International Journal of Innovative Research in Computer Science and Technology (IJIRCST)
ISSN (Online): 2347-5552, Volume-12, Issue-3, May 2024
https://doi.org/10.55524/ijircst.2024.12.3.18
Article ID IRP1453, Pages 113-119
www.ijircst.org

Enhancing Laboratory Experience: A Combination of RFID and Machine Learning Techniques to Track Attendance and Upgrade Hardware

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Received: 30 April 2024 Revised: 14 May 2024 Accepted: 27 May 2024

ABSTRACT- Practical subjects have grown in importance in student lives over time. Certain components may malfunction or not be suitable for the experiment being conducted. The RFID system facilitates the tracking of both student attendance and experiment details, which are saved on a MySQL server and shown inside a PHP environment. After being collected by means of an RFID reader, RFID tags, and a nodeMCU, the data has been applied to artificial understanding that identifies usage and then notifies the service. Based on mean square error (MSE) value, we have constructed three models: gradient boosting (1.00), random forest (0.5), and linear regression (0.14).

KEYWORDS- RFID reader, RFID Tags, nodeMCU, Machine Learning

I. INTRODUCTION

A. Review Stage

With advances in the healthcare sector, digitalization, and broad remote aid, there is a growing push for electronic solutions and platforms offering people with the necessities they want to feel in charge of an own monitoring method[1].”Radiofrequency identification,” or RFID for short, is the name given to a method of reading electronic data stored in RFID chips or electronic labels (described below) via radiation. The process of reading data off stickers or labels and putting it into a file using a device is similar for both bar-coded and RFID. There are several advantages to systems with RFID over those that use detector tracer systems. Additionally, RFID tag material will be detected far past the craft of contact, whereas barcodes must be aligned with a laser sensor. The phrase ”away reading” refers to a group of methods that use observing the ground in addition to telescopes in addition to space-based technologies for enhanced detail and precision[2].

RFID tags come in two varieties ,they are passive ones and RFID tags that run on batteries. RFID tags that are passive transfer their stored data to the reader through the utilisation of wireless magnetic waves. RFID tags that run on batteries have tiny batteries inserted into them to supply electricity message transmit. Typically, a computer tag consists of a digital baseline, a persistent storage device (NVM), and an external chip[3].

Although RFID has been around since the 1940s, its application became increasingly widespread in the 1970s. Broad commercial adoption was long restricted by the excessive expense of both ids and viewers. RFID use rose along with a decline in hardware fees. RFID tags are regularly employed for observation of pets and animals, administration of inventory control, resource and property observing, transport and freight logistics, auto monitoring, excellent client service, and loss prevention enhanced flow and insight within logistics cycle restriction in risk scenarios. RFID technology has been explained in Figure 1.

Figure 1: RFID Technology Overview

Among the most common immediate time uses of RFID chips are in logistics administration, vehicle monitoring, and Internet of Things (also known as IoT) geolocation recognition. The need for cooperation, innovation, flexibility in the face of within-company setbacks, efficiency, and synchronisation amongst a PC organization’s Iot and its procurement divisions is especially clear in the context of logistics management [4]. RFID systems—are being utilised more and more in real world Internet of Things applications due to their broad operating range—which can reach as many tens in meters—and gathering data in real- time[5].

In our research, we describe the implementation of RFID technology in the student laboratory system to monitor student attendance and student-handled experiments. The information produced by RFID is then collected and subjected to machine learning models for analysis. This aids in the tracking of attendance with equipment with their return for maintenance also.

II. LITERATURE REVIEW

Our laboratory management model and our ability to make decisions quickly were both aided by the literature research of the most current paper, which helped us fully comprehend the RFID concept.

Kheawprae et al, presents a chipless multi-tag detector for RFID, which is implemented in this research. Compound harmonic resonant states (CNRs) provided the input for the suggested system, which used a single-dimensional convolutional neural network (1D CNN) as a smart predictor. To gather data points for the 1D CNN's testing and training operations involving a single chipless RFID tag were carried out.In contrast to the 1D Cns supplied by harmonics alone, the accuracy gained from the 1D CNN's calibration and validation using CNRs was noticeably greater. studies were conducted using contexts of many tags to be able to evaluate the effectiveness of real-time multi-tag detection using the suggested system. The results of the studies indicate that the 1D CNN feed by periodicity solely was unable to identify more than one tag. On the other hand, the suggested system achieved 100 per accuracy in multi-tag detecting[6].

