VEHICLE ACCESS CONTROL AND SECURITY SYSTEM: UNIVERSITY OF LAGOS SECURITY GATE AS A CASE

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ABSTRACT

Nigeria (and in extension Africa) is grappling with security challenges – kidnapping, terrorism, militancy, porous border. Advances in information technology has highly upgraded the way crimes are perpetrated nowadays. One of the prominent issues identified is lack of adequate surveillance technology or a harmonized national database to rely on for thorough investigation. This paper aims at exploring and proffering a robust electronic gate access system that collects and archives relevant data securely, which can be retrieved for helpful leads, for example, during a security breach. Powered by OpenALPR API and based on SDLC principles, the system employs Raspberry Pi, biometric and number plate scanning technologies to create a working prototype that could be deployed in schools, offices, military installations, oil rigs, worship centres, and public car parks. Data collected could help the school management and government in physical planning – vehicles and drivers can be easily identified and tracked. This system will help boost Nigeria's national security – foreigners can be clearly differentiated from citizens. This alternative solution to our porous border crisis also helps plug revenue leakages in government spending and optimize resources. A locally developed solution like this will help minimize cost for institutions relying on them to address similar challenges.

Keywords: Electronic gate access system, OpenALPR, Raspberry pi, SDLC, Security, UNILAG.

INTRODUCTION

The 2019 Global Peace Index *(Global Peace Index, 2018)* ranked Nigeria 148th globally and 40 in Africa according to their level of peacefulness. Only Central African Republic, DR Congo, Somalia and South Sudan performed worse. Nigeria's security threat was categorized by *Mac-Leva (2016)* into seven broad areas: Boko Haram terrorism, armed robbery, militancy, cultism, piracy, kidnapping and cattle rustling.

Some of the major causes of insecurity in Nigeria are Internal Security Disorder, Poor System of Governance and Concentration of Political Power to the Center, Weak Judicial System, Injustice, Nepotism and the Culture of Impunity, Bribery and Corruption, State of Origin/ Indigeneship Syndrome or the "Quota System", Wasteful Resources, Religious Fanatics, Political Praise Singers and Unemployment *(Idoko and Dasuma, 2014)*.

While the federal and the state governments' onslaught against Boko Haram seemed to be winning the war, another simmering crisis erupted – farmers-herdsmen conflict. From cattle rustling to unlawful invasion/takeover of farms and incessant killings, crimes attributed to nomadic herdsmen is increasingly worrisome as their animals graze openly around the country. Following requests from several quarters, Nigeria's President Muhammadu Buhari had constituted a military taskforce tagged *Operation Sharan Daji* to rid the affected northern states of hoodlums (*Abu, 2019)*. However, this response is limited in the sense that it is not only difficult to ascertain the nationalities of these nomads but there is no registration for their businesses and herds. This presents a huge security gap for the country and revenue loss because they cannot even be taxed.

To understand the impact of Boko Haram, a paper published by *Harvard International Review (2014)* affirmed that:

> "*The most existential threat to Nigeria's national security is the violent extremism being unleashed by the Boko Haram group which has its main base in the northeast. Although the Niger Delta militant groups were the first to use improvised explosive devices (IEDs) for their operations, the idea of suicide bombing was introduced into Nigeria by the Boko Haram violent extremists. The emergence of this group came at a time when the international community was still grappling with the strategy to contain the spread of the activities of Al-Qaeda in the Maghreb (AQIM), spanning across the Sahel (especially Algeria, Morocco and Mali), and also the expanding threats from the militant wing of the Somali Council of Islamic Courts, commonly referred to as Al Shabaab, especially in the Horn of Africa. While taking advantage of the political instability in northern Mali, in 2012 AQIM consolidated its control within the region by aligning with the Tuareg rebel group, the National Liberation*

> *Movement of Azawad (MNLA), at the same time that another Islamic militant group, Ansar al-Din, moved to carve out an Islamic state out of northern Mali. Meanwhile a faction of AQIM formed the Movement for Unity and Jihad in West Africa (MUJAO). Of course, that meant that all 15 ECOWAS countries became the target of MUJAO, and this would have given a boost to the homegrown Nigerian terror group, Boko Haram.*"

Another security challenge the country is grappling with is armed robbery. As with the Zenith bank robbery in Owerri, Imo State (*Eze, 2018)* and lately, Offa bank robbery in Kwara State *(Punch Newspaper, 2018),* the operations of these hoodlums are carried out in broad day light without any fear of the security agencies who are unprepared to combat them. Besides, they have no adequate surveillance technology nor centralized database to rely on to conduct thorough investigation and probably secure the robbers convictions. Most of the time, arrests were made without any justice being served.

