International Journal of Scientific & Engineering Research Volume 9, Issue 7, July-2018
ISSN 2229-5518

RFID Enabled Arms and Ammunition Depot Management System with Human Tracking Capacity

Victor O. Matthews, Etinosa Noma-Osaghae, Uzairue Stanley Idiake

Abstract— In developing nations, arms proliferate on the streets due to intentional and unintentional leakages from depots managed by the armed forces. The somewhat manual system used to manage the inventory of arms stored in depots can be blamed for the leakages. This paper proposes the use of Radio Frequency Identification (RFID) technology to manage ammunition depots in developing nations. The RFID enabled solution has a human tracking capability and provides updates on a regular basis to a database. This gives the implemented RFID ammunition system a real-time monitoring capability.

Index Terms— RFID, Radio signals, Arms, Ammunition, RFID tag, RFID reader, Interrogator, UHF

1 Introduction

The use of RFID-based solutions is not new [1] [8]. It has been applied in several areas among which are mining [2] [9], environment, transportation [3] and warehousing. The application potentials of RFID continue to find niche applications.

The use of RFIDs to manage the inventory of an armory has great potential especially to curb the leakage of dangerous arms to the streets. The ability to closely monitor the way security personnel handle arms within and without the premises of security outfits is an investment that most governments and private firms are very willing to make. Small arms being what they are, can be easily smuggled, stolen or sold without much ado. A lot of terrorist organizations, robbery gangs and organized criminals sometimes depend on leakages from security depot to meet their arms need [10].

This paper proposes an RFID-based system that can be used to effectively manage the inflow and outflow of arms and ammunition into a depot. It uses active RFID tags for small arms and passive RFID name tags for all security personnel that want to gain access into the depot. RFID readers installed at strategic locations within the depot captures the name of personnel that gained access into the armory and the arms or ammunition taken. Every data captured is used to regularly update a database. This makes it possible to closely monitor how the arms in a depot are managed [11].

2 Literature Review

RFID tags may be active, semi-passive or passive. Passive RFID tags have no power source but the semi-passive and active RFID tags have a power source. The tag consists of an antenna, semiconductor chip that performs the function of coordinating the response of the tag and some form of encapsulation to protect the integrity of the tag [4] [12].

In passive tags, the reader powers and communicates with the tag. The tag "captures" the electromagnetic energy sent to it by the reader and places the tag's identification (ID) on it. Transfer of power from readers to the antenna of tags can be actualized through magnetic induction and electromagnetic wave capture. These two methods of transferring power from the reader to the tag's antenna are all based on the "near-field" and "far-field" properties of radio frequency antennas. The near-field and far-field based properties allow the transmission and reception of data [5] [13].

2.1 Near-Field RFID

This makes use of Faraday's law of magnetic induction. In near-field RFID, the tag sends information back to the reader using load modulation. Load Modulation is the small increase in the reader's coil current that is proportional to the current drawn from the tag's coil [14]. The tag's electronics applies a load to its antenna coil and varies it over time. This causes slight variations in the electromagnetic field around the tag's antenna coil. These variations can be used to encode information representing the tag's identification. The reader monitors and sets this signal (information) as slight variations in the current flowing through its coil [6][15]. The near-field is good for passive RFID systems and it relies heavily on magnetic induction to get the job of identification done. In near-field RFID, the range is given as:

$$Range = \frac{C}{2\pi f} \tag{1}$$

All Where C is the speed of light and f is the frequency of transmission. For every increase in frequency, the range decreases. The energy available for induction is given as:

$$Energy\ available\ for\ Induction = \frac{1}{r^3} \tag{2}$$

Where r is the separation between the tag and reader along a line orthogonal to the plane of the coil. Here, the magnetic field drops off at the rate; 1/r3.

2.3 Far-field RFID

Electromagnetic waves propagated from dipole antennas are captured by tags in a far-field emission based system [16]. The dipole antenna of the tag receives the emission from the reader as an alternating potential difference across the dipole antenna's arm. A rectifying diode linked to a capacitor can use the alternating current developed across the tag's antenna. The tags are far away from the near-field of the reader and thus, information (Tag's ID) cannot be transmitted from the tag to the reader via load modulation. A unique means of communication between RFID tag and a reader is needed in the far-field region [7] [17].

Back scattering is achieved when a precisely dimensioned antenna, tuned to a particular frequency, reflects back some of the radio signals sent to it due to impedance mismatch or a variation of impedance with time. The variations in impedance can be used to code information that is sent by a tag to a reader. This can be achieved in practice when a transistor, placed across and RFID tag's antenna is switched partially on and off [18].

