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A SURVEILLANCE WIRELESS CAMERA SENSOR NETWORK SYSTEM FOR INTRUSION DETECTION USING IMAGE PROCESSING TECHNIQUES

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ABSTRACT

Surveillance systems are becoming critical part of our society and they play major roles in monitory of critical infrastructure, streets, public buildings, private buildings, properties etc. Policing and visual evidence gathering has supported and changed the way our judicial systems use supporting evidence in passing verdicts. Warfare are being changed by such systems as well. Wireless sensor networks are playing key roles in how we pick information from our physical environments and analyze them and the dawn of internet of things has open up new opportunities in using sensors in making life better. Its advantage can be seen from monitory of air pollution, temperature conditions in freezer and homes, wearable health devices etc. Yet special devices are being developed to meet these ever increasing technologies. Cameras for surveillance activities are developed with surveillance capabilities and making old monitory cameras fade away from the system. Hence an integration approach is needed to integrate and make sensing properties present in those old systems. In other to contribute to the field of security and surveillance, we proposed a new approach of using disparate camera devices with or without image processing techniques and built an image sensor based application to give capabilities to these systems as well as reduce latency at the end nodes during surveillance activities. This means that any off-the-shelf camera can be bought and plugged in into our proposed system which will have sensing ability based on our proposed method. We design the system and implemented it as well as performed analysis on them.

Keywords: image processing, surveillance, security, wireless sensor networks, intrusion detection.

INTRODUCTION

Security and monitory of systems and places are very critical part of our modern society. Private surveillance activities, visual evidence gathering, intrusion detection are among the important reasons for the adoption of surveillance camera sensor networks. Image processing techniques have helped over time in making images easily track able and objects easily indefinable. Yet most of these devices and applications come at a cost. Damage to these devices may render both the application software and the devices not usable. Deployment of such devices with sensing techniques may come at a very high cost for homes and institutions and these make it very costly and replacement of old monitory system are needed for the new one to be implemented. Hence solutions are needed to make these old and new camera monitory systems more effective and monitory and surveillance activities.

Image processing techniques provide a wide range of applications to visuals obtained both in real time and with earlier recordings. This paper provides solution by integrating old, new or any device that can stream video into a monitory and surveillance systems. This makes it cheaper and provides lots of benefits as well. Photographs can be taken automatically and mail messages and alerts sent, alarm systems can be triggered, video recording can be done automatically or programmed and other capabilities can easily be plugged into the system. The entire sensing approach was deployed on a server that receives video feeds from the devices and processes the frames in such a way that it can detect intrusion and perform other functions. The paper has the following structure: related works, methodology, results and analysis, and conclusion.

RELATED WORKS

The integration of video technology and sensor networks constitutes the fundamental infrastructure for new generations of multimedia surveillance systems, where many different media streams (audio, video, images, textual data, and sensor signals) will concur to provide an automatic analysis of the controlled environment and a real-time interpretation of the scene [1, 2]. The availability of low-cost hardware in different varieties for different applications such as CMOS cameras and microphones has fostered the development of Wireless Multimedia Sensor Networks (WMSNs), i.e., networks of wirelessly interconnected devices that are able to ubiquitously in a distributed environment for monitory and observation retrieve multimedia content such as video and audio streams, still images, and scalar sensor data from the environment [3]. In such networks like any other wireless sensor networks, data aggregation eliminates redundancy and improves bandwidth utilization and energy-efficiency of sensor nodes. In providing solution to that for network communications efficiency, [4] in their paper presented a secure energy-efficient data aggregation protocol called

