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A Surveillance Robot For Real Time Monitoring And Capturing Controlled Using Android Mobile

K. Damodhar, B. Vanathi and K. Shanmugam

Computer Science and Engineering, Valliammai Engineering College Chennai, India

Abstract: A robot is generally an electro-mechanical machine that can perform tasks automatically. The surveillance system is one which is used for the purpose of security system in intrude areas. This system is designed to develop a video monitoring, capturing the image and to store video frames in SD (Secure Digital) memory mounted on the robot for further verification. Smart mobile phones have been important Electronic devices in our life. Consequently, House automation and safety system becomes one of the projecting futures on mobile devices. A mobile application has been developed that interfaces smart phone with the security system over Wi-Fi (Wireless Fidelity) network. The Wi-Fi technology is relatively new as compared to other technologies and there is huge growth in practical applications. A mobile application is loaded on mobile devices, can connect with security system and easy to use GUI (Graphical User Interface). The security system acts on the user commands and responds. The CMOS (Complementary Metal Oxide Semiconductor) camera and the intrusion detector are attached with surveillance system to detect the intruder. In addition, a mike and a speaker are placed to transmit voice in both directions. The mobile application allows the user to access the files in the memory card from mobile phone. To enhance security to access the robot and data produced by robot, password is used in LAN (Local Area Network) and password with OTP (One Time Password) for WAN (Wide Area Network). Conference option is enabled to connect multiple users to make an enhanced security system.

Key words: Surveillance system · SD memory · Wi-Fi · CMOS Camera · OTP

INTRODUCTION

Surveillance is the process of monitoring the circumstances, an area or a person. This generally occurs in a military scenario where surveillance war areas and adversary territory is crucial to a nation's security. Human surveillance is accomplished by conveying work force close sensitive areas so as to continually screen for changes. People have their restrictions and organization in blocked off spots is not generally possible at all the time. There are also added risks of losing work force in the occasion of getting got by the adversary. With advances in technology over the years, however, it is possible to monitor areas of importance remotely by using robots instead of human. Apart from the obvious advantage of not losing any work force, physical and ethereal robots can detect subtle elements that are not evident to people. By furnishing the robots with high resolution cameras and different sensors, it is possible to gain information about the particular location remotely. Satellite communication makes it conceivable to speak consistently with the robots and acquire real-time audio visual feedback. Thus, in recent times, surveillance technology has become an area of great research interest. Over the years, the need for security and surveillance systems has changed significantly due to the influence of various events and attacks. Different kinds of sophisticated electronic devices including surveillance alarm, Closed Circuit Television (CCTV) surveillance etc. is flooding the market at a greater pace. With the advancement in technology, locations can be monitored from remote places at anytime from anywhere in the world. These advancements have greatly improved the scope of security and surveillance devices in various credible applications like monitoring

Corresponding Author: K. Damodhar, Computer Science and Engineering, Valliammai Engineering College Chennai, India.

factory premises, government buildings, manufacturing units, airports etc. The traditional Surveillance system covered only a particular direction. Its outputs are stored in hard disk with help of DVR (Digital Video Recording). Here it is not possible to turn to a particular direction required.

