A RASPBERRY PI BASED SYSTEM TO HELP THE VISUALLY IMPAIRED AT HOME

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DANIEL SEKYERE-ASIEDU: A RASPBERRY PI BASED SYSTEM TO HELP THE VISUALLY IMPAIRED AT HOME

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Name, Last name: DANIEL SEKYERE - ASIEDU
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To my family…

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ABSTRACT

Humans rely largely on vision as the main senses used to familiarize ourselves with our environment. Independence in navigation has to do with the ability to survey new surrounds and identify obstacles as well as locate and differentiate between objects without difficulty. These however are very challenging tasks for persons with visual impairment, as a result limiting their independence to move freely, identifying and differentiating objects. Although other researchers have used technologies such as personal computer, microcomputers together with other sensors and cameras to help the blind accomplish these tasks. These approaches produced either very expensive or complicated products. Furthermore none of them utilized RFID and Raspberry Pi to help the visually impaired identify and differentiate between object of the same kind. The visually impaired use some traditional methods to identify and differentiate object such as arranging the object in a particular manner and tying rubber bands around them. They however encounter challenges in identifying and differentiating objects of the same kind.

This Thesis seeks to combine RFID and Raspberry Pi to develop a simple but very important system to assist the visually impaired to identify and differentiate objects to the same kind. The uniqueness of this thesis is its ability for the name of the detected object to be read aloud to the visually impaired. Additionally, the number of tags is easily expandable because there is no database involved in storing names of objects.

Keywords: Object detection; Raspberry pi; Radio Frequency Identification; RFID; visually impaired

ÖZET

İnsanlar büyük ölçüde kendi vizyonlarına dayanırlar, çevremizle aşina olduğumuz ana duyulardır. Navigasyonda bağımsızlık, yeni çevreleri araştırma ve engelleri belirleme, ayrıca nesneleri zorlamadan bulma ve ayırt etme yeteneğiyle ilgilidir. Bununla birlikte, bunlar görme bozukluğu olan kişiler için çok zor görevlerdir. Sonuç olarak, görme bozukluğu olan kişiler bağımsızlıklarını serbestçe hareket ettirme, nesneleri tanımlama ve ayırt etme konusunda zorlanırlar. Birçok araştırmacılar, kişisel bilgisayar, mikrobilgisayar gibi teknolojilerle, gözü görmeyenlerin bu görevleri yerine getirmesine yardımcı olmak için çalışmışlar ve diğer sensörler ve kameralarla yardımcı olmuşlardır. Bu araştırmacılar ya çok pahalı ya da çok karmaşık ürünler üretmiştirler. Ayrıca bu çalışmaların hiçbiri görme engelli kişilere yardımcı olmak ve aynı türden nesneler arasında ayrım yapmak için RFID ve Raspberry Pi kullanmamıştırlar. Görme engelli kişiler, nesneyi belirli bir şekilde düzenlemek ve etrafındaki nesneleri tanımlamak ve farklılaştırmak için bazı geleneksel yöntemleri kullanırlar. Bununla birlikte, görme engelli kişiler aynı türdeki nesneleri tanımlamak ve farklılaştırmak için zorluklarla karşılaşırlar.

Bu tez, RFID ve Raspberry Pi'yi, nesneleri aynı şekilde tanımlamak ve farklılaştırmak için görme engelli kişilere yardımcı olmak için geliştirmek olan bir sistemi açıklamaktadır. Bu tezde, algılanan nesnelerin isimleri görme engellilere yüksek sesle okunmaktadır. Ek olarak, RFID etiketlerinin sayısı kolayca genişletilebilir çünkü nesnelerin adlarının depolanmasıyla ilgili herhangibir veritabanı yoktur.

Anahtar Kelimeler: Obje tanımı; Raspberry Pi; Radyo frekansı tanımı; RFID; görme engelli

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LIST OF ABBREVIATIONS

RFID:	Radio Frequency Identification.
VI:	Visually Impaired
GPIO	General-Purpose Input Output
RAM	Random Access Memory
USB	Universal Serial Bus
CPU	Central Processing Unit
LF	Low Frequency
HF	High frequency
UHF	Ultra High Frequency
ISO	International Standards Organization
GPS	Global Positioning System
IEC	International Electrotechnical Commission

CHAPTER 1
INTRODUCTION

In this chapter, statement of problem is stated and explained. The aim of the study, the importance of this study, the limitations as well as the overall overview of this study are also stated.

1.1 Background

As humans, vision is one the most important and relied upon senses we use in familiarizing ourselves with our environment (Nazari et al., 2017). Independence in navigation is directly associated with our ability to survey new surrounds and identify obstacles as well as locate and differentiate between objects. These are very difficult tasks for the VI people thereby putting limitations on their independence to move freely.

Approximately 285 million people worldwide are VI and blind according to World Health Organization (Krishnaiah et al., 2018). There are mobility challenges usually encountered by these VI persons. This makes it strenuous and unwilling for them to move about freely without any assistance. Some of them use cane to familiarize themselves with their environments by making physical contacts. This approach of navigation may not be preferable in some situations such us walking on a pedestrians walk way and other public places. In such a situation, a computer aided device of some sort can be used to assist them navigate and identify objects easily (Wang et al., 2017).

Shakespeare (2017) referred to visual impairment as both low vision and blindness. The researcher describes low vision as vision sharpness to or keenness of vison below 6/18 but above or equal to 3/60. It could also be described as vision lost equivalent to 20 degrees in the eye with best sight even when correction. Blindness on the hand is define as sharpness in vision below 3/30 and could also be described as lost in vision equivalent to 10 degrees best sight even when correction (Martinez and Koester, 2017).

For independence and smooth ability of blind persons to undertake their day-to-day activities, they require specific services. They require the ability to move from one place to another, identify obstacle, locate and identify objects as well as the ability to differentiate objects of the same kind (Al Kalbani et al., 2015). Takizawa and Yamaguchi (2015) revealed in their study that, cane is an internationally accepted tool consisting of a white cane and a red tip. They revealed that, it can is used by the blinds to help them move from one place to another without someone’s help. Although there are modernized versions of these canes such us smart canes and white cane, their usage are limited by their lengths, ability to recognize obstacles and to keep the VI on track in public places. (Agarwal and Arora, 2017).

Tsirmpas et al. (2015) in their study stated there are different equipment that employ the GPS to aid the visual impaired navigate outdoor, but GPS are not functional in providing useful information about local positions indoor. Although some indoor navigation tools are developed to help VI people, most of those tools are too expensive due to the expensive hardwares installed (Rituerto et al., 2016).

Elmannai and Elleithy (2018) developed an intelligent tool made of different sensors fixed in wearables to assist VI. Sensors are combine with computer vision-based technology to produce a cheaper but quality visual aid devise to assist the VI persons. They proposed the use of two cameras to be used in recognizing objects within a nine-meter range. The writers also proposed some image depth and fuzzy control rules to aid obstacle avoidance. The developed structure in their view helped the VI to independently familiarize themselves with environment they were not use to.

Rodríguez (2015) in his study revealed the VI encounter significant number of challenges in their daily lives, most of these challenge hinder them form their freedom of navigation, access to information and undertaking hobbies of their choice to mention a few. VI are experience many challenges when using the internet. Lot of studies have been made in recent times to improve the user experiences of the internet by the VI. One of those studies is the development of assistive technology that reads the screen to the user, thereby aiding navigation and interactions of the web page. Nevertheless, the particularities of websites with various languages have been for the most part ignored the writer alluded.

According to Brock et al. (2015), more than fifty percent of VI persons in France are confronted with mobility and orientation challenges in carrying out their day-to-day activities. In the writer's study, although there are geographical information on the internet and on smartphone to help the VI to navigate in new and unfamiliar environments, they do not have easy access to this information. This in the writers view hinder their professional and social lives, resulting in making them either reluctance to travel to new places or ply new routes.

Many technologies have been developed to assist the VI in reading, writing as well as making voice call and sending text messaging (Men et al., 2018). The general concept behind this technology is that, information are converted to Braille symbols and subsequently an audio is generated in other to permit communication between the VI and others. However, these technologies may not be beneficial to persons who are both deaf, VI and the uneducated VI.

Raspberry Pi is a computer that runs Linux with the dimensions of a credit card. Raspberry Pi is neither microcontroller nor microprocessor but a small single board computer which has the ability to function as normal computer regardless of it size. When initialized, Secure Shell (ssh) command line interface and Virtual Network Computing (VNC) graphical user interface can be used to control is remotely (Raspberry PI, 2018). The Raspberry Pi in recent times been employed in lots of application, with home automation been one of them. It has been at the centre of home automation systems to monitor and ensure efficient energy usage because of its relatively low price compared to other systems. In the educational sector, some governments such as the UK have taken steps to provide Raspberry Pi to schools to facilitate and enhance computer science and programming education. Some countries in the Middle East have expressed interest and have taken steps to ensure every girl child have access to Raspberry Pi to increase their chances in the job market (Dhami et al., 2017).

Ansari et al. (2015) in their study proposed a security system alert to monitor and detect motion of humans and objects. This system detects motion and sends alerts to the cloud. Photos and videos of the detected motion are sent to a cloud server. This Internet of things (IOT) based system can alternatively save the videos and pictures on a Raspberry Pi when there is no data connections between the system and the cloud, because all the sensors are connected and controlled by the raspberry pi.

Radio Frequency Identification (RFID) system belongs to the Identification and Data Capture (AIDC) technologies (Stimac and Egonut, 2017). It uses radio wave in reading and stored information on a smart label know as tag. It further sends this data into a computer system automatically. It consist of a tag, a RFID reader and an antenna. The tag is embedded with an integrated circuit and antenna which sends and receives data to and from the reader .The reader then converts received radio wave into usable data and sends it to a computer system for storage into a database, manipulation and so on (Lavedas, 2012).

Amendola et al. (2014) in their study describes a tag as readable and detectable from several distance and requires no line of sight communication with the reader. The passive low frequency tags which works within the range of 125 kHz and 134.3 kHz are detected with a range of 30cm or less. Digital data are written to the tag in electromagnetic wave form and later converted back to digital form by the RFID reader. RFID has been employed in various applications in the logistics managements such as inventory management, tracking of assets, security or access restricted areas. Identification badging is one of the sectors in which RFID has been utilized in recent times. It is also used checking and controlling counterfeits product in the pharmaceutical industries (Gallini, 2002).

The Raspberry Pi and the RFID have been combined in a number of researches to solve different identification and location problems. (Suryatali and Dharmadhikari, 2015; Jindarat and Wuttidittachotti, 2015; Suryatali and Dharmadhikari, 2015). There are also several researchers that has utilize the amalgamation of Raspberry Pi and RFID to assist the VI in one way or the other, to solve problems they encounter in their day to day activities (Al Kalbani et al., 2015; Harsur and Chitra, 2017; Elmannai and Elleithy, 2017; Poddar and Gothwal, 2016; Yamashita et al.,2017).

1.2 Problem

Dakopoulos and Bourbakis (2010) in thier study mentioned that VI people faces difficulty in navigation, recognizing obstacles, identifying or differentiating objects from others. Although there are various tools designed to help people having this disability navigate from one point to another, nonetheless one of their greatest challenge is differentiating between objects of the same kind. There are some traditional ways of dealing with this problem such as arranging objects alphabetically in shelves or by putting different number of rubber bands or stickers on the individual objects for easy identification of a particular object. This traditional method is limited to certain objects. For instance, this method of identification is not applicable to objects like shirts or bunch of keys. Consequently the need for the development of a computerized way to solve this problem.

1.3 The Aim of the Study

This study aims to develop a system using RFID with Raspberry Pi to help the VI people identify and differentiate objects of the same kind.

1.4 Significance of the Study

The VI go through a number of challenged in their day-to-day life, one of these problem has to do with differentiating between objects of the same kind. Although there are a number of traditional ways of solving this problem, it comes with its own sets of setbacks. This study seeks to develop computerized system to aid the VI people identify and differentiate between objects of the same kind.

1.5 The Limitations of the Study

During this study, a number of limitations were encountered due to time constrains, hardware and logistics.

- This study is limited to RFID reader and tags.
- This study is limited to passive RFID tags

- The identification and differentiation is limited to only shirts some few kitchen items.
- This study is limited to only four RFID tags.
- The proximity between reader and tag is proximately 30 cm.
- This study is limited to Raspberry Pi 3 model B Vi2.
- This study is limited from February 2018 to October 2018.
- When an object is tagged wrongly, the VI will be misinformed.

1.6 Overview of the Study

The thesis comprises of 6 chapters in all: Introduction, Related Research, Theoretical Framework, Systems Development, System Implantation, And Conclusions and Recommendations.

Chapter 1 gives the overall introduction to RFID and Raspberry Pi systems, the problem, the aim of the study, importance of the study, the limitations as well as the overall overview of the entire study.

Chapter 2 is the related research on RFID and Raspberry Pi carried out by other researchers. Various research already published in this subject area was analysed, examined. Their findings with the missing gaps in those subject were mentioned.

Chapter 3 is the theoretical framework of the study. This chapter discusses and give detailed explanations on VI. It also explained RFID and raspberry pi, their features and the alternatives usage.

Chapter 4 explains the system development and architecture

Chapter 5 is the system implementation discussed in details with the aid of diagrams.

Chapter 6 the system was tested in a kitchen environment and a wardrobe.

Chapter 7 concludes the study, recommends, and make suggestions for future studies.

CHAPTER 2
RELATED RESEARCH

This chapter is the analysis of related research on RFID and Raspberry Pi technologies that implemented in combination with other technologies by different researchers to assist the blind. Moreover, various studies published in this area of study analysed, their findings as well as missing gaps are outlined. The final part of this chapter talks about the originality of this study.

