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EVALUATION & TRENDS OF SURVEILLANCE SYSTEM NETWORK IN UBIQUITOUS COMPUTING ENVIRONMENT

Sunil Kr Singh
CSE Department, Bharati Vidyapeeth College of Engineering
Affiliated to GGSIP University, New Delhi, India
E-mail:drsunilsingh@acm.org
Anuj Aggarwal
ECE Department, Bharati Vidyapeeth College of Engineering
Affiliated to GGSIP University, New Delhi, India
E-mail:anuj.aggarwal@acm.org
Kavneet Kaur
CSE Department, Bharati Vidyapeeth College of Engineering
Affiliated to GGSIP University, New Delhi, India
E-mail: kavneetk@acm.org

ABSRACT

With the emergence of ubiquitous computing, whole scenario of computing has been changed. It affected many inter disciplinary fields. This paper visions the impact of ubiquitous computing on video surveillance system. With increase in population and highly specific security areas, intelligent monitoring is the major requirement of modern world .The paper describes the evolution of surveillance system from analog to multi sensor ubiquitous system. It mentions the demand of context based architectures. It draws the benefit of merging of cloud computing to boost the surveillance system and at the same time reducing cost and maintenance. It analyzes some surveillance system architectures which are made for ubiquitous deployment. It provides major challenges and opportunities for the researchers to make surveillance system highly efficient and make them seamlessly embed in our environments.

Keywords- surveillance systems, ubiquitous computing, cloud based surveillance, challenges in surveillance system, generations of surveillance system

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1. INTRODUCTION

A noteworthy quote by Mark Weiser “the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” [11]. These words gave emergence to the new third wave of computing know as **Ubiquitous computing** (UbiComp), which prospects the vision of making computing appear everywhere and anywhere. It enhances and empowers the human-computer interaction to a whole different dimension in which the user is surrounded by a complete smart environment with devices/sensors communicating with each other and combining their functionalities to provide an array of amalgamated services. Fundamentally, it takes conventional computing that deals with virtual world to modern computing which deals with physical or real world with unobtrusive human interactions.

A feel of the ubiquitous computing concept can be perceived by a simple example. Let us consider that a person in sitting in a room and his clothes are fabricated with invisible biometric monitors. It records his behavior and movement i.e. sleepy, excited, and reading, etc. With the calculation of readings, smart environment controls light brightness, air conditioner temperature and noise, thus making one’s life more comfortable.

1.1 SMART DEI MODEL

A three dimensional approach called the smart DEI model has been proposed to analyze and design a comprehensive framework for ubiquitous computing [17]. The dimensions are included in the acronym DEI, in which ‘D’ stands for Device, ‘E’ for Environment and ‘I’ for Interaction. Model consists of architecture design, internal model and interaction with physical environment.

1.1.1 Architecture Design

The architecture design of smart DEI model is a sack of three types: Smart Device, Smart Environment, and Smart, Smart interaction. ‘Smart’ means that the entity is active, digitally networked, can operate to some extent autonomously, is reconfigurable and has local control of resources (such as energy, data storage, etc.) It needs. Smart devices mostly focus on interaction within a virtual world and are less context aware of the physical world compared to smart environment devices. They are manually activated devices. Smart devices consist of three basic forms with three additional forms. The three basic forms consist of Tabs (wearable centimeter sized devices), Pads (hand held decimeter sized devices), and Boards (meter sized interactive display devices) .We have seen these basic forms in our environments but three additional forms which are about to blow up in future, giving future technologies a new shape, are Dust, Skin, and Clay. Dust is a miniature sized device that can be without visual output displays. It senses every minute thing and can be fabricated ubiquitously such as on buildings, streets, traffic. This device may be proven highly effective in military. Skin is the fabrics based upon light emitting and conductive polymers. Organic computer devices can be formed into more flexible non planar display surfaces and products such as clothes and curtains. Example – OLED (Organic Light Emitting Diode) technology can be used as an efficient way of lightning and it is flexible too. Thus may be employed in future PDA's. Clay ensembles MEMS (Micro Electro Mechanical System) that can be formed into an arbitrary 3D shapes as artifacts resembling many different physical objects. One such example is tangible user interface.

Smart Environment consists of a set of networked devices that have some connection with the physical world. These devices are strongly context aware of their physical environment. Example- automated door opens/closes.