Wireless Sensor Network (WSN) can assist in object recognition, intrusion recognition and identification. In light of the possibility to encourage information securing and data handling a smart communication framework could be developed utilizing these sensors and cameras. Smart phones are turning out to be more famous nowadays and can see in every person hand. They have changed our way of life and have turned into the key a portion of our lives. Because of changes in operating systems these smart phones are easy to use for common person also. Android is the biggest player of this smart phone industry. In 2015 almost 75% of the Smart phones are running with android OS. Android OS provides a good facility to design and develop suitable applications. As android devices are much flexible, we are using them in lots of our works. A new surveillance system for indoor surveillance is developed where it can be wirelessly controlled by a mobile phone. The robot can be moved in all four directions (left, right, front and back) by using an Android mobile application having motion control keys. The mobile phone is used to give the commands to the robot to turn and move and receive the video of surrounding environment, captured by the camera mounted in the robot. The communication between the surveillance system and the mobile phone is by internet. In this paper we have proposed a surveillance system controlled by android device over the Wi-Fi network. We have selected Wi-Fi than Bluetooth due to its wider range of Wi-Fi network when compared to Bluetooth. Bluetooth have low range of bandwidth, while Wi-Fi, we have higher bandwidth which provides more speed in data transmission and more efficient. Moreover using the IP address we can guarantee our data to reach to the specified address. A model predictive controller is designed to compensate large time delay caused by the internet. The features of smart phones make the robot surveillance more flexible and convenient to control and allow the users to operate surveillance system from different locations apart from Loss (Line of Sight). The proposed method deals with 360 degree angle. Videos captured by camera are transmitted to android mobile through modem and it can be zoomed to a high extent for desired clarity and capacity to do night surveillance. To give secure access to the robot and data produced by the robot, we are going to use the password in LAN and password along with an One Time Password in WAN. The user wants to access the robot, has to request for password with the email ID. The user email is verified and an OTP is generated and sent to the user. The user will be authenticated by verifying the OTP. The security system is not a complete one without the conference option. So the conference option is enabled that, one robot can be controlled by multiple controllers and a single mobile can control multiple robots. The idea behind this is to build a security system that enable user to access the entire surveillance network. To avoid data loss when network failure occurs, an SD (Secure Digital) chip memory is mounted on the robot. The video frames captured are stored on the SD memory in fixed time length. The stored files are accessed by user with the mobile phone itself. The mobile application allows the user to perform this function. It is very useful when the network fails between the robot and mobile phone. The video loosed by the user because of network failure can be retrieved from the SD memory. The speaker and mike are added as additional features to transmit voice from mobile to robot and surveillance area to mobile phone. Using the voice optionsthe user can know what is happening at the surveillance area effectively.

Related Work: The field of Surveillance system is entirely well popular. More no. of researches has been carried out in navigational procedures and circuitry system of wireless surveillance robots. A common motivation is usage of a camera on the robot in order to receive live video stream at receiver. Several research works are done so far on surveillance system. Some innovative research works have also been successfully carried out. Various authors discussed about various aspects of different types of observing activities and tracing applications. An examination team in DRDO has done a shared research work where they have suggested and applied intrusion detection in large secure place using ad-hoc wireless sensor network. They have placed PIR sensors for human footstep recognition purpose and TelosB motes to forward the captured sensory data and established a training based algorithm that helps in actual intruder identification in open environment [1].

Wireless robot systems are developed using the Arduino microcontroller have been implemented, but wireless communication between mobile and robot is through Zigbee protocol, which limits the coverage range of the robot [2]. A robot which performs image processing utilizing the camera on an Android smartphone has

additionally been developed. However, this model is bounded by the power backup of the mobile, an issue that we have tended to by remotely performing all imaging processing operations on an alternate PC, subsequent to transmitting the camera's feed [3]. The proposed system is unique in the sense that it is a low-cost solution that we can remotely control a robot from any range (by using the internet) and also offers the live video transmission. There is no constraint on any extra processing as everything is done from remote location [4].

The In2DS system is implemented using the Passive Infrared sensors and CCTV cameras. A decentralized object tracking system is defined with video capturing subsystem and Wireless Sensor Network subsystem. In system architecture, information collected with the WSN and the video taken by the camera system are additionally processed by the centralized Surveillance system [5]. Another research on target tracking and pointing the motion path is depicted in. The researchers combined the outcome of PIR sensor, video cameras, acoustic sensor and seismic sensor to make an accurate and best detection process but, the system lacks in trigger based event detection. The authors in paper have incorporated camera with WSN that comprises of motes with microphone and tone detector and proposed a surveillance framework that uses trigger-based camera. They have expected that the target range will transmit some sound or light so that the sensor could track the occasion [6]. In another research the researcher have combined DSPCam with Firefly sensor to identify the changes in the video frames taken by the camera and wrap the image and transfer it over the network [7].

In [8] an Adriano based robot is designed which uses blue tooth technology to control robot and Wi-Fi network to transmit the video. In this system, the robot and controller both should be in Loss (Line of Sight) to control the robot. The range of Bluetooth is very limited when compared to the Wi-Fi network, the controller can't move away from the region. Another one research [9] uses the features of both WSN (Wireless Sensor Network) and CCTV (Closed Circuit Television). When sensor detects some abnormal event, sends notification to the centralized surveillance system, the centralized system trigger the corresponding camera to capture the visual evidence. In this method, the network delay between sensor to main system and main system to camera will degrade the system performance gradually.

