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San Jose de Buenavista, Antique 5700



AUTOMATED UMBRELLA RENTAL SYSTEM

A Design Project

Presented to

The Faculty of the Engineering Department

St. Anthony's College

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science in Computer Engineering

by

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May 2026



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APPROVAL SHEET

This design project entitled “Automated Umbrella Rental” prepared by Allendire B. Ras, Dave Arthur A. Arangote, Myla Camel A. Vargas, and Mary An Y. Dela Cruz in partial fulfillment of the requirement of the degree BACHELOR OF SCIENCE IN COMPUTER ENGINEERING, has been reviewed and approved by the Panel of Evaluator of BSCpE program.

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GRAMMARIAN'S CERTIFICATE

This is to certify that the undersigned and/or have reviewed all pages of the proposed project study/research titled, “Automated Umbrella Rental System” against the set of structural rules that given the composition of sentence, phases and words in the English language.

Signed:

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Grammarian



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DEDICATION

We, the researchers, would like to dedicate this project design to our parents and family members who guided us during our journey in creating this project design. Thanks to all of you for all of your help.

This project is also dedicated to our design instructor in CpEPD 102, Engr. Myla H. Daduya, who guided us in completing our design project.

Then, we want to dedicate this project to our instructor, Miss Rhiza Joi Navallasca, for giving us knowledge and guidance to complete our design project.

We would also like to dedicate this project design to our classmates who helped us create and formulate ideas for our design project.

Also, we hope that our project design will be dedicated to future research that will have the same or similar project design.

As researchers, we want to dedicate this design project to our panelists who asked us questions and gave us advice, which made us strong enough to guide us on how to improve our project design.

Lastly, we would like to dedicate this project design to our group members who worked hard in designing our project design.



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ACKNOWLEDGEMENT

The researcher is grateful to those individuals who gave their valuable time, support, and expertise to assist in completing this project.

The researchers want to thank the Engineering Department, specifically Dean, Engr. Lorenzo John C. Navallasca, for his invaluable contribution in making this design project happen.

The researchers would like to acknowledge the following individuals: Engr. Myla H. Daduya and Engr. Rhiza Joi C. Navallasca for her expertise, assistance, guidance, and patience throughout the duration of the design project and for supporting us. This design project would never be possible without the two of them.

To .the team, thank you for not giving up and for giving your very best even though at first you think we will going to fail because of some reasons, but now we did it.



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ABSTRACT

This study, the development of the Automated Umbrella Rental System that is intended to offer users with an efficient and reliable automated method of borrowing umbrellas during sudden changes in the weather condition will be analyzed. The system is expected to overcome the challenges and limitations associated with conventional manually done umbrella rental practices, which often lead to errors and delays in transaction completion.

The system incorporates use of RFID authentication, coin validation, solenoids for locking, automatic tracking of umbrellas and moisture detection for keeping the returned umbrellas dry and ready to be used by other users of the system. These components are managed using a microcontroller system built around the Arduino system, while the transactions are done using IoT technology for tracking transaction details and managing the umbrellas effectively.

The performance of the system was measured in terms of effectiveness in transactions, ease of use, and accuracy. In the analysis, it was found that the system is better than traditional manual systems.



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CHAPTER 1

INTRODUCTION

The weather can be considered as one of the most unpredictable forces. While we might enjoy the blue skies during our day out, sudden downpour can catch us off-guard without any prior warning. For the students and faculty members of the Computer Engineering course under the Engineering Department of St. Anthony's College (SAC), this unpredictability may cause them to get wet from time to time while moving around campus without any umbrella due to the movement among classrooms, laboratories, and other areas in the campus.

This very experience led to the creation of a concept that focuses on providing quick yet efficient means of renting an umbrella when required. The concept is referred to as the Automated Umbrella Rental System. As one of the engineering courses with its students and faculty members always developing innovative ways of doing things, the development of an umbrella rental system through automation is a practical application of technology.

The proposal of this study suggests an automated umbrella rental and return mechanism to provide convenience and readiness. Automation will be introduced in this study by making use of IoT. The access to the umbrellas will be facilitated by the absence of any human interaction due to the use of RFID equipped identification cards.



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Umbrellas will be managed by being monitored in the system. Moisture sensors and fans will be installed to dry any wet umbrellas in addition to waterproof paints which will be used to prevent the damage of any water in order to facilitate longevity. Besides, monitoring the rental transaction will be done using IoT.

The project not only focuses on offering umbrellas to those in need but promotes sharing culture while at the same time reducing the burden on carrying the umbrella all the time. Moreover, the project demonstrates how the Computer Engineering students can utilize technology to turn their idea into reality.

1.1 Project Context

The Automated Umbrella Rental System aims to offer umbrella rental services to the Computer Engineering students and faculty members of St. Anthony's College (SAC) during any instances of rain or heat. The project will help them deal with instances of changing weather conditions and make them feel ready.

In this project, Arduino, RFID technology, and Internet of Things will be used to enable Computer Engineering students and faculty members of St. Anthony's College to rent and return umbrellas using automated systems. This can be done by scanning their respective RFID enabled ID cards. Tracking of umbrellas will also be done as a means of keeping track of the umbrellas.

The purpose of using a fan is to help dry out the wet umbrellas and make them available for the next user. Besides that, a solenoid is also utilized to manage the



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process of borrowing and returning an umbrella easily. Moreover, a waterproof coating is applied to safeguard hardware parts from moisture.

Thanks to IoT technology connectivity, the administrations will be capable of monitoring transactions.

1.2 Purpose and Description

This system is intended to ensure that users are protected from any sudden adverse weather conditions easily. The main purpose of developing this system is to ensure that computer engineering students and faculty can access the umbrellas in an efficient manner without needing someone to supervise the procedure. The automation system has ensured that there is safety while handling, availability, and maintenance of the umbrellas, where the solenoid helps manage the renting and returning of the umbrellas.

Every single umbrella is tracked and controlled via an admin dashboard to simplify its monitoring while the moisture sensor and fan help keep the item clean and dry. Through its the Internet of Things capabilities, it becomes possible for an administrator to track the activity on rentals in real-time. In addition to making the process more convenient and responsible, such innovation helps boost sustainability as well since sharing resources is encouraged.

1.3 Objectives of the Project

The general objectives of the study entitled "Automated Umbrella Rental System" for the Computer Engineering Program of St. Anthony's College (SAC)



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include the development of an automated umbrella rental system that facilitates easy, safe, and efficient access to umbrellas by students and faculty members during sudden changes in weather through a process involving user identification, automation of rental and return of umbrellas, and online transaction documentation.

Specific Objectives:

1. Implement RFID-based authentication for secure renting and returning of umbrellas
2. Integrate a coin slot payment mechanism to enable controlled and automated rental transactions.
3. Develop an automated umbrella unlocking and locking mechanism to ensure secure access and prevent unauthorized use.
4. Integrate IoT connectivity with a web-based dashboard to display real-time umbrella slot status, user information, and recent transaction, as well as allow system connection and monitoring.
5. Incorporate a maintenance system to detect wet umbrellas and ensure they are clean and ready to use.



1.4 Conceptual Framework

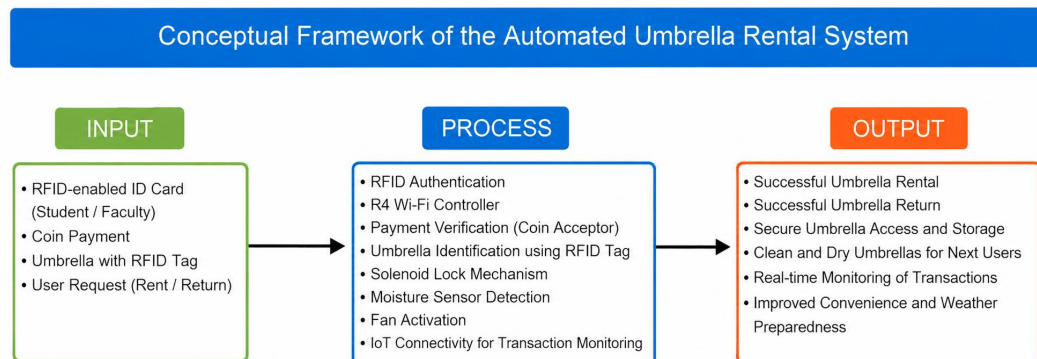


Figure 1: Conceptual Framework

Conceptual Framework of Automated Umbrella Rental System in Computer Engineering Program of St. Anthony's College is depicted in Figure 1 below. The figure depicts the combination of software and hardware elements that allow the automation of the renting and returning of umbrellas as well as monitoring the transactions using IoT technology.

The users start the process through authentication using their RFID card. Other inputs include coins for rental fees, umbrellas, and commands from the user to either rent or return an umbrella.

The Arduino UNO R4 Wi-Fi controller performs tasks related to the validation and processing of the input data. Authentication through the RFID reader validates the identity of the person whereas the coin validator authenticates that the payment was made. The solenoid facilitates the locking and unlocking mechanism. Individual umbrellas are tracked and monitored by the system whereas the moisture detectors



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sense any wet umbrellas and trigger the fan for drying. The system is programmed using an Arduino Uno R3 controller for receiving inputs from the sensors.

The system ensures successful umbrella rentals and returns, secure access, storage of umbrellas, clean and dry umbrellas ready for the next user. The real-time monitoring transaction helps improve convenience, encourages responsibility, and promotes preparedness for rapid weather changes.

1.5 Scope and Limitation

Scope

The Automated Umbrella Rental System is a project designed for the Computer Engineering program at St. Anthony's College (SAC). This project is based on an automation technique which involves the use of Arduino, RFID, LCD, push buttons, and electromagnetic solenoids. RFID cards will be used by both students and faculty members of SAC during the process of renting and returning the umbrellas.

