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Efficient Projector Management: IR Transmitter Powered by HDMI Cable Interception

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***Abstract*— The rise of automated systems and data growth has highlighted the inefficiencies of traditional remote-controlled devices. This paper presents a novel approach to enhance projector efficiency in classrooms and businesses by eliminating reliance on remote controls. We identified a trend in the automation industry aimed at improving everyday task efficiency. While many projectors utilize infrared (IR) technology for remote control, manual operation is often inefficient. To address this, we propose an automated system that reduces time spent on low-value tasks like turning the projector on/off. Our solution employs IR technology to control the projector from a circuit powered directly by the HDMI cable. Through a study of High-Definition Multimedia Interface (HDMI) protocols, we developed a functional circuit that transmits specific IR signals. This innovative approach enhances convenience and efficiency, streamlining projector control in educational and professional settings**

***Keywords*— Projector Automation, Remote Control Elimination, HDMI-Powered IR Transmitter, Efficiency Improvement, IR Technology, High-Definition Multimedia Interface (HDMI), Convenience, Automation Industry, Classroom and Business Settings..**

I. INTRODUCTION

Projectors are now essential tools for learning in classrooms and entertainment in theaters. However, reliance on remote controls can lead to inconvenience and loss. In this paper, we offer a comprehensive analysis of the complete process involved in developing a remote-free projector system. The inspiration for this highly engaging project stemmed from observations made in our college classes. In numerous cases, issues with a remote-controlled projector may appear insignificant until further examination is conducted. A substantial amount of time is wasted attempting to start the projector. In certain situations, a misplaced remote can result in a significant loss of productive time as efforts are made to locate or use it. Given the size of the school environment, using various remote controls for different projectors in each classroom can be time-consuming. Even with efforts to use a single projector remote control, there are notable issues associated with the suggestion. Most often, moving between classrooms to locate the 'precious' remote control is inconvenient. There is a growing recognition that 'time is money', prompting educators and students to seek automation of the system. Regarding the latter point, the main objective of this project is to create a time-efficient system for operating projectors by utilizing IR technology and extracting power from an HDMI cable.

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This diverse study covers two main topics. The first component of the project involves implementing Infra-Red technology, while the second component focuses on studying the HDMI cable. Emphasis is placed on protocols for signal transmission using IR sensor technology. The initial step was to analyse different sources discussing the protocols. The research must focus on the particular type of remote control used for testing and the specific module of the IR sensor device to be utilized.

Infrared LEDs emit light that is invisible to the human eye. Typically, the wavelength of light output by such devices is approximately 950 nanometre. However, other sources besides IR LEDs can emit IR or near IR waves. Many other sources, such as light bulbs and the sun, emit infrared waves, presenting a challenge in infrared communications. It should be noted that IR communication is a broad topic. However, for our discussion, understanding the protocols is crucial.

The signal sequence from the remote control needs to be decoded by a micro-controller and a new circuit in order to reproduce the functions of the remote system. The encoding and decoding process is essential for the system's functionality.

Powering the system remains a challenge. For this stage, a detailed examination of an HDMI cable is necessary, with a focus on carefully analysing the wiring. The exercise aims to determine the current flow in the HDMI cable and identify the safest method for locating the source wires for current extraction. Once a circuit is established, it can be powered by the current from the HDMI extraction circuit. The implementation is highly beneficial due to the absence of additional expenses in acquiring the circuit. The paper is structured as follows:

- Brief introduction on the topic,
- Literature Review of work in related fields,
- Detailed outline of the project method, which encompasses the entire process starting from the purchase of the IR transmitter and receiver. The section includes circuit diagrams and implementations.
- Summarizes the project's results and guarantees a comprehensive view of the project's implications.
- The conclusion includes recommendations for the next prototype and real-life manufacturing.

The research paper focuses on implementing a time- efficient projector control system that eliminates the need for a remote control.

II. Literature Survey

Luis Puche Rondon et al. (2019) [1] discuss the Consumer Electronic Control protocol, utilized in contemporary HDMI cables, enabling the control of multiple devices connected through HDMI using a single remote control. CEC was created in 2005 to facilitate communication between HDMI devices. Even though the CEC protocol offers benefits over our IR system by eliminating the need for remote controls, the projector must be powered on first for it to work. This does not completely eliminate the need for remote controls. Leonardo Babun et al. (2021) [2] outlines the role of CEC in facilitating control and communication among HDMI devices via HDMI cables, enabling audio and video functionalities in smart network systems.