The far-field RFID typically works in the ultra-high frequency range. The efficiency of the far-field RFID depends on the amount of radio frequency energy reaching the tag, the sensitivity of the reader's radio receiver, the returning energy and the interrogating distance between the tag and the reader. Radio frequency voltage is developed during unmodulated periods and the chip sends back information by varying its front end complex input impedance. The impedance toggles between two different states (a match and a mismatch).

2.4 The Read Range

This is the most important tag performance characteristic and it depends heavily on the tag's orientation, the material the tag is placed on and the propagation environment. The read range r is given as:

$$r = \frac{\lambda}{4\pi}\sqrt{\frac{P_t G_t G_r \tau}{P_{th}}} \tag{3}$$

This is Friis free-space formula where λ is the wavelength, Pt is the reader's transmitted power, Pth is the power threshold needed to turn on the RFID tag chip, τ is the power transmission coefficient, Gt is the transmitting antenna gain and Gr is the receiving tag antenna's gain.

$$\tau = \frac{4R_c R_a}{Z_c + Z_a^2}; 0 \le \tau \le 1 \tag{4}$$

Where;

$Z_c = R_c + jX_c \rightarrow$ The Chip Impedance
$Z_a = R_a + jX_a \rightarrow$ The Antenna Impedance

When the chip and the antenna of the tag are perfectly matched at a particular frequency, τ =1, $dB_i = 0$.
The range becomes normalized as:

$$r_0 = \left(\frac{\lambda}{4\pi}\right)\sqrt{\frac{P_t G_t}{P_{th}}} \tag{5}$$

3 METHODOLOGY

The major components of the proposed RFID-based arms depot management system are the RFID tags, reader, wireless/wired connections and the database. The database keeps all information about the movement of arms/ammunitions and the personnel that had access to them updated. The RFID tags and readers collect this information in real-time and updates the database with it. The architecture of the proposed RFID-based ammunition/arms depot management system is shown in Figure 1.

The tags attached to the arms and ammunitions are active while the tags attached to the outfits of security personnel are passive.

The details updated on the database include:

1. Name of personnel.
2. Arm/ammunition taken.
3. Date and time personnel arrived/departed and when arm/ammunition is picked up.
4. Date and time personnel arrived/departed and when arm/ammunition is returned.
5. Amount of time spent within the depot.
6. The purpose for which the arm/ammunition was taken.
7. Real-time tracking of active tags on collected arms/ammunition.

Details carried by the tag attached to the arms/ammunitions:

1. Serial number.
2. Price.
3. Batch Code
4. Brief description of the arm.

Details carried by the tag attached to security personnel outfit:

1. Name of personnel.
2. Rank of personnel.
3. The current department where personnel works.
4. Brief description of security personnel.

Table 1 gives a summary of the tag's parameters:

- *Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*
- *Co-Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*
  (This information is optional; change it according to your need.)

The Other specifications of the proposed system are shown in Table 2. An example of a tagged arm is shown in Figure 2.

3.1 The Human Tracking Function

The designed and implemented system has two tracking functions. The UHF RFID readers installed at strategic locations throughout the barrack and within the armoury keep tabs on all personnel through their specially designed RFID enabled name tags:

1. Within the armoury
2. Outside the armoury

The installed RFID readers pick information concerning personnel and update the database accordingly. Within the armoury, the readers update the database with information regarding personnel and the weapon assigned to them. Outside the armoury, the readers simply update the database with information about personnel location within the barrack and notes when any personnel leaves the barrack. The flowcharts for human tracking actions within and outside the armoury are depicted by Figure 3 and Figure 4. The algorithms for human tracking within and outside the armoury are both highlighted in Algorithm 1 and Algorithm 2.

Algorithm 1: Within the armoury
STEP 1: Initialize RFID reader
STEP 2: If personnel are within the armoury
GOTO STEP 3
ELSE GOTO STEP 2
STEP 3: Read personnel's' name tag
STEP 4: If personnel are given weapon
GOTO STEP 5
ELSE GOTO STEP 2
STEP 5: Read weapons' tag
STEP 6: Update database

Algorithm 2: Outside the armoury
STEP 1: Initialize RFID reader
STEP 2: If personnel are within the barrack
GOTO STEP 3
ELSE GOTO STEP 4
STEP 3: Send current location to database
STEP 4: Update database

- *Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*
- *Co-Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*
(This information is optional; change it according to your need.)