The umbrellas will be monitored and controlled through the automated system. Other components such as moisture sensors and fans will also be integrated in order to ensure that the umbrellas are clean and available for reuse. The rental activity of the umbrellas can be tracked through the Internet of Things via the website.

Limitations

The proposed system would be functional only within the Computer Engineering department at St. Anthony's College (SAC), involving registered



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students and faculty who hold valid RFID cards. Moreover, the system only handles automation, payments, tracking, and umbrella maintenance. It does not monitor weather conditions or any real-time weather updates, hence, cannot react to any rains and any changes in weather forecasts.

Additionally, the system does not include any predictive measures, implying that it cannot estimate future demands or optimally distribute umbrellas based on such predictions. The system operates using external information, hence, will be inefficient if there are no input factors and cannot work offline independently.

Moreover, it does not incorporate any smart city technologies, advanced user functionality such as customization and voice commands, or any AI-supported decisions. The maintenance aspect is also elementary since the system can identify issues but cannot prevent any future problems.

1.6 Significance of the Study

The results and outputs of this study will benefit the following groups:

Students and Faculty. The system offers an effective method of getting the umbrellas in case of any changes in the weather conditions that could cause delays and inconvenience when moving from one place to another in the campus premises.

Administrators and Staff. The administrators staff members will be able to control the process of loaning umbrellas and maintain their inventory effortlessly and promptly, using IoT. In addition, it reduces the need for constant supervision as the system maintains an accurate record of every transaction made.



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The Institution. St. Anthony's College will be seen as an innovative and progressive institution with high levels of technological development and environmental awareness by implementing such a project on its premises.

Future Researchers and Developers. The present research will prove to be a useful source of information for future studies focused on developing a smart umbrella lending facility using IoT, RFID technology, and automation.

1.7 Definition of Terms

The definitions below will provide clear meanings of the terminologies and parts involved in the study:

R4 Wi-Fi controller - it refers to the use of a micro-controller board which can be called a mini computer that facilitates electronics and IoT projects, however, it features Wi-Fi capability thus connecting directly to the internet without any extra module.

RFID (Radio Frequency Identification) - it refers to the wireless technology using radio waves for identification and tracking of tagged objects. This particular study uses RFID for identifying users' IDs and monitoring umbrellas through RFID tags for safe tracking.

RFID Card - an RFID card acts as an input and identification device used for authentication purposes. This card facilitates the recognition of users allowing them to perform actions such as rent or unlock umbrellas.



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RFID Reader - this particular device detects and decodes data from RFID tags and RFID cards in order to verify the user identity and umbrella details.

Coin Slot - it refers to the input/payment device which recognizes inserted coins to trigger actions, such as rent or unlock umbrellas.

Soil Moisture Sensor - the soil moisture sensor is an input device that measures the moisture levels in the soil. This technology is employed for automating irrigation systems by providing relevant data for watering plants.

IoT (Internet of Things) - this concept stands for a network of electronic devices which exchange information via the Internet. In our project, IoT is applied to monitor the presence of umbrellas and changes to the system.

LCD (Liquid Crystal Display) - the LCD is an output device responsible for presenting alphanumeric data. The method of connection with an LCD might involve different communication methods, such as parallel and I2C communication, during which the microcontroller transfers data for the screen.

Solenoid - the solenoid is an actuator device that controls various functions such as locking/unlocking, pushing, and pulling. The solenoid needs more current than a microcontroller can provide. Thus, its interface is established using a relay or transistor.

Push Button - a push button serves as an input device responsible for notifying the control system about user requests. The push button may be used in process initiation, confirmation of rent/return instructions, or navigation between options.



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Buck Converter - a buck converter is used as an electronic component in a power supply that generates the necessary reduced voltage (such as from 12V to 5V or 3.3V) in order to support the working of components like microcontrollers, sensors, and modules.

Renting and Returning Mechanism - the method that allow users to rent or return their umbrellas using RFID identification and servo motors.

Administrator Interface - a web interface that allows an authorized users to execute actions on the umbrella-sharing system remotely with the used of IoT technology.



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CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Theoretical Background

The automated umbrella rental system relies on certain existing theories and concepts that aid in understanding how the system works and its significance. The theories allow one to gain insight into how automation, user recognition, tracking, and monitoring systems work. What is more important, the theories stress the necessity of having a system that will make people's lives easier and enhance preparedness.

According to the Systems Theory, a system comprises various elements working towards the same goal. In relation to the Automated Umbrella Rental System, this theory will help to determine how the various elements within this system should interact to make the renting process effective. Some of these elements include the storing, logging, and handling of umbrellas. Each element has its own role to play within the system. Umbrellas can be given out and collected by staff members manually. On the other hand, the logging process is used to document which individual rented or returned the umbrella. Effective interaction among these elements results in an efficient umbrella renting process since each element plays a unique role in ensuring this process becomes successful.

Another significant theory is Microcontroller System Theory. The Microcontroller System Theory focuses on the interaction between the embedded systems and their ability to gather input, process information, and generate an output.



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In this system, the Arduino serves as the controller for this system. It receives input from RFID, humidity sensors, and the user interface, and then performs the necessary action. Microcontroller System Theory connects the system input (ID scan/LRN), process (identification and verification), and output (umbrella release/notifications).

The research design also relies on Radio Frequency Identification (RFID) theory. According to this theory, items can be identified via wireless connection by sending electromagnetic waves to them. RFID theory supports the premise of the study by providing each umbrella with a unique ID card. Therefore, there is a direct relationship between identification and monitoring.

The framework of Internet of Things (IoT) is equally important. IoT theory provides an understanding of how devices can be connected to the internet in order to share information. In this case, IoT allows the administrator to control the number of umbrellas available, moisture level, and the transaction details without being physically present. The IoT theory emphasizes the importance of connectivity and is supportive of the objective of achieving transparency in the use of the system.

It has been confirmed in studies about smart rental systems, university campus convenience technology, and resource sharing schemes that automated systems have the highest chances of success if they are simple and easy to use. Such systems would help in achieving user adoption, a feature that will ensure the success of the system designed in this study.



2.2 Review of Related Foreign Literature

2.2.1 IoT Based Smart Umbrella

According to “IoT-Based Smart Umbrella” (Karthik & Sagar, 2021), the authors mention that the utilization of regular umbrellas in outdoor situations leads to problems such as exposure to unexpected weather changes, difficulties when operating phones at the same time, and the potential loss of an umbrella through theft or misplacement. Some of these problems include the manual control of the umbrellas, failure to provide real-time weather reports, inadequate support for navigation, and ineffective supervision of their operation. Although efforts have been made to address these safety and convenience concerns, they are still hindered by lack of automation, sensors, and alerts. The research reveals that IoT technology and automation in controlling open-close functions, LED guidance lights, Bluetooth and GPS tracking, Wi-Fi, and audio alarms contribute to improved security and comfort during walks outdoors regardless of weather changes (Karthik & Sagar, 2021).

In relation to the proposed study “Automated Umbrella Rental System,” the findings mentioned above could be applied in solving a similar issue in a different scenario. The automated umbrella rental system uses automation technology to aid in the renting and return of the umbrellas and notify users of this matter. While Karthik & Sagar (2021) focused on the integration of IoT, sensors, and navigational technologies for each umbrella separately, the automated rental system utilizes all such technologies in an umbrella rental scenario using application software for booking and anti-theft purposes.



2.2.2 Automating the Rental Process of Bridal Dresses

According to “Automating the Rental Process of Bridal Dresses” (Isayev & Makhamatshoyevich, 2025) explains how the process of renting a bridal dress is long, inconvenient since it needs physical presence on the part of the customers, and limited due to low inventory accessibility, which lowers the level of customer satisfaction and business efficiency. The problems include lack of automation in the reservation process, inability to arrange for appointments conveniently, failure to provide personalized advice to clients, and inefficient control over the inventory. Although there is an intention to enhance the services, it is limited by lack of technological means for doing so, such as automation, monitoring, and analysis of data.

In relation to the proposed study “Automated Umbrella Rental System” research proposal, these results can be considered a useful basis for dealing with comparable problems in an alternative environment. An automated system for umbrella renting uses technology to handle renting and return procedures, control the umbrellas' availability, and inform users about their status in real-time. Where Isayev and Makhamatshoyevich (2025) recommended using digital technologies, AI recommendations, and CRM for managing wedding rentals, the automated umbrellas' system employs IoT, sensors, and mobile applications.

2.2.3 Bike Rental Management System

According to “Bike Rental System” (Shinde, S. 2024), the researcher have pointed out that the traditional system for renting bicycles is inefficient, transactional in nature, lacks real-time data updates, thereby making the process inconvenient for both the customers and operators. Some of the issues associated with such a system



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include booking problems, lack of ability to track bikes, payment security concerns, as well as problems related to the management of accounts and bike renting services. While attempts are made to make mobility solutions more accessible and sustainable, their efforts are hindered by the lack of automated systems. The findings indicate that automation using web-based software makes the process easier and more convenient for all parties involved (Shinde, S. 2024).

In relation to the proposed study “Automated Umbrella Rental System,” these results present an important platform that can be used in tackling the same issues under another environment. This includes using automation in managing the availability of bikes, booking, payments, and providing updates to users. In comparison to what Shinde, S. (2024) recommends on using websites, real-time tracking, and administrative dashboards in managing bike rentals, these strategies have been applied to umbrellas through IoT sensors, real-time tracking, and application booking.

