

INTELLIGENT CAMERA FOR REAL-TIME RECOGNITION OF ARMED BANDITS USING MACHINE LEARNING

Author: Muhammad Alamin Ahmad

ABSTRACT

Armed banditry cases in Nigeria have risen drastically in recent years with an approximation of 200 cases in each month of 2020. Security forces in Nigeria have not completely repelled to the hilt these uprising crises due to a high number of cases, vast uninhabited areas across the country and low technological resources. This paper comprehensively discusses an intelligent camera for real time image recognition of armed bandits. Convolution Neural Network as a machine learning technique that models a system from a dataset has been adopted in accurate recognition of armed bandits. 5G networks that provide communications at fastest speed and low latency have been involved in integration of the intelligent cameras and signal transmission. The intelligent camera meshed with convolution neural network, speeded-up robust algorithms and 5G networks can localize, detect, and produce an alarm when guns are detected on images of a real-time video recording.

Key words: Armed bandits, Intelligent Camera, Machine Learning

1.0 INTRODUCTION

Nigeria's security forces' have not been equipped with modern intelligent technologies to combat insecurity in Nigeria, which remains, a major challenge to various Nigerian governments. The country has been limping with insecurity for nearly 13 consecutive years (Adagba 2012). During this period potential solutions have been proposed and implemented but all of their results help little to the problem. The population's outcry is increasing and citizen's patience towards the issue is degrading every day.

In April 2014, two hundred and seventy six (276) female students in Chibok were abducted by Boko Haram and hidden in allegedly, unknown place in the country. Few months later another attack occurred in the Grand Mosque of Kano where a suicidal bomber caused the death of 120 people and injured 260. In December of 2020, seventy six (76) farmers were attacked and slaughtered by Boko Haram in bright daylight in Zabarmari village (Adagba 2012)

Kidnapping cases started spiking in July of 2013, where travelers on road linking Kano, Katsina, Zamfara, and Sokoto were regularly attacked by kidnappers. On 11th December 2020, over 300 pupils studying in Kankara Local Government, Katsina State were kidnapped by gunmen. Months later another attack was staged at Governments Science Secondary School in Jangebe Zamfara where pupils were encircled by tens of kidnappers who manage to drive the kids from their school like a flock of sheep into the bush. What is common in all these cases is that, the security forces had been completely unaware of the crimes on due time until after the attack occurred. Fig 1. Below shows bandits fully armed with weapons.

The number of police in Nigeria is significantly low that the ratio of police population and the citizens of Nigeria is one is to six hundred (1:600), which is below the United Nation (UN) ratio requirement that a single police should survey four hundred people. However, recruitment of more police staff is always conjoined with difficulty due to cost requirements for recruitment, training and salary budget (Christopher 1995).



Fig 1: Kidnappers Scouring the forests of Zamfara State

Source: <https://www.vanguardngr.com/2021/02/bandits-kill-18-in-kaduna-govt/>

The current government claims during its election campaign that it would exterminate Boko Haram and all major security threats in a full military crackdown. It has been six years, since its inception. However, Boko Haram and Kidnappers are still breathing Nigeria's air.

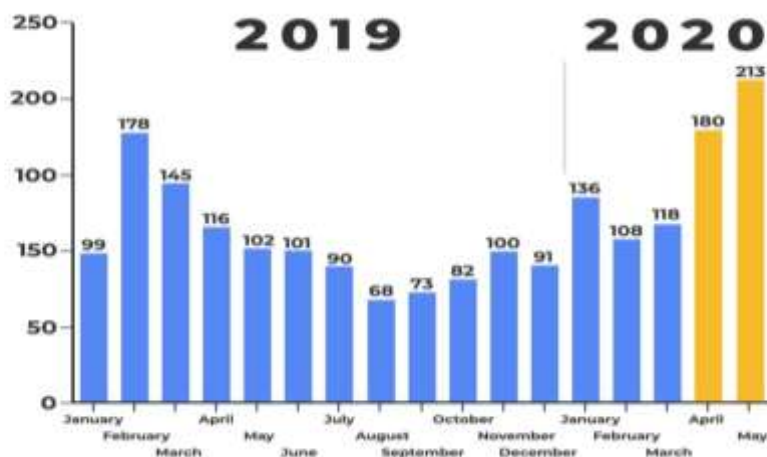


Fig 2: Statistics For Armed Robbery in Nigeria From 2019 to 2020.

