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The Use of an Intelligent Surveillance System in Developing Countries-Rwanda

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Abstract: ***Artificial intelligence area ongoing research on Intelligent Surveillance System of CCTV cameras has attracted many researchers where CCTV cameras system can flag scenarios of interest and communicates to security services for quick interventions and it has been emerging as a demanding research area in the domain of artificial intelligent. This survey paper proposes a literature review detailing the current state-of-the-Art in Intelligent Surveillance System and if it can be appropriate to be applied in Rwanda's main cities as one of security measures. It also looks at how the Rwandan Ministry of Internal Security (MININTER) should be better to develop an intelligent surveillance system that can conduct active surveillances in the main cities such as Kigali, Gisenyi and others. In this survey, we have discussed the feature of metadata rule that are used in CCTV Cameras where the system consists of low-level context-aware, high-level context-aware and intelligent services to generate metadata for the surveillance systems. In this survey, we have seen some architecture and metadata scheme of some surveillance systems. The emphasis of this review is to discuss the possible creation of Intelligent Surveillance System of CCTV Cameras in the Rwandan Ministry of Internal Security (MININTER. Lastly the main challenge and techniques were observed for more understanding in the context of how the system should be applied in the Rwandan interior Ministry within the main cities. The survey brings up main challenges, key techniques, and areas that need more research.***

Keywords: Intelligent Surveillance, Closed Circuit Television (CCTV) Camera, Object Tracking.

I. INTRODUCTION

In recent years, the current state-of-the-Art in Intelligent Surveillance System has become very important not only in preventing crimes and other incidents but also in helping further investigations in case crimes have already occurred. For that reason, main cities in Rwanda should start intelligent surveillance system of CCTV Cameras that can conduct active surveillance throughout the main cities to flag potential dangers to national security. Based on horizon scanning, today Rwanda's main cities are developing at high speed which means that the Rwandan interior Ministry must start intelligent Surveillance system of CCTV cameras. This one, connected to an active back end system, can flag scenarios of interest and communicate to security services for quick interventions. As I have mentioned, Rwanda's main Cities such as Kigali, Gisenyi, Butare, Ruhengeri and others are growing very fast, thus becoming very crowded and increasing security concerns.

II. CLOSED CIRCUIT TELEVISION (CCTV) DEFINITION AND RELATED WORKS

Closed circuit television (CCTV) refers to the use of video cameras to transmit signals to a Specific place with a set of monitors and It is increasingly used by many countries for critical applications, such as bank monitoring, retail control and crime detection,where manual monitoring can be difficult, problematic or unfeasible (J. R. Agustina and G. Galdon Clavell, 2011).

Yong Wan Ju at al. (2013) stated the industry and technology of CCTV (Closed-Circuit Television) has been increased and moved to an important position for over decades, because terrors, anti-social behaviors and arsons have happened rapidly after the advent of CCTV in the 1950s. The technology capable of transforming into digital files which can be stored into a hard drive has been developed to see the files through the Internet. Also the CCTV converged with network and IT technologies progressed to watch behaviors of objects and human and identify them automatically. And the CCTV namely intelligent CCTV has applied to multi-areas. "The technological evolution of intelligent surveillance systems (1st, 2nd and 3rd generation), also have outlined the main problems and current research in each of them" (M. Valera and S.A. Velastin, 2005). The main goal of intelligent surveillance consists of providing security systems with the skills required for correctly detecting and analyzing events in monitored environments. Since these environments are complex and the information is distributed through them, the use of agent-based approaches has become more and more popular when monitoring moving objects (D. Vallejo et al., 2014). Yong Wan Ju et al.(2013) Clarified that an intelligent

CCTV is a system to inform special objects and behaviors by identifying them automatically through software program attached to the intelligent CCTV. It has benefits for not watching everything manually, but automatically. Closed-circuit TV (CCTV) systems use a variety of methods of data transmission, including coaxial cable, wireless technology and fibre-optic cable. It has been established that the most efficient, future-proof and reliable transmission method, uses fibre-optic technology, but the corresponding expenditure for its roll-out is substantial. As a result of the Beaufort Street system, the City has made use of alternative technologies, including Cat 6 cabling, wireless and 4G transmission methods (Closed Circuit Television (CCTV) Strategy 2013-2018, 2013).

