UNIVERSITY of RWANDA

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COLLEGE OF SCIENCE AND TECHNOLOGY

AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THING (ACEIoT)

THEISIS TITLE:

IoT BASED STUDENTS' ATTENDANCE MONITORING SYSTEM

Case Study: Wisdom School Musanze

……

MASTER'S DISSERTATION

Submitted in partial fulfilment of the requirements for the award of master of science in internet of things: Program of Embedded Computing System (M.Sc In IoT-ECS)

Submitted by:

MUNYANEZA Midas Adolphe

Ref Number: 220014266

March, 2022

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Main Supervisor: Dr. TWIZERE Celestin

Co – Supervisor: Dr. NGENZI Alexander

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DECLARATION

I, MUNYANEZA Midas Adolphe, hereby declare that this dissertation report is my original work and has not been submitted before for any academic award in either my university or other higher learning institutions for academic publication or any other purpose.

MUNYANEZA Midas Adolphe

……/March, 2022

BONAFIDE CERTIFICATE

This is to certify that the dissertation report titled "IoT BASED STUDENTS' ATTENDANCE MONITORING SYSTEM" is the genuine work of MUNYANEZA Midas Adolphe registered to 220014266 in partial fulfillment of the requirement for the award of a Master's degree in Internet of Things – Embedded Computing System (MSc in IoT-ECS) from College of Science and Technology at University of Rwanda.

Main Supervisor:

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Head of Masters studies and training ACE - IoT

Dr. RWIGEMA James

Date:

DEDICATION

I dedicate this dissertation to:

My wife PELAGIE and my children ANGEL, BRUNO, BLAISE, CHRIS and EVA without whom this dissertation would have been completed.

My parents, who took me to the school!

My supervisors, lecturers and close friend, who supported me a lot during my master's studies!

ACKNOWLEDGMENT

I cannot express enough thanks to my supervisors for their continued support and encouragement: Dr. TWIZERE Celestin the main supervisor and Dr. NGENZI Alexander Yusuf the co-supervisor. I offer my sincere appreciation for the learning opportunities provided by the High Education Council (HEC).

My completion of this project could not have been accomplished without the support of my classmates' cohort two of IoT-ECS. In addition, I express thanks to the African Centre for Excellence in Internet of Things management that re-integrated and allowed me to continue and complete my master's studies and being able to catch up after abrupt interruption.

To my children, ANGEL, BRUNO, BLAISE, CHRIS and EVA thank you for allowing me time away from you to research and write.

Finally, to my caring, loving, and supportive wife PELAGIE, my deepest gratitude. Your encouragement when the times got rough is much appreciated and duly noted. It was a great comfort and relief to know that you were willing to provide management of our household activities while I completed my work. My heartfelt thanks.

ABSTRACT

Personal identification is an important aspect in recognizing the identity of a particular individual. A person's identity is validated through the traditional or biometric methods; biometric technology associated with Internet-of-things (IoT) provides a framework for integrated computing devices capable of managing efficiently the students' attendance.

This project aims to implement an IoT based system that monitor students from home to schools, during class hours and from school to home and notify parents and school administrators about the irregularity observed to their respective children.

The system is equipped of a finger print sensor to register and verify students and staff attendance, a PIR sensor to detect the presence of human to wake-up the device, a real time clock to synchronize each generated report with the local time. A web application is developed to allow students real-time monitoring for parents and school administrators and the system will be able to generate a daily, monthly and annually report to education decision makers.

Classification machine learning with decision-tree algorithm is used to analyse data and generate a model to evaluate the impact of monitoring attendance on preventing students to dropout. The generated model with accuracy of 91.4% shows that keeping students' attendance at high percentage would reduce significantly the dropout rate in secondary schools.

Keywords: biometric, Internet of Things, fingerprint, sensor, regression and Decision-Tree.

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ABBREVIATIONS

API: Application Programming Interface

DC: Direct Current

FAR: False Acceptance Rate

FRR: False Rejection Rate

ID: Identification

IEEE: Institute of Electrical and Electronics Engineering

IoT: Internet of Thinks

KNN: K-Nearest Neighbors

LCD: Liquid Crystal Display

LED: Light Emitting Diode

MCU: Microcontroller Unit

MINEDUC: Ministry of Education of Rwanda

NGO: Non-Government Organization

NYC: National Youth Council

PIN: Personal Identification Number

RFID: Radio Frequency Identification

RISC: Reduced Instruction Sets Computer

SMS: Short Message Services

SoC: System on Chip

SPI: Serial Peripheral Interface

TTL: Transistor-Transistor-Logic

UART: Universal Synchronous Receiver Transmitter

USB: Universal Serial Bus

CHAPTER 1 GENERAL INTRODUCTION

1.1 Introduction

Personal identification is considered an important aspect in recognizing the identity of a particular individual. A person's identity can be validated through the traditional or biometric methods. There are two types of traditional methods which are token-based and knowledge-based identifications (A. Jain, L. Hong, and S. Pankanti,, 2000). Examples of the token-based method include possession of a passport, driving license, and different types of cards such as identity (ID) card and credit card. Although it is convenient to carry these identity documents, these documents can be reproduced, stolen, or lost. On the other hand, the knowledge-based method is related to a password or personal identification number (PIN) created by each individual for authentication. Nonetheless, it tends to be forgotten easily, especially if the person has several passwords or PINs for different applications. Another alternative method is through biometric adoption, which considers the physical or behavioral characteristics distinctive to an individual. Physical characteristics refer to inherent features of the human body part. These include the face, fingerprints, and iris. On the contrary, behavioral characteristics deal with features observed from human action. Examples of human action are gait, voice, and signature (Hancke, L. M. Dinca and G. P., 2017).

1.2 Background and Motivation

Currently, biometrics are employed in a wide variety of domains. According to a 2018 report by German and Barber from the Center of Identity, University of Texas at Austin (R. L. German and K. S. Barber, 2018) the top three sectors which embrace biometric methods are financial services, technology, and government.

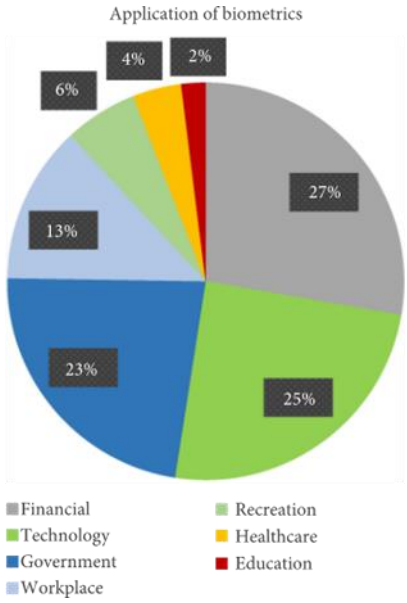

Figure 0: *Use of biometric in different sectors* **(R. L. German and K. S. Barber, 2018)**

Application of biometrics in different domains (R. L. German and K. S. Barber, 2018)

Biometric-based attendance recording or tracking system is part of the low percentage of biometric applications in the education sector, Attendance marking is considered as one of the crucial parts of a class. This is to ensure students participate in the class activities and learn from their educators. Student academic attendance is very crucial on account that it's going to have an effect on students from gaining knowledge, skills and their grades.

Currently in our country, most of the attendances are marked by using the conventional methods such as calling out names or signing off attendance in paper. Unfortunately, these methods are not suitable for a large class. It is a waste of time for the educator to call out all the students' name to mark their attendance whereby the time can be utilized more efficiently for the teaching and learning processes. Another method is by signing off attendance. Distraction happens because the student needs to sign the attendance list and pass on to the other student during class.

Moreover, it can be compromised by a student who signs on behalf of their friend who does not attend the class. Therefore, biometric systems have been developed as an alternative way to mark attendance in class. One of the advantages is that the student cannot manipulate the attendance as each individual

has different biometric characteristics. In addition, it also helps in improving efficiency and reduces the educator's burden as the attendance is marked automatically

This project is about taking the student fingerprint templates and matching them to fingerprint stored in database to confirm their attendance. The predominant purpose of carrying out this project is to design and implement an IoT-based student attendance system where the data are collected from a remote fingerprint device and sent to a web-based application for analysis and reports are automatically generated to concerned educational partners.