Smart Interaction consists of components that dynamically organize and interact to achieve goals. This organization may occur internally without external influence, thus making it a self organized system.

1.1.2 Internal model

Internal model of smart DEI is based upon five fundamental properties, namely, Distributed ICT, iHCI, Context Awareness, Autonomy, and Artificial Intelligence. Distributed ICT systems are in layers, in which bottom layer forms hardware, middle layer forms operating system, and top layer forms human computer interaction (HCI). Implicit human computer interactions (iHCI) consist of calm computing and systems that interact autonomously with human actions without being noticed. Context awareness is to make a system dedicated to a particular task or context rather than supporting all. Autonomy can be defined as a system which is self governing and capable of own independent decisions and actions. Artificial Intelligence refers to intelligence or decision making by machines pertaining to some algorithm or sensors.

1.1.3 Interaction with external environment

This model consists of three types of interactions

- The interaction with virtual environment (conventional C2C computing like mobile phones).
- HCI interaction between human and computer.
- CPI interaction between computer and physical world

1.1.4 Aims of smart DEI model

The ubiquitous systems should be as small as possible so that they can be hidden in our environment. They should be inexpensive so that they can reach to every human in every corner of the world. They should form a robust network which do not fails as once they enter our lives; we shall be highly reliable on them. The ubiquitous systems should be mobile to provide nomadic computing. The user interfaces on the systems should be as simple as possible. They should form a reliable system.

1.2 APPLICATIONS

Ubiquitous computing has wide range of applications as it can be embedded everywhere in our environment. It can be applied on devices forming smart PDAs, smart classrooms, medicinal purpose, home environment, high performance systems, and surveillance system. Significantly, the vision of surveillance will be revolutionized with the advent of ubiquitous computing. It will not be very hard to figure out that you are being watched, due to video surveillance cameras protruding from every building. But with the internet of things, the surveillance grid will unite seamlessly and invisibly into the entire environment. In a ubiquitous environment, every object, as well as person who wears RFID tagged clothes or are using electronic devices, would be "readable" by a computer or wireless network. The node's details, exact location and other information can be obtained electronically by invisible sensors in sidewalks, roads, or doorways. Ubiquitous vision system utilizes redundant visual information for robust monitoring tasks in large scene area. Several vision sensors observe a common area and provide redundant information [6]. This redundant observation contains rich information for robust vision functions. Key specifications of the ubiquitous vision system are summarized as follows:

- Covers large scene area to observe dynamic events happening in the environment.
- Tracks dynamic event in real time.
- Synthesizes views for visualization at arbitrary viewpoint.
- Enables us to develop integrated information framework that can access both real world and virtual world through computer network.

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2. SURVEILLANCE SYSTEMS

In domains of computer vision, the needs of intelligent surveillance systems are rising in huge demand. The deployment of distributed surveillance systems in commercial, government monitoring and military operations plays a vital role. Recent terrorist attacks and criminal offences made it necessary to embed efficient surveillance systems in the environment. Networks of large number of cameras are required to provide wide scene coverage for many surveillance tasks. In designing such networked camera systems, considerations of practical aspects matters such as cost, complexity and robustness. Automated surveillance systems deals with real time monitoring of persistent and transient objects within a specific environment. The primary aim of these systems is to provide an automatic interpretation of scenes, to understand and predict the actions along with interactions of the observed objects based on the information acquired by sensors. The main stages of processing in an intelligent visual surveillance system are: moving object detection and recognition, tracking, behavioral analysis, and retrieval.

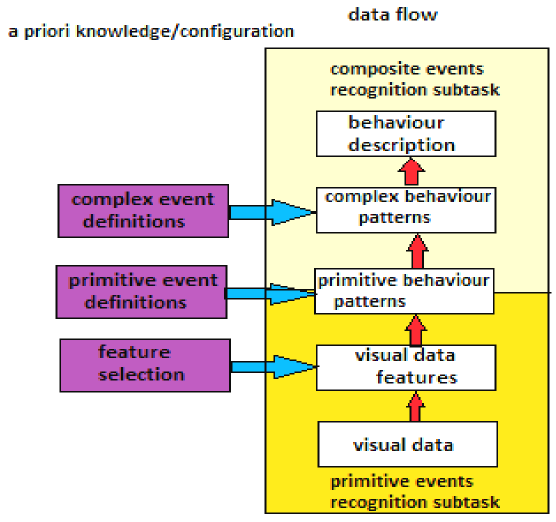

Figure 1: Generalized architecture of visual surveillance system [18]