Therefore, it can be operated by minimum operators. The research indicated in their paper the current CCTV namely simple CCTV and intelligent CCTV comparison is as below

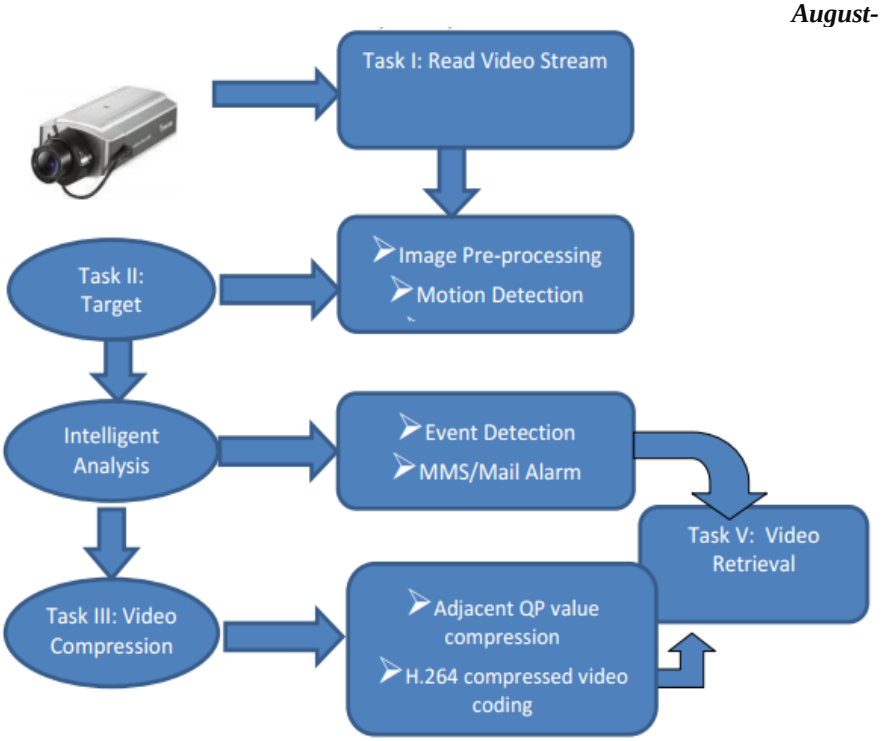
	Simple CCTV	Intelligent CCTV
Feature	· Watching everything manually	· Watching everything automatically
Example		 ※ Automatically the S/W identify the behavior of assault
Benefits & Weak-Ness	· Easy maintenance · 24hr monitoring by human · Identify special behavior by human	· Minimumoperator · Automaticinformtooperatorwhenhappening aspecialsituation · Hard implementation
Function	· Monitoring road 24hr by human manually 	· Monitoring road 24hr by video surveillance solution automatically 

Simple CCTV VS Intelligent CCTV **(**Yong Wan Ju et al., 2013).

Yunyoung Nam et al.(2010) Presented an intelligent video surveillance system with the metadata rule for the exchange of analysed information .this system has consisted of low-level context-aware, high-level context-aware and intelligent services to generate metadata for the surveillance systems. Fernández (2013) suggested an implementation of an intelligent surveillance platform based on the usage of large numbers of inexpensive sensors designed and developed inside the European Eureka Celtic project HuSIMS. The researcher had aim of maximizing the number of deployable units while keeping monetary and resource/bandwidth costs at a minimum **(**Velastin, 2005).

