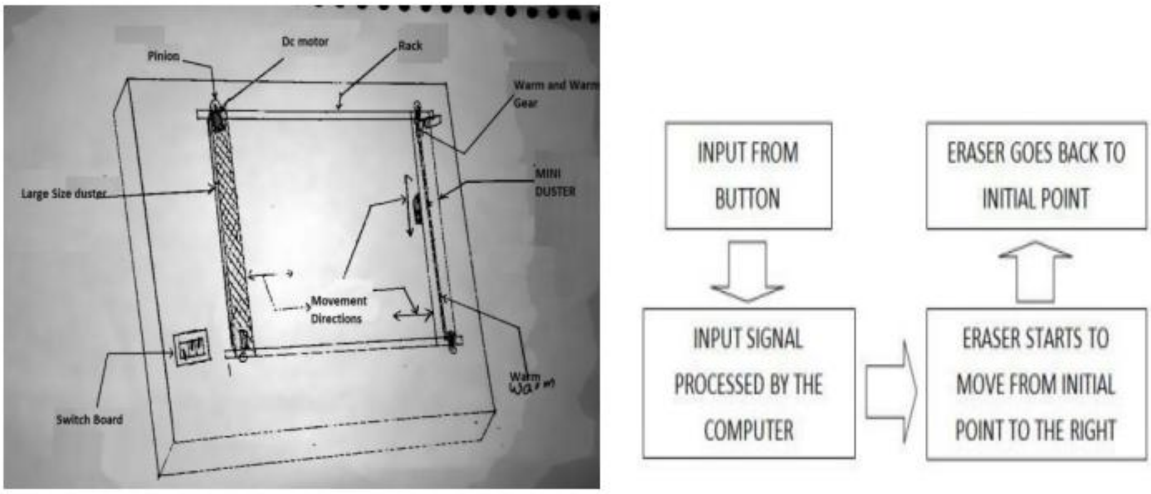


**Fig.2.5 Class room blackboard erasing machine mechanism and its operating circuit**

**Contributions:**

The development of the Automatic Blackboard Cleaning System contributes to the field of education and automation by offering a practical solution to reduce the manual effort involved in blackboard cleaning. By integrating a motorized sliding mechanism with a simple control system, the design significantly enhances efficiency, allowing educators to focus more on teaching rather than erasing. The system's ability to collect chalk dust promotes a cleaner and healthier classroom environment, addressing a common issue in traditional blackboard usage. Its cost-effective design and adaptability make it accessible for institutions of all sizes, encouraging the adoption of automated solutions in educational settings. Moreover, the project demonstrates the effective application of mechanical engineering principles, electronics, and programming in solving everyday challenges, paving the way for future innovations in classroom technology.

**Advantages:**

- The Automatic Blackboard Cleaning System allows for quick and effortless cleaning of blackboards, significantly reducing the time and effort required compared to manual erasing.
- By collecting chalk dust during the cleaning process, the system minimizes exposure to airborne particles, creating a healthier environment for teachers and students.
- The system uses readily available materials and simple mechanisms, making it affordable and easy to implement in educational institutions of various sizes.

**Limitations:**

The Automatic Blackboard Cleaning System has limitations, including its dependency on electrical power, making it unsuitable during power outages. The system may not accommodate irregularly shaped or custom-sized blackboards effectively. Additionally, maintenance requirements for the motor and mechanisms could increase operational costs over time. Finally, the initial installation process might be complex and time-consuming, especially in older classrooms.

## 2.7 Summary

This chapter gives the overview of the exhaustive literature survey done before arriving at problem statement of the project.

# Chapter 3

# REQUIREMENT ANALYSIS

## 3.1 Functional requirements

The following are the functional requirements for the project:

- AI-Powered Automated Cleaning: The device autonomously cleans whiteboards using AI algorithms to determine the most efficient cleaning path, ensuring complete surface coverage with minimal redundancy, thereby reducing human effort and time.
- App Control: The device shall be controllable via a mobile or desktop application, allowing users to start, stop, and customize cleaning operations remotely.
- Consistent Cleaning Quality: The device shall ensure uniform, streak-free cleaning, maintaining the whiteboard's usability.
- Board Video Streaming – The device shall feature real-time video streaming to remotely monitor the cleaning process, ensuring effective supervision and control from a distance.
- Voice Control – The system shall support voice commands to start, pause, and stop the cleaning process, enabling hands-free operation and improving accessibility.
- User Interface and Notifications: The device shall feature a user-friendly interface for control and notify users of operational issues like low power or cleaning pad wear.
- Marker Compatibility: The device shall effectively clean both dry-erase and semi-permanent marker residues without damaging the board surface.

## 3.2 Non-Functional requirements

The functionalities to be fulfilled in the project is supplemented by a list of non-functional requirements such as

- Performance: Cleans an average-sized whiteboard within 2 minutes while maintaining consistent speed and accuracy.

- Scalability: Adapts to various whiteboard sizes and configurations with minimal modifications.
- Reliability: Operates continuously for at least 8 hours with a failure rate of less than 1%.
- Durability & Maintainability: Allows easy replacement of consumables and supports remote software updates, designed for at least 5 years of use, resistant to wear, and functions in various environmental conditions.
- Energy Efficiency: Consumes less than 50 watts and includes a low-power standby mode.
- Aesthetics: Features a compact, modern design suitable for professional and educational spaces.
- Security: Includes user authentication for the control software or mobile app.

## 3.3 Hardware Requirements:

### 3.3.1 Arduino uno

Arduino is an open-source electronics platform designed for building and programming interactive devices. It consists of hardware in the form of microcontroller boards and software tools for programming them using Arduino's Integrated Development Environment (IDE). Arduino boards, such as the Arduino Uno, Mega, and Nano, are equipped with digital and analog input/output pins, enabling them to interact with a variety of sensors, actuators, and other electronic components. The platform supports multiple programming languages, with C and C++ being the most commonly used. Known for its simplicity and ease of use, Arduino is widely adopted by beginners and professionals in fields like robotics, automation, and IoT. Its open-source nature allows for extensive community support, providing libraries, tutorials, and forums for troubleshooting and innovation.


**Fig. 3.1: Arduino Uno Wi-Fi Rev2**

## 3.3.2 Servo motor

The MG996R is a high-torque digital servo motor commonly used in robotics, automation, and RC applications. Manufactured by TowerPro, it is renowned for its durability and performance. The servo is equipped with a metal gear system, ensuring strength and resistance to wear, making it ideal for high-load tasks. It operates at a standard voltage range of 4.8V to 7.2V, with a stall torque of up to 11 kg-cm at 6V, providing powerful rotational force. The MG996R supports a wide range of motion, typically 0° to 180°, controlled via Pulse Width Modulation (PWM) signals. Its speed is also noteworthy, with a rotation time of approximately 0.17 seconds per 60 degrees at 6V. The servo is compact, with a weight of around 55 grams, and includes mounting hardware for easy installation. Widely available and affordable, the MG996R is favored by hobbyists and professionals for projects requiring reliable and precise motor control.

**Fig. 3.2 A Continuous MG996R Servo motor**

### 3.3.3 Raspberry Pi 4b

The Raspberry Pi is a small, versatile single-board computer developed by the Raspberry Pi Foundation, designed to promote computer science education and support various DIY projects. It is equipped with a Broadcom ARM processor, RAM, HDMI output, USB ports, and GPIO pins for hardware interfacing, making it suitable for a wide range of applications. The Raspberry Pi operates on various operating systems, with Raspberry Pi OS being the most common. It supports various connectivity options, including Ethernet and Wi-Fi, depending on the model. With a low price point and a robust community, the Raspberry Pi has become a popular choice for hobbyists, educators, and professionals in fields like robotics, home automation, and IoT.

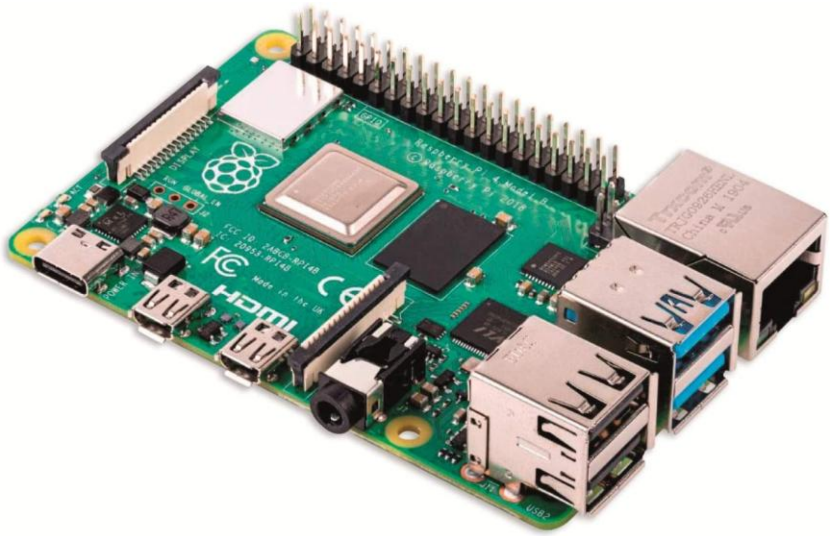

**Fig. 3.3 A Raspberry Pi 4b**

### 3.3.4 Web Camera

A webcam is a small digital video camera used to capture live video and images, typically connected to a computer or embedded in devices like laptops and tablets. Webcams are commonly used for video conferencing, streaming, and surveillance. They come equipped with lenses, image sensors, and built-in microphones, providing both video and audio capabilities. Most webcams connect via USB, while modern versions also support wireless connectivity through Wi-Fi or Bluetooth. Resolution and frame rates vary, with standard models offering HD (720p) or Full HD (1080p) quality, while high-end webcams deliver 4K video. Webcams are widely used in applications like virtual meetings, online classes, live broadcasting, and facial recognition systems, making them essential tools for communication and security in the digital age.


