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ProxiFan: A Sensor-Activated Electric Fan Using Arduino

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Abstract

This study presents the design, development, and evaluation of ProxiFan, a sensor-activated electric fan using Arduino technology. Traditional electric fans rely on manual operation, often leading to energy inefficiency and reduced user convenience. ProxiFan integrates a Passive Infrared (PIR) motion sensor, an Arduino Uno R4 WiFi microcontroller, relay modules, and a mobile application to automate fan operation based on human presence while allowing manual override and remote control. Guided by the Agile Development Life Cycle, the system underwent iterative design, implementation, and testing. Evaluation was conducted through expert assessment using ISO/IEC 25010 quality characteristics and usability criteria. Results indicate that ProxiFan demonstrates strong functional suitability, reliability and user satisfaction. The system provides an effective, low-cost smart-home solution for automated climate control.

Keywords: *IoT Automation, Smart Fan System, PIR Sensor, Arduino Microcontroller, Mobile App Integration, Agile Methodology, Expert Evaluation.*

1. Introduction

The rapid advancement of Internet of Things (IoT) technologies has transformed household appliances into intelligent systems capable of adapting to user behavior and environmental conditions [1]. Automation using sensors and microcontrollers has become a practical approach to improving comfort, efficiency, and energy conservation in residential

and office environments [2]. Among commonly used appliances, electric fans remain essential, particularly in tropical regions; however, most conventional fans still rely on manual switching, which can result in unnecessary power consumption when left operating in unoccupied spaces [3]. Existing smart fan solutions often depend on temperature-based automation or continuous user input through mobile applications [4], [5]. While effective, these approaches may continue operating even when no occupants are present or require additional user interaction. A simple, privacy-preserving, and cost-efficient system that responds directly to human presence rather than environmental conditions alone meets the need for the emphasized gap. ProxiFan: A Sensor-Activated Electric Fan Using Arduino addresses this gap by integrating motion-based automation through a PIR sensor with Arduino-based control logic and optional mobile application interaction. The system automatically activates when human presence is detected and deactivates after inactivity, minimizing energy waste while maintaining user comfort.

1.1 Objectives of the study

This study aims to develop PROXIFAN: A SENSOR-ACTIVATED ELECTRIC FAN USING ARDUINO.

Specifically, it aims to:

1. Design and develop ProxiFan, a smart electric fan that automatically turns on or off when a person is detected nearby.
2. Integrate Arduino technology to enhance automation capabilities.
3. To incorporate the key functionalities of ProxiFan, including:
   a. Adjustable fan speed
   b. Real-time status monitoring
   C. Dual operating modes (manual and automatic)
4. To provide a hands-free and an android mobile application-based method of operating the fan for improved user convenience.
5. Determine developed the quality system of based the on ISO/IEC 25010:2011 Systems and Software Quality Requirements and Evaluation (SQuaRE) Quality Model
6. Determine the usability of the developed system based on the following criteria: Usefulness; Satisfaction; Ease of Use and Learning.

2. Methods

The research study of ProxiFan: A Sensor-Activated Electric Fan Using Arduino operates with Developmental Research Design, focusing on the systematic design, development, testing, and evaluation of an IoT-based hardware–software system. Agile Methodology serves as the foundation method as it presents adaptability and response to changes that were so important in our approach [6], [7].

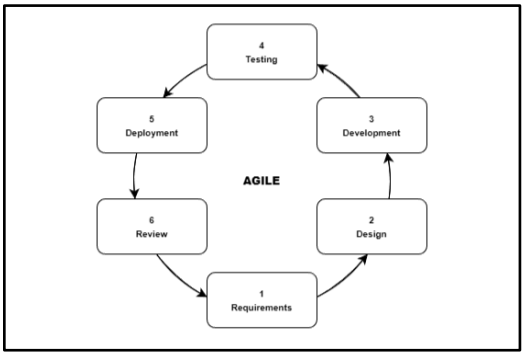

Fig. 1 Agile Development Method

Phase 1. Requirements Gathering and Analysis

This phase focused on identifying the functional and non-functional requirements of the ProxiFan system. Key requirements include automatic fan activation through human presence detection, adjustable fan speeds, manual override capability, and mobile application integration. Non-functional requirements such as reliability, safety, usability, and maintainability were also defined. Users expectations and system constraints were analyzed to establish clear development objectives.

