Automated Sliding Door System Using Pir Sensor

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ABSTRACT

Automated systems have become increasingly significant in modern infrastructure, particularly in enhancing convenience, accessibility, and safety. This study presents the design and implementation of an Automated Sliding Door System using an Arduino Uno microcontroller. The system utilizes a DC geared motor controlled through an L298N motor driver to enable smooth opening and closing of the sliding door. A motion detection mechanism, such as a Passive Infrared (PIR) sensor, is employed to detect the presence of a person near the entrance, triggering the automated operation of the door. Additionally, limit switches are integrated to define the maximum open and close positions, ensuring safe operation and preventing mechanical damage. The Arduino Uno serves as the central controller, processing sensor inputs and generating appropriate motor control signals. A 7.4V lithium-ion battery pack provides sufficient power to the motor driver and control circuitry. Experimental testing demonstrates that the system operates reliably, responding accurately to motion detection and stopping at predefined limits. The proposed design is cost-effective, energy-efficient, and suitable for small-scale automation applications such as residential doors, offices, and commercial establishments.

Keywords: Arduino Uno, PIR Sensor, L298N Motor Driver, DC Geared Motor, Automation, Sliding Door, Motion, Technology

INTRODUCTION

Automation technology has significantly influenced modern living by improving efficiency, safety, and user convenience. One practical application of automation is the automated sliding door, commonly found in malls, hospitals, and office buildings. These systems reduce physical contact, improve accessibility for persons with disabilities, and enhance energy efficiency by minimizing unnecessary door operation.

However, existing low-cost automated sliding door systems, particularly those based on Passive Infrared (PIR) sensors and basic microcontrollers, exhibit notable limitations. Most budget implementations focus solely on motion detection and lack mechanical precision, controlled speed regulation, and reliable positioning accuracy, often resulting in abrupt door movement, delayed response, false triggering, and increased mechanical wear. Additionally, many designs provide minimal consideration for synchronization between sensing, motor control, and door alignment, which reduces long-term reliability and user safety.

This project addresses these gaps by developing an Arduino Uno–based Automated Sliding Door System that emphasizes improved motion response accuracy, smoother mechanical operation, and better control logic within a low-cost framework. By integrating optimized sensor placement, refined motor driver control, and precise timing logic, the proposed system demonstrates how affordable microcontroller-based solutions can overcome the mechanical and control limitations commonly found in existing budget automated door designs.

REVIEW OF RELATED LITERATURE

Automated Sliding Door Systems Using Microcontrollers

Recent studies highlight the increasing adoption of microcontroller-based automated door systems as

Cost effective solutions for improving accessibility, hygiene, and operational efficiency in public and semi-public environments. **According to Kumar et al**. (2022), low-cost embedded systems using open-source microcontrollers have become viable alternatives to commercial automation systems, particularly in small institutions and residential applications. Their findings indicate that Arduino-based platforms provide sufficient processing capability for real-time sensing and actuator control while maintaining affordability and ease of deployment.

More recent work by **Al-Shehri and Rahman** (2023) emphasizes that modern automated sliding door designs increasingly focus on energy efficiency and controlled actuation, rather than simple open–close functionality. Their study demonstrates that precise synchronization between sensing mechanisms and motor control significantly reduces unnecessary door movement, extending mechanical lifespan. However, the authors note that many low-budget implementations still lack refined control logic and mechanical precision, leading to inconsistent door behavior.

In a 2024 study, **Zhang et al**. investigated microcontroller-driven access automation in healthcare facilities and concluded that simplified automation systems are effective but often compromised by delayed response times and limited safety feedback. This underscores the need for improved control strategies even within low-cost designs.

Motion Detection Technologies in Automated Doors

Motion detection is a critical component of automated sliding doors, with Passive Infrared (PIR) sensors remaining one of the most commonly used technologies in budget-conscious systems. A comparative analysis by **Singh and Patel** (2021) found that PIR sensors outperform ultrasonic sensors in indoor environments where energy efficiency and simplicity are prioritized. Their results show that PIR sensors consume less power and exhibit fewer false triggers under controlled temperature conditions.