Source: <https://humangle.ng/data-crime-rates-insecurity-worsened-significantly-in-nigeria>

Fig 2. Above is a statistics data of armed robbery in Nigeria in 2019 and 2020. The picture depicts the increasing rate of armed robbery with a positive gradient, the data showed unacceptable two hundred and thirteen (213) cases of armed robbery in Nigeria during May 2020. Since then the cases continue to sky-rocket upward till today.

This has proven without uncertainty that brick and mortar military patrol alone cannot provide a sweeping operation towards the liquidation of the security threats currently bedeviling

Nigeria. Technology remains the most viable, if not the only hope for the Nigerian government to provide security of lives and property across the nation.

Many machines invented in developed countries had helped greatly in reducing crimes and apprehending its perpetrators. Closed-circuit television (CCTV) had helped in identifying and arresting culprits all over the world but this device faces two major drawbacks today. Firstly they require constant lookout by a human observer (the performance of human observer reduces significantly over twelve minutes of a constant lookout,) and cost associated with hiring and recruiting observers is significantly high (Raajan 2012).

Intelligent Camera is machine learning software embedded in cameras for intelligent video surveillance and security systems (kamal 2020). The camera has the advantage of not only recording the video of activity in an area but also the ability to detect objects and supervise the kinds of the object to automatically generate a result for security feedback.

The heart of this paper is the intelligent camera which has the potential to combat insecurity in Nigeria. The camera is programmed using machine learning algorithms, which are intelligent algorithms that mimic the behavior of the human brain. For the learning process, approximate twenty thousand (20000) images are required to model the network, so that an accurate output will be received from the system. A speeded-up robust algorithm is added to the system to localize the area of the image with humans while discarding the rest of the image areas. The images will then undergo several algorithms to detect edges of the image with guns and produce desired output (For images without gun, however, the program will not produce any output.) The outputs will then be fed to a security alarm circuitry to provide an appropriate signal.

1.1 OBJECTIVES OF STUDY

This paper is geared towards providing a safe and reliable mechanism for detection of the location of bandits across the country and to alert security personnel if guns are found on the images of the intelligent camera so that insecurity would be combatted. Hence, the objectives of this study are:-

- To study insecurity in Nigeria and the government's inability of traditional brick and mortar approach to curb the issues.

- To discuss the paramount advantage of an Intelligent Camera in Image recognition and hence, its significance in identifying armed bandits
- To illustrate the concept of machine learning in model training, using images of armed bandits

2.0 LITERATURE REVIEW

The earliest technology for video surveillance are closed-circuit television (CCTV) cameras, CCTV systems were first invented in June 1927 by a Russian physicist (Brandon 2009). The system consists of a manually operated scanning-transmitting camera and wireless shortwave transmitter and receiver (Raajan 2012). In 1949 United State of America (USA) implemented the use of CCTV cameras for commercial use. CCTV cameras have been designed in huge quantities and used in various industries across the world. Lately in 1990 multiplexers were developed which have the advantage of integrating many cameras and provide transmission through a single media (Frederic 2004).



Fig 3: CCTV Camera with human observer

Source: <https://observer.ug/news/headlines/58873-cctv-cameras-game-finished-for-criminals>

However CCTV cameras depend on a human observer to carefully survey video recordings of activities in an environment as shown in fig 3 above. A study shows that the performance of observer reduces significantly after first twelve minutes of constant observation, and also the

cost associated with the observer constitute the major disadvantages of using CCTV cameras for video surveillance. These devices do not possess the intelligence of distinguishing dangerous situations from peaceful scenarios. They completely depend on a human person for observation.

The intelligent camera, however, has been used in various applications for image recognition, the intelligent camera was used in intelligent parking space recognition (Rahayu 2012), intelligent car plate recognition through intelligent vision (Luis 1999), Intelligent face recognition, and navigation system using neural networks for smart security and internet of things (Dengpan 2018), Intelligent camera for intruder alarm (Seung 2018) etc.