2.1 FIRST GENERATION

The intelligent surveillance systems are evolved from analog CCTV systems. [1] In that systems multiple cameras are placed in remote locations and were connected to set of monitors kept in a monitoring room. It needs a person to monitor all the events. They were mainly used to store visual recordings and use the recordings, if any mishappening takes place. It uses rectilinear images for stereo matching and their cameras were arranged densely with short baseline. The scene, where they were looking at, was restrained to small area. Therefore, the major problems of such systems are less intelligent monitoring, and data degradation due to digital data recorded being converted to analog for transmission to monitors leading to attenuation in signals.

2.2 SECOND GENERATION

After first generation, around 1980 the second generation of computer came, that uses algorithms in digital video processing for automated data extraction from CCTV systems and alert the concerned person or authority if something unusual or illegal takes place. It also helps the government authorities to track specific persons and vehicles in case of breaching of laws.

2.3 THIRD GENERATION

The third generation is now taking its shape with the help of various kinds of sensors which are being embedded ubiquitously in environment. It uses systems which are very efficient and provides large number of information about an environment from recordings, in real time by offering omni-directional view. The agenda is to make an extensively distributed multi-sensor wiretap system, possessing concentrated, and time authenticated computer algorithms which enable execution on several applications employing minimum manual reconfiguration. Such devices must be compatible to the extent that, they adopt and combat variations (physical, natural or geographical) in the environment. The merger of radio communication technologies and algorithms, for calculating locations, constitutes smart video security surveillance, which in turn is based on pervasive sensor network technology. Wireless Fidelity (Wi-Fi), Radio Frequency Identification (RFID), ZigBee, Ultra Wide Band (UWB), and etc., are examples of representatives' radio communication technologies. Angle of Arriva (AoA), Time of Arriva (ToA), Received Signal Strength Indication (RSSI), Chirp Spread Spectrum (CSS), and etc., are some of the algorithms employed for computing locations. CSS method, which is known for its accuracy amidst location identification methods in radio technology, is engaged for intelligent video security surveillance system based on ubiquitous sensor network technology.

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FIRST GENERATION (1960-80)	
TECHNOLOGY	-Analogue CCTV system -use VCRs
PROBLEMS	-rectilinear images -limited to small area -degradation of video quality over time -manual monitoring
MAINTENANCE	-Labour intensive - very costly
ADVANTAGES	-monitoring of activities in a remote place -Recorded videos to watch past proceedings.
STORAGE	Video tapes, required to change manually on regular basis

SECOND GENERATION (1980-2000)	
TECHNOLOGY	-Hybrid analog digital system -use of DVRs -digital processing -LAN connection
PROBLEMS	-poor transmission of data to mobile agents -low quality fusion of various sensors -poor occlusion handling
MAINTENANCE	-Moderate cost -annual or biannual manual servicing
ADVANTAGES	-to focus the operator's attention in alarming situation automatically -compression methods to save bandwidth resources
STORAGE	-hard drive used as in computers in which most recent recordings overwrites the oldest, allowing uninterrupted and continuous recording

THIRD GENERATION (2000-till now)	
TECHNOLOGY	-Distributed computing -Ubiquitous computing -IP based -digital image processing -WAN connection
PROBLEMS	-low energy efficiency -privacy issues -some sensors are very costly
MAINTENANCE	-expensive -can be maintained from remote locations.
ADVANTAGES	-omni directional view -3D images -high performance -multiple sensor provides much accurate information -easy monitoring -data can be accessed from anywhere in the world - automatically adapt and withstand with the changes in the environment, such as lighting, scene geometry or scene activity
STORAGE	-cloud storage/high storage capacity hard disks

Table 1: Phase Wise Evolution of Surveillance System

3. BASIS OF FUTURE SURVEILLANCE SYSTEMS

The foundation of future surveillance systems, based on ubiquitous computing, will require interplay/integration of various interdisciplinary fields. In this paper we are concentrating on essential factors such as cloud computing and context awareness that will contribute to surveillance systems.