Despite of the recent technological advancements in developing automatic surveillance systems, their effectiveness is usually affected by different factors and they are not completely reliable. These "imperfect" systems might still be useful if they inform users of their deficiency. In other words, if the automatic system could inform the user about its level of confidence in the generated alarms, then the users' reliance on the system would be increased. A series of experiments were designed to investigate various design features such as functionality of automatic system (Spotting and Tracking) and different levels of accuracy ranging between 66% and 75% (Dadashi, 2008).

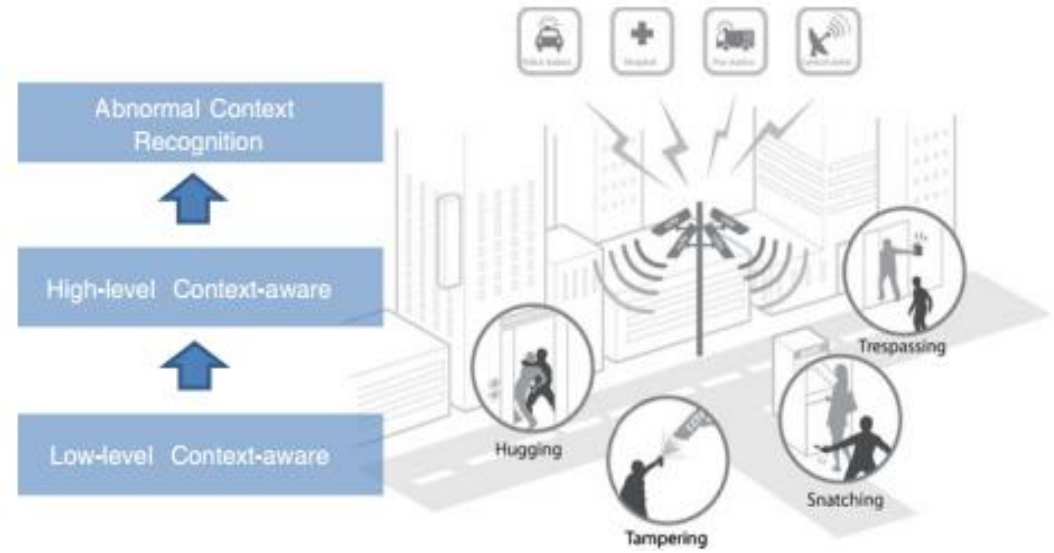
M.Sivarathinabala et al.(2013) proposed a model for Intelligent Video Surveillance System Framework as depicted in Figure 1



Intelligent Video Surveillance System Framework (M.Sivarathinabala et al., 2013).

Described the intelligent surveillance system architecture and its components are described as follows (Yunyoung Nam et al., 2010).

- **Sensing Infrastructure:** Sensing Infrastructure is used to collect various data from heterogeneous sensing hardware devices in a ubiquitous network environment. This paper used cameras, GPS for a location awareness sensors, and microphones for a noise sensor to acquire various data in the monitoring areas. Data from the Sensing Infrastructure are transmitted to the Context Aggregator and are modified as our predefined format for the context awareness
- **Context Database**: Context Database refers to the module in which the modified data from;
- The Context Broker (which is used for the future awareness of context) is stored. The corresponding data are represented as space safety index, personal safety index and so on.
    - **Context Broker:** Context Broker stores the data into the context DB that is transmitted from the Context Aggregator. Data are processed for the usage of the corresponding space.
    - **Community Manager:** When an event occurs in a specific location according to our predefined criteria, Community Managers gives instruction to its Service Invocators to construct relevant services that are defined by Community Editors.
    - **Community Editor:** Community Editors construct the community that makes a service when a pre-defined event occurs in our monitoring area. The Community is dynamically constructed and stored in the Community Template Repository.



3-tier context-aware surveillance system (Yunyoung Nam et al., 2010).