Mobile device technology enhancements make people lives simple. Person can control a few gadgets and tools from their smart phones, tablets, PCs etc., remotely a long way from kilometers away than controlled devices. These days, farmers can water their nurseries through mobiles remotely. People can get such a great amount of data about their home circumstances from smart house frameworks, when they are a long way from the houses. Clients can control white goods, which they use at house. Users can see white goods program status or give a few control commands from his/her suit. In this study, one remote controlled portable framework is accomplished [10]. Limitations in the existing system are,

- Emerging technologies have metamorphosed the nature of surveillance and monitoring applications.
- Sensory data collected using the gadgets still remains unreliable and poorly synchronized.
- Surveillance system covers only a particular direction. Not possible to turn to a particular direction based on priority.
- The output is stored in hard disk with help of DVR, which requires more disk space.
- The systems do not have conference features.
- Security to access the robot is lacked and thus anybody nearby can access the robot.

Proposed System

Research Goal: The objective is to use robot for surveillance system over Wi-Fi network. The surveillance system provide conference option and its output are controlled by android phone through internet connection. This model also includes night vision in surveillance system and to move and turn to particular direction using mobile application. The data loss occurred by network failure is limited by using the memory over the robot itself. This system is useful for people in dangerous areas, where life threat and possibility of losing the property is more. Another motivation is to reduce expenses in companies, labs, factories, etc. People may use simple and inexpensive security system in their homes.

System Design: In Traditional surveillance, large number of video cameras is deployed and the live video is transmitted through wires. The angle and direction of camera is fixed. To overcome such drawbacks we are moving for surveillance robots. The initial surveillance robots are developed with infrared technology and controlled with specially designed remote. After that the Radio Frequency controlled robots and blue tooth based robots were developed for surveillance purpose. All these kind of systems should be in LOS. It is limiting the applications of surveillance robots.

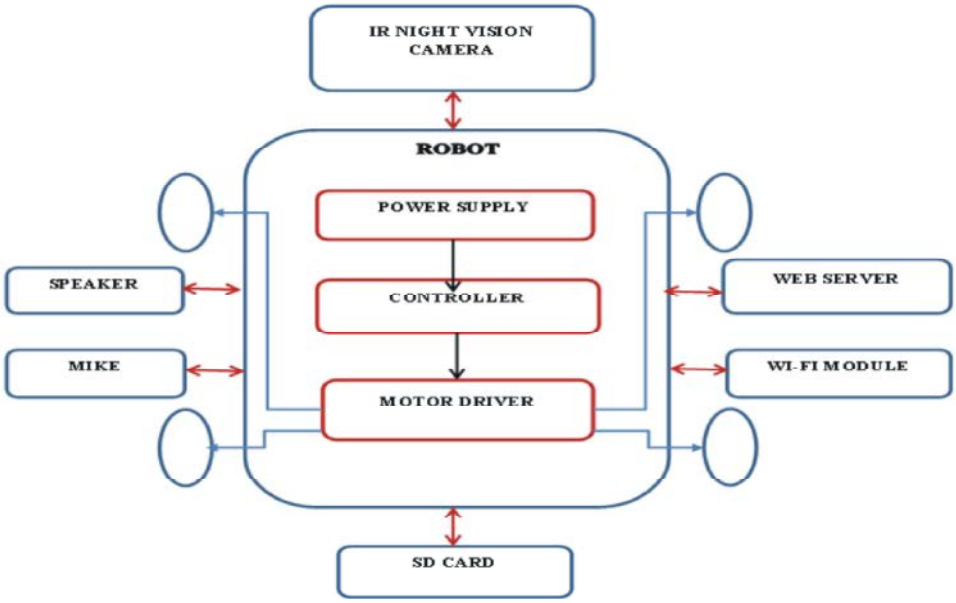

Fig. 1: Block Diagram of Robot Module

As the technology improved we are in hunt for newer systems with high end features. The proposed surveillance system consists of two parts namely mobile robot part and robot controller part. Communication between these two parts happens wirelessly. When the system gets started, robotic system begins to make its entire system. System initializes the camera and other peripherals and waits for commands from the controller. Controller application is loaded in the android mobile can control the robot module. The robot module block diagram is as in the Fig. 1. The robot module consists of the controller board with latest ARM processor. The ARM processor can handle the processing effectively. The motor driver is used to drive the stepper motors connected. These motors can drive the robot in all four directions. The stepper motors are used because of their positional accuracy. So we can control the robot more accurately.