2.3 Review of Related Local Literature

2.3.1 Securing Campus Resources: Smart Locker System with Student ID Authentication in a University Setting

According to “Securing Campus Resources: Smart Locker System with Student ID Authentication in a University Setting” (Barillo, 2025), traditional locker systems are usually manually activated by using keys and simple locks, thus making them vulnerable to theft and loss of keys. According to the study, standard storage methods do not satisfy the contemporary requirements of university students, as their



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flaws include insufficient security, inconvenient handling of keys, and insufficient storage space. The emergence of innovations makes it necessary to create systems that involve automation and identification processes. The research shows that using a QR code scanner, microcontroller, and electronic lock can positively affect the level of security, resource management, and convenience of borrowing. These results have implications for automated rental systems, as they show that using digital verification, automated access, and monitoring can enhance the effectiveness of the process (Barillo, 2025).

In relation to the proposed study "Automated Umbrella Rental System," the study conducted by Barillo (2025) is a pertinent technology study to address issues in the area of umbrella rental systems. Although the technology discussed in the study was designed to ensure the security of personal belongings through the use of smart lockers, the application of this technology in the area of renting umbrellas is quite feasible, considering that it includes several aspects that can be successfully implemented in the suggested project. The main aspects include digital authentication through QR codes, automatic access using electronic locks, and the involvement of a microcontroller in the operation of the system. These technologies will be combined with the use of Arduino-based controls, RFID/QR code authentication, and automated locking and dispensing in the umbrella rental project.



2.4 Review of Related Foreign Studies

2.4.1 An intelligent umbrella rental system with drying function

According to “Intelligent Umbrella Rental Platform” (Meng Yongjiang, 2019), conventional ways of umbrella rental have been reported to be inefficient, vulnerable to damage, and provide minimal real-time information. Among some of the problems include corrosion, inability to track umbrellas automatically, and inability to manage umbrella availability.

While conventional methods have made efforts to make rentals more convenient, they cannot do so without IoT technology, automation, and durability of equipment.

This study argues that IoT technology, intelligent locking systems, drying mechanism, rotation system, and unique ID chipper for each umbrella will increase efficiency, enhance the lifespan of an umbrella, and enhance overall user satisfaction (Meng Yongjiang, 2019).

In relation to the proposed study "Automated Umbrella Rental System," the findings above present an appropriate structure in solving the same problems but in a different situation. The intelligent umbrella rental system employs automation in the handling of umbrella availability, renting, returning, maintaining hygiene, and tracking users' activities. In the case where Meng Yongjiang (2019) recommended using IoT technology, intelligent locks, drying systems, and identification tags for umbrellas, the above-mentioned suggestions have been converted into automation



technology, RFID, moisture sensors, and booking through an application in the proposed project.

2.4.2 A Comprehensive Study of IoT-Enabled Smart Umbrella Rental

System Using Mobile Application

According to Mosalla Sophia and Jeong-Dong Kim's article, "IoT Smart Umbrella Rental System Using Mobile Application," dated 2025, the umbrella rental systems are known to cause inconvenience among users because of many factors, including the absence of automated tracking and inefficient rental procedures. The difficulties encountered in the traditional methods include inefficiency in terms of rental and return process as well as the inability to monitor umbrella usage through automation. Despite the effort of current umbrella rental stations to provide convenience, there is still much room for improvement, especially in the form of integrating IoT technology, using mobile applications, and improving tracking. This study argues that the inclusion of GPS tracking, cloud management, and mobile applications would greatly improve convenience.

In relation to the proposed study "Automated Umbrella Rental System," the above findings offer useful guidelines towards tackling similar problems in contemporary umbrella rental systems. As seen from the IoT-based umbrella rental system proposed by Mosalla and Kim (2025), the implementation of automation would be effective in enhancing tracking, processing of rentals and returns, and data handling in real time. While the system by Mosalla and Kim (2025) employed technologies like NEO-6 GPS module, ESP32 microcontroller, Firebase, and React



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Native app to allow for tracking, update management, and interactions through QR, the suggested research topic is focused on using the principles of these technologies in Arduino-based automation, RFID technology, moisture detection, and application-based reservations.

2.4.3 Car Rental System

According to “Car Rental System,” Yadav and Pawar (2021) point out that the conventional rental systems, including those of vehicles like cars, suffer from cumbersome manual processes, poor accessibility, and inefficient tracking mechanisms that make the systems less convenient and efficient. The authors have identified certain problems associated with such traditional systems, including the challenges of monitoring the availability of cars and processing reservations and updating data in real time. It is clear that the introduction of an online automated rental system would significantly improve the operations.

In relation to the proposed study “Automated Umbrella Rental System,” the following results present a useful framework to tackle analogous issues in an entirely new environment. Yadav and Pawar’s (2021) automated car rental system is an example of an effective solution using online mediums to monitor vehicle availability, facilitate bookings, and securely manage centralized databases. While Yadav and Pawar incorporated an Android application, real-time reservation tracking, and centralized management systems, the suggested solution uses an automated process based on Arduino technology, RFID identification, moisture sensor, and mobile applications.



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2.5 Review of Related Local Studies

2.5.1 iNotified: An SMS and RFID-Based Parent Notification System of Lipa City Colleges

According to “iNotified: An SMS and RFID-Based Parent Notification System of Lipa City Colleges” by Mojares (2019), conventional methods of monitoring the attendance of students in school institutions have been found ineffective in giving the parents an immediate and accurate notification about their children’s attendance. The problems encountered include a lack of real-time communication, manual registration processes, and automatic verification of the attendance of the students in the institution. Therefore, the researcher came up with an innovative solution that involves use of database management, RFID technology, and SMS modules to make the process more efficient. It involves capturing of data relating to the attendance of students using RFID modules and then sending notifications to parents automatically using the SMS modules. Technologies used for development and evaluation of the system included Java, Visual Basic, MySQL, RFID, and GSM modules. According to Mojares (2019), the system worked effectively in real time and proved reliable, easy to use, and efficient in performance.

In relation to the proposed study “Automated Umbrella Rental System” is concerned, the iNotified system offers useful guidance on the application of RFID technology to automate processes within the campus environment. Although the iNotified system uses RFID technology for attendance tracking and sending parent alerts, RFID technology can easily be used in the process of identity authentication and automated logging of umbrella rentals within the proposed project. Just like the



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way Mojares (2019) was able to automate student movement through the use of RFID and real-time SMS messages, the same technologies can be incorporated in the proposed project to make the borrowing and returning of umbrellas convenient and efficient.



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CHAPTER 3

TECHNICAL BACKGROUND

In order to design and develop the Automated Umbrella Rental System, the project will be developed among the students and teachers of the Computer Engineering Department at St. Anthony's College (SAC). With this system, the users will find it easy to access the umbrellas whenever necessary and return the umbrellas upon completion of their use. In choosing the materials that will be used in developing this system, there are three important factors to consider, which are reliability, durability, and affordability.

3.1 Technicality of the Project

The Automatic Umbrella Rental System ensures ease of access to the umbrellas through a combination of simplicity and automation. This part provides a technical description of the system in terms of the tools, materials, and processes that have been used for development and implementation of the project. The technical structure of the system includes various elements, such as hardware components, which involve microcontroller, power supply, different sensors such as, soil moisture sensor, RFID reader and card system, LCD display, fan, payment module such as, coin acceptor, and umbrella dispensing device.

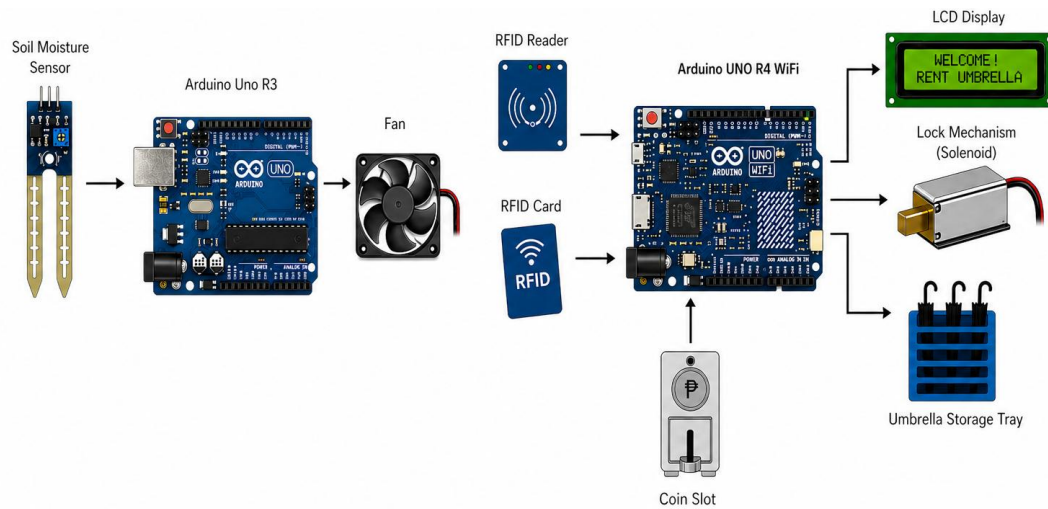


Figure 2: Technicality of the Project

This is an automated umbrella rental machine that utilizes various electronic parts, thus facilitating convenient, safe, and systematic access to umbrella rentals by users. In this particular case, the central part of the umbrella rental machine is the Arduino UNO R4 WiFi controller because this machine can be considered the "heart" of the machine. With the aid of this controller, the major input/output devices of this machine work properly. These devices include the RFID Reader, the payment system, the LCD screen, the lock mechanism, and the umbrella tray.

Apart from the drying functionality of the automated umbrella rental machine, there is also the Arduino UNO R3 microcontroller which takes care of the soil moisture sensor and fan in this umbrella rental machine. Through this device, the soil moisture sensor can detect humidity levels and automatically activate the fan.

First, the user must scan his or her RFID card. This is detected by the system with the use of the RFID reader. When the RFID card is authenticated by the system,



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the machine will permit the user to continue with the next process, which involves making a payment using the coin slot. It serves as another way to authenticate and provide security from theft.

After accepting the payment, the Arduino UNO R4 WiFi will process the request and unlock the solenoid lock mechanism, giving way to the user to access the umbrella storage tray where they can take an umbrella.