2.1 Radio Frequency Identification

Al Kalbani et al. (2015) in their study proposed RFID bus detection system to facilitate the travelling of blind persons from one place to other. In their proposed system, RFID reader and tag was mounted on a bus and bus station. During the ticket purchasing, the blind person's travelling details in inputted into RFID tag, which was then entered in the database. The bus subsystem detects the nearest stations on the bus's route and announces to passengers on board. Furthermore, it also detected and notified the driver if there is any blind person who needs the service of the bus. The bus station subsystem on the other hand detected the arrival for the next bus and announced to the blind persons there. A computer at the bus station was used for the processing, coordinating and dissemination of this collated information. The researchers concluded that their proposed system will not only assist the blind but also every other passenger and the drivers of the buses as well.

Hanwate and Thakare (2015) proposed a smart trolley, which makes use of RFID. In their proposal, products in the shop should have an RFID tag uniquely identifying the individual item. These tags were then be read by an RIFD reader installed in the trolleys when item is placed in the trolley. This read information would then be transmitted to a microcontroller (ATmage16). The ATmage16 would automatically identified the product and displayed it price, as well as compute all the prices of all the products in the trolley and sent these information to the billing counter via a suitable wireless technology. In their view, their proposed system would eliminate the use of barcode reader to scan the individual items at the counter thereby reduce the queues and time spent at the counter by customers. They also estimated that the system would enhance security at shops because product were scanned once they are placed in the trolley and the information sent to the counters for billing.

Murad et al. (2011) proposed an object identification system that will help blind people recognize objects without any help. The system was designed using RFID. RFID tags with unique code were programmed and attached to some house objects. There is also a mobile RFID reader connected to a personal computer using ZigBee technology. The reader captures the code from each tag then send the code to the computer where there is a database of all tags and corresponding audio data. The computer searches through its database to match the received code then transmit the corresponding audio via frequency modulation (FM) transmitter of 90MH. The information was then received on a mobile device or radio handset when tuned to that specific frequency. The developed system in their view aided the IV in an organized indoor environment and was equally helpful in a relatively unorganized environment but required some modification in such conditions.

2.2 Raspberry Pi

Jain et al. (2014) stated that lots of research have been made on using Raspberry Pi 3 to assist the blind in one way or the other. In their study, they developed a Raspberry Pi based home automation system. A Raspberry Pi was used to read the subject of a mail in their system. An algorithm was then used to generate a corresponding feedback to the user and instruction to control home appliances. In their study, they concluded that using a Raspberry Pi is very easy, economical, efficient and effective way of developing a home automation system. Furthermore they mentioned in their study that, raspberry systems are easy expandable and also easy to develop. They concluded that, using this method to develop a home based automation system is preferable to other methods such as Dual Tone Multi-Frequency systems and a web server based home automations system

Kulkarni et al. (2017) also developed a Raspberry Pi based home appliance control system. Their system contained two main parts, namely the server and the client parts. In their set up, the server part consisted of a Raspberry Pi hosting a server with the assistance of a

LAMP (Linux, Apache, MySQL, PHP) on which two php files (index.php and switchDevice.php) were stored. The Raspberry Pi’s GPIO controls relay driver circuitry. The circuitry intends regulated relays. These relays were then used to turn appliance on and off. The second part (the client system) was made of a web page designed with Dreamweaver, which the user accessed on a mobile device to control the appliances. In their development, more than one appliance were simultaneously controlled. The mobile device accesses the Raspberry Pi based server via the internet with the help of the IP address of the raspberry pi. They successfully developed the system with the help of Raspberry Pi and the internet. In addition, they alluded to the fact that, Raspberry Pi was reliable and scalable for the implementation of a home automation system.

Younis et al. (2017) created a Raspberry Pi based speech recognition home automated system to assist the disable persons, elderly and medial patient. Their project was segregated into two main part: base station and remote station. These two parts communicate to each other wirelessly by ZigBee. In their design, a Raspberry Pi was the central processing part of the base station, it received vocal command form a microphone and status updates of the appliances generated by sensors as inputs. These audio inputs go through speech recognition processes in the Raspberry Pi and the appropriate controlling commands are generated. These commands are then sent to a microcontroller in the remote station via ZigBee to control switches of the home appliances. In their view, the proposed home automation system which utilized speech recognition, Raspberry Pi and zig bee was more cost effective way of achieving home automation. The use of these technologies in their view was efficient and effective because of low power consumption and it ensures easy installation

Gouiaa and Meunier (2015) used a Raspberry Pi in an image recognition robotic system in which two stereo cameras were used to identify and estimate the proximity an obstacles. This gathered visual information was processed by a Raspberry Pi B+ with the help of an image proceeding algorithm. This enabled the robot to identify and estimate the obstacle in its path. The processed information was used to control a STM32F4 Discovery model in other to manipulate the robot to either turn, stop or move depending on the position of the obstacle.

2.3 RFID and Raspberry Pi to Assist the Visually Impaired

Chang et al. (2018) proposed an intelligent walking stick. In their system, sensors were mounted on a walking stick to assist in the detection of obstacles in the user's path. A GPS module was also used to know the location of the blind person. An android application was used to ensure safety and security as it aided in navigation and real-time location tracking of blind person. In their developed system, a Raspberry Pi Zero was used together with a Programmable Interrupt Controller (PIC18F4525). A SRF08 Ultrasonic range finder was used to detect the obstacles. When the obstacle was detected, ultrasonic sensor sends signals to the Raspberry Pi, PIC intend command I2C to communication information about the obstacle to the user. In their system, water sensor was also used to detect moist surface on the walkways and a vibration motor was used in to communicate to the user (both blind and deaf persons). From the experimental results, the writers observed that the system was capable of detecting the exact proximity of an obstacle to avoid collation. In addition, the application aided the users to reach their destinations safely and independently and it furthermore helped track their location by their appropriate persons. In the study, the writer mention the fact that it was not desirable to use RFID in some conditions such as pedestrian crossing because it has the tendencies of interfering the frequency generated by the traffic light.

2.4 Summary

From the above review, it is obvious that there are limited research carried out using RFID and the Raspberry Pi to identify and differentiate objects. The review reviled that, there is a missing gap in using these two technology to assist the VI identity and differentiate of the same kind.

CHAPTER 3
THEORETICAL FRAMEWORK

This chapter explains what visual impairment, RFID and Raspberry Pi are in details.

3.1 Visually Impaired

As per the World Health Organization report in 2014, a little above 280 million people worldwide have some degree of visual impairment (World Health Organization, 2017a). Bourne et al. (2017) also made mention of the fact that, approximately 253 million persons are visually impaired. 36 million are of the aforementioned number are blind and 217 million are moderately or severely visually impaired.

Approximately 8.7 million people are VI in the United States of America alone, whilst 1.3 million others are sightless (Elmannai and Elleithy, 2018). The National Federation for the Blind together with the American Foundation for the Blind announced that, 100,000 of the VI people are students (Jiang et al., 2017). 90% of VI worldwide are low-income earners and are found mostly in developing countries. Furthermore, 80% of VI persons are above the age of 50. Their population however, is estimated to raise by roughly 2 million every decade and by 2020 their population is predicted to double. (Velázquez et al., 2018). Students with visual impairment are not mainly visceral by nature as a result of physical condition that affects their visual functionality. Consequently customized curriculum, learning materials, and services are required in other to education them. (Henderson, 2014).

Visual impairment in other words is any visual acuity less than 20/40 with the outmost available correction, blindness on the other hand refers to complete or nearly complete sight loss. Visual impairment can also be defined as reduction in sight to the extent that is not corrected by glasses or contact lenses. (Guo et al., 2017). The following classifications of visual impairment are used by the World Health Organisation; when the visual acuity in the better eye after outmost available correction are:

- 20/30 to 20/60: is regarded as mild sight loss, or almost-normal vision
- 20/70 to 20/160: is regarded as moderately low sight.
- 20/200 to 20/400: is regarded as critically low sight.
- 20/500 to 20/1,000: is regarded critically visual impairment.
- Greater than 20/1,000: is regarded almost absolute sight loss.
- No light awareness: is considered as absolute sight loss.

Bourne et al. (2017) in their study said 81% of blind, moderately or severely visually impaired people are aged 50 years and above. The researchers mentioned that chronic eye diseases are the primary cause of sight loss worldwide. Refractive errors that are not corrected and cataract cases that do not undergo surgical operations are the topmost causes of sight loss, with the latter accounting for majority of sight lost in low and middle-income countries. Within this couple of decades, the occurrence of infectious eye diseases, such as trachoma and onchocerciasis, have been significantly reduce the researcher stated. Bourne et al. (2017) alluded that more than 80% of all vision impairment are avoidable or correctable.

Vision functionality is classified in four main categories by International Classification of Diseases (World Health Organization, 2017b).

- Normal vision
- Moderate sight loss
- Severe sight loss
- Total sight loss.

“Low vision” is a terminology used to describe the combination of moderate with severe impairment. “Low vision” along with blindness represents all vision impairment. (Guthrie et al., 2018)

3.1.1 The causes of sight loss

A recent study done by Bourne et al. (2017) attributed the main causes of moderate to severe sight impairment globally to the following:

- refractive errors that are not corrected, 53%
- cataract conditons that have not under gone surgical operation, 25%
- age-related macular degeneration 4%
- glaucoma, 2%
- diabetic retinopathy 1%.

3.1.2 Major factors attributed to visual impairment:

As mentioned by Holloway et al. (2018) in their studies.

- cataract conditons that do not under go surgical operation 35 %
- refractive errors that are not corrected 2%
- Glaucoma 8%

The VI experience numerous difficulties when performing most regular activities in their daily lives. For example, distinguishing static or dynamic objects and securely walking through them. Under taking these activates pose high level of danger to the VI and difficult for them to do, particularly in environments unfamiliar to them. For this reason, VI utilize a similar course most of the time and doing things they are familiar with. These as a result limits them in exploring and living their lives to the fullest.

3.2 Raspberry Pi

Dennis (2013) describes Raspberry Pi essentially a small single board computer with its length, breadth width being 8.56 cm – 5.398 cm – 1.7 cm respectively. These dimensions make Raspberry Pi easy to fit in cases and electrical boxes. The size also makes it easy for the Raspberry Pi to be implemented in the construction of media streamers, arcade machines and home automation systems. Edirisinghe (2018) in his book stated that Raspberry Pi could also be used in internet radio, controlling robots, temperature monitor, security camera and cosmic computer. It is affordable with prices ranging from a 5$ to 35$ depending on the models. All Raspberry Pi models consumes less power, are cheap but has very powerful processors (Biswal and Agarwal, 2017). The processors are built on SoC chips called BCM2851. Raspberry Pi is made up of a RAM and graphics chip. It also has interfaces and connectors that makes it possible for it to be connected to peripheral devices (Schmidt, 2012).

3.2.1 Power supply

The Raspberry Pi are powered by a variety of power sources that has the ability to generate an output current of 700mA. This can be attained by diverse power sources: (Vujović and Maksimović, 2015). Computer USB Port, powered USB hub, mobile phone backup battery and solar charger meant for mobile phone are all means by which a Raspberry Pi can be powered. In some cases, six rechargeable AA alkaline batteries can be used to power the Raspberry Pi since it is capable of generating the required current.

3.2.2 Power modes

The Raspberry Pi run on four power modes namely; run, standby, shutdown and the dormant modes (Horan, 2013).

The run mode: In this mode, the entire function of the CPU and the ARM11 core are active and accessible.

The standby mode: In this mode, though the power circuits on the CPU still runs and remains active, the core clock where the instructions are executed is shut down. In this mode, an interrupt signal can be generated by usually an input device. This signal is sent to the processor to stop it present process and attend to the request of the interrupt signal.

The shutdown mode: In this mode, power supply to the Raspberry Pi is completely shut off.

The dormant mode: All caches are powered up while the core is powered down.

The Raspberry Pi with it functions as a personal computer needs power supply, display unit and some basic input devices as such keyboard and mouse. However, it may not need display unit, mouse and keyboard when used as a Web server. When used a web server, the

Raspberry Pi connects with a number of single purpose devices such as sensors to form a network.

3.2.3 Operation system

Raspberry Pi runs on a Raspbian, which is Debian-based Linux based operating system. It entails a number of already installed software as such Python, Sonic Pi, Java, Mathematica and scratch just to mention a few. Though the Raspbian has a terminal (Command-Line Interface), it comes with a full graphical User interface. (Vujović and Maksimović ,2015). The Raspberry Pi can however run other third party operating systems such as Ubuntu mate, windows 10 IOT core, OSMC, Snappy Ubuntu core. Furthermore, the Raspberry Pi runs on LIBREELEC. PINET, RISC OS, weather Station, ICHIGO JAM RPI. Nevertheless, it is limited by its inability to run some windows operating and some Linux distributions. And it also has challenges running applications that utilizes CPU (Ansari et al., 2015).

3.2.4 Models of Raspberry Pi

There are three main models: pi Zero, model A and model B. The model A consist of Raspberry Pi 1 Model A and Raspberry Pi 1 Model A+ revision 1.1. Secondly, the model B, consist of Raspberry Pi 1 Model B revision 1.2, Raspberry Pi 1 Model B+ revision 1.2, Raspberry Pi 2 and Raspberry Pi 3 which happens to be the latest. The Model A+ is a powerful board for implementing robotic projects, it however have no Ethernet port but has one USB port. (Core – electronics, 2016)

Table 3.1: Models of Raspberry Pi (Core- electronics, 2018)

	Raspberry Pi 1 Model A	Raspberry Pi 1 Model A+	Raspberry Pi 1 Model B	Raspberry Pi 1 Model B+	Raspberry Pi 2 Model B	Raspberry Pi 3 Model **B**	Raspberry Pi Zero
Release Date	2013	2014	2012	2014	2015	2016	2015
SoC	Broadcom BCM2835	Broadcom BCM2835	Broadcom BCM2835	Broadcom BCM2835	Broadcom BCM2836	Broadcom BCM2837	Broadcom BCM2835
COU Speed	700Mhz ARM 1176JZF - S	700Mhz ARM 1176JZF - S	700Mhz ARM 1176JZF - S	700Mhz ARM 1176JZF - S	900Mhz ARM- Cortex-A7	1.2GHz ARM- Cortex-A7	1GHz ARM 1176JZF - S
Cores	1	1	1	1	4	4	1
SDRAM	256MB	256MB	512MB	512MB	1GB	1GB	512MB

3.2.5 Features of Raspberry Pi.

Is has a system chip (SoC) of Broadcom BCM2837. A 4× ARM Cortex-A53, 1.2GHz central processing unit and a graphical processing unit being a Broadcom VideoCore IV.
It also has a RAM of 1GB LPDDR2 (900 MHz). The Model A, Models B and B+ have 512 MB 246 RAM. For data transition and reception of data, the Raspberry Pi 3 uses a 10/100 Ethernet, 2.4GHz 802.1. In wireless communication, the system is coupled with a Bluetooth 4.1 Classic, a low energy Bluetooth. In addition, internet connectivity of the model B utilizes a standard RJ45 Ethernet port. The Model B Ethernet port is auto-sensing (Vujović and Maksimović, 2015). The A model on the other hand can be only connect to a wired internet with the help of a USB Ethernet adopter.