**Fig. 3.4 Web Camera**

## 3.3.5 Rack and Pinion gears

Rack and pinion gears are a mechanical system used to convert rotational motion into linear motion. The system consists of a circular gear, called the pinion, which meshes with a flat, straight gear, known as the rack. As the pinion rotates, its teeth engage with the rack, causing it to move in a straight line. This system is commonly used in steering mechanisms, such as in cars, and in machinery requiring precise linear motion. The gear ratio between the pinion and rack affects the speed and force of movement, with a larger pinion providing faster motion and a smaller one offering more force.

**Fig. 3.5 Rack and Pinion gears**

## 3.4 Firebase

- **Firebase Firestore -** Firebase Firestore is a flexible, scalable database for mobile, web, and server development. It allows developers to store, sync, and query data in real time, making it suitable for apps that require real-time updates and collaboration features. Firestore supports rich, nested data models and powerful querying capabilities.
- **Firebase Realtime Database -** Firebase Realtime Database is a cloud-hosted NoSQL database that stores data as JSON. It enables real-time synchronization across all clients connected to the database, making it ideal for apps that need to reflect changes instantly, such as chat applications or live feeds.
- **Firebase Cloud Storage -** Firebase Cloud Storage provides a powerful, simple, and secure way to store and serve user-generated content, such as photos and videos. It integrates seamlessly with Firebase Authentication, ensuring secure access to stored files based on the user's authentication state.

## 3.5 Summary

This chapter considers all the system requirements which the project require to develop this proposed system. The functional requirements for this project have been explained in section 3.1. The non-functional requirements for this project have been explained in section 3.2. The hardware requirements for this project have been explained in section 3.3. The back-end software is clearly explained in section 3.4.

# Chapter 4

# DESIGN AND IMPLEMENTATION

## 4.1 Design Issues

- Internet Connectivity: Poor or unstable internet can disrupt remote monitoring and control functions. Reliable network access is crucial.
- Mechanical Wear: Moving parts like motors may degrade over time, requiring maintenance or replacement.
- Power Issues: Power outages can interrupt cleaning. A backup power source is needed.

## 4.2 System Architecture

The modular architecture of proposed project is given in Fig. 4.1.

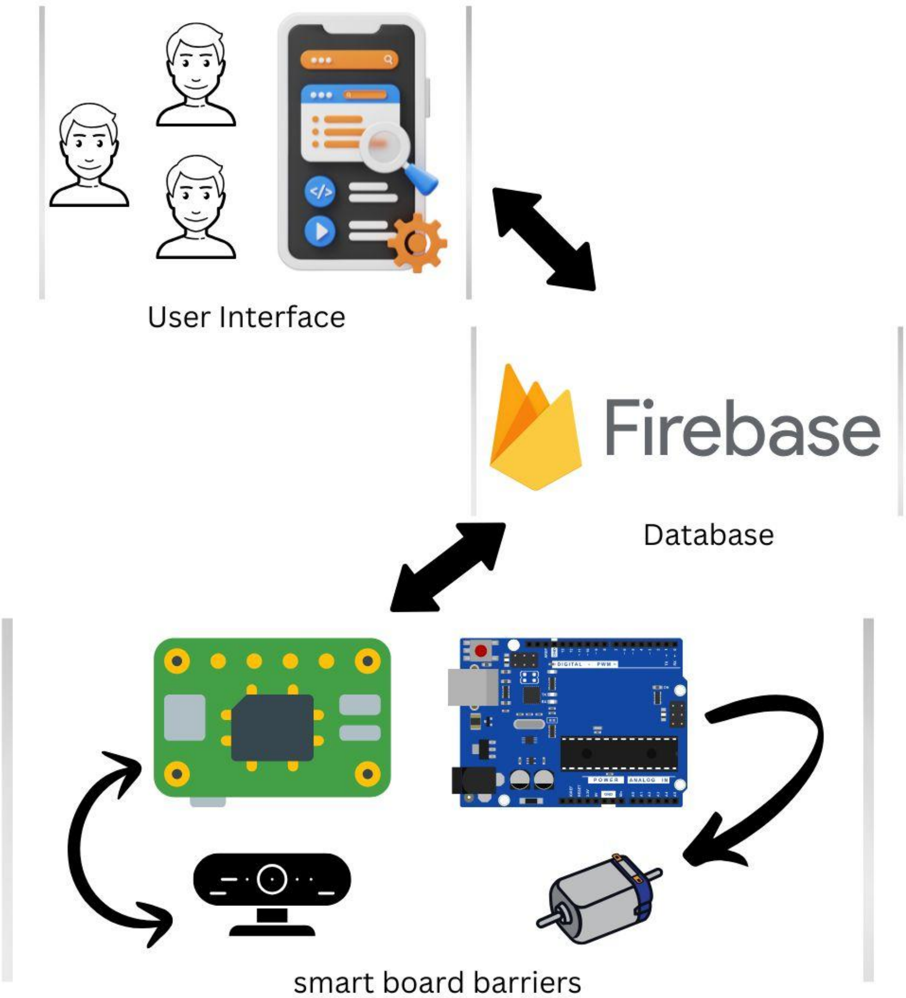


**Fig. 4.1 System Architecture**

Different modules involved in the project are:

- **Raspberry Pi and webcam:** the Raspberry Pi and webcam work together to monitor the whiteboard's fill status. The webcam, connected to the Raspberry Pi, continuously captures images or video of the whiteboard, which the Raspberry Pi processes to detect whether the board is filled with writing or clean. Based on this analysis, the Raspberry Pi updates the board's status in real time to Firebase Firestore.
- **Arduino and motor:** Arduino is responsible for controlling the motor that drives the cleaning mechanism. The Arduino reads the board's fill status from Firebase Firestore, which is updated in real time by the Raspberry Pi based on the webcam’s analysis of the whiteboard’s content. When the board is detected as filled, the Arduino activates the motor to start cleaning. The motor, which can either be a servo motor or a continuous motor, moves the cleaning device (such as a wiping cloth or brush) across the whiteboard to clean it.
- **Cloud FireStore:** Cloud Firestore acts as the central database, storing real-time data about the whiteboard’s fill status. The Raspberry Pi updates this status to Firestore, and both the Arduino and Flutter app read from Firestore to control the cleaning motor and display the current board status. Firestore ensures seamless synchronization across the system, enabling real-time updates and communication between components for automatic or manual operation.
- **Smart Board Cleaning App:** the Flutter application serves as the user interface for controlling the system. It allows users to switch between manual and automatic cleaning modes, view real-time webcam streaming of the whiteboard’s status, and interact with the system remotely. The app receives live updates from Cloud Firestore to display the current fill status of the board. Additionally, the Flutter app incorporates voice control mechanisms, enabling users to give voice commands to start or stop cleaning, switch modes, or activate specific actions, enhancing the user experience.

## 4.3 Implementation

In this section the implementation of various modules involved in the design of AI powered automatic board cleaning system is discussed.

### 4.3.1 Implementation of User Interface

Figure 4.2 shows how the user login using the android application and how the slot is allotted to the user. It also describes about the payment option.