TABLE 1
SUMMARY OF TAG'S PARAMETERS

Tag Parameter	Specification
Material tag is placed on	Metal/Wood
Propagation environment	Free space
Tag resonance	775MHz
Frequency band of tag	600MHz - 950MHz
Tag's size and shape	Small/Rectangular
Tag's read range	2cm (near)/1m (far)
Objects around tag	Metals
Orientation of tag's antenna	Omnidirectional

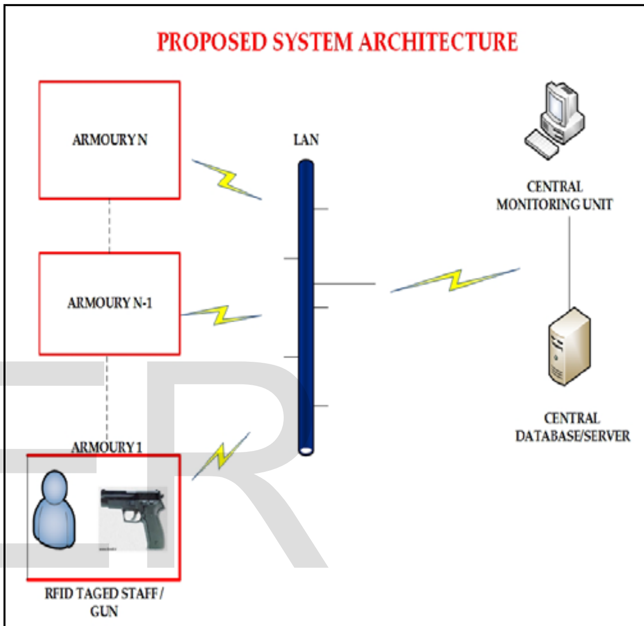

Fig. 1. The Proposed System Architecture.

Fig. 2. Example of a Tagged Arm.

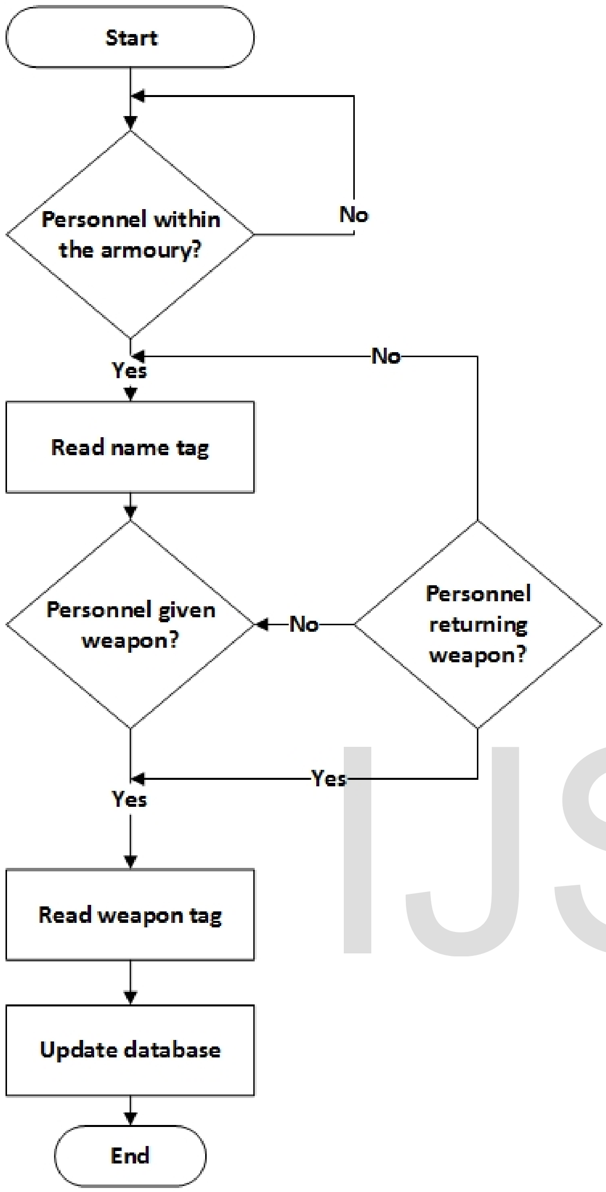

Fig. 3. The Flowchart for Human Tracking within the Armoury.