1.2 Problem Statement

National statistics, NGO and researchers produce in 2015 an alarming information regarding the teenage pregnancy in young girls and drug abuse in young old between 14 and 19 years. Teenage pregnancy in high secondary schools of Rwanda

Despite an overall improvement in most aspects of health in Rwanda, adolescent pregnancies are increasing from 6.3% in 2010 up to 7.3% ($n = 818$), in regard to the total number of pregnancies in 2015. The highest percentage of adolescent pregnancy is observed in Huye District (14.2%) (CLADHO, 2016) . However, when examining more precisely the distribution of these data, it is alarming that the problem mainly exists in adolescents attending secondary school. In this context, also Kirehe district draws the attention**.** Approximately 85% of all adolescent pregnancies is observed in adolescents attending school, and only a small proportion in adolescents who do not enjoy any form of official education (National Youth Council , 2015)**.** This is somehow surprising, since adolescent pregnancies are more likely to occur in communities with low education and employment opportunities (Neal SE, Chandra-mouli V, Chou D, 2015) . On the other hand, Rwandan public press published articles on pregnancy scandals in Rwandan schools caused by adults in powerful positions taking sexual advantage of young adolescent girls.

According to official statistics, 17,849 underage girls were impregnated in 2016. The number slightly increased to 17, 337 in 2017 before jumping to 19,832 in 2018. From January to August 2019, teen pregnancies increased to 15,696, which translate to an average of 1,962 a month.

Based on this, an estimated 23, 544 children were born to teen mothers in 2019 (DROPOUT-STUDY-FULL-REPORT, 2018).

1.2.1 Drug abuse in high secondary schools of Rwanda

Alcohol and drug abuse among the youth are public health concern and family challenges in Rwanda (Ngamije J and Yadufashije C, 2016). According to recent study conducted by the ministry of youth in collaboration with the university of Rwanda, demonstrated that more than half (52.4%) of the participants reported that they had used one or more substances at least once in their life time and concluded that tobacco, alcohol, marijuana and other substance use are realities in the daily lives of youth in Rwanda (Kanyoni M, Gishoma D and Ndahindwa V, 2015).

In addition, the study revealed that the youth consumed more than one substance: 50.6% of the youth had consumed alcohol, reported to have used cigarette smoking was 10.6% tobacco, 4.4% cannabis, 5% solvents and 0.1% revealed that they had consumed other drugs such as diazepam. In addition, about 1% had consumed local brews with a mixture of sorghum, sugar and cannabis with regard to sex, the results demonstrated that the proportion of male youth consuming substances (67.03) was nearly double that of females (36.9%) and youth from rural areas were more likely to experiment with substances than those from urban areas. This research showed that parental status and students' status was also been found to have an influence on drug use.

It was found that being a student was linked with low rates of substance experimentation while dropping out of school and never going to school were associated with a high prevalence rate of substance use (Kanyoni M, Gishoma D and Ndahindwa V, 2015).

1.3.2 Rwanda education statistics

Rwanda has established a 12 years' basic education that include 6 years of primary school and 6 years of secondary school; most of these secondary schools are non-boarding school where the students leave their home in morning and return back home after classes.

Table 1.1: *Secondary school student's enrolment by grade from 2017 to 2019* **(MIMEDUC, 2020)**

Level	2017			2018			2019		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Senior 1	71,441	84,448	155,889	71,441	84,448	155,889	71,441	84,448	155,889
Senior 2	58,353	67,779	126,132	58,353	67,779	126,132	58,353	67,779	126,132
Senior 3	47,003	53,637	100,640	47,003	53,637	100,640	47,003	53,637	100,640
Senior 4	24,925	31,521	56,446	24,925	31,521	56,446	24,925	31,521	56,446
Senior 5	21,757	26,794	48,551	21,757	26,794	48,551	21,757	26,794	48,551
Senior 6	19,566	24,153	43,719	19,566	24,153	43,719	19,566	24,153	43,719
Total	243,045	288,332	531,377	243,045	288,332	531,377	243,045	288,332	531,377

Source: MINEDUC

Table 1.2: *Lower secondary school student's drop out from 2013 to 2019* **(MIMEDUC, 2020)**

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/2019
Promotion rate	73.6%	74.%	81.9%	86.4%	86.9%	85.9%
Repetition Rate	11.6%	11.6%	11.6%	7.3%	6.%	5.%
Dropout Rate	14.7%	14.4%	6.5%	6.3%	7.1%	9.1%

Table 1.3: *Upper secondary school student's drop out from 2013 to 2019* **(MIMEDUC, 2020)**

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Promotion rate	92.2%	90.1%	90.1%	91.5%	94.40%	95.5%	92.60%
Repetition Rate	1.7%	3.8%	4.0%	6.0%	3.10%	5.0%	2.30%
Dropout Rate	6.0%	6.2%	5.9%	2.5%	2.50%	1.7%	5.10%

According to Rwanda_ Education Statistics (2018), students enrolled in secondary schools were 578897 including 163135 boarding students and 415762 non-boarding students (Dimitri Stoelinga,Sachin Gathani, 2018). The above statistics show that teenage pregnancy and drug abuse percentage are high in the range of 14 to 19 years old the age of secondary school. And it is likely to be high in rural than in urban where we fund most of the 12-years basic education. The research has shown that the non-boarding students are more likely to be implicated in drug abuse and teenage pregnancy than boarding students because they are less monitored by parents and educators.

Today, most of twelve-years basic education schools are non-boarding where there is no existing system of monitoring students when coming/returning from/to home and no real time

communication between parents and school manager, the students get profit of this absence of communication and monitoring to go in illegal activities during the class hours such as drug abuse and teenage pregnancy. So monitoring students and implementing a real time system that allow communication between parent and school managers will contribute in eradication of such illegal practices. Hence I am proposing an IoT based solution that will monitor the non-boarding students through their attendance at school and parent notification via SMS or Email.

1.4. Study Objectives

1.4.1 General Objective

The main purpose of this project is to design and implement an IoT based attendance monitoring system that monitor non-boarding students from home to schools, during class hours and from school to home and notify parents and school administrators about the irregularity observed to their respective children.

1.4.2 Specific Objectives

- To develop a web-based student attendance system in displaying every student attendance results effectively.
- To design and implement a fingerprint-based device used for identification, autentification and evaluate the students and staff while making attendance.
- To generate areal time report to parents and education decision maker and provide an efficient co-parenting communication regarding student's behaviors during class hours.
- To generate a model that shows the impact of monitored attendance on students' dropout in secondary schools

1.5 Hypotheses

The secondary school students' dropout caused by drug abuse or teenage pregnancy can be reduced by daily students' attendance monitoring.

1.6 Study Scope

The study of this project focuses on the use of IoT in daily students' attendance monitoring in secondary school and its impact on dropout, the data used to take from Wisdom school Musanze located in Musanze district. These are for six classes taken randomly from senior one (S1) to senior six (S6) in academic year 2020-2021.

1.7 Significance of the Study

The project has a valuable impact on different actors that are involved in education sector like students, parents and families, teachers, school owners and managers, government decision makers and other partners like NGO and the hole society in global.

A. **For students:** attendance is the predominant factor for success, the time you spend in class impact a lot on the results you obtain. Forcing students to attend courses will increase their level of success.
B. **For parents and families:** parents are always caring about the future of their children, a system which provide the students real-time monitoring is profitable to their families as long as parent are sure that their children are doing what they are supposed to do for their future. In addition, a teen mother and his baby is a burden to the family that affect its economical sustainability, therefore, to prevent such circumstances is profitable to family.
C. **For teachers and school managers:** The time is a big matter in learning process, allowing an automatic and real time attendance or reporting will contribute to the teacher's efficiency. School managers are gaining from this system as they get real-time organizes and analyzed information from cloud analytics platform.
D. **For government decision makers:** insight information is the base of any decision, to elaborate polices to eradicate drug abuse and teenage pregnancy in secondary school, decision makers need to base on reliable information, the system is providing such information.

1.8 Organization of the Study

This project will be consisting of six chapters: Chapter one: The general introduction, describes the project as well as problem statement, objectives, and project scope for the project. Chapter two: Literature review described the use of fingerprint biometric and its advantages over other biometric

technology in education environment and present an overview literature of students' attendance monitoring. Chapter three: Research methodology, research methodology of the project used for getting information, data collection and the project's hardware and software requirements. Chapter four: System Analysis and Design, it most discusses the existing system and new system, proposed simulation models, simulation parameters, simulation scenarios. Chapter five: Results and Analysis, Chapter six: conclusion and recommendation, it shows all facts about the project as well as the operation of the project design and it contains conclusion and recommendation of the project.