The LCD screen will provide instructions for the whole process by informing the user to scan first before making a payment or letting him or her know whether he has access already. On the other hand, the Arduino UNO R3 will continuously detect the wetness of the umbrellas and turn on the fan whenever necessary.



3.2 Details of the Technologies to be Used

The following materials and equipment are required for this project.

3.2.1 Hardware

Arduino Uno R4

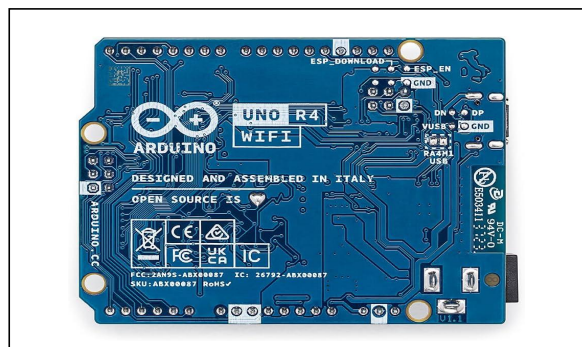


Figure 3: Arduino Uno R4

A microcontroller board, which is the Arduino Uno R4 WiFi board, is a tiny computer that is designed for controlling specific activities within the electronic devices. The board features an inbuilt microcontroller, memories and input/output ports that enable the microcontroller to connect with various electronic parts within the device. The microcontroller is responsible for processing the instructions whereas the memories will store the instructions for programming. On the other hand, the input and output ports are used for connecting the sensors, modules and actuators.

The Arduino Uno R4 WiFi microcontroller comes with an inbuilt capability for communicating via the Wi-Fi network. Therefore, it can communicate wirelessly when necessary.



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In the case of the Automated Umbrella Rental System project, the Arduino Uno R4 WiFi will be the control unit that coordinates and automates the process of rental and return services. It will be the “brain” of the entire project where it processes inputs from the RFID card, RFID reader, push button, LCD display, and coin slot module to execute instructions that will determine access and perform the functions assigned to the system.

The controller also regulates the functioning of output devices like the solenoid that is used to lock or unlock the locking mechanism of the umbrella. It coordinates the entire system to make sure that everything works smoothly and effectively when renting or returning the umbrella.

Arduino Uno R3



Figure 4: Arduino Uno R3

A microcontroller board (Arduino Uno R3) is a small computer that helps perform tasks related with a particular electronic system. It includes an embedded microcontroller, memory storage, and input/output pins used in connection with the various electronic components. Microcontrollers help process information, while the memory stores programs and data that run the process. On the other hand, input and output pins work in connecting various components such as sensors and modules.



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However, the Arduino Uno R3 microcontroller does not have inbuilt WiFi but is widely employed in automation systems due to the ease with which it operates and how efficient it is. Arduino IDE programming language software is employed in this microcontroller whereby the code is written and uploaded in the controller using the C/C++ programming languages.

On the other hand, the Automatic Umbrella Rental System employs the Arduino Uno R3 in controlling the dryer mechanism in the system. This serves as the controlling mechanism for the dryer mechanism as it collects input signals from the moisture sensors showing whether the umbrella is either wet or dry. Depending on the results received, it controls the operation of the fan.

RFID Card

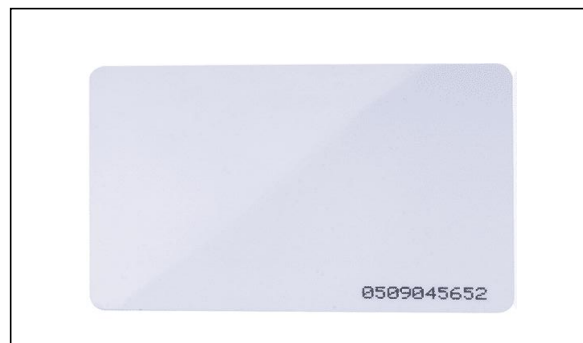


Figure 5: RFID Card

An RFID card is one form of a smart card which utilizes Radio Frequency Identification (RFID) technology that facilitates wireless communication and storage of information. The card consists of a chip and an antenna through which it can send out information wirelessly upon coming close to an RFID reader. An RFID card is extensively used in access control, identification, attendances, and transactions due to



its speed and convenience compared to smart cards where contact is necessary for the transaction.

In the Automated Umbrella Rental System, the RFID card is the main identifier used by the user in verifying access and allowing the rental or return of umbrellas.

RFID Reader

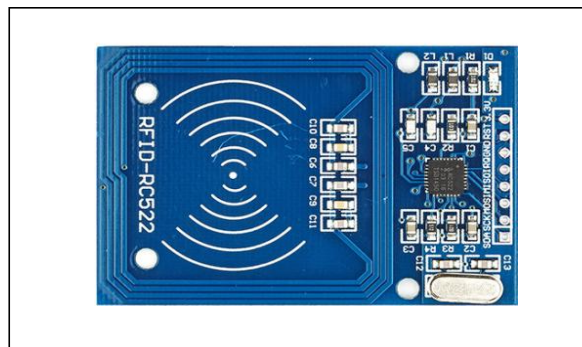


Figure 5: RFID Reader

RFID readers are devices that assist in scanning and reading, as well as writing information on RFID tags or RFID cards through radio frequencies. The RFID reader starts the entire communication process by sending a low-powered radio frequency wave that acts as an energy source for powering up the RFID chip once it gets in touch with it. Once the RFID chip is activated, the RFID card sends all the information stored within it to the RFID reader, including the unique ID code. After receiving the data from the RFID chip, the RFID reader analyses the data before relaying it to a computer or microcontroller for further processing.

The RFID readers have been applied in the Automated Umbrella Rental System for scanning the RFID cards of the users.



Coin Acceptor



Figure 6: Coin Acceptor

Coin acceptor are electronic mechanisms which are used for detecting, identifying, and verifying whether the coins inserted into the machine are genuine. This process of detection and verification occurs via the measurement of the physical attributes of the coin, such as, weight and size.

In case of authentication of the coins, the coin acceptor sends an electronic signal to a microprocessor indicating that payment has been done. The control system will then take the next step such as granting access to use a device or receive a service.

In the case of the Automated Umbrella Rental System, the coin acceptor is employed as the payment device that confirms the authenticity of coins prior to their usage in accessing the rental services provided by the system.



Push Button

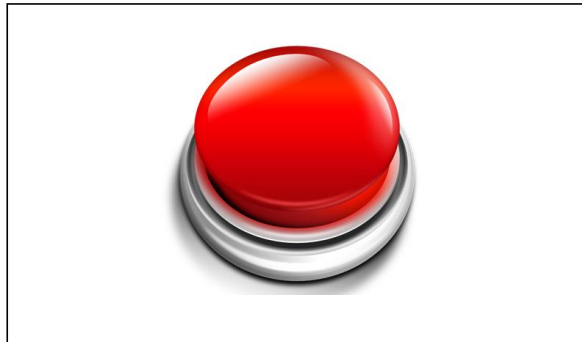


Figure 7: Push Button

Push buttons are simple forms of electromechanical switches used in the electronics field in order to perform an action following the depression of the button.

The push button works through the interruption of the electric current in a circuit. Pressing the push button generates a signal which can either be high or low and is transmitted to the microcontroller or circuit before reverting back to its initial state after releasing the button.

In the Automated Umbrella Rental System, the push button serves as a means of controlling the system manually when it comes to performing certain actions within the system.



LCD Display

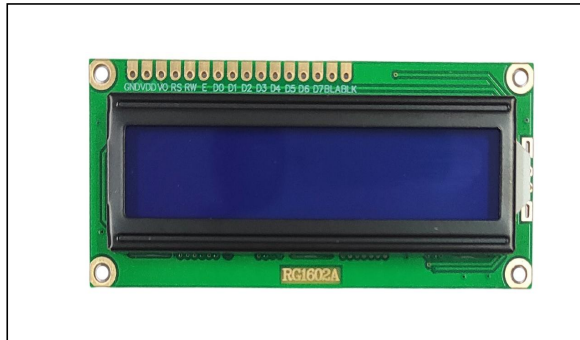


Figure 8: LCD Display

An LCD Display is referred to as an output device that uses liquid crystals and back lighting to display alphanumeric texts, numeric numbers, and pictures. The working principle of this device involves the regulation of light passing through liquid crystals layers to form visible texts.

The use of LCD display modules in electronic devices is common because of its reliability, user-friendliness, and ability to display real-time information. This device can be used to display various messages and information concerning the operations.

In the automated umbrella rental system, an LCD display serves as the main output device for displaying crucial information regarding the rental and return of umbrellas



Solenoid



Figure 9: Solenoid

Solenoids are electromagnetics actuators that convert electrical energy to a mechanical linear actuation force. Solenoids are comprised of a solenoid coil, together with a metallic slug, which can be moved either towards or away from the coil.

Whenever electric current flows through the coil, a magnetic field is created, which attracts or repels the slug to create mechanical movement.

Uses of the solenoid would involve all applications that require locking, unlocking, or switching.

The Automatic Umbrella Rental System makes use of the solenoid to lock or unlock the umbrellas inside the box for easy release or return.



Umbrella



Figure 10: Umbrella

An umbrella is a portable invention used to prevent oneself from getting wet with rain or the effects of the sun. Umbrellas comprise a waterproof fabric canopy held up by foldable ribs, connected by a shaft.

Umbrellas operate on the principle of expanding the canopy in such a way that it shields one from water from rains or reduces exposure to sunlight. It also folds easily for easier portability.

In the case of the Automated Umbrella Rental System, an umbrella serves as the primary rental and returnable object for the user. Each umbrella in the system is kept track of by the system to ensure that everything runs smoothly.