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ESPDA (Energy-Efficient Secure Pattern based Data Aggregation). Unlike conventional data aggregation techniques, ESPDA prevented the redundant data transmission from sensor nodes to cluster-heads and performance evaluation showed that ESPDA outperforms conventional data aggregation methods up to 50% in bandwidth efficiency. Purushottam *et al*., in their work presented the design and implementation of senseye-a multi-tier network of heterogeneous wireless nodes and cameras. They implemented a surveillance application using senseye comprising three tasks: object detection, recognition and tracking. They proposed novel mechanisms for low-power low-latency detection, low-latency wakeups, efficient recognition and tracking. Their techniques showed that a multi-tier sensor network can reconcile the traditionally conflicting systems goals of latency and energy-efficiency. Their experimental evaluation of their prototype showed that, when compared to a single-tier prototype, their multi-tier senseye can achieve an order of magnitude reduction in energy usage while providing comparable surveillance accuracy [5]. Video-based wireless sensor networks continue to gain increasing interest due to their ability to collect and process visual information for a wide range of applications when engaged. However, knowledge about these types of networks is mostly related to visual algorithms, leaving the networking perspective aside. Soro, S. etal in their work of “On the coverage problem in video-based wireless sensor networks," analyzed how an algorithm designed for traditional wireless sensor networks, which integrates the coverage and routing problem, behaves in video-based networks. Their results showed that because of the unique way that cameras capture data, the sensor network algorithm does not give the expected results in terms of coverage preservation of monitored areas. Yet these gaps can be field through other plug-in approaches in covering for the deficiencies [6]. Further developments in wireless sensor networks for control and monitoring functions has created a vibrant investigation scenario, where many critical topics, such as communication efficiency and energy consumption, have been investigated in the past few years. This is due to the fact that most systems can be left for long in an operational environment and power consumption and the efficiency of the algorithm in making good use of bandwidth is very crucial. However, when sensors are endowed with low-power cameras for visual monitoring but a new scope of challenges is raised, demanding new research efforts. In this context, the resource-constrained nature of sensor nodes has demanded the use of prioritization approaches as a practical mechanism to lower the transmission burden of visual data over wireless sensor networks. Lots of works over the years looked at local-level prioritization parameters to enhance the overall performance of those networks, but global-level policies can potentially achieve better results in terms of visual monitoring efficiency [7]. The problem of resource-constrained sensor nodes can hamper a lot of operations during transmission processes and most of the devices used are operating processing the images at the node end before transmission. This causes a lot of delays and also increases data capacity in transmission. Focus is on visual analysis tasks during processing requires the extraction of local visual features, which form a succinct and distinctive representation of the visual content of still images or videos [8]. Many works have been done to minimize the processing time of the feature extraction algorithms by offloading the visual processing task to neighboring sensor nodes. In the work of [8], the optimal offloading strategy was formally characterized under different networking and communication paradigms. The performance of the proposed offloading schemes was evaluated using simulations and was validated through experiments carried out on a real wireless sensor network testbed. The results show that the proposed offloading schemes allow reducing the feature extraction time up to a factor of 3 in the reference scenario. With their proposed approach, we performed the image processing techniques and detections at the server side by reducing latency and maximizing efficiency in data transmission and processing. We obtain visuals from remote devices and process the data obtained from them at unit servers before carrying out decision processes on the final outputs.

METHODOLOGY

With the approaches engaged, we obtained the video from our distanced and remote cameras via our wireless networks and transmit it to the data processing servers where different kinds of analyses are performed on the images such as object detection, fire detection etc. The video data is then stored as well in file servers. Based on predefined processes, actions are then sent to the decision based servers for triggers or other operations or decisions to be taken. If it is intrusion detection, then alarms may be turned on, automatic voice messages may be sent etc. below is the described summary of the processes and the architecture.

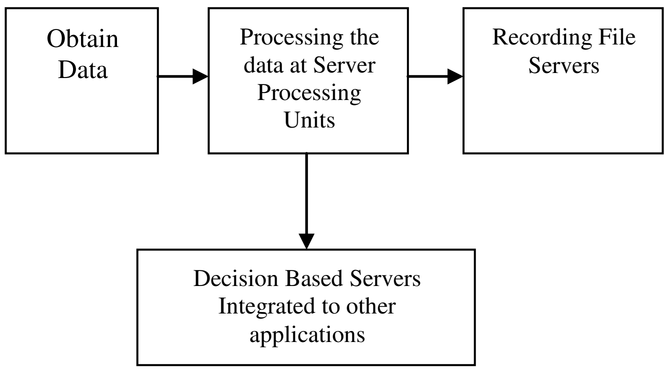

Figure-1. The summary of the approaches.

With the proposed approach, a frame of video image fi is streamed from the camera to the processing unit which then apply series of preset operations on the image to analyze the situational environment of the data acquire.