A CMOS night vision camera with IR sensors is placed to capture the video of the area under surveillance. The IR sensors produce the Infra-Red light beam which is not visible, to do night surveillance. The CMOS camera is used because of its low cost and low power consumption. As we are implementing in robot device, the power consumption should be very minimum. The speaker and mike are placed to transfer the voice from robot to mobile and mobile to robot device for effective surveillance. A web server along with Wi-Fi driver is fixed for the communication. A separate IP address is assigned to the robot to locate it uniquely over the Internet. The Wi-Fi driver enables the robot to connect to the internet through wireless. An SD card is mounted to store the video files captured by the camera. The storage capacity of SD card should me of minimum 64GB or capacity to store up to minimum ten days of video recordings. All these components are connected to the controller board. The controller will control all the connected components efficiently.

The controller part block diagram is shown in the Fig. 2. The controller part contains video display area, file access option and function control panel. The video display area will display the live video captured by the robot. The robot can be moved and turned in all 360° by giving touch input over the four axes (i.e. x-right, -x-left, y-forward and -y-backward) in the video display area as shown in the Fig. 3.

The buttons are actually invisible on the video display screen. By touching over particular axis itself we can move the robot. The idea behind this is to improve the visibility as the mobile phone display size is less and the buttons shouldn't occupy the screen. The video should be displayed in full screen mode. On clicking the conference button in the GUI, the user can able to watch all the live video sequences generated by the connected robots. It is very useful to do surveillance over the entire intrude areas of different locations. The full screen button is used to display the live video in full screen mode.

The functions control panel consists of options to start or stop the video recording, capture snapshots and to transmit the voice from robot to mobile and vice-versa. The voice transmission will be helpful to instruct the people in the surveillance area.

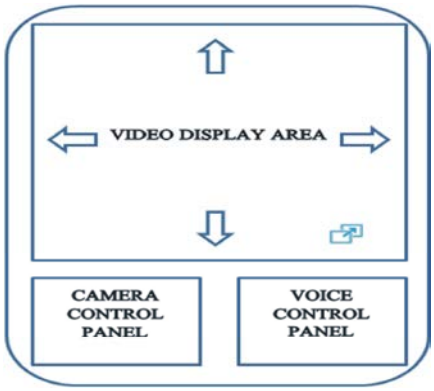

Fig. 2: Block Diagram of Mobile Controller

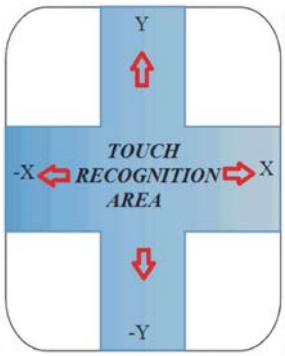

Fig. 3: Touch recognition areas on video display

Fig. 4: The logical connection between mobile and Robot

Apart from manual start and stop of video recording, we can automatically record and store the video files with fixed time frames in the robot SD memory. The videos and snapshots generated manually are stored in the mobile phone local memory. File access option enables the user to access the video files and snapshots stored in the local memory as well as on the robot SD memory. The video files are transferred to the mobile controller through Internet. The user can view or delete the files in the SD memory from remote area itself. The entire operation is over the internet and the connection between the mobile and the robot device is as shown in the Fig. 4. The robot consists of web server with separate IP address. The robot is connected to the wireless router with its IP address. The wireless router initializes the robot and connects it to the internet. On the other hand, the mobile phone with internet and mobile application can establish connection to the robot by giving the robot name and password. After verifying the username and password the mobile gets connected to the robot. The signals from mobile device go to particular base station and to World Wide Web. The router is connected to the internet and thus the signals are routed to the robot through the wireless router. The wireless router produces the wireless coverage area within which the robot can be controlled through Wi-Fi.

