



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Handwave Home Tech Hub: Enhancing Home Control with APDS 9960 and Raindrop Sensor

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ABSTRACT: The goal of the quickly expanding subject of home automation is to give households with a more useful and practical means to manage their homes. The "Handwave Home Tech hub" project intends to create an Arduino-based home automation system that can identify hand gestures and control the appliances by utilizing an APDS9960 gesture sensor and a raindrop sensor. Using the Arduino IDE, the hand gesture algorithm is built to recognize hand movements like moving hands upside down, left, and right, so that to turn on and off lights, fans and close window in response to raindrop detection, along with other functions. The suggested method makes using household appliances easier and more feasible by eliminating the requirement for complex stages.

KEYWORDS: Home Automation, APDS9960 Sensor, Arduino UNO, Raindrop sensor, No contact Communication, IOT

I. INTRODUCTION

At the vanguard of contemporary home automation is the "Handwave Home Tech Hub" project, which introduces a novel method of user engagement by using hand gestures as the main control mechanism. With the use of this cutting-edge technology, consumers will be able to interact with household appliances in a whole new way by utilizing their natural and intuitive hand gestures. The creation of a dependable and user-friendly hand gesture recognition system to control windows, fans, and lights in place of conventional physical switches is one of the project's main goals.

Using IoT to recognize hand gestures Using hand gestures, an Arduino, an APDS9960 sensor, and a raindrop sensor, users may operate their appliances with home automation technologies. The hand motions captured by the system's sensors are processed by a computer or microcontroller to comprehend and carry out the desired actions, such as opening and closing windows with the Raindrop Sensor or turning on/ off lights or fans using the APDS 9960 sensor. Without needing any physical switches, this technology enables a simple and useful way to handle equipments in house. With a focus on multi-device integration, this project goes beyond single device control and gives users a unified interface for controlling windows, fans, and lights using a simplified hand gesture interface. In order to improve overall user experience and control, real-time feedback methods, such as visual indications, make sure users are always informed about the successful identification of gestures and the execution of associated actions.

Inclusion of sensors, like motion, light, and environmental sensors, increases the scope of the system. One particularly noteworthy feature is the addition of a raindrop sensor, which allows windows to be automatically closed in the event of precipitation and shows how flexible the system is with respect to outside influences. The Arduino Uno, the APDS-9960 gesture sensor, the relay driver, the relay board, the LCD display, the raindrop sensor, and other crucial electrical parts form the technological cornerstone of the "Handwave Home Tech Hub". The combination of these state-of-the-art technologies allows users to automate window operations based on current weather conditions in addition to controlling lights and fans with hand gestures.

II. RELATED WORK

In the field of Home Automation technologies researchers have conducted literature surveys to explore the trajectory, methodological intricacies, wide ranging applications and relevant challenges. One study focuses use of finger gestures and movements to operate household appliances. A MATLAB-based algorithm is employed to quickly identify hand gestures. The produced hand image is compared to preloaded gestures. Devices are controlled by data provided to the hardware of microcontrollers. For people who are physically unable to reach switches, this can be an option. Cameras, microcontrollers, fans, lights, power supplies, LEDs, and GSM modules are examples of common hardware devices [1].

Another research introduces presents an architectural paradigm for a home automation system that is controlled by natural gestures. In addition to capturing rotation and orientation of movement, the device measures electrical activity. The appliance control system's real-time application is assessed by the study [2]. In a different study, Hand gloves are used with a gesture-controlled home automation system. aids blind people in controlling electrical lights and fans. The hardware module consists of the Arduino UNO, Arduino Nano, NRF24L01, ADXL355 accelerometer, and relay. The idea is to develop a gesture-based hand-held appliance control device. 27 movements were used to evaluate the suggested strategy, which enhanced device usage. Software called Arduino IDE is used to program transmitter and reception codes [3].

Some studies includes machine learning algorithms for hand gesture recognition. Various techniques were employed, such as the use of MATLAB and a pic microcontroller, hand gloves, smartwatches, and cellphones. uses hand gestures and machine learning to recognize input from users and operate equipment. PIC microcontroller, light, fan, camera, power supply, LED, and GSM module are examples of hardware modules. A gesture-based home automation system uses MATLAB software to process gestures that are captured by a camera. seeks to emulate the naturalness of human-to-human connection in human-computer interaction [4].