Soil Moisture Sensor

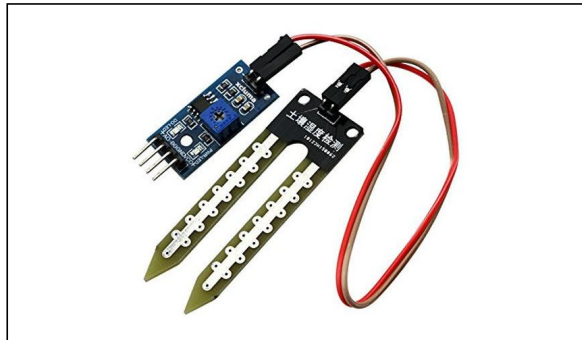


Figure 11: Soil Moisture Sensor

A Soil Moisture Sensor is the electronic equipment used to determine the amount of water (moisture) present in the soil or any other material. The equipment determines the electrical conductivity between the two probes that are put inside the soil and whose electrical conductivity varies according to the amount of water present.

This information is relayed to the microcontroller in the form of the electrical signal, which will analyze the moisture levels in the soil or surface.

In the Automated Umbrella Rental System, the soil moisture sensor will play a critical role in checking whether the returned umbrellas are either wet or dry before they are ready for storage.



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Fan



Figure 12: Fan

The fan is an electronic system designed for the creation of airflows. This can be done using blade rotations caused by energy from an electric motor.

The signals used in controlling the operation of the fan are generated by the microcontroller. These electronic signals are responsible for determining when the fan operates according to specific conditions.

In the automated umbrella rental system, the fan is applied for drying wet umbrellas prior to their storage and reuse by other persons.



Buck Converter

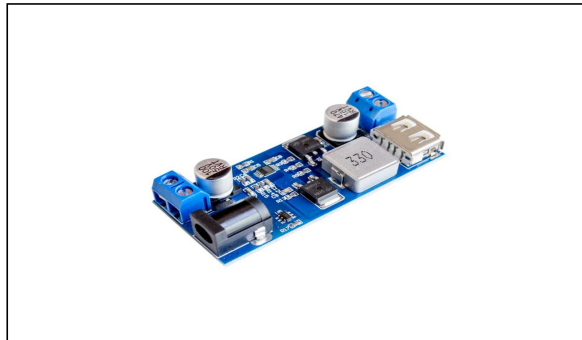


Figure 13: Buck Converter

A buck converter is an electrical circuit that lowers the input voltage to a certain lower voltage. In essence, it is a DC to DC converter, where DC voltage is converted to another DC voltage with a lower voltage value.

The voltage is lowered through the switch mode, which is achieved by turning on/off an electronic component (for instance, transistor), followed by the use of smoothing circuits (capacitors and inductors).

In turn, the buck converter provides a steady and lower voltage for the electronic components to work with. Additionally, the voltage provided by the buck converter can be controlled or monitored through a microcontroller if need be.

In the Automated Umbrella Rental System, a buck converter is applied to lower the high supply voltage to lower voltage levels required by components like the microcontroller, sensors, and fan.



Relay Module



Figure 14: 12V Relay Module

A 12V relay module is an electronic switch utilized for controlling the high voltage or high current devices via low-voltage signals provided by a microcontroller. It serves as an intermediary device linking low power control circuits with the high-power devices.

The functioning of this particular module includes giving an input 12V signal to energize the electromagnet in the relay. This results in a magnetic field from the electromagnet, activating or deactivating the switch in the relay. Therefore, this makes the relay activate or deactivate the electric power source. This particular module has its own driver and safety elements within it.

Thus, the relay makes the connection safe and protects the microcontroller from exposure to high voltages or currents.

In the Automated Umbrella Rental System, a 12V relay module can be applied to operate the devices such as a fan or a dryer. If there is a need to dry umbrellas, the control signal from a microcontroller turns the relay ON or OFF.



3.2.2 Software

Arduino IDE

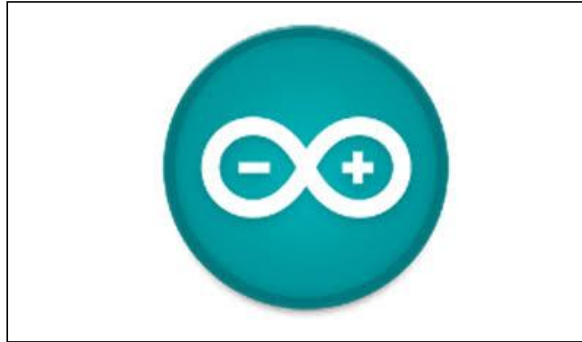


Figure 15: Arduino IDE

The software program that we used in this project was the Arduino IDE using C++ as the programming language, which controlled the process within the system through coding. The Arduino C++ code was used to handle the input process in form of information obtained from the sensors, the process of making decisions based on this input, and the output of the processes to other hardware elements including the relay module, fan, solenoid, LCD screen among others.

The choice of using Arduino IDE (C++) was due to simplicity, efficiency, and wide use in microcontroller programming where it has built-in libraries used to interact with different hardware elements such as the RFID reader, sensor, and other actuators. Fast upload of code to the microcontroller is also possible.

Because of its performance, flexibility, and reliability, the system can operate smoothly and respond quickly to different conditions in the Automated Umbrella Rental System.



3.3 How the project will work

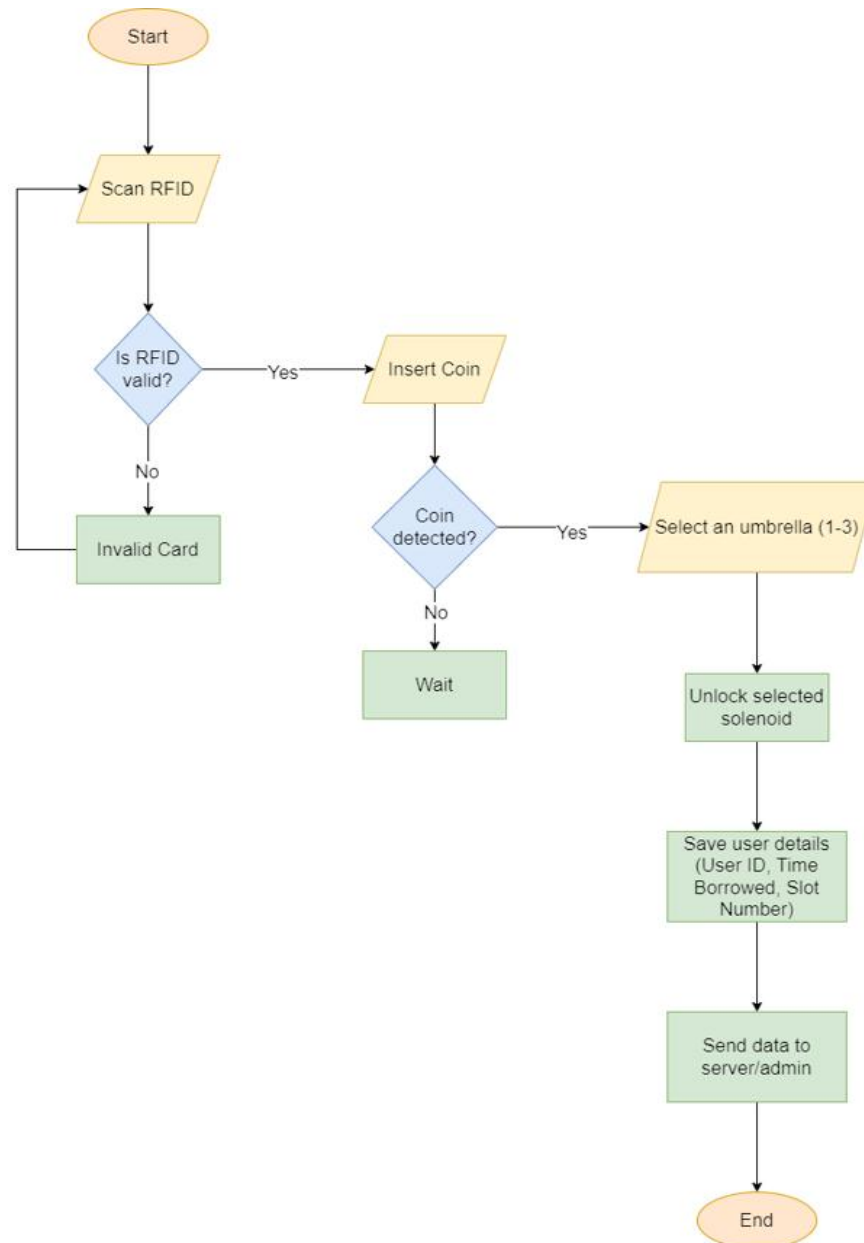


Figure 16: System Flowchart - Rent

The first step of the flowchart involves the action of the user to start the process by swiping his/her RFID card. It is then upon the RFID reader to establish



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whether the RFID card being used is valid. If not, an “Invalid Card” message will be printed on the screen, and then the process goes back to the scanning point.

In case the RFID card is valid, the user is free to go to the next stage, which involves putting in a coin. The system detects whether there is a coin in place or not, and if there isn't, the system stays at the detection stage until the coin is detected.

The process concludes by recording the data regarding the user ID, date borrowed, and slot number chosen. All of the recorded data will be delivered to the server/admin side.

Finally, the data concerning the transaction that was performed (user ID, borrow time, and selected slot) is stored and then sent to the server/admin. This marks the end of the whole process only after all the data is transmitted.