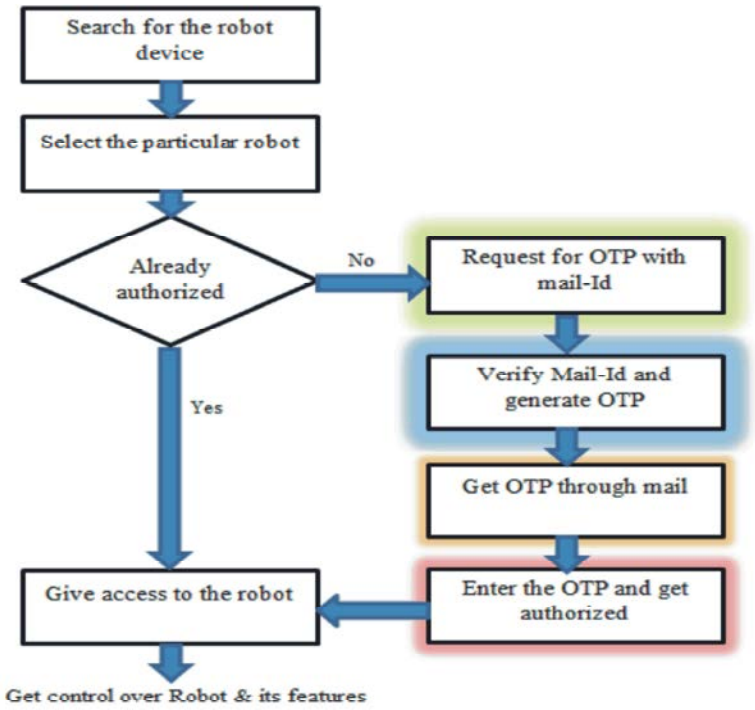

Fig. 5: User authorization scheme flow chart

The person who accesses the robot is an important issue. The selected users only should access the robot. The scheme to authorize the user is as shown in the Fig. 5. The user who wants to access the robot should login to the application with username and password. After login the user have to search for the particular robot. If both the user and robot are in same LAN, User can select the robot and can get access by giving the fixed password of the robot. If they are in different geographical locations, the user is validated with two step verification to maintain secure access to the robot.

After selecting the particular robot, the user credentials are verified in the database. If the user is already authorized, give access to the robot. If the user is a new user, the user should be registered with mail id and have to request for One Time Password. The administrator has to verify the user details and generates the OTP and sent through e-mail. The user has to enter the OTP received to get authorized. After the successful authorization, the user can get access to the robot and can control the robot and all its functions.

RESULTS AND DISCUSSIONS

A scheme for modern surveillance system is defined here with its real time implementation and experimental result. By decreasing traditional human intervention method, an automated event triggered system is proposed. An integrated network of IR sensors and IP Web cam is deployed and tested with the help of the interface designed for the surveillance purpose. The set of IR sensors continuously monitor the environment and communicate with the controller. The controller will be continuously comparing the values detected by the IR sensors. Based on the change in sensor values, the controller detects the intrusion in the surveillance area. When the intrusion is detected the alarm notification will be given to the controller. The live video is transmitted to the controller part. The mobile application implemented on android OS with Java code is installed in the android mobile. The screenshots of the robot functionalities at controller module are as shown below from Fig. 6 to Fig. 13.

The Fig. 6 shows the full screen mode of live video transmitted by the robot. By using the horizontal and vertical cruise buttons on the screen, we can control the motion of the camera. In Fig. 7 We have various frames to display the pre-set cruise, live video display and operation panel. We have control options to record video, to take snapshot and to talk and listen. We have an option to navigate to full screen mode. The data transmission speed is also displayed at that particular instance of time. The snapshots and videos recorded at controller side are stored in the local memory.