This paper presents the use of an Intelligent Camera for video surveillance. The system has the advantage of localizing sections of the image with humans so that unwanted areas around the image can be discarded and detection of weapons on the image is implemented. The system would also contain a wireless communication circuit so that immediate response could be provided for security purposes on crime scenes.

2.1 OVERVIEW OF INTELLIGENT CAMERA

An intelligent camera is a machine vision system that, in addition to image capture circuitry, is capable of extracting application-specific information from the captured images, along with generating event descriptions or making decisions that are used in an intelligent and automated system (Bosh 2021). The intelligent camera show in fig 4 below consists of video sensing, video processing, and communication unit. In the video sensing unit, the camera combines high pixels resolution and tracker. Video processing unit consists of the intelligent unit, where intelligent algorithms like convolution neural network (CNN,) speeded up robust features (SURF,) and Fast retina keypoint (FREAK) play a huge role in processing the image frames, performing localization and detection of weapons on the image and finally the communication unit consists of a transmitter which transmits the video recordings via wireless communication module to a recorder installed at a suitable place.



Fig4: Intelligent Camera

Source: <https://scitechdaily.com/intelligent-cameras>

2.2 OVERVIEW OF MACHINE LEARNING ALGORITHMS

Machine Learning is a technique that figures out “model” out of “data.” The data means information such as documents, audio, images, etc. The “model” is the final product of Machine Learning (Phil 2020). Machine learning requires training data, the data are collected from the different and dynamic environments which will be fed to the system along with correct output (supervised learning) (Michael 2013) as shown in fig 5. below. The model created can accurately predict output when different input is given to the system. In this paper, images of bandits carrying guns are to be fed to the system, the training data could be obtained from Google photos, Facebook images, or Newspapers photos. The machine will learn the shape of weapons and produce accurate output when guns are detected (Justin 2017).

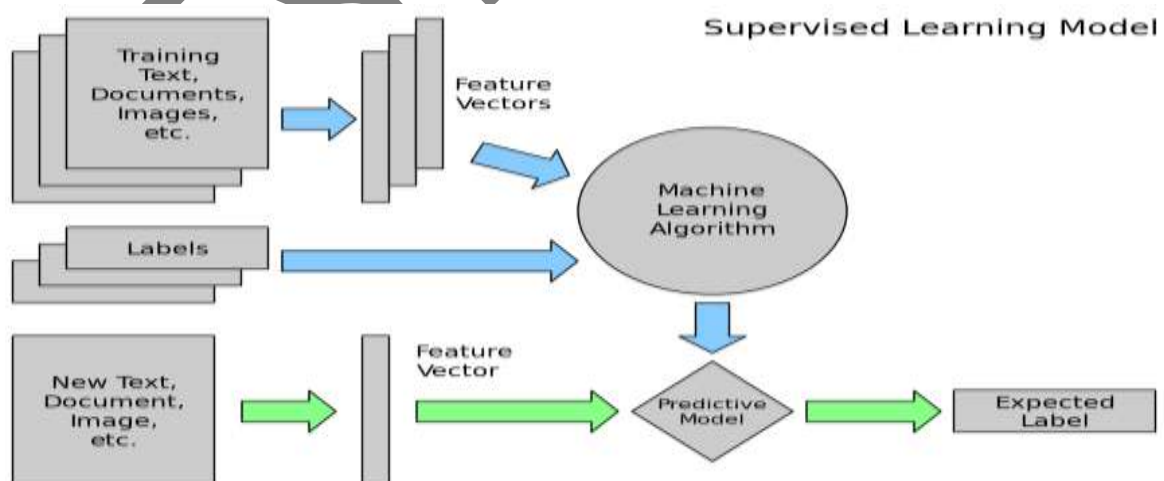


Fig5: Machine Learning Data Flow Diagram

Source: <https://quantumcomputingtech.blogspot.com/2019/07/machine-learning.html>

2.3 OVERVIEW OF 5G COMMUNICATIONS IN VIDEO SURVEILLANCE SYSTEM

The service provided by 5G networks which include among others enhanced Mobile BroadBand (eMBB), Ultra Reliable and Low Latency Communication (URLLC) and massive Machine Type Communication (mMTC) will significantly play a huge role in integration of billions of devices together and autonomous control (Jasneet 2021, pp. 3-7). The 5G network will make possible the integration and control of intelligent cameras across vast regions, fast response at a fraction of second will be provided to a security base, however 5G networks required multiple small grid base at close proximity which constitute to major cost in infrastructure.