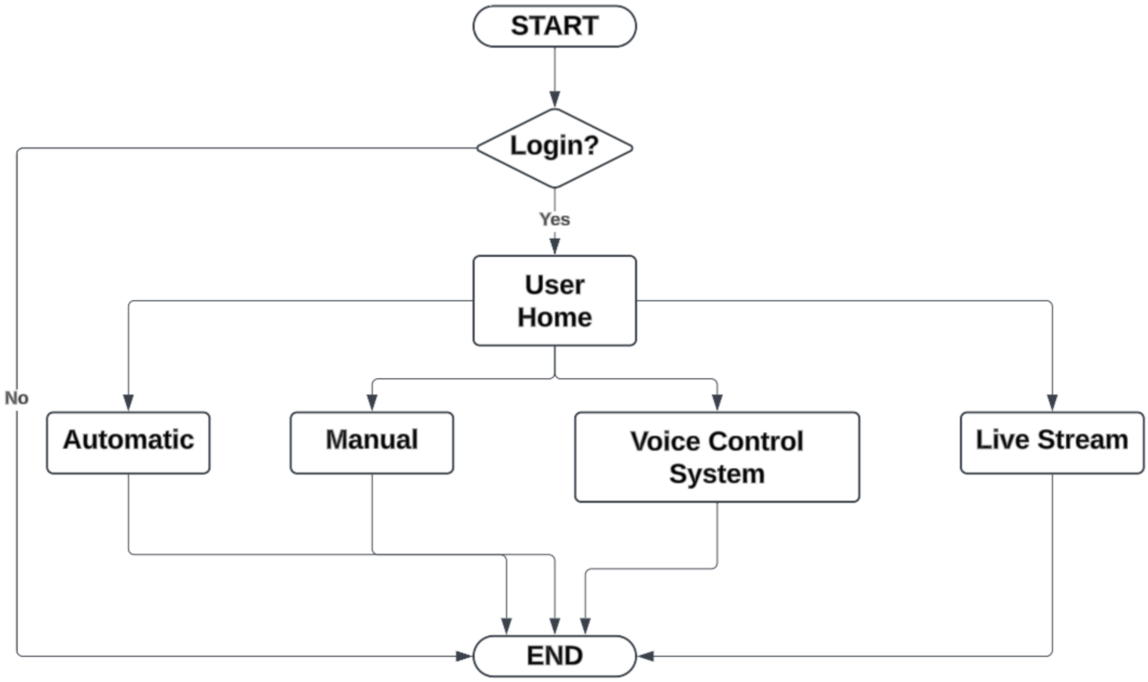


**Fig. 4.2 Flowchart of user interface**

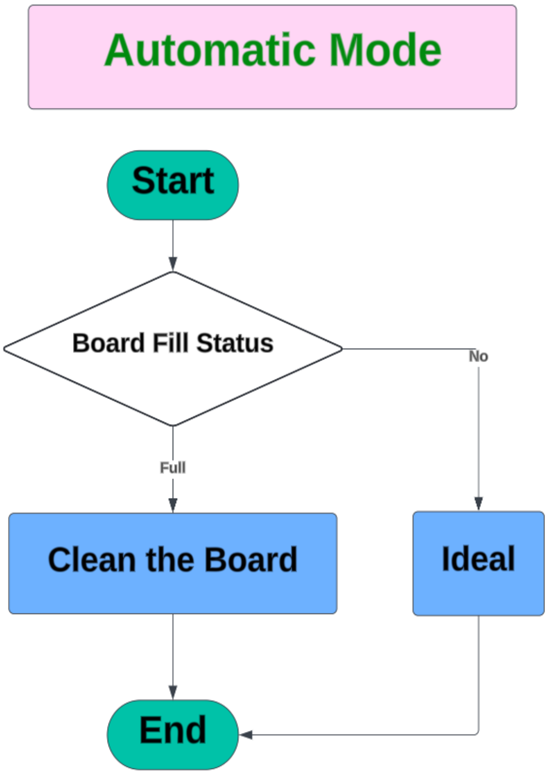


**Fig. 4.3 Flowchart of Automatic Mode**

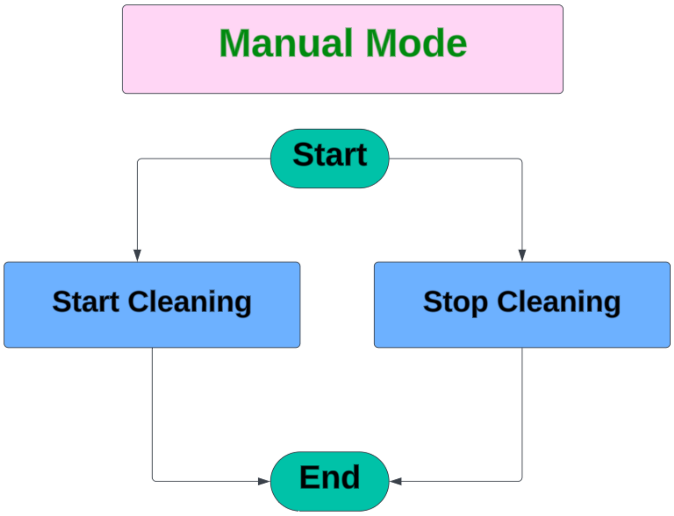


Fig. 4.4 Flowchart of Manual Mode

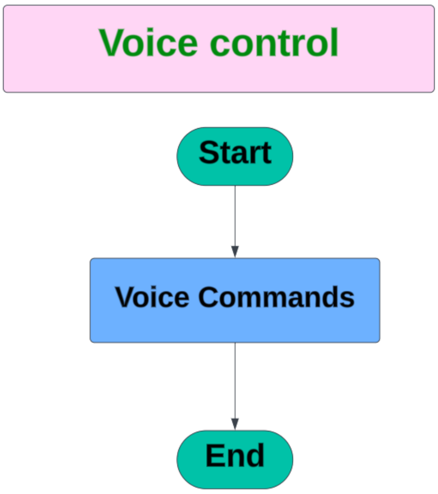


Fig. 4.5 Flowchart of Voice Control Mode

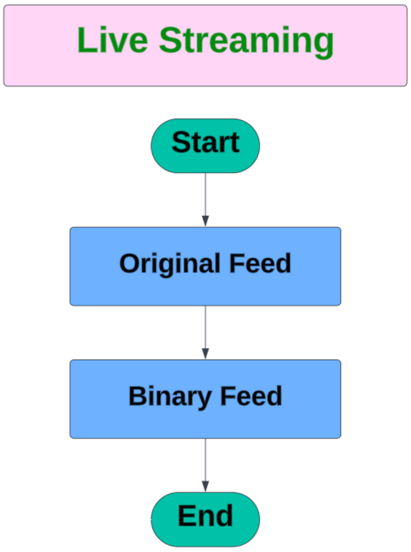


Fig. 4.6 Flowchart of Live Streaming Page

## 4.4 Hardware Architecture

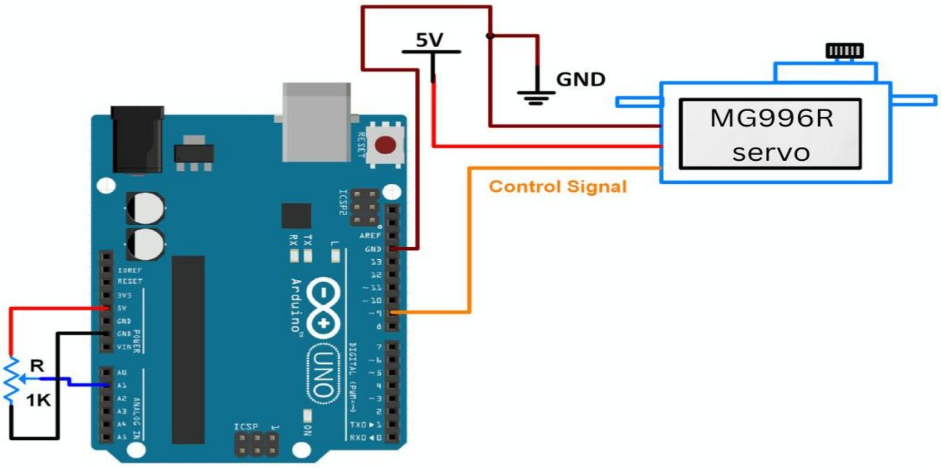


**Fig. 4.7 Arduino Board with Servo motor**

The Arduino program consists of a _toggleCleaning function controls the smart whiteboard cleaner by toggling isCleaningActive, reflecting the state in Firebase. When activated, it sets boardStatus/status to 1 and manual_cleaning to true, starting the servo motor. When deactivated, it sets them to 0 and false, stopping the motor. This ensures the motor operates only in manual mode, managed via Firebase updates.

**Fig. 4.8 Raspberry pi with web camera**

Raspberry Pi with a webcam to monitor a whiteboard's fill status using OpenCV for image processing and Flask for live streaming. The capture_frames function continuously processes frames, converting them to binary to calculate the board's fill percentage, updating Firebase with the status. The Flask app streams the original and processed video feeds via routes /original_feed and /binary_feed. Firebase modes are initialized with initialize_firebase_modes, and monitor_firebase_changes listens for real-time updates to handle mode switches.

