UNIVERSITY of RWANDA

Research and Postgraduate Studies (RPGS) Unit

Research Thesis Title:

Contribution of Smart Intelligent Video Surveillance Solutions for Public Safety in Kigali City: Case Study of Rwanda National Police

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A dissertation submitted in partial fulfilment of the requirements for the degree of Masters of Science in Information System with specialization in Internet Technologies

DECLARATION

This thesis is my original work; it has never been submitted to any institution of higher learning for the award of Master degree of Science in Information System with specialization in Internet Technologies. No part of this thesis should be reproduced without the content of Author or that of University of Rwanda

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Declaration by supervisors

This thesis was conducted under our research advisory as University of Rwanda supervisors and the student is recommended for further consideration.

Supervisor: Dr. Alfred UWITONZE (PhD)

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God bless you all.

ABSTRACT

Public safety in Rwanda has been negatively affected by a number of accidents and incidents that took place without the recognition of Rwanda National Police. Thus, this thesis intends to study the contribution of smart intelligence video surveillance solutions to the public safety in Kigali city. The specific objectives of this study include to find out the effect of video analytics features on public safety in City of Kigali with a case of Rwanda National Police, to determine the role of facial recognition system on public safety in City of Kigali with a case of Rwanda National Police and to determine the relationship between vehicle identification and tracking and public safety in City of Kigali with a reference case of Rwanda National Police. The researcher used descriptive research design with a mixed approach of both qualitative and quantitative data to collect the information from 86 respondents. The researcher used 86 respondents who are the total of number of Rwanda National Police employees who are deployed in video surveillance that implies that the researcher selected the whole number of target population as respondents through census as a sampling method. The results have proved that there is a positive significant relationship between smart intelligence video surveillance and public safety because there is also a positive relationship between video analytic feature and reduction of response time (p=.877 and sig=.000), between VIT and protection of people and properties (p=.557 and sig=.000) between reduction of accident and Reduction of response time (p=.815 and sig=.000) because all calculated p- values are less than 0.01 level of significance. Basing on the findings of the study, the researcher would like to recommend to the Rwanda National Police and other security organs to use the information provided by smart intelligence video surveillance to ensure public safety in terms of reducing accidents, reduction of response time and protection of people and properties in City of Kigali. Basing on the research findings, the researcher would like also to recommend to the camera monitors in Rwanda National Police to be so vigilant during their duties and work time so that all the information disseminated by the CCTV cameras from onsite should be well analysed and be transferred to the related department for further scrutiny and analysis to ensues safety of the public through accidents reduction, response time reduction and protection of people and properties in the City of Kigali.

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LIST OF ACRONYMS AND ABBREVIATIONS

2D	Two Dimension
3D	Three Dimension
ANPR:	Automatic Number Plate Recognition
AVR	Automatic Vehicle Recognition
CCTV:	Closed Circuit Television
CoK:	City of Kigali
DBN	Deep Belief Network
DCT:	Discrete Cosine Transform
FMS:	Facility Management System
FRS:	Facial Recognition System
GIS:	Graphic Information System
GPS:	Global Positional System
HMM:	Hidden Markov Method
IR	Infrared Radiation
IVS:	Intelligent Video Surveillance
IVSS:	Intelligent Video Surveillance System
LDA:	Linear Discriminant Analysis
LPR	Licence Plate Recognition
MDGs:	Millennium Development Goals
MLN	Markov Logic Networks
MRF	Markov Spatio-Temporal Random Field
PCA:	Principal Component Analysis
PTZ:	Pan Tilt Zoom
RGB	Red Green Blue
RNP:	Rwanda National Police
SDK:	Software Development Kit
SPSS	Statistical Package for the Social Sciences
SVM	Support Vector Machine
ODF:	Optical Distribution Frame
UNICEF:	United Nations Children's Fund
UPS:	Uninterrupted Power Supply
UR:	University of Rwanda
UTP:	Unshielded Twisted Pair
VA:	Video Analytics
VBS:	Video Backup System
VES:	Vehicle Information System
VIP	Very Important Person
VIT:	Vehicle Identification and Tracking
VMS:	Video Management System

CHAPTER 1: GENERAL INTRODUCTION

1.0.Introduction

This chapter presents the background to the study, the statement of the problem, research hypotheses, the research objectives, significance of the study, the scope of the study, the limitation of the study, research methodology, dissemination of findings, and it will end by presenting a road map of the thesis for guiding the reader.

1.1.Background and Motivation

The today's technology driven world is constantly changing and this requires the public safety to be also quickly evolved by involving public surveillance systems to reinforce the role of law enforcement agencies (Bernard, 2011). Public surveillance systems conducted by video surveillance are the useful eyes on the streets but they cannot replace patrol officers of investigators (Nancy *et al*, 2011). Video offers both officers and investigators the unique ability to see incidents, circumstances, and people of interest with their own eyes. Investigators can use footage to assist them in interviewing witnesses and corroborating stories. Patrol officers, familiar with individuals residing in neighbourhoods, may be especially helpful in identifying witnesses, suspects, or victims. The cameras allow police officers to identify the people that were present at the scene of the crime and then use their personal ties with the neighbourhood to gain cooperation of those eyewitnesses.

As with other technologies, video surveillance systems by public cameras are best viewed as tools to support and enhance traditional policing of reducing crime rates, protecting people and their properties. Cameras typically produce colour images, when there is sufficient lighting, and black and white images at night without audio and often with varying image quality. Alone, these images may mean little. In the hands of trained officers and investigators, however, these images can provide information on people, circumstances, and incidents leading to arrests and prosecutions against the criminals and public safety violators.

Rwanda is one of the fastest emerging economies in the world like other countries that take public safety as first priority in security matters. Rwanda is faced with ever changing societal dynamics that challenge this economic growth. According to UNICEF, 70% of people around the world will live in cities by the year 2050; this trend toward urbanization will necessitate new operational models and pose challenges in terms of how to protect residents and their properties. People in Kigali city need safety in order to live well and undertake business and communications where Public safety innovation is important because it is a major contributor to economic development. The rapid growth of Rwanda's population and urbanization also throws up several challenges that if not dealt with threaten the very growth that the country aspires to pursue. The inevitability of income disparities as the economy grows invariably leads to increased crime and threats to property.

The Rwanda National Police (RNP) plays a crucial role in safety and security system to support real time access to information held in areas related to crime prevention, Intelligence gathering, Community Policing, Emergency Response, Traffic management among others. RNP needs an efficiently smart intelligent video surveillance solution with advanced databases and analytic intelligence features to ensure public safety systems that can help to provide accurate information for operational purposes.

Recognizing the national urgency to quickly transform Rwanda and take it further on the path of prosperity and fulfil its Vision 2050 and MDG targets, Rwanda needs to provide an enabling environment that is safe and assures the security of individual and corporate property, boost investor confidence and contribute to the growth of the overall business climate.

These situations have an implication of the need for smart intelligent video surveillance as a solution for information asset to respond to the business change. Smart Intelligent is necessary in the design of an information infrastructure with a specific framework for the creation of an information system that is effective and efficient, which supports the information society easily within the organization. The information infrastructure can refer to the communications networks and associated applications that support interaction among people and organization (Blair, 1994).

This research activity focused on understanding, and identifying problems, as well as providing a contribution of intelligent video surveillance solutions could solve this problem. The work is mainly focuses on the evolution and growth of the video surveillance system which is useful in integration of video analytics, facial recognition, and vehicle identification and tracking.

1.2.Problem Statement

The security and safety of people moving to and from the City of Kigali by walking or cycling, by bus or in a private vehicle, and the provision of safe road networks are a key priority for Rwanda National Police. In cities, where the number of population continuously increases faster than the available cities infrastructure to support them, security and safety is a difficult issue to deal with. This problem affects many aspects of modern society, including economic development, traffic accidents, time spent on investigating issues related to public violence and others (Paden, 2004). In this context, modern societies can rely on security and safety management system to minimize the incident, accident, and its negative effects.

Based on observations and results obtained during the research at RNP, we noted that most of the critical Information Systems exist in RNP except for few systems that can greatly enhance safety in a great way, which prevents RNP from having an intelligent system that reduces response time (RNP, 2019). Therefore, this study examined the contribution of smart intelligent video surveillance solutions for public safety to contribute to the efficient system and give recommendations to both public and Rwanda National Police, whereby Rwanda National Police drew attention to engage in re-formulation of the strategy to reduce the number of incidents and accidents in Kigali city.

Meeting these challenges marks the critical success of Kigali city in promoting public safety of the people and properties. The RNP mitigates these challenges related to public safety for better protection of people and properties. The research benefit has to develop sustainable intelligent video surveillance strategies and programmer's in-depth reviews the main challenges and future perspectives at RNP in order to increase safety awareness and to boost the confidence of business community in the security of life and property. Thus, it is upon this regard the researcher conducted this research to examine the contribution of smart intelligence video surveillance on public safety in Rwanda.

1.3. Research Hypothesis

H_o: Smart intelligence video surveillance does not contribute to public safety in City of Kigali with a case to Rwanda National Police

H_1: Smart intelligence video surveillance contributes to public safety in City of Kigali with a case of RNP

The researcher expected that the findings of the study will reveal that smart intelligence surveillance contributes to public safety in the City of Kigali because smart video intelligence have contribute in enhance public safety in a number of countries that use CCTV cameras to ensure public safety. The researcher also expected to finding that video analytic features have an effect on public safety, facial recognition having a significant contribution in promoting public safety in City of Kigali and proving that there is a positive and significant relationship between vehicle identification and tracking and public safety in City of Kigali.

Basing on the results expected to be drawn from the hypothesis of the study, the researcher expected to recommend to the government and other stakeholders in public safety matter to put much effort in implementing the new system include the use of video analytic features, vehicle identification and tracking system that works with Automatic Number Plate Recognition and facial recognition. Fortunate the results expected have revealed the same data that have indicated that there is a significant positive relationship between smart intelligence video surveillance and public safety which implies that smart intelligence video surveillance has great contribution to the promotion of public safety in City of Kigali.

1.4.Study Objectives

1.4.1. General Objective

The general objective of this study is to determine the contribution of smart intelligent video surveillance solutions to the public safety in Kigali city with reference to the case of Rwanda National Police.

1.4.2. Specific Objectives

The main objective is broken down into the following specific objectives:

(i) To find out the effect of video analytics features on public safety in City of Kigali with a case of Rwanda National Police

(ii) To determine the role of facial recognition system on public safety in City of Kigali with a case of Rwanda National Police

(iii) To assess the relationship between vehicle identification and tracking and public safety in City of Kigali with a case of Rwanda National Police.

1.5.Significance of the Study

The research findings will contribute to the understand the role of Rwanda National police in collecting safety related data from different sources of information including information given by CCTV cameras and ANPR cameras. Furthermore, the exploration and aggregation of such information in collaborative manner involving the data centre, Traffic police and fire brigade will help to identify safety and security related accidents or risks easily and consequently get controlled and managed on time to ensure safety and security of both people and properties in Rwanda.

The research findings are also significant to the future researchers whereby they work as the point of reference in the areas regarding contribution of smart intelligent video surveillance in promoting public safety in Rwanda. The research findings also are significant to the library of University of Rwanda where the findings are the added literatures to the existing literatures in the library.

The research findings are also significant to the policy formulators who use the results of this study as key information to formulate public safety related policy. The researcher findings are significant in mobilizing and sensitizing the role of public security and can also be used by the community to be aware that their safety and security of the public is the primary priority of the country in order to reduce crimes, accidents and incidents in the city of Kigali, Rwanda.

1.6.Study Scope

In general the research aimed to find out the contribution of smart intelligent video surveillance to the public safety in City of Kigali. In particular the Kigali city was given special attention because it is backbone of CCTV infrastructure development. The research study took ten months to complete; this also included the field surveys meant for data collection. The survey data was obtained from employees of RNP who have worked on different public CCTV projects scattered around the country and those who work in video surveillance department in the timeframe of 4 years. The study conducted in-depth semi-structured interviews with a range of interviewees who are operators of CCTV devices. Specifically, this study focused on improving video surveillance technology to promote public safety.

1.7.Organization of the Study

This thesis is structured into six chapter; the chapter one that deals with introduction which presents the context and background information on the research topic, the research questions are presented and the importance of the study is discussed. Chapter two that focuses on literature review. This chapter critically reviews and examines the relevant literature to the research question. The chapter defines the Video surveillance and its impact on technology. The chapter then discusses the relevant enabling technologies of video surveillance. The benefits of the Intelligent video surveillance are outlined and its importance. Chapter three deals with research methodology which defines the methodological approaches applied in the study. The techniques, methods, approach and research strategies are presented and then the research choice is justified, data collection procedures and analysis, and the ethical considerations are explained. This chapter four deals with current model and expected model analysis and Design. This chapter also analysed the qualitative research, then the themes and finally the system models, proposed simulation models are discussed. Chapter five deals with result findings and analysis and it also presents the analysis and findings of the data collected during the research and explain the graphs of results. Chapter six focuses on summary of findings, conclusion and recommendations.

1.8.Gantt Chart / Project Research

The Gantt chart refers to a chart that demonstrates the amount done or production completed in certain periods of time in relation to the amount planned work for the periods.

Activity\Months of 2020	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Research Area Identification										
Research Topic Formulation										
Research Hypothesis										
Research Objectives										
Review of Literature										
Research Methodology										
Questionnaire Formulation										
Pilot study										
Research Proposal Writing										

Data Collection										
Data Analysis										
First Draft of Thesis										
Second Draft of Thesis										
Third Draft of Thesis										
Final Thesis										
Defence of Thesis Due										

Figure 1: Gantt chart

Source: Researcher, 2020

Basing on the figure 1 of Gantt chart the right bleu highlights the so far achieved thesis activities in a specified time of the month while yellow colour is highlighted in the expected activity in the précised time of activity.

CHAPTER TWO: LITERATURE REVIEW

2.0.Introduction

This chapter focuses on the review of related literatures whereby the theoretical review of key concepts were reviewed, the empirical review of previous studies were also reviewed and conceptual framework demonstrating the relationship between the variables of the study which are smart intelligence video surveillance as the independent variable and public safety as the dependent variable.

2.1.Theoretical review

2.1.1. Smart Intelligence video surveillance

Intelligent video surveillance is the cutting edge video technology that records criminal activity in homes, businesses, and municipalities based to the preferences of the user. Features of Intelligent video systems include tracking a moving target and automatic detection of suspicious activity, which can trigger alarms and alert homeowners and business owners to potential threats. Intelligent video can provide high definition picture quality as well as night vision technology triggered by motion sensors, so the tape isn’t running while nothing is happening at the location (Security Alarm, 2014).

It is predicted that nearly 60% of the world's population will live in urban areas by 2025, which will increase the growth of smart cities, which would require innovative and efficient technologies to support smart systems. Video data and analysis would play a major role in the design of such systems. Existing urban cameras can act as activity sensors and the inputs of these cameras can be powered in custom algorithms for analysis.

The most important aspect of Smart Cities would be intelligent security and surveillance. With video analysis, remote and unmanned monitoring is possible. For example, there would be no need for manual surveillance, no object detection without surveillance, no securing of precious goods, no illegal parking, no intruder detection. All of this can be done efficiently and automatically using configurable video analytics which can help reduce false alarms, and most importantly, leveraging personalized alerts in real time so that appropriate and timely action can be taken. This can also be applied in many other cases such as stroll detection, crowd monitoring, counting people, vandalism, queue management, etc. Facial recognition systems can help us reduce criminal activity by helping us catch criminals faster.

Another important aspect of smart cities is intelligent traffic management. Counting vehicles in high traffic areas can help with re-routing to avoid traffic congestion. Recognition of license plates helps reduce traffic violations. Bad sense, illegal parking, speed zones and vehicle tracking are some of the other applications of video analytics, which will help create an intelligent traffic system with real-time assistance.