Fig 6. below shows some applications of 5G networks in intelligent systems which include machine to machine (M2M) communication, mobility and virtualization, however 5G faces three major challenges as shown in the figure: security and privacy, networking infrastructure and service and business models.

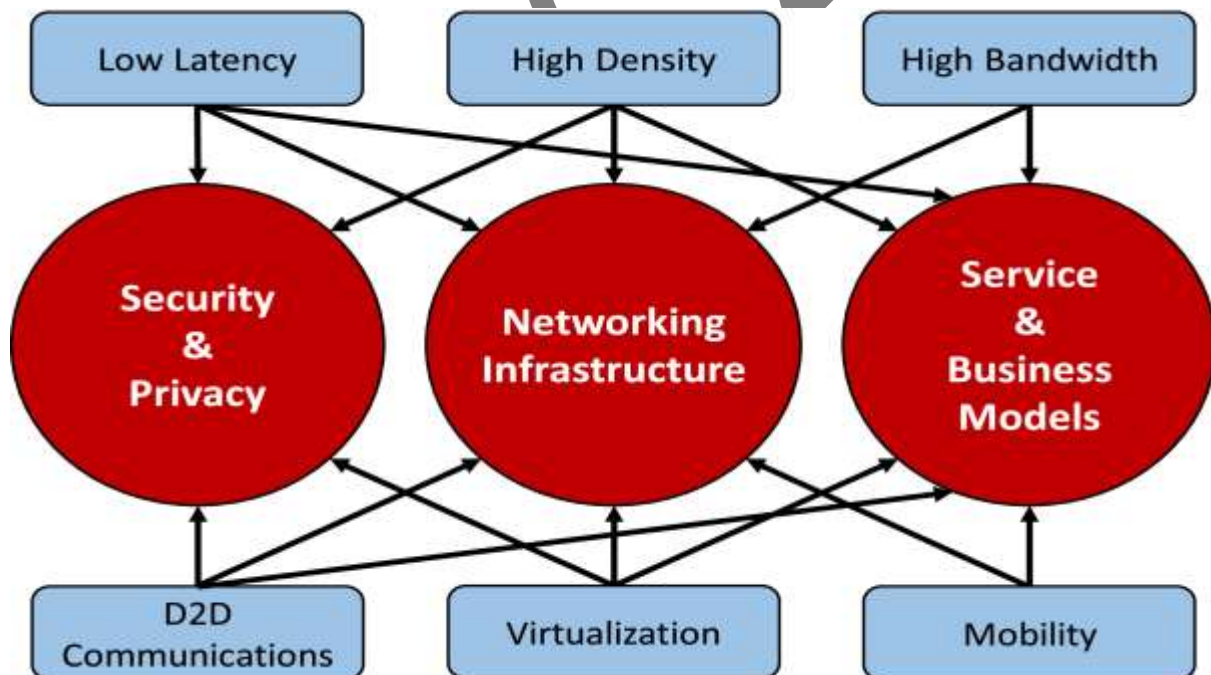


Fig 6: 5G networks applications.

Source: https://www.researchgate.net/figure/Challenges-red-introduced-by-key-5G-features-blue_fig6_338673850.