As can be observed from the publication in the Harvard International Review, security is not just a Nigerian albatross but a global phenomenon. Lack of reliable national identification database and associated IT facilities means that our porous borders continue to suffer from free flow of foreigners within the ECOWAS zones and Africa at large. The implication is that our demographics statistics may be largely unreliable. It also implies difficulty in curtailing and monitoring cross-border crimes by law enforcement agencies. With no reliable national identification database, it is almost impossible to conduct forensic investigation.

Beyond our borders, global terrorism, cross border crimes, money laundering, oil bunkering etc. are some of the prominent cogs in the wheels of the international community.

Recent advances in information technology, which have conferred us with enormous processing and storage capabilities, have also brought along attendant sophistication and mastery in the way modern crimes are perpetrated. Organized crimes are clearly one of the probable reasons why countries are cautious in the extent to which they corporate and trade with others. This is evident from the recent blame game between the US and China over cyberattacks and industrial espionage, as reported in various media in 2014. Credit card fraud, identity theft, virus threat, nuclear attack, lethal chemical agents, etc. have been used to cause collateral damage to national, social, economic and political institutions.

It had been observed that whenever a car drives in through the front or back gates of the University of Lagos (UNILAG), a metal tag is handed over to the driver as a gate pass. Sometimes, the security operatives check the boot or the interior of the car, but most times they do not. At the point of exit, motorists are required to hand over the gate pass. Although the university has CCTV surveillance systems installed and active police patrol teams, these cannot do much to guarantee safety of lives and properties in a large environment like that of UNILAG. This scenario can be understood from one of the prominent rape cases the university witnessed in the past. Criminals come to campus with exotic cars to kidnap and rape young innocent ladies. Another boy was shot in front of Jaja hostels. It is sad that there was no justice in the end for these victims. Suffice to say that CCTV playback may not be helpful in some situations.

Apart from recorded surveillance video (which may be purged after a short period of time to free memory space), the school does not keep any record of who, which car and at what time someone drive in and out of the school premises. This project is intended to fill this lacuna by providing a software system that keeps a record of who, which car, and when entrance and exit from the school premises occurred.

RELATED RESEARCH

Security is defined by Merriam Webster (2019) as *measures taken to guard against espionage or sabotage, crime, attack, or escape.* According to Abraham, Peter & Greg (2013), *security protects the integrity of the information stored in the system (both data and code), as well as the physical resources of the system, from unauthorized access, malicious destruction or alteration, and accidental introduction of inconsistency. Protection and security require the system to be able to distinguish among all its users and defend a system from external and internal attacks*, he added. Ko M. and Dorantes C (2006) reported that *(information) security is now a major concern for top managers.*

Access control is defined in *Cambridge Dictionary (2019)* as *ways of controlling who can see or enter information on a computer system*. Broadly speaking, it involves all (electronic and non-electronic) measures put in place to limit access (including entry and exit) to a supervised perimeter, resources and privileges from unauthorized persons or things.

Keys and locks are no longer sufficient to protect us. Businesses today require the knowledge of not only who call at their offices but also maintain a record of them. Thus, continuous research and development in electronic access control systems is linked with modern advancement in computer technology *(Enokela and Tyowuah, 2014)*.

Although most businesses require one form of access control or the other, each of them (organizations) tend to have unique features that needed to be taken into considerations when choosing a suitable form. For instance, the access control to be used at a nuclear/atomic plant facility may differ in some respect to one used on a university campus or military base. Other areas of applications include datacenters, security agency, warehouse, perimeter fence, laboratories, government MDA, gated estates, etc.

Farooq et. al. (2014) describes the design of RFID (radio frequency identification) based security and access control system for use in hostels inside the Punjab University premises. RFID technology and biometrics are combined to achieve the task. When a number is detected by the RFID reader installed at the entrance, the user image and the database are scanned for a match. If both the card and captured image belong to a registered user, access is granted; else the alarm system is triggered, and an emergency call is made to the security van through GSM modem.