Their paper primarily explores the security of HDMI networks by exploiting vulnerabilities in the CEC protocol and conducting proof of work attacks on HDMI distribution networks. They examine how insecure CEC protocol practices and poorly implemented HDMI distributions could create new vulnerabilities for HDMI devices that were previously thought to be secure from traditional network attacks. The options discussed in the prior sentence demonstrate the security and privacy challenges of the CEC. The CEC protocol must be securely protected from potential intruders prior to deployment.

Stevan Eidson et al. [3] discussed HDMI combines audio, video, and control data in one cable, using TMDS encoding for reduced interference and HDCP for content protection. It supports multiple formats, up to 8 audio channels, and unified device control via CEC. HDMI is compatible with DVI and uses smaller, user-friendly connectors without an analog interface.

JianJun Lv et al. [4] studied about Infrared Remote Control Protocols (IRCP), including NEC, Philips RC-5, and Simi- NEC protocols, each with specific signal structures and modulation techniques. It proposes a versatile system using AVR ATmega8, CP2102, and HS0038 chips to decode and process these protocols, enabling a universal remote control for home automation via PC. The system emphasizes compatibility, efficiency, and accurate modulation/ demodulation for reliable operation.

The paper by Karishma Bonia et al. [5] discusses a home automation system using an IR remote control and Arduino Uno. This system aims to reduce human effort and enhance energy conservation by allowing a single remote to control multiple home appliances. The proposed system by Bonia et al. uses an Arduino Uno micro-controller and an IR receiver (TSOP1738) to receive signals from an IR remote. The Arduino processes these signals and controls various appliances through relays.

I used Pallavi Deshpande et al.'s writings as a basic guide for my literature survey while I was preparing my paper. I gained important insights into optimization approaches from the publication "Accuracy enhancement of biometric recognition using iterative weights optimization algorithm" [6], which guided my strategy for raising system accuracy. Furthermore, a key resource for comprehending multimodal biometric systems and the use of score-level fusion was their paper, "An accurate hand-based multimodal biometric recognition system with optimized sum rule for higher security applications" [7]. The theoretical framework and methods of my research were influenced by these works.

III. METHODOLOGY

This project aimed to develop an automated system for projector activation using HDMI connection detection and IR signal transmission. The methodology was divided into four distinct phases, each building upon the findings of the previous stage to create a comprehensive solution.

In the first phase, we focused on identifying the specific wire within an HDMI cable responsible for carrying the signal from a computer or laptop to a projector. This involved carefully disassembling a standard HDMI cable to expose its 19 individual wires. Each wire was systematically tested using signal detection equipment while a known video signal was transmitted. Through this process, we were able to isolate and confirm the wire that consistently carried the strongest video signal, documenting its position within the HDMI bundle and its unique signal characteristics [8].

The second phase of our research centred on capturing and decoding the infrared (IR) signals emitted by a projector's remote control. Fig.2 describes the block diagram. We utilized a TSOP (Thin Small-Outline Package) IR receiver sensor connected to an Arduino Nano microcontroller to capture the raw IR signals as shown in Fig.1. Multiple trials were conducted to ensure consistency in the captured data. The raw signal data was then converted to a hexadecimal (HEX) format, the code that was used is shown in Fig.3 which is more suitable for reproduction and analysis. This phase was crucial in understanding the specific IR command structure used by the projector, particularly focusing on the power-on command [9][10].

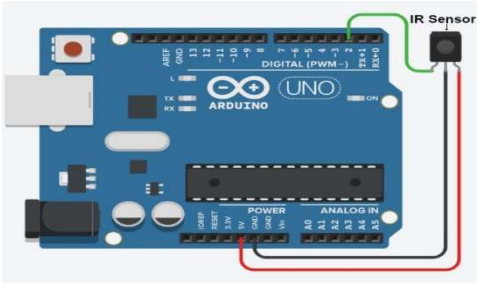

Fig.1 Circuit for Signal Capturing (i.e. with Arduino)

