DEVELOPMENT OF AUTOMATED SENSING SYSTEM TO AID RESCUE OPERATIONS AFTER AN EARTHQUAKE

Kashish Gupta, Nitesh Jaiswal
Student, SENSE, VIT University, Chennai, Tamil Nadu, India

V. Berlin Hency
Associate Professor, SENSE, VIT University, Chennai, Tamil Nadu, India

Arockia Selvakumar A
Associate Professor, SMBS, VIT University, Chennai, Tamil Nadu, India

ABSTRACT

This work aims to develop an automated sensing system to aid rescue team and their operations after an earthquake. Earthquakes lead to great damage of property and loss of lives. Only, robust and intelligent planning systems can reduce the loss. The unpredictable scale of disaster is beyond the scope of human mission planning and hence results in extremely hopeless conditions and further not suitable for rescue operations. Disasters like earthquakes needs immediate attention and the victims must be pulled out of danger without delay. In addition, the structural conditions may be unfavorable, dangerous and unknown. Hence, there is a fundamental need to investigate such conditions without compromising victim's safety. Techniques need to be developed for the safer access to victims under these hostile conditions. So, now-a-days the robotic systems for Urban Search and Rescue (USAR) have become a thrust area that needs a greater attention. In this paper, a movable robotic system is proposed to detect the human existence in unmanned geographical structures. The system constitutes monitoring sensors and equipment for studying the conditions of human body and transmit the data to server. These portable robots make localization tracking to communicate over wireless sensor networks. The sensing system on the USAR mobile robot will contain a camera unit, thermal and PIR based imaging, processor (probably a laptop for high-end processing), high frequency based detection (motion and existence) and a GPS module for latitude and longitude detection.

Keywords: FHSS, GPS, GSM, WSN

1. INTRODUCTION

Federal Emergency Management Agency (FEMA) introduced the proposal of miniature robots for Urban Search and Rescue (USAR) in U.S after Oklahoma City bombing. It was first kind of such proposal for rescue operations. The earlier mobile robots for USAR [1] are too huge and defective for deployment in physical collapse situations. However, the current mobile robot technology offers small weight, robust performance for challenging USAR task domain. Currently, there are no such systems exist for search and rescue operations [2] in real experience.

The related expertise can be found in industries like power and management. Here, several micro-rover platforms [3] are used for distant examination of containment vessels and processing systems. In the proposed work, a mobile rescue robot system based on wireless sensor network technology is discussed and the main objective of the system is to help the people on time during natural calamities like earthquake. This goes on the localized dynamic situation of the great unwashed in the disaster region from underground to control room, so that the rescue squad of experts can be ravished to the victim's location for primary treatment.

Wireless sensor network can be used to address some key issues like communication bandwidth, information transmission, real-time detection & so on. Wireless sensor network [4] comprises of a big bit of micro-sensors nodes with small volume, low cost, battery operable and good compatibility. Analysis reports can be obtained by using sensors like PIR, Thermal, microwave and visible range imaging. Natural disasters do happen and they are unusual and uncontrollable events which disrupt both financial & social equilibrium of society. Natural disasters like earthquakes, tsunamis are evitable and unstoppable events which leads to destruction of normal lives and contribute to huge for economic development. Now a day, awareness about rescue operations during these kinds of calamities are getting prevailed so that valuable life and material can be salvaged. The timely rescue operations can also save people who are concealed and injured.

In such kind of situations, rescue system [5] must act immediately and take decisions in a fast manner, and try to carry victims to safe location at their own peril. The rescue organization must acquire the information like location, status of victims, stability of the structures as rapidly as possible so that medical experts can enter the disaster area and save the multitude. All these duties are carried out largely in very serious and risky circumstances by human and skilled mutts. Detection by rescue workers [6] will require a much amount of time and also sometimes it is unmanageable if the affected area is huge. For this reason, today mobile robots have been suggested to aid them and to perform tasks that replace humans, dogs and other creatures. Here, a mobile rescue robot is proposed that is active in the calamities region and assists in detecting the alive people and to aid rescue processes.