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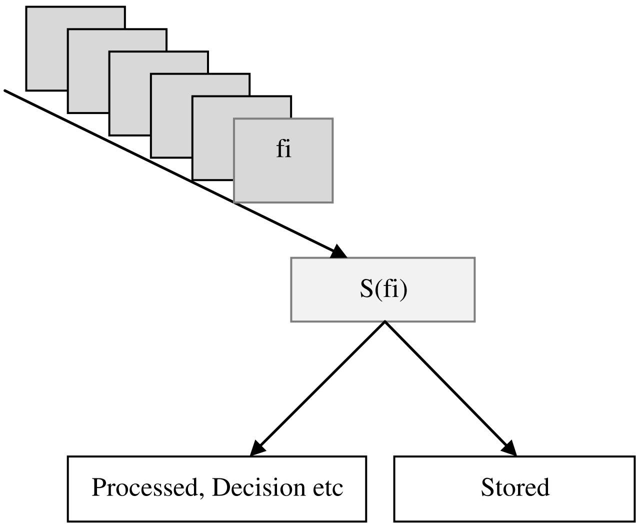

Figure-2. The frame processing.

The frames were analyzed and stored and based on the analyzed data, preset decisions were made based on the configurations.

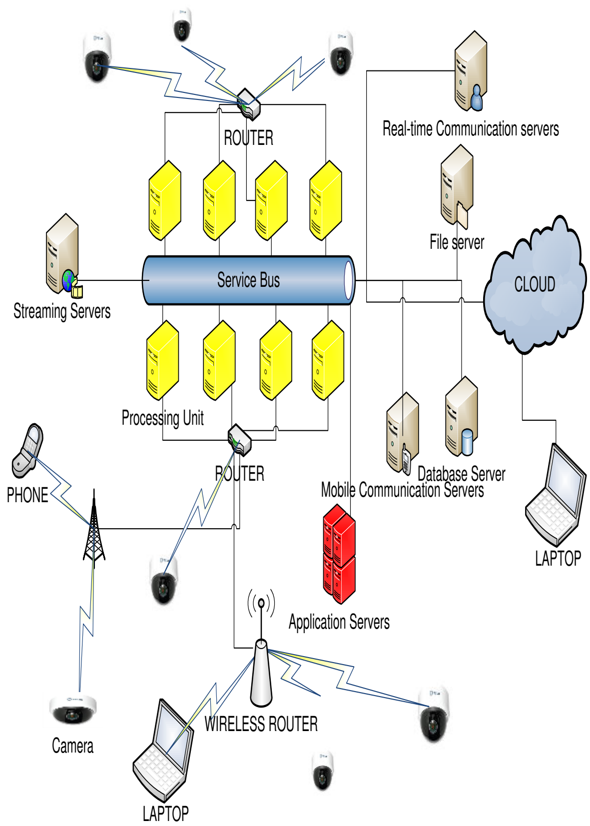

Figure-3. The surveillance system design over an enterprise service bus.

Figure-3 represented the design environment in which the application was deployed with all the processing units and servers. The application has capabilities of sending alerts, triggering systems, processing heat maps, sending data over the internet etc. Digital video were obtained from remote wires cameras fixed at different locations. The cameras consisted of different capabilities in terms of frame capturing rates, focus, and are from different vendors. The default camera configurations were done and then streamed over a network via a processing which reroutes the streamed data to the appropriate nodes. The applications developed to process the streamed videos then operate on the frames to determine the situational environment in which the video is being captured from. The frames are processed for intrusion, thermal conditions and other possible features. Based on the settings of some applications, alerts can be triggered to send messages or make certain preset operations. The service bus was engaged in other to create easy interoperability between applications and certain process during data transactions. This created situations for easy engagement of new devices and addition of other sensors in an integrated way to help understand the situations being monitored into detail using the surveillance cameras. Different kinds of information can also be sent via the service bus, such as text messages, emails, etc. Video captures can also be streamed to respective or designated locations by engaging the streaming servers. This created opportunities for live footage of events to be relayed over the internet to a service requestor remotely via the service bus.

RESULT AND ANALYSIS

Below are the results and illustrations from the system, data sensing, processing and other capabilities built into the system. Visual interfaces, graphs as well as detection graphs etc.