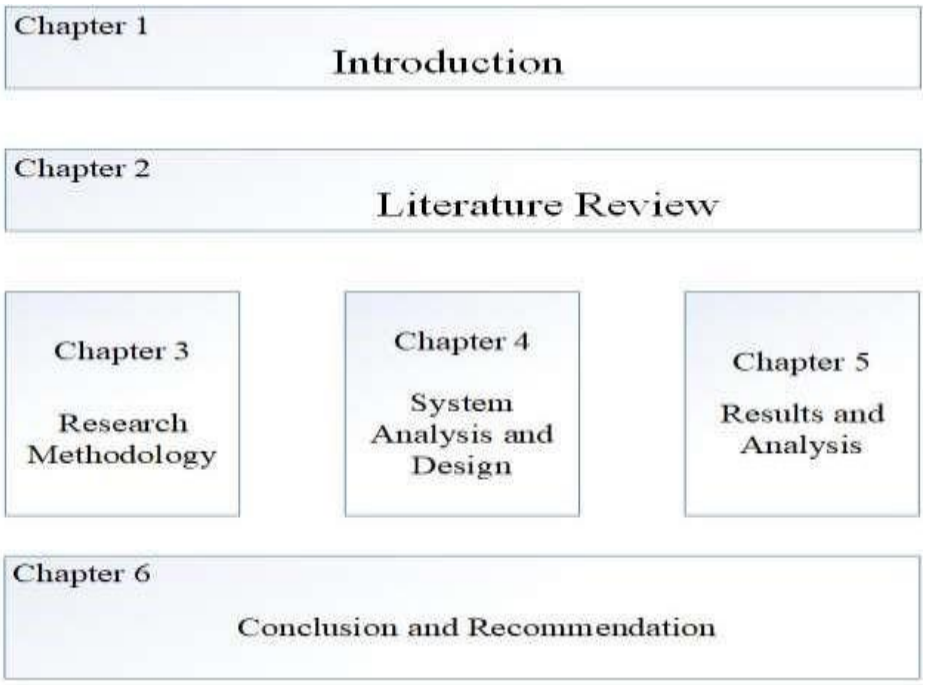

Figure 1.1: *Organization of study*

CHAPTER 2: RETERATURE REVIEW

2.1. Introduction

Research was carried out to identify the requirements of any biometric system, and specifically of a fingerprint system for use within the education environment, before comparing fingerprint suitability with that of other biometric techniques. A choice of fingerprint device had to be considered, and consideration given to the role of identification or verification, so that the best method of operation could be applied. I introduced some biometrics attendance in different regions and show their drawbacks in education especially in case of Rwanda.

2.2 Critical factors to select a biometrics-based system

In designing a biometric based application (Tanuj Tiwari, Tanya Tiwari, and Sanjay Tiwari, 2015). Seven characteristics have been identified for consideration in any system, which uses biometrics for authentication of individuals. Table 4 shows Newman's characteristics and how they have been considered.

Table 2.1: *Considered characteristics of a biometric system.* **(Tanuj Tiwari, Tanya Tiwari, and Sanjay Tiwari, 2015)**

Feature	Comments
Universality: every individual should have specific biometric feature.	A NIST report shows that there are only 98% of the population who can provide a good quality fingerprint; the other 2% would be excluded Fingerprint of this application.
Distinctiveness: the biometric traits should be unique and different among individuals.	It is widely accepted that although unique, fingerprints offer no greater uniqueness than most other biometric elements with the exception of voice.

Permanence: biometric features should be unalterable in different conditions and over time.	It is unlikely that a student's fingerprint will change during the life of their course.
Collectability: biometrics features can be determined quantitatively.	Whereas facial recognition needs a highly professional system, accurate lighting, subject positioning and long scan times, scanning a fingerprint is simple and can be done by small, cheap scanners without changing any of the existing infrastructure of the school.
Performance: speed of obtaining biometrics features and processing, which may **Define the accuracy of the recognition.**	The identification time per ID is in the order of a few milliseconds.
Acceptability: User acceptance of the methods employed by	FINGERPRINT, in comparison with other techniques such as iris scanning, has a relatively high user acceptance rate.
biometrics techniques in their daily lives.	

Circumvention: whether biometric methods can be fooled or hacked by fraudulent methods.	Fooling fingerprint scanners is extremely difficult (O'Gorman 2002, Newman 2010). Different card readers respond to different tricks so no universal "fooling" method can be made, and there are several algorithms, which have been recommended to detect non-natural fingers. In the secondary schools, the likelihood of students circumventing the fingerprint scanner is lower than the chance of them fooling the RFID scanners or paper signatory registers.

2.3 Critical comparison of biometric technology

A comparison of fingerprint techniques with the other biometrics methods is given here. This comparison is completely based on the scientific literature but examples are given in an attempt to elucidate the findings (Tanuj Tiwari, Tanya Tiwari, and Sanjay Tiwari, 2015). Table below shows a comparison of each technique's suitability (low, medium or high) against Newman's seven concerns.

Table 2.2: *Comparison of Biometric Techniques* **(Tanuj Tiwari, Tanya Tiwari, and Sanjay Tiwari, 2015).**

Biometric identifier	Universality	Distinctiveness	Permanence	Collectability	Performance	Acceptability	Circumvention
Face	H	L	M	H	L	H	H
Fingerprint	M	H	H	M	H	M	M
Hand geometry	M	M	M	H	M	M	M
Hand/finger vein	M	M	M	M	M	M	L
Iris	H	H	H	M	H	L	L
Signature	L	L	L	H	L	H	H
Voice	M	L	L	M	L	H	H

2.2 Type of fingerprint hardware

The main five mechanical techniques for scanning fingerprints are capacitance, thermal, ultrasound, tactile, and optical. Optical scanners can be fooled by presentation of an image, rather than the actual finger and they may not image a real finger properly if the finger is dirty or marked (Tanuj Tiwari, Tanya Tiwari, and Sanjay Tiwari, 2015). However, they are mechanically robust, less susceptible to electrostatic damage and also one of the cheapest forms to purchase. It is unlikely that a student would have an image of an absent student's fingerprint to scan, or would attempt to do so, therefore optical scanners were used throughout this project.

2.2 Role of fingerprint

To understand the role of the fingerprint system it is vitally important to understand the difference between verification and identification.

2.5.1 Verification (one-to-one)

An identity is authenticated by matching the stored biometric features of a specific individual with those of the point-of-checking biometric characteristics. This process performs a one-to-one comparison in order to authorize the individual's identity. A working verification scheme only has two results, accept or reject the provided identity

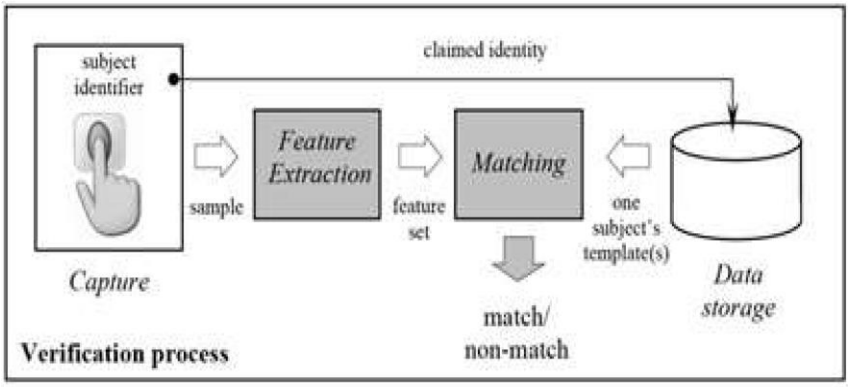

Figure 2.1*: Maltoni's process of verification* **(Tanuj Tiwari, Tanya Tiwari, and Sanjay Tiwari, 2015).**

2.5.2. Identification (one to many)

An identification scheme authenticates a person by examining all the templates in a dataset in order to find a match. It performs one-to-many evaluation in order to determine if the captured biometric features are available in the enrolled biometrics database or not. The result should return the enrolment reference, which is match to the captured biometric or indicate that individual is not enrolled in the database (PARVINZAMIR, 2012). Errors in this type of system are more serious, as they could potentially apply the wrong ID to the person trying to gain access. The failure modes of a functional scheme are False Acceptance Rate (FAR) where an unregistered user is given access and False Rejection Rate (FRR) where a registered user is not given access.