A microSD is used for storage and it functions as hard drive to the processor. The minimum size of the SD storage required varies from an operating system to the other, however, 2 GB is usually minimum size required. It is preferable to use the class 10 SD card. The capacity of storage is expandable with the use of flash drives, Solid State Drives, USB ports and USB Mass Storage. (Halfacree and Upton, 2012).Other features include General Purpose Input and Output 40-pin header, and Ports: HDMI, 3.5mm analogue audio video jack, 4× USB 2.0, Camera Serial Interface (CSI), and Display Serial Interface (DSI).

It also has two USB ports, a 3.5 mm analogue audio jack output, and a composite RCA port for attaching the yellow video cable to Television monitor. A High Definition Multi-media Interface (HDMI) port allows the Raspberry Pi connection to high-definition televisions as well as monitors and for streaming audio video signals from the web to TV.

The Raspberry Pi can be used in a wide variety of projects because of it flexibility of use. It is employed in general purpose computing and it is helpful in learning programing. It is also used to learn incorporating electronics with programming (Horan, 2013). Raspberry Pi can be used in projects such as; a smart television, desktop PC, wireless print server, a media centre, retro game machine, Minecraft game server, robot controller. In like manner, it can be applied in building systems such as a stop motion camera, time-lapse camera, FM radio station, web server, and a motion capture security camera system. (Make-Use-Of, 2018).
Table 3.2 explains the models and the specifications of the various models of the Raspberry Pi

Table 3.2: Models specifications of Raspberry Pi (Raspberry Pi, 2018)

	Raspberry Pi 3 Model B	Raspberry Pi Zero	Raspberry Pi 2 Model B	Raspberry Pi Model B+
Introduction Date	2/29/2016	11/25/2015	2/2/2015	7/14/2014
SoC	BCM2837	BCM2835	BCM2836	BCM2835
CPU	Quad Cortex A53 @ 1.2GHz	ARM11 @ 1GHz	Quad Cortex A7 @ 900MHz	ARM11 @ 700MHz
Instruction set	ARMv8-A	ARMv6	ARMv7-A	ARMv6
GPU	400MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV
RAM	1GB SDRAM	512 MB SDRAM	1GB SDRAM	512MB SDRAM
Storage	micro-SD	micro-SD	micro-SD	micro-SD
Ethernet	10/100	none	10/100	10/100
Wireless	802.11n / Bluetooth 4.0	none	none	none
Video Output	HDMI / Composite	HDMI / Composite	HDMI / Composite	HDMI / Composite
Audio Output	HDMI / Headphone	HDMI	HDMI / Headphone	HDMI / Headphone
GPIO	40	40	40	40
Price	$35	$5	$35	$35

The figure below outlines the various components and specifications of the raspberry pi and the

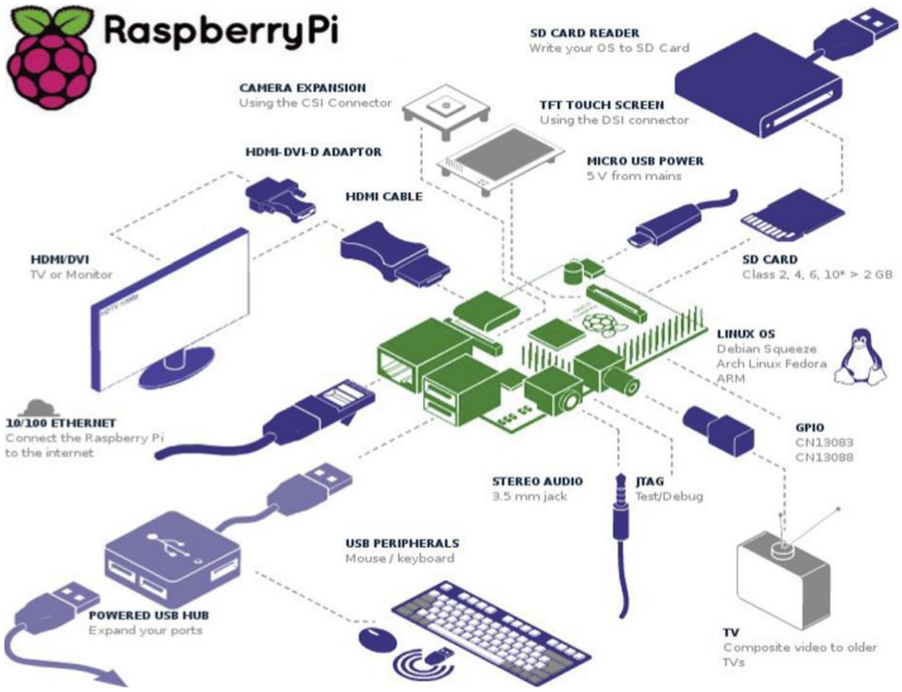


Figure 3.1: The components and features Raspberry Pi (Raspberry Pi, 2018)

3.3 Radio Frequency Identification

RFID works by digital data encoded into RFID tag and this data read by a reader through radio waves with the intension of identifying and tracing objects (Bolic et al., 2010). In this system, a RFID reader regularly emits radio waves, when an object with a RFID tag comes within the range of the emitted waves, the tag in responds transmits a feedback signal to the reader for identification and tracking the information stored on the tag (information about the object) (Kumari et al,2015). RFID is comparable to the bar code system in which data in a tag is picked up by a reader and stores it in a database. But RFID has a number of leverage over the barcode system, with the most outstanding is of them being the fact that, RFID tags do not need line-of–sight in order for the tags to communicate with the reader. While in the barcode system, the optical scanner must be in line with the barcodes to enables the reader to read data from tag. Moreover, in the RFID system, multiple tags are read simultaneous.

Trappeyet al (2017) in their study discribed RFID as an Automatic Identification and Date Capture (AIDC) system which automatically identify objects, gather data form the identified object and enter those data into a computer system automatically without human assistance. RFID uses radio waves to achieve this. Figure 3.2 illustrates the how an object is tagged and data is retrieved by the reader. Figure 3.3 also talks about the working principles of the RFID system.

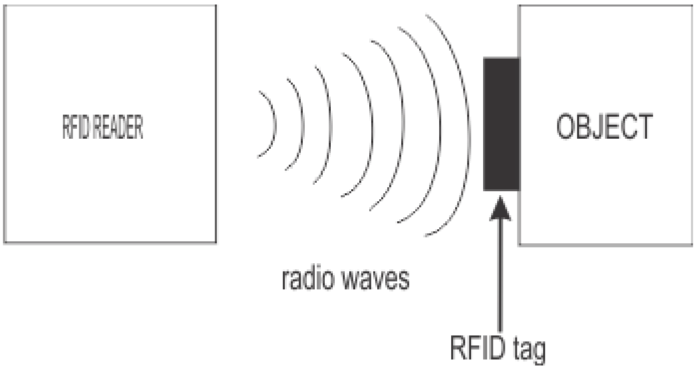


Figure 3.2: RFID system

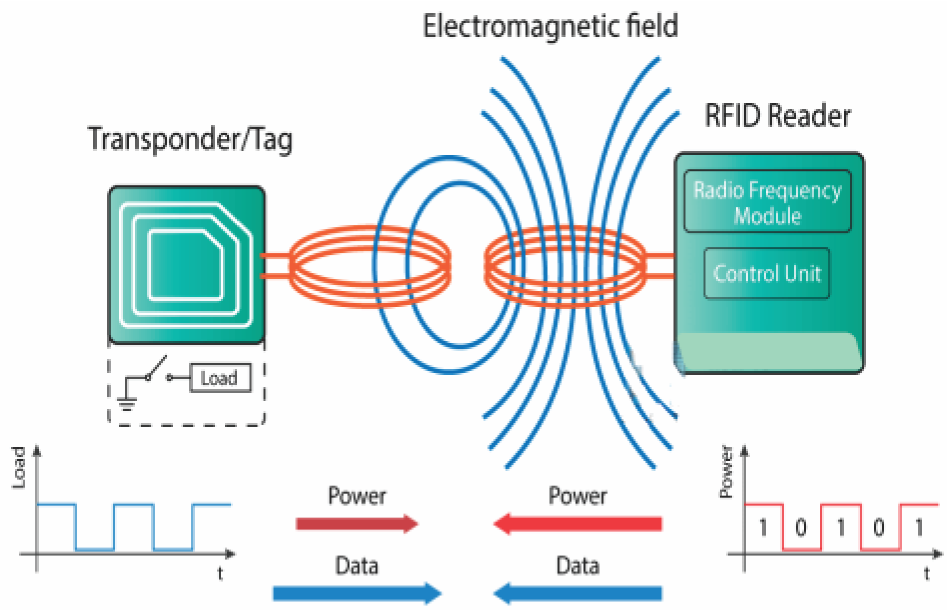


Figure 3.3: Working principle of RFID system (How To Mechatronics, 2018)

3.3.1 The RFID system

RFID system comprises of three main segments, which are the RFID tag, an RFID reader and an antenna. Figure 3.4 explains pictorially the components that makes up the RFID system.

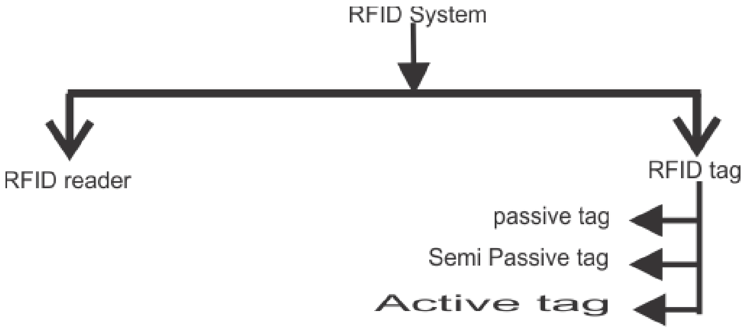


Figure 3.4: Components of the RFID system

3.3.2 RFID reader

As shown in Figure 3.5, the RFID reader constitute of three components, firstly a radio frequency generator, which converts data from the microcontroller into radio waves. These waves are transmitted by an antenna. The reader has a receiver or signal detector, which receives signal detected form the antenna and convert it into data. The microcontroller on the order hand processes data received or uses or sends it to a computer system. This data can further be sent to a computer system through a communication medium such as a cable or blue tooth for data manipulation, storage or analysis

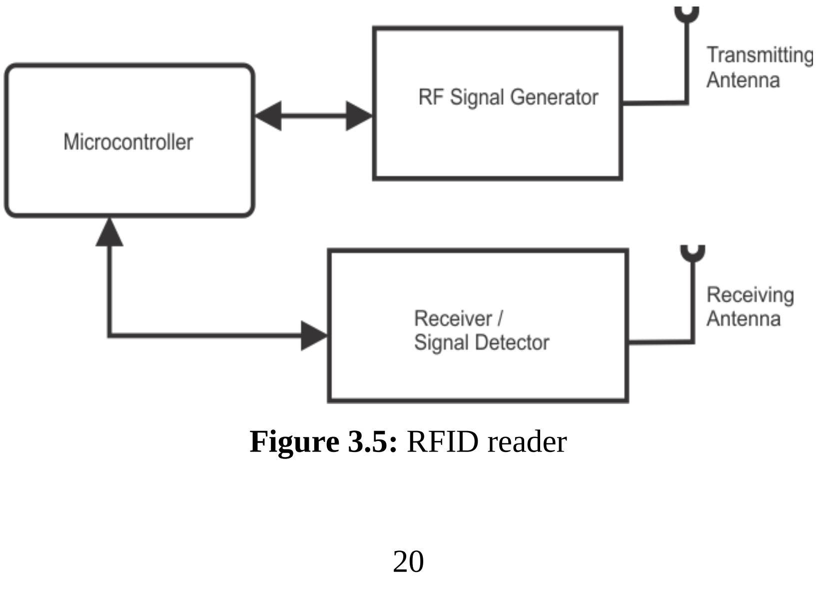


Figure 3.5: RFID reader

3.3.3 RFID tags

As illustrated in Figure 3.6 the RFID tags are made of integrated circuits and an antenna, these two components are used to transmit data to the reader. Data is written to the tag through radio waves. This data is then stored is the tag. A distinct ID number also known as UID (Unique Identification Number) is assigned to each RFID tag.

The RFID tag is made of a transponder which receives and send radio waves from antenna to be transmitted to the reader. The radio waves are sent to a rectifier circuit, which rectifies and stores the voltage in a capacitor. Some to the energy is used to power the controller and memory in the case of the passive tags.