TABLE 2
MISCELLANEOUS SPECIFICATIONS

Parameter	Specification
Type of modulaton	Back Scattering
Numbe of ID bits required	32 bits
Data transfer rate	100Mbps
Type of field	Near/Far
Frequency	Ultra high
Parameter	Specification
Type of modulaton	Back Scattering
Numbe of ID bits required	32 bits

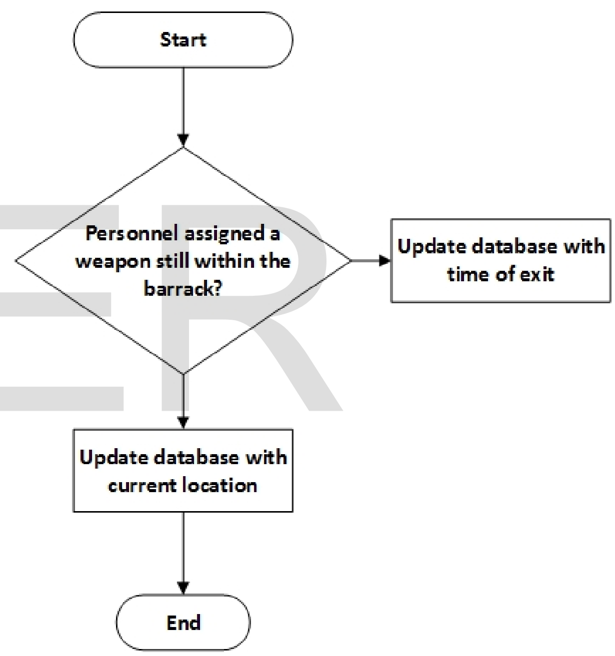

Fig. 4. The Flowchart for Human Tracking outside the Armoury.

4 TEST ANALYSIS

The near-field range was plotted against the near-field frequency using the values shown in Table 3 and it was observed from Figure 3, that the near-field RFID's range decreases for every increase in frequency.

Table 3 was used to plot the near-field frequency versus drop rate between the reader and the tag and it was observed from Figure 4, that the near-field RFID's drop rate increases with every increase in frequency.

The read range in the far-field depends on several factors which includes; the wavelength, transmitting power, antenna gain and the transmitting coefficient. These parameters vary very largely with various RFID tag vendors and the propagation environment. The graphs shown in Figure 5 and 6 were derived from Table 4. The results from these graphs show clearly that the read range in the far-field region increases with every increase in the transmission frequency and the drop rate also decreases at higher frequencies in the far-field.

TABLE 3
NEAR-FIELD RANGE AND DROP RATE

Frequency (MHz)	Range (m)	Drop Rate (m^{-3})
600	0.0796	1.983
650	0.0734	2.528
700	0.0682	3.152
750	0.0637	3.869
800	0.0597	4.796
850	0.0562	5.634
900	0.0530	6.717
950	0.0503	7.857