3.1 CLOUD BASED MULTIMEDIA SURVEILLANCE SYSTEMS

With the advent of cloud based computing, surveillance systems will be enormously benefited as video recording can be stored on cloud (on a remote server with access of data via internet). This will lead to establishment of cheaper surveillance systems as there will be no need for the user to buy and maintain physical storage devices. This will also lead to lesser manpower requirement to maintain and control the surveillance system as software based surveillance systems will be put in place [16]. The main benefit of the cloud based surveillance system is automated backup of data on the cloud which can be accessed from anywhere in the world. As the cost and maintenance overhead will be minimal, small organizations and companies can also establish their own surveillance system.

3.2 CONTEXT BASED SURVEILLANCE SYSTEMS

In ubiquitous computing environment, multiple sensors are embedded to provide accurate information and data recording. As military surveillance, home surveillance, city market surveillance have its own requirements, there is a need to develop target-oriented architecture. Therefore, global ubiquity of a particular architecture or model of surveillance systems cannot be achieved. Hence, surveillance systems must be context aware so that the architecture may be fabricated as per user requirement in different locations.

4. ARCHITECTURAL ANALYSIS OF MODERN SURVEILLANCE SYSTEMS

There are various existing architectures for ubiquitous surveillance systems having their own merits and demerits. In this paper we are analyzing some renowned architecture of surveillance systems which are proposed for ubiquitous deployment. Some of the highly successful modern surveillance systems are DETER, PRISMATICA, VIGILANT

4.1 DETER

DETER (Detection of Events for Threat Evaluation and Recognition) is a surveillance system for commercial outdoor environments such as parking location.[19] It is used to monitor vehicles, objects and pedestrians. It visions the bridging of gap between current systems that

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use to notify isolated events and automated systems that can notify systems without any human user. The technique DETER used is fusion of overlapping field of vision of various cameras. The threat analyzer is assisted by off line thread model that analyses in real time whether specific activity is threat or not. It reports abnormal moving patterns of pedestrians and vehicles in outdoor environment.

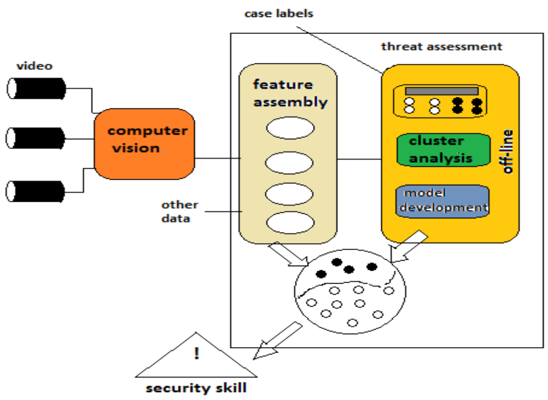

Figure 2: Architecture of DETER surveillance system [19]

4.2 PRISMATICA

PRISMATICA was an EU funded project that was made to monitor tramps and buses, and become part of its surveillance system. The agenda of the project is the fusion of visual and audio information, using crowd and object detection algorithms to perform analyzing process within the subsystem and transferring of high level data so that no loss of clarity and misidentification happens [20]. Basically in PRISMATICA system, the tasks and processes are performed locally in each computer forming a distributed system in which each device is carrying out their own standalone processes which are then connected and synchronized with the help of COBRA (Common Object Request Broker Architecture) and it communicates only high level information to the monitor room.

4.3 VIGILANT

VIGILANT is a multi-camera surveillance system that understands the scene with query driven search algorithm and can generate retrospective video report from previous events. [21] It is utilized to monitor the pedestrians walking in a parking lot. VIGILANT system tracks people across multi-cameras using software agents. An agent is made for each camera for each detected person and those agents from each camera communicates to obtain a combine decision to analyze that each agent is tracking the same person or not by using trajectory geometry.