A low-cost private office access control system is discussed in *Khan (2012)*. It enables a user with the correct password to enter an electromagnetically locked door. The danger is that someone's password can easily be stolen without the owner's permission. RFID has been used in conjunction with microcontrollers to control gates to enable vehicles to pass through according to *Bhosale and Wavhal (2013)*. *Olatinwo and Shoewu (2013)* have described a system in which swing gates are controlled electronically using microcontrollers and infrared transmitters.

Automatic Vehicle Identification AVI, developed by traffic solutions provider TagMaster (2019), uses wireless communication in a secure and convenient solution for vehicle access control. TagMaster's RFID system is ideally suited for AVI applications, where long read-range, high reliability and open connectivity are required. The reader can be connected to a central host or be used in a stand-alone configuration.

While physiological (or passive) biometrics refer to fixed or stable human characteristics, behavioral (or active) biometrics measure characteristics in form of skill/function performed by an individual. Physiological biometrics include hand geometry, fingerprints, facial image, iris patterns, and DNA, while signatures, mouse movements and keystroke dynamics represent behavioral biometrics (Gasson, Meints & Warwick, 2005) (Andronikou, Demetis & Varvarigou, 2017).

According to *Li, B., Tian, B., Yao, Q. and Wang, K. (2012)*, pattern recognition is one of the most important techniques for license plate recognition (LPR) system, and many works have studied LPR-related image processing technique to improve the accuracy ratio and efficiency.

In general, the traditional LPR system is verified to be a rather successful one in the scenario where the vehicle images can be recognized one by one in a serial manner (Yongchun, Xiaohong, and Jing, 2010).

MATERIALS AND METHODS

To achieve the aforementioned aim and objectives, the project requires biometric scanner, single-board computer *Raspberry Pi* 3 B+ (microcontroller) and casing, *Raspberry Pi* night vision camera, fingerprint module (e.g. R305), cloud-based database, jumpers etc.

For automatic number-plate recognition library OpenALPR to work, a Windows/Ubuntu Linux 16.04 (64-bit) with a minimum PC Intel 4th generation or better, 4 GB RAM, 20GB HDD (or greater depending on how long one chooses to retain the plate images).

For software, a working knowledge of Python/C++ to ensure compatibility with both raspberry pi, its camera and the OpenALPR is needed.

The fingerprint module is connected to one of the USB ports on Raspberry Pi in order to capture driver's biometric data during enrolment exercise. Similarly, the Pi camera is connected to the Raspberry Pi via a cord. The camera, as a NOIR (no infra-red) device, is capable of working in the night/dark. From both input devices, feeds are collected by the raspberry pi for storage in the database. The idea is to have a real-time database that can be queried when the need arises.

This project is based on iterative software development lifecycle (SDLC) principles, i.e. planning, requirements analysis, design, development/programming, testing/review, deployment and maintenance *(Existek, 2019)*. Under requirement analysis, the Raspberry Pi is headless (no video display unit attached). Users desire a friendly user interface UI through which events can be monitored. This is achieved through PC connected remotely to the Pi and the LCD unit attached to the circuit board. Fast processing time with least downtime will also enhance the system performance.

Our SDLC model allows for different project components to be developed per iteration. It also grants the right to do unit test on each component prior to deployment. Thus, the Raspberry Pi, biometric and number plate scanning can be done stepwise.

The proposed system has the capacity to enroll vehicles' details, such as number plates, vehicle colors, manufacturers, model etc. Drivers/owners biometrics are stored in a cloud-based database. Mounted at the security point within the entrance and exit, and with a combination of fingerprint and number plate scanners, the device will be able to identify, verify and clock registered users.

New users will be registered on the spot at a designated area. It is expected that in a short while, most frequent visitors (university staff, students, and non-members of the university) would have been registered. This would keep on-the-spot registration delays for visitors at a manageable minimum in terms of time and logistics.

Figure 1 shows the level 1 data flow diagram. The main processes are broken down into subprocesses that can then be analyzed and improved on a more intimate level.