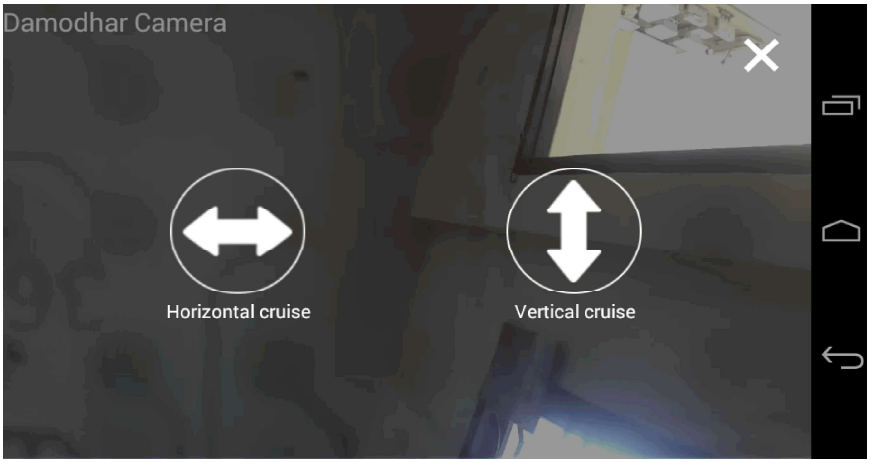

Fig. 6: Live video screen at controller (Full Screen mode)

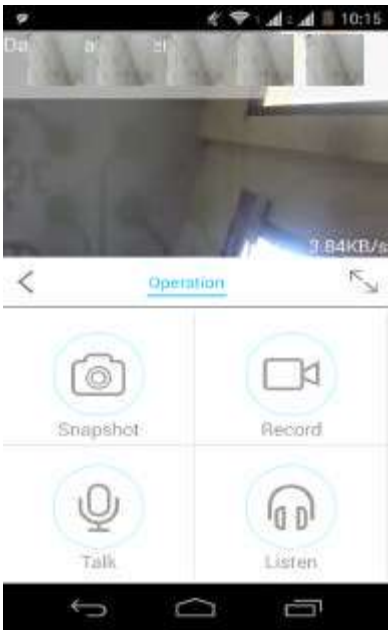

Fig. 7: Controller screen with basic functionalities

The full centralized surveillance system with conference is shown in Fig. 8. The live video stream from several connected robots are displayed in a single screen. Each and every camera will have separate display area in conference option. The status and name of cameras are displayed along with the video. From the no.of cameras we can select and view it in the full screen mode and we can control the particular robot over wireless network. The pre-set cruise option is designed to take multiple snapshots from multiple angles when an intrusion is detected. These option will be useful for future reference. It will be easy to trace out the fast moving intruder by verifying the multiple snapshots in sequence. Fig. 9 explains this pre-set cruise scheme.

The another function of the proposed robotic system is giving notification to the user when any intrusion is detected in the surveillance area. The controller board will trigger the alarm option at the controller side when intrusion is detected. The controller screen when alarm detected is as shown in the Fig.10. The alarm will be in both sound and also visual display.

The image and video files produced are stored in mobile memory as well as SD card on the robot. The mobile application is capable of opening and accessing the files. The SD card is capable of storing files upto fifteen days. The Fig. 11 shows the accessing of files stored in local memory and SD memory simultaneously.