The RNP holds a comprehensive and integrated smart intelligent system with enhanced efficiency and effectiveness smart technology used to support public safety needs to make Kigali city safer, smarter, secure and sustainable based on the following keys elements:

2.1.2. Video analytics

Currently, a big number of cameras have been installed in public spaces as part of intelligent video surveillance systems. These systems are continuously developed due to advances in video content analysis algorithms. Due to the variety of solutions, the following categories have been considered: systems based on the detection, monitoring and analysis of object movements, systems capable of preventing, detecting and identifying abnormal and alarming situations, systems based on detection and circulation of vehicles or analysis of parking lots, object counting systems, systems based on multiple views of integrated cameras, systems preserving confidentiality, etc. The literature describes several solutions for each category and highlights the main characteristics of current intelligent surveillance systems. Analysis of the applications of alternative systems has shown that it is necessary to build the video surveillance solution of public space to effectively detect events threatening public security, especially in places characterized by the simultaneous movement of a large number of persons.

As a result, many companies are now able to do video processing, and, in doing so, they can claim that they can provide many Video Analytics (VA) features (as shown in Table 1). Obviously, some of these features are much more difficult than others, if at all possible. The key question is therefore to know which of these functionalities are to be deployed and which are not. A non-exhaustive list of VA functionalities reported according to their documentation and their websites. The left column lists the technologies that are much more difficult than those listed in the right column.

Table 1: Video Analytic (VA) features

Harder	**Easier**
Human / Object Recognition and Tracking	Intrusion Detection / Virtual Tripwire
Object Classification	Autonomous PTZ Tracking
People Counts	Stopped Vehicle Detection
Vehicle recognition	Camera Tampering Detection
People recognition / Face recognition	Congestion detection
Unattended Baggage Detection	Counter Flow
Object Removal Detection	Automatic Licence Plate Recognition
Loitering Detection	Object Alteration Detection
Tail-gating	Audio and Sound Classification
Waiting Line Control, Crowd management	Face Detection / Face Tracking
Special Attribute Detection	Vandalism detection
Advanced Behaviour Analysis	Highway (vehicle) count

Source: (Elliott, 2010)

2.1.3. Main issues related to intelligent surveillance systems used in public spaces

As a public space, we mean how to reach people and generally open areas such as roads, parks, sidewalks, parking lots, squares, etc. Some parts of buildings and other urban infrastructure can also be considered public spaces if they are open to the public, e.g. public transport (railway platforms, halls, and waiting rooms), shopping centre (corridors), and government buildings (e.g. library or rooms where customers are served by officials). Today, video surveillance systems are rapidly being placed in public spaces to strengthen public security. Numerous surveillance cameras have been installed due to their decreasing costs. The law enforcement community is increasingly relying on video surveillance for crime prevention and community security.

Originally, video surveillance systems were designed for human operators to remotely observe the protected space or simultaneously record video data in the form of files for further analysis. Watching surveillance videos is a labour intensive task when you have to control a large number of cameras. Furthermore, it is also a tedious task and human observers can easily lose their attention. Automation can help overcome cost and performance issues. Additionally, it can free security personnel from routine tasks and allow them to focus on higher-level cognitive work that best utilizes their capabilities. Intelligent video surveillance (Singh, Sep. 2009) is of great interest to industrial applications due to the increased demand for reduced analysis of large-scale video data.

Regarding terminology, Elliott recently defined an Intelligent Video Surveillance System (IVSS) as any video surveillance solution that uses technology too automatically, without human intervention, process, manipulate and / or perform actions on or due to live video images or stored (Elliott, 2010). The industry and academics, being motivated by the availability of powerful and low cost computing hardware, have developed the key technologies for intelligent surveillance, such as object tracking (Avidan, Feb. 2007) (Khan, Sep. 2010), pedestrian detection (Dalal, 2005), gait analysis (Wang, 2006), vehicle recognition (Wang S. L., Jun. 2007), privacy protection (Yu, 2008), face and iris recognition (Park, Sep. 2010.), video summarization (Cong, Feb. 2012)and crowd counting (Cong Y. G., 2009). Video surveillance systems have been used for various applications, such as traffic monitoring, security, post-incident analysis, etc. IVSS integrates computer vision technologies into video devices such as cameras, encoders, routers, digital video recorders, network video recorders, and other video storage and management devices (Venetianer, 2010).

Recent advances in image processing, photographic equipment and wireless communication have led to an increase in the rate of installation of new video surveillance systems in private and public places, such as airports, train stations, banks, restaurants, schools, hospitals, homes, etc. The video data collected by the cameras present in the facilities have many applications outside the surveillance field. Most notable of these are smart environments where video data can be used to identify occupants and analyse activities taking place in these environments. The ability to "see" enables smart solutions to meet the needs of its users. Existing smart video surveillance systems offer many features. Simultaneously, it adequately expresses the capabilities of advanced techniques in the field of visual content analysis: detection of moving objects, in particular human silhouettes, that is, the classification of the object detected as people (Paul, 2013) (Nguyen, 2013), intrusion detection/perimeter protection crowd behaviour analysis

(Zhang, 2013), activity recognition and behaviour understanding (Vishwakarma, 2013), abnormal/irregular behaviours detection, such as fight (Blunsden, 2009), faint (Rougier, 2011), fall (Ngo, 2012), sudden events (Suriani, 2013), counting the number of moving objects (Karpagavalli, 2013), object tracking and trajectory analysis (Morioka, 2010), vehicle tracking and traffic analysis (Jiang, 2013), smoke/fire detection (Çetin, 2013) camera tampering detection abandoned/taken object detection (Miyahara, 2013).

Video surveillance systems used in public spaces must cope with a high traffic density, as well as the heterogeneity, variability and occlusions of the objects that appear. These systems often have to detect sudden and complex events. However, there is another set of problematic aspects associated with confidentiality, namely the preservation of the confidentiality of the monitored area in public spaces. The widespread use of video surveillance has raised privacy concerns and undermines people's right to anonymity. Video surveillance combined with biometric technology (e.g. face recognition) raises even more of these concerns (Barhm, 2011). Video cameras constantly monitor the movements of pedestrians on the streets, in stations, in stores, in the workplace and others.

People generally do not like their activities to be recorded and observed by others. With increased automation and the growing network of computers and various information systems, the potential for information linking has raised concerns about the harmful effects of video surveillance on our privacy. The main challenge here is to understand and analyse the different channels of inference that can lead to a violation of privacy. Although these inference channels are well studied in the context of traditional data exchange applications (for example, a hospital that publishes patient records and GPS-based location services), it is difficult to understand the inference channels. Inference embedded in a semantically rich video (Saini, 2014). For example, by incorporating an automatic face detection mechanism into the video surveillance system and connecting it to the database or networked systems, important information can be extracted. Surveillance systems are owned and operated by public and private organizations that may abuse surveillance data to their advantage. Surveillance data can be used to identify people, their daily activities, the collection of demographic information, etc. Therefore, mechanisms capable of meeting surveillance objectives and guaranteeing people's privacy are necessary (Zhang P. T., 2012).

2.1.4. Face recognition

Facial recognition is a method widely used for safety concerns and is also used in various applications. This technique is widely used as the most reliable real-time application for victim identification. The facial recognition technique is the method of making people by combining two images or video sequences based on the characteristics of the face. Figure 1 below shows the facial recognition process.

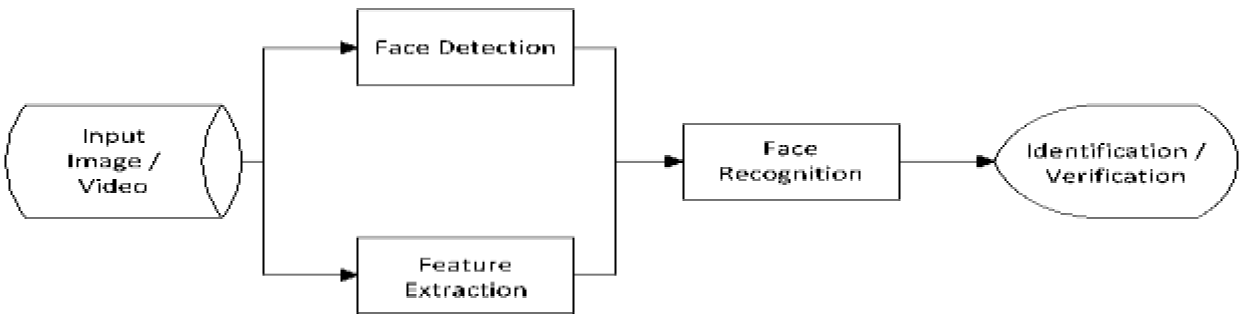

Figure 2: Block Diagram of Face Recognition

Source: (Naeem, 2015)

Initially, as the functional diagram indicates, the facial recognition technique wanted to detect the face. If a particular face of the image is detected first (Jyoti S. Bedre, 2012). The next process is the extraction of the characteristics of this method, different characteristics of the image will be detected. Some of the characteristics are visual characteristics, coefficient characteristics, pixel characteristics, light characteristics and algebraic characteristics which provide details of a particular image. Taking into account the above characteristics, the details of the image will be classified according to certain criteria.

This literature on facial recognition studies the evolution of the facial recognition method in each period and analyses the merits and demerits of each evolutionary period. This helps to understand the importance of the facial recognition technique.

Eigen faces are widely used face recognition method. This method is also known as the Eigen picture, Eigen vector, and principal component (Pentland, 1991).The basis of the Eigen face method is Principal Component Analysis (PCA) which performs dimensionality reduction. Eigen face is the practical approach for the face recognition in which principle components are divided into feature vectors. Eigen faces are very easy to implement because of the simplicity in algorithm and storage space required is very low. It has high processing speed. The accuracy of Eigen face method depends on many things. There will be a high correlation between training data and recognition data. In Eigen face method single face images as well as double face images can also analysed. In 1997, Dual PCA projections also proposed. Advantage of the system is identifying the necessary Eigen faces only to make system perform efficiently (SushmaJaiswal, 2011). Demerit of the Eigen face method is very difficult to detect the faces in various head position and it is very sensitive to detect Eigen values in some lightening conditions. Sometimes the process of identifying the Eigen vectors and Eigen values are time consuming event. It is concluded that Eigen face method is simple, accurate method. It has wide variety of application such as motion tracking in films. Some drawbacks like sensitive to change in light, direction, angle, position and distance are there. Even though there is drawback it provides good results.

Fisher Faces: Fisher faces is based on the appearance method which is widely used in the face recognition method (Fisher, 1936).R.A Fisher developed the linear discriminant analysis for face recognition during 1930s. (SushmaJaiswal, 2011)In this method the various classes with in the image will be detected but the demerit of this method as it shows less accuracy in various lighting conditions.

Elastic Bunch Graph Matching: As the name mentioned above this face recognition technique is using a data structure named bunch graph. Here the land marks are identified by this bunch graph (LaurenzWiskott, July 1997).The features are extracted from the images and detect the face by taking the number of instances of Gabor filter which is called as the Face Graph. In this method images are compared with the graph and will generate a new graph. A Particular image graph shows its jet orders such as spatial arrangement it will compare with the other image if it is matched with the other one then we can easily analyse the matching of the two images. Sometimes the direction, spatial order, rotation and distortion will give increased similarity. (SushmaJaiswal, 2011)The main advantage of this method is missing of one vector cannot be led to the missing of the face. If a new face is recognized by this method it will automatically save in the database. We can say the demerit of this method as the recognition rate is less when change in lightening is large.

Hidden Markov Models Method: Hidden Markov Method (HMM) is well promised for detecting the face in the difficult conditions such as variation in lighting, facial expression and orientation.

The objective of this method is to find out the hidden parameters from the observable parameters. It will perform well in speech signal as well as character recognition. Probability distribution method is highly used to recognize the hidden parameters from observable one. Sometimes in HMM method 2D discrete cosine transform can also be used to feature vector (Nefian A.V., 1998).In many tests it is proved that HMM method is better than Eigen faces when we compare the image with variations.

Principal Component Analysis: Dimensionality Reduction is the statistical method for principal component analysis. In this method there is a serious problem in accuracy and classification time (Ahmed, May 2017) (Mohammed Javed, April 2013).Even though this method is also powerful tool for the face recognition technique.

Discrete Cosine Transform: Discrete Cosine Transform (DCT) is using for transforming images, compacting the variations, allowing an effective dimensionality reduction. (Ahmed, May 2017)It has strong energy compaction properties. When DCT applied to image the energy will compact to the upper left corner.

Linear Discriminant Analysis: Linear Discriminant Analysis (LDA) is used to find linear combination of the features between the classes in the images while the modelling. Two demerits are introduced in 2014 by Murtaza et al. The prime demerit is about the instability of the LDA when number of samples in the intra class is smaller than dimensionality of the sample in the training phase. Second demerit is the higher computational cost (Ahmed, May 2017).For solving the problem, applied an Adaptive Margin Fisher's Criterion Linear Discriminant Analysis (AMFC-LDA).When this algorithm applied far more better results are obtained.

Neural networks Algorithms: These algorithms are used as the research tools in the face recognition method. This may be used along with the Gabor filter in order to overcome illumination variations. It will give better results by applying the multi-layer perceptron with back-propagation algorithm and this method gives better results in which fuzzy neural networks is the latest approach.

Gabor Wavelet: This function provides conjoint resolution of information in the 2D Spatial and 2D Fourier domains. Gabor Wavelet is spatial band pass filter. When we consider the image it will classified into four different dimensions; and two spatial directions and other two spatial frequencies (Senan, 2017). The local image features can also detect by the Gabor Wavelet. These are biologically motivated convolution kernels of different orientations and frequencies. This type one image pixel is known as jet (SushmaJaiswal, 2011).

Template Matching: Consider a test image which is two dimensional arrays of intensity values, such as Euclidean distance. (Ahmed, May 2017) In which a face is representing with single template. For analysing a particular person's face we can use different types of templates. The main drawback of this method is the complexity in the computations. Descriptions in these templates also faces the another problem. There may be some feature changes between the template and the test image which leads to average out the differences that make individual faces unique.

Graph Matching: Graph Matching is another method of Face Recognition. Here the elastic graph matching helps the dynamic link structure for distortion invariant object recognition to find the closest stored graph (Lades, 1993).The image vertices are labelled with a multi resolution description in terms of a local power spectrum, where the edges also labelled with the geometrical distance vectors. Object recognition is obtained by the elastic graph matching.

3D model: 3D data usage increased the opportunity of working predominately with the face recognition technique. Camera always captures the image which is come after the reflection from the body. Many factors depend upon this reflected image such as surface geometry, albedo, brightening, contrast, illumination and spatial characteristic. The only way of detailed analysis of the image is to apply 3D Model analysis (Hamouz, 2007).3D model always gives the various parts in the images, align the model and cover various property analysis (Zisserman, 2004).

Infrared: Infrared analysis obtained by considering the thermos grams that is calculating the amount of heat discharged from an object. The temperature discharged from an object varies with another one because this depends upon the various properties such as characteristics of material and temperature of the object itself. Thermal image analysis is very popular in these days. It happens by analysing the temperature generated by blood vessels under the facial skin (Kong, 2005).Particular camera is used to detect the thermal variation and detect the images (Dowdall, 2001). (Dowdall I. &., 2003) When the two images provide the same spectra of information we can conclude that the person is same. In conclusion, each method has its own demerits. So the advanced methods want to be applied for improving the greater results.

The facial recognition technology is a popular scientific technique that also has a great application. Therefore, facial recognition techniques are also vulnerable to many challenges. Today, most crimes are detected through image analysis. We discuss in this article the evolution of the facial recognition technique. In each period, this technique has improved even though we have experienced demerits in each phase. Finally, facial recognition techniques are becoming very accurate and widely used in many fields. We have examined many algorithms and methods to increase the efficiency of the facial recognition technique. It is true that in the future a new algorithm can be applied in this technique to improve performance more precisely.