The state-of-the-art (SoA) in semi-passive is thoroughly reviewed and analysed in this study by Hector et al. Such tags may have an electric power mechanism or a power source, but they function according to the same standard of communication as purely passive sensor tags.Furthermore, in order to maximise the sensitivity of the tag IC in BAP mode, it is critical to evaluate either the forward and reverse routes for communication. Remarkably, just a third of the SoA solutions were able to reach the theoretical communication range that a tag IC's feelings predicted.Last but not least, to ensure that the energy generated matches the energy consumption of the tag. As per the further complexity, only a small number of studies using energy harvesters perform a fuel estimation, whereas the majority of options use cells and their fuel and analyse battery longevity[7].

In this work by Mekk et al,,In commercial uses, particularly in the realm of the Internet of Things (IoT), chipless RFID holds a chance to revolutionise current practices. Advanced chipless RFID layout for Internet of Things tools is still challenging, despite significant advancements over the past generation. For object surveillance and classification in Internet of Things networks, a novel chipless plane RFID tag is presented in this study. To enhance tag reliability and writing diversity, the interaction from the resonance spaces has been reduced.Several patterns plans were implemented to a Rog RO4350B substrate to form tags, and the resulting radio section answers were examined. The recommended tag layout showed superior slimming and effective band utilisation when compared to conventional multi-resonator tags. Moreover, neither the calculation power and the factor Q were significant[8].

In this essay written by Erick et al, Using animal tracking has important applications. Significance in a variety of economic areas, those are related to agriculture, animal husbandry, and the preservation of animal populations. It seeks to monitor and comprehend the behaviour, migration patterns, and general health of animals. The disciplines of logistics, localization, and products tracking are where RFID technology is most commonly used. Notably, there has been a notable upsurge in popularity recently regarding the application of this science in the field of animal tracking. In light of RFID signals, active UHF tagging become more prevalent. Furthermore, a lot of works also use GPS and cameras in addition to Radio. In the end, by methodically outlining a cutting-edge use of RFID for animal administration, our work can make a substantial contribution to this topic[9].

In this effort by Emidio et al, how the reversed RFID seems on the object being detected varies in rhythm with gadget go is a useful feature for several translational strategies. In some configurations, however, a sticker and detect beacon arrangement also influences the amount of the period shift. We investigate in this study how the SLAM (in tandem location and charting) question is affected by this reliance. In particular, we juxtapose approaches where this reliance is taken into account within a measuring scheme with one that offsets it via a dynamic phase offset that is subject to computation. Along with some indications and statistical findings, the study evaluates whether or not this dependency could contribute to solving the Sdm problem[10].

Nearby Area Collaboration, or NFC, has become a key mobile technique for brief communication of data between gadgets like cell devices and gadgets, according to this paper by Rao et al. NFC provides safe interactions in immediate vicinity by utilising reliable verification and electromagnetic (RF) signals. In order to build confidence across device pairs, a shared authentication, or MA, is crucial. Radio Frequency Identification (RFID), which allows an antenna and a tag to communicate seamlessly, is an ideal instance of NFC, or nearfield communication, technology. Effective authentication processes are necessary because security and privacy issues are important aspects of RFID systems. With thin block cyphers (LBCs), this work presents an effective and secure MA mechanism for RFID devices. A thorough evaluation of results has also been carried out in the article, which compares important performance measurements with current LBC and authentication procedures[11].

A novel physical design approach for chipless RF ID is presented in this study by Norman et al.It presents (RFID) tags in the sound domain. By adding micro-metallic cells (MMC) to a flexible its resonator, the tag geometry is created. This insight led to the development of a sort of checker reflector with its infrared area contains radio waves that are incredibly manipulable. For doubling the signal density within a Rogers a base, the reflection pattern is dispersed on both sides of the base. The suggested chipless RFID tag contains an entire set of 8 bits of data. The tag operates between 6.5 through 10.5 GHz. RFID designers will have the capacity to use the suggested tag in a variety of

contemporary applications thanks to the straightforward structuring approach and effective resonance areas arrangement[12].