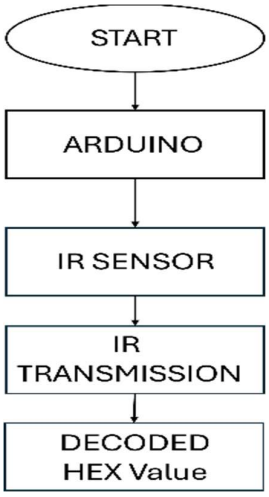

Fig.2 Block Diagram of Signal Capturing

```
#include <IRremote.h>

const int recvPin = 2;
IRrecv irrecv(recvPin);
decode_results results;

void setup() {
  Serial.begin(9600);
  irrecv.enableIRIn();
}

void loop() {
  if (irrecv.decode(&results)) {
    Serial.print("Decoded HEX: 0x");
    Serial.println(results.value, HEX);
    irrecv.resume();
  }
}
```

Fig.3 Code for Signal Capturing

Building upon the knowledge gained in the second phase, our third phase involved transmitting the captured IR signal to control the projector Fig.5 shows the block diagram. We designed and implemented an IR transmission circuit using an Arduino Nano, an IR LED, and supporting components shown in Fig.4. An Arduino sketch was developed to generate the appropriate IR signal based on the HEX value obtained earlier shown in Fig.6. The effectiveness of this transmission system was rigorously tested, measuring factors such as transmission range, angle, and reliability in activating the projector.

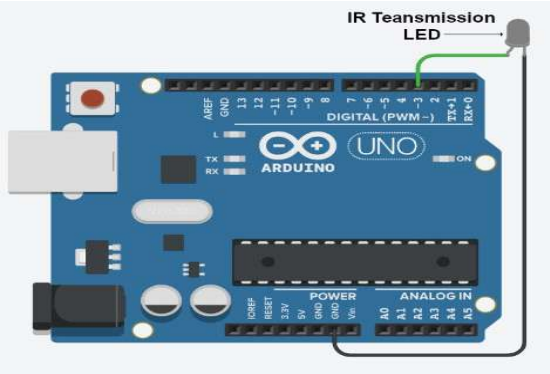

Fig.4 Circuit for Signal Transmission

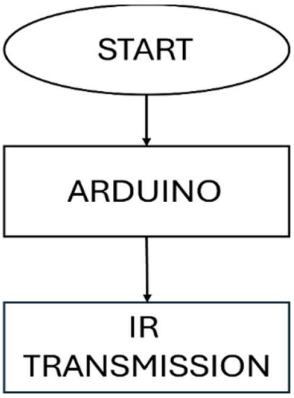

Fig.5 Block Diagram of Signal Transmission

```ino
#include <IRremote.h>

IRsend irsend;

void setup() {
  Serial.begin(9600);

void loop() {
  for (int i = 0; i < 3; i++) {
    irsend.sendSony(0x542a, 15);
    Serial.println("Signal Transmitted");
    delay(40);
  }
  delay(2000);
```

Fig.6 Code for Signal Transmission

The final phase of our methodology focused on creating an automated triggering mechanism for the IR transmission system Fig.8 shows the block diagram of the logic. We utilized the knowledge gained from the first phase to identify an appropriate pin in the HDMI connection that could serve as a reliable indicator of an active connection. This pin (Power Pin) was connected to the Arduino Nano through a carefully designed interface circuit shown in Fig.7. When the HDMI is connected to the source, the LED turns ON indicating the HDMI is connected to source. Further, there is a switch to pass the signal forward to projector. When the switch is ON, the IR-LED turns ON and starts to transmit the signal, similarly, when the switch is turned OFF, the IR-LED turns OFF, stopping transmission of the signal. We then modified our Arduino sketch to monitor this HDMI pin and automatically trigger the IR transmission upon detecting an active connection shown in Fig.9. This created a seamless system where plugging in an HDMI cable would automatically turn on the projector.

