Practical Approach to Urban Crime Prevention in Developing Nations

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ABSTRACT

The growing surge of urban-crime rate represents a global complex endemic that is beyond the immediate capability of the policing apparatus of nations. This trend is particularly prevalent in urban cities in developing nations, where crime-rate exhibit dynamic tendencies in contrast to the static policing apparatus. Thus, the policing apparatus in urban cities in developing nations often play catch-ups with crime; a phenomenon that further elicits crime complexity. As a way to ameliorate this societal menace, this study evaluates probable practical approaches that can be integrated into the modern policing modality in developing nations. The approach considers the development of a dynamic surveillance management system which considers the contextual peculiarity of developing nations. Using a self-administered measurement instrument from Police respondents in South Africa and Nigeria, the implementation feasibility and the probable effectiveness of the proposition will be evaluated. From the preliminary result from sampled Police officers, this practical approach could present a complementary paradigm that can leverage modern technology towards an effective urban-policing mechanism. Furthermore, this approach presents modalities for the maximization of the human capacity of the Policing service, as well as the management of policing response-rate in developing nations.

CCS Concepts

•Hardware→Communication hardware, interfaces and storage•Hardware→Communication hardware, interfaces and storage→Electro-mechanical devices•Security and privacy→Software and application security→Domain-specific security and privacy architectures•Hardware→Emerging technologies→Electromechanical

Keywords

Urban crime; dynamic and static policing; crime prevention; dynamic surveillance methods.

1. INTRODUCTION

Crime prevention involved any plan or strategy that is aimed at reducing or eliminating the level of criminal activities, as well as the risk and fear of being a crime victim. To reduce crime and to ensure that the rules of law and fundamental rights of citizens are adequately protected in the current technology-assisted society, security agencies would require modern automated information system and to vigorously pursuing community policing for effective detection, prevention, and control of crimes. To this effect, [1] assert that the introduction of sophisticated modern scientific and technical methods in crime prevention and control has proven to be effective. However, rural-urban migration is a major component in most developing nations which has consequently led to a decrease in the police-citizen ratio. One approach to bridging this gap has been identified as the provision of adequate surveillance. Surveillance is thus generally regarded as a policing instrument that can be used to deter, and consequently prevent crime in urban settings. Traditional surveillance mechanisms are usually mounted on a stationary platform interconnected to a centralized, human-controlled, and (constant) visual monitor of video frames. This model of surveillance is hinged on the effectiveness of the human monitoring the video frames and the sanity of the society towards minimal vandalization. This presupposition greatly differs from the practical dynamics in most developing nations, particularly in the African States, where such policing infrastructures are highly vulnerable to vandalization, human lackadaisical tendencies, as well as subjective interpretation of video frame events. Considering this inherent peculiarity, the adoption of classical surveillance approach to crime monitoring would result in ineffective policing. Moreover, studies have suggested that the integration of aerial surveillance mechanism is a viable surveillance approach in urban settings. Aerial infrastructure is vulnerable to energy failure, and storage limitation. Whilst this approach presents a logical approach to surveillance, its practicality remains a major concern for the African States. Therefore, there is a need for a context-based surveillance approach to addressing urban crime in developing nations. To do this, this study proposed the development of a crime management process which comprises a dynamic surveillance approach and a crime-management application. Crime control approaches include the installation of the electronic alarm system, Close-Circuit Television (CCTV), security guards and GIS crime mapping [2]. The state-of-the-art of the approaches to crime prevention is further presented in the next section.

2. APPROACHES TO CRIME PREVENTION

Technology-assisted crime prevention approaches have been identified [2] as a potential measure for effective crime management. These approaches are generally categorized into static and dynamic approaches. However, the static approach has been majorly deployed for urban areas. Static approach to crime prevention is a situational crime prevention that employs surveillance tools and strategies to avert crime occurrence through constant monitoring of envisaged risk factors from fixed positions. Basically, the approach is ideal for situational crime prevention, which is characterized by the ability of security agents to lessen the chances of perpetrating crime at a specific location and time [3]. Thus, it is predominantly dominated by installing surveillance gadgets such as video cameras and closed-circuit televisions (CCTV), which are monitored in real time from the control Centre. Interestingly, the task of actively monitoring crime events from the Centre by trained security personnel is now being researched for possible automation by machine agents through artificial intelligence (AI) and machine learning [4]–[8]. AI enabled surveillance method such as intelligent video analytics is gradually seeing a rise in adoption.