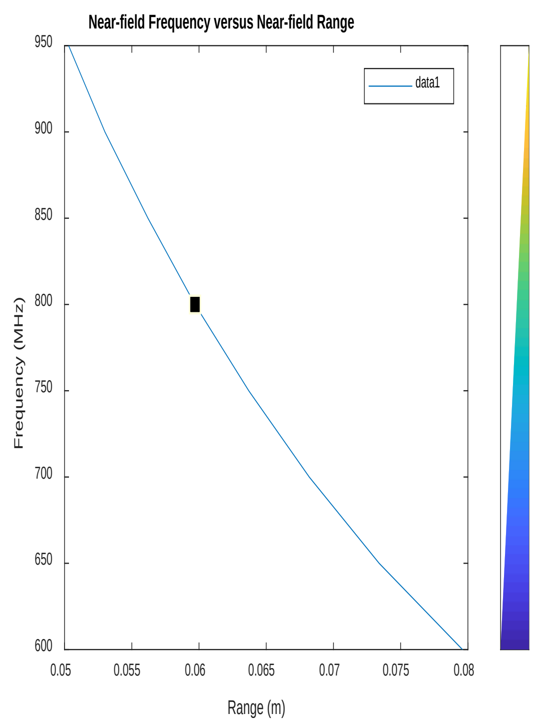

Fig. 5. Near-field Frequency versus Near-field Range

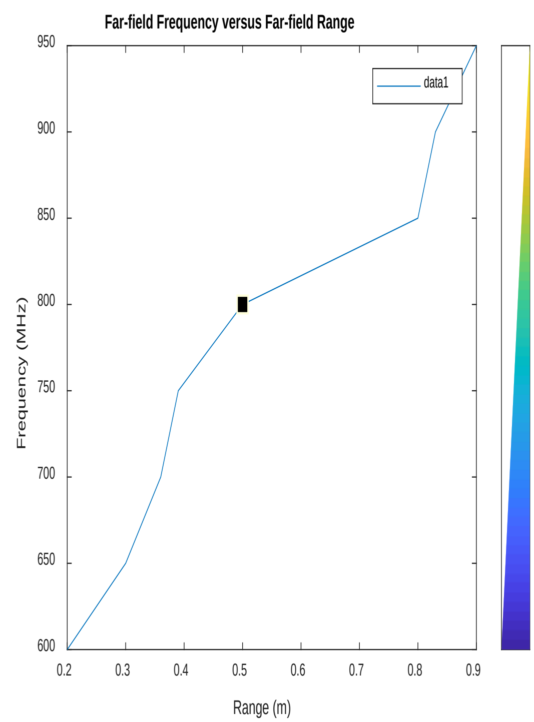

Fig. 7. Far-field Frequency versus Far-field Range

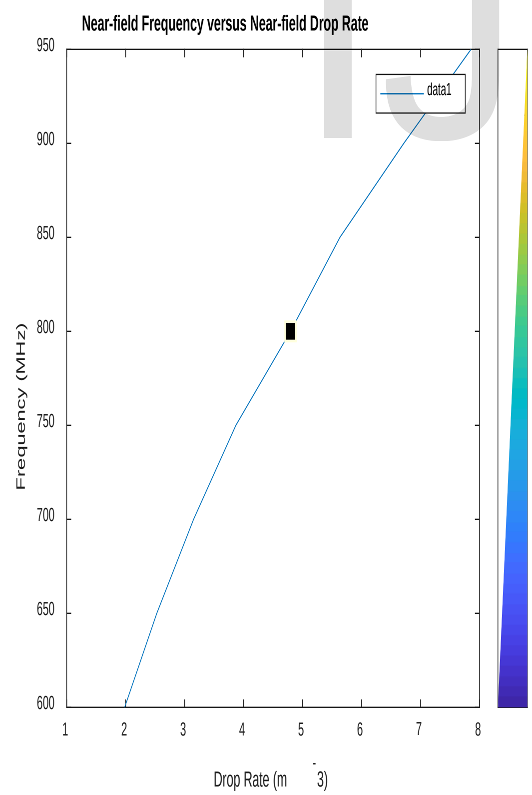

Fig. 6. Near-field Frequency versus Near-field Drop Rate

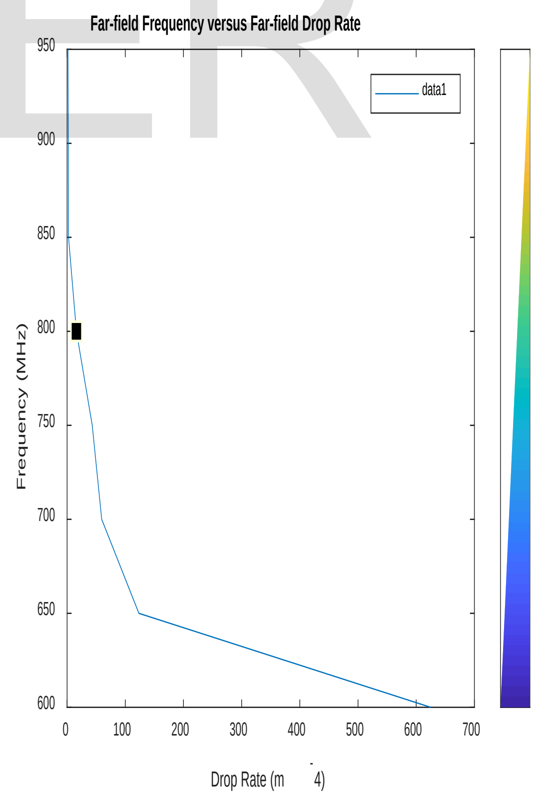

Fig. 8. Far-field Frequency versus Far-field Drop Rate

TABLE 4
FAR-FIELD RANGE AND DROP RATE

Frequency (MHz)	Range (m)	Drop Rate (m^{-4})
600	0.20	625.0
650	0.30	123.4
700	0.36	59.5
750	0.39	43.2
800	0.50	16.0
850	0.80	2.4
900	0.83	2.1
950	0.90	1.5

4 CONCLUSION

This paper succinctly presents a RFID –based model for managing the inventory of arms/ammunitions kept in a depot. It closely monitors those who access the depot, the arms/ammunition taken or returned and many other details. This model is simple, straightforward and easy to implement.