# 4.5 APIs used

## 4.5.1 APIs used in Flutter

**Table 4.1 APIs used in Flutter**

| API | DESCRIPTION |
|---|---|
| flutter/material.dart | Core Flutter UI framework providing Material Design widgets and theming. |
| firebase_database | Real-time database package for Firebase integration and data synchronization. |
| firebase_core | Base Firebase package required for Firebase initialization. |
| speech_to_text | Package for implementing voice recognition and speech-to-text conversion. |
| permission_handler | Handles runtime permissions for device features like microphone access. |
| flutter_mjpeg | Enables MJPEG video streaming display in Flutter applications. |
| google_fonts | Provides easy access to Google Fonts for custom typography. |
| dart:async | Core Dart package for asynchronous programming with Timers and Streams. |

## 4.5.2 APIs used in Arduino

**Table 4.2 APIs used in Arduino**

| API | DESCRIPTION |
|---|---|
| WiFi.begin(ssid, password) | Initializes WiFi connection with provided network credentials. |
| deserializeJson(doc, jsonString) | Parses JSON string into JSON document object |
| doc.containsKey("key") | Checks if JSON document contains specified key |
| Serial.begin(baudRate) | Initializes serial communication at specified baud rate |

### 4.5.3 APIs used in Raspberry Pi

**Table 4.3 APIs used in Raspberry Pi**

| API | DESCRIPTION |
|---|---|
| cv2.VideoCapture(0) | Initializes video capture from the default webcam (index 0). |
| cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY) | Converts color frame to grayscale for image processing. |
| cv2.countNonZero(binary) | Counts non-zero (white) pixels in binary image for fill percentage calculation. |
| cv2.imencode('.jpg', frame) | Encodes image frame to JPEG format for streaming. |
| db.reference("boardStatus") | Creates reference to Firebase database path for board status. |
| ref.listen(handle_mode_change) | Sets up real-time listener for Firebase database changes. |
| Flask() | Initializes Flask web application for video streaming. |
| Response(generate_feed()) | Streams video feed through Flask web server endpoint. |

## 4.6 Summary

This chapter details on the system architecture and the modules used in this project. The implementation of the project is explained along with the APIs used in Flutter, Arduino and Raspberry pi.

# Chapter 5

# RESULT AND SNAPSHOTS

## 5.1 Splash and Authentication Screen

The splash screen of the mobile application is the first screen displayed upon launching the app. The Screen incorporates a loading animation and transitions smoothly into the login screen after a few seconds.

The login screen provides secure access to the application, ensuring that only authorized users can operate the smart whiteboard cleaner. Users are required to enter their credentials.

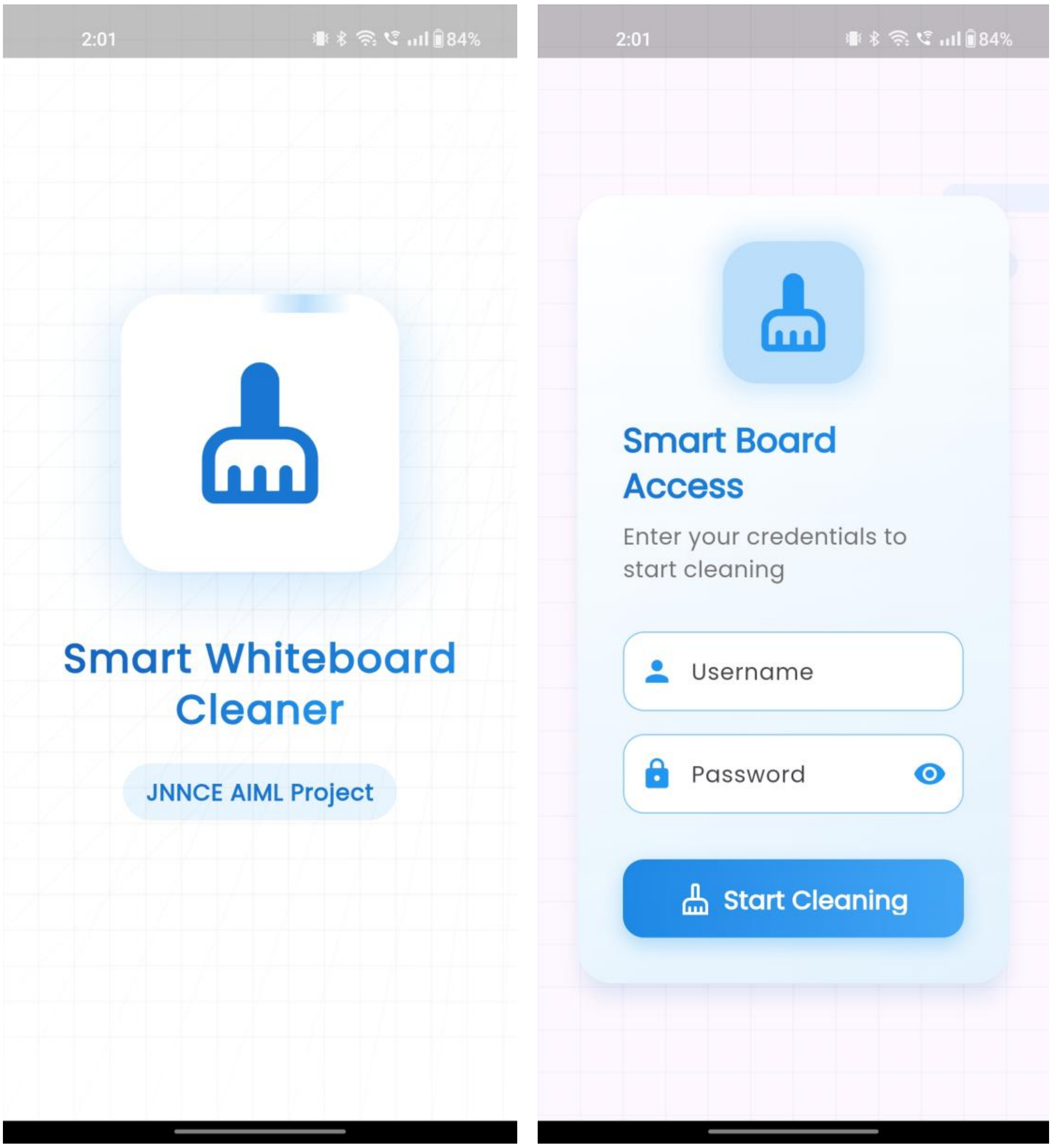


**Fig. 5.1 Splash Screen and Login Screen**

## 5.2 Home Screen

The home screen of the mobile application is shown in Figure 5.2, featuring options such as Auto Mode, Manual Mode, Streaming, and Voice Control. These options provide users with flexible control over the smart whiteboard cleaner. Auto Mode enables automatic operation for the cleaner, while Manual Mode allows for hands-on control. If Manual Mode is currently active, the app will display instructions prompting the user to disable it before granting access to Auto Mode. Additionally, the Streaming option allows users to view real-time updates of the board's status, and the Voice Control feature provides hands-free operation.