Again, to effectively monitored large spatial area at all times, the static surveillance devices are often networked through wired or wireless media [9]. In addition, the individual gadget could perform activities like axial rotation and zooming from a fixed location for optimal security coverage of concerned jurisdiction. Notably, it is requisite for such device to aid crime prevention by capturing colorful image [10], quality video frames [4] and soundtracks to assist crime monitoring and forensic exercises. However, irrespective of the flexibilities built into the gadgets and event monitoring automation, the overall surveillance system configured from them is limited to static surveillance [5]. This is because the motionless gadgets cannot be configured to autonomously respond to spatiotemporal parameters. Examples of static these approaches include the following; CCTV deployment, Geographical Information System (GIS) and Crime Mapping, Establishment of telephone “hotlines”, Collaboration with the media, Security Guard, Wireless Home Security System, Electronic Alarm System, and Drug Education/ rehabilitation. A brief description of each approach is further presented.

2.1 Closed-Circuit Television (CCTV)

The growth in the use of CCTV to control/prevent crime in the past decades, especially in the developed societies. A CCTV is an enclosed video camera that transmits a signal to a specific designation. A common justification for using CCTV is that it reduces crime by deterring potential offenders, thus a CCTV can be effective in reducing crime [11]. The mechanisms by which CCTV may control/prevent crime include the following;

a. Caught in the act - perpetrators will be detected, and possibly removed or deterred.
b. Effective deployment of security personnel
c. Deter crime through actual crime publicity
d. Detection of actual time for crime occurrence
e. Memory jogging through induce elementary security precaution
f. Reduce security risk by elevating the security awareness and cautious
g. Potential to report the incident with comprehensive detail

2.2 Geographical Information System and Crime Mapping

A geographic information system (GIS) is a powerful tool that allows the user to create any kind of geographic representation, from a simple point map to a visualization of spatial or temporal data. A GIS is a set of tools that allows the user to create any kind of geographic representation, a map such representation to a three-dimensional visualization of spatial or temporal data for onward query and analysis. Crime Mapping refers to the process of using a geographic information system to conduct spatial analysis of crime problems and other police-related issues. Crime mapping serves three main functions within crime analysis:

a. It facilitates visual and statistical analyses of the spatial nature of the crime and other types of events.
b. It allows analysts to link unlike data sources together based on common geographic variables (e.g., linking census information, school information, and crime data for a common area).
c. It provides maps that help to communicate analysis results.

A geographic information system translates physical elements in the real world— such as roads, buildings, lakes, and mountains—into forms that can be displayed, manipulated, and analyzed along with police information such as crime, arrest, and traffic accident data. A GIS uses four types of features to represent objects and locations in the real world; these are referred to as a point, line, polygon, and image features. A GIS places all points on such a map that share the same address directly on top of one another, which makes it impossible for the map to show how many points there really are. Crime analysts often use graduated maps, its size map, the sizes of the symbols used for point and line features reflect their value.

2.3 Establishment of Telephone Hotlines

Well-publicized telephone “hotlines” can be an enormous asset in spreading awareness on a safety issue and providing information to potential victims in urban settings. Hotlines offer a non-judgmental, anonymous and secure source and help build knowledge for police services to enhance crime control.

2.4 Traditional Mass Media Collaboration

The three generally known mass media include television, Radio and Newspapers outlets. They are essential for keeping society informed about local, national and international news. This includes live publicity of near real-time crime and incident reportage, as well as public interaction on policing strategies. In this respect, the mass media can be important sources of awareness-and security education from the respective security agencies.

2.5 Security Guard

A security guard functions as a deterrent to trespassers, burglars, and vandals when you have the right people and use them effectively. Guard services are frequently practical for businesses or for properties that have multiple buildings.

2.6 Wireless Home Security System

A wireless security system uses an access control mechanism that can be remotely controlled and maintained. The features and capabilities of a wireless security system general cover video surveillance and home automation. Summary of the advantages and limitations of the current modalities for urban crime control approaches is presented in Table 1.