2.1.5. Vehicle identification and tracking

In this study, we study various traffic monitoring models that attempt to manage and manage a huge traffic flow with optimized human intervention. Applications for these systems include identifying the vehicle in traffic, detecting traffic congestion on a highway, measuring vehicle speed, traffic density at intersections, the presence of VIP vehicles or ambulances, traffic accidents, the pedestrian path and many others. Typically, intrusive and non-intrusive embedded technologies are used for traffic monitoring, but image processing techniques take precedence over these traditional techniques. The purpose of this research is to discuss previous research work done to monitor traffic using video and image processing techniques and future perspectives. Due to traffic congestion, there is an obvious waste of many resources. Traffic congestion can occur for the following reasons (ROSEN, 2013):

1. Too many cars for the roadway due to inadequate mass transit options or other reasons.
2. Obstacles on the road cause a blockage and merger. These can be double parking, roadwork, lane closure due to utility work, road narrowing down, and an accident.
3. Traffic signals out of sync many times on purpose or occasionally when the computers are malfunctioning.
4. Inadequate green/red time.
5. Too many pedestrians crossing not permitting cars to turn.
6. Too many trucks on the road due to inadequate rail freight opportunities.

7. Overdevelopment in areas where the mass transit system is already overcrowded and the road system is inadequate.
8. Delay in removal of accidental vehicles on roads.
9. Poor weather conditions.

2.1.6. Vehicle identification and tracking methods

Messelodi *et al.* (2005), they proposed a real-time vision system by analysing sequences of monocular images from subsequently mounted cameras. Their experimental results demonstrated the detection, monitoring and classification in real time of vehicles in different hours of video shot in different lighting conditions.

Lee and Baik introduced a vehicle tracking video system to provide information on directional traffic counting at intersections. The extracted data were fed to estimate a travel table from origin to destination that was information necessary for the study of the impact on traffic and transport planning (Lee S. B., 2006).

Aycard et al. proposed an intersection security approach developed within the INTERSAFE-2 European project. A complete solution to the safety problem, including risk perception and assessment activities using the integrated Lidar and stereovision sensors presented, and better results were presented (Aycard, 2011).

Wang et al. introduced an approach to monitoring and counting multiple vehicles in real time using a fisheye camera based on the detection, grouping and association of individual function points. Movement similarity and close weighted grafting were used to transfer knowledge of movement between long and short point paths (Wang W. G., 2015).

Jodoin et al. they proposed a tracking system to track different road users in different ways and aspects. The finite state machine has successfully fragmented, divided and joined road users to correct and improve the trajectories of the resulting objects. This tracker has been tested on various urban intersection videos and has performed better (Jodoin, 2016).

Liu et al. used a method that accurately detects vehicles using a probabilistic classification method followed by a refinement based on segments of objects. Both classification and segmentation methods used recorded aerial RGB images and LiDAR data in the air (Liu Y. M., 2016).

Huang et al. they introduced vehicle detection in the tunnel, which is a difficult problem due to the use of heterogeneous cameras, various camera installation positions, low resolution video, poor tunnel lighting and reflected lights on the tunnel wall. The proposed method was based on background subtraction and the Deep Belief Network (DBN) with architecture with three hidden levels (Huang, 2017).

Tang et al. proposed a vehicle type detection and recognition technique based on static images. This technique was very practical and directly applicable to various operations in a traffic monitoring system. First, functions similar to the Haar and AdaBoost algorithms have been applied for the extraction of the characteristics and the construction of the classifier, which have been used to locate the vehicle in the input image. Hence, Gabor wavelet transformations and a local binary pattern operator were used to extract vehicle characteristics on multiple scales and multiple orientations (Tang, 2017).

Ukani et al. uses video surveillance systems to detect and classify vehicles in real time. The background and subtraction of each vehicle was extracted from the SIFT (Scale Invariant Characteristic Transformation) functions. The vehicles were classified using the neural network and the support vector machine (SVM). SVM showed a better generalization than artificial neural networks (Ukani, 2017).

For smarter systems, it is always necessary to collect large amounts of data across the city and then analyse it to extract information useful for decision making and to create an intelligent response system. Smart City solution providers will face challenges in increasing network load due to the large amount of video data passing through their networks. The next is the integration of video analysis with the city's existing infrastructure and algorithms, depending on the scenarios in which they are used.

Video analytics has been on the market for a long time, but it must evolve with evolving trends and sophisticated requirements. For profitable analysis, distributed architecture with user control seems to be a good solution. The architecture should take advantage of the integrated functionality of existing cameras, reducing the need to configure the infrastructure from scratch.

This video analytics platform identifies the most accurate algorithms / components based on your configuration and can report results and create customized alerts in a preconfigured way for greater accuracy. For greater hardware independence and efficiency, video analysis processing can be deployed across all core hardware, helping to reduce costs by avoiding the need for high-end servers. In smart cities with different applications of video analytics solutions in sectors such as security systems, utilities and emergency response systems, it offers users an easy way to choose the transmission they want, by instrumenting the analysis they want and underlines the shape they need in a simple and configurable way.

2.2.Empirical review

Automatically detecting and tracking multiple objects in the scene is a difficult problem. There are multiple solutions for human detection, ranging from generic algorithms and ending in specially developed architectures to manage the human silhouette. The most common challenges are related to the detection of collisions and occlusions. Additionally, the algorithm must be able to re-identify the target in other camera views, or when an element in the scene temporarily or partially hides it. This task is particularly difficult when two or more people (following targets) are obstructed in front of the camera, which can cause an identification problem. The main idea of multiple object tracking systems is, a priori, to include information about the object of interest. In the case of human objects, information about their shape is used (Cancela, 2014).

The method proposed in (Tathe, 2013) deals with detection and monitoring. Detection includes face and eye detection. Once the face is detected in the frame, the coordinates of the eye region are calculated and tracked. The face, as the most individual part of the human body, is an important element of human identity. It varies from person to person, but can be located using certain background information. The complexity of the face causes most of the difficulties in developing the face model. Internal (facial expression, beard, moustache, glasses) and external factors (scale, conditions and beam orientation) influence the human face. Face detection based on skin colour segmentation is the simplest technique and requires the least amount of calculations.

In (Kushwaha, 2012) the authors propose another technique to detect and track various human objects in the video. The solution includes the Haar-like type classifier for object detection and a particle filter for tracking. Based on the experimental results, the proposed technique performs well in the presence of poor lighting conditions, variation of human objects in poses, shape, size, clothing, etc. It handles variable times in number of people.

In (Andersson, 2013) the problem of abnormal movement patterns in urban video surveillance is studied. Abnormal movements are generally caused by people merging into dense groups and causing riot or threatening situations within the group. The authors attempt to detect abnormal crowd movements automatically. They use unsupervised Kmean clustering and semi-supervised Hidden Markov model (HMM) as a crowd analysis tool. By modifying the K-means values, and by examining the density of the groups, the quality of the groups, and changes in the shape of the groups, the results show patterns of movement that correspond well to the events in the sequences of video. This leads to the conclusion that the analysis process can be automated. The results also show that very accurate detections of people in the dense group would not be necessary. Uncertainty in detections does not have an essential influence on the analysis process.

Video surveillance systems are capable of managing hundreds or even thousands of cameras, for example to cover a large mall or busy airport. A large number of cameras can cause communication problems. Therefore, by compressing the captured video on a local camera processor or on the nearby video server, it is possible to avoid communication bottlenecks. The compressed video is streamed at a central storage and viewing facility. The key to effective and economical video surveillance is automatic detection of abnormal movement in real time. Automatically detected abnormal motion can trigger video streaming and recording and can be used to draw the attention of the human observer to a particular video channel or even to alarm appropriate security services (Kiryati, 2008).

The study conducted by Calavia (2012) revealed that an intelligent video surveillance system that, when analysing the movement of objects, is capable of detecting and identifying abnormal and alarming situations. The main advantage is that by minimizing video processing and transmission, the system allows a large number of cameras to be deployed. This advantage makes the system suitable for use as an integrated security solution in smart cities. The system detects abnormal and alarming events based on the parameters of moving objects and their trajectories. The system also uses an easy-to-understand, high-level conceptual language for human operators using semantic reasoning and ontologies. Therefore, it is capable of activating alarms enriched with a description of the situations in the video. Furthermore, the system can automatically react to these alarms by alerting the appropriate emergency services through the Smart City safety network.

The results revealed by Lim (2013) stated that an intelligent framework for detecting multiple events in surveillance videos. The basic principle of the framework is compositionality. The authors of the system modularize surveillance problems into a set of variables: regions of interest, classes, attributes and a set of event concepts. The results of the reasoning process allow for a broader and more integrated understanding of complex patterns of activity on the scene. In general, according to the proposed method, the process of detecting various events is classified into three main levels. The first level is associated with the data acquisition process. At the second level, knowledge of the environment is constructed, followed by analysis and reasoning based on the principle of compositionality. At the third level, any abnormal event triggers an alarm.

Cong (2013) have done a study on the detection of video anomalies that play an essential role in intelligent video surveillance. The researcher considers spatial and temporal contexts to detect abnormal events in the system. Spatio-temporal video segmentation is performed to characterize the video. Then, using a new region-based descriptor, the motion and appearance information of the space-time segment is described. The authors formulate the detection of abnormal events as a coincidence problem. They explain this approach emphasizing the greater robustness of this solution compared to the methods based on a static model, particularly when the training data set is limited in size (Lee, 2014). The abnormal event detection process is based on finding the best match for each space-time segment tested in the training dataset and aims to determine how normal it is by using a dynamic threshold. Compact random projections are used to accelerate this process (Su, 2013). Experiments and comparisons with advanced methods confirm the superiority of this approach (Park, 2012).

The framework described in (Onal, 2013) is capable of detecting complex events in surveillance videos. The system consists of three components. The first one detects moving objects in the foreground. The second component tracks and labels each detected object and manages occlusion situations. The last component creates and forms rule-based event models using Markov Logic Networks (MLN) to assign a weight to each rule. In the training process, events are inferred using MLN. The weight values assigned in this process are used to determine the occurrence of the event. The proposed system is capable of handling many complex events simultaneously.

In the traffic monitoring (Santos, 2013), the segmentation of traffic information brings particular advantages, e.g. automatically wraps traffic analysis regions. As a result, it speeds up the analysis of video feeds and helps detect driving crimes. In addition, road segmentation improves contextual information in traffic videos. In turn, in urban scenes, it is linked to the following challenges: urban scenes present more crowded landscapes; these landscapes are made up of many vehicles stopped on the roads; The paths in these scenes are not only parallel lines, but also deviate and intersect from different angles; And finally, pedestrians can complicate the challenge as they can cause errors when analysing road boundaries.

In (Bulan, 2013), the video-based real-time street parking occupancy detection system is presented. It is made up of video cameras that monitor street parking areas. The cameras continuously capture videos and transfer the image sequences to the central processing unit. Video data is processed to estimate street parking occupancy. This information can be transmitted to drivers via smartphone, radio, Internet, traffic signals or auxiliary signals of the global positioning system. The proposed method is designed to address various challenges associated with computer vision, such as shadows, reflections, lighting changes, occlusions, rain, and other adverse weather conditions, as well as camera shake due to wind or vehicle-induced vibration. The method takes advantage of various components of video processing and computer vision for background subtraction and vehicle and motion detection.

The authors of (Rao, 2014) study several key challenges of automatic vehicle recognition in multi-camera video surveillance systems and propose new technologies for these systems. The authors focus on two main questions for vehicle recognition: Automatic Vehicle Recognition (AVR) and License Plate Recognition (LPR). Automatic vehicle recognition addresses challenges such as multifunctional fusion, heterogeneous properties of cameras to extract regions, and detection / recognition of imperfect objects. A new idea for various AVR cameras for the video surveillance application presented in this article is based on the proposed adaptive license plate detection technique, connected component analysis and region level comparison algorithm. Furthermore, to improve the precision of LPR, the paper introduces a new LPR method based on a self-organizing neural network to identify alphanumeric characters on plates. The experimental results indicate the simplicity and efficiency of the proposed algorithms. The composite image has a quality comparable to the results of advanced methods.

Estimating the number of objects in a video is constantly a difficult task in computer vision. From a video surveillance point of view, the most common problems are related to counting people and vehicles in the sense of a dense estimation of traffic. Detection counting is a common approach. However, this requires explicit object detection and occlusion modelling and management. The authors of (Zhou, 2013) propose the method of counting arbitrary objects in an arbitrary scene. The method automatically determines the area of interest through the movement of objects in the scene. Also, a perspective effect is compensated when detected.

The other paper (Li J. H., 2011) presents an efficient automatic people counting system. You can accurately count the number of people in a region of interest. To effectively detect pedestrians, a functional bag model is used. It provides an acceptable distinction between static or slow moving pedestrians and the background. The proposed system has the ability to automatically select samples for pedestrians and non-pedestrians to update the classifier. It has the ability to adapt in real time to the specific scene. The experimental results have demonstrated the robustness and high precision of the system.

The regions monitored by video surveillance are often large. Due to the camera's limited field of view and to cover the entire scene area, multiple cameras are required. In the traditional video surveillance system, the monitored area is controlled by security guards. Guards can have a hard time tracking targets as it is difficult to watch many screens simultaneously for a long period of time. Therefore, it is practical to develop a surveillance system capable of integrating all video transmissions captured by multiple cameras into a single full view.

In (Chen, 2010) a 3D surveillance system based on the integration of several cameras is presented. The authors of the approach build the 3D environment model using flat patches and dynamically map the texture onto the 3D model to view the videos. By estimating the homographic transformations for each pair of image regions in the video content and the corresponding areas in the 3D model, the relationship between the camera content and the 3D model is obtained in the form of lookup tables. These lookup tables speed up coordinate mapping in video display processing. A complex environment requires smaller texture corrections to be processed accurately. On the other hand, this results in a higher calculation cost. Texture patches are automatically divided into appropriate sizes using the root mean square error (MSE) method to estimate the amount of distortion during image patch rendering. Finally, for better 3D visuals, moving objects that have been segmented from the background are displayed through an axis-aligned display panel.

Video surveillance systems play a strategic role in a variety of critical tasks, such as personal security, traffic control, resource planning, and law enforcement. They are widely implemented in many strategic locations, such as airports, banks, public transportation, or busy urban centres. People generally appreciate the feeling of increased security that these systems provide. However, some of them have raised serious concerns about the privacy and trust of the captured data. In addition, wireless cameras pose another major risk factor for the security of transmitted video transmissions. Illicit parties may intercept visual data and use it for harmful purposes, such as obtaining confidential data or maliciously manipulating it to hide some evidence and / or introduce false information. Therefore, it is necessary to introduce a reliable solution to protect the images and videos obtained their source devices and transmission media.

The (Castiglione, 2010) presents a video surveillance system that provides distributed trust and content confidentiality through the use of a hybrid cryptographic system based on a threshold multiparty key exchange scheme. The approach offers a flexible basic access control scheme for video content that can handle the problem of users losing their private shares. You can dynamically add new users who can participate in rebuilding content. The system can be practically realized in low-cost devices for special purposes.

Authors of (Zhang P. T., 2012) offer a novel, selectively revocable on-demand privacy preservation mechanism. Surveillance video can, preferably, for anyone, activate or revoke a view in complete privacy and without any influence on the privacy of other pedestrians on the scene. This is accomplished by tracking pedestrians using a new Markov chain algorithm with two hidden states. The system detects the contour of the pedestrian's head followed and hides her face using the encryption mechanism. The encryption mechanism uses a unique key derived from a master key for privacy preservation purposes.

A crucial requirement of privacy solutions is the understanding and analysis of inference channels that can lead to a violation of privacy. The estimation of the privacy of the video data has been reduced to different identifiers, such as the faces in the video. Other important inference channels such as location (Where), time (When) and activities (What) are generally neglected. In (Saini, 2014) the privacy deprivation model is presented. The model emphasizes and takes into account identity leakage through multiple inference channels that exist in a video due to what, when and where information. The approach models identity leakage and incorporates confidential information to determine privacy deprivation. The proposed model allows the consolidation of identity leakage through multiple events and multiple cameras.

The research studies associated with the development of intelligent video surveillance systems include several features and characteristics. The most current trends refer to the application of calculations in the cloud. On the other hand, the main problem seems to be related to the legal aspects of the protection of privacy and the anonymity of the people present in the captured scenes. In addition, there are some problematic technical aspects that entail difficulties with the analysis of the movement of objects for the management of the occlusion and the synchronization of various camera views during the operation of the system in real time. Furthermore, there is a continuing interest in the studies and development of existing standard features of video surveillance systems, such as the detection, monitoring and classification of moving objects, as well as the recognition of anomalous activities, behaviours and events.