In the secondary school context, it is not suitable to require a teacher to attend each class with a portable dataset of user IDs and matching templates. The system is not providing access control; it is simply being used to verify a student presence. Therefore, the best process to use is identification, where the data capture and feature extraction (steps 1 and 2 in Maltoni's process) take place in the class, but the matching process take place later on, using the templates on the server rather than downloading them to the scanner

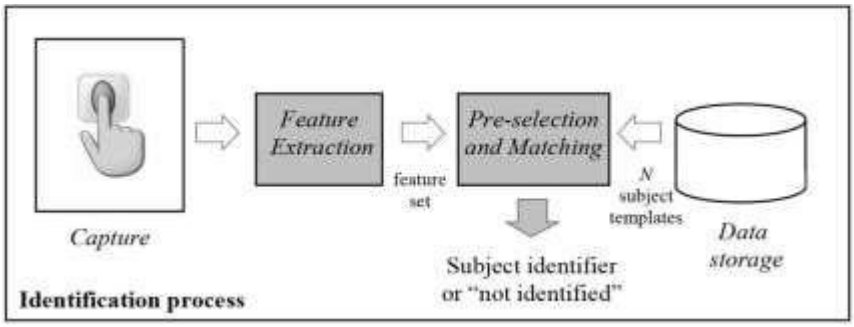

Figure 2.2: Maltoni's process of identification **(Tanuj Tiwari, Tanya Tiwari, and Sanjay Tiwari, 2015).**

2.6 Benefits

fingerprint is trying to increase the metrics of the security mechanisms whilst reducing the complexity of the data capture. It eliminates many, if not all, of the risks and issues associated with token-based access protocols. The major benefits of fingerprint systems are:

- Fingerprint features cannot be forgotten, stolen, or lost
- It is hard to forge or share a fingerprint
- Fingerprints can be combined with token use or other ID structures, meaning they could be added to a current security scheme without changing existing infrastructure. (PARVINZAMIR, 2012).

2.7. Students monitoring

In general school and students monitoring is done through video surveillances. Cameras are installed on entrance and exit of schools and in classroom, laboratories, library, dormitories and school's offices to monitor school activities through facial recognition.

The video surveillance is mostly used in developed countries and in some of the countries under development, some special case that require special attention are listed below:

2.7.1. Students monitoring in developed countries

In USA (theguardian, 2019) Gaggle, Bark and similar tech companies are now monitoring the emails and documents of millions of American students, across thousands of school districts, looking for signs of suicidal thoughts, bullying or plans for a school shooting.

The new school surveillance technology doesn't turn off when the school day is over: anything students type in official school email accounts, chats or documents is monitored 24 hours a day, whether students are in their classrooms or their bedrooms.

Tech companies are also working with schools to monitor students' web searches and internet usage, and, in some cases, to track what they are writing on public social media accounts.

In (freebrowsinglink, 2021) Chinese schools are using 'smart uniforms' to track their students' locations. The reason of tracking the children is to encourage better attendance rates.

For tracking, each of student uniform has two inbuilt chips in the shoulders. This will enable the appropriate management to know when a child exists the school. Face ID, built right inside the

uniforms, is a small quantity of facial recognition software at the entrances to make sure that the right student is wearing the right outfit.

Alarm, and to keep the school premises in order, when you try to leave during school hours, an alarm will go off. The chips can apparently detect when a student has fallen asleep in class, and allow students to make payments (using additional facial or fingerprint recognition to confirm the purchase).

Despite having those little techs built right inside those clothing, students can also wash, and rewash their uniforms without any hindrances. The developers on this Smart Uniforms are Guizhou Guanyu Technology Company, confirmed that each outfit can endure up to 150 degrees Celsius (302 degrees Fahrenheit) and 500 washes.

In UK (luminositylab, 2021) Guardian Drones is an autonomous drone system designed by Luminosity researchers to increase university campus safety by augmenting existing emergency response teams with autonomous agents. Using a proprietary mobile application, students can request to be escorted through campus by an autonomous drone. The drone fleet provides illumination and establishes a live video link for ASU's Police Department to monitor activity. To ensure the success of the system, the drones were designed with multiple functional safety features, such as deployable parachutes and encryption protected software. The drone fleet is capable of responding to a student's request and arriving at their location on campus within a minute. The system was designed to be self-sufficient, in addition to the development of the drones, Luminosity students developed and submitted an invention disclosure for a base station that is capable of automatically docking and charging drones through a contact driven system.

2.7.2. Students monitoring in developing countries

In (Srinidhi Mb, Romil Roy, 2015) Srinidhi from Indonesia proposed a new AI-based system that can automatically detect the student's presence or absence in a classroom using the Wi-Fi signal information collected from student's smartphone. The proposed system does not require any additional investment in hardware or infrastructure and achieves up to 94% accuracy by implementing the Logistic regression-based machine learning classification algorithm. This system is not applicable in

Rwanda because the rule of ministry of education (MINEDUC) doesn't permit the use of smartphones in secondary schools. Shoewu and Olaniyi in (Shoewu O., Olaniyi O.M. and Lawson A, 2011)

proposed an embedded computer-based lecture attendance management system where a single-chip computer-based subsystems (an improvised electronic card and the card reader) were interfaced serially to the serial port of the digital computer. The electronic card is a model of a smart card containing the student identity (ID Name, Matriculation Number and five pin encrypted code). The student ID is authenticated by the card reader which compares the entrance code with the encrypted code on the card swiped through the card reader. The student is granted and or denies specific lecture attendance based on the result of the comparison by the backend software system running on the PC to which the card reader is serially interfaced. The system though provided a simplified, low-cost embedded computer-based system solution to the management of lecture attendance problem in developing countries but does not eliminate the risk of impersonation. The system is devise-based in which students have to carry RFID cards and also the RFID detectors are needed to be installed.

2.7.3. Other biometric attendance systems

In (Shehu V. and Dika A., 2011) proposed a real time computer vision algorithms in automatic attendance management systems using Computer vision and face recognition algorithms and integrating both into the process of attendance management. The system eliminates classical student identification such as calling student names, or checking respective identification cards, but still lacks the ability to identify each student present in class thereby providing a lower recognition rate because facial images are subject to change between the time of enrolment and time of verification and also poses a bigger financial burden during installation and does not offer any privacy protection.

In (Jomon Joseph1, K. P. Zacharia, 2013) proposed a face recognition-based attendance system based on Eigen face recognition. Images are converted into Eigen faces; Recognition is performed by comparing Eigen face got from the input image and Eigen faces in the database. The problem with this approach is that this method is very sensitive to face background, head orientations and it doesn't recognize the face of a person if the person is wearing glasses or a grown beard, etc.

In (Kadry S. Smaili M, 2010) a wireless attendance management system based on iris recognition was proposed using Daugman's algorithm. The system uses an off-line iris recognition management system that can finish all the process including capturing the image of iris recognition, extracting minutiae, storing and matching but it is difficult to lay the transmission lines where topography is bad. And in (A. Khatun, A. K. M. F. Haque, S. Ahmed and M. M. Rahman, 2015) and (Kadry, Seifedine Smaili, Mohamad, 2010) iris-based attendance system is used. The problem with this approach is that it is sensitive to environmental factors in fact they present a low performance when used outside.

There are also papers involving using biometrics for attendance. In (O. Shoewu, PhD, O.A. Idowu, B.Sc, 2012) fingerprint is used for marking the attendance of students. There is a biometric sensor that will take the fingerprint, feature extraction done on that data. If it is for enrolment, then that data is stored in the database else if it is for authentication then that data is started matching with the data in the database. The problem with this method is that for attendance students should go to the place where this hardware device is located or pass the hardware device around the students during class which can be a distraction to the students. (M. B. Chaniago A. Junaidi, 2016) presenting a student attendance application based on the SMS Gateway application that was made to ensure that students attend classes, with the following steps: students must submit an identity card to the teacher in charge, then the teacher scans the barcode printed on the card, and finally the data will be stored in the database automatically. This application provides services for parents to find information on a weekly and monthly basis. This application can also be taken into consideration in making decisions for principals by downloading student attendance data in the Microsoft Excel file format. The implementation of SMS gateway-based applications for student attendance in schools is expected to be the solution to students' absenteeism problems.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

Methodology refers to the procedures or techniques to be used to collect data and analyse them. They are many techniques and this project will use data collection, data analysis to generate a model then we will be able to predict outcome and future use of information extracted from provided data.

3.1.1. Data Collection

In this project, I plan to collect primary data from the school by installing my device, the students and staff will at the beginning enroll to the system and then their attendance will be taken and stored in database data captured will be send on cloud platform.