3.0 THEORETICAL ANALYSIS

3.1 CONVOLUTION NEURAL NETWORK

A neural network is a kind of machine learning that was designed based on the learning process of the human brain (Gyanendra 2017). The human brain uses neurons to store and transmit information, the neurons are arranged in a way that, a response from one neuron results in response to many other neurons. Neural networks structure has three layers. An input layer, hidden layer, and output layer (Junyi 2019). For this paper the input to the neural network is the images captured by the intelligent camera, the output layer is the response that could trigger an alarm. The hidden layers are just planted to improve the accuracy of the neural network. The more hidden layers connected the more complex the network becomes but the higher the accuracy of the network (Kamal 2020). Moreover, a convolution neural network is a kind of neural network that is well suited for image processing it consists of the serial connection of feature extraction and classification network (Schmitt 2020).

3.2 SPEEDED UP ROBUST FEATURES (SURF)

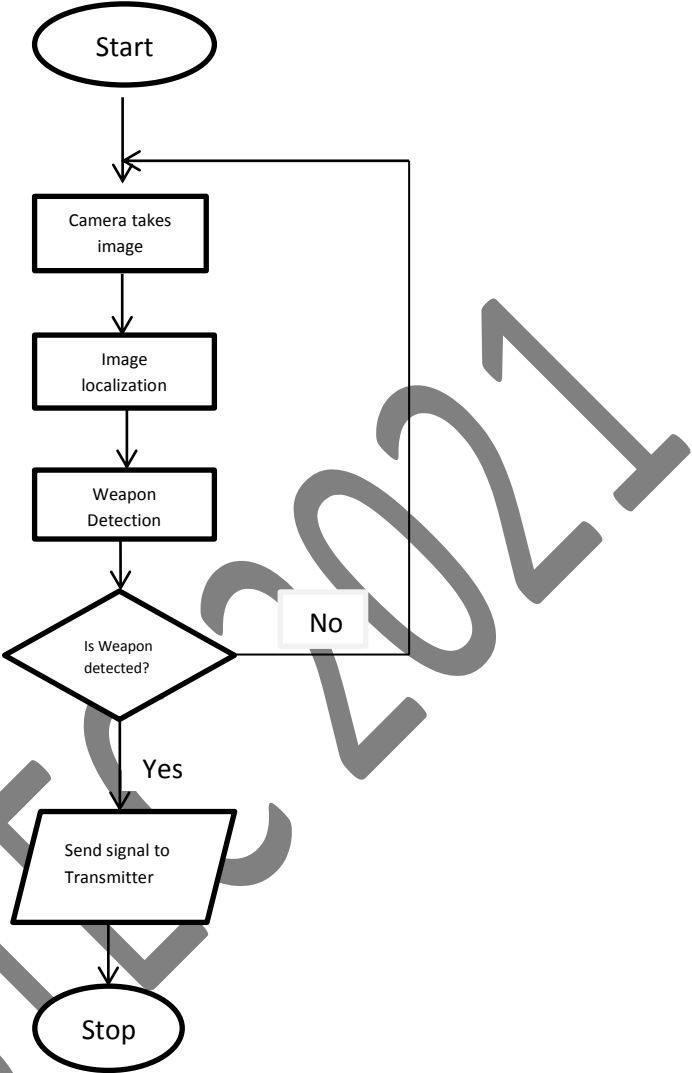
Speeded up Robust Features (SURF) is an intelligent algorithm that is used in feature extraction and localization and it uses Hessian-based detectors (Schmitt 2011). The detector computes the determinant of the Hessian matrix rather than its trace (Xiaozhi 2016). It introduces non-elongated and ill-localized structures. It depends on integral images to lessen computation time. The algorithm performs localization task in this paper, it search for human shape on the images and crop those sections, its purpose is to reduce the error of weapon detection and to increase the performance of the machine learning model

3.2 TRAINING DATA

The Training Data which could be used to train the convolution neural network are images of real bandits taken from Google photos, Facebook, Twitter, etc., carrying weapons and/or explosives. Below are samples of the Training Data. Figure below shows sample of training data obtained from Google images.