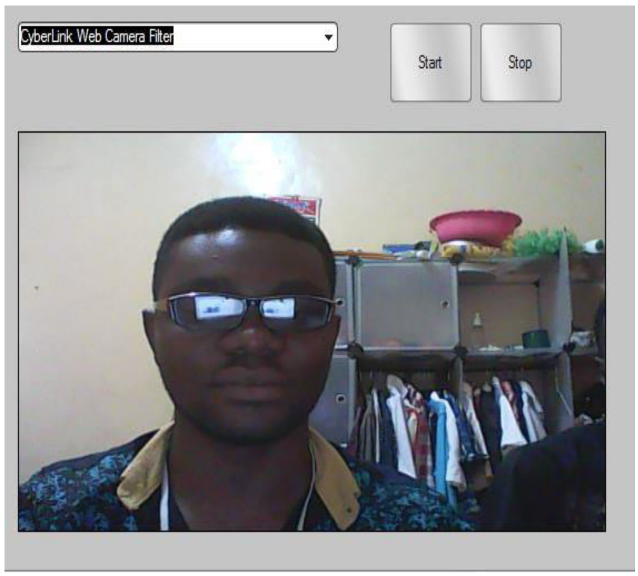

Figure-4. Live feed capturing.

Figure-4 showed a captured video footage from the application developed remotely from a camera by the application.

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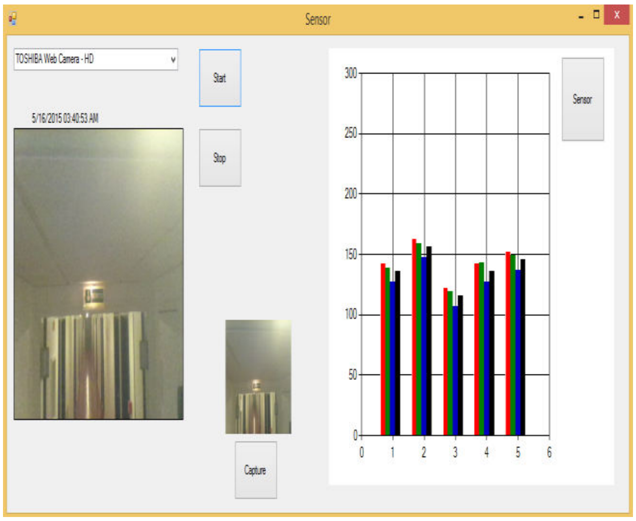

Figure-5. Intrusion sensing interface.

Figure-5 represents the developed intrusion setting sample window that processes the images obtained by a camera remotely to detect intrusion. The frames an environment is analyzed to predict a stable situation of movements and image intensity values stability and a rapid change in these values may occur as an object moves in the background and the image will then be processed to confirm detection of intrusion.

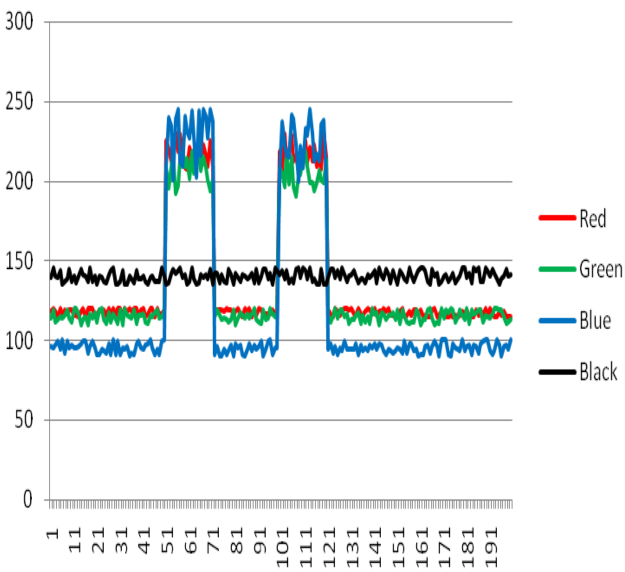

Figure-6. The graph indication of intrusion detection.

The graph in the above Figure showed a rapid variation in the analyzed signal data when an intrusion was detected. The graph of the frames became normalized overtime if there is no disturbance in the transmitted signal and this signified the absence of object. An intrusion may cause a rapid change in signal data obtained from the surveillance cameras. The radar graph of the above situation is showed below.