Table 1: Matrix of Urban Crime Control Approaches

Controls	Strength	Limitation
Wireless Home Security System	• Flexibility of relocation • The system can send alerts directly to your smartphone via an app, text or email. • The Special alerts can be set up to remind you to test the batteries and connectivity of the wireless security system.	• The limited distance of signals strength • Signal blockage and jamming • Interruption in service. • Users dislike self-install the system and time it will take. • Security vulnerability
Close - Circuit Television (CCTV)	• Potential to deter potential offender. • It has a modest effect on personal property crime but not on levels of violent crime.	• Could be expensive • Limited to line of sight effect • Maintenance could be high

Geographical Information System (GIS) and Crime Mapping	• It can facilitate visual and statistical analyses of the spatial nature of the crime. • It allows analysts to link unlike data sources together based on common geographic variables. • Can be used to convey criminal activity information to the public.	• Single-symbol maps are not appropriate for displaying data about crimes that occur at the same locations repeatedly. • Single-symbol maps are not useful when analysts are dealing with large amounts of data.
Security Guard	• Potential to recognize potential hazards and security risks. • Potential to fix simple problems while on duty. • Security system maintenance is part of the guard's job description to check the status of sensors, cameras and control panels.	• Potentially cost intensive. • Requires supervision which could induce additional logistics • Human could fall asleep, abscond or show up late when they are not supervised.
Collaboration with The Media	• Partners to enhance awareness of police activities. • Strengthen community dialogue and participation. • Can aid the police in different jurisdictions in their investigation work, and transnational crimes, and provide mechanisms and resources for victims' assistance in the city.	• Most stations situated in urban centres • Cannot provide details • messages have short life plus time shifting • no visuals for radio
Establishment of Telephone Hotlines	• Help the police uncover new cases. • Ease of information dissemination • Help build knowledge for police services to enhance crime control.	• Could require increasing logistics

2.7 The Need for the Dynamics Approaches

Primarily, the traditional approach to curbing urban crimes through demographic data was quite insufficient owing to the spatiotemporal dynamisms and complexities patterns associated with the crimes [6]. Furthermore, the capability of static surveillance systems to support urban crime prevention is limited due to their inflexible mode of operations [7], [12]. Particularly, the reason ascribed to these shortcomings is the non-static nature of crime patterns [3], especially in urban areas. Thus, to adequately meet up with the sophistry of urban crime, dynamic surveillance system which involves unmanned aerial vehicle (drone) and a robot that can be aptly deployed to monitor crime scenes becomes a necessity [12]. More so, the system should encompass tools and technologies for real-time extraction and analysis of pictures and video frames to assist security operatives in ascertaining the nature and level of crime before deploying necessary counter-crime facilities. No doubt, dynamic surveillance system will significantly complement the initiative of hotspot policing, which has inherent potentials to drastically reduce crime rate within delineated regions of interest in urban areas [8]. Leveraging the potential of the dynamic approach, this study, therefore, proposed a dynamic surveillance approach to urban crime prevention. Detail of the proposed approach is presented in the next section.

3. PROPOSED APPROACH

A process diagram of the proposed approach is presented in Figure 1. The proposed dynamic surveillance approach integrates the development of a dual-renewable energy aerial surveillance vehicle for potential evidence acquisition. The logic of dual-renewable-energy drone presupposes that for any given aerial feed, there exists a drone interchange protocol which utilizes an overlapping data capture sequence for feed handover. This handshake thus attempts to prevent data loss. Noting that a typical aerial surveillance drone could be limited to shorter flight duration, and energy challenge, the proposition integrates renewable energy power source. Furthermore, the synchronization in the time-to-leave, take-off, handover, and landing between two aerial facilities is considered.

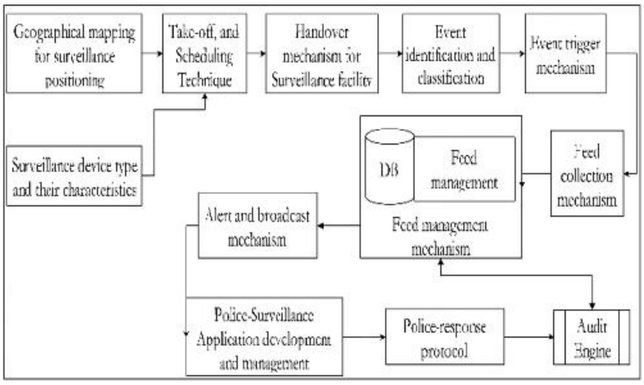

Figure 1. Framework of the proposed police surveillance System.