3.3 FLOWCHART OF THE NETWORK



3.3.1 OVERVIEW OF THE FLOWCHART

The flowchart above describes the procedures to be followed when programming an Intelligent Camera for image recognition of armed bandits. When the system is first fired up, the camera will take video recordings of activities in an environment. Image frames from the video will be sent to a localization section where positions of the images with humans are localized and all other regions discarded, this can be done using the speeded-up robust algorithm. The images are then passed to the convolution neural network (image processing network) for weapons detection. If weapons are detected the system will send a signal to the transmitter using 5G communications to alert the security station, otherwise the program will loop back for other images. The camera could be mounted on poles at various locations along dangerous roads where banditry cases are high or atop long trees in uninhabited areas.

3.4 NETWORK STRUCTURE

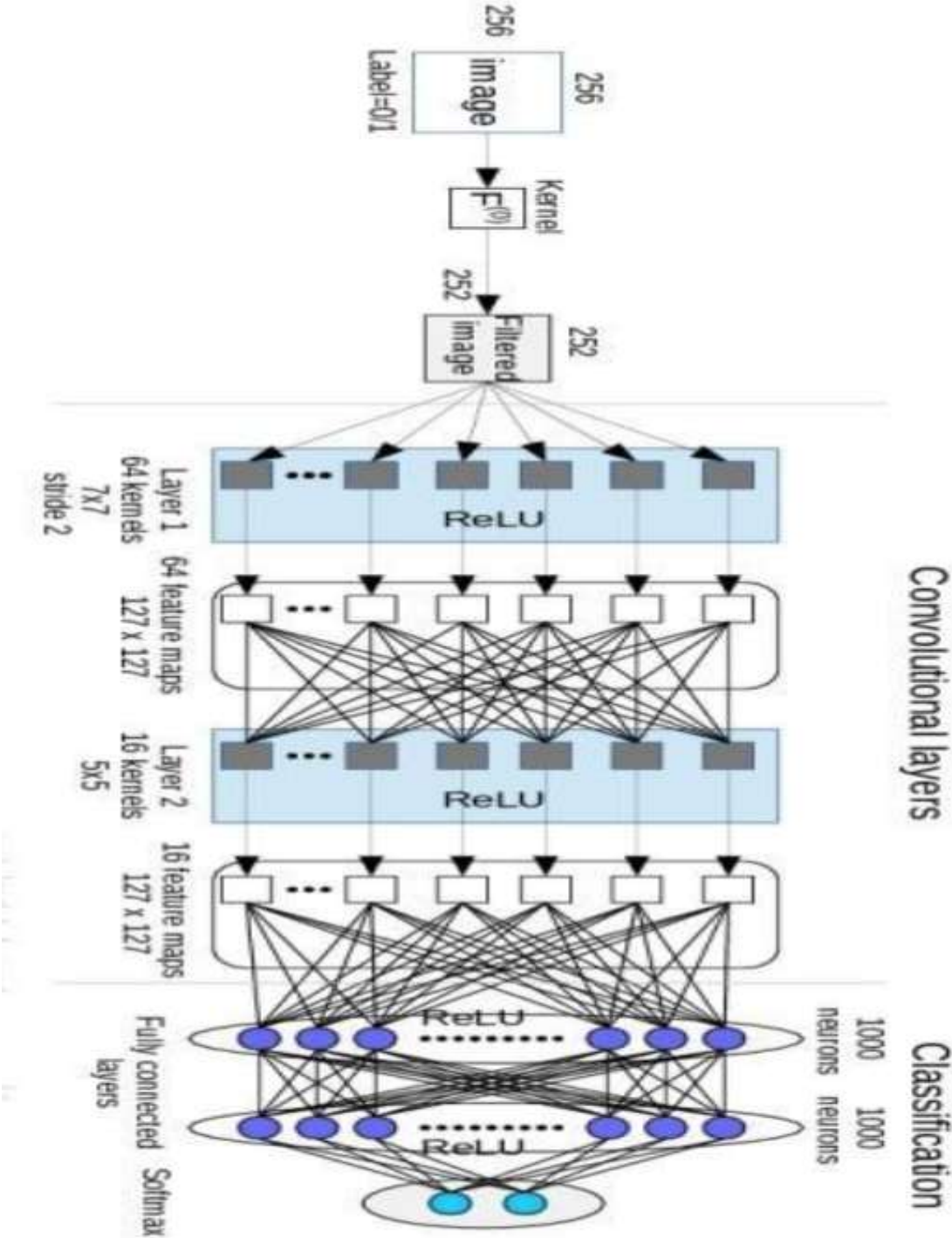


Fig 7: Architecture of Machine Learning for Image Recognition

Source: <https://www.nature.com/articles/s41598-020-70542-9>

4.0 DISCUSSIONS

Insecurity in Nigeria is worsening every day. First, it started with Boko Haram who induced heavy burden to the country. Then the issue of kidnapping emerges which claims lives and wealth of millions of individuals across the country. The dynamic challenges that this problems introduced has sunken the country to its knee. Hence the government must provide an urgent and sweeping technique to fully contain the issues and to restore the country to its standard so that developments in terms of education, safety, travel, and trade would be secure and safe. The system introduced in this paper provided an alternative that if adopted can help curb the troubles of insecurity in Nigeria. It can unveil the locations of armed bandits, gunmen, and criminals across all local communities and cities within the country.

Intelligent Camera had been used in various fields of engineering such as in intelligent parking space detection, license plate recognition, blind assistance systems, pedestrian detection, face recognition, etc., also CCTV cameras had been used in surveillance systems in various governmental and commercial sectors for security reasons, however, CCTV requires constant intervention by the human observer for detection of activities. The system presented in this paper uses the intelligent camera for video surveillance, using machine learning algorithms.

