
ANALYSIS THE EFFECT OF DISTANCE AND ENVIRONMENTAL NOISE ON THE PERFORMANCE OF A HANDCLAP-BASED LIGHTING CONTROL SYSTEM

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Abstract: The development of microcontroller technology is currently driving the creation of various innovations in automatic control systems to simplify daily activities, one of which is a smart lighting system. This study designs a clap-based lighting control system using an Arduino Uno microcontroller as the main controller, a sound sensor as an input detector, and a relay module as an electronic switch. The research method includes hardware design, software programming through the Arduino IDE, and system testing at various distance parameters and environmental conditions. Based on the test results, the system shows a fast and stable response at an optimal distance of 20–30 cm. However, the system's sensitivity decreases at a distance of 50 cm due to a response delay, and becomes inconsistent at a distance of 60 cm. In addition, it was found that the level of environmental noise significantly impacts the sensor's accuracy in distinguishing clapping sounds from background noise. This study proves that microcontroller implementation can be a practical solution in simple home automation, with the note that optimization of sound threshold settings is needed to overcome noise interference.

Keywords: arduino Uno; sound sensor; relay; light control; sensitivity analysis.

Abstrak: Perkembangan teknologi mikrokontroler saat ini mendorong terciptanya berbagai inovasi sistem kendali otomatis untuk mempermudah aktivitas sehari-hari, salah satunya adalah sistem pencahayaan pintar. Penelitian ini merancang sistem kendali lampu berbasis tepukan tangan dengan menggunakan mikrokontroler Arduino Uno sebagai pengontrol utama, sensor suara sebagai pendeteksi input, dan modul relay sebagai sakelar elektronik. Metode penelitian mencakup tahap perancangan perangkat keras, pemrograman perangkat lunak melalui Arduino IDE, serta pengujian sistem pada berbagai parameter jarak dan kondisi lingkungan. Berdasarkan hasil pengujian, sistem menunjukkan respon yang cepat dan stabil pada jarak optimal 20–30 cm. Namun, sensitivitas sistem menurun pada jarak 50 cm dengan adanya delay respon, dan menjadi tidak konsisten pada jarak 60 cm. Selain itu, ditemukan bahwa tingkat kebisingan lingkungan berdampak signifikan terhadap akurasi sensor dalam membedakan suara tepukan dengan suara latar. Penelitian ini membuktikan bahwa implementasi mikrokontroler dapat menjadi solusi praktis dalam otomasi rumah sederhana, dengan catatan diperlukannya optimasi pada pengaturan ambang batas suara untuk mengatasi gangguan kebisingan

Kata kunci: arduino uno; sensor suara; relay; kendali lampu; analisis sensitivitas.

INTRODUCTION

The rapid development of electronics and microcontroller technology has had a significant impact on the automation of everyday life. The implementation of embedded systems is no longer limited to the industrial sector but has also expanded into the domestic environment to increase efficiency. One of the most widely used microcontroller platforms is the Arduino Uno due to its open-source nature, ease of programming using the Arduino IDE, and extensive community support. The Arduino Uno, based on the ATmega328P microcontroller, is an effective learning and development tool for creating inexpensive yet reliable control systems.

In the field of lighting management, various innovations have been developed to replace conventional mechanical switches. Several previous studies have explored the use of Passive Infrared (PIR) sensors for motion detection and Bluetooth modules for remote control via smartphones. However, PIR-based systems have weaknesses in detecting stationary objects, while Bluetooth control requires reliance on second-party devices that are not always practical for rapid deployment. On the other hand, mechatronic systems that integrate mechanical and electronic aspects offer more responsive voice-based control solutions. The use of a sound sensor as a trigger allows for hands-free lighting control. However, a research gap exists regarding the stability of the sound sensor against low-frequency interference and the influence of the sound source distance, which often causes inconsistencies in simple automatic control systems.

The urgency of this research lies in the need to optimize home automation systems that rely not only on ease of operation but also on the accuracy of the device's response to user input. Many automatic lighting systems fail to function optimally in noisy environments due to a lack of analysis of the sensor's sensitivity threshold. As a solution, this study proposes the design of an automatic clap lighting system using a relay module as an electronic switch that is safe for AC loads. By utilizing logic processing in Arduino software, this system is designed to differentiate sound input signals to stably trigger the lights to turn on/off.