Furthermore, the process model integrates identification and classification of surveillance feed for event automation and feed collection trigger. This process identifies pointers that can be used as a precursor to a crime incident. The output from this stage serves as input for an event trigger mechanism. In addition, the proposed surveillance integrates a feed management mechanism which ensures effective data storage process. This comprises a sliding window, event trigger storage technique. The output from this feed management is channeled through an alert broadcast mechanism to a police surveillance application.

As shown in Figure 2, the output from the feed-collection is stored and maintained in a repository. This repository also serves as a feed for a management system which connects to the broadcast mechanism. In the management process, an intelligent software can be used to control the nature of the alert signal to the alert messaging process. Such a software can utilize the input from the event identification and classification process, and the event trigger mechanism to define the situational occurrence in the feed, and then communicate the corresponding alert message to the alert broadcast mechanism. The broadcast mechanism uses a predefined broadcast protocol to communicate with the (mobile and stationary) surveillance application installed on a handheld device or a stationary control Centre. As a way of evaluating the effectiveness of the policing service, the application integrates a response-protocol which manages the alert-response process. The outcome of this protocol is fed into an audit engine which further synchronizes the response with the feed-management process, for future audit or forensic process. Detail of the core processes is further discussed in the proceeding subsections.

3.1 Mapping Tracked Events

It is appropriate to geo-reference the captured events for ease of response. Consequently, the UAV systems that are equipped with mapping capability could be deployed. Such an integrated system can convert the positions of events tracked through video analytics into geographical latitude and longitude coordinates, which can be displayed as an icon on a map. Several studies [13]–[15] have investigated visual navigation using UAV. For instance, [14] developed a system known as the Simple UAV Environment (SUAVE) for investigating the use of model inspection techniques to exploit real-time video feeds. SUAVE samples imagery from the video stream to apply textures to its map hence, as the UAVs capture live video streams, individual frames are selected and projected onto the terrain replacing the old texture. Once the terrain is created georeferencing is used to map the triangles in the mesh. Then a list of pixel points corresponding to these triangles is used to map the imagery onto the map. Along with the texture coordinates each pixel point has 3D world space coordinates. The concept is adopted in this study; Figure 2 illustrates the SUAVE system.

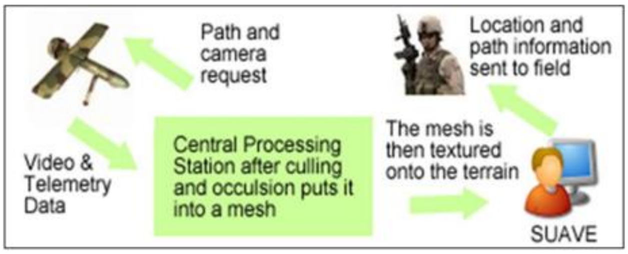

Figure 2. Illustration of the SUAVE system [14].

3.2 Take-off and Scheduling Technique for Crime Surveillance UAV

The proposed surveillance system comprises two key preparatory phases; UAV take-off plan and resource scheduling technique. The UAV take-off process considers the take-off position of each UAV in a predetermined geo-location. The take-off positioning considers the geo-location profile of crime, geo-location spot of optimal area coverage, as well as the wind pattern of the area. Stage involves the determination of the number and location of physical resources, such as UAVs and the surveillance area partitioning. The resource scheduling stage orchestrates the operations of these resources to achieve the mission objectives. This study proposes a split-zone surveillance area system design (unit area to be cover by a set of surveillance UAVs) and each zone is to be monitored by a pair of UAVs. The scheduling can be programmed in a decision process considering zone coverage period, take off and handing over time of the surveillance UAVs. According to [16], Markov Decision Process (MDP) formulation is more appropriate in the presence of real-world uncertainties due to explicit modeling of randomness which characterizes a typical continuous security surveillance for real-time intelligence gathering. Therefore, the MDP modeling approach is proposed in this study. The approximate altitude of 100m and radius of operation is a function of the battery life as well as UAV equipment. MDPs consist of states, actions, transitions between states and a reward function definition. This study proposed harvesting wind energy from the UAV propeller or solar energy as the energy source for onboard replenishment.