Phase 2. Design

During the design phase, the system architecture and physical layout of ProxiFan was put into

concept. This includes the creation of wiring diagrams, system flow logic, and enclosure design. Hardware components such as the Arduino Uno R4 WiFi, PIR sensor, relay modules, speed control capacitors, LED indicators, and power supply were logically arranged to ensure safe power distribution and efficient signal flow using few references [8]. The interaction between automatic (sensor-based) and manual (mobile application) control modes was also defined at this stage.

Phase 3. Development

In this phase, the actual construction and programming of the ProxiFan prototype were carried out. Hardware components were assembled based on the finalized wiring diagram, while the Arduino microcontroller was programmed to process motion detection signals, control fan operation, manage speed levels, and synchronize with the mobile application. Iterative system development was applied to refine code logic, improve response time, and ensure stable system behavior.

Phase 4. Testing

The testing phase involved evaluating the functionality and performance of the ProxiFan system in a controlled environment. Tests were conducted to verify accurate motion detection, correct fan activation and deactivation, reliable speed control, and seamless communication between the mobile application and the Arduino controller. Hardware stability, relay switching accuracy, and LED status indicators were also examined. Identified issues were corrected and retested to ensure system reliability.

Phase 5. Deployment

After successful testing, the ProxiFan system was deployed for actual use and demonstration. The system was operated under real-world conditions to observe response behavior, sensor accuracy, and user interaction. Users were taught on system operation, including automatic and manual control modes. Performance data and user observations were gathered to assess operational effectiveness.

Phase 6. Review

The final phase focused on system evaluation and validation. Expert assessments were conducted using structured questionnaires tailored on the ISO/IEC 25010:2011 Systems and Software Quality Requirements and Evaluation (SQuaRE) Quality Model and Usability criteria: Usefulness; Satisfaction; Ease of Use and Learning [9], [10]. The collected data were analyzed using descriptive statistics to determine the overall quality and usability of the ProxiFan system. Feedback from this phase was used to identify limitations and recommend future improvements.

2.1 System Architecture and Materials

The ProxiFan: A Sensor-Activated Electric Fan Using Arduino, consists of the following primary components:

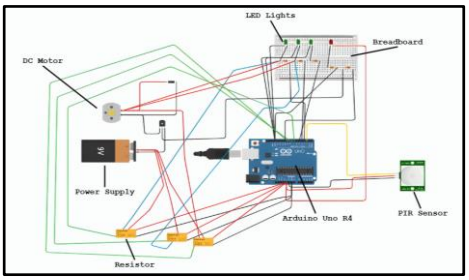

Fig. 2 Wiring Diagram

- Arduino Uno R4 WiFi microcontroller
- HC-SR501 PIR motion sensor
- Relay modules for AC fan control
- Speed control capacitor for multi-speed operation
- LED indicators for system and speed status
- Rocker switch for manual power control
- Android-based mobile application for remote operation

3. Results

Table 1. In terms of automatically turning the fan on or off when motion is detected

Automation Functionality Using Arduino Technology	Mean	Verbal Interpretation
How functional is the automatic motion detection feature of the ProxiFan?	4.67	Functional
How functional is the fan in detecting a person's presence accurately?	4.00	Functional
How functional is the fan in responding quickly when motion is detected?	4.67	Functional
How functional is the automatic on-and-off operation when a person approaches or leaves?	4.33	Functional
How functional is the motion detection system in improving daily convenience?	4.33	Functional
How functional is the motion detection feature in avoiding false detections?	4.00	Functional
How functional is the motion sensor during low-light or dim lighting conditions?	4.33	Functional
Total	**4.33**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 1 shows the results of IT expert's evaluation on ProxiFan: A Sensor-Activated Electric Fan Using Arduino based automatic on/off feature using motion detection. The feature received an average rating of 4.33, showing that it is Functional. The experts found all aspects effective and reliable, although small improvements in motion detection could still improve its accuracy and responsiveness.