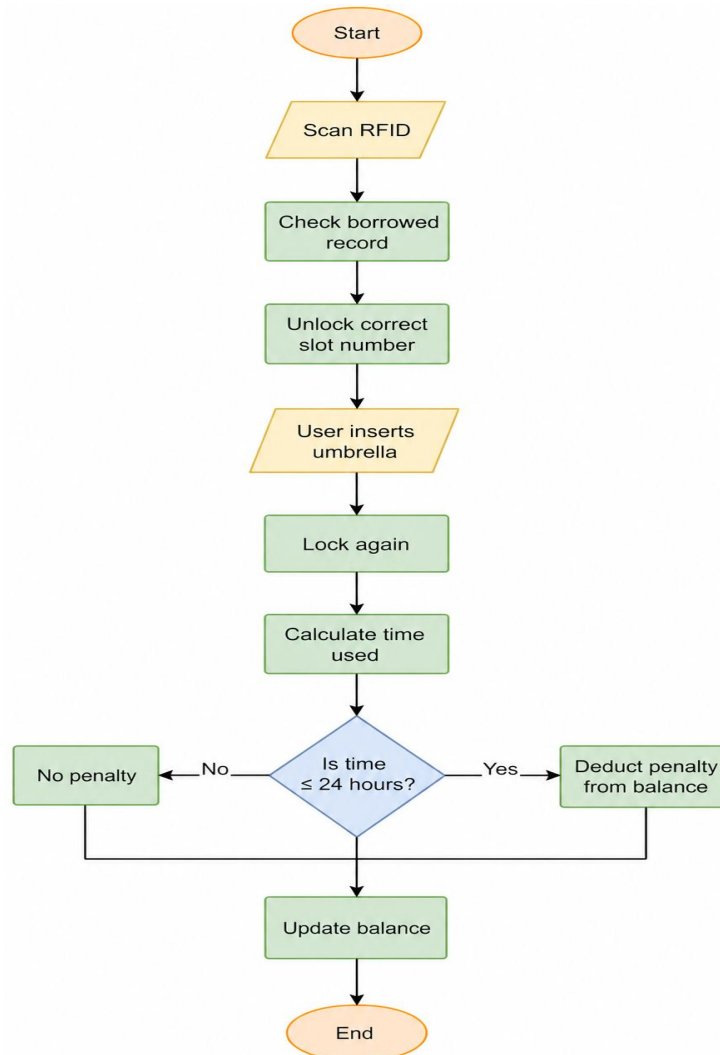


Figure 17: System Flowchart - Return

In the flowchart, the process begins as soon as the user initiates the process and scans the RFID tag of the umbrella. After that, the system validates the borrowed record to ensure that the umbrella is listed under the borrowing record of the user.

When the record is found valid, the system unlocks the slot allotted to that umbrella. The user places the umbrella in the unlocked slot. Once the umbrella is placed correctly, the slot gets locked back again.



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Subsequently, the system determines the total duration for which the umbrella has been used according to the total borrowing time.

It is further determined by the system whether the period is less than or equal to 24 hours. In case the total period is up to 24 hours, a penalty amount is deducted from the balance of the user, while in case of exceeding 24 hours, no penalty is applied.

The system subsequently deducts the penalty amount and adjusts the user's balance. At last, the process is ended as soon as the user's balance gets adjusted.



CHAPTER 4

METHODOLOGY

This chapter discusses the environment requirement specifications, risks assessments/analysis, output design, deployment diagram, conclusions and recommendations.



Figure 18: Agile Methodology

4.1 Agile Methodology

Agile Methodology was applied in this project due to its adaptability and improvement nature. With the Agile methodology, a project is divided into several stages to make the problem identification, implementation of changes and improvements, and even enhancements easier.



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In the first stage, the problem was determined, which was inconvenience resulting from weather changes as well as lack of umbrellas within the campus. Brainstorming of ideas followed, where possible solutions and the required system features were identified. The need for automation, ease of use, and dependability were among the most important system features. The necessary components like RFID reader, coin acceptor, microcontroller, solenoid, and sensors were identified at this stage.

In the prototyping phase, the researchers put together the first piece of hardware and a rudimentary software to find out whether there were any problems with the pieces that might be improved in future during actual development. Integration involved putting together all of the hardware and software components of the system.

The system was programmed to read RFID, check for coins, control the solenoid lock, as well as display system information on the LCD screen. IoT functionalities were also incorporated into the system to monitor transactions. Refinement was done for better efficiency of the system.

The testing phase involved checking and correcting possible problems, such as errors and delays in processing, among other errors.



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System completion took place after all other phases had been successfully completed.

4.2 Environment

4.2.1. Locale

The Automated Umbrella Rental System will be undertaken at St. Anthony's College situated in San Angel, San Jose de Buenavista. There is an engineering department in the college which helps in carrying out innovation by introducing new technological systems.

The figure below shows the location map of St. Anthony's College, where the Automated Umbrella Rental System will be carried out.



Figure 19: St. Anthony's College Location Map

The system is strategically located in visible locations inside the department where both students and teachers can conveniently rent and return their umbrellas.



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The main reason behind such an arrangement is that there is instant access when faced with any form of unexpected weather.

The system has been developed to function either indoors or semi-outdoors to ensure protection of electronic equipment without compromising on user convenience. The process is fully automated using the RFID scan and coin insertion method.

4.2.2 Population of the Study

The population in this study comprises students and faculty of the Computer Engineering Department of St. Anthony's College (SAC), who are the actual beneficiaries of the Automated Umbrella Rental System because the system was created in line with their demands due to unexpected weather conditions in the college premises.

The chosen population comprises of registered individuals that have been issued RFID identification cards that will be needed in authenticating access into and out of the automated system. The selected group of individuals is made up of those who are always moving around campus and would find the automated system very convenient and accessible.

4.3 Scheduling Feasibility

Feasibility of scheduling deals with the capacity of the researchers in finishing the Automated Umbrella Rental System within the scheduled period. It involves



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appropriate scheduling, allocation of tasks, system development, testing, documentation, and implementation of the project. The researchers formulated an activity schedule to make sure that all processes of the project will be conducted orderly and timely.

Step-by-step procedures were applied in developing the project starting from project concept to project planning. At the first process, the researchers defined the problem, obtained relevant information, and determined the objectives and scope of the study. After project planning, the researchers moved forward to the development of Chapters 1 to 3.

The next stage involved sourcing the necessary materials and electronic parts including Arduino boards, RFID devices, sensors, LCD screens, solenoid valves, relays, and others that would be used in the creation of the system. After acquiring the necessary materials, the researchers proceeded with the assembly of the hardware parts as well as the programming of the system utilizing the Arduino IDE and the C++ programming languages.

Following the assembly and programming stage, integration and testing of the system was done to ensure that all the parts worked together cohesively as a system. All errors that emerged during the testing process were rectified immediately to enhance the efficiency and performance of the system. Other adjustments were made regarding the physical aspects of the system.

Lastly, the project was tested, documented, and prepared for presentation and implementation. By means of proper scheduling and time management, the research



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team succeeded in completing the project on schedule. Thus, the Automated Umbrella Rental System is feasible from the standpoint of scheduling since all tasks related to the project may be accomplished within the allotted period of time.

4.3.1. Gantt Chart

	Activities	
Planning		
Analysis		
Design		
Testing		

4.3.2 Economic Feasibility

An evaluation of the Automated Umbrella Rental System was conducted in order to determine whether or not the system is economically viable. The purpose of the system is to offer students and staff members of the college an efficient way of renting umbrellas when there are sudden rainfalls or very high temperatures. The system incorporates affordable materials including Arduino, RFID modules, solenoids, sensors, fans, and LCD display screens. These factors contribute towards the low cost and maintenance involved in the design of the system.

Additionally, the automated aspects of the system minimize the involvement of manual intervention thereby increasing efficiency.



Lastly, the use of the Automated Umbrella Rental System is also energy efficient due to its low energy consumption nature, and automated operations.

Furthermore, with the implementation of IoT, administrators can monitor transactions hence minimizing any losses.

4.3.3. Cost and Benefit Analysis

The following tables shows the cost of materials and components utilized in developing the Automated Umbrella Rental System:

AUTOMATED UMBRELLA RENTAL SYSTEM		
Materials	Quantity	Cost
ESP32	1	₱279.00
Arduino Uno	1	₱189.00
Arduino Kit	1	₱499.00
Breadboard	1	₱68.00
RFID Reader	2	₱156.00
Jumper Wire M-M	1	₱84.00

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Jumper Wire F-M	1	₱84.50
Jumper Wire F-F	1	₱55.00
Screwdriver (Flat) 6*150mm	1	₱49.00
Screwdriver (Philip) 6*150mm	1	₱49.00
Screwdriver (Flat) 3*75mm	1	₱35.00
Screwdriver (Philip) 3*75mm	1	₱35.00
Screw & Bolts	1	₱55.00
5V Relay Module	8	₱560.00
Coinslot	1	₱499.00
DC 5V 12V Push Pull	3	₱497.00
Soil Moisture Sensor	4	₱220.00
LCD 16X2 ICC Display	2	₱238.00
Umbrella	6	₱780.00
OLED	1	₱100.00
Push Button	6	₱378.00



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Mini Drill	1	₱598.00
Paint	2	₱215.00
Paint Brush	1	₱90.00
Plywood	1	₱687.00
12V Adaptor	1	₱195.00
Cable Wire	6	₱60.00
12V Fan	3	₱510.00
Glue Gun	1	₱169.00
Multimeter	1	₱540.00
Arduino Uno R4	1	₱550.00
Buck converter	3	₱345.00
Servo motor	2	₱167.00
DC 12V Door lock	3	₱381.00
Cable organizer	1	₱49.00
Keychain	10	₱174.00



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Stepdown	1	₱340.00
Hock up wire	24	₱120.00
No, 16 wire	1	₱40.00
Paint Brush	1	₱36.00
Multi-seal	1	₱125.00
Power Supply	1	₱195.00
	Total:	₱10, 496.00

Table 2: Cost Analysis

4.4. Requirement Modeling

4.4.1 Input-Process-Output

Input	Process	Output
The system gets input from Computer Engineering students and faculty by using their RFID-based ID card to	The Arduino processes the data received from RFID, operates the solenoid lock system, registers transactions involving	The umbrella is either released or returned successfully, with the transaction status appearing on the LCD



either borrow or return the umbrella. It also verifies if there is an available umbrella and connects with the IoT network.	umbrellas, and updates the database using the IoT. The moisture sensor and fan aid in drying any wet umbrellas, whereas the transaction status is monitored via the admin panel.	display screen. There is convenient availability of umbrellas, effective monitoring, enhanced safety due to weather changes, and organized umbrella management.
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Table 3: Input-Process-Output

4.4.2. Performance

The Automated Umbrella Rental System is dependable and efficient in its working due to the automation involved in the whole rental and return process. In case users are pressed for time or the weather turns out unexpectedly, the system allows for renting of the umbrellas with ease and in a timely manner. The IoT Automated Umbrella Rental System ensures that processes are carried out at faster rates with improved monitoring and service delivery. Thanks to the use of sensors, RFID, and automatic locks in the system, accurate monitoring and checking of the availability of the umbrellas and transactions made by the users becomes possible. The system is also safe, secure, and energy efficient.