2. BACKGROUND

In this part, a brief literature study of the research carried out by urban search and rescue robots is presented. There is an extensive amount of work done in this area in the past 25 years. Here, a summary of the work done during the last decade is briefly discussed. The literature discussed here summarizes both the theoretical and experimental research.

B. Doroodgar, Y. Liu, and G. Nejat:

In [7], a Learning-Based Semi-Autonomous Controller for robotic exploration is proposed in which a Hierarchal Reinforcement learning technique is used to make the robot learn from experience. Also, direction based exploration technique is integrated with the controller. In this paper, the author performed physical experiments in USAR environments.

Todd Lupton and Salah Sukkarieh:

In [8], Visual-Inertial-Aided Navigation for High-Dynamic Motion in Built Environments without Initial Conditions has been proposed. Its main emphasis is on visual-inertial navigation system, i.e, fusing the observation of the IMU with the visual sensor, so that the initial conditions of inertial integration to be recovered easily without any specialized initialization procedure.

Babak Mobedi and Goldie Nejat:

In [9], the writer proposed a 3-D Active Sensing in Time-Critical Urban Search and Rescue Missions to map the unknown cluttered environment and locate the victim. 2D and 3D information of scene are used to create a 3D map of the disaster area. Experimental results are used to verify the performance of using a 3D sensory unit to map the disaster environment.

Brendon Rhys Le Comte, Gourab Sen Gupta:

In [10], author used distributed Sensors for Hazard Detection in an Urban Search and Rescue Operation. The purpose of this paper is to modernize a system for distributed sensor network that can monitor environmental factors and report them back to the rescue squad. It highlights the idea of these sensors and discussed the effects of the trials taken using sensors.

George C. Pallis:

In this paper [11], a viable off-the shelf system for victim's dynamic signs wireless transmission is tested every bit part of a likelihood study in which noninvasive methods such as breath or sweat analysis can be used for medical monitoring. Further, there has been extensive research going on in the field of mobile robots for disaster relief operation. The robots designed are of three main control levels, i.e., tele-operated, semi-autonomous and fully autonomous.

Trupti B. Bhondve, Prof.R.Satyanarayan, Prof. Moresh Mukhedkar:

In [12], wireless sensor network is used for the detection of human in disaster area. The major blocks of monitoring system are sensor unit, camera to capture, transmit data for human body localization.

Geetha Bharathi.V.S, Dr.S.Sudha:

Passive InfraRed (PIR) sensors are used in this work [13] to detect alive human. Also, a working prototype is created and experiments are conducted.

Sandeep Bhatia, Hardeep Singh Dhillon, Nitin Kumar:

A monitoring scheme is proposed in [14] which use ultrasonic sensors, camera to record, send and investigate human condition. Additionally, other sensors include temperature, blast and metal detector works as bomb sensor to notice the presence of bomb in Warfield and in liberation processes. The main aim here is to study the various sensors designed.

3. PROPOSED METHOD

We have two processing units in our project. One to handle the lower level sensors (PIR, and microphone) while other is kept busy with real time image processing. The image processing in our described model helps in motion and skin detection. Whenever the sensor identifies any skin component using the HSV or YCBCR luminescence in the visual data it tries to localize the information. In addition, it confirms the sighting with motion detection localized data with reference to the robot's motion. The image processing data via a RGB camera is sent to the

higher processing unit module that keeps a track of the motion and skin detection. In parallel working of the model, a microcontroller will continuously monitor any PIR based thermal signal or high frequency pitch sound. (A shrill cry for help or a cry in distress). This data again with reference to the robot, will be localized and send to the higher processing unit. With the help of all available data from the sensors and other analysis, our system will try to locate any victim in real time and stamp the data with respective timestamp and coordinates (reference to robot). The live image (if detected someone), will be uploaded to a server for rescue team's reference and location will be sent to mobile robot if the system is being carried with the robot. In the second block diagram as well the PIR/VOICE/GPS module would be sending a trigger pulse that will activate the camera on board.