The constant development of new techniques and an increasing number of scientific publications indicate intense research and the presence of unresolved problems. Therefore, there is still a large field for new advances and new applications of intelligent solutions, which explain the need to build the video analysis system that was able to increase the safety of public spaces using some of the latest scientific results in technology.

2.3.Critical Review and Research Gap Identification

This contribution of the current researcher is addressed through critically reviewing and identifying the gap left out by previous researcher. Thus, the previous researchers in this study of video surveillance and public safety have such as Tathe (2013) was interested in the complexity of the face that causes most of the difficulties in developing the face model. Internal (facial expression, beard, moustache, glasses) and external factors (scale, conditions and beam orientation) influence the human face. However, this current study has focuses on analysing the contribution of smart intelligence video surveillance and public safety.

The study conducted Kiryati (2008) have ignored the contribution of smart intelligence video surveillance and public safety and focused on the key to effective and economical video surveillance which is automatic detection of abnormal movement in real time. He asserted that automatically detected abnormal motion can trigger video streaming and recording and can be used to draw the attention of the human observer to a particular video channel or even to alarm appropriate security services.

The study conducted by Calavia (2012) revealed that an intelligent video surveillance system that, when analysing the movement of objects, is capable of detecting and identifying abnormal and alarming situations. The main advantage is that by minimizing video processing and transmission, the system allows a large number of cameras to be deployed. This advantage makes the system suitable for use as an integrated security solution in smart cities. The system detects abnormal and alarming events based on the parameters of moving objects and their trajectories. The system also uses an easy-to-understand, high-level conceptual language for human operators using semantic reasoning and ontologies. Therefore, it is capable of activating alarms enriched with a description of the situations in the video. Furthermore, the system can automatically react to these alarms by alerting the appropriate emergency services through the Smart City safety network.

The study conducted by Chen (2010) concluded that video surveillance systems play a strategic role in a variety of critical tasks, such as personal security, traffic control, resource planning, and law enforcement. They are widely implemented in many strategic locations, such as airports, banks, public transportation, or busy urban centres. People generally appreciate the feeling of increased security that these systems provide. However, some of them have raised serious concerns about the privacy and trust of the captured data. In addition, wireless cameras pose another major risk factor for the security of transmitted video transmissions. Illicit parties may intercept visual data and use it for harmful purposes, such as obtaining confidential data or maliciously manipulating it to hide some evidence and / or introduce false information. Therefore, it is necessary to introduce a reliable solution to protect the images and videos obtained their source devices and transmission media.

Though, most of the researcher who conducted their studies in this field of video surveillance and public safety has associated them with play a significant role in strategic place to ensure personal security, traffic control and law enforcement purposes. They have ignored the role of video surveillance in enhance safety of the public in terms of crime reduction, reduction of response time in case of emergence incidents and protection of people and properties.

2.4.Conceptual Framework

The conceptual framework demonstrates the relationship between the variables of the study including independent variable, dependent variable and intervening variables. In the case of this study, the independent variable is smart intelligent video surveillance which is measured by video analytic features, facial recognition features, Vehicle Identification and tracking; dependent variable which is public safety which is measured by reduction of accidents, reduction of response time and protection of people and properties and the intervening variables which can cause change in public safety and are internet availability and national security.

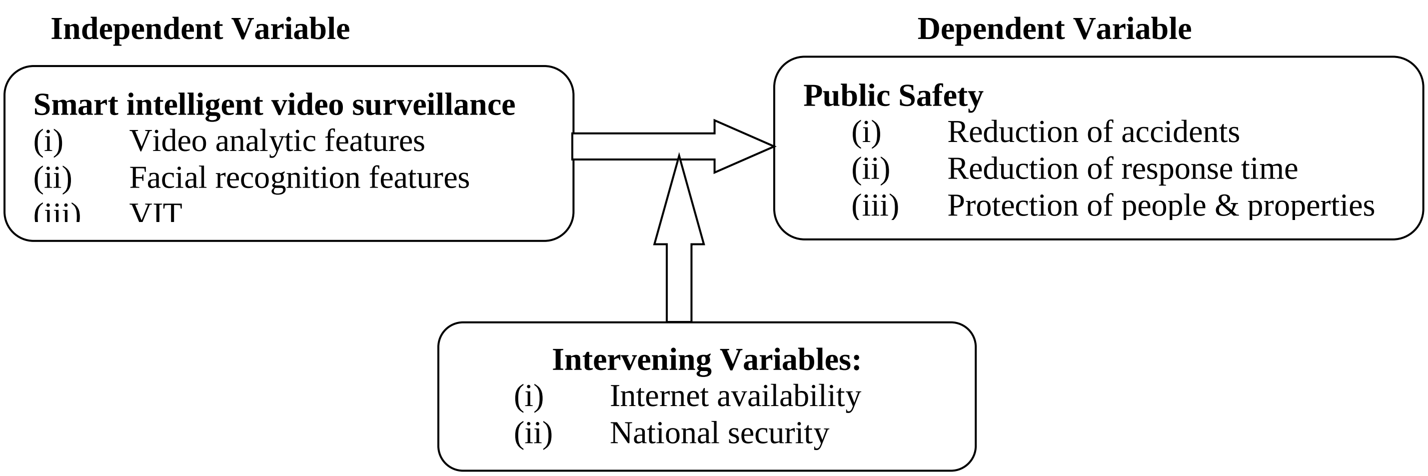

Figure 3: Conceptual Framework

Source: Researcher, 2020

The figure 3 demonstrates that there is relationship between smart intelligence video surveillance which is dignified by video analytic features, facial recognition features, Vehicle Identification and tracking; public safety which is measured by reduction of accidents, reduction of response time and protection of people and properties and the intervening variables which are internet availability and national security.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0. Introduction

This research methodology covers the techniques and methods that the researcher applied in data collection and analysis process. This techniques and methods includes descriptive research design, target population, sample size and sapling techniques, data collection instrument, reliability and validity of data collection instrument, data collection procedures, data analysis and ethical principles applied in this research.

3.1. Research Design

The researcher applied descriptive research design with a mixed approach of both qualitative and quantitative data to enhance this researcher to capture the broader picture of the situation of smart intelligence video surveillance and its contribution on public safety in City of Kigali with a case of Rwanda National Police. The descriptive research design helped to provide answers to the questions of who, what, when and how associated with a particular research problem (Mugenda, 2008); descriptive research design is also used to obtain information concerning the current status of the phenomena.

3.2. Target Population

The targeted population of this study are 86 employees of Rwanda National Police deployed in Video Surveillance. Mugenda (2008) defined target population as the entire group of individuals or objects that share the common characteristics that the researcher wants to generalise the research findings from. In the case of this study the employees of RNP that are employed in video surveillance are used as the whole target population.

3.3. Sample Size

3.3.1. Sample Size Determination

The sample of respondents has to be drawn from the target population. However, since the number of the employees of RNP deployed in Video surveillance comprises a manageable and a good sample for this researcher, the researcher has selected the whole number of target population as the sample size of respondents. Thus, it implies that the total number of respondent is 86 respondents who are selected using census as a sampling method.

3.3.2. Sampling Technique

The researcher applied census to the total number of target population to enable him to use 86 employees of RNP as the primary informant for this researcher. This census sampling technique were employed because the number of respondents are manageable and reasonable in terms of financial and time to involve in the whole study including proposal writing, data collecting, analysis, final thesis writing and defence of the final thesis.

3.4. Data Collection Instruments

Data collection tools are defined as the devices or instruments used to collect data from the field and these comprise the questionnaire, interview guide and observation checklist. In the case of this study the researcher used questionnaire and interview guide to collect information from the field.

3.4.1. Questionnaire

The researcher has used the questionnaire to collect the information from the primary respondents of the study. The researcher used closed and open questions to collect information from 83 respondents who are not in managerial position of Video surveillance at RNP in City of Kigali, Rwanda.

3.4.2. Interview Guide

The researcher has used interview guide to collect information from 3 respondents who are in the managerial position of Video surveillance at RNP in City of Kigali, Rwanda.

3.5. Reliability and Validity of Data Instrument

The researcher tested the data to make sure that collected data are valid and reliable. This was done through a pilot study using 10 respondents to test the reliability of the instruments and the collected data was analyzed to prove the reliability of the instruments. For the validity reasons, researcher consulted supervisor, coworkers as well experts that are knowledgeable in the area of video surveillance and public safety while formulating research instruments and later be tested in a pilot study to measure the competence and relevancy of the instruments.

3.6. Data Collection and analysis procedure

Data processing and analyzing entailed organizing data that are collected from the field, typing and editing, coding and cleaning and later be entered into SPSS version 21.0 to be analyzed and produce inferential statistics that included tables of descriptive statistics, tables of regression and tables of correlation that demonstrate the relationship between smart intelligence video surveillance and public safety in Rwanda.

The regression model used was Y= □0 + □1X1+□2X2 +□3X3 +□. Where: □0 = Constant, X1= represents video analytic features, X2= represents facial recognition system and X3= represents vehicle identification and tracking and □1, □2, and □3= represents regression coefficients. The five point Likert scale was used to find out the contribution of smart intelligence video surveillance to public safety in Rwanda. As mentioned, the results were presented in descriptive statistics, correlation and regression tables for easy understanding and this facilitated the researcher to interpret the findings in relevancy to study objectives and generate recommendations and suggestion for further studies in the areas of same field that would have been ignored by this researcher to time and financial constraints.

3.7. Summary

This chapter has concentrated to the methodologies that were applied during data collection process to collect data from 86 respondents whereby 83 were given questionnaire and 3 were interviewed. The researcher used questionnaire and interview guide to collect primary data from 86 respondents whom were selected using census sampling technique because the number of respondents were reasonable and manageable in relation to financial and time constraints. There was a combination of both qualitative and quantitative analysis of data in this research. After coding various themes, there was the deployment of the SPSS software to aid in the entire process of analysing data. During the study and collection of data, however, some difficulties were encountered. Some of these difficulties include challenges in the attempts to focus on some services provided by the intelligent security surveillance and a relatively small sample size. These factors generally impacted the manner in which generalization of the findings was made in this particular study. Additionally, these factors compromised the accuracy of the collected data. Therefore, there is a need for the surveys and studies that were conducted in the future to have sample size that is relatively large to enhance the representation of the entire population.

CHAPTER FOUR: SYSTEM ANALYSIS AND DESIGN

4.1 Introduction

This chapter four of the study dealt with system analysis and design which basically focused on the analysis of the current system analysis and design in comparison with the system analysis and design in the identified innovation one. The existing video surveillance system in the city of Kigali involves video management system, graphic information system, facility management system, video backup system, and vehicle enforcement whereas the innovative system of intelligence video surveillance involves video analytic, vehicle identification and tracking, facial recognition system and automatic number place recognition on site.

4.2.Analysing the existing video surveillance in City of Kigali

The existing video surveillance in the City of Kigali gets public related video data from CCTV surveillance onsite and vehicle enforcement through closed network and informs the server and storage part of main monitoring centre. The current video surveillance system disseminate data of main monitoring centre through the support of video management system, graphic information system, facility management system, video backup system, and vehicle enforcement to ensure public safety.

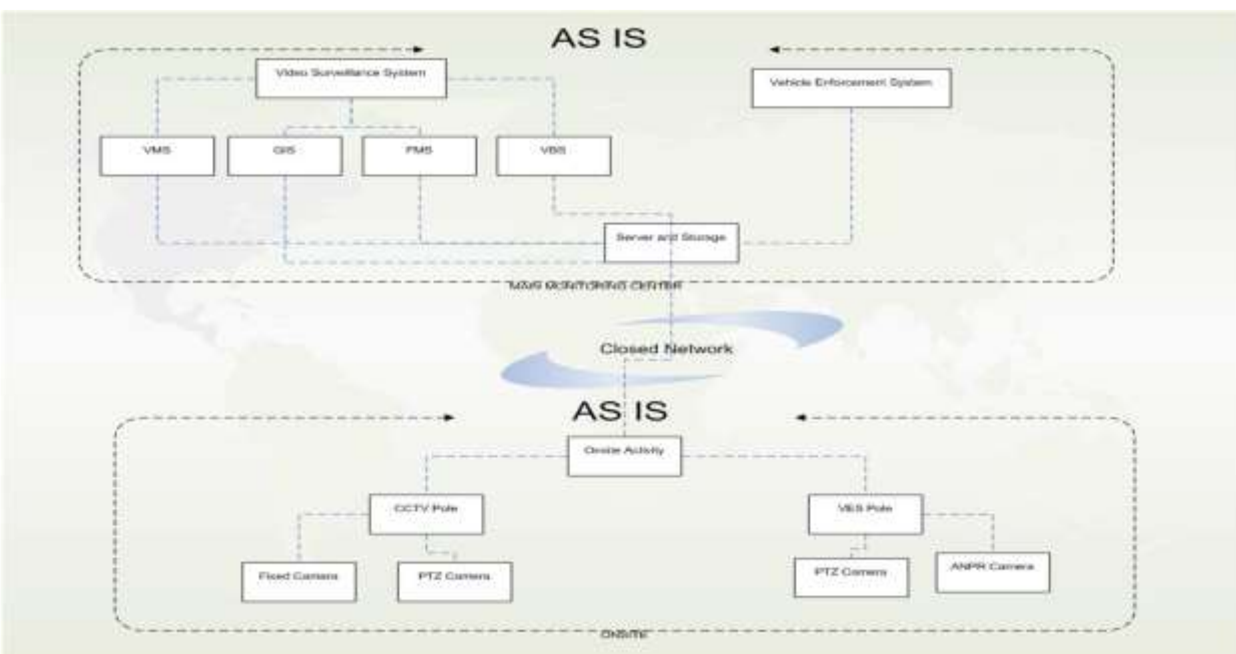

Figure 4: Current video surveillance system in City of Kigali

Source: Researcher, 2020

The figure 4 demonstrates how the current video surveillance system in city of Kigali collects the data for public safety use through Video Surveillance System that manages video surveillance cameras including Video Management System (VMS) that provides a wide variety of features to effectively monitor a large size location and multiple locations. Live monitoring, playback, event search, remote monitoring features are all included. The Graphic Information System (GIS) that supports in Quick location and easy control of cameras and GIS enables operators to identify and locate specific cameras on the map. The Facility Management System (FMS) that provides real time each camera's status and identity information to the monitoring center, the FMS also checks and displays the device status on each pole' enclosure through monitoring screen such as: Input/output Voltage, UPS temperature, and Battery Voltage and FMS also provides useful statistics and event reports.

The figure 4 also demonstrates that Video Backup System (VBS) is to stop illegal release of video information from internal users, integrated management of various video information requests such as violent crime, crime prevention, taxation, and civil services, and VBS is available to control for exporting image material and its utilization, abuse prevention, and third party extension. Vehicle Enforcement System (VES) which captures and recognizes for front or rear license plate of Rwanda registered motor-bicycle, motor-car, bus, truck or other motorized platforms when there is a violation While VES also detects the speed violation and red-light violation of motor-bicycle, motor-car, bus, truck or other motorized platforms and all these above are captured by onsite system made by CCTV surveillance cameras.

4.3. Identified innovation in the existing video surveillance in City of Kigali

The current video surveillance system have shown a gaps in regard to video analytic, vehicle identification and tracking, facial recognition system and automatic number place recognition on CCTV pole which delays the system in reducing accidents, reduction of response time and protection of people and properties in City of Kigali. This identified needed innovation in the existing video surveillance system in the City of Kigali requires improvement to enhance smart intelligence video surveillance for public safety in the City of Kigali.

Therefore, it is in this regard the researcher conducted this study to find out the contribution of smart intelligence video surveillance for public safety with specific objectives of determining the effect of video analytics features on public safety in City of Kigali with a case of Rwanda National Police, to determine the role of facial recognition system on public safety in City of Kigali with a case of Rwanda National Police, to assess the relationship between vehicle identification and tracking public safety in City of Kigali with a case of Rwanda National Police in regard to the views and perceptions the 86 respondents from Rwanda National Police.