In this Sun et al. article,Data about employee attendance has long been crucial to business management. Nevertheless, some shrewd workers might assign others to punch their time cards, undermining the accuracy of attendance records and filing records procedures. Therefore, the creation of a creative anticheating system for office attendance is required. Since RadioFrequency verification (RFID) is non-intrusive and has a high blocking capability, it provides novel solutions to such issues. In order to facilitate target honour, we describe in this work a sophisticated attendance mechanism that extracts individual distinguishing phase properties. Tests show that our approach is accurate and efficient, with an ordinary accuracy of 92 percentage[13].

This work proposes by Khan et al, a unique Radio Frequency Identification (RFID) based sensor that supports localization and touch detection characteristics. The sensor that has been developed makes use of the chipless version of the RFID system to create an inactive, fully-printable tag that is integrated into the frequency spectrum. It is made up of oddly ordered cube resonators for that are placed in a 3 × 2 grid.The suggested sensor integrated tag easily tracks the position of a human digit, enabling tracking of palm swipes that may one day be utilised to identify pin codes and unlock patterns. A unique dip in the RCS response indicates the resonance tone for each component reactive device that makes up the detector. Following a touch event, the colour dip moves well outside of its designated band[14].

According to work by Casula et al,An eighth-mode material built waveguide cavity-based wearable textile wireless RFID tag is introduced. Using a cylindrical surface built photonic (SIW) cavity's H-field symmetries planes allows for a feasible lower antenna area for operating in the [865-870]-MHz RFID UHF band. Adopting an energy-baseda development plan that attempts to decreased the base domain, high isolation from the human body and exceptional resiliency with regarding fluctuations in antenna-body range are possible. It is possible to make tag at a minimal cost and it shows very little mechanical complexity. An operational working version for that tag was recently produced and examined in an actual setting. The CST Microwave Studio software was used for layout and testing[15].

The design, fabrication, and testing of an RFID thermometer that operates autonomously at all times is done this work is done by Shafiq et al, This battery-free sensor can identify degree border breaches for several temperature cycles, from house to cold and from cold to area, respectively. Shapemorphing, cold-temperature active Liquid the author These (LCEs) are used for the first time; they offer reversible actuation. A patch antenna with a specially designed slot makes up the suggested sensor design. The frequency switching is provided by a passive mechanical switch that is linked across this slot and can be turned on and off. Through the use of cosimulation, this switch and the antenna are integrated[16].

Registering pupil attendance is just one among the regular tasks done by Jelena et al.but laborious duties for academic faculty members organisations. There are several technological approaches used to reduce the workload associated with administration and partially robotic endeavour. In addition to the capabilities found to be typical of systems of this kind that deal with pupil attendance, the device contains functions that allow it to be integrated with other systems, capture the information which is required about the task students do in class, and generate results on a regular basis about that job[17].

According to Shobha et al.'s analysis, the majority of academic authority are concerned about the laborious process of manually tracking each worker's attendance. It takes a long time and is not secure to sign documents by hand.Such locations must implement an effective surveillance system. A way around problems like proxies is offered by a time clock based on RF identification, or RFID. This paper details the development of an Identification-based punctuality tracking tool that uses an employee or pupil RFID tag, linked to their ID card, to individually identify each individual. Just stick the RFID card or tag on the reader for staff members or learners, and their activity throughout the entire time gets collected[18].

Rosa and colleagues' work, One tool utilised to evaluate learners at the close of session is how they stay not the lecture hall. However, some pupils falsify their absence when the laborious process of signing forms or sheets is in place. Additionally, since online technology is now easy to access, hand page verification proves to be an outdated method. The electronic monitoring method that this study suggested would require educators and pupils to tap their educational cards on a reader for RFID in front of the room before they may access. Attendees is tracked for the duration of the class, both in and out. The tool provides efficient and productive treatment, clean and productive management of employees, and human timekeeping is one of its features[19].