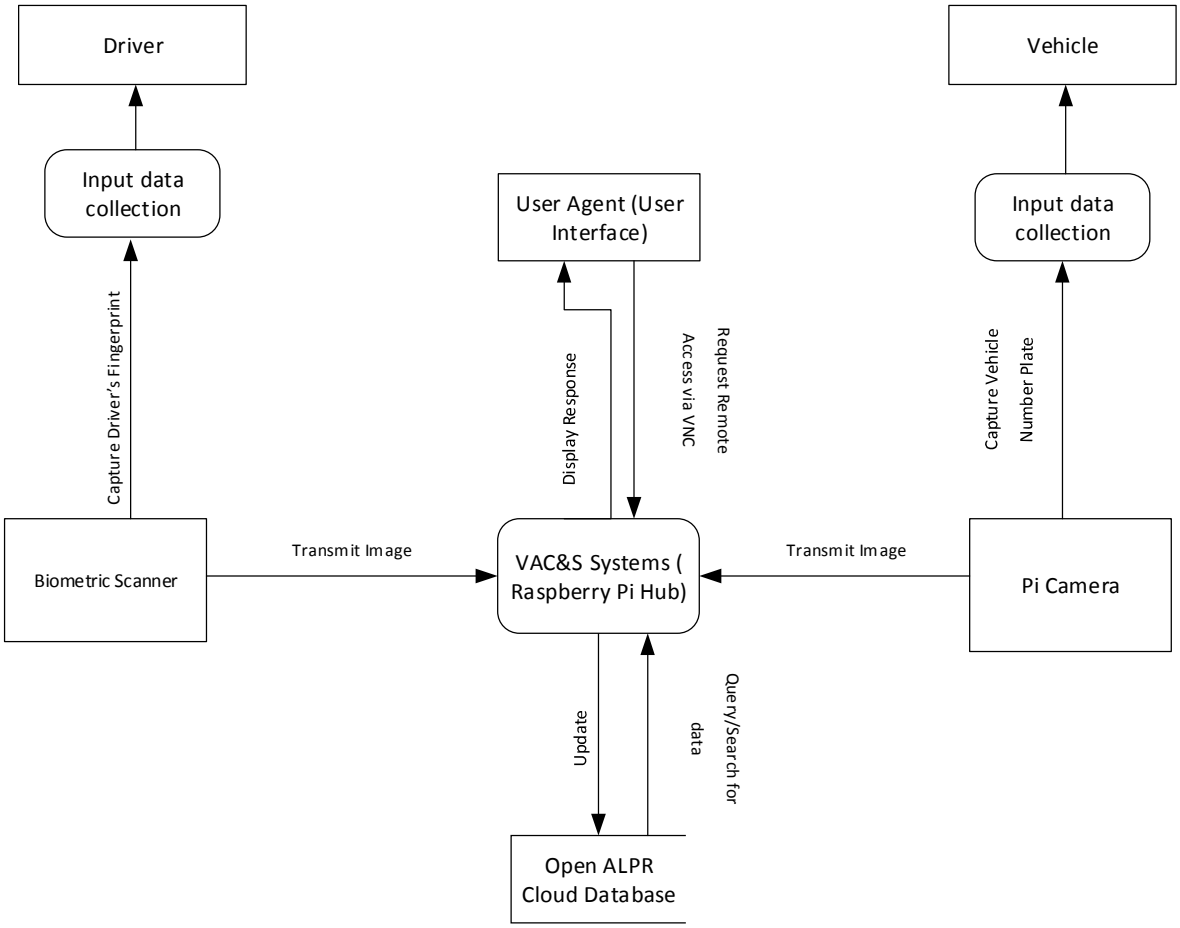

Fig. 1. Level 1 data flow diagram

For basic account users, the Windows/Linux OpenALPR Agent works with any IP camera that supports H.264 and MJPEG streams. All video is processed on your own PC/server, and the plate information is uploaded to the OpenALPR Cloud Stream portal, where it is viewable for 30 days. This hybrid cloud service is cost-effective because the license plate processing is performed on your own hardware and plate images are stored locally. Users define how much CPU and storage to utilize for the OpenALPR Agent, which is managed through the Cloud Stream portal with a web browser. Minimal bandwidth is required because only the metadata is uploaded. Full resolution plate images reside locally and can be viewed on demand when the user requires visual verification.

OpenALPR Agent works with any IP camera and will run on 64-bit Windows or Ubuntu Linux 16.04 operating systems. It is installed as an app on Axis cameras. The agent sends video to the cloud for processing. OpenALPR Agent requires a supported Axis camera, an SD Card with at least 2GB storage space, Internet connectivity (minimum 2Mbps upload speed), accurate date/time, DNS Configuration, the latest Axis firmware.

OpenALPR Agent is installed on a 64-bit Ubuntu Linux 14.04/16.04 OS. It will operate as a background daemon. The dashboard after installation is shown in Figure 2.