One study examines machine learning techniques for the identification of hand gestures. Many methods were used, including the usage of telephones, smartwatches, hand gloves, MATLAB, and a pic microcontroller. employs machine learning and hand gestures to identify human input and control devices. Hardware modules include PIC microcontrollers, LEDs, fans, lights, cameras, power supplies, and GSM modules. Gestures that are recorded by a camera are processed by MATLAB software in a gesture-based home automation system. aims to replicate in human-computer interaction the organic nature of human-to-human connection [5].

In one system, Gesture recognition is achieved by a variety of techniques, including vision data gloves and image processing. To increase accuracy, classification stages like SVM, ANN, and CNN are applied. Natural forms of engagement are provided via hand gestures in a variety of applications. The goals of home automation are to save time, use less energy, and need less human labor. A system of authentication is created to grant authorized access to household appliances. Interaction between humans and computers ought to seem as natural as interaction between humans. Gestures help the elderly and others with physical disabilities and increase safety. Energy efficiency and contactless equipment use are made possible by home automation. Comfort and peace of mind are the main goals of home automation [6].

The technology that uses voice instructions and hand gestures to allow people with physical disabilities to operate household appliances is discussed in one article. By using an Android application, a Bluetooth module allows voice commands to be used to switch between devices. The system makes use of a PIC microprocessor for speech recognition and gesture identification as well as a MEMS accelerometer sensor for hand motion detection. Certain devices are controlled by distinct gestures and vocal instructions. The system's low-cost design aims to improve the quality of life for people with physical disabilities. Larger electric currents can be controlled by relays using low-power signals. [7]. A vision-based hand gesture recognition system for home automation is presented in a research. SVM and CNN algorithms are used by the system to accurately recognize gestures. For feature extraction, a CNN network called Resnet50 is pre-trained. An applause pattern recognition module is also included in the system to control appliances. Upcoming improvements will involve employing IoT to manage increasingly intricate gadgets and duties. The application for hand gesture recognition is developed using MATLAB. Serial connectivity and Arduino are used in the system's implementation to control appliances. A matrix- based programming tool with integrated mathematical functions is called MATLAB. An IDE offers many benefits and capabilities for creating and organizing sketches [8].

A study investigates if deep learning models can be applied to enable gesture control of smart home appliances. With an astounding F-score of more than 75%, the research focuses on gesture recognition using a smart-watch application that gathers accelerometer and gyroscope data. Hand motions are recognized by the analytic transmission layer, which receives and interprets sensor data. The deep learning model is trained via the cloud layer, which also makes continuous gesture recognition possible. For smooth and continuous hand motion identification, a sliding window method is used. The study reveals two different vocabularies with eighteen motions each, showing how gesture-based interactions can be used to effectively control smart home devices [9].

One research explores the possibility of using deep learning models to enable gesture control for smart home appliances. The research focuses on gesture detection utilizing a smart-watch application that collects accelerometer and gyroscope data, and it has an amazing F-score of more than 75%. The analytic transmission layer, which receives

and interprets sensor data, recognizes hand gestures. The cloud layer is used to train the deep learning model and enables continuous gesture recognition. A sliding window approach is utilized for recognition of smooth and continuous hand motions. The research demonstrates how gesture-based interactions may be utilized to efficiently control smart home devices by presenting two distinct languages, each containing eighteen gestures [10].

In one survey, A hand gesture recognition prototype is intended to enable elderly people to operate networked household appliances. It uses an embedded device and the FAST algorithm to achieve an average recognition accuracy of about 80%. Seniors with Parkinson's disease can benefit from the system's locking mechanism, but accuracy decreases beyond a distance of one meter because of limits in camera feature identification. Still, there's room for improvement with better cameras and bigger datasets. The home automation system simplifies the operation of household tools, and the hand gesture control makes daily tasks easier for people who live independently. The FAST algorithm's selection is noteworthy due to its robust performance and real-time implementation, which fills a vacuum left by other studies' lack of attention to home automation [11].