ACKNOWLEDGMENT

This paper is sponsored by Covenant University, Ota, Ogun State, Nigeria.

REFERENCES

[1] J. Landt, "The history of RFID," IEEE potentials, vol. 24, pp. 8-11, 2005.
[2] P. Mishra, M. Bolic, M. C. Yagoub, and R. F. Stewart, "RFID technology for tracking and tracing explosives and detonators in mining services applications," Journal of Applied Geophysics, vol. 76, pp. 33-43, 2012.
[3] Y. S. Chang, M. G. Son, and C. H. Oh, "Design and implementation of RFID based air-cargo monitoring system," Advanced Engineering Informatics, vol. 25, pp. 41-52, 2011.
[4] R. Want, "Enabling ubiquitous sensing with RFID," Computer, vol. 37, pp. 84-86, 2004.
[5] R. Want, "An introduction to RFID technology," IEEE pervasive computing, vol. 5, pp. 25-33, 2006.
[6] K. S. Rao, P. V. Nikitin, and S. F. Lam, "Antenna design for UHF RFID tags: A review and a practical application," IEEE Transactions on antennas and propagation, vol. 53, pp. 3870-3876, 2005.
[7] C. M. Roberts, "Radio frequency identification (RFID)," Computers & security, vol. 25, pp. 18-26, 2006.
[8] K. O. Okokpujie, E. C. Chukwu, E. Noma-Osaghae, and I. P. Okokpujie, "Novel Active Queue Management Scheme for Routers in Wireless Networks," International Journal on Communications Antenna and Propagation (I. Re. CAP), vol. 8, pp. 53-61, 2018.
[9] K. O. Okokpujie, A. Orimogunje, E. Noma-Osaghae, and O. Alashiri, "An Intelligent Online Diagnostic System With Epidemic Alert," An Intelligent Online Diagnostic System With Epidemic Alert, vol. 2, 2017.
[10] K. Okokpujie, E. Noma-Osaghae, S. John, and A. Ajulibe, "An Improved Iris Segmentation Technique Using Circular Hough Transform," in International Conference on Information Theoretic Security, 2017, pp. 203-211.
[11] K. O. Okokpujie, E. Noma-Osaghae, G. Kalu-Anyah, and I. P. Okokpujie, "A Face Recognition Attendance System with GSM Notification," 2017.
[12] C. Atuegwu, S. Daramola, K. O. Okokpujie, and E. Noma-Osaghae, "Development of an Improved Fingerprint Feature Extraction Algorithm for Personal Verification," International Journal of Applied Engineering Research, vol. 13, pp. 6608-6612, 2018.
[13] K. Okokpujie, E. Noma-Osaghae, S. John, and R. Oputa, "Development of a facial recognition system with email identification message relay mechanism," in Computing Networking and Informatics (ICCNI), 2017 International Conference on, 2017, pp. 1-6.
[14] N.-O. Etinosa, C. Okereke, O. Robert, O. J. Okesola, and K. O. Okokpujie, "Design and Implementation of an Iris Biometric Door Access Control System," in Computational Science and Computational Intelligence (CSCI), 2017, Las Vegas, USA, 2017.
[15] K. Okokpujie, E. Noma-Osaghae, S. John, and P. C. Jumbo, "Automatic home appliance switching using speech recognition software and embedded system," in Computing Networking and Informatics (ICCNI), 2017 International Conference on, 2017, pp. 1-4.
[16] C. Atuegwu, K. O. Okokpujie, and E. Noma-Osaghae, "A Bimodal Biometric Student Attendance System," 2017.
[17] K. Okokpujie, N.-O. Etinosa, S. John, and E. Joy, "Comparative Analysis of Fingerprint Preprocessing Algorithms for Electronic Voting Processes," in International Conference on Information Theoretic Security, 2017, pp. 212-219.
[18] K. O. Okokpujie, N.-O. Etinosa, O. J. Okesola, J. N. Samuel, and O. Robert, "Design and Implementation of a Student Attendance System Using Iris Biometric Recognition," in Computational Science and Computational Intelligence (CSCI), 2017, Las Vegas, USA, 2017.