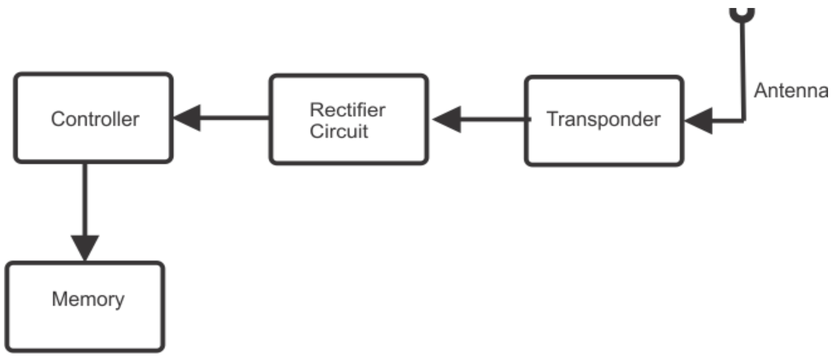


Figure3.6: Block diagram of RFID tag

In Figure 3.7, a number of different forms of FRID tags are shown and named.

Figure 3.7: RFID tags

3.3.3.1 Types of tags

There are three basic classification of the RFID tags:

Passive RFID Systems

The passive system works without a battery, it therefore relay on the electromagnetic waves from the reader for it source of power. The passive tags can withstand extreme conditions such as moisture, temperature and have long life span. It is light weighted, inexpensive and electromagnetically noiseless as well. The passive tags have short ranges because of the absence of active antenna. It also has limited storage because non-volatile memories demands on power to retain much data. It also requires high powered readers to work properly. These therefore makes it unsuitable to be implemented in sensing applications because most of such systems requires constant power to work and memory to store data.

Semi - Passive Systems

Whereas the semi passive tags have medium range because they use battery to power the integrated circuits. They are however limited by high communication range: (the minimum distance between the tag and the reader to ensure communication). Because it relies on the radio waves from the reader to transmit feedback signals. Is has detection range of 100 feet or more. Another advantage of the semi passive is that, the onboard battery and the active components enables it to support sensors and memory systems application. Although they are more expensive than the passive tags, they are cheaper than the active tags and does not add much electromagnetic noise to the environment.

Active RFID systems

The active tag happens to be the most complex type of RFID. It has an active transmitter, which requires a large battery. It does therefore neither depends on the reader for power supply nor for transmitting feedback signals. The active RFID tag is powered by higher battery voltage, which is enough to provide power for fast processor as well as other more energy requiring parts. An active transmitter can convey data over longer proximity, three times more than the semi – passive. It has communication proximity of approximately 300 feet and above. Active RFID tags do not need high powered interrogators (reader) to prevent attenuation because they utilize powered antennas thus low power reader. Additionally, the active tag is appropriate choice for a multi task usage because they provide bigger memory, more sensors as well as a fast and powerful processor. It is suitable for outdoor use as well. Regardless of the aforementioned advantages of the active tag, it is expensive and has a shorter life span (3-5 years). Moreover, it adds electromagnetic noise to it environment because of the presence of a transistor. It is also bulky and heavy.

3.3.4 Working principles of RFID

RFID operates in three frequency ranges and works based on two principles. These three frequency rages, their communication proximity and working principle are represented in Table 3.3 below.

Table 3.3: Frequency of operation and working principle

Frequency	Range	Distance	Working principle
LF	125kHz to 134kHz	10cm	Inductive coupling (near field coupling)
HF	13.56 MHz	1 m	Inductive coupling (near field coupling)
UHF	860 to 960 MHz	10-15m	Electromagnetic coupling (far field coupling)

3.3.4.1 Inductive coupling (Near Field Coupling)

In this technology, the radio waves transmitted by the coil of the reader induces an electromagnetic field into the tag's coil when it is within its range. As result of this mutual coupling, voltage is induced across the antenna of the RFID tag. Part of the induced voltage is rectified, this serves as power source for the memory and controller. Because the generated voltage by the reader is of a specific frequency the induced voltage is also of the same frequency, it generates a synchronization clock for the tag's controller. When a load is connected across the coil, current will start flowing across the load in this ratio I = V/R. (I is current, V is voltage and R is resistance). Consequently, when impedance of the load is varied the current is varied as well. When the load is turned on and off, the current will also be turned on and off. The rate of change in the current will generate a voltage across the tag's coil a phenomenon known as load modulation. Load modulation according to the data stored on the tag will generate an equivalent voltage, which will be transmitted in the form a radio waves to the reader RFID by the antenna of the tag. Accordingly, the voltage across the RFID reader's coil changes to the modulated carrier frequency. Data by this technique of load modulation is transmitted to the reader in the LF and HF ranges.

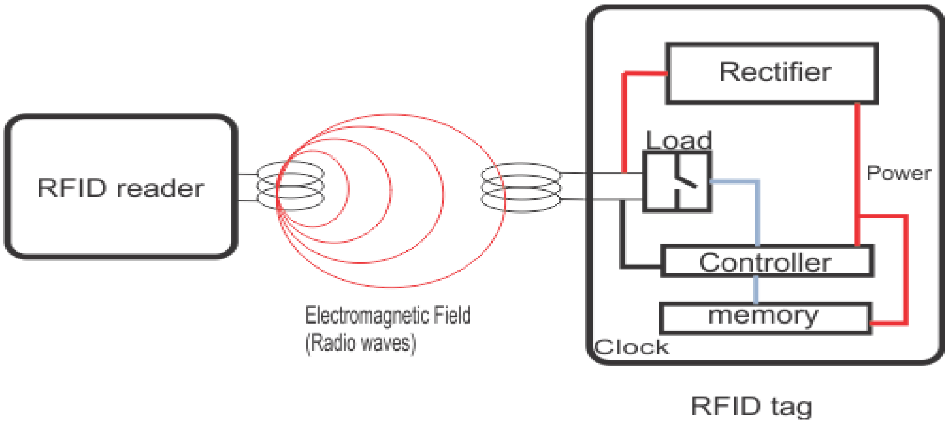


Figure 3.8: Inductive coupling (near field coupling) (RFID4U, 2018)

3.3.4.2 Electromagnetic coupling (Far Field Coupling)

The ultra-high frequency uses the far field coupling (electromagnetic coupling). In this technique, proximity between the reader and tag is wild thus; the coupling between their coils is far coupling. The reader regularly transmits radio waves towards the tag, the tag in return transmits a weak feedback towards the reader. This radio wave is known as backscatter signal. The intensity of this backscatter signal in proportional to load matching across the tags coil. Therefore, in the case of a matching load, the intensity of the backscattered signal is high. Additionally varying the conditions of the load would vary the intensity of the backscattered signal. Varying the conditions of the load according to the stored data across the tag will therefore generate a corresponding backscatter signal. This would enable data across the tag to be sent to the reader. The intensity of the radio waves initially sent by the reader must be strong enough to ensure that it gets to the tag, because the proximity between them is usually big. The process of data sent to and from the tag to the reader is known as backscatter modulation.

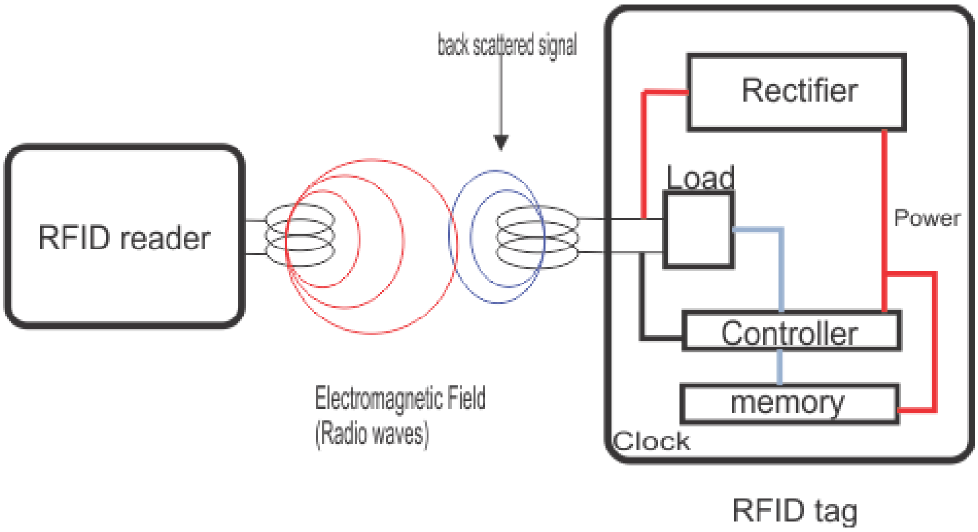


Figure 3.9: Electromagnetic coupling (far field coupling) (RFID4U, 2018)

3.3.5 Some applications of RFID

The following are some examples of the application of RFID (Suryanto et al., 2018)

1. ***Access control*** to allow entry into places without key like gyms, offices.
2. ***Asset tracking*** for checking and trucking asset in and out of restricted places such us library, hospital and Schools
3. ***Asset tagging*** and identification for inventory.
4. ***Authenticating*** products to prevent counterfeit.
5. It can also be implemented in Supply Chain Management for tracking products.
6. It can also be used to tag and track animals.

3.4 Python

Python is a powerful object oriented programming language. It is has a dynamic syntax which makes it an attractive choice for application development as well as scripting to control components together with electronic appliances. Its uncomplicated and easy to learn syntax makes it readable and easily maintainable. Python supports modules and packages for which reason it incites code reuse and modular programming. It is a high level programming language and has extensive open source library that supports most platforms. It very fast to debug because it has no compilation procedure. Debugging python is uncomplicated because bad input cannot cause the segmentation fault to occur, python detects the error, and raises an exception with its printed stack trace in case the program does not catch the error.

3.4.1 Python libraries

A library is essentially a reusable machine language component whose functionality can be utilized within another program. It is usually contains functionalities needed for other programs but is not a complete program in itself. It is a collection of functions and methods that enhances perform without writing many codes. (Geldenhuys et al., 2006). Python libraries are usually imported at the beginning of a script to allow its usage in the script.

CHAPTER 4
DEVELOPED SYSTEM

In this chapter, the methodology used for the developed system would be discussed. The system has two main component, the software part and the hardware part. This chapter explains the various component. Furthermore, this chapter explains python libraries.

4.1 System Architecture

There two main components of the proposed system: hardware and software parts. The hardware consist of the Raspberry Pi 3, the RFID – RC522 reader and the RFID passive tag. And the software is made up of python libraries and scripts

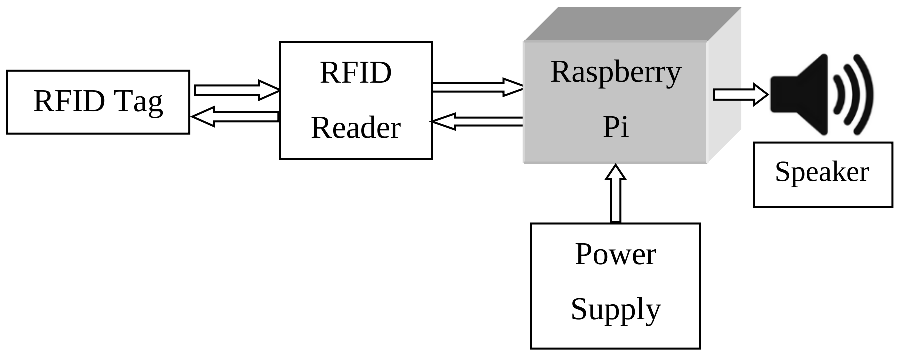


Figure 4.1: Block diagram of the developed system

4.2 System Technology

A number of technologies were used to implement this project. These technologies aided in setting up the raspberry pi, writing to tags reading from the tags and reading out audibly the read text to the user.

4.2.1 Hardware

4.2.1.1 Raspberry technology

There are various single board computer (SBC) but the raspberry foundation has made tremendous impact on the SBC market because of its flexibility, affordability and availability. Although the Raspberry Pi was initially intended for the improvement of teaching computer science, it is currently utilized in assorted projects: engineering, logistics sector, arts exhibition and medical sector just to mention a few. Is supports a number of operating systems including Windows, Linux, BSD, Risc OS and Debian (Cox and Johnston, 2018).

Raspberry Pi was first released in February 2012, Raspberry Pi Model B first generation. The Raspberry Pi had received a massive patronage because of it low cost and performance. An added advantage it has is that, by adding a couple of peripherals the Raspberry Pi functions as a completely working computer with Raspbian, a Debian-based Linux as it operating system. It is usual described as a Single Board Computer (SBC), implying that it runs a full operating system and adequate peripherals to execute instructions. Some versions of the Raspberry Pi are network bootable if it has a file storage system such as a micro SD card (Vogiatzaki and Krukowski, 2014).

Although Raspberry Pi was not the first SBC, the Raspberry Pi foundation make the SBC available to nearly everybody and has exposed and made the GPIO connection pins very versatile. Software programs in the operating system are used to control these GPIO. The GPIO connects to assorted electronic devices and components. It also support a variety of features such as interrupts, USB UART, SPI just to mention a few. This has prompted the popularity of the Raspberry Pi in computer science education as well as with industry, researchers, model developers, gamers and the inquisitive. Because of it cost, it easily to be experimented with and damages due to wrong connection are tolerated than to have a personal computer blown up. The Raspberry Pi has become core component of many complex project in recent years. Figure 4.2 is a block diagram of the Raspberry pi whiles Figure 4.3 shows a picture of the Raspberry pi and labels the various components of the pi.