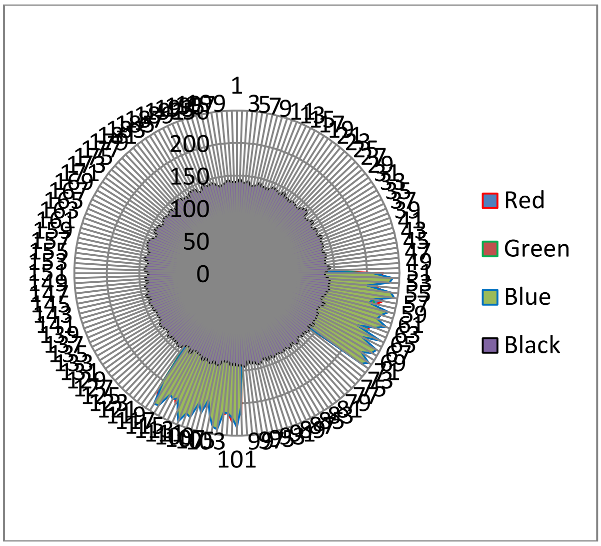

Figure-7. The radar graph of intrusion detection.

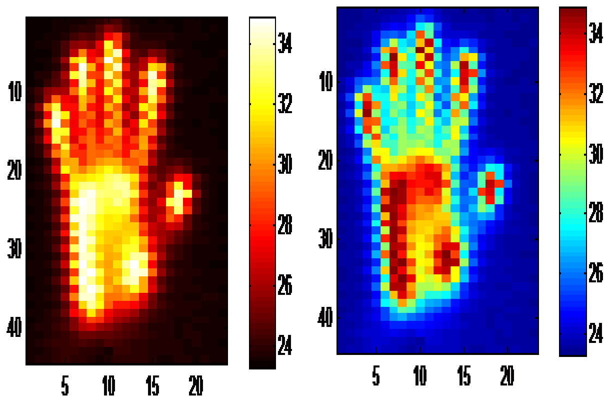

Figure-8. Thermal heat map graph.

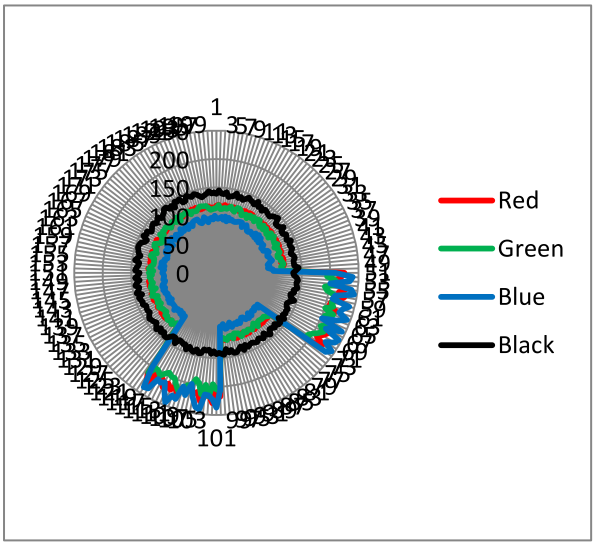

Figure-9. The radar graph of intrusion detection.

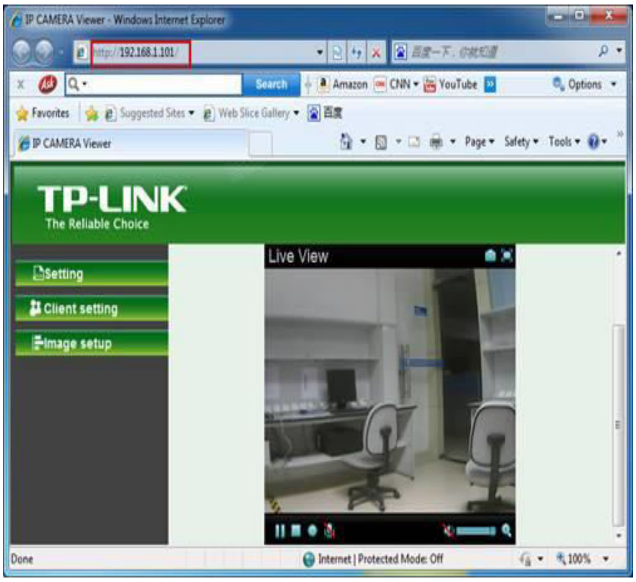

Figure-10. IP camera configurations.