With the time limitation, I decided to use secondary data taken manually by teachers and school's administrators, the used data are obtained from the school's record of Wisdom school Musanze located in Musanze district. These are for six classes taken randomly from senior one (S1) to senior six (S6) in academic year 2020-2021.

After interview with educators, parents, students and education partners, I realized that there is no available record of student's implication in drug abuse or teenage pregnancy, but I found that both always end up with dropping out from the school, this is the reason I decided to monitor the dropout as its data were available.

I included in this research a field of data related to the students punished for escaping school during class hours because they are suspected to go in illegal activities such as drug consummation and adultery.

According to the literature some researchers shown that student's dropout might be influenced by parent poverty, being orphan or age, the data base will include such data related to payment historic, which is in charge of a student and their age (researchgate, 2020)

Finally, I included a field of data related to attendance (in percentage) because I assuming that by daily monitoring attendance I can reduce the case of drug abuse and teenage pregnancy, hence reduce the dropout.
In total 240 students' data were gathered from S1 to S6. The data base contains the following: students 'ID, class, age, orphan, pay school fees, attendance and dropout.

3.1.2. Data Analysis

This is taken as a tool used to extract useful information from raw data collected and stored in database to help to make decisions. Collected data are accessed by a cloud platform that generates insight information to education partners.

Multiple algorithms of machine learning will be applied to the data to generate a model with high accuracy which shows the contribution of deferent variable to the school dropout.

3.1.3. Data Interpretation/Reporting plan

Information gathered are shared to the end users like parents, school managers and education decision makers.

3.2. System requirement

3.2.1 Hardware requirement

1. NodeMCU ESP8266 development board

Node MCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

The NodeMCU ESP8266 development board comes with the ESP-12E module containing the ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects.

NodeMCU can be powered using a Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface. (components101, 2020)

2 Fingerprint sensor modules

Fingerprint sensor modules, optical fingerprint recognition more accessible and easier to manipulate. This means that is super easy to make fingerprint collection, registration, comparison and search. These modules come with FLASH memory to store the fingerprints and work with any microcontroller or system with TTL serial. These modules can be added to security systems, door locks, time attendance systems, and much more. (components101, 2020)

Here's the specification of the fingerprint sensor module used

- Voltage supply: DC 3.6 to 6.0V
- Current supply: <120mA
- Backlight colour: green
- Interface: UART
- Bad rate: 9600
- Safety level: five (from low to high: 1,2,3,4,5)
- False Accept Rate (FAR): <0.001% (security level 3)
- False Reject Rate (FRR): <1.0% (security level 3)
- Able to store 256 different fingerprints

3. 20*4 Liquid Crystal Display

A 20x4 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. (components101, 2020)

A 20x4 LCD means it can display 20 characters per line and there are 4 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. This is standard HD44780 controller LCD.

20 Characters x 4 Lines

Built-in HD44780 Equivalent LCD Controller

Works directly with ATMEGA, Node MCU, PIC and many other microcontroller/kits.
4 or 8 bit data I/O interface

Low power consumption

LCD is used in this project to display the information related to the attendance done

4. **5-volts rechargeable Lithium battery**

Model:ER 9V 1200mAH Lithium Rechargeable Battery

Diameter:48.8×17.8×27.5mm

Up to 10-year backup battery in ac-powered IoT devices

Low self-discharge rate (less than 1% per year at 25°C).

This battery is used to supply the attendance device when disconnected to main supply and is able to work for five hours without power interruption. (components101, 2020)

3.2.2. Software requirement

1. **Anaconda3.2021.11**

Anaconda is a free and open-source distribution of the programming languages Python and other software mostly used in data science for data analysis. This software include:

- An open-source package and environment management system called Conda**,** which makes it easy to install/update packages and create/load environments.
- **Machine learning libraries** like TensorFlow, scikit-learn and Theano.
- **Data science libraries** like pandas, NumPy and Dask.
- **Visualization libraries** like Bokeh, Datashader, matplotlib and Holoviews.
- **Jupyter Notebook**, a shareable notebook that combines live code, visualizations and text.

In this project, anaconda is used to create an algorithm that analyse and generate an accurate model to predict the dropout and the impact of attendance monitoring on students' dropout.

2. Arduino IDE

Arduino IDE is an open-source software, designed by Arduino.cc and mainly used for writing, compiling & uploading code to almost all Arduino Modules and other microcontroller based board like Node MCU.

In this project, it is used for writing, compiling & uploading the executable code to Node MCU as the microcontroller board

3. JavaScript

JavaScript is a dynamic programming language that's used for web development, in web applications, for game development, and lots more. It allows you to implement dynamic features on web pages that cannot be done with only HTML and CSS.

In this project JavaScript is used to create the web application the manage the attendance monitoring system

3.2.2.4. MySql

MySQL is an open source relational database management system (RDBMS) with a client-server model. RDBMS is a software or service used to create and manage databases based on a relational model.

CHAPTER 4 SYSTEM DESIGN ANALYSIS AND RESULTS

In this chapter we discuss how model and algorithm works on data toward the expected results. We discuss also the outcome of the algorithm and its efficiency and if it can be trusted at what percentage to be realistic on predicting students 'dropout.

4.1. System design

The student's attendance monitoring system consists of three main parts. The first is IoT hardware component that build the entire circuit. This part involves sensing components, data processing component and actuators components. The second part consists of programming to make system hardware operational. The last part is data processing and analytics, which will be done using Python programming and regression as machine leaning technique and will be visualized on graph.

4.1.1. System design block and circuit diagram

The system is equipped of a finger print sensor to register and verify students and staff attendance, a PIR sensor to detect the presence of human to wake-up the device, a real time clock to synchronize each generated report with the local time.

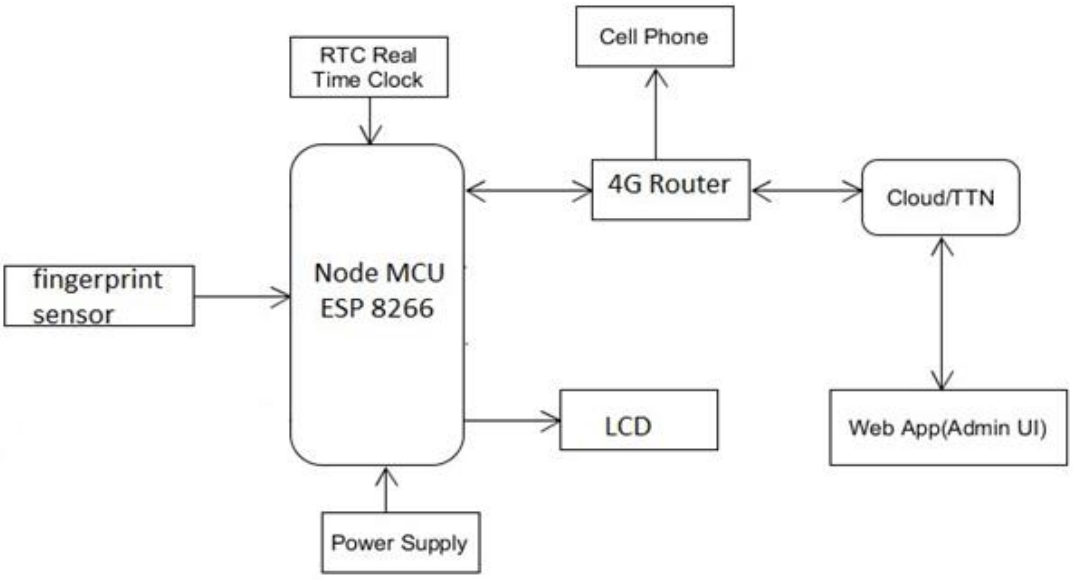

Figure 4.1.: *Block diagram of the attendance monitoring system*

Solar energy harvesting is used to charge the device's internal battery, the system requires a router to connect to the internet and a web application is developed to analyse data and generate insight information. A web application also allows students real-time monitoring for parents and school administrators and the system will be able to generate a daily, monthly and annually report to education decision makers.

1 Circuit description

The first thing is to do in the program is to include all the required libraries. Here in my case, I have included "**Adafruit_Fingerprint.h**" for using R305 fingerprint sensor and

"**ESP8266WiFi.h**" for using ESP8266 NodeMCU Wi-Fi module. To use the I2C interface of an LCD display I used **LiquidCrystal_I2C.h** library. Then I configured the serial port in which fingerprint scanner will be connected. In my case, I declared D5 as RX Pin and D6 as TX pin.