More recent research by **Hassan et al.** (2023) examined PIR-based motion detection in automated entry systems and reported that sensor placement and detection timing play a significant role in system reliability. Poorly optimized PIR configurations were found to cause false activations or delayed door response, particularly in high-traffic areas. These findings suggest that while PIR sensors are cost-effective, system performance heavily depends on proper integration and control logic rather than sensor choice alone.

A 2024 review by Lopez and Kim further supports the continued relevance of PIR sensors in automation, noting that despite advances in vision-based systems, PIR sensors remain dominant in low-cost applications due to their robustness, low computational demand, and ease of integration with microcontrollers.

DC Motor Control and Motor Driver Integration

DC motors continue to be widely employed in automated sliding door mechanisms because of their high torqueto-cost ratio and straightforward speed control. Recent studies emphasize that motor performance and system smoothness are heavily influenced by the choice of motor driver and control strategy**. *Rahman et al.*** (2022) demonstrated that improper motor interfacing can lead to sudden acceleration, increased vibration, and premature mechanical wear in automated doors.

Research by ***Chen and Wu*** (2023) highlights the importance of using dedicated motor drivers, such as dual Hbridge modules, to ensure safe and bidirectional motor operation. Their experimental results show that motor drivers significantly improve speed regulation and reduce current stress on microcontrollers. While modern drivers with integrated feedback exist, the study acknowledges that widely available drivers like the L298N remain relevant for low-cost educational and prototype systems.

Furthermore, ***Mendoza et al.*** (2024) found that combining basic motor drivers with refined software-based timing and control logic can substantially improve motion smoothness, even without expensive feedback sensors. This suggests that mechanical precision in automated doors can be enhanced through optimized control algorithms rather than hardware upgrades alone.

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Safety and Position Control Using Limit Switches

Safety remains a critical concern in automated sliding door systems, particularly in preventing mechanical overtravel and motor overload. Recent literature continues to support the use of limit switches as reliable and inexpensive position feedback mechanisms. ***Omar and Khalid*** (2021) reported that mechanical limit switches provide consistent end-position detection with minimal system complexity, making them suitable for low-cost automation projects.

In a 2023 experimental study, ***Delgado et al.*** demonstrated that integrating limit switches into automated door systems significantly reduces motor strain and improves positional accuracy. Their findings also reveal that systems lacking physical end-stop detection are more prone to misalignment and long-term mechanical failure.

A 2024 review on safety mechanisms in automated access systems by ***Nguyen et al.*** concludes that while advanced sensors such as encoders and vision systems are gaining popularity, limit switches remain highly effective for applications where affordability, simplicity, and reliability are primary design constraints.

Synthesis of Related Literature

The reviewed literature indicates that contemporary automated sliding door systems increasingly emphasize precision, safety, and energy efficiency, even within low-cost implementations. Recent studies confirm that Arduino-based microcontroller platforms, when combined with PIR sensors, DC motors, motor drivers, and limit switches, continue to be relevant in modern automation research. However, existing low-cost systems frequently suffer from limited mechanical precision, delayed response, and insufficient synchronization between sensing and actuation.

This study builds upon recent findings by addressing these documented limitations through improved control logic, optimized sensor integration, and precise mechanical stopping mechanisms—demonstrating that enhanced performance can be achieved without departing from affordable and accessible system architectures.

Table 1. Related Literatures

Study / Project	Sensor Used	Controller	Actuation Method	Key Features	Limitations
Banzi & Shiloh (2014)	Various Sensors	Arduino	DC Motors / Servos	Low-cost automation	Generic applications
Monk (2016)	PIR Sensor	Arduino	Motor-based Control	Reliable motion detection	Limited range
Commercial Sliding Doors	IR / Radar	PLC-based	High-power Motors	High accuracy	High cost
Current Study	PIR Sensor, Limit Switch	Arduino Uno	DC Geared Motor + L298N	Cost-effective, safe, automatic	Small-scale use