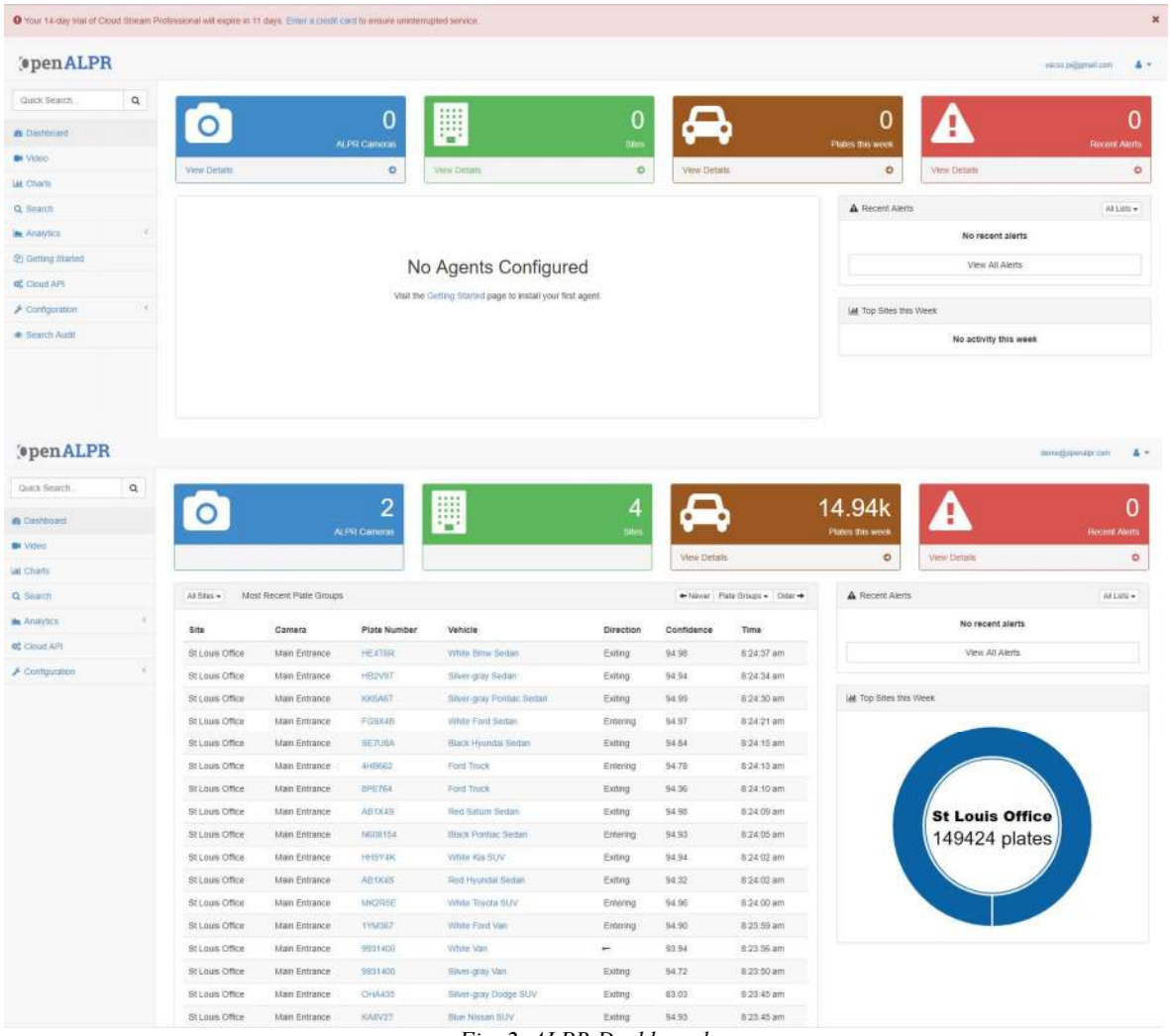

Fig. 2. ALPR Dashboard

RESULTS

Hardware components were coupled according to the circuit diagram presented in Figure 3 *(Circuit Digest, 2019)*. The installed pi camera captured number plate images successfully. However, the format is different from what is currently in operation in Nigeria. To use Nigerian license plate format, a similar template can be explored among available country templates or further configuration will be required. The user agent employed is a PC connected to the raspberry pi and also serve as the user interface. While raspberry pi receives internet Wi-Fi connection via a mobile modem.