A comprehensive assessment of the scalability of the techniques has not yet received as much attention as it should, despite the fact that numerous studies publications evaluate the efficacy of their recommended methodologies. To close this disparity, one must assess the results in several contexts and confirm their accuracy with data from the actual world.

III. METHODOLOG

Because To enable us to scan two cards with a single RFID reader, we have included an LCD display, a microcontroller (NodeMCU), an RFID reader (RC522), and a push button in this specific RFID lab inventory system. The data is delivered to MySQL through PHP server where it is saved after the card information are scanned in.ML algorithms have been used in conjunction with that data.

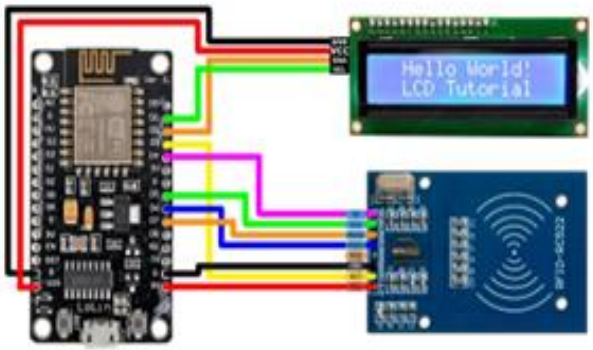

Figure 2: Circuit diagram of RFID connections

RFID reader(RC522)- Among the least affordable RFID choices is the RC522 RFID device from NXP, which is built on the MFRC522 IC. An Identification chip tracker or an identification fob tags with 1KB of memory are typically included. Most importantly, it is able to enter a tag.In order to connect all the RFID tags (ISO 14443A grade tags), the RC522 RFID Reader module is made to produce a magnetic signal at 13.56MHz. A 4-pin parallel and cost-effectiveness enable cost-effective project deployment and effortless incorporation into a variety of configurations. Moreover, the NodeMCU's broad GPIO interface enables the integration of RFID courses, which makes it a perfect option for creating all-inclusive presence tracking systems.

Peripheral interface (SPI) allows a device to interact at a maximum data rate of 10Mbps with a computer. Additionally, it can communicate via UART and I2C methods. The module can be linked to an Arduino or any other 5V logic microcontroller without the need for a logic level converter because its operational voltage range is 2.5 to 3.3V and its logic ports can withstand up to 5V.Because of its low cost, simplicity for use with microcontroller-based systems, and dependable short-range signaling capabilities. All of which enable effective and automatic identification and tracking of lab participants—the RC522 RFID modules is frequently utilised in lab time attendance systems.

According to Figure 2, the circuit diagram contain the following components-

RFID tags- Using intelligent barcodes to identify objects, RFID tags are a kind of tracking device. Radio wave science is used by RFID tags, which stand for "radio frequency identification," as the name suggests.RFID chips come in two primary varieties: rechargeable and quiet.An internal battery serves as the power source for RFID tags that run on batteries. Another name for rechargeable RFID tags is active RFID tags. RFID tags that are passive function by utilising the radiation that is received from a reader with RFID chips, rather than requiring batteries. Using the MySQL technique, data gathered in RFID tags is saved here. The student name, semester, batch number, and roll number are recorded on the card for student card details (Card 1), with the card number (id) serving as the primary key.Experiment no., experiment name, and component lists are all obtained using the same procedure.Additionally, data from the database will assist the tracking method in retrieving data using its primary ID.

NodeMCU- An affordable System-on-a-Chip (SoC) known as the ESP8266 serves as the foundation for the a Node M (Node MicroController Unit), a free hardware as well as software ecosystem. The CPU, RAM, networking (WiFi), and even a contemporary computer's OS and SDK are all present in the Espressif Systems-designed and -built ESP8266. For Connectivity of Things (IoT) projects of kinds, all this contributes to it a great option.Because of its integrated Wi-Fi module, which allows for direct data transmission with online services for immediate time timekeeping, the NodeMCU is chosen for RFID-based lab monitoring systems. Because of its compatibility with the Arduino IDE, developers with different degrees of expertise can easily learn programming. NodeMCU's small form factor.