Fig. 8: Video Conference Screen of Multiple Robots

Fig. 9: The preset cruise when intrusion detected

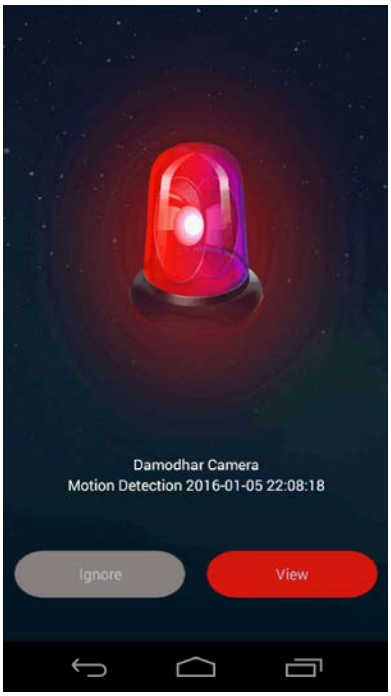

Fig. 10: Alarm when intrusion detected

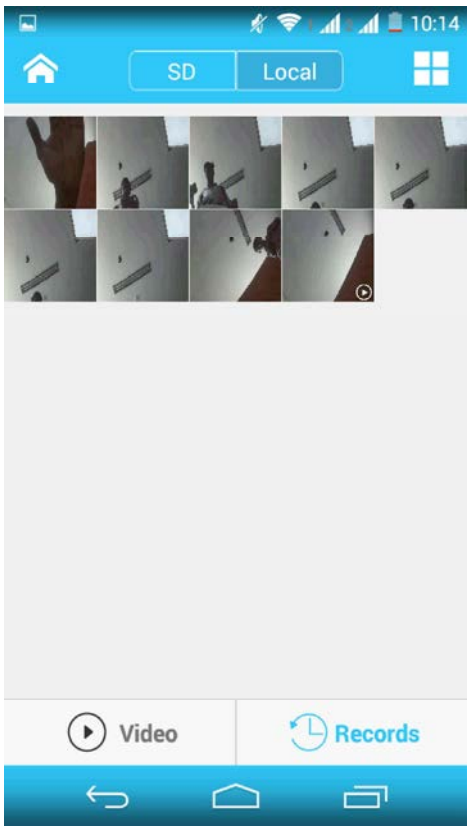

Fig. 11: Local File Access from Mobile

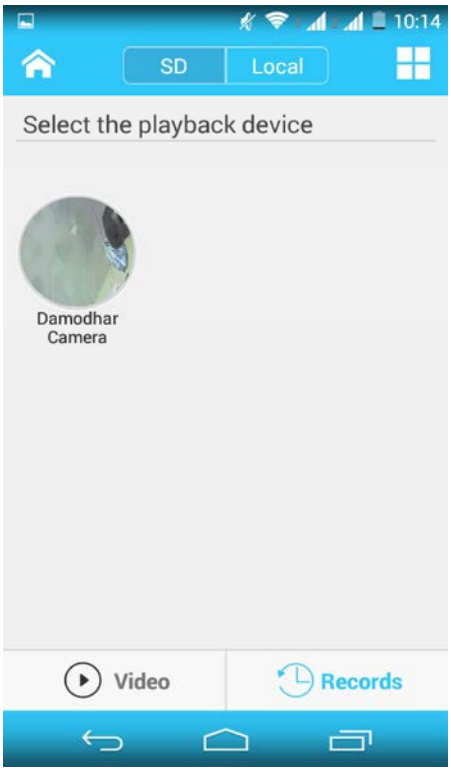

Fig. 12: Selection of particular Robot

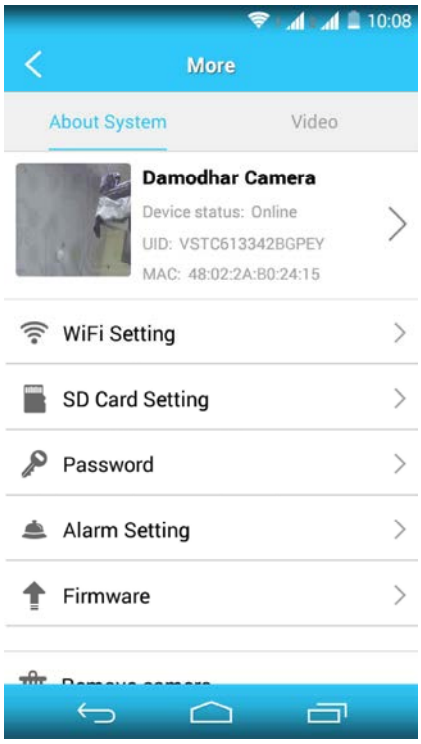

Fig. 13: Settings of Particular Robot

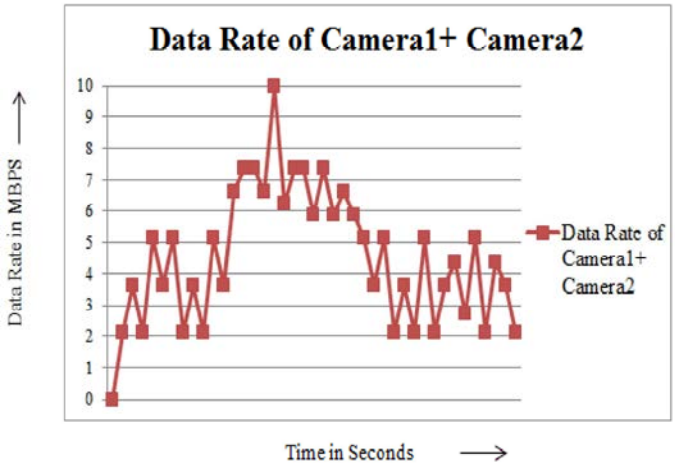

Fig. 14: Data traffic produced by Traditional System

The Fig. 12 shows the selecting of particular playback device from a group of connected devices. After selecting the particular device, user will be able to access the particular robot and can control the robot. User should give the correct password to access the particular robot.