The Open ALPR cloud API was set up on a limited account. This provides an integrated view of events via the dashboard. It reveals the location, camera, number plate, vehicle description, log time as well as confidence level (accuracy) of the scanning system. It also renders extended analytics and alert flag.

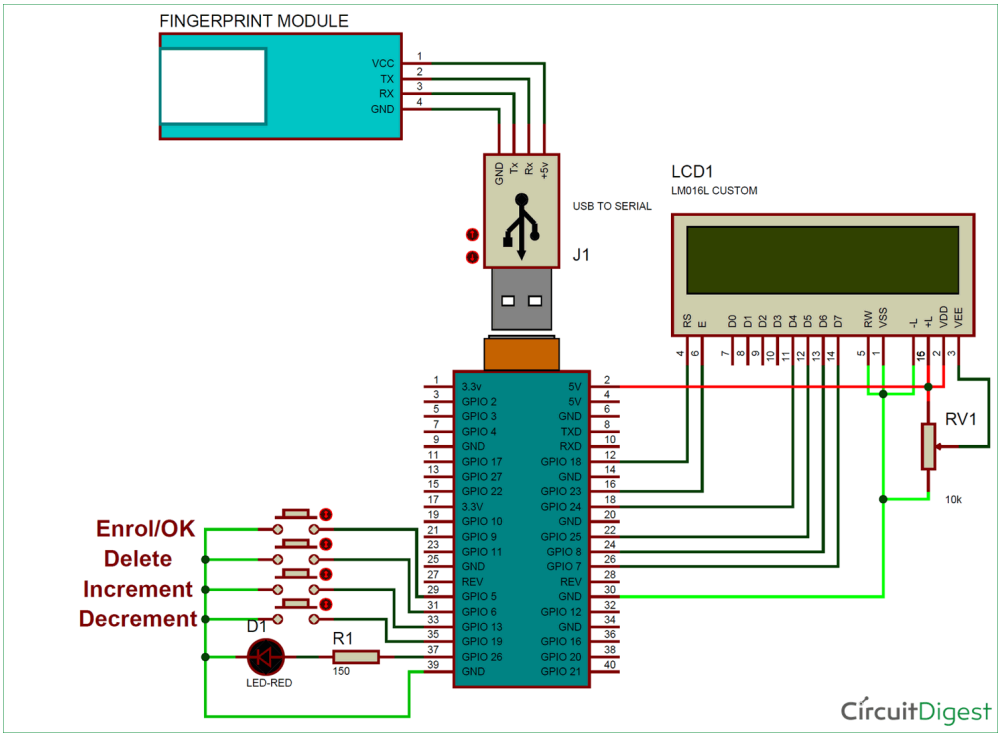

Fig. 3. Circuitry system

The green component with numbers on its left and right sides in Figure 3 above is the pin part of the raspberry pi to which wires from board, LCD display etc. connect. A more detailed view of the raspberry pi pins, which have been labelled for clarity, is shown in Figure 4 *(Circuit Digest, 2019)*.