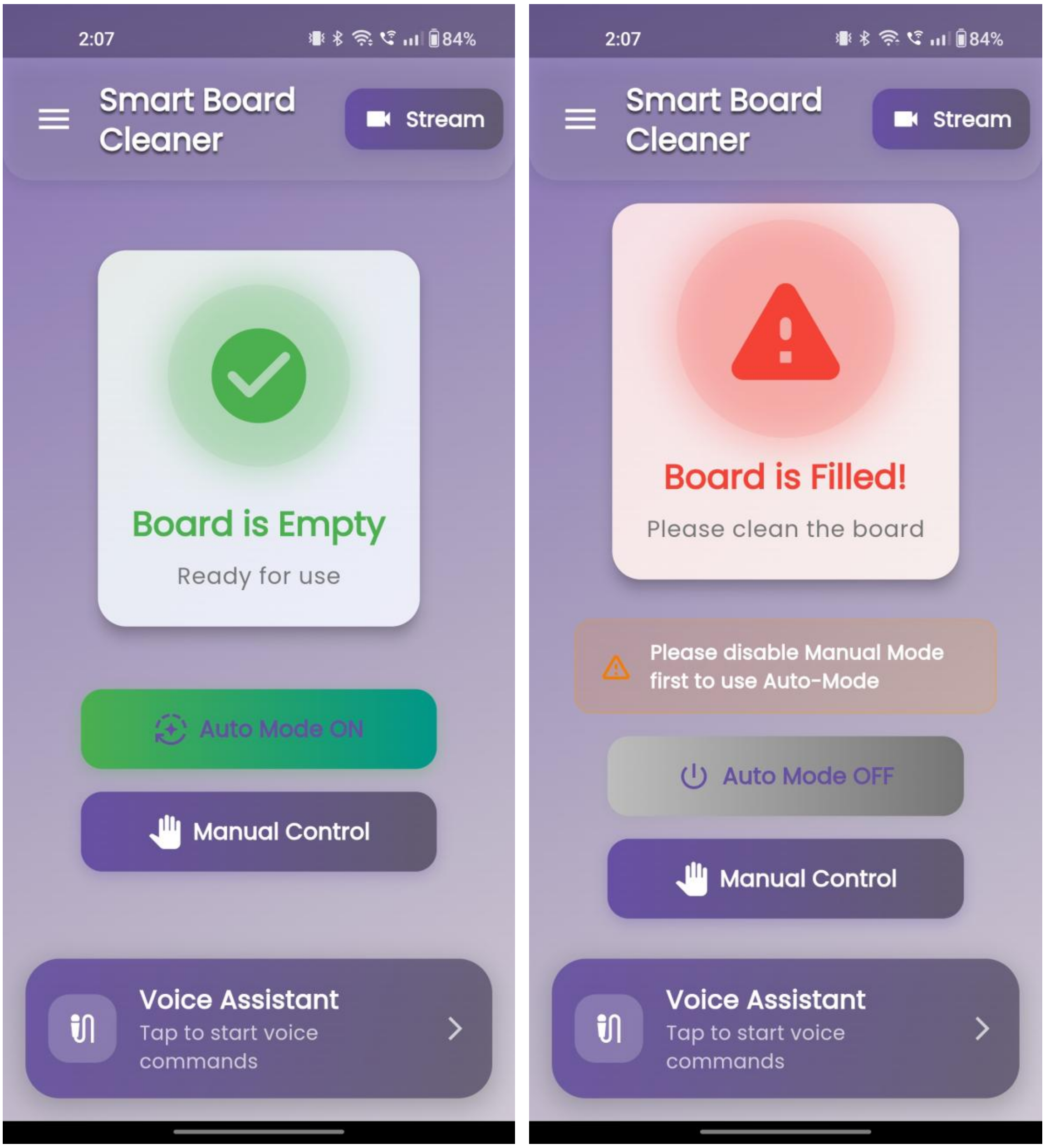


**Fig. 5.2 Home screen when board is empty and filled with Auto mode on/off**

## 5.3 Voice Control Screen

The Voice Control feature of the mobile application, as shown in Figure 5.3, allows users to operate the smart whiteboard cleaner using voice commands. Users can issue commands like "Start Cleaning" and "Stop Cleaning," enabling hands-free control for a seamless experience. This functionality enhances convenience, making it easier for users to manage the cleaning process without manual input. The intuitive interface listens for commands, ensuring quick and accurate responses. By incorporating voice control, the app simplifies interaction and improves user experience, offering a more accessible and efficient way to operate the cleaner.

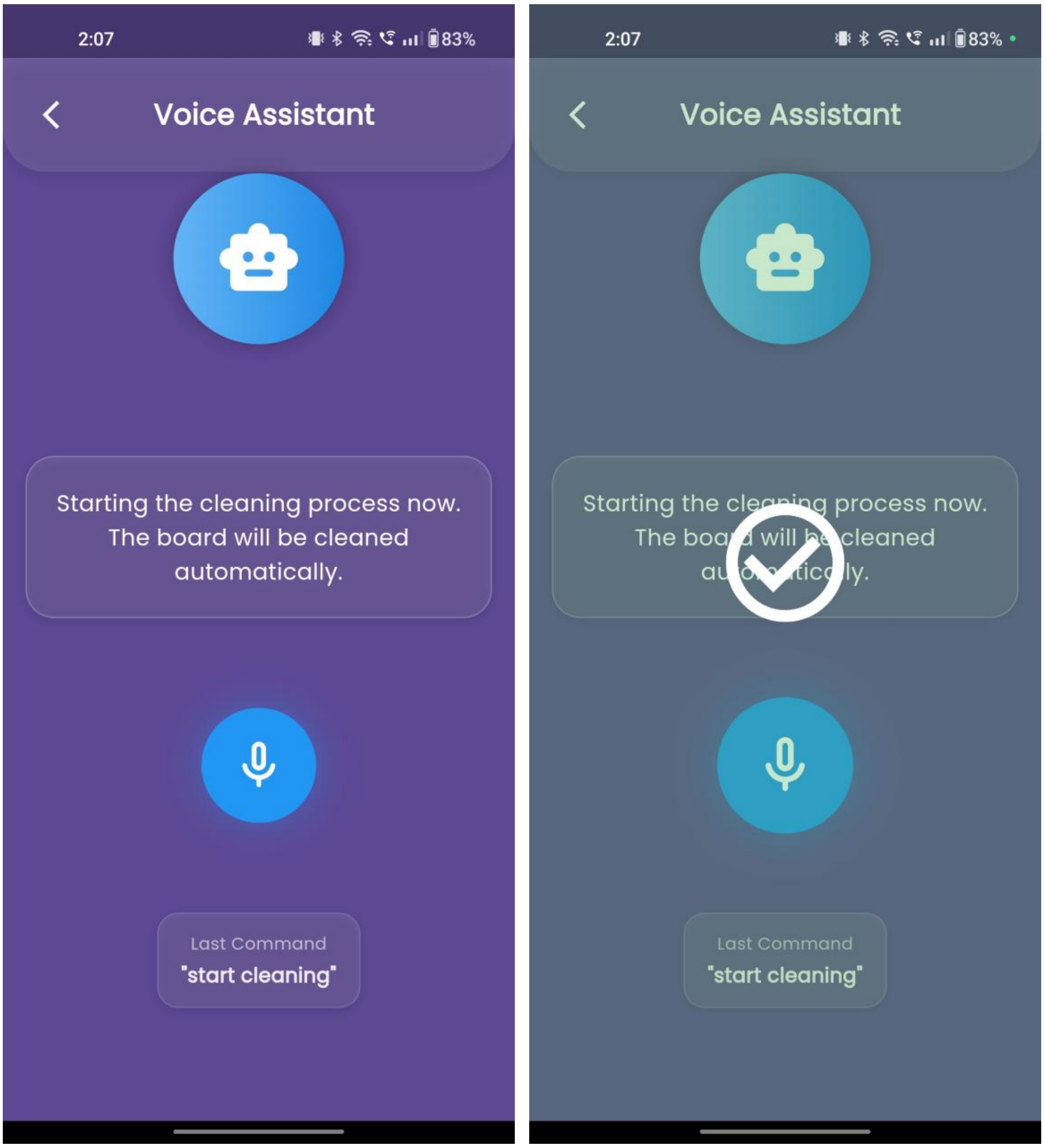


**Fig. 5.3 Voice Control**

## 5.4 Board Streams

The Board Stream interface of the mobile application, shown in Figure 5.4, displays both the Original Feed and Binary Feed. It provides real-time monitoring of the board’s status, including the board fill percentage. This feature allows users to track the board's condition visually and ensures timely activation of the cleaning process. The clear, dual-feed display enhances accuracy and efficiency in board management.

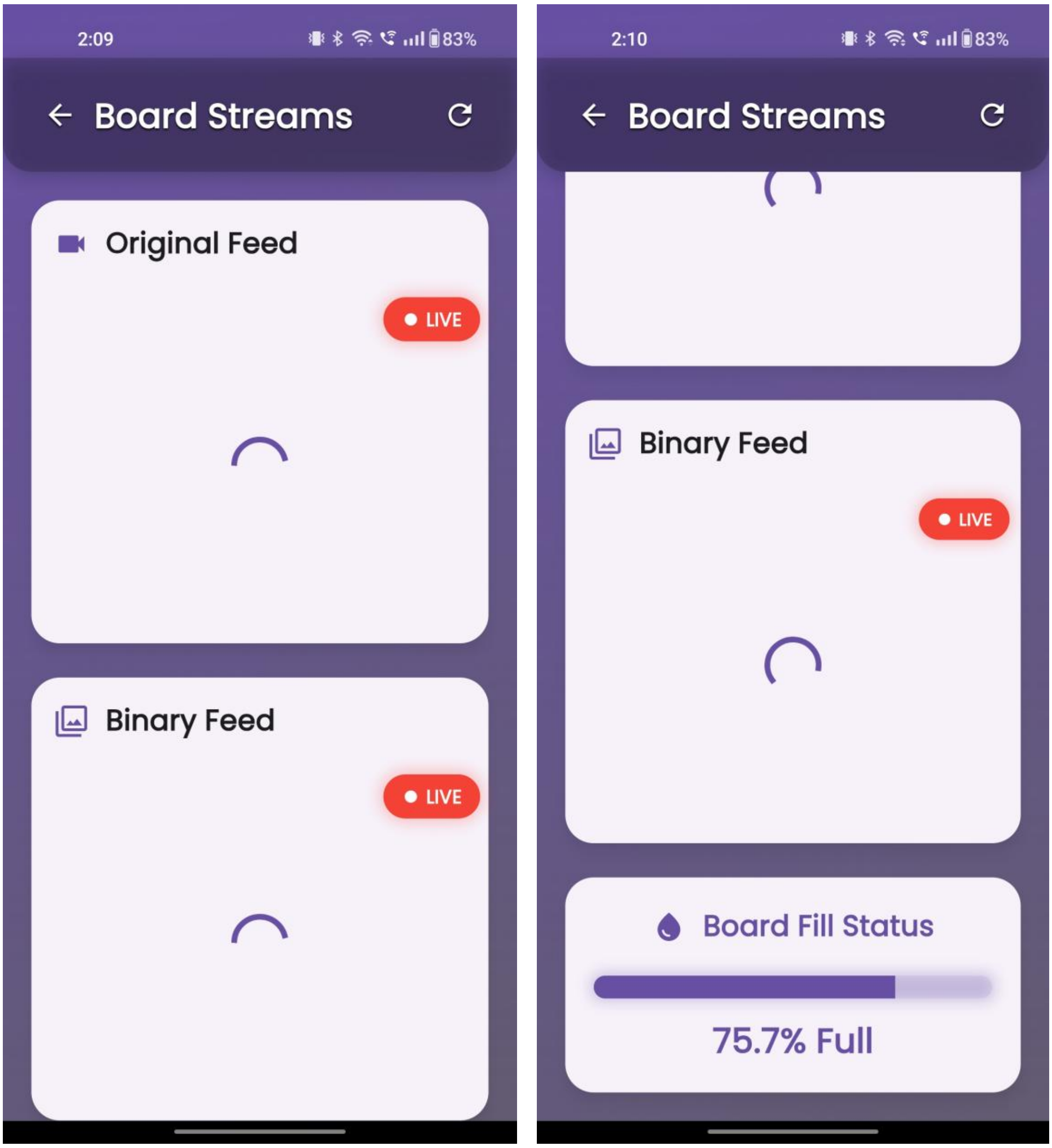


**Fig. 5.4 Board Streams**

## 5.5 Manual Control

The Manual Control screen of the mobile application, shown in Figure 5.4, allows users to manually operate the cleaning process. The interface provides options to start and stop cleaning, along with controls to pause, continue, and move the cleaner forward or backward. This hands-on functionality gives users precise control over the cleaning process, ensuring flexibility and ease of use. The intuitive design enhances user engagement and responsiveness.