The captured images can be viewed in real-time or recorded for later review (F. Conche and M. Tight, 2006). This includes devices such as VHS video tapes, CDs, DVDs, tapes or a computer-based medium connected to a viewing monitor. Observers, on-site or off-site, can review captured images directly on screens or through telephone lines, the Internet or any other network.

III. KEY TECHNIQUES/ALGORITHMS

3.1. Object Tracking: Object tracking is the process of tracking the object over the time by locating its position in every frame of the video in the surveillance system. It may also complete region in the image that is occupied by the object at every time instant (Yilmaz, 2006). Moving Object detection is the first low level important task for any video surveillance application. Detection of moving objects is a challenging task (Kinjal A Joshi et al., 2012)**.**

Varas, D. and Marques (2012) presented an algorithm for detecting and tracking moving objects using automatic initialization based on background modelling. Their proposed region competition level-set method was used for motion detection and tracking based on the statistical information of image intensity within each subset instead of searching geometrical boundaries. Before going to object segmentation and tracking background modelling is done. Hidden Markov Model: In recent days Hidden Markov Model is widely used for background subtraction. Corresponding to the events in the environment it represents the intensity variations of a pixel in an image sequence as discrete states. As for example, image pixels can be in the background state, the foreground (car) state, or the shadow state in highway car tracking scenario. Hidden Markov Models (HMM) applied by Stenger, B., Ramesh, V., Paragios, N., Coetzee, F., and Burmann, J. (2011) described small blocks of an image into three states. Using HMMs for the background subtraction in the context of detecting light on /off events in a room. Those events which are hard to model correctly using unsupervised background modelling approach advantage HMMs are used for training samples.

The Tacking methods can be roughly divided into four major categories, and algorithms from different categories can be integrated together Region-based Tracking and Region-based tracking algorithms track objects according to variation of the image regions corresponding to the moving objects (Cavallaro at al., 2005).

Contour-based Tracking in contour-based methods, instead of tracking the whole set of pixels comprising an object, the algorithms track only the contour of the object (Isard, M. & Blake, A., 1996).

Feature-based Tracking; Feature-based methods use features of a video subject to track parts of the object. Feature based tracking algorithms perform recognition and tracking of objects by extracting elements, clustering them into higher level features and then matching the feature between images**.**

Model-based Tracking; Model-based tracking algorithms track objects by matching projected object model. The models are usually constructed off-line with manual measurement, CAD tools or computer vision techniques.

Hybrid Tracking Hybrid; approaches are designed as a hybrid between region-based and feature-based techniques.

Video Processing Techniques:

There are five Video Processing Techniques used Intelligent Video Surveillance System M.Sivarathinabala (2013) as highlighted below:

3.2. Pre-Processing; first, the videos are separated as frames and pre-processing method is used for colour conversion to subtract foreground objects from the background. Pre-processing is mainly used to enhance the contrast of the image, removal of noise and isolating objects of interest in the image.

3.3. Target Detection; analysis of Motion detection is an important step. In this step, we have to extract the foreground object from the background. Then classify the object whether it is human or non-human. Once the object classification is done, object tracking is next step. The tracking is done based on region and contours. There are three conventional approaches to moving object detection: temporal differencing, optical flow and background estimation methods

3.4. Intelligent Analysis; intelligent analysis module is the core of the video surveillance system, which mainly includes the number of target identification and extraction of statistics. Automatic activity recognition plays a key part in video surveillance. Recognition accuracy is always a major concern for automatic event recognition. Activity Recognition can be achieved through body part modeling and pose estimation. Many algorithms have been proposed which try to detect human activities with high accuracy.

3.5. Video compression; the video is compressed by H.264 coding. The quantization parameter value and extent of data loss are associated with the picture quality. Less important information can be lost compression of in the surveillance video background. The area containing the moving object is the important information, so lossless compression or appropriate lossy compression is used.