The main objective of this research is to design and implement a clap-based lighting control system using an Arduino Uno. Furthermore, this study aims to conduct an in-depth analysis of system performance by testing the effective detection distance and the effect of environmental conditions (quiet vs. noisy) on sound sensor accuracy. The results of this research are expected to be a reference in the development of a more complex and adaptive smart home automation system in the future.

METHOD

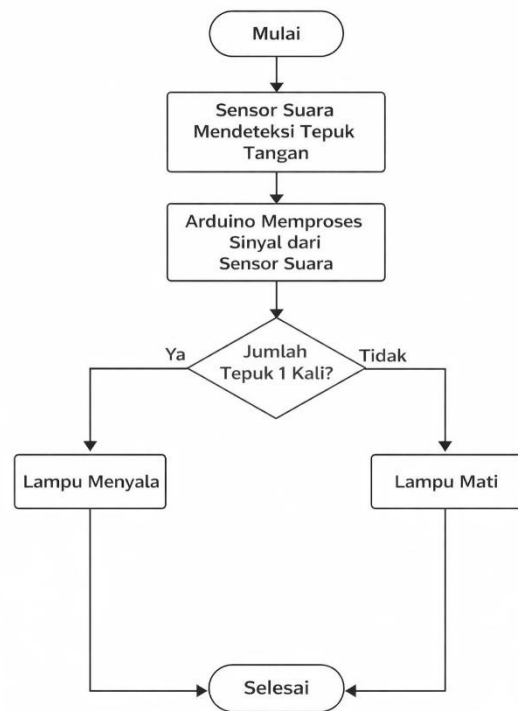


Image 1. Flow Diagram

The methodology used in this research follows an experimental approach through the development of a mechatronics system prototype. The research flow is divided into four main stages: system requirements identification, hardware design, software development, and functionality testing methods.

System Tools and Components

Component selection was strategically based on power efficiency and inter-module compatibility. The tools and materials utilized in this research include:

Arduino Uno (ATmega328P): Serves as the Central Processing Unit (CPU) that manages input and output logic. According to Ambarita (2019), Arduino Uno is a highly effective microcontroller learning medium due to its modular nature and stability in handling both digital and analog inputs from various sensors.

Sound Sensor Module: This component functions to detect acoustic waves in the surrounding environment and convert them into electrical signals. The module is equipped with a potentiometer to adjust the desired sound sensitivity threshold (Kadir, 2017).

5V Relay Module: Utilized as an electronic switch that isolates the low-current circuit (Arduino) from the high-current circuit (220V AC Lamp). The use of a relay is crucial for device safety to prevent backflow currents that could potentially damage the microcontroller (Mustar, 2017).

Lamp and Fitting: Acts as the output load controlled by the system.

Jumper Wires and Breadboard: Serves as the connection medium between components without requiring permanent soldering, facilitating the prototyping process and circuit modifications.

Arduino IDE: The primary software used for writing, compiling, and uploading program code to the microcontroller. Rohmanu (2018) emphasizes that code efficiency within the Arduino IDE significantly determines the system's response speed in processing sensor data in real-time.

System Architecture

The system is designed using an open-loop control architecture with triggering logic. The sound sensor is connected to the Arduino's digital input pin. When the sensor detects a clap sound exceeding the preset threshold, a signal is transmitted to the Arduino to toggle the status of the output pin connected to the relay. This implementation adheres to the fundamental principles of mechatronic systems, where there is an integration between electronic control and mechanical action within the relay to manage electrical loads (Bolton, 2024).

Research Flowchart

The stages of this research are systematically illustrated through the following steps:

Literature Study: Conducting a collection of references regarding light control systems, Arduino programming, and sound sensor characteristics.

Hardware Design: Developing a circuit schematic that connects the sound sensor to digital pin 7 and the relay module to digital pin 8 on the Arduino Uno.

Source Code Development: Writing the script using C++ language in the Arduino IDE. The program logic utilizes a "state" variable to store the last condition of the lamp (ON or OFF), ensuring the first clap turns the lamp on and the subsequent clap turns it off.

Prototype Assembly: Integrating all physical components according to the pre-designed schematic.

Testing and Data Collection: Performing functional testing with distance variables (20 cm to 60 cm) and environmental condition variables (quiet vs. noisy) to determine the limits of the device's effectiveness.