4.4.Design smart intelligent video surveillance solutions in City of Kigali

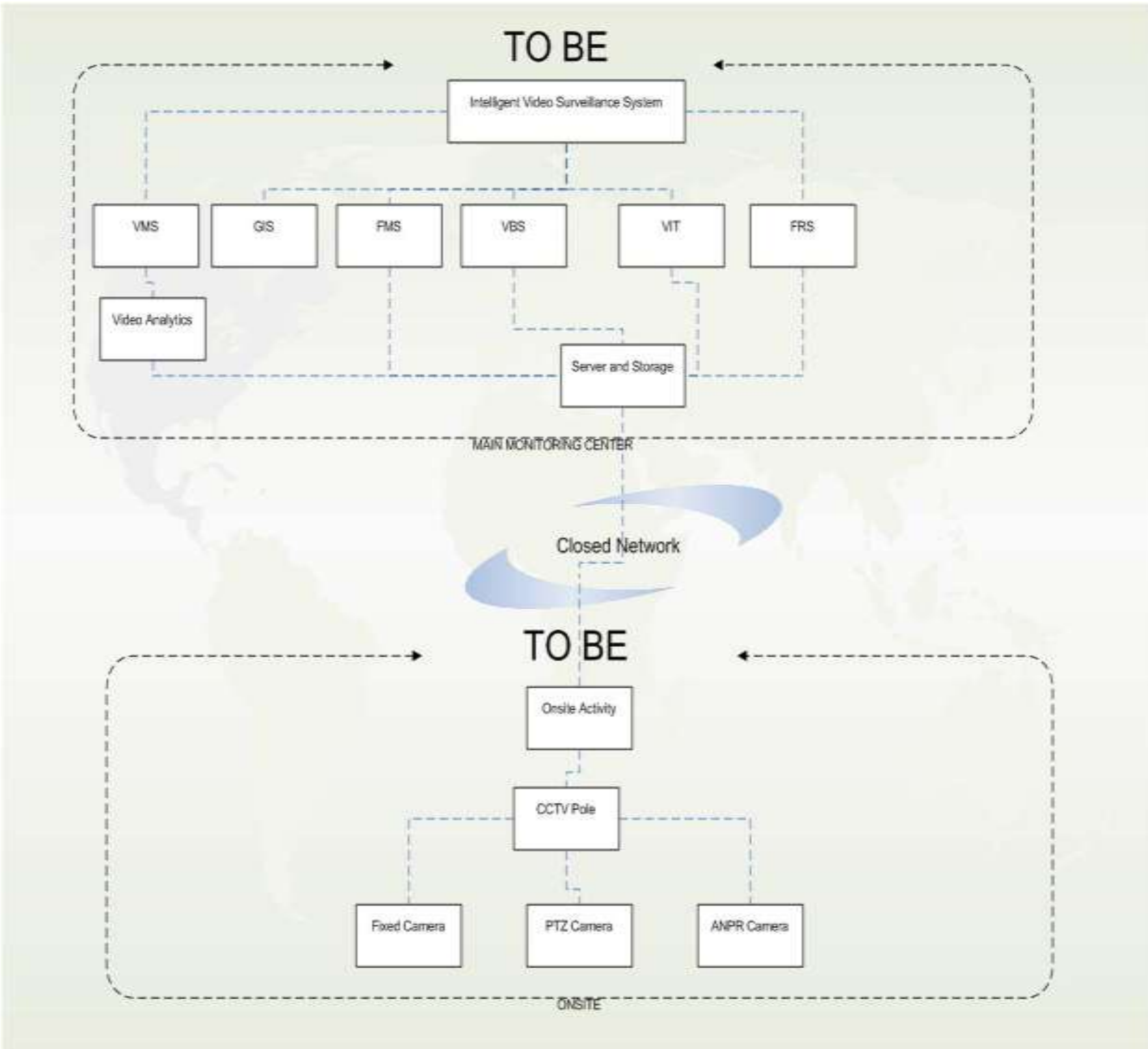

Figure 5: New Intelligent Video Surveillance System

Source: Researcher, 2020

The figure 5 demonstrates that the new intelligent video surveillance system has three main parts that include the part of onsite activities that comprise the CCTV cameras with automatic number plate recognition (ANPR) that gives data to server and storage through closed network to main monitoring center which comprises intelligent video surveillance (IVS) which embeds general management center integrating the software and hardware together related to video surveillance with video analytics features, vehicle identification and tracking, and facial recognition systems.

The proposed model of intelligent video surveillance system has video analytic conducted by video management system (VMS) to make intelligent video surveillance system by applying the role of video analytic in counting a number of people entering/ exiting a specified area, analysing body heat to highlight the area with the highest population for monitoring activity and conducting business analysis, triggering when motion occurs in a defined area, triggering when an object crosses the defined area, triggering when a person or object enters or exits a defined area, detecting if there is a change in the scene and triggers an alarm according to the judgment, detecting when an object is abandoned or is removed from a specific area, detecting immediately when cameras vandalized or attacked in a multitude of ways.

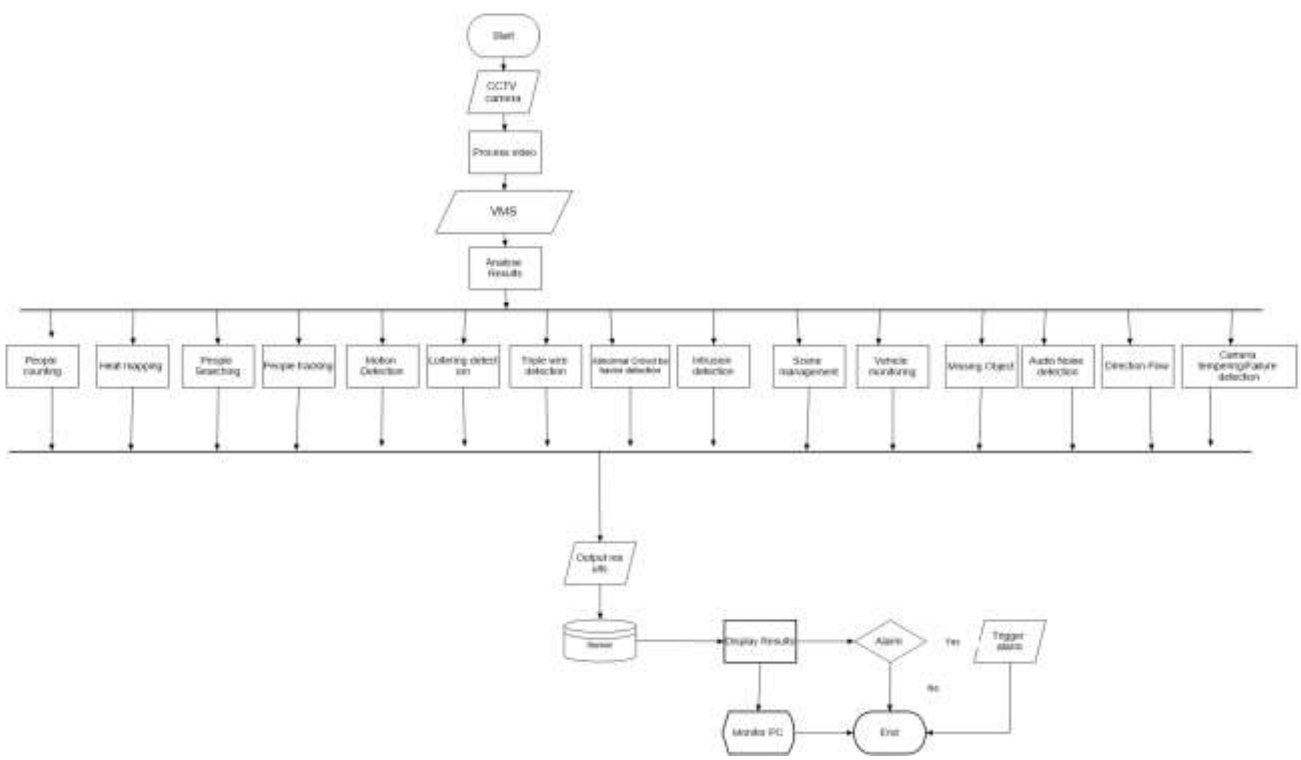

Figure 6: Video Analytic Diagram
Source: Researcher, 2020

The figure 6 demonstrates that video analytic identifies people whose appearance matches that of specific subject, enables monitoring people in view of a video camera, automatically detecting and tracking a variable number of persons in complex scenes, allows an exact recognition of suspicious movements, detect whether the crowd is abnormal or not in particular scene, such as stampede, fight and panic, automatically alert for potential and real incidents as they occur, and enable quick, relevant actions to minimize the consequences for instance aggressive behaviour, gunshots or breaking glass, and alerts when a vehicle has stopped the area for longer than a defined period where there is no parking zones, drop-off zones, pedestrian crossings

The figure 6 also demonstrates that video analytic identifies the direction of a moving object, analyses a series of body related attributes including gender, upper and lower body clothing colours. The technology tracks and analyses moving objects (also called events), and converts video streams into a database of objects and activities. Enables the review of hours of video footage in just minutes, searching vehicle by using its image, and colour, a PTZ camera can receive command from the general security camera or the smart hemispheric camera, and use its PTZ functionality to track the vehicle automatically to keep it within line of sight.

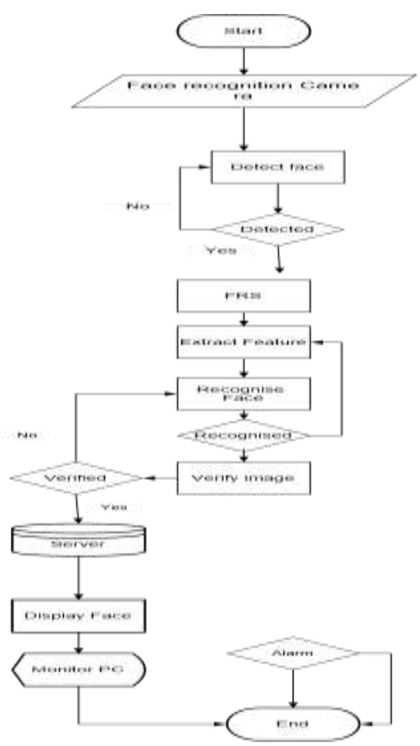

Figure 7: Facial Recognition System Diagram
Source: Researcher, 2020

The figure 7 demonstrates that Facial Recognition System (FRS) is a technology capable of identifying or verifying a person from a digital image or a video frame from a video source. Detect and record faces for analysis and processing for future use. The Facial Recognition System analyzes a series of face related attributes including age, gender, smile intensity, head pose, eye status, emotion, beauty, eye gaze, mouth status, skin status, ethnicity, face image quality and blurriness, checks the likelihood that two faces belong to the same person and locates and returns key points of face components, including face contour, eye, eyebrow, lip and nose contour.

The figure 7 also demonstrates that Facial recognition system finds similar-looking faces to a new face, from a given collection of faces, analyzes and identifies emotion of detected faces, detects unlawful activity without the suspect's knowledge, enables to easily create Whitelists/Blacklists for specific areas, makes it easier to track wanted criminals, missing people and suspected terrorists, performs fast and accurate detection of multiple faces in live video streams and still images, tracking trajectory based event detection and alarm is triggered or something of concern is detected via a CCTV system at any time of day or night.

Figure 8: Vehicle Identification and Tracking Diagram
Source: Researcher, 2020

The figure 7 demonstrates that Vehicle Identification and Tracking (VIT) application plays an important role such as in highway traffic surveillance control, management and urban traffic planning. Vehicle detection process on road are used for vehicle tracking, counts, traffic analysis and vehicle categorizing objectives and may be implemented under different environments changes.

4.5.Design requirements of New System

The requirements design of main components for the new intelligent video surveillance is designed with capabilities of video analytics, VIT and facial recognition which extract the data from onsite activities that comprise the CCTV cameras with automatic number plate recognition (ANPR) that gives data to server and storage through closed network to main monitoring centre which comprises intelligent video surveillance (IVS) which embeds general management centre integrating the software and hardware together related to video surveillance with video analytics features, vehicle identification and tracking, and facial recognition systems.

The capabilities of video analytics, VIT and facial recognition are very beneficial within a CCTV system to monitor real-time video captured by CCTV cameras to enhance security surveillance of people, vehicles, objects, and their associated behaviours within a camera's view. Those Analytics should be applied mostly in traffic and tollbooth monitoring, facility and border surveillance, building and parking security, and identifying persons or vehicles of interest. This new system of video surveillance if applied in the City of Kigali, it should increase safety of the public through reduction of crime, response time, accidents and protection of people and properties.

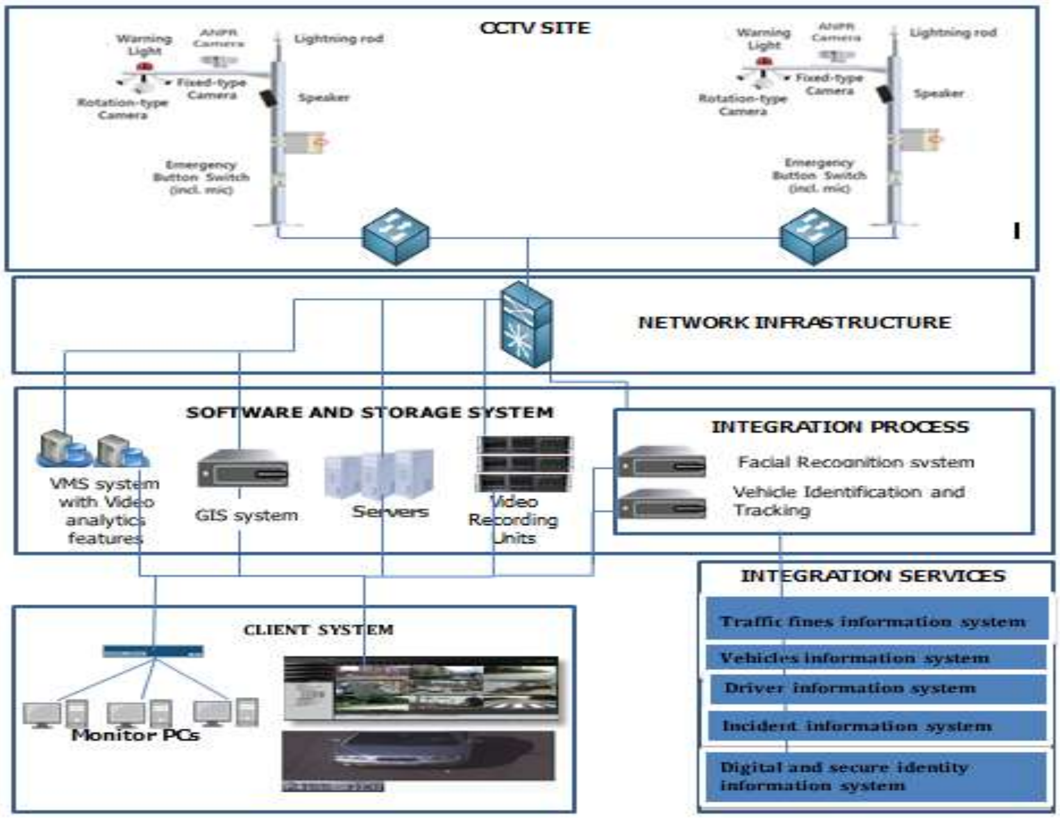

Figure 9: Main Components of Intelligent Video Surveillance System Implementation
Source: Researcher, 2020

The main components of intelligent Video Surveillance system implementation:

(i) Onsite equipment including Pole and Arm, ANPR cameras, CCTV Cameras (Fixed and PTZ), Switches (Layer 2), ODF and Patch cords, UPS, Surge Protector, Circuit Breaker, UTP cables and Electrical Cables.

(ii) Transmission process equipment including Fibre, Networking Gears, and electrical equipment.

(iii) Software and Storage system: VMS (Video Management System) capable of Video Analytics, Geographic Information S/W, Recording Units, Distribution Server, Facial Recognition System, and Vehicle Identification and Tracking system.

(iv) Client system: Control Room Equipment including Client Program On PC monitors, and Air conditioner

(v) Integration process: Facial Recognition Systems and Vehicle Identification and Tracking.