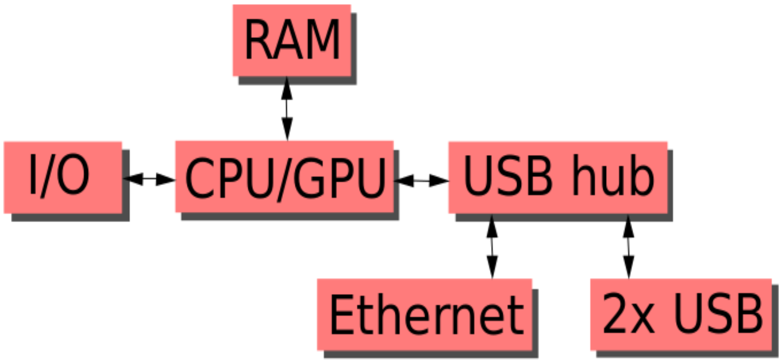


Figure 4.2: Block diagram of Raspberry Pi

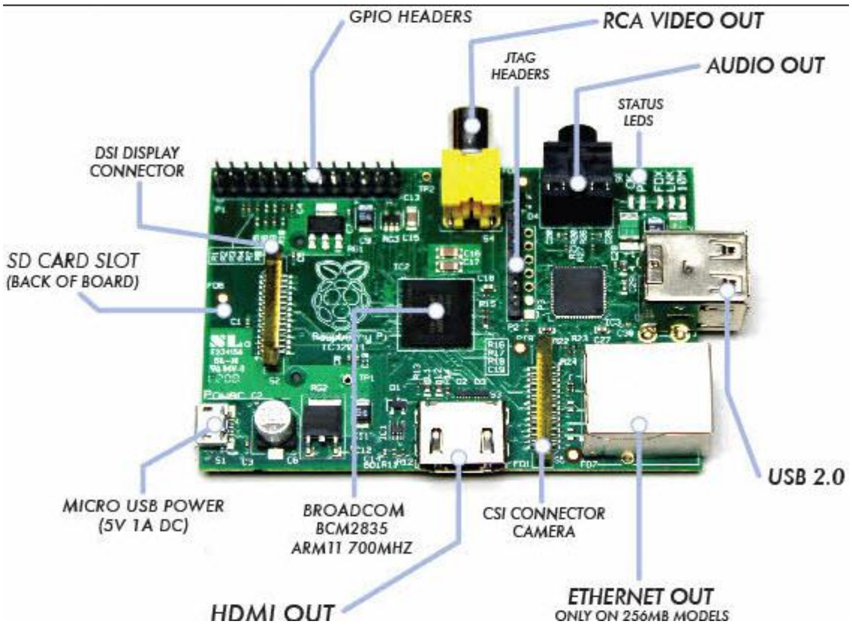


Figure 4.3: Hardware Specifications of Raspberry Pi (Edgefxkits, 2018)

4.2.1.2 Technology behind RFID

A RFID system entails readers (interrogators) and tags (transponders).

The RFID system usually constitute numerous tags fastened to objects readers and very few readers. The readers can either immobile or mobile. A reader communicates with the tags within its range and reads the information stored on it (information about the objects tagged).

Tags are generally categorized into three depending upon their working principle: passive, semi-passive, and active. A passive tag has no internal power source hence uses the electromagnetic (EM) field emitted by a reader to power its internal circuit. It sends data back to reader by a process known as backscattering. A semi-passive tag is self-powered but also uses backscattering to transmit data to the reader. An active tag on the contrary is both self-powered and has transmitter in the tag.

Short history of RFID

Communication with reflected electromagnetic energy is an ancient technology dated back in the early 20th century. Numerous development in those days applied radio backscatter technology. One of the most significant of them was it usage in the II World War by Manhattan. Radar sent out radio waves for the purpose of detecting and knowing the geographical position of an object by the reflection of these radio waves. The speed and the positon of these objects could be determined by this technology. Continuous time modulation of reflected signals was one of the initial and most influential works on RFID. Stockman in 1948 used this technology to design a device to modulate human voice on reflected light signals. During the 1960s and 1970s, researches on RFID sprang up, and in 1963, Richardson developed and patented passive RFID transponder. The device was used to rectify and couple energy from an interrogator's EM field. These signals were then transmitted at a harmonic of the received frequency. There were a number of invention about RFID during the aforementioned period: Interrogator-transponder system based on inductive coupling by Vinding, transponder antenna load modulation as a means for backscatter modulation by Koelle, Depp and Freyman, just to mention a few.

RFID was first commercially applied by Kongo, Sensormatic and Checkpoint in the late 1960s for Electronic Article Surveillance. Form the 1980s to 1990s, application of RFID in various forms broke out. It was applied in the transportation and personnel access control systems in the United States while the Europeans employed it in animal tracking, electronic toll- collection and in their industries. The increase of commercialization of RFID necessitated standardization in the 1990s. ISO and IEC spearhead the standardization of RFID. ISO are responsible for industrial standards and IEC are responsible for electrical and electronics standards. RFID in the 1990s made its way into the supply chain management which, this also led to the addition of more standards about the usage of RFID. In 1996 a significant stage in RFID development was made by Article Number Association (ANA) and European Article Numbering (EAN) groups as a data carrier. EAN International, and the Uniform Code Council (UCC) in the United States (GS1) (currently both known as GS1) approved a UHF band for RFID and established the Auto-ID Centre at the Massachusetts Institute of Technology in the 1999. RFID since then evolved in it usage and standardization.

4.2.2 Software

4.2.2.1 Linux operating system

Anand et al. (2012) in their study describes Linux as a free and open source Unix-like software, primarily developed in C and assembly developed around Monolithic (Linux kernel) by Linus Torvalds. It is a multilingual software first released on the September 17, 1999. Linux was initially created to be used by personal computer base on the Intel x86 design, but currently runs on variety of devices ranging from mainframes, supercomputer, mobile devices, embedded devices to servers (Tolu, 2018).

The Linux operation system runs on a number of platforms: Hexagon, Itanium, Alpha, ARC, ARM, C6x, x86, H8/300, Microblaze, MIPS, and PowerPC. It also runs on OpenRISC, Nios II, RISC-V, PA-RISC, Xtensa, m68k, SuperH, NDS32, s390, SPARC, Unicore32. It is open source, and therefore the source code can be modified and used for both commercial and non-commercial for any purposes under the licenses of GNU General Public License.

Arch Linux, CentOS, Debian, Fedora, Gentoo Linux, Linux Mint, Mageia, openSUSE and Ubuntu are among the most popular and mainstream Linux distribution. Red Hat Enterprise Linux and SUSE Linux Enterprise Server are also among the popular commercial Linux distribution. There are other Linux distribution such as GNOME (a desktop environment), LXDE and LAMP modified distributions, for specific purposes.

4.2.2.2 Raspbian operating system

Raspbian is an open source Debian based operating system belonging to the Unix-Like family developed by the Raspberry Pi foundation and optimized for Raspberry Pi. The latest version is Raspbian Stretch with PIXEL/2018-06-27. Raspbian is the preferable operating system for Raspberry Pi and has about 35,000 software packages recompiled, including educational, programming languages and general-purpose software. The Raspbian uses Advanced Package Tool (APT) (an open source software user interface together with core libraries updates) to uninstall and install software on Raspbian.

4.2.2.3 Programming languages

Raspberry Pi has a significant number of programming language suitable for it. It for beginners, python is the suggested language by the Raspberry Pi foundation. Primarily, any programming language complied for ARMv6 are runnable by the Raspberry Pi. Users are therefore not confined to utilize just the Python. C, C++, Java, Scratch and Ruby are a few of the preinstalled languages on the Raspberry Pi. (Yli-Heikkilä, 2015)

4.2.3.4 Python for Raspberry Pi

Python is a flexible, powerful and essay to use programming language developed by Guido van Rossum in the 1980s at the National Research Institute. Python has gain in popularity in recent times and it is broadly utilized economically (Upton and Halfacree, 2012). It has clear and simple syntax making it user friendly as well as an important language for bingers. Consequently, the Raspberry Pi Foundation recommends it for Raspberry Pi. Python can be executed on a variety of operating systems such us Windows, OS X and Linux published under an open source licenses (Upton and Halfacree, 2012). Upton and Halfacree (2012) in their research described python as a cross platform supported language and therefore compatible with other platforms, even though there are couple of exceptions of incompatible platforms. Python can be used in controlling some hardware such Raspberry Pi GPIO

4.3 Use-Case Diagrams

The functionalities of the performance of the system is usually represented pictorially using a Use Case Diagrams from the user's point of view. Figure 4.4 is a representation of the interaction between user and developed system. The user's responsibly is to place the reader on the tag of it to detect the tag. The system intend verifies the tag, displays an error if the tag is not detected. The system subsequently undertakes the rest of the actives as shown in the diagram below.

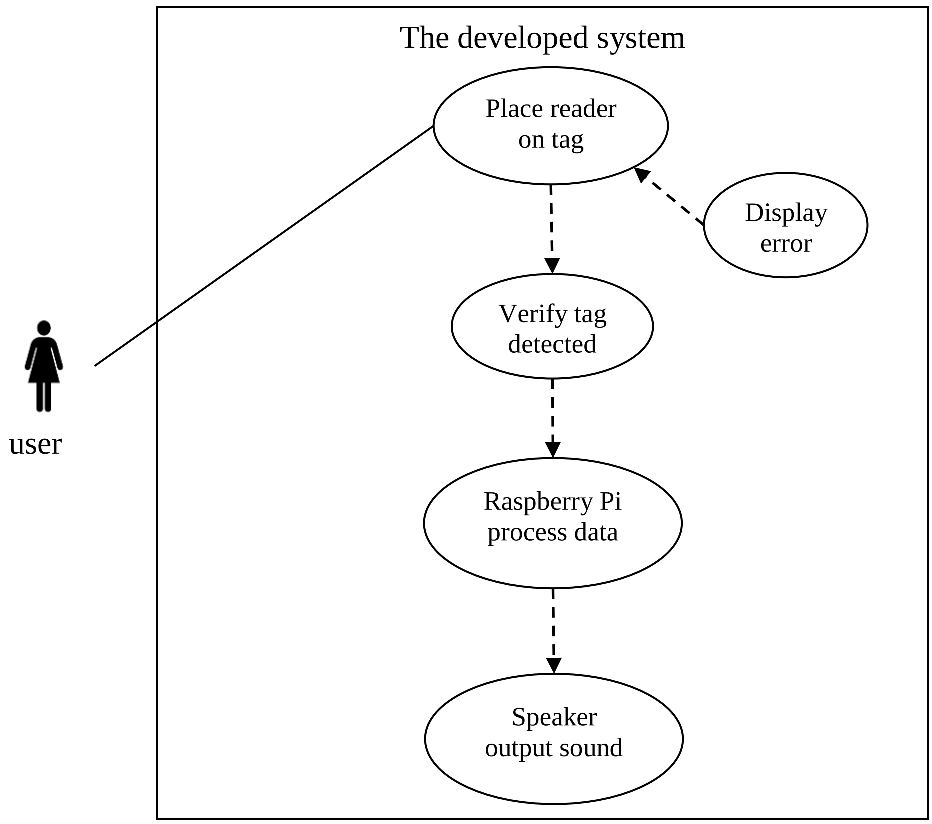


Figure 4.4: Use case diagram of the system

Flow chart of the system

This flow chart is a graphical representation on how the developed system works sequentially. The represents the distinct stages involved for the developed system to read aloud the detected tag. Figure 4.5 shows the flowchart of the developed system to assist the VI.

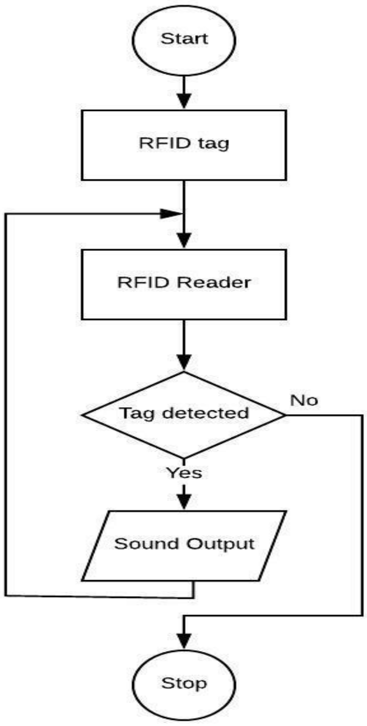


Figure 4.5: Flow chart of the system

4.4 System Requirements

This developed system is made up of some hardware and software component. Below are the components used to developing the system.

4.4.1 Hardware components

Firstly, below are the hardware components used in the development of this system.

4.4.1.1 Raspberry Pi 3 Model B Vi 2

Below in Figure 4.6 is Figure of Raspberry Pi 3 Model B Vi 2 together with its specification

Figure 4.6: Raspberry Pi 3 Model B Vi 2 (Raspberry Pi, 2018)

Kuznetsova et al. (2017) pointed out some the specifications of the raspberry pi 3 Model B Vi 2

- Broadcom BCM2837 64bit ARMv7 Quad Core Processor with its speed being 1.2GHz
- 1GB RAM
- BCM43143 WiFi on board
- On-board Bluetooth Low Energy
- 40pin GPIO
- 4 x USB 2 ports
- 4 pole Stereo output and Composite video port
- Full size HDMI

- CSI camera port to connect Raspberry Pi camera
- DSI display port to connect Raspberry Pi touch screen display
- Micro SD port for loading operating system and storing data
- Micro USB power source of 2.4 Amps

4.4.1.2 RC522 RFID reader and tag

The MFRC522 RFID readers works together with a RFID's tag. Communication between them is usually with the proximity of 1cm at 13.56MHz electromagnetic field.below in Figure 4.7 is a picture of a RC522 RFID reader and tag.