3.6. Video retrieval: in the video analysis, the systems first segments video objects (VO) from surveillance videos, and the fundamental semantic information is then extracted and indexed into the database.

3.7. Gaussian Mixture Model: The moving objects distribution in the first frame of the video sequences; we can localize the object in the next frames by tracking its distribution. Gaussian Mixture Model is a popular technique for modelling dynamic background as it can represent complex distribution of each pixel. But GMM suffers from slow convergence at the starting stage of detecting backgrounds. Also it sometimes leads to false motion detection in complex background (Vu Pham et al., 2010). Computer vision-based fire detection algorithms are usually applied in closed-circuit television surveillance scenarios. The researcher proposed the use of filter banks, frequency transforms, and motion tracking, requiring more computational processing time, making them unsuitable for real time processing (RAGITHA.K, 2013).

IV. MAIN CHALLENGES

Some researchers relieved that the Processing videos captured by a single fixed outdoor CCTV camera overlooking areas where there are a variety of vehicle and/or people activities, though the techniques developed can be applied to indoor scenarios and there are typically a number of challenges associated with the chosen scenario in a realistic surveillance application environment as follows (L-Q Xu, 2004).

4.1. Natural cluttered background; stated that natural outdoor environment is usually noisy and difficult to characterize. The video sequences captured are also often subjected to a compression process such as MPEG or JPEG before being transmitted via a network or stored for analysis. This introduces coding-induced noise into the already noisy imaging sources.

4.2. Dynamic background; the scene background is not normally a fixed structure, but often changes with time. In the case of a swaying tree or flag, each pixel in the background cannot be fully characterized by a single color; two or more different appearances could be alternating.

4.3. Illumination changes; pointed that Outdoor surveillance systems suffer heavily from the change of weather conditions. Rain, sunset, sunrise, as well as floating clouds can have a dramatic impact on the scene illumination.

4.4. Occlusions; in a typical outdoor scene with many moving objects, occlusion is a crucial issue that needs special treatment. M.Sivarathinabala et al. (2013) realized that in outdoor surveillance, moving backgrounds (waving trees clutter) and illumination changes (weather changes, reflections, etc.) are the major challenges for background modeling.The challenges that are faced by intelligent surveillance systems possibly involving a huge number of cameras/sensors as they described in this context from the first to the eighth challenge as follow:

First challenge is the quality of CCTV data ; Images or audio recordings are not always perfect in such systems, objects of interest can be partially obscured; camera lenses maybe covered or damaged, the person (object) being recognized may have deliberately covered itself up. Even when these problems do not exist, there are other factors causing quality concerns, such as, poor illumination, sensor noise, particularly in poor lighting conditions and low resolution of the cameras.

The second challenge is the uncertainty of recognized events; from a source (e.g., a camera) due to the poor quality of data provided. Any events detected from such imperfect information are subject to uncertainty and many possible events can be generated from the same set of images, e.g., multiple explanations.

The third challenge is the inconsistency or conflict among multiple sources; A CCTV-based; Surveillance system could consist of hundreds of cameras, such as in a medium-sized airport;

The fourth challenge is the adequate modelling of events information; For real-time surveillance involving multiple sources, the representation of events is particularly important, since it influences fundamentally the ways to merge detected events from multiple sources and the uncertainty and inconsistency handling during the fusion process;

The fifth challenge is the composition of elemental events for inferring and predicting threats; a single event cannot reveal potential threats most of the time unless it is extremely significant;

The sixth challenge is the scalability of the system; imaging a real-time intelligent surveillance system with many hundreds of cameras across a large network, the scalability of its modelling and reasoning power is greatly challenged;

The seventh challenge is building ontologies for surveillance systems; to realize the scalability of a large surveillance system can be a challenge. Ontology is a description of the concepts and relationships that can exist for an agent or a community of agents. If each camera/sensor/equipment is taken as an agent, then surveillance ontology is needed, at least for events models, in order to allow information from multiple sources to be exchanged and merged. For example, taking a seat should be explained as equivalent to sitting down under the context of bus surveillance.