One system has recorded input gestures by the Android app and sent to a Raspberry Pi server, which acts as a preprocessor to prepare images and train the CNN model. The matching action on the home interface is determined by the predicted image class. Hardware elements such as Raspberry Pi, SD card, relay module, and appliances are needed for the system, and Ethernet, Wi-Fi, and the Android application are used for communication. This home automation system makes use of the Keras, OpenCV, and NumPy libraries to improve security, comfort, and help with everyday tasks. It also provides web-based control via on/off buttons on a web application, which makes it appropriate for locations where traditional cabling is difficult or impracticable and allows for short-distance communication [12]. One research has introduced a system that recognizes and extracts hand movements using mathematical calculations and picture processing. The hand skeleton is used to extract features such as directed active model, neural gas, and joint color cloud. For classification, the characteristics are refined and fed via a recurrent neural network (RNN). On several datasets, the suggested approach obtains good accuracy rates. The model demonstrates higher accuracy when compared to other cutting-edge techniques. The marker-less method for gesture classification in smart homes reduces costs and saves time [13].

In a survey, natural gestures are used to control home automation systems. The MYO armband is used to capture hand gestures, orientation, and rotation. The system can be customized based on user profiles and expanded to industrial control. Gestures provide non-verbal communication, but a sequence of gestures may be needed for complex ideas. Various research and devices have been developed for gesture capture and interpretation [14]. In One investigation, to handle home devices like fans and lights hand motions are used. For motion recognition MATLAB simulation tool is used. Future advancements will be based on IoT for global appliance control. Motion control can be used for software applications. GSM module enables communication with the GSM network. Video input is taken using a web camera and processed in MATLAB. Frames are extracted from the video and resized to 640 x 480 pixels [15].

Through varied approaches, the literature provides a comprehensive understanding of evolving landscapes of gesture-controlled home automation systems.

III. PROPOSED METHOD

The proposed system makes use of microprocessor along with sensors to develop a home automation system that is intuitive.

Hardware Configuration- The system includes a microcontroller, such as an Arduino, relay driver, relay module, with a gesture sensor.

Gesture Detection- The APDS9960 gesture sensor module detects the user's hand movements and sends the necessary information to the microcontroller.

Gesture Interpretation- Using a relative driver, relay module, Arduino, and raindrop sensor, the microcontroller runs an algorithm to analyze the inputs that are gestures and associate them with preset motions that are linked to specific household devices .

No Contact Communication- The gadget or appliance (such a lightbulb) will send a signal to perform the necessary action after the microcontroller interprets the motion.

AutoRainSense Windows- The window will open and close in accordance with the microcontroller's interpretation of the Arduino and raindrop sensor.

COMPONENTS REQUIRED:

For Light and Fan system

1. Arduino UNO:

In this project, the Arduino Uno serves as the central controller, communicating with the APDS9960 gesture sensor to detect hand gestures. It sends signals to the relay driver module, which amplifies the control signals to operate the relay module connected to the light bulb. The Arduino also interfaces with the LCD display to provide real-time feedback to users about the light's status. When a gesture is recognized, the Arduino triggers the relay module to turn the light on or off accordingly. This setup enables intuitive hand gesture-controlled home automation for lights, enhancing user convenience and interaction.

2. APDS 9960 Sesnsor:

In this project, the APDS9960 gesture sensor detects hand gestures, such as swipes up or down, and communicates this information to the Arduino Uno via the I2C protocol. Connected through the SDA and SCL pins, the sensor provides input to the Arduino, which processes the data to determine the appropriate action, such as turning the light on or off. This integration enables intuitive hand gesture-controlled home automation for lights, enhancing user convenience and interaction.

3. Relay Module:

The relay module receives control signals from the Arduino Uno and acts as a switch to control the flow of electricity to the connected device, such as the light bulb. When the Arduino sends a signal to activate the relay, it completes the circuit, allowing electricity to flow and turning the device on. Conversely, when the Arduino sends a signal to deactivate the relay, it interrupts the flow of electricity, turning the device off. The relay module ensures safe control of high-voltage devices and provides electrical isolation between the Arduino and the connected load, enhancing overall system reliability and safety in home automation applications.