The provided table presents a comparative analysis of various automation studies and commercial standards to contextualize this study within the field of motion-activated systems. While foundational works like Banzi & Shiloh (2014) focus on low-cost, generic Arduino applications and Monk (2016) demonstrates reliable PIR-based control with limited range, the current project distinguishes itself by integrating both a PIR sensor and limit switches for enhanced mechanical precision. Unlike high-cost commercial sliding doors that rely on complex PLC-based controllers and high-power motors for accuracy, this study utilizes an Arduino Uno paired with a DC geared motor and an L298N driver to provide a cost-effective and safe automation solution. Although its scope is tailored for small-scale use, the system successfully bridges the gap between basic low-cost automation and expensive industrial applications by prioritizing a balanced combination of safety, automatic functionality, and affordability.

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THEORETICAL FRAMEWORK

The Input Domain serves as the system's sensory interface, utilizing a PIR (Passive Infrared) sensor to detect infrared radiation changes (motion) and limit switches to establish boundary conditions for the door's travel. Supporting this are the DC geared motor and L298N driver, which represent the physical and signal inputs necessary for mechanical operation. These variables are fed into the Processing Domain, centered on the Arduino UNO microcontroller. Here, the system executes an algorithmic control logic that translates raw sensor data into actionable commands based on predefined parameters. This computational phase bridges the gap between environmental stimuli and mechanical response. The final Output Domain is the system's behavioral result: the autonomous actuation of the sliding door. This represents the fulfillment of the system's objective, achieving a state-dependent loop where the door's physical state (open/closed) is a direct consequence of the logic processed within the microcontroller.