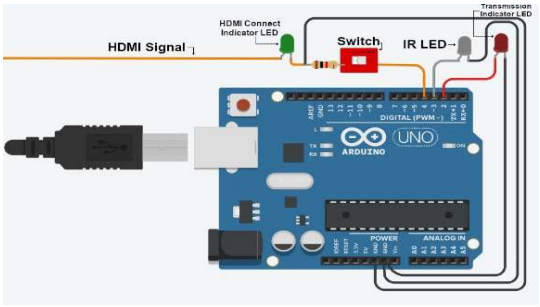

Fig.7 Final Circuit

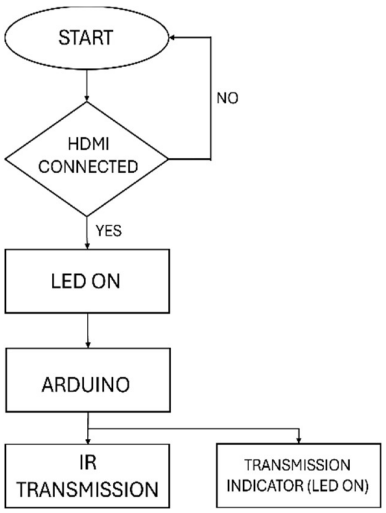

Fig.8 Block Diagram of Complete Logic

```
#include <IRremote.h>
IRsend irsend;

const int hdmiPin = 7;
const int ledPin = 2;

void setup() {
  Serial.begin(9600);
  pinMode(hdmiPin, INPUT);
  pinMode(ledPin, OUTPUT);
}

void loop() {
  int hdmiStatus = digitalRead(hdmiPin);

  if (hdmiStatus == HIGH) {
    digitalWrite(ledPin, HIGH);
    for (int i = 0; i < 3; i++) {
      irsend.sendSony(0x542a, 15);
      Serial.println("Signal Transmitted");
      delay(40);
    }
    delay(2000);
  }
  else {
    digitalWrite(ledPin, LOW);
    Serial.println("HDMI signal disconnected, IR transmission
stopped.");
    delay(1000);
  }
}
```

Fig.9 Final Logic Code

In conclusion, our methodology provided a comprehensive approach to understanding and manipulating HDMI signals and IR communication for projector control. By breaking down the process into distinct phases and employing a combination of hardware manipulation and software development, we were able to create an innovative solution for automated projector activation. This research lays the groundwork for future advancements in automated audio- visual systems and contributes to the broader field of smart technology integration.

IV. RESULTS

A. HDMI Interception

The initial conjecture regarding the hypothesis that an HDMI cable could serve as a makeshift power supply was demonstrated to be valid. An analysis of the standard HDMI cable revealed the arrangement and functionalities of its 19 pins. Notably, the pin that conveyed the most robust and viable signal was subsequently identified and configured for use. This analysis also included a review of the positioning of the Power signal wire, which was found to hold significant importance in relation to the specific criteria required for the operation of the automated power supply. More investigation underscored the critical role of the HPD pin, as it activates only when a signal is present between the source and sink, thereby enabling power provision precisely at the moment of necessity. Additionally, the examination of the HDMI cable included the identification of a suitable wire that could function as the ground for our network. Measurements obtained from a multi-meter indicated a stable voltage, exhibiting a deviation of less than 0.1% from the nominal 5V, thus affirming the reliability of the power supply configuration.

B. Infra-Red Reception

The criteria established for capturing the sequence of infrared (IR) signals positively influenced the project's objective of replicating remote control functionalities. The IR receiver demonstrated high efficiency in interpreting the signal logic emitted by the existing projector remote. The sequence, encoded using a Thin Small Outline Package (TSOP), effectively facilitated the generation of a replicable signal capable of toggling the projector on and off from an independent circuit. This phase of the project underscored the success of a systematic trial-and-error methodology, confirming that the entire code was both viable and free from errors. The findings not only validated the approach taken but also reinforced the reliability of the replicated remote-control functionalities.[11].

C. Infra-Red Transmission

After the infrared (IR) signal was captured and decoded, the acquired sequence was transmitted to the projector by utilizing an Arduino Nano microcontroller connected to an IR transmitter. The initial stages of the

transmission process proved challenging; however, through iterative trials and by minimizing the distance between the projector and the experimental circuit, the results aligned with expectations, demonstrating maximum viability. The circuit was configured with an LED, which served as an indicator to visualize both the transmission period and instances of signal cessation. The primary objective of the initial prototype was to enable the powering of the projector without reliance on a traditional remote-control module. This approach not only facilitated greater operational independence but also provided a foundation for further enhancements in remote control capabilities [12].