(vi) Integration services: 3rd Party Solution Products developed using the SDK

All cameras (CCTV and ANPR) are combined and managed together on a unified centre. Each different function, objective, and configuration of monitoring is fulfilled via customized settings in the client system (VMS, FRS, and VIT).

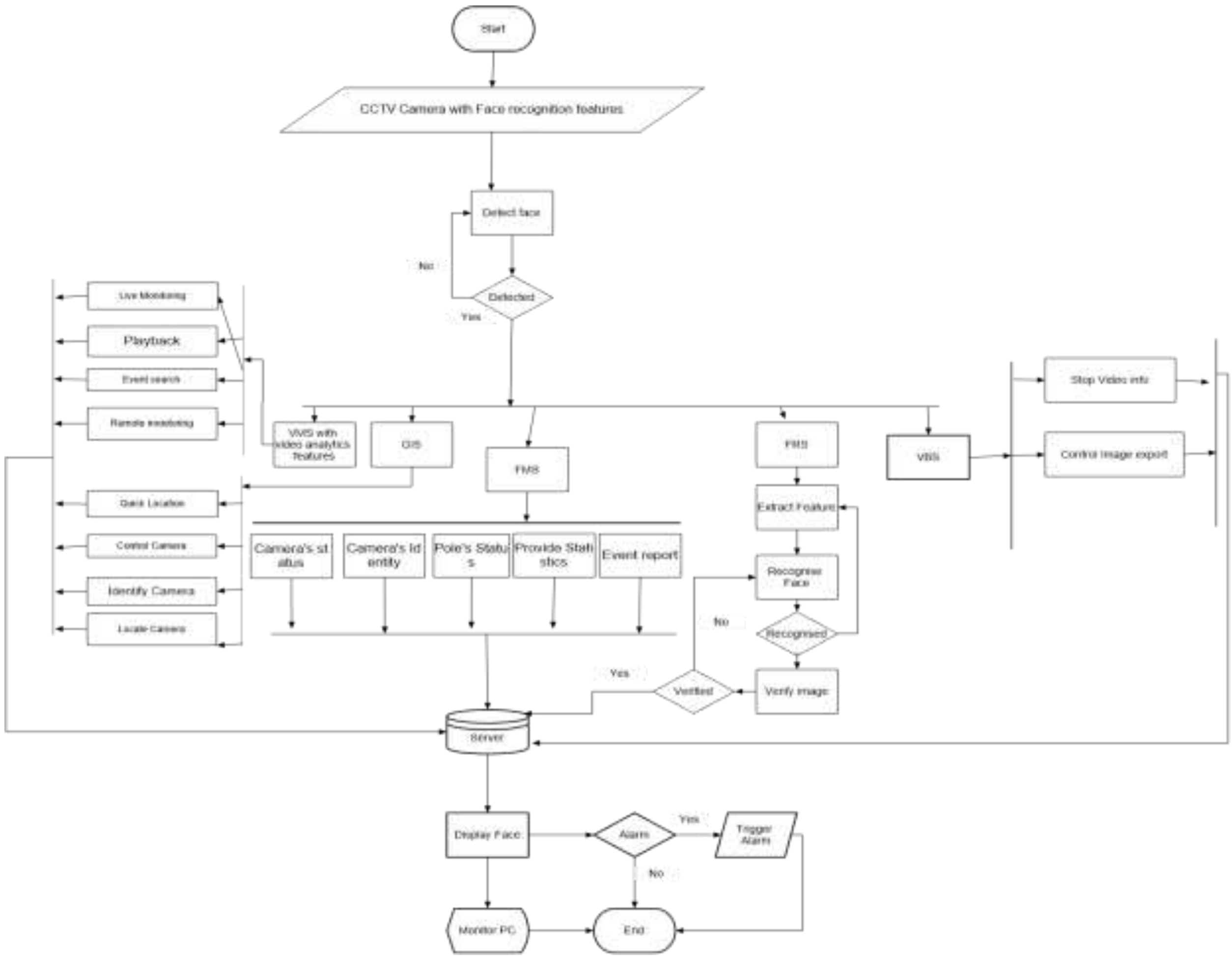

Figure 10: Diagram of Intelligent Video Surveillance System using CCTV camera with Face detection features
Source: Researcher, 2020

Therefore, this intelligent system of video surveillance contributes to the increase public safety and security awareness, the improve incident and accident response time. The moving to shared intelligent infrastructure action with shared operation services, procedures and planning for better decision making, support easily access of security and safety information, single point of contact for support across all technologies used, best in class synergized facial recognition platform and edge analytics supported by software with GIS integration and configurable GUI creating robust package to reduce Human Resource overhead.

4.6. Assessment of applicability of intelligent video surveillance solutions in public safety in City of Kigali

The CCTV cameras capture the information from onsite, the data gets to the main monitoring centre through closed network and the captured information by video analytic features, facial recognition system and Vehicle Identification and tracking are utilised for the public safety rated matters to enhance the protection of the people living in the City of Kigali, reduction of response time and protection of people and properties in City of Kigali.

The proposed model of intelligent video surveillance system has video analytic conducted by video management system (VMS) to make intelligent video surveillance system by applying the role of video analytic in counting a number of people entering/ exiting a specified area. The video analytic identifies the direction of a moving object, analyses a series of body related attributes including gender, upper and lower body clothing colours and the technology tracks and analyses moving objects (also called events), and converts video streams into a database of objects and activities.

Facial Recognition System (FRS) is a technology capable of identifying or verifying a person from a digital image or a video frame from a video source, detects unlawful activity without the suspect's knowledge, tracking trajectory based event detection and alarm is triggered or something of concern is detected via a CCTV system at any time of day or night.

Vehicle Identification and Tracking (VIT) application plays an important role such as in highway traffic surveillance control, management and urban traffic planning. Vehicle detection processes on road are used for vehicle tracking, counts, traffic analysis and vehicle categorizing objectives and may be implemented under different environments changes.

4.7.Summary

This chapter four of the study has concentrated on the current existing video surveillance system and the proposed smart intelligence video surveillance system that comprised video analytic features, facial recognition system and vehicle identification and tracking to ensure public safety that is measured in terms of accidents reduction, response time reduction and protection of people and properties in City of Kigali.

CHAPTER FIVE: RESEARCH FINDINGS AND DISCUSSION

5.0. Introduction

The chapter five of this study deals with the implementation of the new system and research findings extracted the views and perceptions of respondents in relation to study variables including the important of video analytic features in facilitating the work of RNP in enhancing public safety in Kigali, importance of vehicle identification tracking for the public safety in Kigali, the role of facial recognition in promoting public safety in Kigali, application of smart intelligence video intelligence solution to reduce accidents in Kigali, the role of video surveillance in protection of people and properties, and the role of video surveillance in reducing time to respond in Kigali. The results of this study are provided by 86 respondents who participated 100% in this study.

5.3. Socio-demographic characteristic of respondents

The socio-demographic characteristics of respondents such as gender of respondents, age of respondents, marital status of respondents, and time spent in video surveillance by respondents help the researcher to interpret the results from the views and perceptions of respondents in relation to the variables of the study including video analytic features, vehicle tracking identification, facial recognition, reduction of accidents, protection of people and properties and reduction of time of responding to incidents.

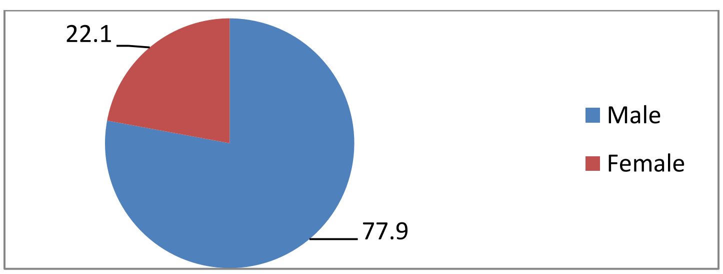

Figure 11: Gender of respondents

Source: Primary Data, 2020

The results in Figure 11 indicate that 67 (77.9%) of respondents who participated in this study are males, while 19 (22.1%) of respondents who participated in this study are females. Thus, it implies that a big number of respondents who participated in this study are males and it also implies that a big number of RNP members deployed in Video surveillance are males.

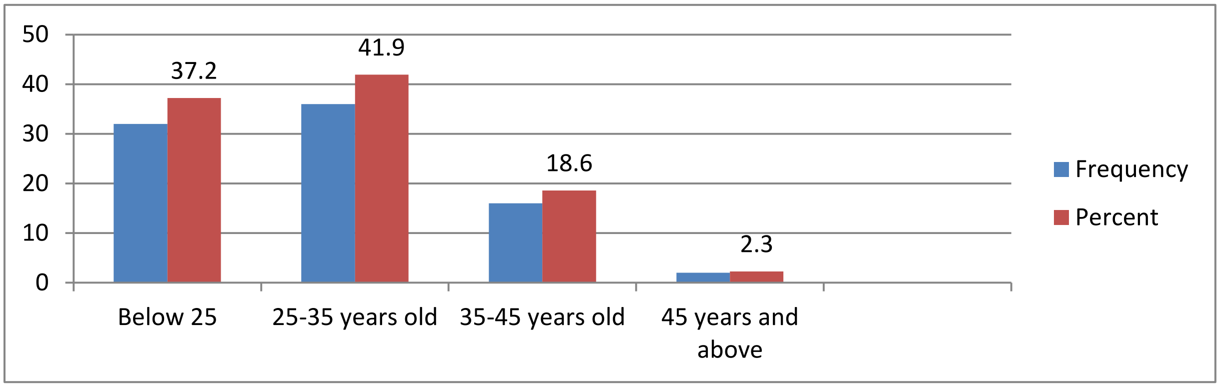

Figure 12: Age of respondents

Source: Primary Data, 2020

The results in Figure 12 indicate that 36 (41.9%) of respondents who participated in this study are 25-35 years old, 32 (37.2%) of respondents who participated in this study are below 25 years, 16 (18.6%) of respondents who participated in this study are 35-45 years old,2 (2.3%) of respondents who participated in this study are 45 and above. Thus, it implies that a big number of respondents have 25-35years old meaning that the members of RNP deployed in video surveillance are still energetic for public safety in Kigali, Rwanda.

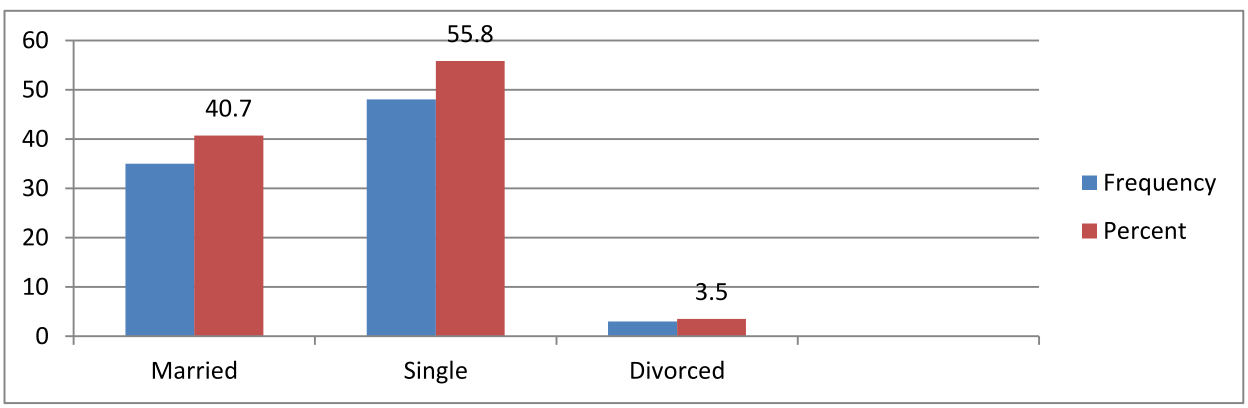

Figure 13: Marital status of respondents

Source: Primary Data, 2020

The results in Figure 13 indicates that 48 (55.8%) of respondents who participated in this study are single, while 35 (40.7%) of respondents who participated in this study are married, while 3 (3.5%) of respondents who participated in this study are divorced. Thus, it implies that the big number of respondents who participated in this study is Single and has to reason to work hard in Video Surveillance for public safety in Kigali, Rwanda.

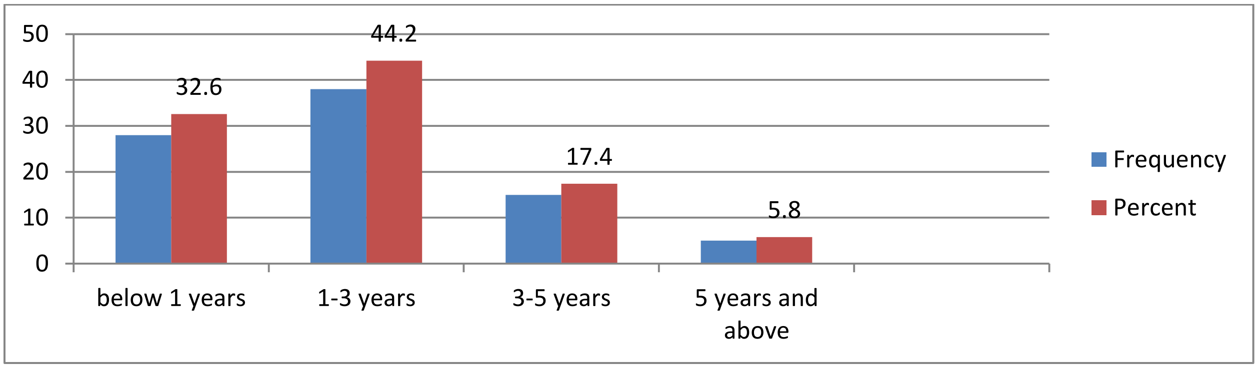

Figure 14: Time spent in Video Surveillance

Source: Primary Data, 2020

The results in Figure 14 indicate that 38 (44.2%) of respondents who participated in this study are 1-3 years of experience in video surveillance, 28 (32.6%) of respondents who participated in this study are below 1 years of experience in video surveillance, 15 (17.4%) of respondents who participated in this study are 3-5 years of experience in video surveillance, while 5 (5.8%) of respondents who participated in this study are 5 years and above of experience in Video surveillance. Hence, it means that a big number of respondents have below 1-3 years of experience in video surveillance for public safety in Kigali, Rwanda.

5.4. Presentation of research findings

The results in this subsection are related to the perceptions of respondents extracted from the statements such as the important of video analytic features in facilitating the work of RNP in enhancing public safety in Kigali, importance of vehicle identification tracking for the public safety in Kigali, the role of facial recognition in promoting public safety in Kigali, application of smart intelligence video intelligence solution to reduce accidents in Kigali, the role of video surveillance in protection of people and properties, and the role of video surveillance in reducing time to respond in Kigali.

5.4.1. The effect of video analytics features on public safety in City of Kigali with a case of Rwanda National Police

The results regarding video surveillance solutions are extracted from the views of respondents in regard to video analytic features help to abnormal crowd behaviour in facilitating safety reasons, and video analytic help in tracking abandoned object for the sake of property security.

Table 2: Video analytic

The Likert scale data presented here in this Table 2 are about video analytic features are important in facilitating the work of RNP in enhancing public safety in Kigali (5-Not important at all, 4- Not important, 3- I don't know, 2- Important, 1- very important).