4.4.3. Control

The design concept intends to offer a solution that will enable users to rent and return umbrellas conveniently. The solution is mainly intended to benefit Computer



Engineering students and teachers in case there are sudden weather changes or when classes are hectic. Utilizing inputs from the user as well as information collected from the environment, the system offers a responsive and convenient way of renting the umbrellas at any time when a person wants to borrow or return them. The system uses Arduino microcontrollers which have particular tasks assigned to them.

4.5. System Flowchart

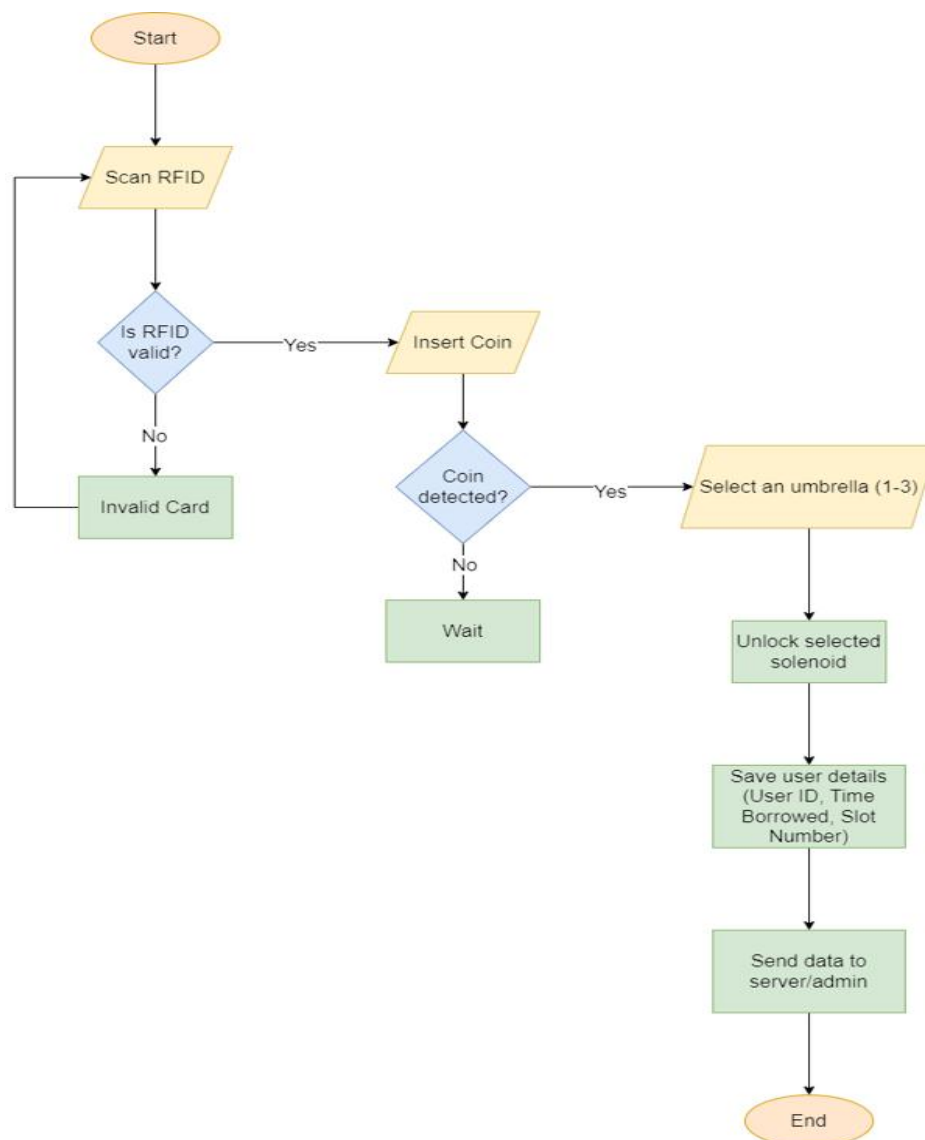


Figure 20: System Flowchart - Rent

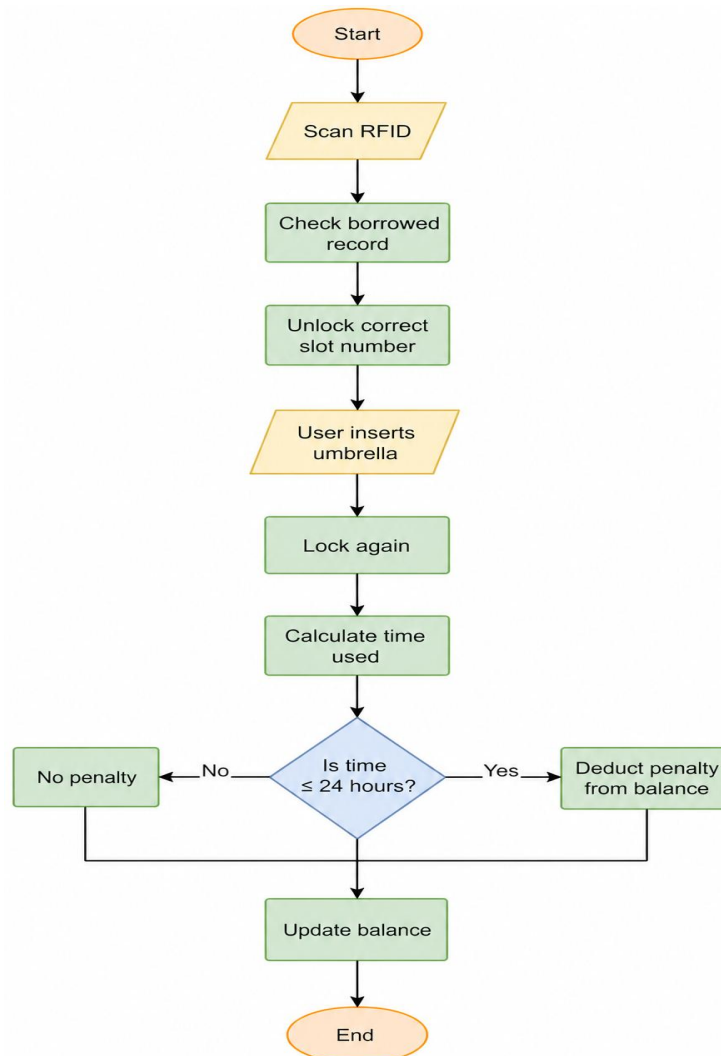


Figure 21: System Flowchart - Return

4.6. Deployment Diagram

4.6.1. Test Plan

Evaluation of the effectiveness of the Automated umbrella rental system will be carried out through evaluations that will be conducted during the study period by way of surveying selected participants and by actual testing of the system. The testing of the system will involve users using the control interface to rent and return the



umbrellas. Testing will be done to evaluate the responsiveness of the sensors and accuracy of the monitoring system. Feedback from the evaluation will provide insights into potential weaknesses and how to improve the system in future.

4.7. Risk Assessment Analysis

Risk Assessment	Solution
RFID or Sensor Malfunction	Restart or reset the system. Check and adjust sensors and RFID reader connections.
Power Interruption	Turn off the system safely and resume operations once power is restored.
IoT Connectivity Failure	Reconnect the Arduino UNO R4 WiFi module or restart the network connection.
Automated Locking Mechanism Failure	Inspect solenoid locks for obstructions or wiring issues.
Umbrella Tracking Errors	Verify registration and database synchronization.
Component Compatibility Issues	Ensure proper coordination between Arduino microcontrollers and connected components.