PHP and MySQL-PHP's connection with databases powered by MySQL provides a reliable way to handle variable information and store when creating web-based applications for organising data. PHP is a language for scripting on the server used for managing and creating web sites that allow users to speak with and handle facts in actual time. MySQL performs well as an online database system, effectively maintaining, accessing, and modifying content. The construction of intricate web-based apps with continually revised and accessible user data is made possible by this blend, including platforms for recording presence. MySQL offers an organised memory storing method that ensures authenticity and privacy, and PHP is utilised by the architecture for server-side logic and data modification.

Machine learning algorithms:-We used Linear Regression, Random Forest, and Gradient Boosting models to estimate required repairs in the investigation of proactive upkeep for labs items based on utilisation frequency. Our goals were to increase the life of equipment and improve operating efficiency. Because it is simple and easy to understand, Linear Regression produced a Mean Squared Error (MSE) of 0.14, which indicates good accuracy and suggests that it works well in situations where the data have linear correlations. From the Table .1, we get to know that ecause of their ensemble learning techniques, Random Forest (MSE of 0.55), and Gradient Boosting (MSE of 1.00), despite having more errors, are notable for handling complicated, non-linear data patterns.

The mean cubed difference (MSE) between the results and the forecasts made by the model is a crucial indicator for evaluating the success of the algorithm. Decreased values signifying increased accuracy. A sophisticated equilibrium of the difficulty of the model, accessibility, and predictability is struck when assigning machine learning for predictive maintenance, as this comparative evaluation highlights the importance of selecting models on the basis of dataset details and the particular keeping track anticipated demands. These models allow us to pinpoint the exact part that has to be sent for service.

Table 1: Performance metrics(MSE) of machine learning models

Model	MSE
Linear Regression	0.14
Random Forest	0.55
Gradient Boosting	1.00

IV. FLOWCHART

From the flow chart of (Figure 3), Students in college laboratories typically encounter problems such as malfunctioning lab equipment, which leads to scepticism As previously discussed in the flow chat above, students first scan their ID card (RFID card), which contains their personal information. Next, they should click a button to begin scanning their allocated experiment card, which contains the specifics of the experiment that they are now conducting. The database, where the card details are registered, will now be Figure 3. Flow chart. used to detect the card details from the scan data.The primary key in this case is the card number, which aids in identifying the remaining card information. Following that, the LCD display will show the scanned details. The experiment data will be used for machine learning, which assists in identifying the defective products by examining their utilisation, while the digitised info will now be utilised for monitoring attendance.