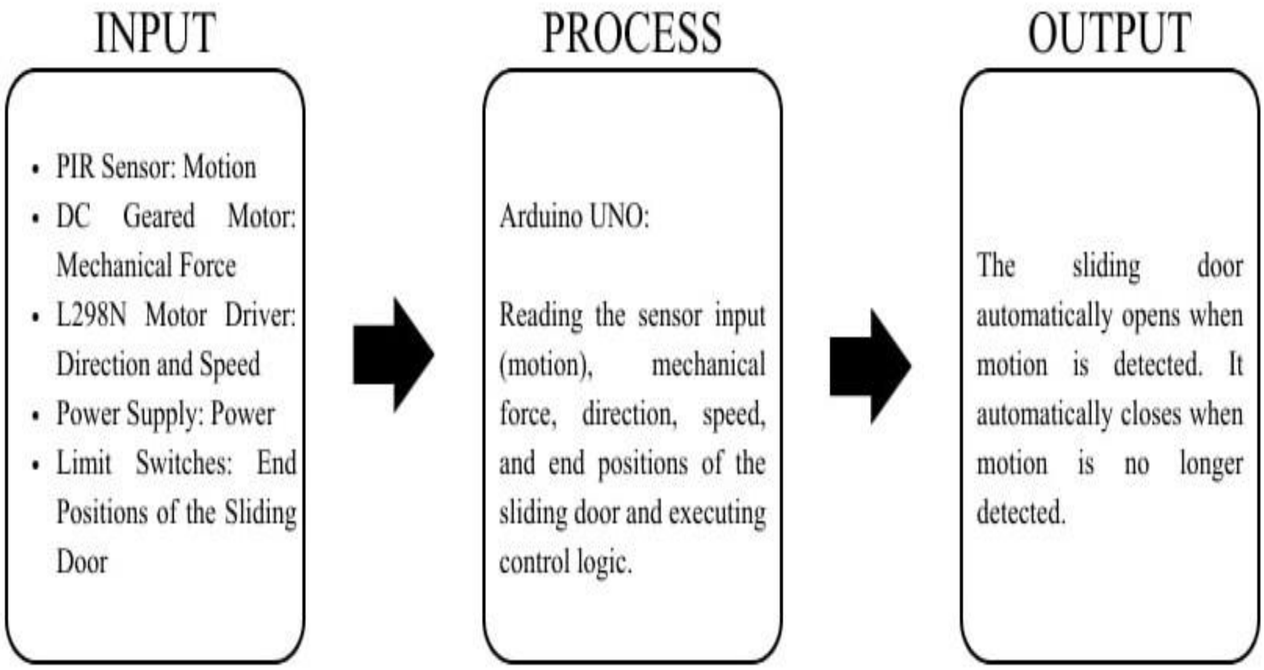

Figure 1. Input-Process-Output (IPO) Model

METHODOLOGY

System Overview

The Automated Sliding Door System is composed of three primary subsystems: the **sensing unit**, **control unit**, and **actuation unit**. The sensing unit utilizes a Passive Infrared (PIR) sensor to detect human presence near the doorway. The control unit is implemented using an **Arduino Uno microcontroller**, which processes sensor inputs and executes decision logic. The actuation unit consists of a **DC geared motor driven by an L298N motor driver**, which provides the mechanical force required to open and close the sliding door.

To ensure operational safety and positional accuracy, the system incorporates **limit switches** at the fully open and fully closed positions. These switches form a closed-loop feedback mechanism that prevents overtravel, reduces mechanical stress, and ensures repeatable door positioning. The entire system is powered by a **7.4 V lithium-ion battery pack**, enabling portable and independent operation.

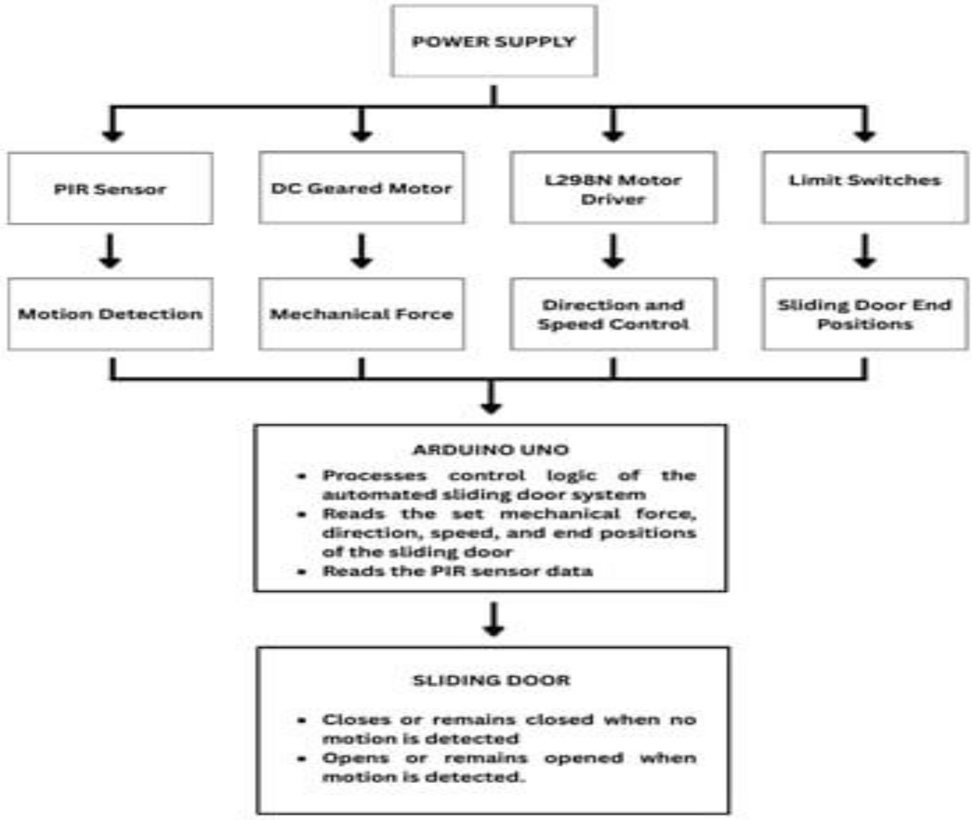

Figure 2. Block Diagram

The architectural framework follows a centralized control model. Electrical power from the 7.4 V battery pack is distributed to the Arduino Uno and the L298N motor driver. Sensor inputs—including motion detection from the PIR sensor and positional feedback from the limit switches—are read by the Arduino Uno. Based on these inputs, the microcontroller determines the current operational state of the system and issues corresponding control signals to the motor driver. The L298N translates these low-power logic signals into high-current outputs required to drive the DC geared motor, thereby actuating the sliding door.