4. Relay Driver:

The relay driver plays an important role in the project's operation by facilitating the control of high-power devices like the light bulb. Connected to the Arduino Uno, the relay driver receives control signals from the microcontroller to activate or deactivate the relay module. These control signals are typically amplified to ensure reliable operation of the relay module, which is directly connected to the light bulb. When the relay driver receives a signal from the Arduino, it triggers the relay module to either open or close the circuit, thereby turning the light bulb on or off. This setup ensures that the Arduino can safely control the high-voltage circuit of the light bulb without directly interfacing with it, enhancing safety and reliability in the home automation system.

5. Zero Board :

The Zero board acts as the central control unit in the project, communicating with sensors like the APDS9960 gesture sensor to detect hand gestures. It then processes this data to trigger actions, such as controlling relay driver modules to turn devices on or off. The Zero board can also communicate with display modules to provide real-time feedback to users about the system's status. In summary, it coordinates the interaction between sensors, control modules, and display modules to enable intuitive hand gesture-controlled home automation.

6. LCD Display:

The LCD display in this project serves as a visual interface to provide real-time feedback to users about the status of the light and fan controlled by hand gestures. It's connected to the Arduino Uno using digital pins and is typically interfaced through a parallel or I2C communication protocol. The Arduino sends data to the LCD display to update the screen with messages indicating whether the light and fan is on or off. When a hand gesture is recognized by the APDS9960 sensor and processed by the Arduino, the corresponding action is reflected on the LCD display, instantly informing the user of the outcome. This setup enhances user interaction and experience by offering immediate visual feedback about the state of the controlled device.

7. 9V Battery :

The 9V battery serves as the power source for the Arduino Uno and connected components. It is typically connected to the Arduino's power input, providing voltage for operation. The Arduino then distributes power to the APDS9960 gesture sensor, relay driver module, relay module, LCD display, and other peripherals. This setup ensures portability and flexibility, allowing the system to function independently of a mains power supply.

7. Transistor:

In this project, the transistor acts as a switch between the Arduino and the relay coils. When the Arduino sends a signal, the transistor amplifies it, allowing current to flow through the relay coil and activate the relay, which controls the connected device. This setup protects the Arduino and ensures reliable operation of the relay module, enabling efficient control of household appliances like lights and fans.

8. Bulb and Fan:

In this setup, both the light and fan are connected to the relay module, which acts as a switch controlled by the Arduino Uno. The Arduino communicates with the APDS9960 gesture sensor to detect hand gestures, interpreting them as commands to turn the light or fan on or off. When a specific gesture is recognized, the Arduino triggers the relay module to either supply power to the light or fan, turning them on, or cut off power, turning them off. The relay module amplifies the control signals from the Arduino, enabling it to safely control the high-voltage circuits of the light and fan. This setup allows for intuitive hand gesture-controlled operation of both the light and fan, enhancing user convenience and automation in the home environment.

For Window system

1. Arduino UNO:

In this setup, the Arduino acts as the central controller. It receives signals from the raindrop sensor, detecting rainfall. When rain is detected, the Arduino commands the servo motor to close the window, preventing water ingress. When rainfall stops, the Arduino signals the servo motor to open the window for ventilation. This automation provides real-time adjustment of the window based on weather conditions, enhancing convenience and protection.

2. Raindrop Sensor:

The raindrop sensor detects rainwater on its surface, causing a change in resistance. Connected to the Arduino, it sends a signal when rain is detected. The Arduino interprets this signal and commands the servo motor to close the window during rainfall, ensuring protection from rain. When the rain stops and the sensor returns to its normal state, the Arduino instructs the servo motor to open the window again. This setup enables automatic window control based on real-time weather conditions.

3. Servo Motor:

The servo motor is connected to the Arduino and window mechanism to automate its opening and closing based on rain conditions. It receives control signals from the Arduino to rotate to specific angles, controlling the window's position. When the Arduino detects rain through the raindrop sensor, a command is sent to the servo motor to close the window, protecting the interior. Conversely, when the rain subsides, the Arduino commands the servo motor to open the window, allowing ventilation and light. This setup ensures the window's automated operation, enhancing convenience and weather protection in the home.