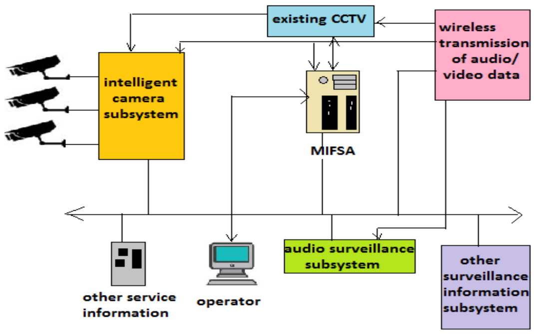

Figure 3: Architecture of PRISMATICA surveillance system [20]

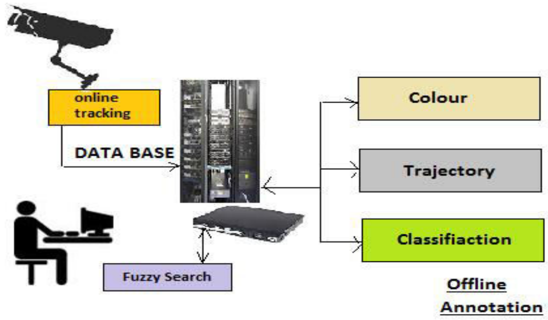

Figure 4: Architecture of VIGILANT surveillance system [21]

5. Qualitative comparisons of results obtained from various techniques used in DETER, PRISMATICA and VIGILANT surveillance systems

We would like to highlight some results of various techniques used in three models i.e. DETER, PRISMATICA and VIGILANT, so a researcher following the particular architecture can look and modify the architecture for increased efficiency. The flaws and effectiveness of all surveillance systems are clearly mentioned to have a proper understanding of the usefulness of these models in environment.

- **DETER**- it uses the technique of overlapping field of vision of different cameras and a threat analyzer to analyze the event. As on the 16 hour testing experiment conducted in Honeywell Laboratories it was found that the system successfully classified and identified most of the vehicles and people but on detection of paths it called 32 times false alarms and several times it also missed tracks of people under surveillance. [23]

PRISMATICA- it uses the technique of fusion of audio and video sensors, and it performs most of the computation at local computers and sends only the high level information to the monitor room. It is a highly successful project and was fabricated in many buses and tramps in London, Paris and New castle which lead to the decrease of robberies, thefts and pick-pocketing by 32% and decrease of breaches by 52% and the overall decrease of threat activities by 23% evaluated over three months. [24]

VIGILANT- it uses the technique of query based search and focuses on creation of user friendly GUI for monitoring and classification of objects and people. The VIGILANT surveillance setup was installed in one of the university car parks to test the efficiency. To monitor wide field of view of car park entrance and exit, various cameras such as pan, tilt, zoom were pre-set. The experimental setup was used to classify objects on the basis of height to width and normalized velocity. To get an account of real monitoring efficiency, a large data consisting of 320,000 frames was captured during busy periods over four days in which approximately 200 vehicles and 400 people came into the periphery of surveillance system. It detected a vehicle event correctly by 89% and incorrectly marked it as person by 6% and detected a person event correctly by 79% and incorrectly marked it as vehicle by 19% and others by 5% [21].

6. KEY APPLICATIONS OF SURVEILLANCE SYSTEMS

The deployment of surveillance systems in ubiquitous environment has enormous number of applications. In this paper we are highlighting the major areas which are listed as:

1) Prime application of the surveillance system is abnormality detection and warning. It is necessary to scrutinize the etiquettes of people and vehicles and determining them as normal or abnormal in certain situations. Usually there are two methodologies of warning: One to automatically make a recorded public announcement whenever any abnormal behavior is detected and the other is to contact the police automatically.

2) Identification of specific persons can aid police very much. Police can build database with biometric details of the suspect and establish visual surveillance in certain public areas such as bus stops, markets. Whenever a surveillance system recognizes the suspect, immediately location of the suspect will be updated to the police.

3) Surveillance system can also be used for the statistical overview of crowd flux and analysis of congestion in certain public areas such as markets, intersection of major roads, local rally, football grounds and provide the information to police and government authorities to adequate action to control and manage people.

4) Control of access for people in some security-sensitive areas such as military bases, hospitals, significant government authorities, and units in which special identification such as biometric identification is used. A database is made in prior to the surveillance system to automatically recognize a person through his characters such as height, walking gait in real time.

7. FUTURE CHALLENGES AND OPPORTUNITIES

As we began research in surveillance systems, we analyzed various challenges that will come before the researchers to establish surveillance system in ubiquitous environment. We have tried to propose major challenges in this paper which is an opportunity for researchers to solve and provide the world with highly efficient and secure surveillance system.