A machine learning algorithms which is the latest technology in the field of programming had been used in the system. The algorithm used is the convolution neural network (CNN) coupled with speeded up robust features (SURF), the dataset is images of armed bandits carrying weapons (guns, explosives, etc.), the output of the network is applied to a communication circuitry which will send an alarm via wireless communication to a security base if weapons are detected from the images taken by the intelligent camera.

4.1 RECOMMENDATIONS

- The Government should determine the key areas where cases are numerous and possible hide-out locations of armed terrorist
- The Government should install an intelligent camera at specific intervals depending on the range of each camera scan.
- The Government should build a security base near the camera's network so that immediate military response could be possible
- Drones should be used with intelligent Camera to survey vast areas.

4.2 CHALLENGES

The challenges that will be faced for the practical implementation of an Intelligent Camera are:

- The machine learning algorithm is broad and complex programming that often results in an error when fed with an inaccurate and vague dataset.
- A very large and numerous dataset is required in programming the CNN and SURF algorithms which range from 20,000 to 100,000 images.
- The location for the installation of an intelligent camera must be secure, so that destruction of the camera could be almost impossible.
- The power supply unit must be stable and steady for smooth operation and must be available at all times for the appropriate operation of the system.
- 5G communications is vulnerable to cyber-attacks and confidentiality.
- Signals in wireless transmission networks often get distorted along the free space channel due to electromagnetic interferences.
- An intelligent camera would produce an alarm when police are seen by the camera, the system only looks for weapons.

4.3 SIGNIFICANCE OF STUDY

- Intelligent Cameras are powered with low dc voltage which could be achieved through solar panels connected to the camera or regulated dc supply from electricity mains, this would ensure constant operation of the system.
- Intelligent Cameras are highly reliable once installed they will operate in useful life periods for many years without crackdown without considering unforeseen failures due to thunder, lightning, or intentionally (by criminals).
- The operating cost of an intelligent Camera is significantly low due to low maintenance and repair costs.
- The Federal Government can provide freedom of security and safety with the use of intelligent Cameras installed in local communities and cities as well.
- Safety of travels and inter-state trade would advance significantly with the installment of intelligent cameras on roads linking states in Nigeria.