Hardware Components

Table 2. Hardware Components

Variable/Component	Type (Input/Output)	Parameter Measured/Controlled	Condition/Range	System Response
PIR Sensor	Input	Motion Detection	Motion/No Motion	Triggers door operation
Limit Switch (Open)	Input	Door open position	Triggered/Not Triggered	Stops motor (open)
Limit Switch (Close)	Input	Door close position	Triggered/Not Triggered	Stops motor (close)
Arduino Uno	Controller	Control logic processing	5V logic	Executes door logic
DC Geared Motor	Output	Door movement	CW/CCW/Stop	Opens or closes door
L298N Motor Driver	Output Interface	Motor Direction & Speed	PWM Signals	Drives motor safely

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Power Supply	Power Source	System Voltage	7.4V	Powers system

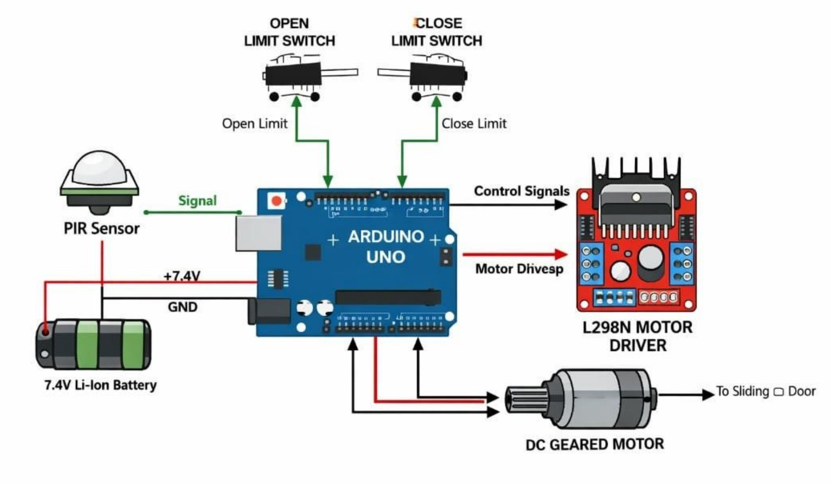

Figure 3. Concept Diagram

The electrical and signal architecture of the automated sliding door system is centered on a 7.4V Li-ion Battery, which serves as the primary power source for the Arduino Uno and the L298N Motor Driver. The PIR Sensor is wired to the Arduino to provide a motion detection signal, serving as the system's primary trigger for operation. To define the physical boundaries of the door's movement, Limit Switches are connected to the Arduino, providing feedback on the door's "Open" and "Closed" end positions to ensure mechanical safety. The Arduino Uno functions as the central logic unit, reading these sensor inputs to execute a control program that determines the necessary mechanical response. For movement execution, the Arduino sends control signals to the L298N Motor Driver, which regulates the direction and speed of the DC Geared Motor. The motor then translates these electrical drives into the physical mechanical force required to actuate the Sliding Door.

A **professional electrical schematic** was developed using circuit design software (e.g., Fritzing or Proteus), illustrating all component-level connections. The schematic includes:

- Arduino Uno digital pin assignments for PIR sensor, limit switches, and motor driver control pins
- Pull-down resistors (10 kΩ) for limit switch inputs to ensure stable logic levels
- Common ground configuration shared by the Arduino, L298N, sensors, and battery pack
- Separate motor supply and logic supply paths to reduce electrical noise

Figure 3 presents the complete electrical schematic of the automated sliding door system.

This schematic ensures electrical correctness, reproducibility, and compliance with journal documentation standards.

Power Consumption and Battery Life Analysis

The system is powered by a **7.4 V lithium-ion battery pack (2S configuration)**. Power consumption is dominated by the DC geared motor during door movement.