7.1 Transmission of data to mobile agents

The clusters of cameras in environment are connected to local processing proxy server (PPS) which is located in monitoring room. There are several base stations for PPS controlling and retrieving useful information from sets of cameras. Consider a situation, a person jumps a red light and traffic cop is tracking him. As the environment is mobile, the PPS changes time to time, inhibiting synchronization. [4] Thus it demands efficient automated synchronization of PPS for the transmission of data to mobile agents.

7.2 Scalability

As real-time surveillance systems grows in sophistication with hundreds of cameras and sensors forming a large network, the scalability of its modeling is greatly challenged.[13] The intensity of computing interactions will increase many folds leading to complex algorithms, bandwidth problems, network failures. New improved technology will be needed to accommodate such a large network of surveillance systems in ubiquitous environments. Some architecture has been proposed for making it scalable but none of them is able to fulfill the problem properly.

7.3 Privacy

Device used for providing security is itself security prone. With the evolution in ubiquitous computing, surveillance is interfering with activities that used to be considered as private.[5] As phones, credit cards, CCTV, e-mail, social media, telecommunications, , digital documents, and health records already tapped, it becomes increasingly difficult to find a space where data are not collected, indexed, distributed, searched, and inferred.[9][10] . There is need of significant protocols [8] and security models to safeguard the privacy of people. [7]

7.4 Energy efficiency

As in ubiquitous environment, the number of distributed networked video surveillance cameras and sensors will be large and deployed everywhere to keep track of activities. Energy efficiency has to put in consideration for the long term effect of surveillance systems. Though, lesser research is oriented towards energy efficiency in surveillance systems. It poses a good opportunity to researchers to make surveillance system using minimum energy but still providing a high performance. Diffusion tree creation and dynamic time synchronization can be used to minimize the high energy demands for surveillance system. [3] Reduced clock speed can also be applied to save energy as formulated at XEROX PARC. [14]

7.5 Bandwidth

The one problem that is faced in every ubiquitous environment is a limiting bandwidth. As surveillance system will make the notion “walls have eyes” real but as they are all in a distributed network forming an ICT system demand of bandwidth will be more than it can be fulfilled. Optical fibers can used in some locations but majority of system will be wireless.

7.6 Occlusion Handling

Occlusion handling is a challenging problem in visual surveillance. [2] At the time of occlusion, only fragment of each object is visible and often at very low resolution. This problem is usually hard to control and segmentation of motion based on techniques such as background subtraction may become undependable. To decrease vagueness from occlusion, better models are needed to evolve to handle compatibility and correlate different characters from multiple cameras and sensors, and hence eradicate compatibility errors that develop in tracking of multiple objects. A bit of resolution is feasible through motion region analysis and partial matching if objects are occluded by immovable objects just as buildings, sign boards, street lamps. However, when multiple moving objects occlude each other, particularly when their speeds, directions and shapes are very similar, their motion regions fuses with each other, which makes the identification and tracking of objects very difficult.

7.7 Fusion of Data from Multiple Sensors

It is evident that the surveillance systems in the future will comprise of multiple sensors and it will revolutionize the visual surveillance information accuracy. The effectiveness of collaboration between various cameras and sensors will depend heavily on fusion of data. Fusion of data is not based on image processing or decision making but it is based on characteristic level. [15] The major problem involves fusion of various types of character such as color, audio, geometry of objects into a single group to track and identify objects and therefore understand their behaviors. Another problem is fusion of characters obtained from multiple cameras having different viewpoints and exchange of data about the same object among themselves.

7.8 Cost effective

The surveillance systems comprising of multiple sensors must be of low cost as they have to be fabricated everywhere and if fabrication is performed by using reconfigurable devices [22] then it will give more cost benefit. Today, better surveillance systems are developing such as AURGUS-IS, LIDAR but they are very expensive. For surveillance system to become ubiquitous, fabrication of cheap but effective systems is necessary so that it can be deployed in every location.

8. CONCLUSION

We conclude that the emergence of ubiquitous computing will affect surveillance system greatly. We studied the evolution of surveillance systems from analog CCTV to multi sensor systems. We proposed that the use of cloud computing will further make the surveillance systems highly effective and cheap. As surveillance systems have to be ubiquitous their architectures must be based on context of user and location. With the analysis of some surveillance system architecture, we provided researchers with an overview of current development so that they can observe benefits and weak points and create a robust surveillance system. The significant challenges of surveillance systems such as occlusion, fusion of data and others are mentioned in the paper which researchers should try to eliminate when developing a robust architecture.

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