Statement	5	4	3	2	1	Mean	Std.
Video analytic features help to detect abnormal crowd behaviour for public safety reasons	2(2.3%)	4(4.7%)	9(10.5%)	18(20.9%)	53(61.6%)	1.6512	1.00314
Video analytic features help to detect immediately cameras vandalized or attached for public safety reasons	2(2.3%)	3(3.5%)	6(7.0%)	10(11.6%)	65(75.6%)	1.4535	.94130
Video analytic features detect change in the scene and alert relevantly	8(9.3%)	9(10.5%)	6(7.0%)	19(22.1%)	44(51.2%)	2.0465	1.36258
Video analytic features counts people in an area for public safety purposes	8(9.3%)	7(8.1%)	11(12.8%)	11(12.8%)	49(57.0%)	2.0000	1.37199
Video analytic features monitors people in video camera view to enhance public safety	2(2.3%)	3(3.5%)	7(8.1%)	20(23.3%)	54(62.8%)	1.5930	.95027
Video analytic help to detect motion for the sake of public safety	2(2.3%)	6(7.0%)	10(11.6%)	5(5.8%)	63(73.3%)	1.5930	1.08874
Video analytic help in tracking lose object for the sake of property security	2(2.3%)	4(4.7%)	6(7.0%)	16(18.6%)	58(67.4%)	1.5581	.97745
Total mean						1.6993	

Source: Primary Data, 2020

The results in Table 2 indicate that 65(75.6%) of total respondents have asserted that Video analytic features help to detect immediately cameras vandalized or attached for public safety reasons, 63(73.3%) of total respondents have asserted that Video analytic help to detect motion for the sake of public safety, 58(67.4%) of total respondents have asserted that Video analytic help in tracking lose object for the sake of property security, 54(62.8%) of total respondents have asserted that Video analytic features monitors people in video camera view to enhance public safety, 53(61.6%) of total respondents have asserted that Video analytic features help to detect abnormal crowd behaviour for public safety reasons, 49(57.0%) of total respondents have asserted that Video analytic features counts people in an area for public safety purposes, 44(51.2%) of total respondents have asserted that Video analytic features detect change in the scene and alert relevantly. The highest mean is 2.0465 while the lowest is 1.4535 meaning that there is moderate effect of video analytic features on public safety. Thus, it implies that video analytic features are important in facilitating the work of RNP in enhancing public safety in Kigali, Rwanda.

5.4.2. The relationship between vehicle identification and tracking public safety in City of Kigali with a case of Rwanda National Police

The results presented in this section are extracted from the vehicle tracking identification help to track vehicle involved in crime scene, vehicle tracking with help of facial recognition help to allocation criminals and vehicle tracking system promote security for VIP protection.

Table 3: Vehicle identification and tracking

The Likert scale data presented here in this Table 3 about vehicle identification tracking as important for the public safety (1 – To a very great extent, 2- to a moderate extent, 3- small extent, 4- To no extent, 5- Not sure)

Statement	5	4	3	2	1	Mean	Std.
Vehicle tracking identification help to track vehicle involved in crime scene	2(2.3%)	2(2.3%)	5(5.8%)	20(23.3%)	57(66.3%)	1.5116	.89106
Vehicle tracking with help of facial recognition help to allocation criminals	2(2.3%)	3(3.5%)	12(14.0%)	14(16.3%)	55(64.0%)	1.6395	1.00484
Vehicle tracking identification help to allocate the missing vehicle	2(2.3%)	13(15.1%)	11(12.8%)	13(15.1%)	47(54.7%)	1.9535	1.22625
Vehicle tracking system monitors the flow of car in the city	2(2.3%)	7(8.1%)	10(11.6%)	5(5.8%)	62(72.1%)	1.6279	1.11721
Vehicle tracking system promote security for VIP protection	2(2.3%)	6(7.0%)	16(18.6%)	8(9.3%)	54(62.8%)	1.7674	1.12380

Source: Primary Data, 2020

The results in Table 3 show that 62(72.1%) of total respondents have asserted that Vehicle tracking system monitors the flow of car in the city to a very great extent, 57(66.3%) of total respondents have asserted that Vehicle tracking identification help to track vehicle involved in crime scene to a very great extent, 55(64.0%) of total respondents have asserted that Vehicle tracking with help of facial recognition help to allocation criminals to a very great extent, 54(62.8%) of total respondents have asserted that Vehicle tracking system promote security for VIP protection to a very great extent, 47(54.7%) of total respondents have asserted that Vehicle tracking identification help to allocate the missing vehicle to a very great extent. The highest mean is 1.9535 while the lowest is 1.5116 implying that vehicle identification tracking is important for the public safety in Kigali, Rwanda.

5.4.3. The role of facial recognition system on public safety in City of Kigali with a case of Rwanda National Police

The results in this section are extracted from the views and perceptions in regard to face detection and recognition help to track the criminals for public safety, face attributes help to recognise the face image of terrorists for public safety and face land marking help to recognise key features of the face of suspect.

Table 4: Facial Recognition System

The Likert scale data presented here in this Table 4 about regarding facial recognition in promoting public safety in Kigali (1 – Strongly Agree, 2- Agree, 3- Neutral, 4- Disagree, 5- Strongly Disagree)

Statement	5	4	3	2	1	Mean	Std.
Face detection and recognition help to track the criminals for public safety	2(2.3%)	3(3.5%)	13(15.1%)	13(15.1%)	55(64.0%)	1.6512	1.01480
Face attributes help to recognize the face image of terrorists for public safety	2(2.3%)	6(7.0%)	15(17.4%)	8(9.3%)	55(64.0%)	1.7442	1.11868
Face comparing differentiate between similar looking criminals and residents for public safety	2(2.3%)	3(3.5%)	12(14.0%)	15(17.4%)	54(62.8%)	1.6512	1.00314
Face recognition help to allocate one individual from many for public safety	2(2.3%)	6(7.0%)	17(19.8%)	8(9.3%)	53(61.6%)	1.7907	1.12842
Facial recognition help to detect the high profile wanted criminals	2(2.3%)	3(3.5%)	10(11.6%)	14(16.3%)	58(67.4%)	1.5465	.91596
Face land marking help to recognize key features of the face of suspect	2(2.3%)	8(9.3%)	15(17.4%)	8(9.3%)	53(61.6%)	1.8140	1.16328

Source: Primary Data, 2020

The results in Table 4 prove that 58(67.4%) of total respondents have strongly agreed that Facial recognition help to detect the high profile wanted criminals, 55(64.0%) of total respondents have strongly agreed that Face detection and recognition help to track the criminals for public safety, 55(64.0%) of total respondents have strongly agreed that Face attributes help to recognize the face image of terrorists for public safety, 54(62.8%) of total respondents have strongly agreed that Face comparing differentiate between similar looking criminals and residents for public safety, 53(61.6%) of total respondents have strongly agreed that Face recognition help to allocate one individual from many for public safety, 53(61.6%) of total respondents have strongly agreed that Face land marking help to recognize key features of the face of suspect. The results have also indicated that the highest mean is 1.8140 while the lowest mean is 1.5465 implying that facial recognition promotes public safety in Kigali, Rwanda.

5.4.4. Results regarding Reduction of accidents

The results presented here below are extracted from the views and perceptions of the respondents regarding accidents reduce in proportion to smart intelligence video surveillance, video surveillance cameras have reduced rate of accidents in City of Kigali, and video surveillance have reduced the number of traffic police deployments in City of Kigali.

Table 5: Reduction of accidents

The Likert scale data presented here in this Table 5 about regarding smart intelligence video surveillance solution to reduction of accidents in Kigali (1 – Strongly Agree, 2- Agree, 3- Neutral, 4- Disagree, 5- Strongly Disagree)

Statement	5	4	3	2	1	Mean	Std.
Accidents reduce in proportion to smart intelligence video surveillance	2(2.3%)	3(3.5%)	9(10.5%)	13(15.1%)	59(68.6%)	1.5581	.97745
Video surveillance cameras have reduce rate of accidents in Kigali	2(2.3%)	5(5.8%)	14(16.3%)	8(9.3%)	57(66.3%)	1.6860	1.08749
Video surveillance cameras reduce the individuals at risk of causing accidents	2(2.3%)	3(3.5%)	10(11.6%)	15(17.4%)	56(65.1%)	1.6047	.98553
Video surveillance have reduced the number of traffic police deployments	2(2.3%)	8(9.3%)	15(17.4%)	8(9.3%)	53(61.6%)	1.8140	1.16328

Source: Primary Data, 2020

The results in Table 5 reveal that 59(68.6%) of total respondents have strongly agreed that Accidents reduce in proportion to smart intelligence video surveillance, 57(66.3%) of total respondents have strongly agreed that Video surveillance cameras have reduce rate of accidents in Kigali, 56(65.1%) of total respondents have strongly agreed that Video surveillance cameras reduce the individuals at risk of causing accidents, 53(61.6%) of total respondents have strongly agreed that Video surveillance have reduced the number of traffic police deployments. The highest mean is 1.8140 while the lowest is 1.5581 which implies that smart intelligence video surveillance solution affect reduction of accidents for public safety in Kigali, Rwanda.

5.4.5. Results regarding Protection of People and Properties

The results presented here below are extracted from the views and perceptions of respondents concerning video surveillance in promoting investigative procedures for people and property protection, video surveillance proactively identify and analyze crimes to protect people and properties and video surveillance eases the job of police in protection of people and properties in City of Kigali.

Table 6: Protection of People and Properties

The Likert scale data presented here in this Table 6 about regarding the role of video surveillance in protection of people and properties (1 – Strongly Agree, 2- Agree, 3- Neutral, 4- Disagree, 5- Strongly Disagree)

Statement	5	4	3	2	1	Mean	Std.
Video surveillance promote investigative procedures for people' and property protection	2(2.3%)	3(3.5%)	10(11.6%)	13(15.1%)	58(67.4%)	1.5814	.98775
Video surveillance proactively identify and analyze crimes to protect people and properties	2(2.3%)	8(9.3%)	15(17.4%)	8(9.3%)	53(61.6%)	1.8140	1.16328
Video surveillance promote better deployments of patrols to protect people and properties	2(2.3%)	3(3.5%)	11(12.8%)	13(15.1%)	57(66.3%)	1.6047	.99740
Video surveillance provide data to handle issues related property and people protection	2(2.3%)	6(7.0%)	14(16.3%)	8(9.3%)	56(65.1%)	1.7209	1.11304
Video surveillance eases the job of police in protection of people and properties	2(2.3%)	3(3.5%)	11(12.8%)	15(17.4%)	55(64.0%)	1.6279	.99465

Source: Primary Data, 2020

The results in Table 6 show that 58(67.4%) of total respondents have strongly agreed that Video surveillance promote investigative procedures for people' and property protection , 57(66.3%) of total respondents have strongly agreed that Video surveillance promote better deployments of patrols to protect people and properties, 56(65.1%) of total respondents have strongly agreed that Video surveillance provide data to handle issues related property and people protection, 55(64.0%) of total respondents have strongly agreed that Video surveillance eases the job of police in protection of people and properties, 53(61.6%) of total respondents have strongly agreed that Video surveillance proactively identify and analyze crimes to protect people and properties. The results show that the highest mean is 1.8140 while the lowest mean is 1.5814 which implies that video surveillance enhances protection of people and properties in Kigali, Rwanda.

5.4.6. Results regarding Video surveillance enhance reduction of time to respond

The results presented in this section are extracted from statement regarding video surveillance in reducing time to respond in case of fire incident, video surveillance reduces time to respond in case of traffic accident and video surveillance reduces time to respond in case of calamity.

Table 7: Video surveillance enhance reduction of time to respond

The Likert scale data presented here in this Table 7 about regarding role of video surveillance in promoting reduction of time to respond (1 – Strongly Agree, 2- Agree, 3- Neutral, 4- Disagree, 5- Strongly Disagree)

Statement	5	4	3	2	1	Mean	Std.
Video surveillance reduces time to respond in case of fire incident	2(2.3%)	3(3.5%)	11(12.8%)	13(15.1%)	57(66.3%)	1.6047	.99740
Video surveillance reduces time to respond in case of traffic accident	2(2.3%)	3(3.5%)	10(11.6%)	13(15.1%)	58(67.4%)	1.5814	.98775
Video surveillance reduces time to respond in case of robbery	2(2.3%)	6(7.0%)	13(15.1%)	8(9.3%)	57(66.3%)	1.6977	1.10687
Video surveillance reduces time to respond in case of terror attack	2(2.3%)	3(3.5%)	10(11.6%)	15(17.4%)	56(65.1%)	1.6047	.98553
Video surveillance reduces time to respond in case of calamity	2(2.3%)	3(3.5%)	16(18.6%)	8(9.3%)	57(66.3%)	1.6628	1.04724

Source: Primary Data, 2020

The results in Table 7 demonstrate that 58 (67.4%) of total respondents have strongly agreed that Video surveillance reduces time to respond in case of traffic accident, 57(66.3%)of total respondents have strongly agreed that Video surveillance reduces time to respond in case of fire incident, 57(66.3%)of total respondents have strongly agreed that Video surveillance reduces time to respond in case of robbery, 57(66.3%)of total respondents have strongly agreed that Video surveillance reduces time to respond in case of calamity, 56(65.1%)of total respondents have strongly agreed that Video surveillance reduces time to respond in case of terror attack. The highest mean is 1.6977 while the lowest mean is 1.5814 which implies that video surveillance promotes reduction of time to respond for the public safety reasons in Kigali, Rwanda.

Table 8: Correlation analysis between smart intelligence video surveillance and public safety in Kigali, Rwanda

	Reduction of accidents	Reduction of response time	protection of people and properties

Video analytic feature	Pearson Correlation	.697**	.877**	.640**
	Sig. (2-tailed)	.000	.000	.000
	N	86	86	86
Facial recognition system	Pearson Correlation	.757**	.596**	.966**
	Sig. (2-tailed)	.000	.000	.000
	N	86	86	86
VIT	Pearson Correlation	.794**	.981**	.557**
	Sig. (2-tailed)	.000	.000	.000
	N	86	86	86

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Primary Data, 2020

The findings in Table 8 prove that there is a relationship between video analytic feature and reduction of response time (p=.877 and sig=.000), between video analytic feature and protection of people and properties (p=.640 and sig=.000), between Facial recognition system and Reduction of accidents (p=.757 and sig=.000), between Facial recognition system and Reduction of response time (p=.596 and sig=.000), between Facial recognition system and protection of people and properties(p=.966 and sig=.000), between VIT and reduction of accident (p=.794 and sig=.000), between VIT and reduction response time (p=.981 and sig=.000), between VIT and protection of people and properties (p=.557 and sig=.000) between reduction of accident and Reduction of response time (p=.815 and sig=.000) because all calculated p- values are less than 0.01 level of significance. Thus, implies that there is a positive significant relationship between predictors of smart intelligence video surveillance and measures of public safety in Kigali, Rwanda.

Table 9: Model Summary of smart intelligence video surveillance and reduction of accidents in Kigali, Rwanda

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.889[a]	.790	.782	.47203

a. Predictors: (Constant), VIT, Facial recognition system , Video analytic feature

Source: Primary Data, 2020

The results in Table 9 indicate that that the R coefficient .889 reveals that smart intelligence video surveillance has a positive relationship with Reduction of accidents. The coefficient of determination .790 R square also indicates that smart intelligence video surveillance explains 79.0 % the progress variability in Reduction of accidents. Thus, it implies that predictors of smart intelligence video surveillance such as video analytic feature, facial recognition system and VIT affect the progress of Reduction of accidents by 79.0 % in Kigali city.

Table 10: Analysis of Variance (ANOVA) of smart intelligence video surveillance and reduction of accidents in Kigali, Rwanda

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	68.660	3	22.887	102.716	.000[b]
Residual	18.271	82	.223		
Total	86.930	85			

a. Dependent Variable: Reduction of accidents

b. Predictors: (Constant), VIT, Facial recognition system , Video analytic feature

Source: Primary Data, 2020

The findings in Table 10 indicate that there is significant relationship between smart intelligence video surveillance and reduction of accidents because the calculated significance value .000 is less than 0.05 level of significance (calculated sig. value.000 < critical level of significance 0.05). Thus, the statistical model predicting the relationship between smart intelligence video surveillance and reduction of accidents is significant.