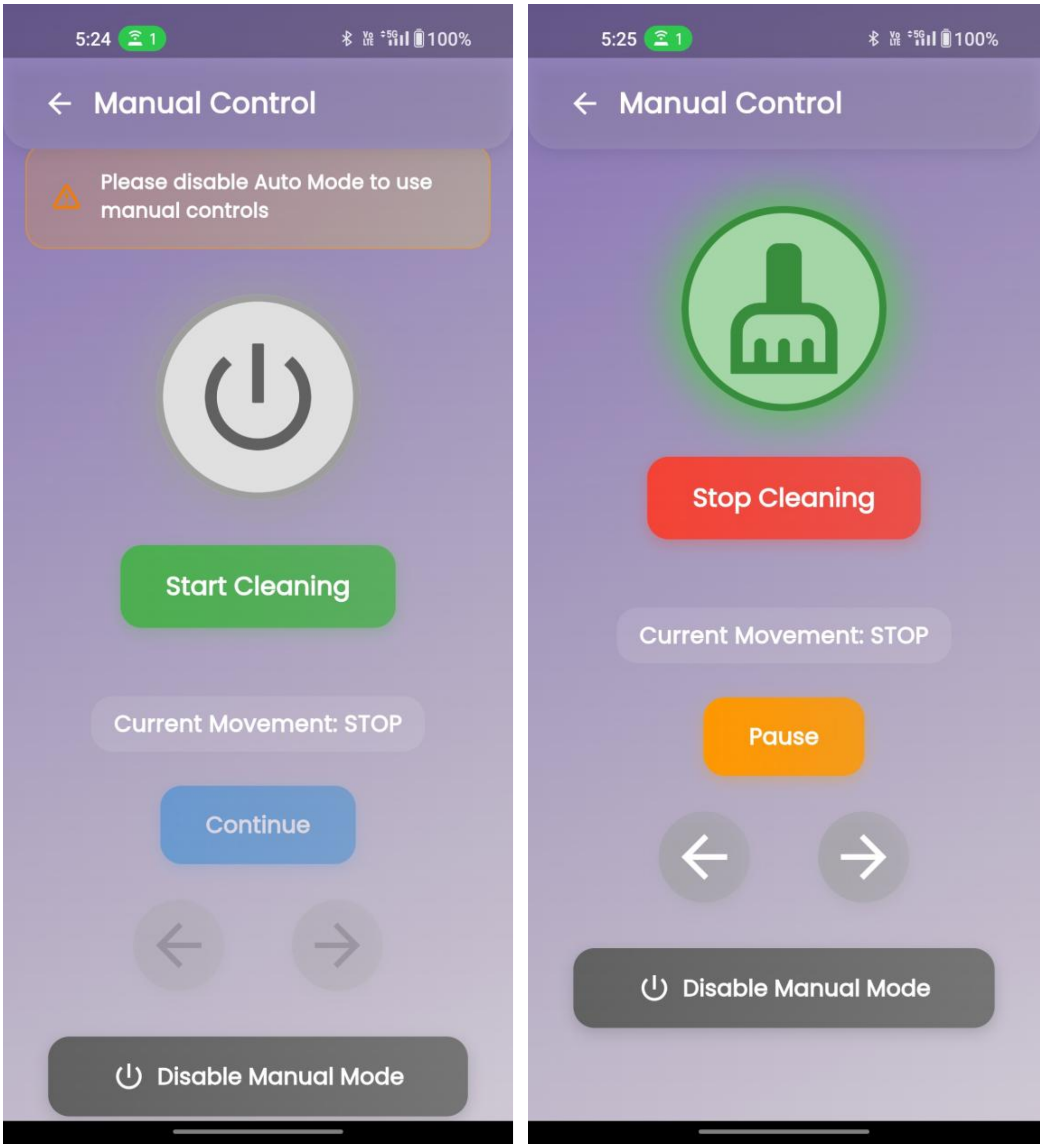


**Fig. 5.5 Manual Control Screen**

The Manual Control page also includes options to pause and continue the cleaning process at any position and with the option to disable manual mode. Additionally, users can move the cleaner forward or backward as needed. This provides greater flexibility and precision in managing the cleaning process. The intuitive controls ensure smooth operation, allowing users to adjust the cleaner's movement easily at any stage.