4. 9V Battery :

The 9V battery acts as the power source for the automation system, supplying energy to the Arduino and other connected components. Its positive terminal connects to the input pins of the Arduino, while the negative terminal links to the ground. This portable power solution enables the system's operation in locations without mains power, making it suitable for outdoor or temporary setups.

IV. WORKING

Working of Light and Fan system

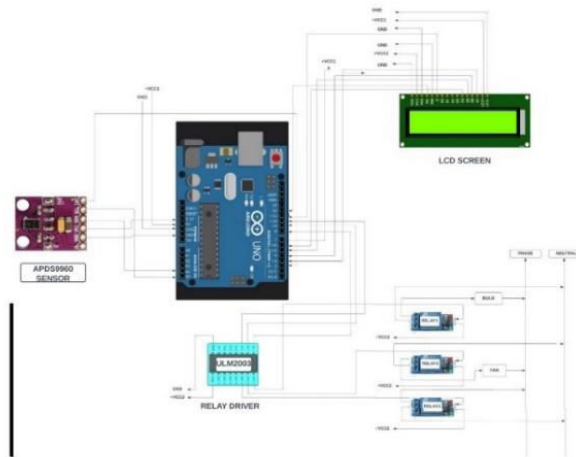


Fig 1. Circuit diagram for Window Open and close implementation

As shown in the figure, the system utilizes an Arduino Uno board and an APDS9960 sensor to recognize four distinct hand motions: left, right, up, and down. This sensor sends out a signal to the board, which uses it to control the devices based on the direction of the hand movement. The system's output devices are a lightbulb and a fan.

Relay driver and relay module are used by the system to control these devices. Relays are utilized to control the light, and a DC motor powers the fan. The bulb is connected to one relay, and the two loads of the system are connected to the relays via AC input wires.

When the system senses a hand movement in one direction, it activates the related relay, which then activates the appliance related to motion. The board has an LCD display attached to it that shows the system's output and status. Lastly, the system uses a regulator power supply card to supply 5 volts of DC power. The AC input is first received by the regulator power supply board, which then distributes it to the other parts of the system.

The following tables shows gestures and their description with associated action.

Sr No.	Gesture	Description
1	Left Right	To navigate through LCD screen and select the desired device (TV and Fan)
2	Up	To turn on the device
3	Down	To turn off the device

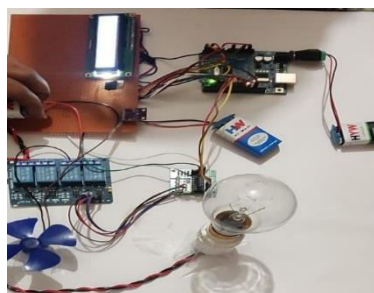


Fig 2 Hardware setup for Bulb and Fan

Working of Window system

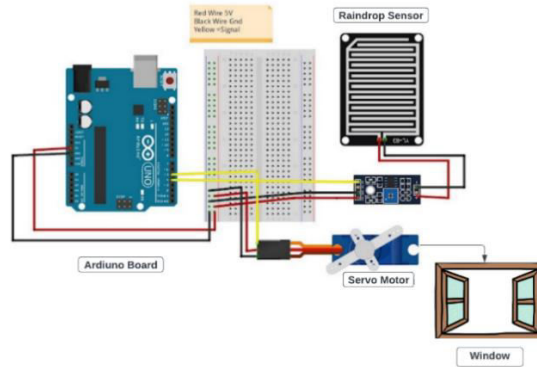


Fig 3. Circuit diagram for Window Open and close implementation

As shown in circuit diagram above, the raindrop sensor is connected to Arduino. In this automated window system, the raindrop sensor plays a critical role by detecting rainfall. Once rainwater is detected, the sensor sends a signal to the Arduino microcontroller, which acts as the brain of the system. Upon receiving this signal, the Arduino processes the information and decides to close the window to prevent rainwater from entering the room. It sends a command to the servo motor, which is connected to the window mechanism. The servo motor then rotates to close the window securely.

This action ensures that the interior remains dry and protected during rainy weather. When the rain stops, and the sensor no longer detects water, it signals the Arduino, which commands the servo motor to open the window. The servo motor reverses its rotation, causing the window to open, allowing fresh air and light back into the room. This automated process ensures that the window is closed during rainfall and opens again once the weather clears, providing convenience and protection without the need for manual intervention.