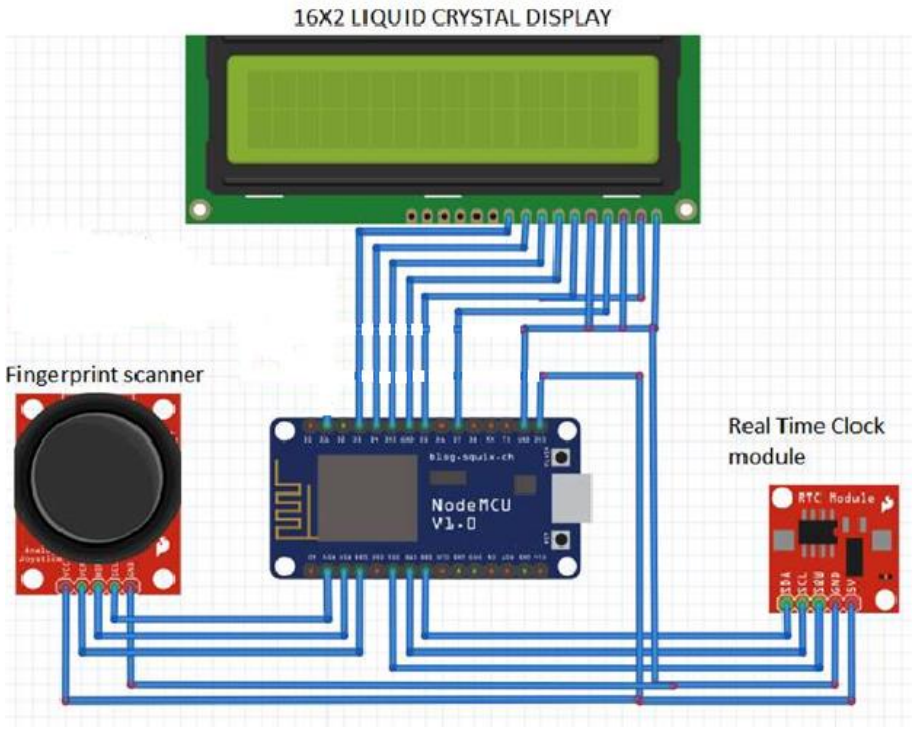

Figure 4-2: *Project's circuit diagram*

Next, I set my Wi-Fi router credentials in the program. Replace your network **SSID** name in place of "xyz" and **password** in place of "123456789". As we are going to use Pushing box API for

sending the data to Google sheet, then I have to check for fingerprint sensor connectivity. This will confirm us regarding the fingerprint sensor's successful pairing with the nodeMCU.

If the connection to the server is successfully established, then a complete URL is created using the device ID which I got in **pushing box** API. If the client doesn't respond for more than 5 seconds, it will show client timeout. Otherwise, it will send the data to Google sheet using the URL via pushing box API.

4.1.2. System design flowchart

A flowchart is a graphical or symbolic representation of a process so that the process will more likely be understood and applied correctly and consistently and it is easy to communicate it to other people.

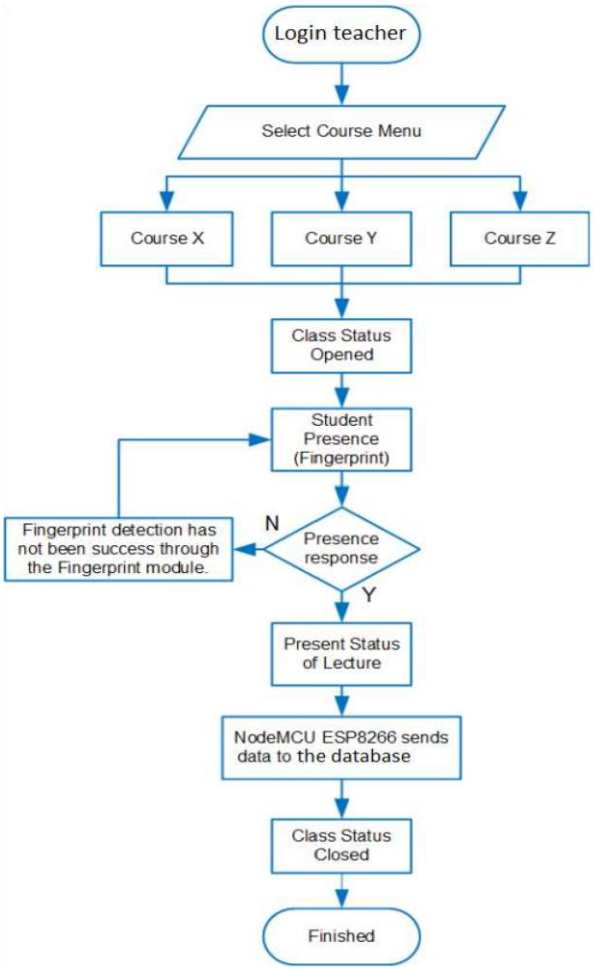

Figure 4.3.: *Flowchart of the attendance system*

The above flowchart shows the steps of process undertaken by the attendance monitoring system when a teacher has to get the students ‘attendance in his respective course.

4.1.3. System high-level design

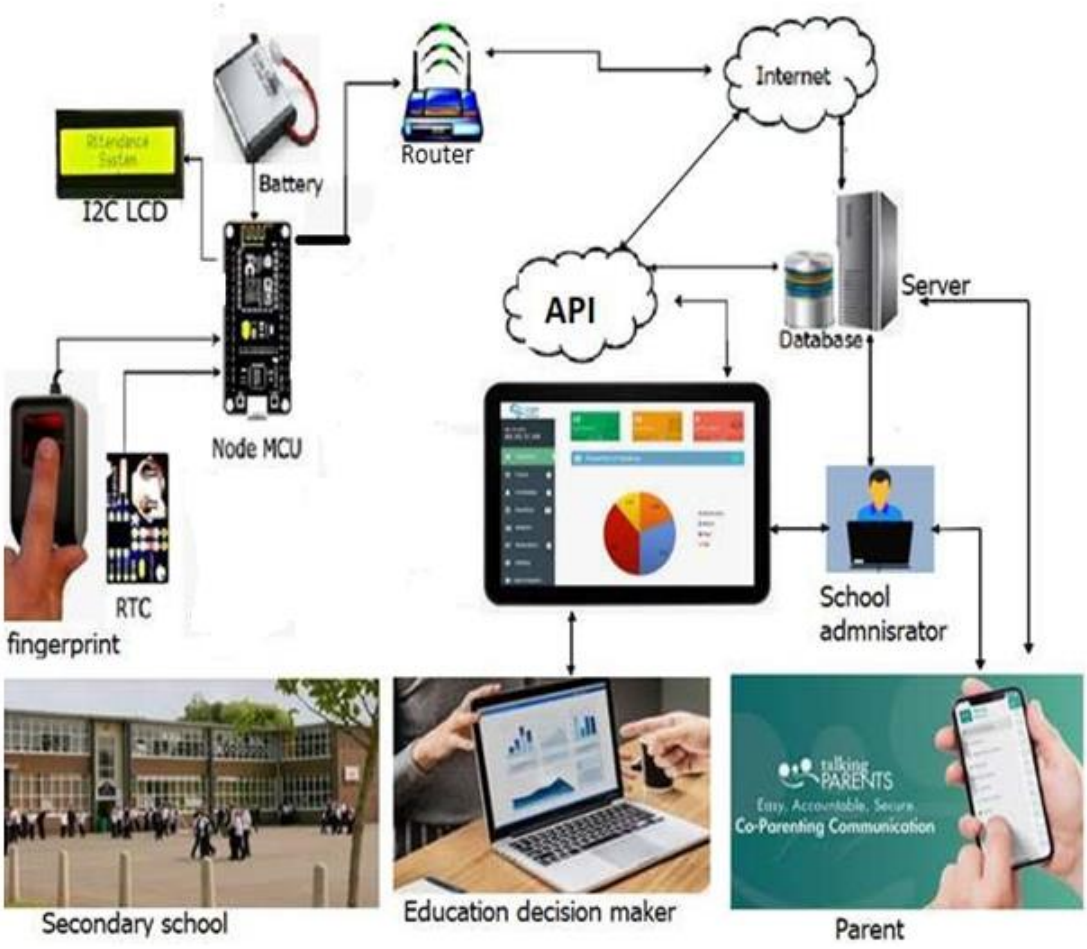

Figure 4.4.: System high-level design

4.2. System analysis

4.2.1 Algorithm to use

An algorithm is said to be a procedure or formula used to solve a problem.so we will need codes to perform manipulations to achieve the results. More explanations and flow chart will be given in as we progress. Due to the type of output to predict which is categorical instead of numerical values, I found that classification algorithm is best fitting among others.