Figure 4.7: RC522 RFID Reader and Tag

Specifications of RC522 RFID reader and tag

- MFRC522 chip based board
- Operating frequency: 13.56MHz
- Supply Voltage: 3.3V
- Current: 13-26mA
- Read Range: Approximately 3cm
- SPI Interface
- Maximum Data Transfer Rate: 10Mbit / s
- Dimensions: 60mm × 39mm

4.4.1.3 Breadboard

A breadboard was invented to facilitate for prototyping of electronics. It got its name because it was initially a bread board, a finished wooden board on which bread was sliced. In the 1970s the solderless breadboard became available for electronics prototype circuits to be built. It is a reusable board that make creation temporary prototypes and experimental circuit design easy. For this reason, breadboards are popular with students and in technological education. Figure 4.8 is a picture of a point solderless breadboard whereas Figure 4.9 is a picture of 400 point printed circuit board (PCB) 0.1 inches hole-to-hole spacing

Figure 4.8: 400 point solderless breadboard

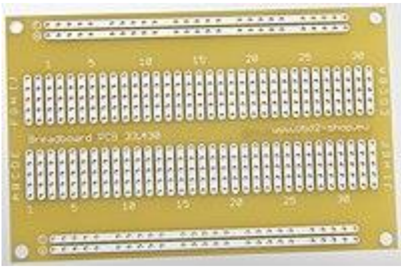


Figure 4.9: 400 point printed circuit board (PCB)

4.4.1.4 Jumper wires

A **jump wire** is essentially an electrical wire, or a group of electrical cable, with a connector or pin at both ends. They are usually used to interconnect the components to test circuit, breadboard or prototypes without soldering. There two types of end connectors, the female and the male connectors. A jumper wire is connected to the breadboard by sticking the male end connector into slots on the breadboard, and the other end to the test circuit breadboard or the prototype. As shown in Figure 4.10 jumper wires usually come in different colours to aid in easy identification.

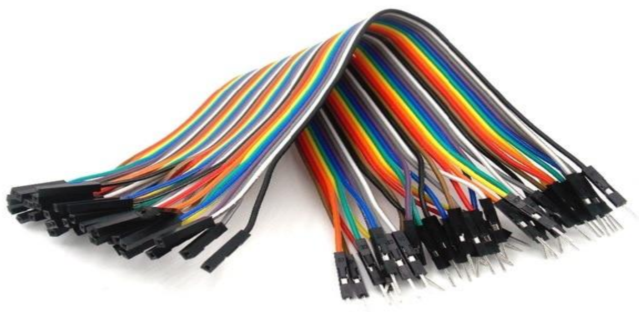


Figure 4.10: Stranded 22AWG jump wires with solid tips

4.4.2 Software

Python 2.7

Python 1 was the initial set of Python language released but almost in extinct. Python 2 happens to be the second release of Python language with the latest edition being Python 2.7.12. Python 3 is the third release of Python language with the latest edition being Python 3.5.2. Even though Python2 scripts will run without major changes on python 3 and vice versa, Python 3 updated the Python 2 with a number of changes such as the syntax and the actual structure of the Python language.

The Python foundation from time to time upgrades Python 2 in regards to bug fixes and security patches. This makes Python 2 a preferable Python language in the programming community today. There are Python libraries for most function need in programming, they all work with Python 3 and Python 2.

CHAPTER 5
IMPLEMENTATION OF DEVELOPED SYSTEM

This chapter is the system implementation section, it present the full description of how the system works to enable the blind to identify shirts of different colours and other kitchen items, it start from the setting up of the Raspberry Pi to the reading aloud the detected item. Screen captures of various stages are presented to show how the system was developed.

5.1 Setting up Raspberry Pi

A Pi 3 Model B was used in building this system, it has a RAM of 1GB capacity which is quad-core processor as well. This enable it handle bigger operating systems us as Ubuntu and Microsoft 10. The Raspberry 3 Pi has four USB port and HDMI port for video output.

Power supply: A 5V1 2.5A micro-USB power supply was used to power the raspberry pi.

USB keyboard: A USB keyboard was used in the system**.**

USB mouse: A USB mouse was used in this system.

microSD card: A 16 GB microSD card was used of storage in this system. NOOBS requires a minimum of 8GB storage.

microSD USB card reader: Was used to connect the microSD card to a computer in order to install the downloaded the operating system.

A monitor: A fifteen-inch monitor was used for display**.**

A HDMI cable to serial convertor was used to aid in the connection of the monitor to the Raspberry Pi

An Ethernet cable: For connection to the internet, an RJ45 internet cable was used. Connection with the Internet do not require configuration.

Steps carried out to set the Raspberry Up

Step 1: Formatting the microSD card:

The initial step was to reformat the microSD, because mostly new microSD cards comes with some irrelevant files on them. Therefore reformatting it completely delete and clear all files on the microSD.

Step 2: Download NOOBS.

NOOBS was then downloaded and installed onto the microSD. Once it this was done, the microSD card was plugged it into the Raspberry Pi. The operating system was then configured. NOOBS can be accessed through https://www.raspberrypi.org/downloads/

Step 3: Initializing Raspberry Pi

The microSD card was inserted into the card socket of the raspberry Pi 3.

A USB keyboard and USB mouse were plunged into the USB ports.

An HDMI to serial converter was utilized in connecting the Raspberry Pi to a monitor.

An RJ45 Ethernet cable was used to connect the Raspberry Pi to internet.

Alternatively, WiFi adapter of the Raspberry Pi could have been used to connect the system to the internet.

The 5.1 volts 2.5 amps micro USB power supply was used power up the Raspberry Pi to boot it.

Step 4**:** Download Raspbian.

Raspbian was downloaded and installed on the raspberry Pi 3. It contains precompiled softwares and over hundreds of projects uses Raspbian as their operating system. Figure 5.1 is picture of Raspbain been Downloaded and installed.

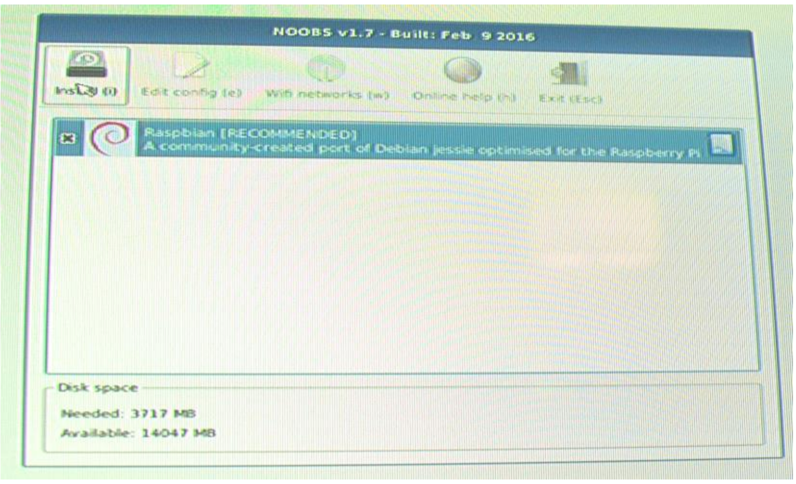


Figure 5.1: Downloading and installing Raspbian

Once the installation was completed the Raspbian automatically began to boot.

Step 5: Configuring Raspberry Pi 3

Upon completion of the boot process, the location, date, and time.is done were configured to suit the local setting.

Menu -→ Preferences → Raspberry Pi Configuration → Localisation → Set Locale, Set timezone and **Set Keyboard** are selected to set location, local time and keyboard language respectively.

After reconfiguring the Raspberry Pi, the system was rebooted. Once the Raspberry Pi was restarted, it was ready to be used.

5.1.2 Configuring and using GPIO Pins

The Raspberry Pi 3, has 40 GPIO pins in total. Below is the GPIO pinout diagram of Raspberry Pi 3 used in this system.

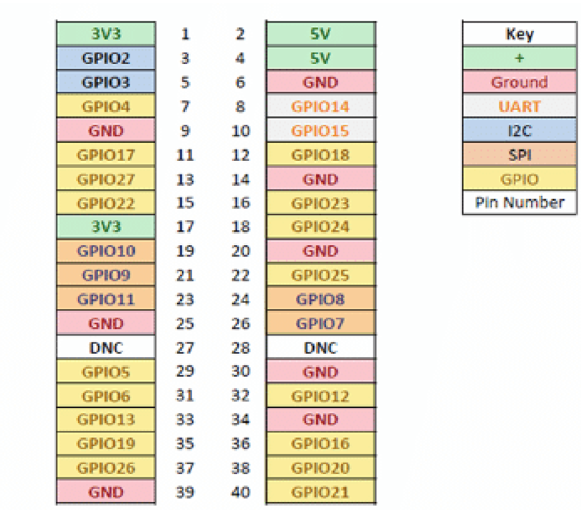


Figure 5.2: Label of GPIO

GPIO are the standard pins use to input and output data into and out of raspberry pi. They generally do not have predefined purposes.

I2C (Inter-Integrated Circuit) pins are synchronous packet switched, single ended serial computer bus that ensures connection and communication to hardware modules that support I2C Protocol, usually multi- master and multi- slave bus. It is used for inter-board communication within short distances

SPI (Serial Peripheral Interface Bus) are used to ensure synchronous serial communication to SPI devices within short distances usually, in embedded systems.

UART (Universal asynchronous receiver/transmitter) are serial pins utilized in transmitting asynchronous communication signals between the Raspberry Pi and other devices.

The **power pins** outputs 3.3volts and 5volts DC power from Raspberry Pi.

GND: used to connect the device to ground electrically.

DNC (do not connect) they are usually left unconnected.

5.1.2.1 Configuring GPIO

There is no need of configuration if the latest version of Raspbian is installed but to unsure successful running of the Raspbian, it had to be updated for the latest packages before commencing programming and utilizing the GPIO.

Running the following commands updated Raspbian:

```
# sudo apt-get update
# sudo apt-get upgrade
# sudo apt-get install rpi.gpio
```

5.1.2.2 Configuration of Raspberry Pi's I2C

To Setting up the I2C pins the following steps and commands were executed.

Step 1 `#sudo raspi-config` (To take you to the Raspi-Config tool)

Step 2 Select advanced options, then to I2c and then it was enabled.

Step 3: the system was rebooted and default setting was selected.

Step 4: To confirm successful enabled of the necessary modules.

```
#lsmod | grep i2c_
```

This command should return any i2c module. Example: i2c_BCM2708.

5.1.2.3 Configuring Raspberry Pi SPI

To Setting up the SPI pins the following steps and commands were executed.

Step 1 `#sudo raspi-config` (To take you to the Raspi-Config tool)

Step 2 Select advanced options, then to SPI and then it was enabled.

Step 3: Reboot and select default setting.

Step 4: To confirm successful enablement of the necessary modules.

```
#lsmod | grep spi_
```

This command should return any i2c module. Example: spi_bcm2835. Figure 5.3 is a figure of how SPI was configured.

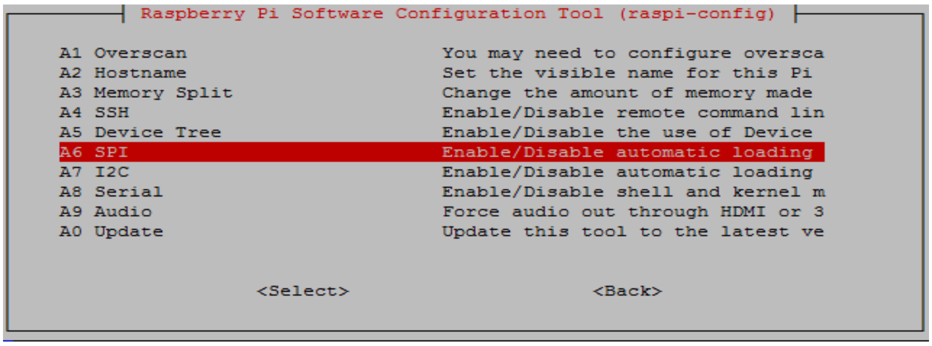


Figure 5.3: Configuring SPI

5.2 Assembling the RFID RC522

Step 1: The header pins were soldered to the RFID RC522 Reader.

Step 2 Wiring the RFID RC522

The RFID RC522 has 8 connections pins: SDA (Serial Data Signal), SCK (Serial Clock), MOSI (Master Out Slave In), MISO(Master In Slave Out), IRQ (Interrupt Request), GND (Ground Power), RST (Reset-Circuit) and 3.3v (3.3v Power In).

Jumper wires were connected to the pins of the RFID RC522 which were then connected to a bread board. Another set of identical jumper wires were then plugged into the breadboard and were connected to the GPIO of the raspberry Pi.

Wiring of the RFID RC522 to the Raspberry Pi was done, according to the table and circuit diagram below with seven of the pins connected to the GPIO Pins exception IRQ, which was not connected. The wiring configuration of between the Raspberry pi and the RC522 RFID is shown in the Table 5.1 and Figure 5.4.

Table 5.1: Wiring RFID RC522 to GPIO

RFID RC522	GPIO
SDA	24
SCK	33
MOSI	19
MISO	21
IRQ	
GND	6
RST	22
3.3v	1

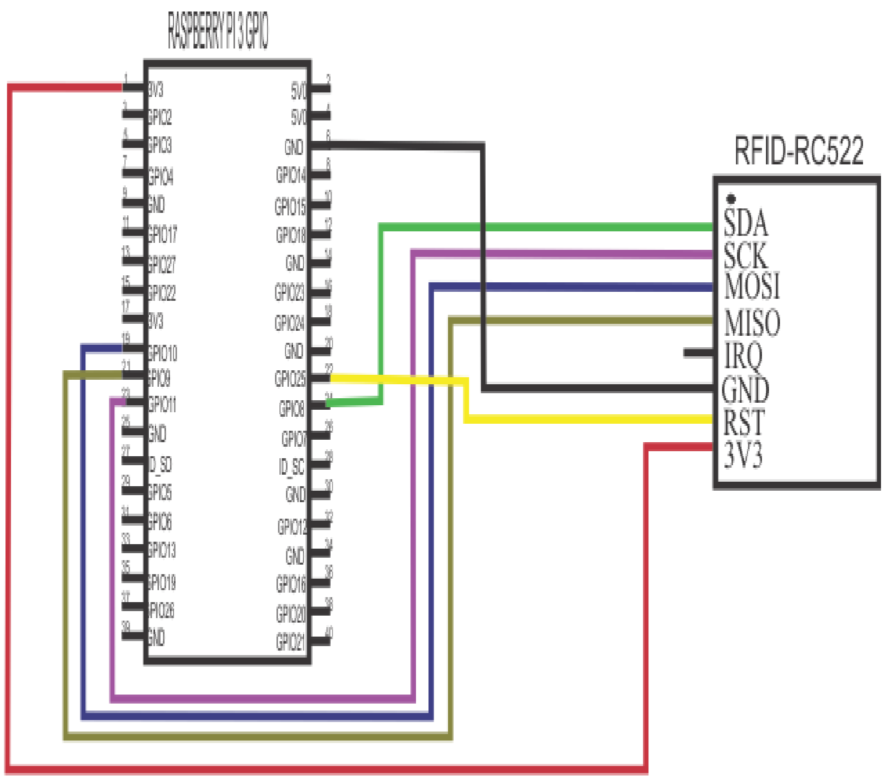


Figure 5.4: Wiring diagram of Raspberry pi and RFID

5.3 Getting Python Ready for the RFID RC522

Step 1: Now, to ensure the latest version of the programmes are running on the raspberry pi, the following commands are run to update the Pi.

```
#sudo apt-get update
#sudo apt-get upgrade
```

Step2: Python2.7 was used as the programming language in this system. Raspbian has an already installed python 2.7.