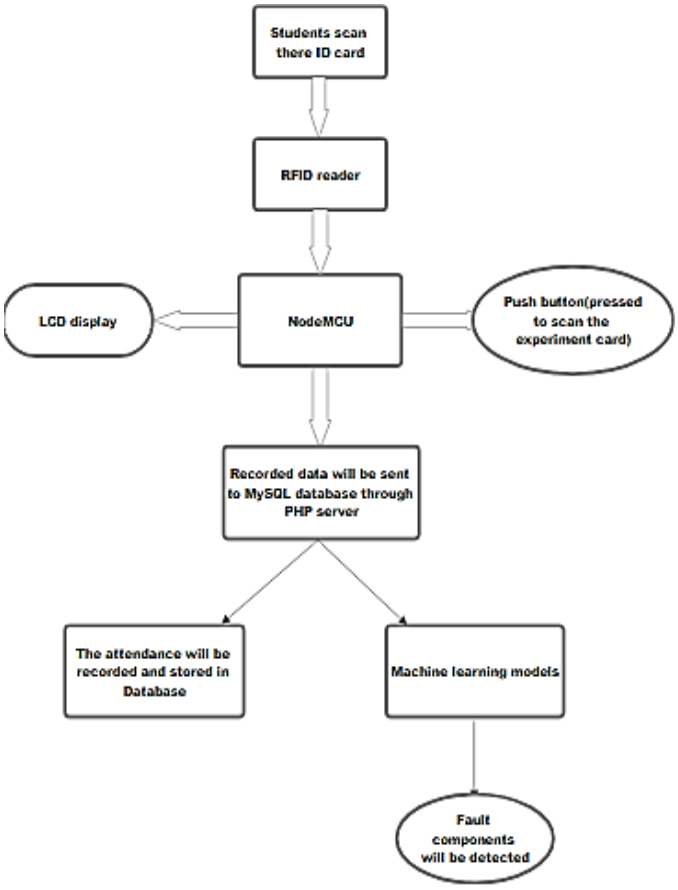

Figure 3: Flow chart of the Lab Attendance System

V. RESULTS AND DISCUSSION

The database is painstakingly built to handle and retain a wide variety of data that is essential for tracking student involvement and lab operations. It has multiple columns, including Student ID, Student Name, Semester, Equipment, and Details of the Experiment. Students who participate in lab sessions can provide their personal information in the Student ID and Name boxes to ensure precise attendance tracking. Education monitoring is made easier by the Experiment ID column, which connects students to particular experiments they are carrying out. Each experiment's apparatus is listed in the Equipment Used section, which provides useful information for inventory control and tracking of utilisation. These findings imply that, in our laboratory scenario, the best model for forecasting maintenance requirements is linear regression, which may enable more proactive maintenance plans. By using these predictive models, we can make sure that lab equipment is maintained effectively, cutting down on downtime and enhancing students' overall educational experience. By reducing the number of equipment failure related disruptions, this method not only extends the life of lab equipment but

also promotes a smooth learning environment.

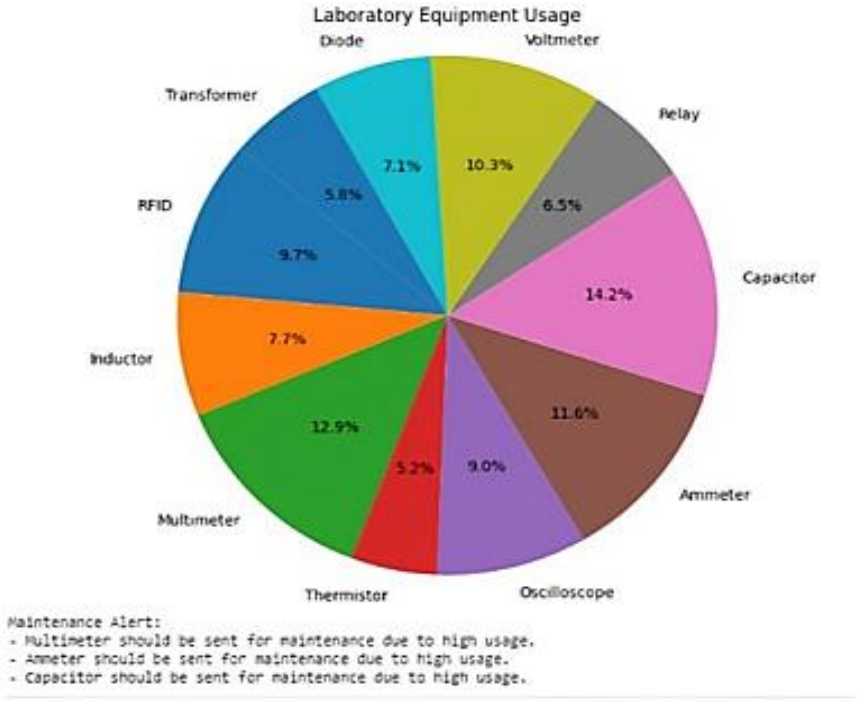

Fig. 4. Components usage pie chart .

VI. CONCLUSION

The integration of deep learning models and the use of RFID in the laboratory attendance and equipment maintenance system signifies a noteworthy progression in the administration of learning laboratories. The technology provides a smooth and automatic way to track student involvement in experiments and participation by using RFID tags for both purposes. Of each model that were examined, linear regression (LR) proved to be most effective in terms of producing precise forecasts to guide ongoing upkeep programmes. This all-encompassing method not only optimises office processes yet guarantees that technological malfunctions are kept to a minimum, improving students' experiences in school. For even higher accuracy and efficiency in lab management, future advancements could investigate the combining of more complex models with current information processing. This study emphasises the possibility

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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