Classification is the type of supervised machine learning which is mostly fitting in a predictive modeling problem where class or labels are categorical instead of numerical values. I chose classification among others because I will be predicting labels like dropout or no dropout.

Machine learning is a method of data analysis that automates analytical model building based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention.

Supervised learning is one of the most basic types of machine learning among others like unsupervised learning and reinforcement learning; here I will focus on supervised learning because of the nature of the data and predicted output.

The dataset obtained from the attendance system are saved in excel sheet named “attendance database” which is called in python software.

Table 4.1: *Attendance monitoring system dataset*

	classe	Age	sex	olphan	pay sc fees	punished for escaping classes	ATTENDANCE	School dropout
0	1	13	F	N	Y	N	86	N
1	1	13	F	N	Y	N	90	N
2	1	14	F	N	Y	N	78	N
3	1	13	G	N	N	N	91	N
4	1	13	G	Y	Y	N	88	N
...	...	...	...	...	...	...	...	...
235	6	19	F	Y	N	Y	42	N
236	6	19	F	N	Y	Y	39	Y
237	6	18	G	N	Y	Y	67	N
238	6	18	G	N	N	Y	77	N
239	6	17	F	N	Y	N	66	N

240 rows × 8 columns

The dataset shows that we have 240 students in 6 classes and among them at least 40 students were dropped out from school.

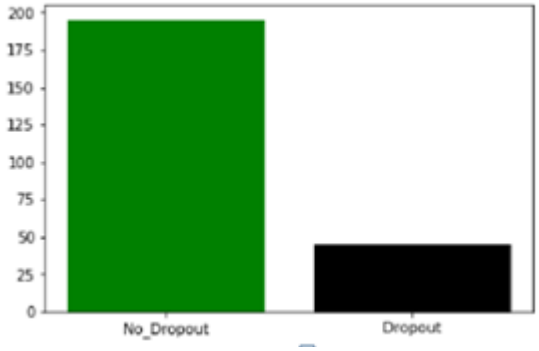

Figure 4.5.: *Non-dropout vs dropout*

There is a problem of class imbalance between dropout and no_ dropout; hence we need to perform oversampling to fix this problem.

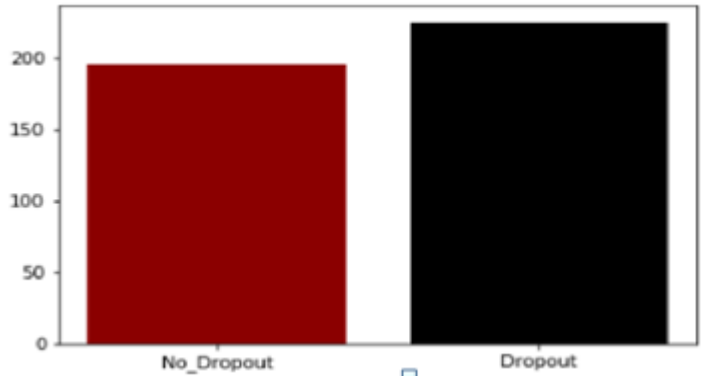

Figure 4.6.: *fix the problem of class imbalance*

Some variables need to be pre-processed to be analyzed

Class input variable: In order to reduce the number of coefficient I decided to use lower secondary (0) and upper secondary (1)

Sex input variable has two fields, female (F) and male (G)

Orphan input variable: has two fields, orphan (Y) and not orphan (N)

Pay school fees: two fields pay school fees (Y) and not pay school fees (N)

Punished for escaping class during class ours: two field punished (Y) and not punished (N)

Table 4.2: *pre-processed dataset*

	F	G	N	Y	N	Y	N	Y	Age	ATTENDANCE	School dropout
0	1	0	1	0	0	1	1	0	13	86	N
1	1	0	1	0	0	1	1	0	13	90	N
2	1	0	1	0	0	1	1	0	14	78	N
3	0	1	1	0	1	0	1	0	13	91	N
4	0	1	0	1	0	1	1	0	13	88	N

Three models of classification machine learning; Logistic Regression, K-Nearest Neighbors and Decision Tree have been applied to the data to see which one is more accurate. Here are the results

- For Logistic Regression we have an accuracy of 81.9 %

Table 4.3: *logistic regression result*

	precision	recall	f1-score	support
N	0.82	0.80	0.81	51
Y	0.82	0.83	0.83	54
avg / total	0.82	0.82	0.82	105

```
[[41 10]
 [ 9 45]]
accuracy is 0.819047619047619
```

- For K-Nearest Neighbors we have also an accuracy of 81.9 %

Table 4.4: *KNN result*

```
==========Model 2 KNN==============
             precision    recall  f1-score   support

          N       0.76      0.76      0.76        51
          Y       0.78      0.78      0.78        54

avg / total       0.77      0.77      0.77       105

[[39 12]
 [12 42]]
accuracy is 0.819047619047619
```

- Finally, for Decision Tree we have an accuracy of 91.4 %

Table4.5: *Decision three result*

```
==========Model 3 Decision Tree Classifier==============
             precision    recall  f1-score   support

          N       0.85      0.78      0.82        51
          Y       0.81      0.87      0.84        54

avg / total       0.83      0.83      0.83       105

[[40 11]
 [ 7 47]]
accuracy is 0.9142857142857143
```

-

4.3. Results discussion

4.3.1. impact of sex on dropout

The analyzed data shows that the number of girls (F) is almost equals to the number of boys (G), but more than 25% of girls are dropping out while on boys' dropout rate is about 18%, this is due to the fact that every student who get pregnant end up by dropping out

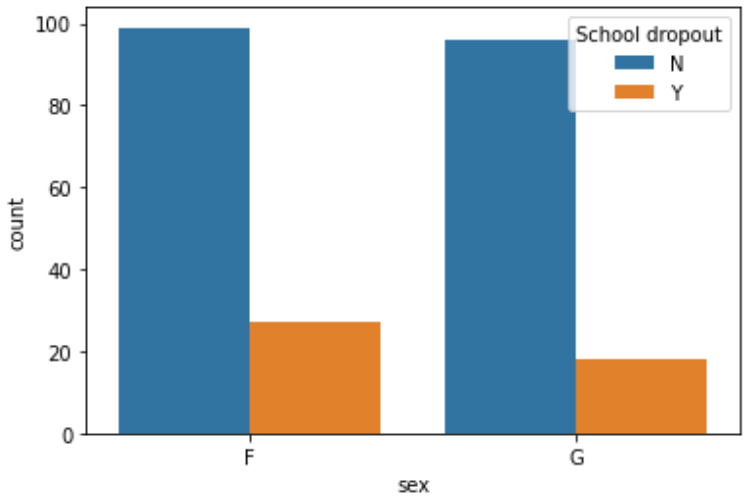

Figure 4.7.: *impact of sex on dropout*

4.3.2. Students' dropout vs secondary school levels

The data shows that the dropout rate is high in lower secondary school and it is reduced as the students progress toward upper secondary school. There are about 9 dropouts over 43 students in senior one (187%) and this rate becomes 5 over 30 students with a percentage of 16.6%.

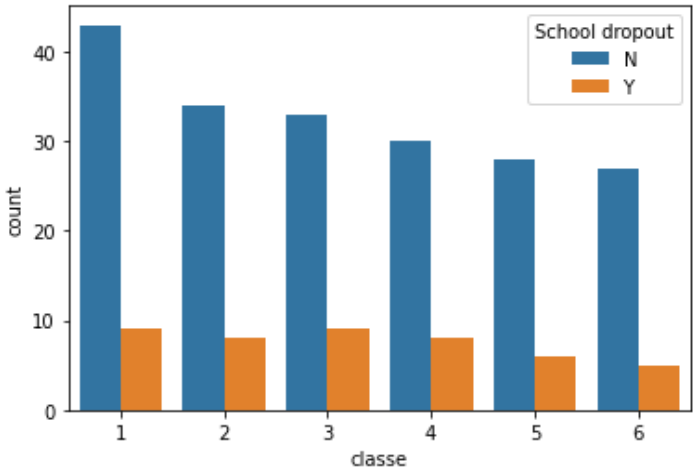

Figure 4.8.: *students' dropout vs levels*

4.3.3. Students' dropout vs parent's poverty

The students' poverty is indicated by the way they pay school fees, on a total of 240 students 155 get school fees easily and 20 students' dropout (12.9%), while 95 pay with difficult among them 20 students dropout (20%). The parents' poverty is one of the factors that influence the dropout.