Table 2. In terms of integrating Arduino technology for automated fan control

Functionality of the Integration of Arduino Technology	Mean	Verbal Interpretation
How functional is the Arduino system in automating the ProxiFan's operations?	4.67	Functional
How functional is the Arduino system in maintaining stable performance during operation?	5.00	Excellent
How functional is the Arduino integration in ensuring reliable automation?	4.67	Functional
How functional is the Arduino technology in enhancing the overall efficiency of the fan?	4.67	Functional
How functional is the Arduino-based control in achieving the automation goals of the ProxiFan?	4.33	Functional
How functional is the Arduino system in processing sensor inputs and responding accurately?	4.33	Functional
How functional is the Arduino integration in preventing system delays or lag in fan operation?	4.67	Functional
Total	**4.62**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 2 shows the results from the IT experts evaluation in terms of integrating Arduino technology for automated fan control. The integration achieved a total mean score of 4.62, indicating Functionality on the integrated system.

Table 3. In terms of the general functionality of the adjustable fan speeds of the ProxiFan: A Sensor-Activated Electric Fan Using Arduino

In terms of the general functionality of the adjustable fan speeds in the Proxifan	Mean	Verbal Interpretation
How functional is the adjustable fan speed feature of the ProxiFan?	4.33	Functional
How functional is the speed adjustment control in the mobile application?	4.67	Functional
How functional is the fan in smoothly changing between speed levels?	4.67	Functional
How functional is the speed control in maintaining the selected fan speed?	5.00	Excellent
How functional is the adjustable speed feature in providing user comfort?	5.00	Excellent
How functional is the fan speed control feature in responding immediately to user input?	4.67	Functional
How functional is the fan in recalling the last selected speed after restart or power interruption?	4.67	Functional
How functional is the real-time monitoring in preventing confusion by presenting clear and easy-to-read information?	4.67	Functional
Total	**4.71**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 3 shows the results of IT expert's evaluation of ProxiFan: A Sensor-Activated Electric Fan Using Arduino in terms of the general functionality of the adjustable fan speeds feature. The result indicates a total mean score of 4.71, which is considered Functional.

Table 4. In terms of functionality of Real-Time Status Monitoring

Functionality of Real-Time Status Monitoring	Mean	Verbal Interpretation
How functional is the real-time status monitoring feature of the ProxiFan?	4.67	Functional
How functional is the display in showing the current fan status (on/off, speed, etc.)?	4.67	Functional
How functional is the application interface in presenting the fan's real-time updates?	4.67	Functional
How functional is the real-time monitoring system in providing accurate status information?	4.67	Functional
How functional is the status display feature in helping users track the fan's operation?	4.67	Functional
Total	**4.67**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 4 shows the feedback from IT experts on ProxiFan: A Sensor-Activated Electric Fan Using Arduino in terms of functionality of real-time status monitoring feature. All indicators received a consistent mean score of 4.67, which implies that the features are all functional in providing accurate and updated fan information. This implies that the current design is performing effectively though it may still be enhanced further, considering that this functionality would benefit from further refinement to ensure more accuracy in fan information provisions.

Table 5. In terms of incorporating automatic modes into the ProxiFan: A Sensor-Activated Electric Fan Using Arduino

Functionality of Automatic Modes	Mean	Verbal Interpretation
How functional is the automatic mode in detecting a person's presence?	4.67	Functional
How functional is the automatic mode in turning the fan ON when motion is detected?	4.33	Functional
How functional is the automatic mode in turning the fan OFF when no motion is detected?	4.67	Functional
How functional is the automatic mode in maintaining proper fan behavior when users enter the room?	4.67	Functional
How functional is the automatic mode in maintaining proper fan behavior when users leave the room?	4.67	Functional
How functional is the automatic mode in using the last selected fan speed when it turns ON automatically?	4.67	Functional
How functional is the automatic mode in preventing unnecessary activation when there is no real human movement?	4.67	Functional
Total	**4.62**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 5 shows the evaluation of ProxiFan: A Sensor-Activated Electric Fan Using Arduino in terms of incorporating automatic modes by IT experts. The automatic modes received a lower score of 4.33 when turning the fan ON with motion detection, suggesting the need for improved accuracy. The rest of the aspect features in terms of incorporating automatic modes in the ProxiFan system received a consistent rating of 4.67. Despite this, the integrated functionality was rated with an average score 4.62, showing that the automatic modes are all Functional. The IT experts find the capability of the integration reliable and functional while allowing room for improvement for better enhancement in automatic approach.