Table 11: Coefficients of Variance (ANOVA) of smart intelligence video surveillance and reduction of accidents in Kigali, Rwanda

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Decision on H_o
	B	Std. Error	Beta			
(Constant)	.004	.106		.034	.973	Ho failed
Video analytic feature	-.396	.117	-.390	-3.382	.001	H_o rejected
Facial recognition system	.495	.063	.556	7.891	.000	H_o rejected
VIT	.867	.110	.807	7.906	.000	H_o rejected

a. Dependent Variable: Reduction of accidents

Source: Primary Data, 2020

The results in table 11 reveal that predictors of smart intelligence video surveillance have positive coefficients that enhance positive effect on the progress of reduction of accident in

Kigali. The regression analysis indicates that there is a positive significant relationship between smart intelligence video surveillance and reduction of accidents because all the calculated p-values are less than 0.05 each. Thus, the coefficient gives regression model, $Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta$. Therefore, the model becomes Y=.004+.396x1+.495x2+.867x3, this regression equation indicates that there is a positive significant between predictors of smart intelligence video surveillance and reduction of accidents in Kigali.

The first objective of establishing the relationship between video analytic feature and reduction of accidents has a positive and significant relationship (b=.396 and p=.001). The second objective of establishing the relationship between facial recognition system and reduction of accidents has a positive and significant relationship (b=.495 and sig=.000), the third objective of establishing the relationship between VIT and reduction of accidents has a positive relationship (b=.867 and p=.000). The results have revealed that Ho is failed on the assumption regarding constant while the coefficient of smart intelligence video surveillance with reduction of accidents, Ho is rejected implying that the H1 asserting that there is contribution of smart video intelligence on public safety. Thus, implies that there is a positive significant relationship between smart intelligence video surveillance and reduction of accidents in Kigali, Rwanda.

Table 12: Model Summary of smart intelligence video surveillance and reduction of response time in Kigali, Rwanda

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.982[a]	.964	.963	.18412

a. Predictors: (Constant), VIT, Facial recognition system , Video analytic feature

Source: Primary Data, 2020

The results in Table 12 indicate that that the R coefficient .982 reveals that smart intelligence video surveillance has a positive relationship with reduction of response time. The coefficient of determination .964 R square also indicates that smart intelligence video surveillance explains 96.4 % the progress variability in reduction of response time. Thus, it implies that predictors of smart intelligence video surveillance such as video analytic feature, facial recognition system and VIT affect the progress of reduction of response time by 96.4 % in Kigali.

Table 13: Analysis of Variance (ANOVA) of smart intelligence video surveillance and reduction of response time in Kigali, Rwanda

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	74.674	3	24.891	734.243	.000[b]
Residual	2.780	82	.034		
Total	77.453	85			

a. Dependent Variable: Reduction of response time

b. Predictors: (Constant), VIT, Facial recognition system , Video analytic feature

Source: Primary Data, 2020

The findings in Table 13 indicate that there is significant relationship between smart intelligence video surveillance and reduction of response time because the calculated significance value .000 is less than 0.05 level of significance (calculated sig. value.000 < critical level of significance 0.05). Thus, the statistical model predicting the relationship between smart intelligence video surveillance and reduction of response time is significant

Table 14: Coefficients of smart intelligence video surveillance and reduction of response time in Kigali, Rwanda

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Decision on H_o
	B	Std. Error	Beta			
(Constant)	-.027	.041		-.661	.510	Ho Failed
Video analytic feature	.094	.046	.098	2.053	.001	Ho rejected
Facial recognition system	.006	.024	.007	.250	.003	Ho rejected
VIT	.904	.043	.891	21.129	.000	Ho rejected

a. Dependent Variable: Reduction of response time

Source: Primary Data, 2020

The results in table 14 reveal that predictors of smart intelligence video surveillance have positive coefficients that enhance positive effect on the progress of reduction of response time in Kigali. The regression analysis indicates that there is a positive significant relationship between smart intelligence video surveillance and reduction of response time because all the calculated p-values are less than 0.05 each. Thus, the coefficient gives regression model, Y=β0+β1x1+β2x2+β3x3+β. Therefore, the model becomes Y=.027+.094x1+.006x2+.904x3, this regression equation indicates that there is a positive significant between predictors of Video surveillance and reduction of response time in Kigali, Rwanda.

The first objective of establishing the relationship between video analytic feature and reduction of response time has a positive and significant relationship (b=.094 and p=.001). The second objective of establishing the relationship between facial recognition system and reduction of response time has a positive and significant relationship (b=.006 and sig=.003), the third objective of establishing the relationship between VIT and reduction of response time has a positive relationship (b=.904 and p=.000). The results have revealed that Ho is failed on the assumption regarding constant while the coefficient of smart intelligence video surveillance with reduction of response time, Ho is rejected implying that the H1 asserting that there is contribution of smart video intelligence on public safety. Thus, implies that there is a positive significant relationship between smart intelligence video surveillance and reduction of response time in Kigali, Rwanda.

Table 15: Model Summary of smart intelligence video surveillance and protection of people and properties in Kigali, Rwanda

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.968	.938	.935	.30291

a. Predictors: (Constant), VIT, Facial recognition system , Video analytic feature

Source: Primary Data, 2020

The results in Table 15 indicate that that the R coefficient .968 reveals that Video surveillance has a positive relationship with protection of people and properties. The coefficient of determination .938 R square also indicates that smart intelligence video surveillance explains 93.8 % the progress variability in protection of people and properties. Thus, it implies that predictors of Video surveillance such as video analytic feature, facial recognition system and VIT affect the progress of protection of people and properties by 93.8% in Kigali, Rwanda.

Table 16: Analysis of Variance (ANOVA) of smart intelligence video surveillance and protection of people and properties in Kigali, Rwanda

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	112.860	3	37.620	410.013	.000[b]
Residual	7.524	82	.092		
Total	120.384	85			

a. Dependent Variable: protection of people and properties
b. Predictors: (Constant), VIT, Facial recognition system , Video analytic feature

Source: Primary Data, 2020

The findings in Table 16 indicate that there is significant relationship between Video surveillance and protection of people and properties because the calculated significance value .000 is less than 0.05 level of significance (calculated sig. value.000< critical level of significance 0.05). Thus, the statistical model predicting the relationship between Video surveillance and protection of people and properties is significant

Table 17: Coefficients of smart intelligence video surveillance and protection of people and properties in Kigali, Rwanda

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Decision Ho
	B	Std. Error	Beta			
(Constant)	.017	.068		.246	.806	Failed
Video analytic feature	-.157	.075	-.131	-2.090	.004	Rejected
Facial recognition system	1.059	.040	1.011	26.310	.000	Rejected
VIT	.101	.070	.080	1.442	.003	Rejected

a. Dependent Variable: protection of people and properties

Source: Primary Data, 2020

The results in table 17 reveal that predictors of smart intelligence video surveillance have positive coefficients that enhance positive effect on the progress of protection of people and properties in Kigali. The regression analysis indicates that there is a positive significant relationship between Video surveillance and protection of people and properties because all the calculated p-values are less than 0.05 each. Thus, the coefficient gives regression model, Y=β0+β1x1+β2x2+β3x3+β. Therefore, the model becomes Y=.017-.157x1+.1.059x2+.101x3, this regression equation indicates that there is a positive significant between predictors of Video surveillance and protection of people and properties of Kigali.

The first objective of establishing the relationship between smart intelligence video analytic feature and protection of people and properties has a positive and significant relationship (b=.157 and p=.004). The second objective of establishing the relationship between facial recognition system and protection of people and properties has a positive and significant relationship (b=.1.059 and sig=.000), the third objective of establishing the relationship between VIT and protection of people and properties has a positive relationship (b=.101 and p=.003). The results have revealed that Ho is failed on the assumption regarding constant while the coefficient of smart intelligence video surveillance with protection of the people and properties, Ho is rejected implying that the H1 asserting that there is contribution of smart video intelligence on public safety is accepted. Thus, implies that there is a positive significant relationship between smart intelligence video surveillance and protection of people and properties in Kigali, Rwanda.

5.5. Summary of research results

The findings prove that there is a positive significant relationship between Facial recognition system and reduction of accidents (p=.773 and sig=.000) between facial recognition system and reduction of response time (p=.500 and sig=.000) between facial recognition system and protection of people and properties (p=.997 and sig=.000) between VIT and reduction of accidents (p=.695 and sig=.000) between VIT and Reduction of response time (p=.987 and sig=.000) between VIT and protection of people and properties (p=.492 and sig=.000) because all calculated p- values are less than 0.01 level of significance. Thus, implies that there is a relationship between predictors of smart intelligence video surveillance and measures of public safety in Kigali, Rwanda.

The findings indicate that there is significant relationship between smart intelligence video surveillance and reduction of accidents because the calculated significance value .000 is less than 0.05 level of significance (calculated sig. value.000 < critical level of significance 0.05). Thus, the statistical model predicting the relationship between smart intelligence video surveillance and reduction of accidents is significant. The results reveal that predictors of smart intelligence video surveillance have positive coefficients that enhance positive effect on the progress of reduction of accident in Kigali. The regression analysis indicates that there is a positive significant relationship between smart intelligence video surveillance and reduction of accidents because all the calculated p-values are less than 0.05 each. Thus, the coefficient gives regression model, $Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta$. Therefore, the model becomes Y=.006+.320x1+.493x2+.096x3, this regression equation indicates that there is a positive significant between predictors of smart intelligence video surveillance and reduction of accidents in Kigali.

The first objective of establishing the relationship between video analytic feature and reduction of accidents has a positive and significant relationship (b=.320 and p=.003). The second objective of establishing the relationship between facial recognition system and reduction of accidents has a positive and significant relationship (b=.493 and sig=.000), the third objective of establishing the relationship between VIT and reduction of accidents has a positive relationship (b=.096 and p=.004). Thus, implies that there is a positive significant relationship between smart intelligence video surveillance and reduction of accidents in Kigali, Rwanda.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The previous studies conducted by Calavia (2012) revealed that an intelligent video surveillance system analyses the movement of objects, detecting and identifying abnormal and alarming situations. The system detects abnormal and alarming events based on the parameters of moving objects and their trajectories. The system also uses an easy-to-understand, high-level conceptual language for human operators using semantic reasoning and ontologies. Therefore, it is capable of activating alarms enriched with a description of the situations in the video. Furthermore, the system can automatically react to these alarms by alerting the appropriate emergency services through the Smart City safety network. The results revealed by Lim (2013) stated that an intelligent framework for detecting multiple events in surveillance videos. Cong (2013) have done a study on the detection of video anomalies that play an essential role in intelligent video surveillance.

Therefore, the results indicate that that the R coefficient .996 reveals that smart intelligence video surveillance has a positive relationship with reduction of response time. The coefficient of determination .991 R square also indicates that smart intelligence video surveillance explains 99.1 % the progress variability in reduction of response time. Thus, it implies that predictors of smart intelligence video surveillance such as video analytic feature, facial recognition system and VIT affect the progress of reduction of response time by 99.1% in Kigali. The results have also proved that there is a positive significant relationship between smart intelligence video surveillance and public safety because there is also a positive relationship between video analytic feature and reduction of response time (p=.877 and sig=.000), between VIT and protection of people and properties (p=.557 and sig=.000) between reduction of accident and Reduction of response time (p=.815 and sig=.000) because all calculated p- values are less than 0.01 level of significance.

6.2. Recommendations

Basing on the findings of the study, the researcher would like to recommend to the Rwanda National Police and other security organs to use the information provided by smart intelligence video surveillance to ensure public safety in terms of reducing accidents, reduction of response time and protection of people and properties in City of Kigali.

Basing on the research findings, the researcher would like to recommend to the public to be sure that their safety and safety of their property is the priority number one to work hard in hard with the smart intelligent video surveillance to promote safety and security in City of Kigali.

The researcher would like also to recommend to the operators in Rwanda National Police to be so vigilant during their duties and work time so that all the information disseminated by the CCTV cameras from onsite should be well analysed and be transferred to the related department for further scrutiny and analysis to ensues safety of the public through accidents reduction, response time reduction and protection of people and properties in the City of Kigali.

6.3. Suggestion for Further Studies

The results of the study have indicated that there is a positive significant relationship between smart intelligent video surveillance and public safety in City of Kigali. Thus, the researcher would like to recommend to the future researchers to conduct studies in the areas following:

(i) To examine the impact of smart intelligence video surveillance on reduction of accidents in City of Kigali;

(ii) To assess the role of facial recognition on reduction of response time in City of Kigali

(iii) To determine the effect of Vehicle Identification and tracking on protection of people and properties in City of Kigali.

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APPENDIX ONE: QUESTIONNAIRE TO RNP RESPONDENTS

Part one: Socio-demographic characteristics of respondents

1. Gender of respondents

   (1) Male

   (2) Female

2. Age of respondents

   (1) Below 25

   (2) 25 – 35 years old

   (3) 35 - 45 years old

   (4) 45 years and above

3. Marital status of respondents

   (1) Married

   (2) Single

   (3) Divorced

4. How long have you been in Police?

   (1) Below 5 years

   (2) 5 – 10 years

   (3) 10 – 15 years

   (4) 15 years and above

Part Two: Questions regarding video surveillance solutions

5. To what extent are video analytic features important in facilitating the work of RNP in enhancing public safety in Kigali (1-Not important at all, 2- Not important, 3- I don't know, 4- Important, 5- very important).

Statement regarding video analytic features	1	2	3	4	5
Video analytic features help to detect abnormal crowd behavior for public safety reasons					
Video analytic features help to detect immediately cameras vandalized or attached for public safety reasons					
Video analytic features detect change in the scene and alert relevantly					
Video analytic features counts number of people entering/existing in an area for public safety purposes					
Video analytic features monitors people in video camera view to enhance public safety					
Video analytic help to detect motion for the sake of public safety					
Video analytic help in tracking abandoned object for the sake of property security					

6. To what extent do you think vehicle identification tracking is important for the public safety? (5 – To a very great extent, 4- to a moderate extent, 3- small extent, 2- To no extent, 1- Not sure)

Statement regarding vehicle tracking identification	1	2	3	4	5
Vehicle tracking identification help to track vehicle involved in crime scene					
Vehicle tracking with help of facial recognition help to allocation criminals					
Vehicle tracking identification help to allocate the missing vehicle					
Vehicle tracking system monitors the flow of car in the city					
Vehicle tracking system promote security for VIP protection					

7. What is your level of agreement on the following statement regarding facial recognition in promoting public safety in Kigali? (5 – Strongly Agree, 4- Agree, 3- Neutral, 2- Disagree, 1- Strongly Agree)

Statement regarding facial recognition system	1	2	3	4	5
Face detection and recognition help to track the criminals for public safety					
Face attributes help to recognize the face image of terrorists for public safety					
Face comparing differentiate between similar looking criminals and residents for public safety					
Face recognition help to allocate one individual from many for public safety					
Facial recognition help to detect the high profile wanted criminals					
Face land marking help to recognize key features of the face of suspect					

Part Three: Questions regarding public safety in Kigali

8. To what extent do you apply smart intelligence video surveillance solution to reduce accidents in Kigali? (5 – Strongly Agree, 4- Agree, 3- Neutral, 2- Disagree, 1- Strongly Agree)

Statement regarding reduction of accidents	1	2	3	4	5
Accidents reduce in proportion to smart intelligence video surveillance					
Video surveillance cameras have reduce rate of accidents in Kigali					
Video surveillance cameras reduce the individuals at risk of causing accidents					
Video surveillance have reduced the number of traffic police deployments					

9. What is your level of agreement on the following statement regarding the role of video surveillance in protection of people and properties? (5 – Strongly Agree, 4- Agree, 3- Neutral, 2- Disagree, 1- Strongly Agree)

Statement regarding protection of people and properties	1	2	3	4	5
Video surveillance promote investigative procedures for people' and property protection					
Video surveillance proactively identify and analyze crimes to protect people and properties					
Video surveillance promote better deployments of patrols to protect people and properties					
Video surveillance provide data to handle issues related property and people protection					
Video surveillance eases the job of police in protection of people and properties					

10. What is your level of agreement on the following statement regarding role of video surveillance in reducing time to respond? (5 – Strongly Agree, 4- Agree, 3- Neutral, 2- Disagree, 1- Strongly Agree)

Statement regarding video surveillance in reducing time to respond	1	2	3	4	5
Video surveillance reduces time to respond in case of fire incident					
Video surveillance reduces time to respond in case of traffic accident					
Video surveillance reduces time to respond in case of robbery					
Video surveillance reduces time to respond in case of terror attack					
Video surveillance reduces time to respond in case of calamity					

Thank for your participation in this study, God bless you!