The eighth challenge is the evaluation of a surveillance system. For data mining or machine learning algorithms, there are now some standard data sets for validating and evaluating new algorithms and for comparing them with existing ones.

Many researchers clarified that despite of the recent technological advancements in developing automatic surveillance systems, their effectiveness is usually affected by different factors and they are not completely reliable. These "imperfect" systems might still be useful if they inform users of their deficiency (Dadashi, 2008).

V. CCTV LEGAL ISSUES

A big issue associated with CCTV systems is that they are offensive to privacy. Therefore, many countries have introduced a code of conduct for CCTV systems to insure that the systems are operated in a highly professional and private manner

As stated by B. C. Welsh and D. P. Farrington (2003) a list of legal requirements must be met by a CCTV system. This includes:

- "CCTV should only be used in public places, i.e. in areas where persons do not have a reasonable expectation of privacy.
- Approval must be obtained from the owners of buildings and structures to which cameras will be attached.
- Personnel operating the system should be carefully screened and selected to ensure

Professionalism and trustworthiness since recorded material is sensitive and confidential.

- The recorded material must be treated as highly-confidential and be erased after a specified period of no longer than 30 days, unless needed for evidence. Material can, under no circumstances, be used for any

purpose other than crime detection and evidence. Video tapes must be kept locked and there must be registers to control the storage of materials.

- There should be sanctions attached to the transgression of guidelines.
- No promises or guarantees should be made to the public or any other role player about the system."

VI. CONCLUSION

In a nutshell, considering present circumstances in Rwanda, it is important to implement an Intelligent Surveillance CCTV cameras system. These cameras should be located in all corners of main cities namely Kigali, Gisenyi, Butare, Ruhengeri, Nyagatare just to mention a few. This system can flag potential dangers to the national security. As I have illustrated in literature review, implementing this system should meet some challenges, since most existing approaches hugely depend on human observers (agents) and there is no unified framework to meet this requirement. Based on horizon scanning for the above authors from literature, the system can be realizable in Rwanda because its main cities are developing very fast, consequently increasing the number of incidents. For instance, fire incidents occur in Kigali and other main cities and with no CCTV Cameras System, it is impossible to track the causes and apprehend suspects if necessary.

Also, Rwandan Ministry of Internal Security (MININTER) was threatened by what could be called "grenade attacks" in public and very crowded areas. With CCTV Cameras system in place, not only the system can be deterrent, but also can be a very reliable tool for investigations.

We cannot however, think of installing the intelligent surveillance system of CCTV Camera System in our cities without planning ahead and solve some important issues like training the security personnel, increasing the public lights on streets and major places where the public tend to gather in a mass. Since the intelligent CCTV Cameras Systems, sometimes are considered as a threat to individual privacy, it can be very important to educate people about the importance of the system is preserving security in our developing countries.

VII. AREAS DESIRING MORE RESEARCH.

Due to the modern society lifestyle, living in secured environments has become a priority and the intelligent surveillance systems are getting more and more important. Therefore, areas desiring more research lines are becoming increasingly relevant with the aim of developing more sophisticated intelligent surveillance systems of CCVT cameras. As clarified in reviewed Journals, I have realized that there are more areas where an intelligent surveillance system can be applicable especially in Rwanda as a developing country. For instance, residential home CCTV camera surveillance can be a good field for research to be conducted. Citizens can have some intelligent surveillance system in their homes, and the technology to help monitor all events happening in their homes, and inform security officers if any incident requires intervention. Moreover, Rwanda as country is still lagging behind in terms traffic safety, the intelligent surveillance system in public transport vehicles is also a nice areas for research where the system once installed inside vehicles, that system can alert the police if the driver is over speeding. That can help because speed has become one of major causes of road accidents.

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