Table 6. In terms of incorporating manual modes into the ProxiFan: A Sensor-Activated Electric Fan Using Arduino

Functionality of Manual Modes	Mean	Verbal Interpretation
How functional is the manual mode in allowing the user to turn the fan ON through the mobile app?	5.00	Excellent
How functional is the manual mode in allowing the user to turn the fan OFF through the mobile app?	5.00	Excellent
How functional is the manual mode in allowing the user to change the fan speed using the app?	5.00	Excellent
How functional is the manual mode in re-enabling automation once the user turns the fan ON again in the app?	4.67	Functional
Total	**4.91**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 6 shows the evaluation of ProxiFan: A Sensor-Activated Electric Fan Using Arduino in incorporating manual modes by IT experts. The functionality of incorporating manual modes received the three highest mean scores of 5.00, indicating excellent performance in allowing users to control the fan through the mobile application. Thus, it received an average rating of 4.91, which implies that it is Functional. Among the three 5.00 scores of the capabilities of the manual feature, the ability to restore automation when the fan was turned on again in the application got the lowest rating of 4.67, which implies the need for further enhancement for better performance.

Table 7. In terms of providing a hands-free operation of the ProxiFan: A Sensor-Activated Electric Fan Using Arduino

Functionality of Hands-Free Operations	Mean	Verbal Interpretation
How functional is the hands-free operation of the ProxiFan?	5.00	Excellent
How functional is the overall system in offering a convenient hands-free experience?	4.67	Functional
Total	**4.83**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 7 presents the feedback of the IT expert's evaluation in terms of providing a hands-free experience. The ProxiFan: A Sensor-Activated Electric Fan Using Arduino received a total mean score of 4.83, which is considered Functional. The ProxiFan meets the terms of improved user convenience by providing a convenient hands-free experience and operations.

Table 8. In terms of integrating an Android app-based method of operating the ProxiFan: A Sensor-Activated Electric Fan Using Arduino

Functionality of App-Based Operations	Mean	Verbal Interpretation
How functional is the mobile application in controlling the fan's features?	4.67	Functional
How functional is the app-based control in providing ease of operation?	5.00	Excellent
How functional is the fan's response to commands from the Android application?	4.67	Functional
How functional is the mobile application in providing a smooth and responsive user experience when controlling the ProxiFan: A Sensor-Activated Electric Fan Using Arduino?	4.67	Functional
How functional are the buttons in the mobile app in terms of sensitivity, smoothness, and ease of tapping?	5.00	Excellent
How functional is the mobile app in responding immediately to user commands in terms of speed change?	4.67	Functional
How functional is the mobile app in responding immediately to user commands in terms of ON/OFF buttons?	5.00	Excellent
How functional is the mobile app in terms of layout clarity?	4.67	Functional
How functional is the mobile app in terms of button placement?	4.33	Functional
How functional is the mobile app in providing a clean and user-friendly interface for first-time users of the ProxiFan?	4.33	Functional
How functional are the labels, icons, text, fonts, colors, and spacing in the mobile app in providing clear and understandable information to the user?	4.67	Functional
How functional is the arrangement of control buttons and status indicators in the mobile app for easy access and usage?	5.00	Excellent
How functional is the Real-Time Status section of the app in displaying accurate, complete, and up-to-date information about the fan?	4.67	Functional
How functional is the mobile app installer in terms of requiring minimal device storage and system resources?	4.33	Functional
How functional is the app installation process in terms of speed and completion time and ensuring the app runs properly after being successfully installed?	4.67	Functional
How functional is the overall system in offering a convenient app-based experience?	4.67	Functional
Total	**4.68**	**Functional**

Legend: 1-Not Functional; 2-Slightly Functional; 3-Moderately Functional; 4-Functional; 5-Excellent;

Table 8 presents the evaluation of ProxiFan's Android app-based control features by IT experts. The integrated feature received a high total mean score of 4.68, which is deemed Functional. Most features, such as ease of operation, button responsiveness and seamless arrangement for easy access and usage, were rated very highly, showing that the system provides a convenient and user-friendly experience. On the other hand, lower ratings given to button placement, storage requirements, and interface familiarity suggest that further enhancement was noted to further improve ease of use, especially for first-time users. To sum it up, the integration is effective and reliable, with small refinements recommended to enhance the user experience.