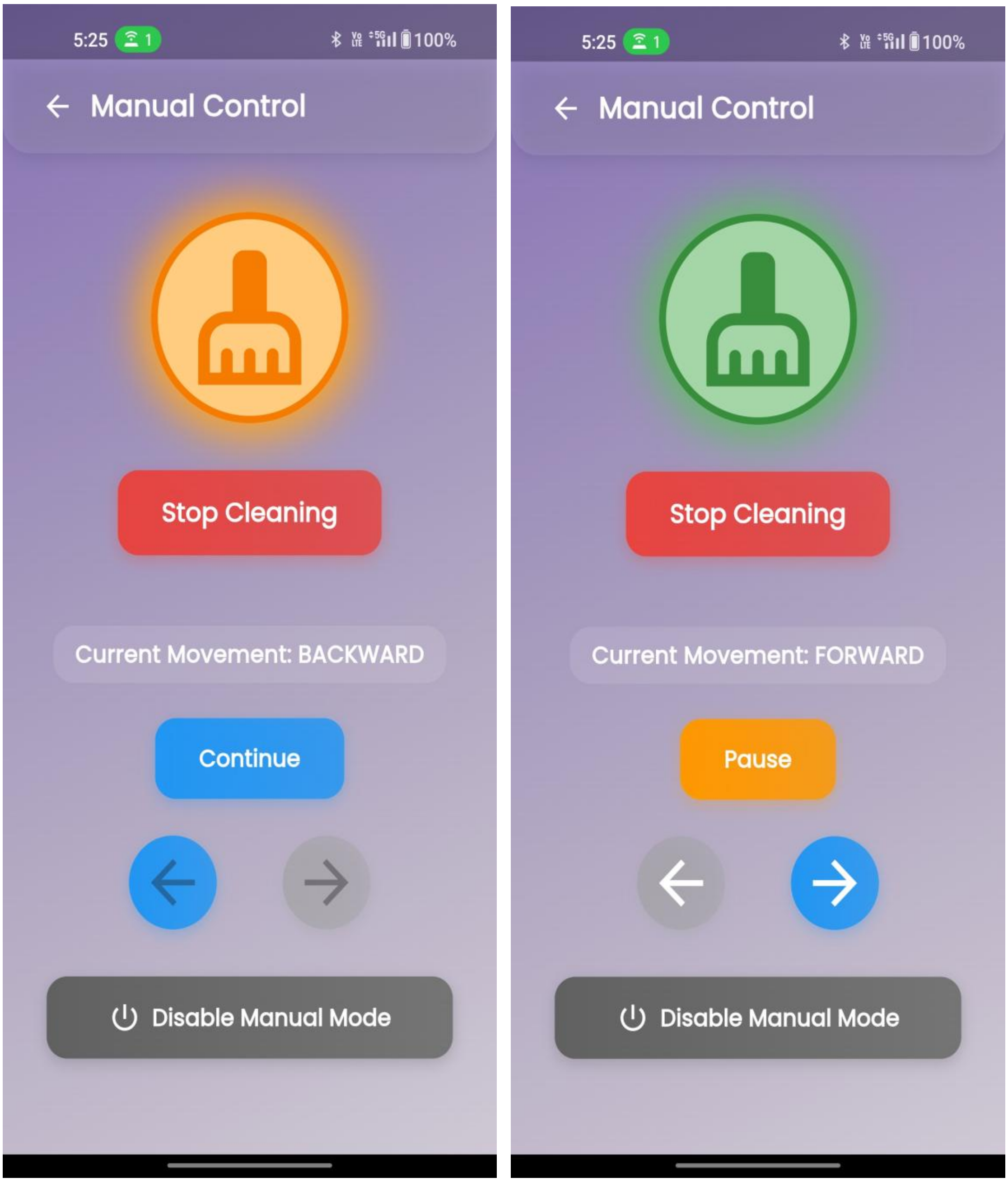


**Fig. 5.6 Manual Controls**

## 5.6 Other Screens

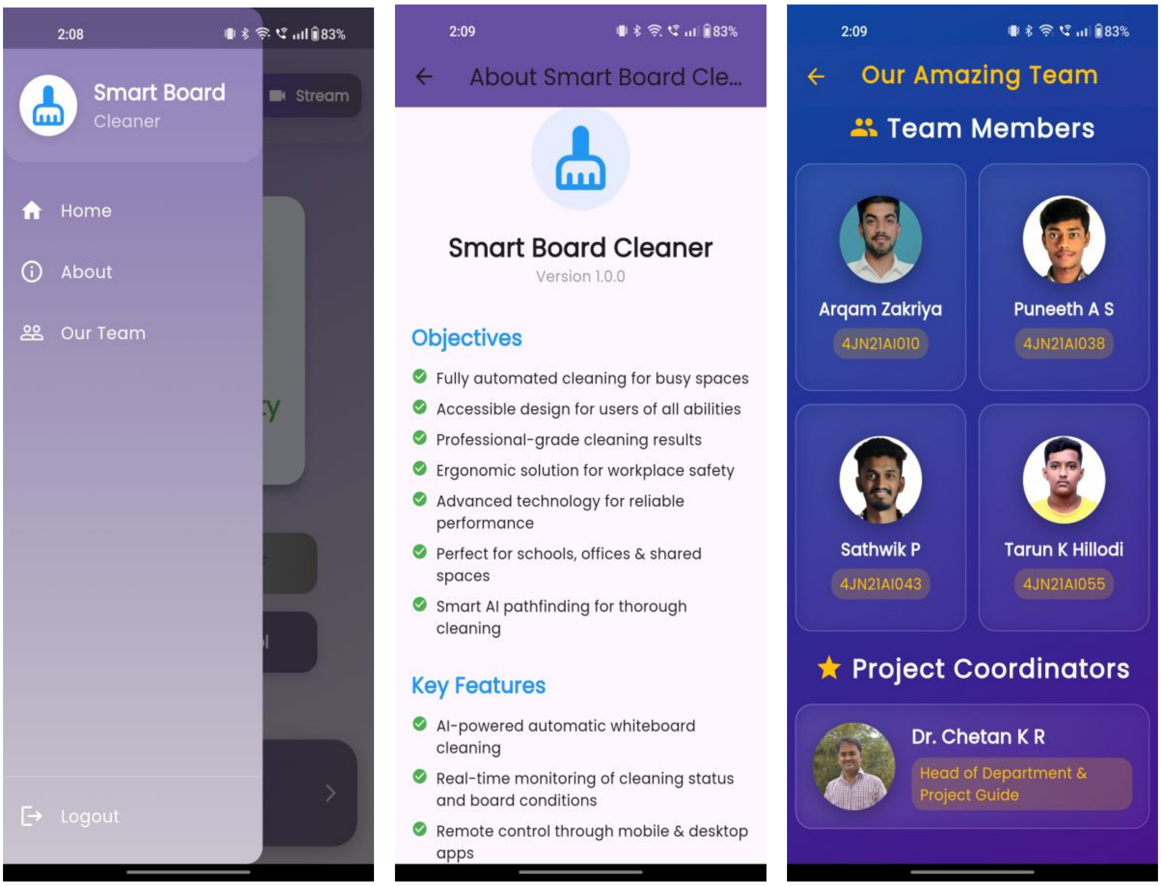


**Fig. 5.7 Drawer, About & team Screens**

The Drawer feature, shown in Figure provides quick navigation with links to Home, About, Team, and Logout. The Home section leads to the main control screen, About shares app details, and Team introduces the developers. The Logout option ensures secure account exit, offering a user-friendly and organized interface.

The About screen, provides details about the app's objectives, key features, hardware and technical specifications, and support. Objectives outline its purpose, while Key Features highlight unique functionalities. Hardware and technical details describe the components used, and Support offers guidance and assistance. This screen ensures users have essential information in an organized format.

The Team screen, introduces the four team members, project coordinator, and supporters behind the smart whiteboard cleaner. It highlights their roles and contributions, showcasing the collaborative effort driving the project. This screen ensures clear and professional representation.

## 5.7 Barrier Results

The rotation of barrier is shown in the Figure 5.6, 5.7, 5.8, 5.9. when the user status in the real time database becomes 1, then the barrier will rotate. After that it will be again set to 0.