Data Analysis Technique

Data obtained from the testing results are recorded quantitatively based on the success rate of the relay's response to handclaps. Success is measured through the following parameters:

Accuracy: Whether the lamp responds correctly to the specific number of claps.

Sensitivity: The maximum distance at which the sensor can still validly capture sound signals.

Robustness: The system's ability to ignore non-clapping noise interference in a loud environment.

This analysis aims to evaluate whether the designed system meets the criteria as a reliable home automation solution or requires further adjustments to the sound filtering algorithm.

RESULTS AND DISCUSSION

After series assembled and program entered to in Arduino, the tool Then tested For see whether system Can Work according to plan. Testing done by providing applause hands

at different distances. From the results experiment, lamp Can light up moment given one clap and you can Off moment given pat next. At a distance about 20–30 cm, sound sensor can detect clap clearly so that light respond quickly. When the distance further away become about 40–50 cm, system Still Can work , but the response A little more slow . At a distance of 60 cm, the sensor does not always detect good clap so that light sometimes No respond .

Apart from distance , conditions The room also has an effect . If the room in condition calm down , tool Work more stable . However moment room rather noisy , sensor sometimes catch another voice so that response light become not enough consistent . This is show that the sensitivity of the sound sensor greatly affects performance tool .

The relays used can also be work well For connecting and disconnecting current electricity to lights . During testing No found significant problems in the circuit .

In a way overall , tool control lights with claps hand This Already walk as expected . System can turn on and off light without manual switch , so that Can become example Arduino implementation in system control simple .

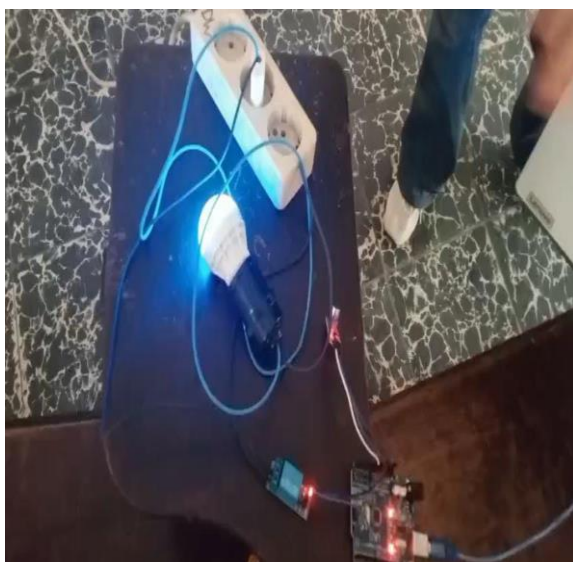


Image 2. Control Results Lights With Applause

Table 1. Test Data

No	Number of Claps	Environmental Conditions	Environmental Conditions	Light Response
1	1 time	20 cm	Calm	Light up
2	1 time	30 cm	Calm	Light up
3	1 time	50 cm	Calm	Delay
4	2 times	20 cm	Calm	Off
5	2 times	30 cm	Calm	Off
6	1 time	20 cm	Noisy	Less Stable
7	2 times	20 cm	Noisy	Inconsistent



Image 1. Test Data Graph

CONCLUSION

System control lights with claps hand based on Arduino Uno can well designed and implemented according to the planning that has been done made , started from stage design circuits , programming , up to testing tools . All component such as sound sensors , microcontrollers , and relay modules can integrated optimally so that system capable

Work in a way automatic .Sound sensor used capable detect wave sound from applause hands and change it become signal the next electricity processed by Arduino. Based on results testing , the sensor shows sufficient response Good in recognize applause hands at a distance certain level sensitivity that has been arranged . Arduino Uno microcontroller is successful operate program logic that has been implanted , namely activate light moment receive clap input first and turn it off moment accept applause Next .

The data processing process is ongoing. fast and stable so that the command given to the relay can executed without obstacle . The relay module is functioning properly as switch electronics that connect and disconnect current electricity in the lamp . On/off movement of the lamp according to orders from Arduino, so that system capable replace function manual switch effective and safe . In a way overall , system This give convenience and efficiency for users in control light without touch switch in a way directly . In addition to being solution practical , project this also proves that implementation technology microcontroller can developed become system automation simple but useful as well as potential For developed more carry on to direction smart home and Internet of Things (IoT) concepts .

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