Step 3: A Python Library (SPI Py) was cloned and install on the Pi. The function of this library is to helps handle communication with the SPI, which happens to be the main component to facilitate communication between for Raspberry Pi and RFID RC522.

The following codes were executed to clone the source code of this library:

```
# cd ~
# git clone https://github.com/lthiery/SPI-Py.git
```

Step 4: With the SPI Py Python Library successfully cloned, the following commands were executed to install it on the Raspberry Pi.

```
# cd ~/SPI-Py (to change director to SPI-Py)
# sudo python setup.py install
```

Step5: After the installation of SPI-Py, RFID RC522 Python scripts were clone (Github, 2018). Two scripts were included in this repository:

MFRC522.py: facilities the control of RFID RC522 circuitry.

To clone this repository done by running the following commands.

```
# cd ~
# git clone https://github.com/coding-world/MFRC522-
python.git
```

5.3.1 Writing data on to RFID RC522 tags

The python script MyWrite.py Python was modified and used to write data onto the RFID tag.

The first few lines of code aids the terminal to interpret the file as a python file and not any other programming language.

The first import was **RPi.GPIO.** This library has all requisite functions for the code to communicate with the GPIO Pins. The second import is the **MFRC522** library, was used to communicate to the RFID RC522.

```
#!/usr/bin/env python
# _*_coding: utf8_*_

import RPi.GPIO as GPIO
import MFRC522
import signal
```

This block of code, takes the objects name to be tagged from the user, converts the name into it corresponding ASCI code and store is as a list datatype in the variable data.

```
name = raw_input('Enter a cad name:')
print("Now place your tag to write")
if len(name)> 16:
     name = name[:16]
     data = [ord(x) for x in list (name)]
     print data
```

The line of code below makes a duplicate of the MFRC522 as an object, execute its setup function then stores it MIFAREReader variable

```
MIFAREReader = MFRC522.MFRC522():
```

This line of code is used to write the data onto the RFID tag

```
MIFAREReader.MFRC552_Write (8, data):
```

With was that done, RFID Tag was places on top of your RFID RC reader and when the data is successfully written to the tag. The process can be repeated and new data can be written to a tag over a hundred number of times.

5.3.2 Reading with the RFID RC522

At this point of when data has been written to RFID tags using our RC522 reader with help of the MyWrite.py script, a Read.py script was modified and used to read data back from the tag.

This script when run waits until RC522 RFID reader detects RFID tag within it range to read data stored on the tag.

The first import was **RPi.GPIO.** This library has all the requisite functions for the code to communicate with the GPIO Pins. The second import is the **MFRC522** library, also used by the Pi to communicate to the RFID RC522 reader.

```
#!/usr/bin/env python
# _*_coding: utf8_*_

import RPi.GPIO as GPIO
import MFRC522
import signal
```

This line creates a function and stores it to be called it later.

```
MIFAREReader = MFRC522.MFRC522():
```

This block of code calls the reader object, instructs the circuit to begin read data from RFID tag placed on the RC522 reader. Converts the data into text as well as prints its out.

```
if status == MIFAREReader.MI_OK
    data = MIFAREReader.MFRC522_Read(8)
    MIFAREReader.MFRC522_StopCryto1

    i = 0
    t = []
    While data[i]!= 255:
        Text = "".join (Chr(x) for x in t)
        Print text
```

5.4 Making the Raspberry Read Speak

5.4.1 Configuring Text to Speech

A software interface to convert text to speech was installed to enable the Raspberry Pi read text aloud. A Text To Speech engine known as eSpeak was installed. The voice sounds little robotic, however it is able to runs without internet connectivity which is an added advantage for using eSpeak.

Step 1 First step was to test the audio of the Raspberry Pi with the following command:

```
aplay /usr/share/sounds/alsa/*
```

sounds output “Front Center”,”Front Left”, “Front Right” and so on, was heard indicating that it was working.

Step 2 the next step was to install eSpeak. This command was executed to in terminal to install espeak:

```
sudo apt-get install espeak
```

Step 3: to test for successful installation the following command was executed to get the Raspberry Pi Speaking.

```
espeak "Text you wish to hear back" 2>/dev/null
espeak "Hello World" 2>/dev/null
```

"Text you wish to hear back" and “Hello World” were respectively heard from the speakers.

Step 4 On the Read.py script the following libraries were imported to access the eSpeak text to speech engine.

```
import sys
from subprocess import check_output
from num2words import num2words
import subprocess
cmd_beg = 'espeak '
cmd_end = ' 2>/dev/null'
```

Step 5 the final step was to include this line of code to make the script read aloud the data contained in the variable text

```
speak = check_output(['espeak',text])
```

CHAPTER 6
RESULTS AND DISCUSSIONS

The system was implemented in a typical kitchen environment where a number of house hold items where tagged. The system further was implemented in a wardrobe where a number of shirts where also tagged.

6.1 Methodology

A number of household items were tagged as shown Figures 6.1 and 6.2. These tagged items included containers that contained salt, sugar, and assorted coffee. Bottle of oil, liquid soap, as well as kettle, plates, assorted tea, fork cups etc were also tagged. Furthermore as shown in the Figure 6.1 and Figure 6.2 other item were tagged to test the performance of the system. A VI was then made to try to identify these items with help of the developed system. Table 6.1 shows the list of the items.

Table 6.1: List of tagged items

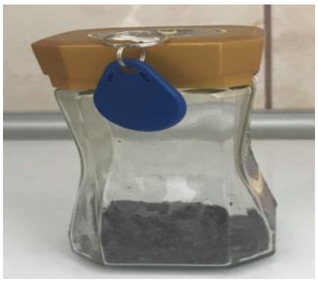
Object No.	Object name
i.	Salt container
ii.	Sugar container
iii.	Coffee Robusta container
iv.	Coffee Arabica container
v.	Turkish coffee container
vi.	Bottle of oil
vii.	Liquid soap
viii.	Kettle
ix.	Assorted plates
x.	Black tea
xi.	Green tea
xii.	Herbal tea
xiii.	Black shirts
xiv.	White shirt
xv.	Red shirt
xvi.	Blue shirt
xvii.	Green shirt
xviii.	Brown Jacket
xix.	Black jacket
xx.	Bottle of oil
xxi.	Bottle of liquid soap
xxii.	Spoon
xxiii.	Knife
xxiv.	Fork
xxv.	Assorted mugs

Below are the images of the tagged items in the kitchen.

(a) Tagged tea container

(**b)** Tagged salt container

(**c**) Tagged sugar container



(**d**) Tagged coffee container

(**e**) Tagged containers

(**f**) Tagged kitchen items

(g) VI identifying items with the system

Figure 6.1: Testing the developed system in the kitchen

The system was further tested in a wardrobe to assist the IV to identify shirts to of different colours as in the figures below.

(a) Tagged shirts

(b) VI identifying shirts with the system

Figure 6.2: Testing the developed system in the wardrobe

6.2 Read Range between Reader and Tag

The proximity between the reader and the tag by specifications of RC522 RFID is approximately 30 cm. The reader therefore could only detect the tag within the aforementioned range. This has its own advantages and disadvantages. Since some of the VI can see but burly or detect objects by touch, the developed system could then help them identify in detail the object they are looking for.

In contrast, if the proximity was greater, the blind users could locate the positions of the objects they were looking for but in this case, the reader could confuse them since RFID systems can read multiple tags at the same time unlike bar code systems that will need line-of-sight for communication between tag and reader.

6.3 Error Rate

When the system as tested, it was found to be accurate and effective. All tagged items were detected and read aloud within a maximum of two seconds. The error rate was therefore zero.

6.4 Discussion

At the end of the experiments, the VI was happy with the system because he could easily identify and select what he wanted with the help of the system. He also advised that, the system should be able to speak in other languages such as Turkish so that to make it useable by VIs whose native languages are not English.

The developed system was successfully implemented with zero error rate. The system is very cheap as compared to other developed systems. This system is very fast in detecting tagged items. It also needs not internet to operate thereby making it usable even rural areas where there is no internet connective. The system is also easily expandable; the tags can easily be increased in number, as well as other new systems can be add to the system because Raspberry Pi is a flexible computer.

As shown from the Table 6.1, the summary of related research revealed, other have used Raspberry Pi and other technologies to assist the disable persons. However, none of them used Raspberry Pi and RFID to assist the VI to identify the items.

Table 6.1: Summary of related research

Author	Method	Purpose
Al Kalbani et al. (2015)	RFID, personal computer, Database(SQL)	Bus detection system
Hanwate and Thakare (2015)	RFID, microcontroller (ATmage16), wireless technology(ZigBee)	Smart trolley to compute prices and to secure products
Murad, et al. (2011)	RFID, FM transmitter, personal computer, database(SQL),mobile device for output audio	Object detection system
Jain et al. (2014)	Raspberry Pi,	Home automation with the help of email
Kulkarni et al. (2017)	Raspberry pi, server, relay, web application, mobile application.	Control home appliances
Younis et al. (2017)	Raspberry pi, zig bee, voice recognition, sensors	Home automation system for the disabled, elderly and medical patient
Gouiaa and Meunier (2015)	Raspberry Pi B+, cameras, microcontroller(STM32F4), image recognition	Image recognition robotic system to identify and approximate proximity of obstacle
Chang et al. (2018)	Raspberry Pi, GPS, android Application, SRF08, PIC18F4525	An intelligent walking stick
Author	Raspberry Pi, RFID, Text to Speech engine	To assist the visually impaired to identify objects

CHAPTER 7
CONCLUSION AND RECOMMENDATIONS

This concluding chapter makes a summary of this thesis and presents recommendation and suggestions for further future studies

7.1 Conclusion

In this thesis, a RFID in conjunction with a Raspberry Pi was used to develop a system to assist the blind to identify and differentiate shirts of the same kind as well as to select items of their choice from a typical kitchen environment. This was attained by connecting a RFID reader to a Raspberry Pi, configuring and wiring them appropriately, and with execution of python scripts.

The color and names of a shirts and kitchen items were encoded into tags and the tag were attached to the shirt. When the RFID reader is brought within the range of the tag, the tag was detected by the reader and the encoded name is read aloud by the Raspberry Pi through a speaker connected to it. With this developed system, a visually impaired person could easily differentiate shirts and kitchen items of the same kind and make choices of his or her own without any assistance. This would have been a very difficult task to execute by the VI because they cannot feel difference in color as well as objects of the same kind.

Although there are other systems that can help them to achieve similar results, these systems are expensive and complicated to use, for these reasons, the poor VI, who happens to be the majority are left to their own fate. Furthermore, because those systems are complicated, the uneducated VI and computer illiterates VI cannot use them. This simple computerized microcontroller system solves these challenges the VI face by using traditional, expensive and complicated methods to identify and differentiate between objects of the same kind.

7.2 Recommendations

The system can be expanded in the following dimensions:

The RFID reader should be able to communicate via wireless means such are Bluetooth and ZigBee technology. This will enhance the mobility of the user, and avoid the user having to moving around with the entire system. Secondly, the system should be able to read aloud detected tags in other languages other than English in other to help nonnative IVs.