Figure 1 Block diagram of Complete System

The camera is an IP web camera assigned IP to the network whose stream can be extracted from any node on that network. The matlab extracts that image snapshots and process them for skin and motion detection which in turn is uploaded on to an Apache http:// server.
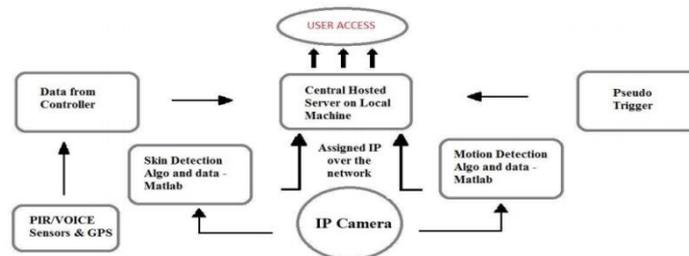
Figure 2 Block diagram cloud data flow

4. SKIN DETECTION

Skin detection will be achieved by using a complex integration of HSV and YCBCR based visual data from a RGB camera that can support YUV2_320X240 format for "winvideo" driver in Matlab. There can be a lot of false detections and triggers based on RGB component of skin color. To compensate this HSV and YCBCR will be used. Also, this should be able to cover all skin ranges. Skin recognition is a method of obtaining skin-colored regions and pixels in an video or a image. This is usually a preprocessing step to determine areas that potentially take human faces and limbs in images. There are many computer vision devices that have resulted for sensing the skin. In skin detection, typically the transformation is performed in a typical pixel element into an appropriate color space and then classify the skin or non-skin pixels. The decision boundary of the skin color is defined by skin classifier using the training data of skin colored pixels. In any given color space, some portion is absorbed by skin color, and might be a compacted or bulky neighborhood in the space and those areas are commonly identified as skin color clusters. The skin classifiers can be handled as one class or two-class classification problem. In the concept of skin arrangement or classification, true

positives are skin pixels that can organize or arrange the suitable labels as the skin True negatives are non-skin pixels that the classifier appropriately labels as non-skin. The skin classifiers can make faults and wrongly label a non-skin pixel as skin or a skin pixel as a non-skin. Broadly speaking, the old type of errors is referred to as false positives (false detections) while the later is false negatives. The classifiers with low false positive and false negative rates are seen as well. While arranging, there is a tradeoff between false positives and false negatives. The more the class limit, the less the false negatives and the more the false positives. The more stacked the class limit, the more the false negatives and the less the false positives. This is also applied to skin detection. Hence, due to these reasons the choice of the color space is extremely important in skin detection and it straightforwardly influences the sort of classifier that ought to be utilized.

5. MOTION DETECTION

Optical flow recognition method is used for motion detection. In this particular algorithm, the pixel of interest sometimes referred to as the ROI are differentiated with respect to the original pixel values. As a result, any changes in the image are reflected as the rate of change of that particular pixel which if not zero, indicates motion. It's better than the conventional difference method of motion detection, because it is capable to determining the velocity and direction of motion as well. In addition, it cancels the robot's motion relatively. There are two fundamental methods to identify the motion of objects, first is optical detection and second acoustic detection. IR light or laser technology may be applied for optical sensing. Motion sensing devices, namely PIR motion detectors, have a sensor that is applied to observe the disturbances in the infrared spectrum. After noticing the disturbance, a signal can activate an alarm or a camera gets an image or video of the object in motion. The significant applications for such location are unapproved sections, identification of suspension of inhabitance of a territory to smother lighting, and recognition of a moving article which triggers a camera to record resulting occasions. The algorithm for motion detection compares the current image with a reference picture and basically processes the different number of pixels. Since the pictures will normally change because of components, for example, differing lighting, camera glimmer, and CCD dim streams, pre-handling is valuable to downsize the figure of false positive alarms. Many complex algorithms are needed to detect motion when the camera itself is moving, or other movement can be dismissed if the gesture is noticed. The work of art encompassed by guests in a workmanship display can be considered as an example. On account of a moving camera, models that depend on optical stream are utilized to recognize clear foundation movement caused by the camera development and that of free of objects moving in the photo.