We have the option to control and manage the settings of each and every robot such as password, wi-fi connectivity, SD card settings such as video file length to be stored and alarm settings. The Fig. 13 shows the settings options and device status.

Consider we have two cameras (i.e. Camera1 and Camera2) fixed inside a room in traditional surveillance system to cover the full room area. To cover the same location we can use the single robot which is of rotating in 360° angle. The data traffic produced by traditional surveillance system and robotic system are compared in the graphs below shown from Fig. 14 to Fig. 16. From the graph comparison we conclude the traditional system is producing more traffic than proposed robotic system.

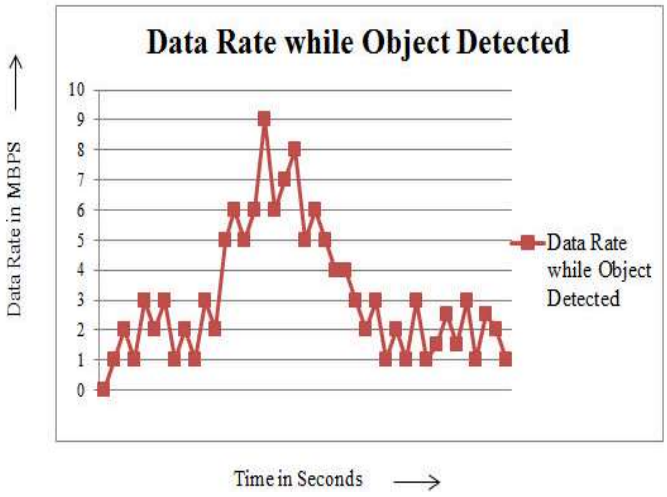

Fig. 15: Data traffic produced by Robotic System

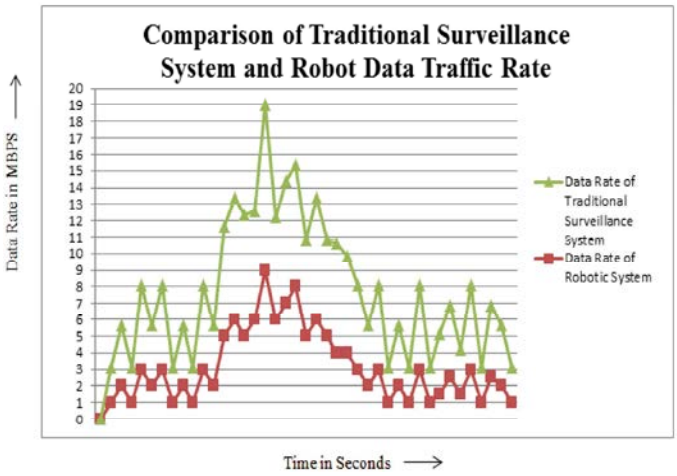

Fig. 16: Comparison of Traditional system and Robotic system

CONCLUSION

The main contribution of the proposed system is the idea of integrating of media devices with ARM CORTEX processor technology to provide better surveillance service. With the use of smart phone, our system can seamless monitor the mobile object. By using video cameras, information returned by ROBOT analyzed the real time images so that the computation effort, cost and resource requirements needed are significantly decreased. The performance evaluation graph shows that the proposed system will be applied in various situations.

The deployment of the IP web cam along with IR sensors not only enhances the overall system but also opens up to new extents for refining the surveillance system. The video track record of the movement stored in the playback devices will help more in detecting the unauthorized movement in the work space. This research work will work as a great idea for a security based advance surveillance system. Using in climbing robots and flying drones with detail functionality is the proposed future work of this application.

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