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APPENDICES

APPENDIX 1:

Source code to control RFID reader

```
#!/usr/bin/env python
# -*- coding: utf8 -*-

import RPi.GPIO as GPIO
import spi
import signal
import time

class MFRC522:
  NRSTPD = 22

  MAX_LEN = 16

  PCD_IDLE       = 0x00
  PCD_AUTHENT    = 0x0E
  PCD_RECEIVE    = 0x08
  PCD_TRANSMIT   = 0x04
  PCD_TRANSCEIVE = 0x0C
  PCD_RESETPHASE = 0x0F
  PCD_CALCCRC    = 0x03

  PICC_REQIDL    = 0x26
  PICC_REQALL    = 0x52
  PICC_ANTICOLL  = 0x93
  PICC_SElECTTAG = 0x93
  PICC_AUTHENT1A = 0x60
  PICC_AUTHENT1B = 0x61
```

```
PICC_READ      = 0x30
PICC_WRITE     = 0xA0
PICC_DECREMENT = 0xC0
PICC_INCREMENT = 0xC1
PICC_RESTORE   = 0xC2
PICC_TRANSFER  = 0xB0
PICC_HALT      = 0x50

MI_OK       = 0
MI_NOTAGERR = 1
MI_ERR      = 2

Reserved00     = 0x00
CommandReg     = 0x01
CommIEnReg     = 0x02
DivlEnReg      = 0x03
CommIrqReg     = 0x04
DivIrqReg      = 0x05
ErrorReg       = 0x06
Status1Reg     = 0x07
Status2Reg     = 0x08
FIFODataReg    = 0x09
FIFOLevelReg   = 0x0A
WaterLevelReg  = 0x0B
ControlReg     = 0x0C
BitFramingReg  = 0x0D
CollReg        = 0x0E
Reserved01     = 0x0F

Reserved10     = 0x10
ModeReg        = 0x11
TxModeReg      = 0x12
```

RxModeReg = 0x13

TxControlReg = 0x14

TxAutoReg = 0x15

TxSelReg = 0x16

RxSelReg = 0x17

RxThresholdReg = 0x18

DemodReg = 0x19

Reserved11 = 0x1A

Reserved12 = 0x1B

MifareReg = 0x1C

Reserved13 = 0x1D

Reserved14 = 0x1E

SerialSpeedReg = 0x1F

Reserved20 = 0x20

CRCResultRegM = 0x21

CRCResultRegL = 0x22

Reserved21 = 0x23

ModWidthReg = 0x24

Reserved22 = 0x25

RFCfgReg = 0x26

GsNReg = 0x27

CWGsPReg = 0x28

ModGsPReg = 0x29

TModeReg = 0x2A

TPrescalerReg = 0x2B

TReloadRegH = 0x2C

TReloadRegL = 0x2D

TCounterValueRegH = 0x2E

TCounterValueRegL = 0x2F

Reserved30 = 0x30

```
TestSel1Reg     = 0x31
TestSel2Reg     = 0x32
TestPinEnReg    = 0x33
TestPinValueReg = 0x34
TestBusReg      = 0x35
AutoTestReg     = 0x36
VersionReg      = 0x37
AnalogTestReg   = 0x38
TestDAC1Reg     = 0x39
TestDAC2Reg     = 0x3A
TestADCReg      = 0x3B
Reserved31      = 0x3C
Reserved32      = 0x3D
Reserved33      = 0x3E
Reserved34      = 0x3F

serNum = []

def __init__(self, dev='/dev/spidev0.0', spd=1000000):
  spi.openSPI(device=dev,speed=spd)
  GPIO.setmode(GPIO.BOARD)
  GPIO.setup(22, GPIO.OUT)
  GPIO.setwarnings(False)
  GPIO.output(self.NRSTPD, 1)
  self.MFRC522_Init()

def MFRC522_Reset(self):
  self.Write_MFRC522(self.CommandReg, self.PCD_RESETPHASE)

def Write_MFRC522(self, addr, val):
  spi.transfer(((addr<<1)&0x7E,val))
```

```
def Read_MFRC522(self, addr):
  val = spi.transfer((((addr<<1)&0x7E) | 0x80,0))
  return val[1]

def SetBitMask(self, reg, mask):
  tmp = self.Read_MFRC522(reg)
  self.Write_MFRC522(reg, tmp | mask)

def ClearBitMask(self, reg, mask):
  tmp = self.Read_MFRC522(reg);
  self.Write_MFRC522(reg, tmp & (~mask))

def AntennaOn(self):
  temp = self.Read_MFRC522(self.TxControlReg)
  if(~(temp & 0x03)):
    self.SetBitMask(self.TxControlReg, 0x03)

def AntennaOff(self):
  self.ClearBitMask(self.TxControlReg, 0x03)

def MFRC522_ToCard(self,command,sendData):
  backData = []
  backLen = 0
  status = self.MI_ERR
  irqEn = 0x00
  waitIRq = 0x00
  lastBits = None
  n = 0
  i = 0

  if command == self.PCD_AUTHENT:
    irqEn = 0x12
```

```
  waitIRq = 0x10
if command == self.PCD_TRANSCEIVE:
  irqEn = 0x77
  waitIRq = 0x30

self.Write_MFRC522(self.CommIEnReg, irqEn|0x80)
self.ClearBitMask(self.CommIrqReg, 0x80)
self.SetBitMask(self.FIFOLevelReg, 0x80)

self.Write_MFRC522(self.CommandReg, self.PCD_IDLE);

while(i<len(sendData)):
  self.Write_MFRC522(self.FIFODataReg, sendData[i])
  i = i+1

self.Write_MFRC522(self.CommandReg, command)

if command == self.PCD_TRANSCEIVE:
  self.SetBitMask(self.BitFramingReg, 0x80)

i = 2000
while True:
  n = self.Read_MFRC522(self.CommIrqReg)
  i = i - 1
  if ~((i!=0) and ~(n&0x01) and ~(n&waitIRq)):
    break

self.ClearBitMask(self.BitFramingReg, 0x80)

if i != 0:
  if (self.Read_MFRC522(self.ErrorReg) & 0x1B)==0x00:
    status = self.MI_OK
```

```
      if n & irqEn & 0x01:
        status = self.MI_NOTAGERR

      if command == self.PCD_TRANSCEIVE:
        n = self.Read_MFRC522(self.FIFOLevelReg)
        lastBits = self.Read_MFRC522(self.ControlReg) & 0x07
        if lastBits != 0:
          backLen = (n-1)*8 + lastBits
        else:
          backLen = n*8

        if n == 0:
          n = 1
        if n > self.MAX_LEN:
          n = self.MAX_LEN

        i = 0
        while i<n:
          backData.append(self.Read_MFRC522(self.FIFODataReg))
          i = i + 1;
    else:
      status = self.MI_ERR

  return (status,backData,backLen)


def MFRC522_Request(self, reqMode):
  status = None
  backBits = None
  TagType = []
```

```
    self.Write_MFRC522(self.BitFramingReg, 0x07)

    TagType.append(reqMode);
    (status,backData,backBits)       =       self.MFRC522_ToCard(self.PCD_TRANSCEIVE,
TagType)

    if ((status != self.MI_OK) | (backBits != 0x10)):
      status = self.MI_ERR

    return (status,backBits)


  def MFRC522_Anticoll(self):
    backData = []
    serNumCheck = 0

    serNum = []

    self.Write_MFRC522(self.BitFramingReg, 0x00)

    serNum.append(self.PICC_ANTICOLL)
    serNum.append(0x20)

    (status,backData,backBits)                                                    =
self.MFRC522_ToCard(self.PCD_TRANSCEIVE,serNum)

    if(status == self.MI_OK):
      i = 0
      if len(backData)==5:
        while i<4:
          serNumCheck = serNumCheck ^ backData[i]
          i = i + 1
```

```
      if serNumCheck != backData[i]:
        status = self.MI_ERR
    else:
      status = self.MI_ERR

  return (status,backData)

def CalulateCRC(self, pIndata):
  self.ClearBitMask(self.DivIrqReg, 0x04)
  self.SetBitMask(self.FIFOLevelReg, 0x80);
  i = 0
  while i<len(pIndata):
    self.Write_MFRC522(self.FIFODataReg, pIndata[i])
    i = i + 1
  self.Write_MFRC522(self.CommandReg, self.PCD_CALCCRC)
  i = 0xFF
  while True:
    n = self.Read_MFRC522(self.DivIrqReg)
    i = i - 1
    if not ((i != 0) and not (n&0x04)):
      break
  pOutData = []
  pOutData.append(self.Read_MFRC522(self.CRCResultRegL))
  pOutData.append(self.Read_MFRC522(self.CRCResultRegM))
  return pOutData

def MFRC522_SelectTag(self, serNum):
  backData = []
  buf = []
  buf.append(self.PICC_SElECTTAG)
  buf.append(0x70)
  i = 0
```

```
    while i<5:
      buf.append(serNum[i])
      i = i + 1
    pOut = self.CalulateCRC(buf)
    buf.append(pOut[0])
    buf.append(pOut[1])
    (status, backData, backLen) = self.MFRC522_ToCard(self.PCD_TRANSCEIVE, buf)

    if (status == self.MI_OK) and (backLen == 0x18):
      print "Size: " + str(backData[0])
      return    backData[0]
    else:
      return 0

  def MFRC522_Auth(self, authMode, BlockAddr, Sectorkey, serNum):
    buff = []

    # First byte should be the authMode (A or B)
    buff.append(authMode)

    # Second byte is the trailerBlock (usually 7)
    buff.append(BlockAddr)

    # Now we need to append the authKey which usually is 6 bytes of 0xFF
    i = 0
    while(i < len(Sectorkey)):
      buff.append(Sectorkey[i])
      i = i + 1
    i = 0

    # Next we append the first 4 bytes of the UID
    while(i < 4):
```

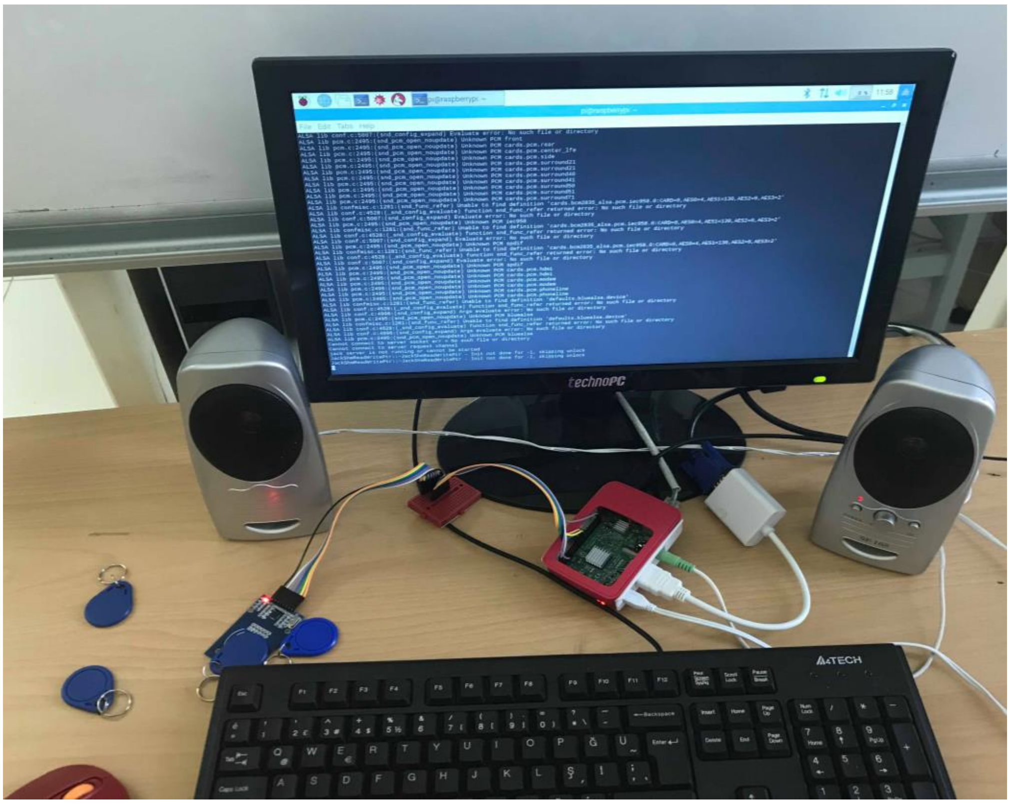
```
      buff.append(serNum[i])
      i = i +1

    # Now we start the authentication itself
    (status, backData, backLen) = self.MFRC522_ToCard(self.PCD_AUTHENT,buff)

    # Check if an error occurred
    if not(status == self.MI_OK):
      print "AUTH ERROR!!"
    if not (self.Read_MFRC522(self.Status2Reg) & 0x08) != 0:
      print "AUTH ERROR(status2reg & 0x08) != 0"

    # Return the status
    return status

  def MFRC522_StopCrypto1(self):
    self.ClearBitMask(self.Status2Reg, 0x08)

  def MFRC522_Read(self, blockAddr):
    recvData = []
    recvData.append(self.PICC_READ)
    recvData.append(blockAddr)
    pOut = self.CalulateCRC(recvData)
    recvData.append(pOut[0])
    recvData.append(pOut[1])
    (status, backData, backLen) = self.MFRC522_ToCard(self.PCD_TRANSCEIVE,
recvData)
    if not(status == self.MI_OK):
      print "Error while reading!"
    i = 0
    if len(backData) == 16:
      #print "Sector "+str(blockAddr)+" "+str(backData)
```

```
        return backData

    def MFRC522_Write(self, blockAddr, writeData):
        buff = []
        buff.append(self.PICC_WRITE)
        buff.append(blockAddr)
        crc = self.CalulateCRC(buff)
        buff.append(crc[0])
        buff.append(crc[1])
        (status, backData, backLen) = self.MFRC522_ToCard(self.PCD_TRANSCEIVE, buff)
        if not(status == self.MI_OK) or not(backLen == 4) or not((backData[0] & 0x0F) == 
0x0A):
            status = self.MI_ERR

        print str(backLen)+" backdata &0x0F == 0x0A "+str(backData[0]&0x0F)
        if status == self.MI_OK:
            i = 0
            buf = []
            while i < 16:
                buf.append(writeData[i])
                i = i + 1
            crc = self.CalulateCRC(buf)
            buf.append(crc[0])
            buf.append(crc[1])
            (status, backData, backLen) = self.MFRC522_ToCard(self.PCD_TRANSCEIVE,buf)
            if not(status == self.MI_OK) or not(backLen == 4) or not((backData[0] & 0x0F) == 
0x0A):
                print "Error while writing"
            if status == self.MI_OK:
                print "Data written"

    def MFRC522_DumpClassic1K(self, key, uid):
```

```
    i = 0
    while i < 64:
        status = self.MFRC522_Auth(self.PICC_AUTHENT1A, i, key, uid)
        # Check if authenticated
        if status == self.MI_OK:
            self.MFRC522_Read(i)
        else:
            print "Authentication error"
        i = i+1

  def MFRC522_Init(self):
    GPIO.output(self.NRSTPD, 1)

    self.MFRC522_Reset();



    self.Write_MFRC522(self.TModeReg, 0x8D)
    self.Write_MFRC522(self.TPrescalerReg, 0x3E)
    self.Write_MFRC522(self.TReloadRegL, 30)
    self.Write_MFRC522(self.TReloadRegH, 0)

    self.Write_MFRC522(self.TxAutoReg, 0x40)
    self.Write_MFRC522(self.ModeReg, 0x3D)
    self.AntennaOn()
```

APPENDIX 2:

The system connected to speakers



APPENDIX 3:
Example of RFID tag data