6. IMAGE PROCESSING MODULE

A camera with live video feed, giving to the higher end processing unit. A chip is a non-specific PC processor which coordinates the parts of a PC's central processing (CPU) on a solitary integrated circuit (IC), or at most a couple of integrated circuits. It takes binary input and processes multiple functions according to instructions stored in memory. It contains clock register and electronic device which accepts the input in binary form. Microprocessors are typically based on the combinational and sequential digital circuits.

Microchips, for the most part, work on numbers and images spoke to in the binary number framework. The reconciliation of the whole CPU onto a solitary chip or on a couple of chips fundamentally diminishes the cost of preparing capacity. Integrated circuit processors are created in vast numbers by highly computerized processes resulting in a low per unit price. Usually single chip processors are reliable, since there are very few electrical connectors to

break. Every bit the design of microprocessor gets faster, the manufacturing cost of chip generally remains the same. In any case, when there are no microchips, little PCs had been assembled utilizing racks of circuit sheets with numerous medium-and little scale ICs. Subsequently, with microprocessors these small ICs are combined into bigger ones. The ceaseless increment in microchip limit has extricated different types of PCs totally superseded, with at least one chip utilized as a part of everything from the little-implanted frameworks and handheld gadgets to the vast centralized computers and supercomputers. Nearly, various procedures of computerized picture preparing, or advanced picture handling as it frequently named the other way around, were produced in 1960s at the Jet Propulsion Laboratory, Massachusetts Institute of Technology, Bell Laboratories, University of Maryland, and a couple of other research offices, with application to satellite symbolism, wire photo gauges change, medicinal imaging, videophone, character acknowledgment, and photo upgrade. The handling cost was genuinely high, though with the computing equipment of that age. This situation got changed in 1970s, when digital image processing started proliferate less expensive PCs and committed equipment was made usable. Images amid that time were prepared continuously for some committed issues, for some dedicated problems such as television standards conversion. As the general-purpose computers become faster, they commenced to supplant the use of dedicated hardware for everything except the most particular and PC escalated operations.

7. MICRO-CONTROLLER UNIT

This will most probably be an Arduino Mega 2560, with interfaced Serial output to laptop and GPIO communication with Voice and PIR sensor. The Voice and PIR sensors will try to detect presence by isolating shrill or high frequency voices in the surroundings along with thermal radiation detection. A microcontroller is normally a little PC on IC which contains handling center, memory, and programmable info/yield peripherals. Program memory as Ferroelectric RAM, NOR flash or OTP ROM is not effortlessly included on chip, as effectively as a normal little measure of RAM. Microcontrollers are particularly expected for embedded applications while the microprocessors are used in general purpose systems and in other personal applications. They are also used in commercial products like automated controlled products, engine control, remote controls, implantable medical devices, home appliances, power tools, electronic toys, business machines and other embedded systems. With their compact size and low cost compared to microprocessor, makes it suitable to economically feasible solution to digital control device. The mixed controllers are obtained by the integration of analog components with non-digital electronic systems. Few microcontrollers use four bit words and operates at clock frequencies at 4KHz for low power consumption. They will normally have some enabled features like holding the functionality by interrupts, low power consumption in sleep mode, makes them suitable for long last battery applications. Close to other microcontrollers may aid performance-critical purposes, where they may be needed to act similar to digital signal processors, with greater clock speeds and low power use.

8. GPS MODULE

An android app will be used for the on-board sensor data which in turn will be communicated to Matlab by a HC05 Bluetooth module. An android phone will be used for the demo and take the place of an actual sensor shield. The Global Positioning System (GPS) is a space-based route framework that gives position, separation, and time data in every single climate condition, anyplace on the Earth at clear viewable pathway conditions with the assistance of at least four GPS satellites. It offers support to critical areas like military personal, civil, and commercial applicants around the world. It is a US based navigation system provides access

to anyone with a GPS receiver. The outline and improvement of GPS is construct to some degree with respect to comparable ground-based radio-route frameworks, for example, LORAN and different ancestors of GPS created amid World War II. Particular and general relativity anticipate that the tickers on the GPS satellites would be dictated by the Earth's onlookers to run 38 microseconds quicker every day than the timekeepers along the globe. The GPS computed positions would rapidly point into error, accruing to 10 Kms per day. The design of GPS corrects relative time effect that runs the clocks on the earth.