5.0 CONCLUSIONS

This paper presents a solution to the vast cases of armed robberies and kidnappings in Nigeria, A study of the attacks along with casualties has been presented and discussed in the paper. The solution introduced is the integration of intelligent camera for video surveillance in the country, a convolution neural network is a program discussed in this paper for programming the network for weapons detection in images of intelligent camera, a speeded-up robust feature is attached to the CNN for image localization so that speedy result could be achieved, 5G networks are involved in the study to introduce the roles of speed and low latency communications. The intelligent Camera would be mounted on structures build on roads site and within the vast forests of the country where criminals and dangerous organizations provide a hideout,

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5.2 REFERENCES

1. Nr Raajan, G Shiva, P Mithun & GN Jayabhavani 2012 ‘Video Surveillance for Real Time Objects’ *Research Journal of Applied Sciences, Engineering and Technology*, vol. 5, pp. 5423-5428
2. Rahayu Yusnita, Fariza Norbaya & Norazwinawati Basharddin, 2012 ‘Intelligent parking space detection system based on image processing’ *international journal of innovation management and technology*, pp. 232-235.

3. Luis Salgado, Jose M Menendez, Enrique Rendon & Narciso Garcia, 1999 'Automatic car plate detection and recognition through intelligent vision engineering' *international Carnahan Conference on Security Technology*, pp. 71-76.
4. Dengpan Mou, 2010 'Machine-Based intelligent face recognition' *Higer Education Press*,
5. Seung Hyun Kim & Su Chang Lim, 2018 'Intelligent Intrusion detection system featuring a virtual fence, active intruder detection, classification, tracking and action recognition' *Annals of Nuclear Energy*, vol. 112, pp. 845-855,
6. Frederic Cupillard, Alberto Avanzi, Francois Bremond & Monique Thonnat, 2004 'Video understanding for metro surveillance' *IEEE international Conference on Networking, Sensing and Control*, pp 186-191.
7. Brandon C Welsh, David P Farrington, 2009 'Public area CCTV and crime prevention: an updated systematic review and meta-analysis' *Justice Quarterly*, pp 716-745.
8. Gyanendra K Verma & Anamika Dhillon, 2017 'A handheld gun detection using faster r-cnn deep learning' *7th International Conference on Computer and Communication Technology*, pp. 84-88.
9. Mai kamal el den Mohamed, Ahmed Taha & Hala H Zayed, 2020 'Automatic gun detection approach for video surveillance' *International Jornal of Sociotechnology and knowledge Development*, pp. 49-66.
10. Drew Schmitt & Nicholas McCoy, 2011 'Object classification and localization using SURF descriptors' *CS 229*, pp 1-5.
11. Xiaozhi Qu, Bahman Soheilian, Emmanuel Habets & Nicolas Paparoditis, 2016 'Evaluation of SIFT and SURF for Vision Based Localization' *International Archives of the Photogrammetry, Remote Sensing & Spatial information Sciences* vol. 2.

12. Maya Dawood, Cindy Cappelle, Maan E el Najjar, Mohamad Khalil & Denis Pomorski, 2012 ‘Harris, SIFT and SURF features comparison for vehicle localization based on virtual 3D model and camera’ *International Conference on Image Processing Theory, Tools and Applications*, pp. 307-312..
13. Phil Kim, 2020 ‘MATLAB Deep Learning with Machine Learning, Neural Networks and Artificial Intelligenc’ pp. 2, 2020.
14. Michal Grega, Seweryn Iach & Radoslaw Sieradzki, 2013 “Automated recognition of firearms in surveillance video” *IEEE International Milti-Disciplinary Conference on Cognitive Methods in Situations Awareness and Decission Support*, pp. 45-50.
15. Adagba, O., Ugwu, S. C., & Eme, O. I, 2012 ‘Activities of Boko Haram and Insecurity Question in Nigeria’ *Arabian Journal of Business and Management Review*, pp. 77-99.
16. Abdulla Chaer, Khaled Salah, Claudio Lima, Partha Pratim Ray & Tarek Sheltami, 2019 ‘Blockchain for 5G: Opportunities and Challenges’ *16th IEEE Annu. Consum. Commun. Netw. Conf.*, no. 644262, pp. 1-4.
17. Jasneet Kaur, M. AEIF Khan, Mohsin Iftikhar & Muhammad Imran, 2020 ‘Machine Learning Techniques for 5G and Beyond’ *Deanship of Scientific Research*, vol.9.
18. Koper Christopher ,1995‘Just enough police presence: Reducing crime and disorder by optimizing patrol time in crime hot spots’, *Justice Quarterly* vol. 12, pp. 649-672.