3.3 Crime Surveillance using Unmanned Aerial Vehicle (UAV)

Urban crime prevention strategy requires continuous surveillance for seamless intelligence gathering and response. This can be achieved by the simultaneous deployment of multiple unmanned aerial vehicles (UAVs). However, UAV missions for continuous crime surveillance must resolve the limitation imposed by the finite UAV energy source and limited area of coverage. Although high-cost military UAVs such as the Predator can remain in flight for as long as 24 hours, commercial UAVs, micro-UAVs, and nano-UAVs are not as capable, hence, practical applications are limited [16]. While UAV efficiency improvements are necessary, the issue of energy replenishment is fundamentally logistical. Thus, the study developed a scheduling model that allows a fleet of UAVs and fuel service stations to provide long-term support of mission objectives which was accomplished by allowing the UAVs to be replenished and return to the field using a mixed integer linear program (MILP). Hence, their scheduling models allow UAVs to recharge at a collection of shared, geographically distributed base stations and then return to work. This scheduling model using MILP assumes known deterministic mission paths and as such, it is only optimally suitable for highly structured customer missions. In addition, [17] jointly addressed the UAV scheduling and system design problems by developing methods that can simultaneously select the resources, their locations, and schedules. In this paper, the concept of intelligent video surveillance using UAV is presented. To address the challenge of finite energy source associated with the UAV mission, our proposition considers an onboard energy replenishment system.

3.4 Handover Mechanism

Handover refers to the process of feed interchange between multiple UAVs. A seamless handover between drones involves synchronizing active sessions from one UAV to another during event capture. A UAV that uses WiFi network can be affected by narrow coverage area and the height of the drones from the ground user s. Thus, conventional handover schemes cannot be applied to UAVs communicating in 3-D space. Furthermore, handover decision is based on the received signal strength (RSS) measurement on the mobile node (MN) with respect to each UAV in the network. These RSS values are compared to a preset threshold value which determines the handshake process. An MN moves from the base station A to base station B if the RSS of the latter is higher when compared to that of the former provided this value is above the preset threshold. The handover procedure is summarized in Figure 3. It primarily comprises four sections; AP scanning, New AP selection, and authentication, and the association. Prior to the association, the selection process considers a preset RSS threshold. Handover in a drone network is quite different from the conventional handover since drones are located in a three-dimensional space as shown in Figure 4. The coverage area, *A*, for a UAV is defined by Equation (1).

$$A = \pi d^2 = \pi(R^2 - h^2) \quad (1)$$

Where *d*, *R* and *h* are the radius of UAV coverage area for ground MN, the radius of UAV transmission range and height of the UAV from the ground, respectively. Study in [3] has shown that the optimum coverage decision algorithm using RSS as the parameter for handover is given by Equation (2).

$$R\ S_n \quad = R\ S\ l(\quad (_m \quad \text{where} \quad RSS_{\min} \quad (2)$$

Where, $R\ S_{n}$ is the minimum RSS required for the MN to communicate with the drone terminal, is the path loss exponent, d is the ground distance (in meters) between the MN and drone terminal and $\pounds$ is the zero-mean Gaussian random variable with a standard deviation that represents the statistical variation in the RSS caused by shadowing in dB. When the RSS of the current drone with respect to the target drone is the same on the MN, then handover is triggered. The ground point where this happens to assume same drone's height from the ground is $D_{same_{RSS}}$ [2, 4] as shown in Figure 5 and expressed in equation (3).

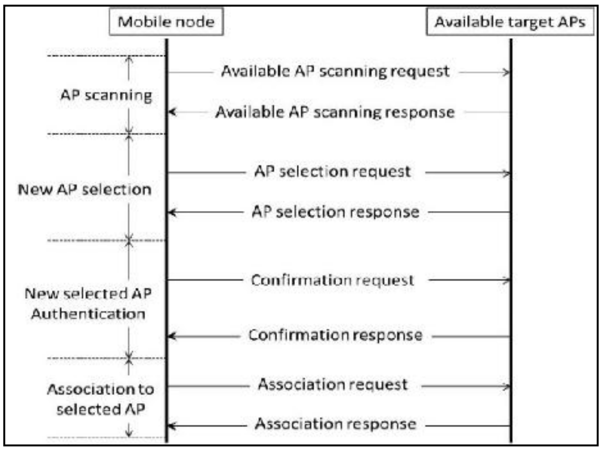

Figure 3. Hanover procedure [1, 2]