Fig 4 Hardware setup of Window

V. RESULTS / DISCUSSIONS

The gesture recognition system successfully interpreted predefined hand gestures, allowing users to effortlessly control the fan and bulb and window with intuitive movements. This not only adds a layer of convenience to daily activities but also aligns with the current trend towards user-friendly smart home solutions. The inclusion of a rain-sensing feature for automatic window closure demonstrated the project's adaptability to environmental conditions. The system accurately identified rain conditions through the APDS sensor, raindrop sensor, triggering the automatic closure of windows to enhance home security and protect against inclement weather.

Working images of Bulb and Fan implementations:



Fig 5. Bulb (Before using hand gestures)



Fig 6. Bulb (After using hand gestures)



Fig 7. Fan (Before using hand gestures)

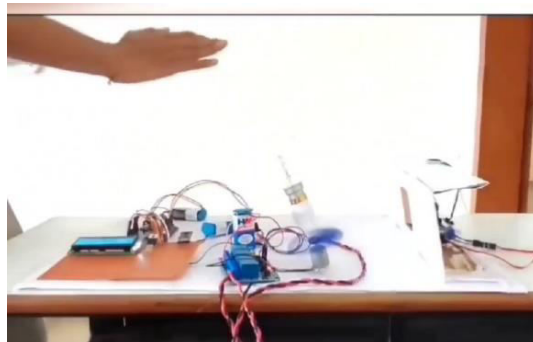


Fig 8. Fan (After using hand gestures)

Working images of Window implementation:

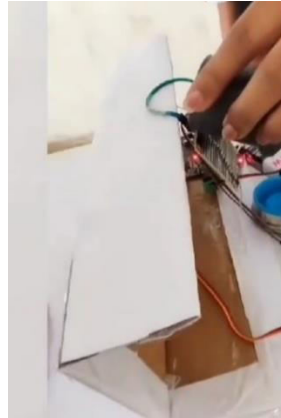


Fig 9 Raindrop sensor detecting rain (Water)



Fig 10. Closed window after rain detection (Water)

In terms of user feedback and experience, the gesture-based controls proved to be a novel and engaging way to interact with home appliances. Users appreciated the hands-free operation, which could be particularly beneficial in situations where manual control is impractical or inconvenient. However, the system's effectiveness may be subject to ambient light conditions, and further refinements in the gesture recognition algorithm could enhance its robustness across varying environments.

VI. FUTURE SCOPE

If almost every household appliance is to be automated, this will not limit the use of home automation to only a few numbers of appliances. To enable autonomous management of household appliances, the prototype may incorporate sensors like a PIR that detects motion and can make some contributions for security applications by sounding an alert and LDR that detects daylight and adjust the timing of lightbulbs. By including residences and small offices in its ambit, the project might be implemented in a variety of locations. The project can be developed so that it allows voice control of Bluetooth devices by including a speech control device to the device. Also With the integration of system with GSM module, we can notify the owners about privacy and security of home appliances.

VII. CONCLUSION

"Handwave Home Tech Hub" project work on Hardware components can be used to build an affordable home automation system with individual control. Additionally, since there aren't many parts needed, they can all be combined into a single, distinct container. Numerous household equipment can be used in the lighting, entertainment, and air conditioning systems, among many other systems, are operated by the intended home automation system. The system design has been developed with features that work with the hardware used making it versatile and scalable. Each module's placement and presence have been carefully studied, which has enhanced the unit's functionality. The project has also been well-executed, making good use of cutting-edge integrated circuits and developing technology.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to Prof. Premanand Ghadekar Sir for their invaluable guidance and support throughout the duration of this project. Their expertise, encouragement, and mentorship have been instrumental in helping us navigate the complexities of the project and achieve our goals. We are truly grateful for their patience, dedication, and willingness to share their knowledge and insights, which have enriched our learning experience and contributed significantly to the success of the project. Their unwavering support and commitment have been a constant source of motivation for us, and we extend our heartfelt thanks for their invaluable contributions. We are fortunate to have had the opportunity to work under their guidance, and we deeply appreciate all that they have done to assist us in realizing our project aspirations.

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