D. Final Implemented Circuit

The final phase validated the usability of the HDMI cable as a power supply for the IR transmitter. As initially hypothesized, the Power wire within the HDMI cable emerged as the most advantageous component for our purposes. The interface circuit established between the HDMI and IR circuit facilitated a streamlined automation process, enhancing the overall efficiency of the system. This integration not only confirmed the feasibility of using the HDMI cable for powering the IR transmitter and also for completely replacing the remote control but also paves the way for further advancements in automated control systems

V. RESULTS

While our current system represents a significant advancement in automated projector control, several avenues for future research and development have been identified:
Automated Transmission Control: Future iterations of the system could eliminate the need for a manual switch by utilizing additional HDMI signals for automatic transmission control. Specifically, investigating the signal sent from the projector to the laptop upon activation could provide a means to automatically terminate IR transmission, further enhancing the system's autonomy.
Integrated Projector Solution: A more advanced implementation could involve integrating the entire control circuit directly into the projector's hardware. This would eliminate the need for external IR transmission altogether, potentially improving reliability and simplifying the overall system architecture. Such an integration would require collaboration with projector manufacturers and could lead to a new generation of smart, network-aware projection systems.

VI. CONCLUSION

Our research successfully developed an innovative automated system for projector activation using HDMI connection detection and IR signal transmission. By meticulously analyzing HDMI signal characteristics, decoding IR commands, and implementing a microcontroller-based control system, we created a solution that seamlessly integrates with existing audio-visual setups.
The system demonstrates significant potential for enhancing user experience in various settings, from educational institutions to corporate environments, by eliminating the need for manual projector activation. The incorporation of a control switch adds an important layer of flexibility, allowing users to prevent unintended projector deactivation while maintaining the benefits of automation. Our methodology, which combined hardware analysis, signal processing, and embedded system programming, provides a robust framework for future research in the field of automated audio-visual control systems. The success of this project underscores the potential for smart, interconnected systems to simplify and streamline everyday technologies.

REFERENCES

[1] L.P. Rondon, L. Babun, K. Akkaya, and A. S. Uluagac, "HDMI-Walk: Attacking HDMI Distribution Networks via Consumer Electronic Control Protocol," in Cyber-Physical Systems Security Lab, Dept. of Electrical and Computer Engineering, Florida International University, Miami, FL, USA, 2019.

[2] P. Rondon, L. Babun, K. Akkaya, and S. Uluagac, "Systems and methods for monitoring activity in an HDMI network," in Cyber- Physical Systems Security Lab, Dept. of Electrical and Computer Engineering, Florida International University, Miami, FL, USA, 2021.

[3] Lv, J., Li, Z., Huang, Q., Mao, M., & Chen, Z., "A New USB Home Appliances Based on PC and Infrared Remote Control Protocol," 2010 International Conference on Computer and Communication Technologies in Agriculture Engineering (CCTAE), 2010, pp. 572-575. DOI: 10.1109/CCTAE.2010.5480354.

[4] K. Elissa, “Title of paper if known,” unpublished.

[5] K. Bonia, M. Basan, N. Sohkhlet, and C. L. Mawphlang, "Controlling Home Appliances by IR Remote Control using Arduino Uno," ADBU Journal of Electrical and Electronics Engineering (AJEEE), vol. 4, no. 2, 2021.

[6] P. D. Deshpande, P. Mukherji, and A. S. Tavildar, "Accuracy enhancement of biometric recognition using iterative weights optimization algorithm," EURASIP Journal on Information Security, vol. 2019, no. 1, p. 6, 2019.
[7] P. D. Deshpande, P. Mukherji, and A. S. Tavildar, "An accurate hand- based multimodal biometric recognition system with optimised sum rule for higher security applications," International Journal of Biometrics, vol. 11, no. 3, pp. 222-242, 2019, doi: 10.1504/IJBM.2019.100830.
[8] S. Smith, "High-Definition Multimedia Interface (HDMI) Structure and Applications," IEEE Transactions on Consumer Electronics, vol. 65, no. 3, pp. 123-130, May 2019.
[9] Circuit Digest, "IR Remote Controlled Home Automation Arduino," [Online]. https://circuitdigest.com/microcontroller-projects/ir-remote controlled-home-appliances. [Accessed: 12-Oct-2024].
[10] Photonics, "IR Sensors Make Smart Devices Smarter," [Online] Available: https://www.photonics.com/Articles/IR_Sensors_Make Smart_Devices_Smarter/a63361. [Accessed: 12-Oct-2024].
[11] Smith, R. (2021). Infrared Communication: Principles and Applications. Wiley.
[12] Barlow, J., & Fenton, S. (2019). Remote Control Systems: Design and Applications. Springer.