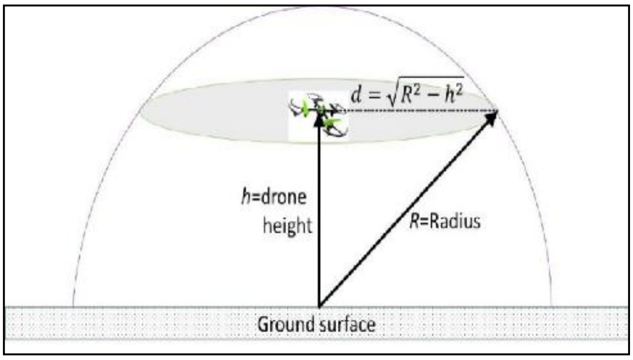

Figure 4. UAV Coverage Area Computation

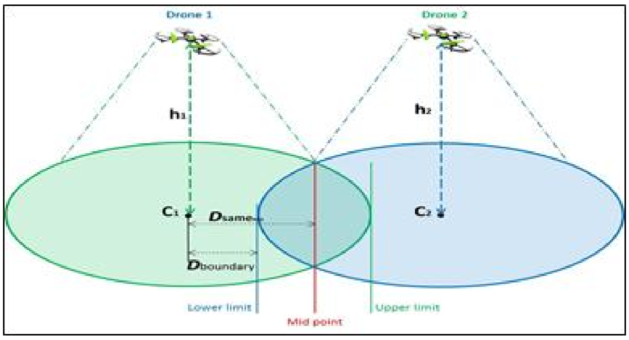

Figure 5. UAV Coverage Area Specification

$$D_{sa\ e_R} = \frac{A \cdot D_{C_1,C_2}}{1-A} + \sqrt{\left(\frac{A^2 \cdot D^2_{C_1,C_2}}{(1-A)^2}\right) + \frac{A}{1-A}\left(D^2_{C_1,C_2} + h_2^2\right)} - \sqrt{\left(\frac{h_2^2}{1-A}\right)} \quad (3)$$

Such that,

$$A = 10^{\frac{(P_1 - P_2)}{5\beta}} \quad (4)$$

Where Where P_1 and P_2 denote the RSS of drone 1 and drone 2, also C_1 and C_2 denote the center of the drones, respectively.

3.5 Feed Collection Mechanism

This module describes the method of feed collection of the proposed multi (dual) channel single feed collection process from the surveillance devices. A logical depiction of the feed collection process is shown in the operation illustrated in Figure 6. The collection process comprises the input feed channels, integrator/synchronizer, and the output feed. In the input feed channel, media feed from a single channel is initially utilized pending when there is a need for channel handshake and channel rotation.

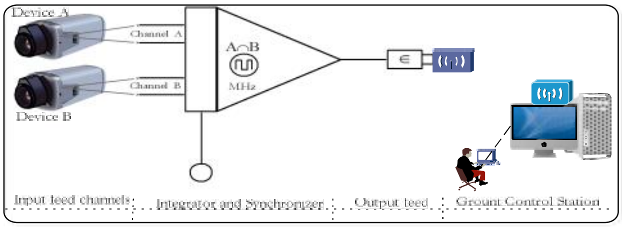

Figure 6. Feed Collection Process

Feed handshake occurs when a given feed-channel device (Device-A for instance) is required to hand over the media feed to another feed-channel device (Device-B for instance). When such handshake or rotation is required, an integrator is invoked. The integrator synchronizes the media feed from both channels into a singular feed. Such integrator can utilize a sliding window technique for feed synchronization. A sliding window technique can enhance reliable feed transmission during the handshake by ensuring that contiguous subsequence of a predefined window size is maintained throughout the handshake process. At the Output feed, a major component will involve the utilization of an efficient lossless compression mechanism which is required to maintain a light-weight data stream.