A digital image is a numeric representation that one can see visually and this numeric representation can be transformed into number formats such as binary, decimal, hexadecimal etc and they can vary in storage forms such as .jpg, .png, .tiff, .gif etc as well in data types.

We deduce the image values from a given frame of the video as follows:

$$\text{Image} = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{14} & \cdot & \cdot & \cdot & x_{1n} \\ x_{21} & x_{22} & \cdot & \cdot & \cdot & \cdot & \cdot & x_{2n} \\ x_{31} & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & x_{3n} \\ x_{41} & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & x_{4n} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ x_{m1} & \cdot x_{m2} & x_{m3} & x_{m4} \cdot & \cdot & \cdot & \cdot & x_{mn} \end{bmatrix}$$

Let I= an image=f (R, G, B)
I is a color image of m x n x 3 arrays

$$\begin{pmatrix} R & G & B \\ r_{i1} & g_{i2} & b_{i3} \\ \vdots & \vdots & \vdots \\ r_{n1} & g_{n2} & b_{n3} \end{pmatrix} \quad (1)$$

(R, G, B) = m x n
Where R, G, B ∈ I
(R o G) i j = (R) ij. (G) ij
Where r_11 = first value of R
r= [ri1] (i=1, 2… m)
x ∈ r_i1 : [a, b]= {x ∈ I: a ≤ x ≤ b}
a=0 and b=255
R= r= I (m, n, 1)
Where g_12 = first value of G
g= [gi2] (i=1, 2... m)
x ∈ g : [a, b]= {x ∈ I: a ≤ x ≤ b}
a=0 and b=255
G= g= I (m, n, 1)
And b_13 = first value of B
g= [bi3] (i=1, 2... m)
x ∈ b_i1 : [a, b]= {x ∈ I: a ≤ x ≤ b}
a=0 and b=255
B=b= I (m, n, 1
Such that R= r= I (m, n, 1)

We processed each frame at a time based on different jobs at different processing severs indicated above. Each server has a capability of processing different frames for different jobs in parallel. The server pick the image and extract the feature RB values and compute the black value as well and at the end use this values to construct a heat map graph to detect fire outbreak in the room as well detecting motion of intrusion. The motion of intrusion detection is based on the fact that at a given moment within a given short period of time in milliseconds, the background of the image remained within a specific RGB value boundary and if an intrusion or motion is detected, there will be a large variation in the values I times of the moving body hence triggering other services it has been program to do like sending SMS, calling, sending snapshots etc. The instantaneous graphs of the channels are shown in the Figure-11 below.

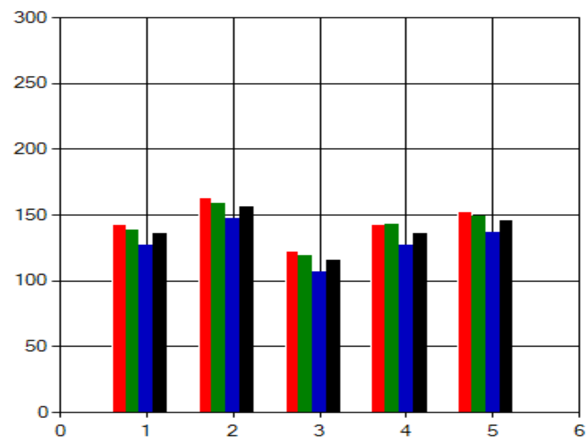

Figure-11. The instantaneous graph of channel values.

CONCLUSIONS AND FUTURE WORK

The implementation of the system was successful and different situations were monitored. Normal digital cameras without were engaged in the process and the frames obtained from their streaming were analyzed and intrusion detection was successful. No additional hardware

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was engaged but the adoption of intensity value processing, the procedure was effective. At the end we were able to engage different set of cameras both IP cameras and other forms of cameras to detect both intrusion and monitor the environment. The alarms were sound to detect intrusion and other applications such as the integrated mail services etc worked effectively. This was able to make cameras without such capabilities in a wireless sensor network possess such characteristics via the applications of signal processing techniques.

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