4.8. Data Diagram

4.8.1. User Case Diagram

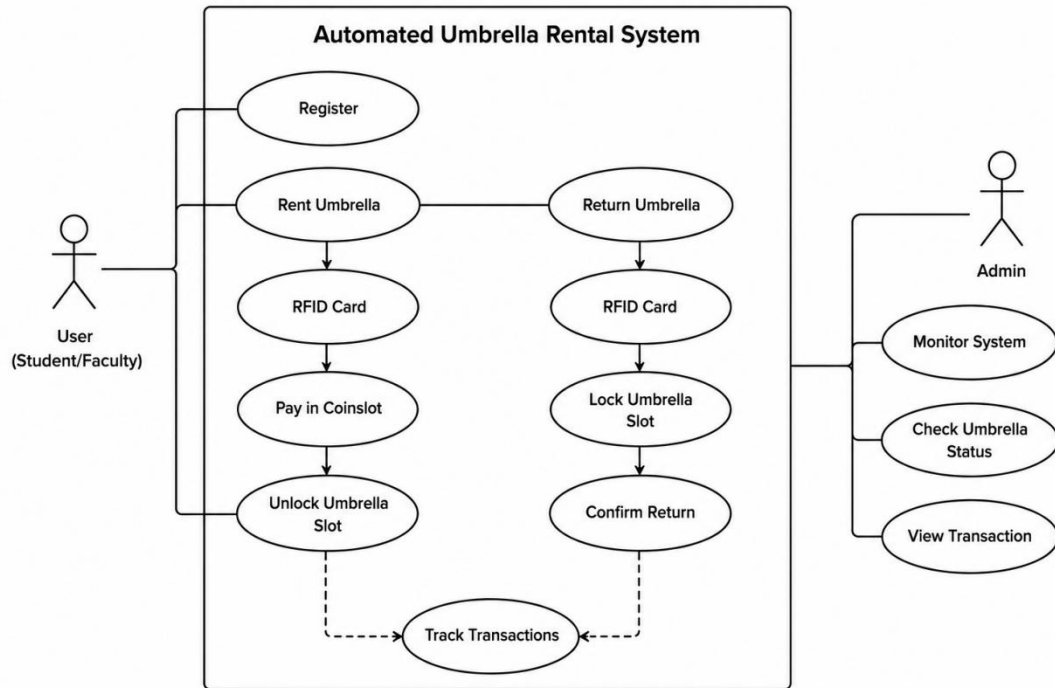


Figure 22: User Diagram

4.8.2. Schematic Diagram

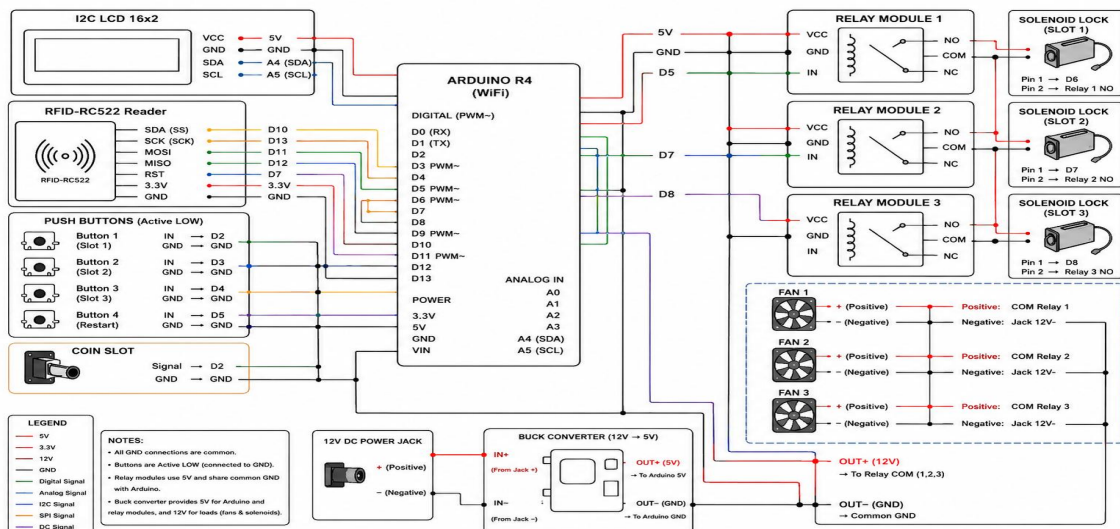


Figure 22: Schematic Diagram

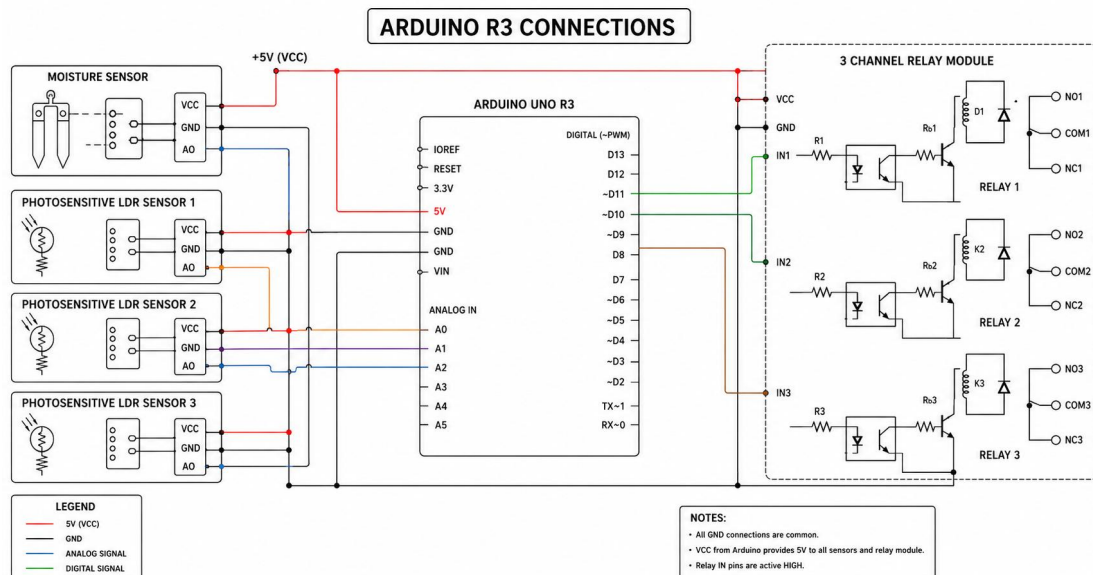


Figure 23: Schematic Diagram

4.9. System Architecture

The Automated Umbrella Rental System is made up of hardware and software elements which combine to make it possible to have automated, IoT-based umbrella rentals and returns.

The User Interaction Layer, users first initiate the system by using an RFID card to authenticate themselves. Users can also pay through inserting coins in the device.

The Input and Authentication Layer, the RFID reader will authenticate the user while the coin validator will verify the payment process.



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The control layer involves the Arduino UNO R4 Wi-Fi which acts as the primary controller for validating inputs, processing logic, and controlling IoT communications. The Arduino UNO R3 acts as a secondary controller which receives sensor input for processing environmental and operation inputs.

The actuation layer involves the use of the solenoid mechanism which locks and unlocks the umbrella storage slot for dispensing and returning of umbrellas.

In the sensing layer, there is an implementation of the umbrella tracking sensors that detect the condition of the inventory of umbrellas. Also, there are moisture detectors that detect wet umbrellas and trigger the fan to dry them up.

In the output and monitoring layer, the system offers transaction updates and condition monitoring using IoT technology.

4.9. Testing

The IoT Automated Umbrella Rental System was subjected to a number of tests by researchers who sought to establish the efficiency and reliability of the system as well as its impact on the users' experience. During the tests, the system was tested for several different conditions pertaining to umbrella rental and return processes in order to establish the efficiency of the authentication process, payment processing, and dispensation.

User inputs were varied including the RFID card authentication, coin validation of rental fees, and rental and return commands. At the same time, it was



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noted whether the RFID reader could correctly validate user identity as well as whether the coin validator could correctly detect valid payments made for the rentals.

The mechanical component test included the test of solenoid locking and unlocking in order to secure umbrellas and to ensure that they unlock on time. Umbrella tracking was also tested to ensure that there is accurate tracking of the umbrellas in stock and those that are rented out. The moisture sensors were tested by inserting wet umbrellas into the box in order to detect the presence of wet umbrellas. The fan was then tested to see if it dries up the umbrellas effectively.

IoT connection test was done to ensure that transactions were monitored in real-time and that there was efficient transmission of data through the WI-FI module in order to send alerts about the low availability of umbrellas in stock and other system updates.

The user interaction tests included the selection of a few users who were tasked with making transactions through the use of the interface, use of the RFID system, and inserting of coins in order to test the effectiveness of the system.

4.10. Deployment Diagram

4.10.1 Test Plan

The performance of Automated Umbrella Rental System was analyzed and compared with traditional manual umbrella rental systems through testing on the following objectives: accuracy of authentication, effectiveness of transactions,



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reliability of the system, and ease of use. Testing was done in several scenarios for umbrella renting and returning processes.

On the other hand, traditional manual methods for umbrella rental entailed manual processes for keeping records, which took much time. There were also chances of mistakes like wrong user identification, failure to record returns, misplaced umbrella, and inconsistent payment verification process. In addition, there was the inefficiency of manual checking of the availability of umbrellas.

In contrast, the IoT Automated Umbrella Rental System showed better performance when RFID-based authentication and coin validation were incorporated in one system. The RFID reader helped to identify users correctly, while the coin validator enabled proper transaction processing after verifying the money paid by the customers.

The use of solenoid locks for locking the umbrellas made sure that they were stored safely and could be used only by authorized personnel. The tracking system for umbrellas helped to maintain correct inventory, as the number of available and rented umbrellas was updated in real-time. Moreover, moisture detectors increased the functionality of the automated system by activating the fan to dry any wet umbrellas returned by customers.

The application of IoT technology improved the performance of the system through real-time transaction management and monitoring of umbrellas.



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4.11. Conclusion

The Automated Umbrella Rental System has succeeded in showcasing an efficient and innovative way of improving the process of umbrella lending by incorporating IoT technologies, automation, and real-time monitoring into the system. In this regard, the system managed to effectively replace the inefficient manual processes used before the implementation, thanks to accurate user identification, payment validation, and greater efficiency.

According to the results of testing the developed system, it can be argued that the use of RFID and coin validation for authenticating users and validating their payments led to the increase in accuracy and safety of transactions, while the use of a solenoid lock mechanism made umbrella storage much safer.

Furthermore, the incorporation of sensors for umbrella detection and moisture detection contributed to the greater effectiveness of the developed system due to the implementation of efficient monitoring of umbrellas and their continuous usability as a result of automatic drying process.

Finally, the implementation of IoT connectivity enabled real-time monitoring, which facilitated administrative decision-making and enhanced convenience for the users.