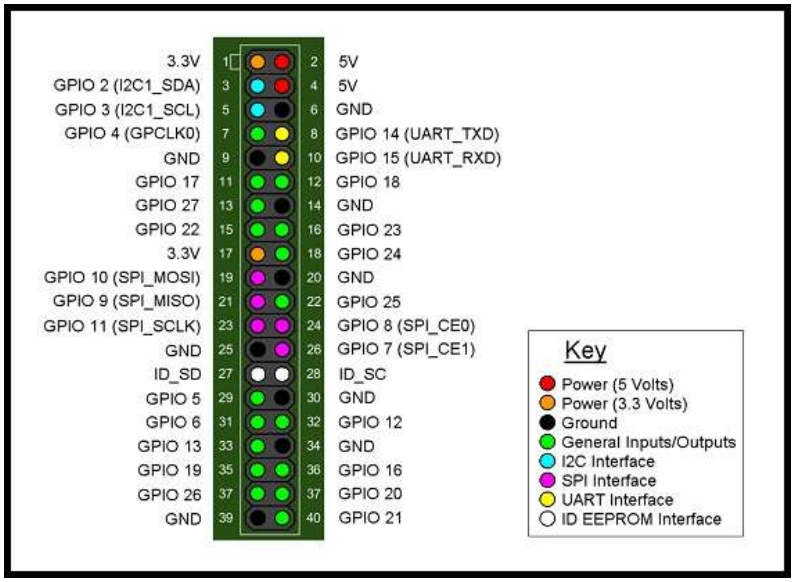

Fig. 4. Raspberry Pi pins

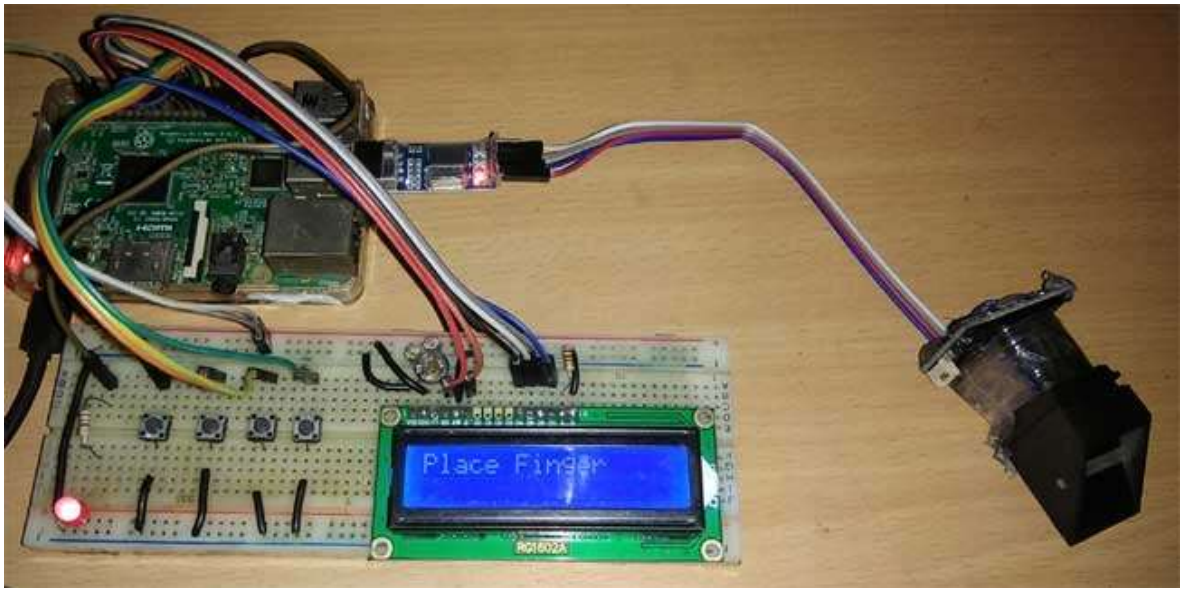

Fig. 5. Coupled hardware components

CONCLUSION

While the objectives of the project are yet to be fully realized, the project stands to add value to the existing operations of the University of Lagos security gate. In turn, both the students, staff and community can benefit in the long run.

With the system, foreigners can be clearly differentiated from Nigerian citizens, thereby helping in security. Serving as an alternative solution to the country's porous border crisis, it helps to plug government's revenue leakages and optimize resources. Such a locally developed solution like this will help minimize cost for institutions. It is also a source of research data for students and staff. Data collected can help the school management and government in physical planning – vehicles and drivers are easily identified and tracked.

With regards to opportunities for further research:

- This project excluded the motorized-boom control due to scope. Including one would improve the robustness of the system.
- Other communication channel can also be explored especially for remote transmission.
- Better add-ons and scripting can lead to better optimization.

Limitations encountered are:

- The pi camera is quite small in size and may not be best for outdoor/ long-range focus. Thus, in real life deployment, a suitable H.264/MJPEG camera would be required.
- For the purpose of this research, raspberry *pi* power pack was used to connect the *pi* to electricity/battery. This may not be adequate for the system when it goes into operation. A sustainable and standalone energy supply will be needed for each device unit without the risk of getting damaged.
- The OpenALPR API for number plate capture provides a free account for a limited number of images. For commercial use, however, a premium account will be advisable for security and scaling.
- Currently, the potential queue that may build up when there are too many visitors (unregistered users) is a demerit that can be researched further.
- For number plates to be captured, they must be in focus. In reality, their positions vary across different classes of vehicles. E.g. For a Toyota Corolla, the position of its number plate will be lower than that of a Mack truck. Thus, a human operator may be required to help in positioning the camera and initiating the number plate capture since there is no motion sensor installed.

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