Table 9. In terms of the characteristics set in the ISO/IEC 25010:2011 Systems and Software Quality Requirements

Criteria	Mean	Verbal Interpretation
Functional Suitability	4.33	Satisfied
Reliability	4.67	Satisfied
Maintainability	4.67	Satisfied
Flexibility	4.42	Satisfied
Safety	4.50	Satisfied
Total	**4.51**	**Satisfied**

Legend: 1-Strongly Dissatisfied; 2-Slightly Dissatisfied; 3-Slightly Satisfied; 4-Satisfied; 5-Excellent;

Table 9 presents the evaluation of ProxiFan based on the ISO 25010 Software Quality Model [9]. The results show high ratings across all quality criteria, with an overall mean score of 4.51, indicating strong user satisfaction. Reliability and Maintainability received the highest ratings, depicting that the system operates consistently and can be easily maintained. Functional Suitability received the lowest rating, suggesting that while the system meets user needs, some improvements could further enhance its features. With this, the findings confirm that ProxiFan demonstrates strong software quality performance.

Table 10. In terms of usefulness, ease of use, ease of learning, and satisfaction

Criteria	Mean	Verbal Interpretation
Usefulness	4.48	Satisfied
Ease of Use	4.85	Satisfied
Ease of Learning	5.00	Excellent
Satisfaction	4.86	Satisfied
Total	**4.79**	**Satisfied**

Legend: 1-Strongly Dissatisfied; 2-Slightly Dissatisfied; 3-Slightly Satisfied; 4-Satisfied; 5-Excellent;

Table 10 determines the usability evaluation of the ProxiFan IoT device based on usefulness, ease of use, ease of learning, and satisfaction [10]. Ease of Learning received the highest rating, implying that the system is easy to understand and operate. It received a 4.79 rating which has a verbal interpretation, Satisfied.

4. Discussions

The following are the detailed presentation, discussions, interpretation, and analysis of research findings:

1. In terms of automatically turning the fan on or off when motion is detected, the overall functionality received a total mean score of 4.33, which is considered Functional.
2. In terms of integrating Arduino technology for automated fan control, the overall functionality garnered a mean score of 4.62, indicating that the Arduino is performing very well in automating the ProxiFan's operations.
3. In terms of the general functionality of the adjustable fan speeds in the Proxifan, it yielded a total mean score of 4.71, indicating that the adjusting fan speed is seamless and commendable.
4. In terms of the functionality of real-time status monitoring, the feature received a total mean of 4.67. All indicators were rated 4.67, showing that the real-time status updates, status display, and interface for presenting fan information are highly functional.
5. In terms of incorporating automatic modes into the ProxiFan, the feature was rated a total average of 4.62, indicating that the IoT system is functioning well. The lowest rating of 4.33 was given to the automatic mode's ability to prevent unnecessary activation without real human movement, suggesting a need to improve accuracy and reduce false triggers.
6. In terms of incorporating manual modes into the ProxiFan, the feature received an overall mean rating of 4.91, indicating that the incorporation of manual operation is functioning well.
7. In terms of integrating a hands-free operation of the ProxiFan: A Sensor-Activated Electric Fan Using Arduino, it received a total mean rating of 4.83, signifying that the evaluators find the feature a good functionality of integrating a hands-free experience.
8. In terms of integrating an Android app-based method of operating, the ProxiFan: A Sensor-Activated Electric Fan Using Arduino was rated 4.68, which is considered Functional. The integrated app-based method was helpful in providing a convenient and responsive user experience.
9. In terms of the characteristics set in the ISO/IEC 25010:2011 Systems and Software Quality Requirements, ProxiFan obtained a total mean score of 4.51, indicating good software quality. With this, the evaluators find that ProxiFan demonstrates strong software quality performance.
10. In terms of usefulness, ease of use, ease of learning, and satisfaction, the system garnered a total mean rating of 4.79, which has a verbal interpretation of Satisfied.

5. Conclusions

The design and implementation of the system successfully demonstrated the feasibility of *ProxiFan: A Sensor-Activated Electric Fan Using Arduino*. Utilizing the developmental research design and iterative system of agile methodology [6], [7], the findings indicate that the developed system demonstrates strong functional suitability, reliability, and user satisfaction meeting the objectives of the study [10]. The system achieved its purpose in offering a practical and effective, low-cost solution for smart home automation, reducing manual operation while enhancing convenience and efficiency [3]. Although the system performance was satisfactory, further refinement in motion detection accuracy and user interface design is encouraged for future researchers to further enhance system reliability. iterative design, implementation, and testing.

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