4. FRAMEWORK EVALUATION

To evaluate the framework, a theoretical underpinning which measures the perception of knowledge field police personnel, was developed. Information systems theories which include the dynamic Capabilities (DC) theory, technology-organization-environment framework (TOE), and task-technology fit (TTF) theory are adapted to measure this perception. The theoretical framework is presented in Figure 7. The theoretical framework integrates demographic variable as a potential control variable for the perception of the utilization of the proposed approach. Police personnel in Nigeria and South Africa will be used as respondents for this purpose. Structural equation modeling technique will be used to evaluate the practicality of the proposition. The model is predicated on the underlying hypothesis that the proposed practical approach to urban crime prevention fits within the required capability of crime prevention. Furthermore, the hypothesis prescribes that the demographic variable can moderate the relationship between projected efficiency, and the perceived practicability of the proposed approach, on the perceived utilization of the proposed approach. A pilot study of the proposed practical policing strategy was carried out using 10-police officers in Nigeria. The respondents were asked to complete the corresponding measurement items divided into three thematics; perceived practicality, projected efficiency, and perceived utilization on a seven-point Likert scale. Seven-point was considred to provide higher granularity and to prevent ambiguity of perception.

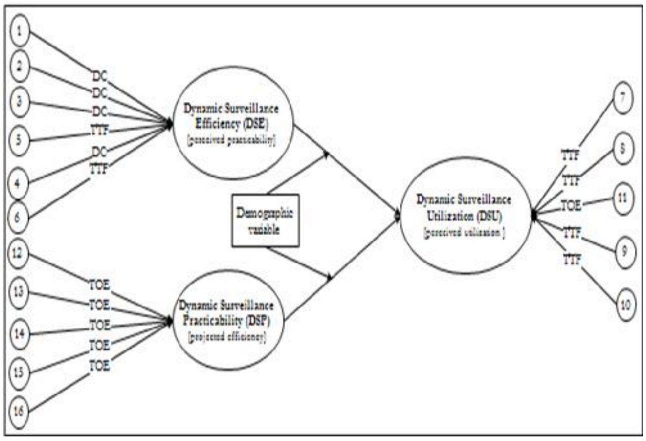

Figure 2. Theoretical framework for perception evaluation - Dynamic Capabilities (DC); Technology-organization-environment framework (TOE); Task-technology fit (TTF).

5. DISCUSSION

The preliminary observation from the pilot study posit that the notion of a dynamic approach to crime control presents a viable solution to urban crime control, and consequently, prevention. Exiting intelligent infrastructure toward this purpose has indeed shown the highlighted limitation, and the need for the dynamic approach. Hi-tech intelligent surveillance systems can therefore benefit from the logic introduced by the dynamics approach. One complementary aspect of the proposed solution is the integration of intelligent surveillance based on object, gait and sudden flight profiling. In contrast to profiling based on individual which focuses on movement prediction and body language analysis, the proposed approach sort to profile potential crime scenario using visual intelligence based on action and event. This therefore requires an updateable database of patterns and accurate classification of event and action. In addition, the audit Log provide a functional process of evaluating and reviewing the activities of respective personnel. This thus provide a basis for forensic investigation, event correlation as well as a platform for improving the classification accuracy. One potential downside to this proposed approach is the privacy and freedom of citizen. However, a conscious mapping of action and event, as against human profiling (predictive policing – the use of video analytics to predict crime commission) could potentially provide a basis to ameliorate privacy concern. This, nonetheless, remain a potential source of concern. Based on the metrics of evaluation, the proposed dynamic approach, presents a viable platform for the integration of existing surveillance infrastructure, particularly for developing nations. The preliminary result shows that police personnel support the perception of dynamic approach to urban crime prevention. However, a critical observation was the projection of the adequacy of infrastructure to support the proposed approach. Infrastructure deficiency is a factor which developing nations grapples with. Thus, a better approach to infrastructural development remains a research focus. Furthermore, the modalities for enhancing and maximizing existing infrastructure remains an open research problem. This is peculiar to developing nations because a standardized framework for resource maximization could potentially be used to enhance efficient use of existing infrastructure.

6. CONCLUSION

A practical perspective on the viability of a dynamic approach to urban crime control is presented in this manuscript. This approach considers the integration of unmanned aerial vehicles and a security management system for crime monitoring and response. The secure management system comprises diverse units which include UAV scheduling, context-based video stream storage, intelligent video analytics, mobile monitoring application, as well as the audit process. The intelligent video analysis address privacy concerns by limiting intelligence to non-human profiling. The approach is contrasted to the traditional surveillance process which uses closed-circuit television and intelligent video analytics to monitor urban settings.

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