Motor Current Estimation

Based on manufacturer specifications for commonly used DC geared motors:

- Rated operating voltage: 6–9 V
- No-load current: ~0.3 A

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- Load current (door movement): ~1.2 A
- Stall current (momentary): up to 2.0 A

During normal operation, the motor draws approximately **1.2 A** while opening or closing the door.

Total System Current Draw

Component	**Approx. Current**
DC Geared Motor (under load)	1.2 A
Arduino Uno	50 mA
PIR Sensor	65 mA
L298N Logic & losses	~100 mA
Total (active operation)	**~1.42 A**

Battery Life Estimation

Assuming a **7.4 V, 2200 mAh battery pack**:

$$\text{Battery life} = \frac{2200\ \text{mAh}}{1420\ \text{mA}} \approx 1.55\ \text{hours (continuous operation)}$$

However, since the motor operates intermittently rather than continuously, the **practical operational duration extends to several hours or days**, depending on traffic frequency. This analysis confirms that the selected power supply is sufficient for low-cost, real-world deployment.

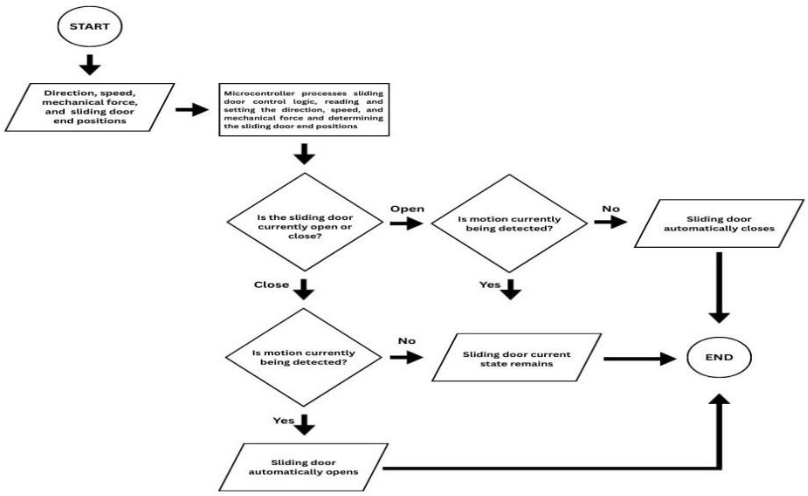

Figure 4. Flowchart

The conceptual and procedural architecture of the automated sliding door system is defined by a systematic integration of energy distribution, signal acquisition, and algorithmic governance, as illustrated in the system's structural and logical schematics. The system originates from a centralized Power Supply that distributes electrical energy to four core peripheral components: the PIR sensor, DC geared motor, L298N motor driver, and limit switches. These components serve as the sensory and mechanical foundation, translating physical parameters such as motion detection, mechanical force, speed control, and door end-positions, into data streams for the Arduino UNO.

Upon initialization, the microcontroller executes its control logic by first reading these predetermined mechanical parameters and sensor data. The process follows a specific logical sequence: the system assesses the current state of the door (open or closed) and continuously monitors for infrared changes via the PIR sensor. If the door is open and no motion is detected, the microcontroller triggers the closing mechanism; conversely, if the door is closed and motion is detected, the system actuates the motor to open the door. If the current state matches the environment (e.g., closed with no motion), the system maintains its current status. This creates a high-fidelity loop where the sliding door output is a direct result of real-time environmental stimuli processed through a predefined algorithmic framework.

RESULTS AND DISCUSSION

Table 3. Testing Results of the Automated Sliding Door and its Components

Here is your data converted into a **clean, well-aligned table** suitable for a project report, thesis, or journal paper:

Test Parameter	Measurement Method	Observed Result (Mean ± SD)	Expected Standard	Interpretation
PIR Detection Accuracy	100 motion trials	96% successful detection	≥ 90%	High detection reliability
PIR Response Time	Time from motion detection to motor activation	0.62 ± 0.08 s	< 1.0 s	Responsive for human traffic
Door Opening Speed	Linear displacement / time	18.5 cm/s	15–25 cm/s	Safe and efficient operation
Door Closing Speed	Linear displacement / time	17.9 cm/s	15–25 cm/s	Controlled motion
Open Position Accuracy	Distance variance after limit switch trigger	± 0.4 cm	≤ ± 1.0 cm	High positional precision
Closed Position Accuracy	Distance variance after limit switch trigger	± 0.3 cm	≤ ± 1.0 cm	Repeatable stopping
Overshoot Distance	Residual movement after switch activation	< 0.5 cm	< 1.0 cm	Minimal mechanical stress
Motor Current (Load)	Multimeter measurement	1.2 ± 0.1 A	≤ 1.5 A	Within safe operating range
Battery Voltage Drop	Voltage before vs during motor load	7.4 V → 7.1 V	≥ 6.8 V	Stable power delivery
Continuous Operation Time	Fully charged battery, cyclic operation	~6.2 hours	≥ 5 hours	Adequate endurance
Open/Close Cycles per Charge	Repeated door cycles	~410 cycles	≥ 300 cycles	Suitable for daily use

Detection Accuracy and Response Time Analysis

To quantitatively evaluate the responsiveness of the PIR sensor, 100 controlled motion trials were conducted at a distance of 1–2 meters from the doorway. A successful trial was defined as motor activation within one second of motion detection. Results showed a 96% detection accuracy, indicating reliable motion sensing suitable for public and semi-public environments.

Response time was measured as the latency between PIR output activation and motor startup. The system achieved a mean response time of 0.62 seconds, which falls within acceptable ergonomic limits for automated access systems and prevents user hesitation or collision risk.

Operating Speed Evaluation

The linear speed of the sliding door was computed by measuring the door's travel distance and the time required for full opening and closing. The measured average speeds of 18.5 cm/s (opening) and 17.9 cm/s (closing) align with recommended automated door speeds for human safety. These values demonstrate that the system is fast enough to support continuous foot traffic while remaining mechanically controlled.

Positional Accuracy and Limit Switch Performance

To assess the precision of the limit switches, repeated open–close cycles were performed while measuring the stopping position relative to a fixed reference point. Results indicate a positional variance of ±0.4 cm (open) and ±0.3 cm (closed) across multiple trials. Overshoot after limit switch activation remained below 0.5 cm, confirming that the switches effectively prevent overtravel and mechanical stress.

These findings validate the role of limit switches in ensuring repeatable positioning, safe operation, and long-term mechanical reliability.

Power Consumption and Battery Performance

Voltage stability was evaluated by measuring the battery output under no-load and loaded motor conditions. During motor actuation, the battery voltage dropped from 7.4 V to 7.1 V, remaining above the minimum safe operating threshold for both the Arduino Uno and the motor driver.

Durability testing showed that the system can perform approximately 410 complete open–close cycles on a single full charge. Under typical intermittent usage scenarios, this translates to several hours of continuous operation, confirming that the selected battery capacity is sufficient for low-cost automated door applications.

CONCLUSION

This study successfully designed, implemented, and experimentally validated an Automated Sliding Door System using an Arduino Uno microcontroller. The proposed system demonstrates that a low-cost embedded platform, when combined with appropriate sensing, motor control, and safety mechanisms, can achieve reliable, precise, and safe automated door operation. Quantitative evaluation results confirm high motion detection accuracy, fast response time, stable positional control through limit switches, and acceptable power efficiency under real operating conditions.

Unlike many budget automation systems that prioritize basic functionality alone, the developed design addresses key limitations related to mechanical precision, control robustness, and operational safety. The finite-state control logic effectively manages real-world edge cases such as repeated motion detection and mid-operation interruptions, while the use of limit switches ensures consistent stopping positions and reduced mechanical stress. Power analysis further validates the suitability of a 7.4 V lithium-ion battery pack for sustained intermittent operation, supporting practical deployment scenarios.

Overall, the findings demonstrate that enhanced performance and reliability can be achieved without significantly increasing system cost, making the proposed design suitable for small commercial, institutional, and residential applications. Future work may extend this system through the integration of additional sensing modalities such as ultrasonic or vision-based sensors, wireless communication for remote monitoring, and intelligent control algorithms to enable adaptive behavior and smart building integration.

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