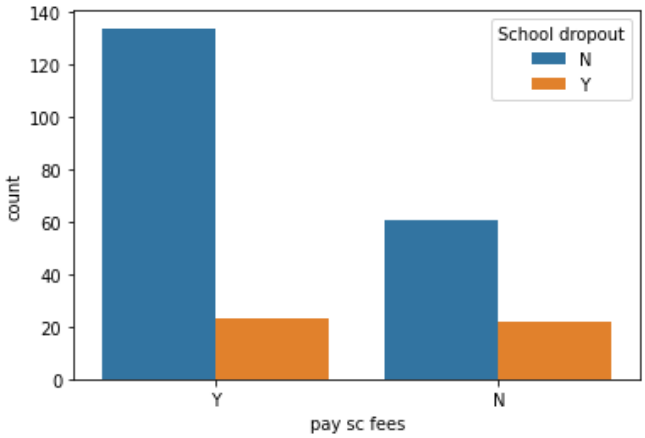

Figure 4.9.: *students' dropout vs parents' poverty*

4.3.4. Students' dropout vs student's punishment

Among 145 students who does not got punishment for escaping class during class hours, only 10 dropped out (6.9%) while 30 dropouts are fund in 95 punished students (31.5%). Escaping classes during class hours is one indicator of tendency to dropout

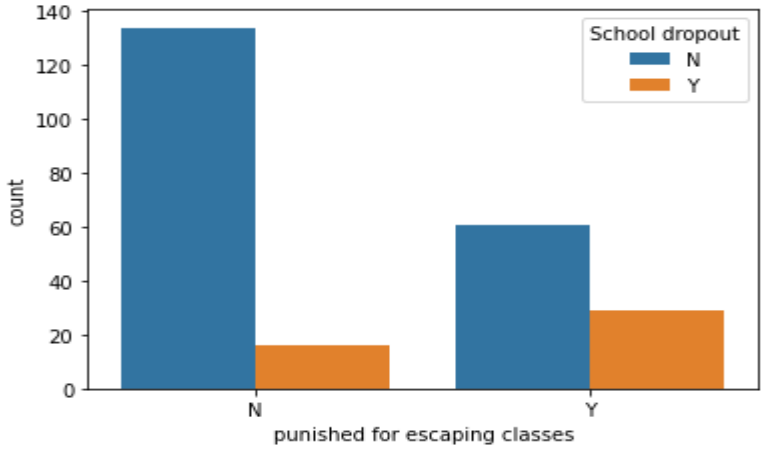

Figure 4.10: *students' dropout vs students' punishment*

4.3.5. Students' dropout vs students' age and attendance

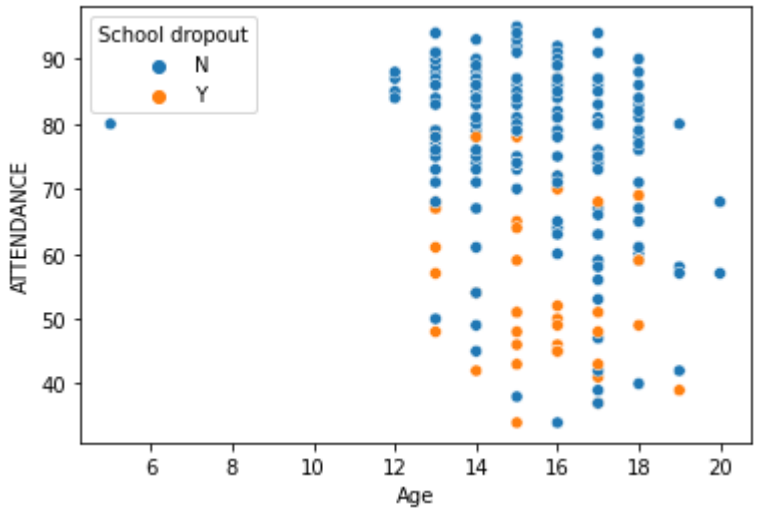

Figure 4.11.: *students' dropout vs students' age and attendance*

The dataset analyzed shows that students in secondary school belong to the range from 12 years to 20 years old, the figure above indicate that the age does not contribute to the dropout as the dropout cases are distributed to the whole range of age. In opposite, the attendance contributes a lot to the dropout as the students with greater than 70% of attendance do not dropout. So, to monitor the students' attendance would reduce significantly the dropout rate in secondary schools.

4.3.6. Results discussion from the model

In this analysis 75% of the dataset have been used for model training and 25% were used for model testing, the algorithms are used to train data and generate prediction results using three different models' algorithm and the results are obtained with different accuracies:

- ✓ Decision Tree we have an accuracy of 91.4 %
- ✓ K-Nearest Neighbors we have also an accuracy of 81.9 %
- ✓ Logistic Regression we have an accuracy of 81.9 %

It is clear that classification with decision tree is generating a model which mostly feet to the collected data to predict the dropout in secondary school

***Table4.6**: Results comparison from three models*

SN	Prediction model	Dropout	Precision	Recall	f1-score	Support	Accuracy
1	**Logistic Regression**	yes	0.82	0.8	0.81	51	**81.90%**
		non	0.82	0.83	0.83	54	
		macro avg	0.82	0.82	0.82	105	
		weighted avg	0.82	0.82	0.82	105	
2	**K-Nearest Neighbors**	yes	0.76	0.76	0.76	51	**81.90%**
		non	0.78	0.78	0.78	54	
		macro avg	0.77	0.77	0.77	105	
		weighted avg	0.77	0.77	0.77	105	
3	**Decision Tree**	yes	0.85	0.78	0.82	51	**91.40%**
		non	0.81	0.87	0.84	54	
		macro avg	0.82	0.83	0.83	105	
		weighted avg	0.82	0.83	0.83	105	

It is true that some other factors contribute to dropout like being orphan and social economic situation of the students' family but those factors can't be controlled, the attendance on contrary when monitored students will be forced to attend even if in some situation they could not without such mechanism.

It is clear that decision Tree provide a model with high accuracy and the dropout is given by:

Dropout = 0.623Female_sex + 0.447Male_sex + 0.909No_orphan + 0.161Orphan + 0.861No_fees + 0.209Fees + 0.207Not_punished+ 0.863 Punished, + 0.099 Age - 0.078Attendance +1.113Lower_secondary -0.042Upper_secondary + 1.07

As the attendance has a negative coefficient (-0.078) this shows that attendance is indirectly proportional to the students' dropout and when the attendance increases the dropout decreases considerably so monitoring the attendance to keep it to high percentage will reduce the dropout rate.

CHAPITER 5 CONLUSION AND RECOMMENDATION

5.1. Conclusion

This project achieved its main purpose which was to design and implement an IoT based attendance monitoring system that monitor non-boarding secondary school's students from home to schools, during class hours and from school to home and notify parents and school administrators about the irregularity observed to their respective children in order to reduce the student's dropout rate.

A fingerprint-based device is implemented for students and staff identification, autentification and evaluation while making attendance. The system is generating a real time report to parents and education decision maker and provides an efficient co-parenting communication regarding student's behaviors during class hours.

In this project a model that shows the impact of monitored attendance on preventing students' drop out in secondary schools is generated with an accuracy of 91.4% and it confirm the hypothesis because shows that keeping the attendance at high percentage would reduce significantly the students' dropout rate, but the model is not deployed to the system.

5.2. Recommendation

During the implementation of this project I realized that students of Embedded Computing System were missing a lot of knowledge of programming especially on web application & database development and data analysis algorithm development; I recommend the center to find how to include such modules to fill the gap

The system uses a single biometric technology (fingerprint) which has some drawbacks when there is skin degradation, so I recommend future researcher to combine more than one technology to implement a more efficient recognition system

The data set used in this project was taken from a single school and a small sample of 240 students data of a single academic year were analyzed; this might not output excellent results of students' dropout. Hence, I recommend the future researcher to expand sample to different schools of different districts and analyses data of more than one academic year.

I recommend that the further study may be applied to this project where a model will be deployed to the system and shows the student's dropout probability based on system's database information.

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