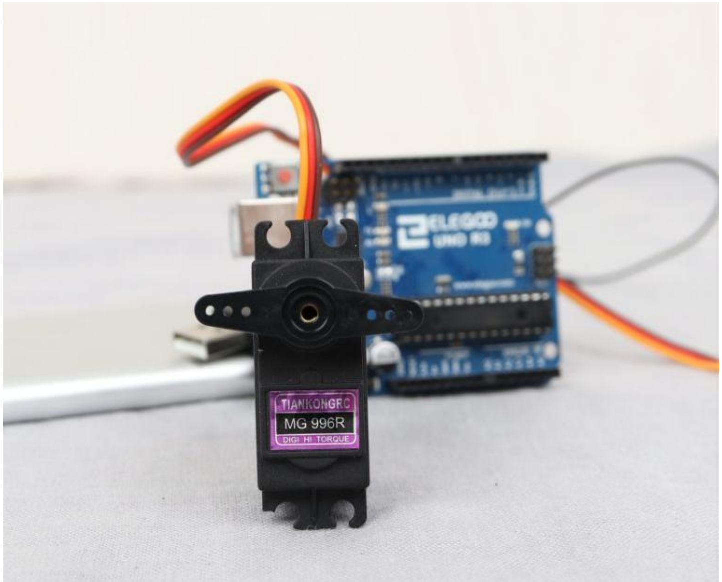


**Fig. 5.8 Barrier result of rotation of motor**

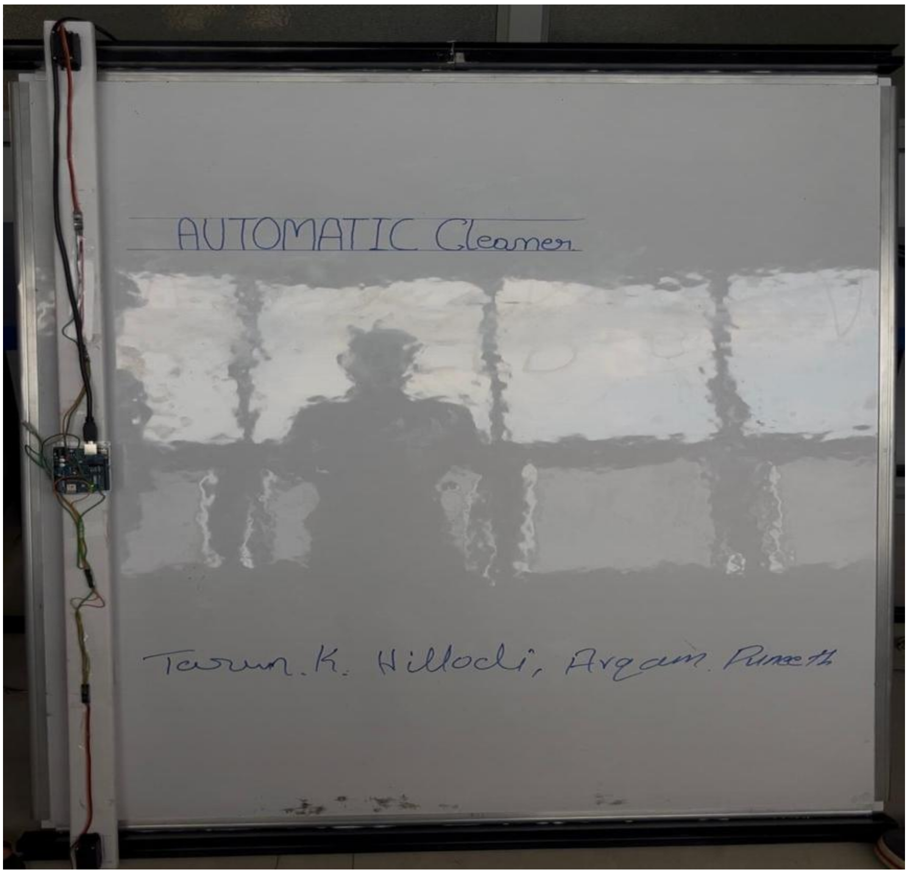


**Fig. 5.9 Barrier result of Board Cleaning - 1**

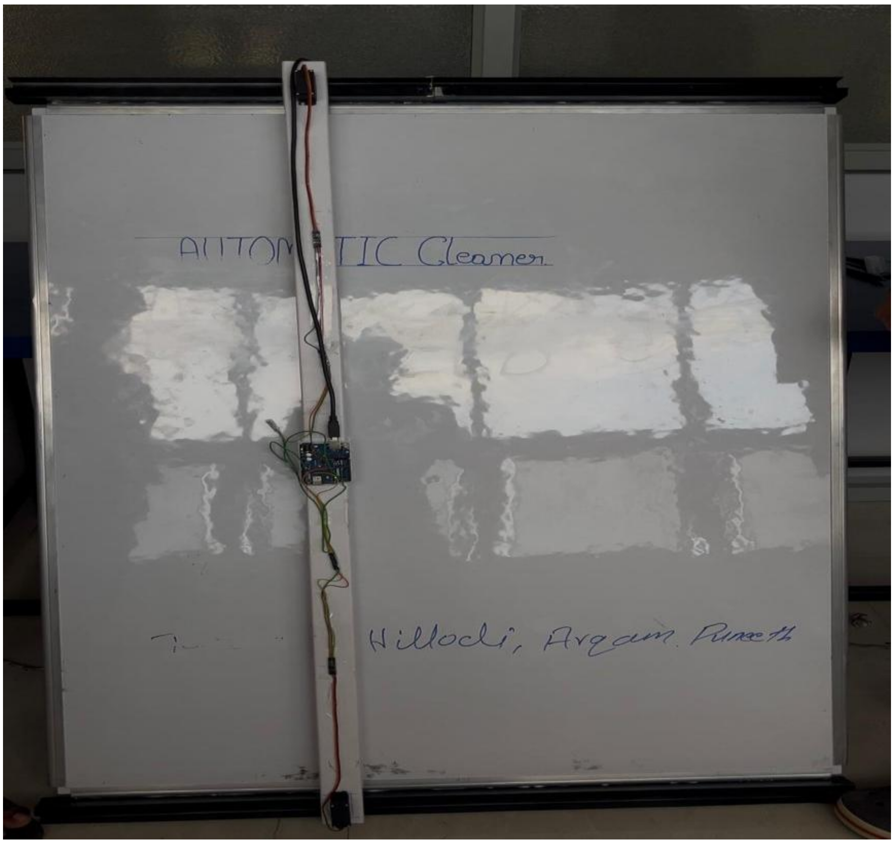

**Fig. 5.10 Barrier result of Board Cleaning – 2**


**Fig. 5.11 Barrier result of Board Cleaning – 3**

## 5.8 Firestore Database

The firestore database as shown in the Figure 5.10 is the backend where the data is stored.

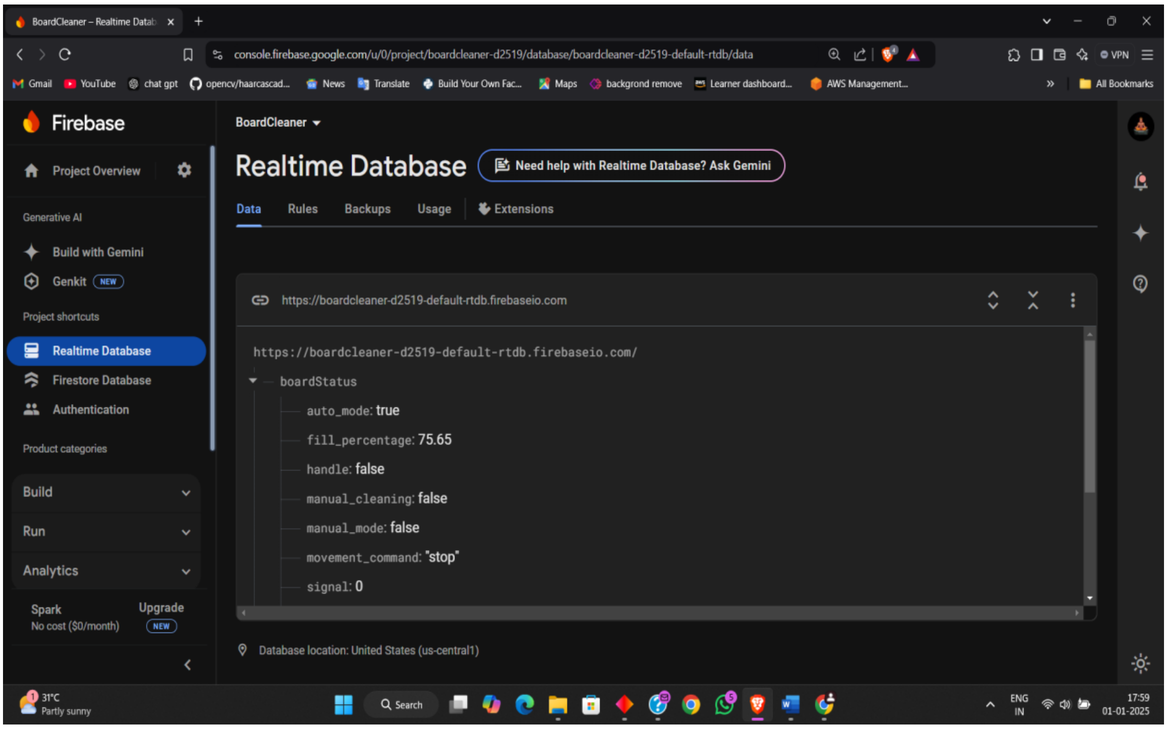


Fig. 5.12 Data stored in firestore database – 1

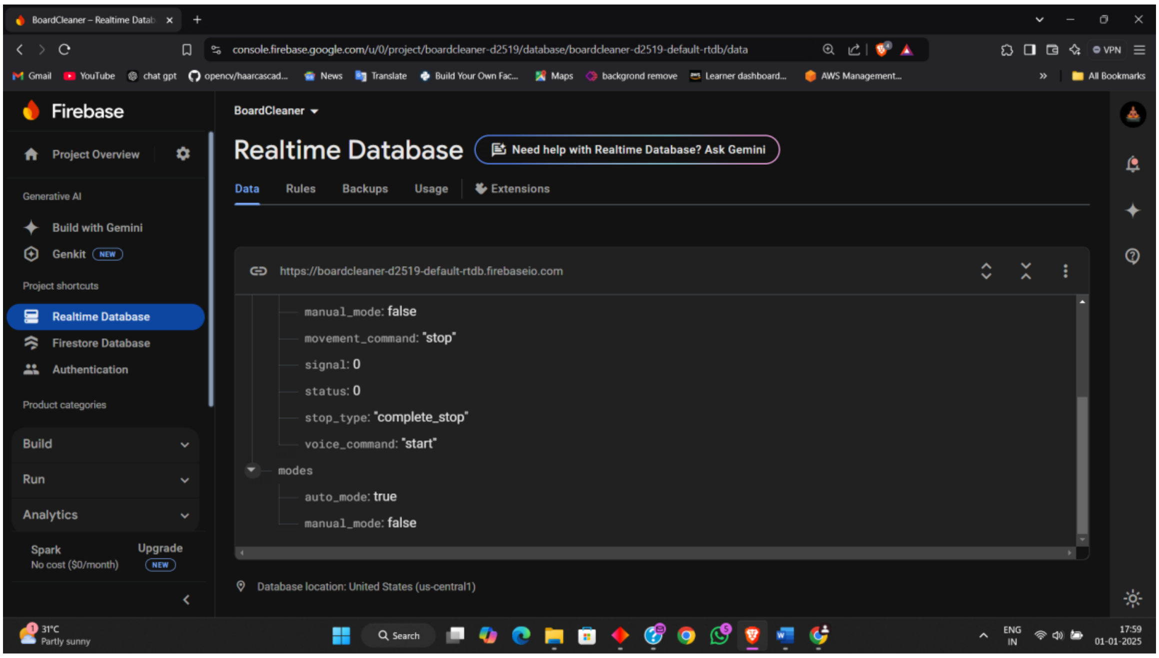


Fig. 5.13 Data stored in firestore database - 2

## 5.9 Applications

- The smart board cleaner can be implemented in classrooms to automate whiteboard cleaning, ensuring efficient use of lecture time.
- It can be deployed in corporate meeting rooms to maintain clean and presentable whiteboards during presentations.
- The system is useful in training centers and coaching institutes to streamline board management during continuous sessions.
- Research labs and development centers can benefit from automated board cleaning, allowing seamless brainstorming and project planning.
- The device can be installed in public seminar halls and conference rooms, reducing manual effort and maintaining cleanliness.

## 5.10 Summary

The snapshots of the results obtained, along with the snapshot of barrier results and firestore database with the applications of the project is detailed in this chapter.

# Chapter 6

# CONCLUSION

In this project, a Smart Board Cleaner system that automates the cleaning of classroom blackboards is developed. This system is designed for use in schools, colleges, and other educational institutions where blackboards are frequently used. The proposed system integrates a Raspberry Pi, webcam, Arduino, and continuous motors to automate the cleaning process, reducing manual effort and saving time. The smart cleaner detects board fill status using the webcam, processes the data, and activates the motor-driven cleaning mechanism. Users can control the system via a Flutter application, allowing both manual and automatic operation. Real-time video streaming and data logging are supported through Firebase, ensuring efficient monitoring and management. This system enhances classroom efficiency, reduces chalk dust exposure, and promotes a healthier learning environment.

## 6.1 Future Scope

The smart board cleaner project holds promising potential for future enhancements. AI-based smudge detection and adaptive cleaning paths can improve accuracy. Integration with voice assistants and IoT systems can enable remote operation and automation. Advanced models may support larger boards and different surface materials. Energy-efficient designs and eco-friendly materials could further enhance sustainability. This project paves the way for smarter, more automated learning environments.

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