9. SERVER

All information will be finally redeemed and pushed onto a local host server. The server would basically show all the images in a particular folder maintained by Matlab, with the image name as a date time encoded string. In computer networking, a localhost is a hostname given to refer the computer. The access to the web services that are running on the emcee will be provided through loopback network interface. It sidesteps any neighborhood arrange interface equipment associated with the system. This system is helpful for testing programming amid advancement, freely of any systems administration arrangements. For example, if a PC has been intended to give a website, a locally running web program is used to demonstrate its point of arrival http://localhost. It can likewise be utilized to serve up nearby records. One can allude document URI plot. Normally the greater part of the PC frameworks utilizes localhost IP address 127.0.0.1, which is the most broadly utilized IPv4 loopback address, and to the IPv6 loopback address::1. Despite the fact that the individual IP deliver extend 127.0.0.1 up to 127.255.255.255 are held for loopback, 127.0.0.1 is the default loopback address in all occasions. The localhost is a saved best level domain name, kept aside to maintain a strategic distance from perplexity with the importance as a hostname. The IETF measures restrict domain name enlistment centers from allotting the name localhost in enlistment procedures, for example, for second-level domains.

10. XAMPP

It is an open source and free cross platform web server solution stack package which was developed by Apache friends, consists majorly Apache HTTP server, MariaDB database and translators for contents written in Perl and PHP programming dialects. XAMPP is an acronym remains for Cross-platform (X), Apache (A), MariaDB (M), PHP (P). It is a lightweight, and straightforward Apache conveyance that assembles it agreeable for engineers to make a nearby web server for purposes like testing and demo.

11. PHP

It is a server-side scripting language utilized for web improvement and additionally programming language. It was right off the bat made by Rasmus Lerdorf in 1994, and now the PHP Group creates the PHP usage. PHP quite stayed for Personal Home Page, yet it now stays for the recursive backronym PHP: Hypertext Preprocessor. It may be introduced into HTML code, or it can be associated in the mix with various web content organization systems, web arrange structures and web structures. The PHP code is typically dealt with by a PHP interpreter executed as a module in the web server or as a Common Gateway Interface (CGI) executable. The web server solidifies the eventual outcomes of the deciphered and executed PHP code, which may be any data sort, including pictures, with the created web page. PHP code may similarly be capable with a common line interface (CLI) and can be utilized to execute free graphical applications. The standard PHP translator, fueled by the Zend Engine, is free programming discharged under the PHP License. PHP has been broadly ported and can be put on most web servers on practically every working framework and stage,

for free. The PHP language advanced without a created formal depiction or standard until 2014, leaving the acknowledged PHP interpreter as a genuine standard. Since 2014 the work prompt creates a formal PHP detail.

12. APACHE

It is additionally a uninhibitedly accessible Web server which is conveyed with an "open source" permit. Version 2.0 keeps running on most UNIX-based working frameworks, (for example, Linux, Solaris, Digital UNIX, and AIX), on other UNIX/POSIX-inferred frameworks. According to the Netcraft (www.netcraft.com) Web server study, 60% of all Web destinations on the Internet are utilizing Apache (62% including Apache subordinates), expressing Apache most broadly utilized web server than whatever other Web servers when consolidated. The Apache HTTP Server, conversationally named as Apache is the universes most famously utilized web server programming. At first in light of the NCSA HTTPd server, advancement of Apache started in mid-1995 after work on the NCSA code slowed down. Apache assumed a fundamental part in the underlying development of the World Wide Web, quickly outperforming NCSA HTTPd as the prevailing HTTP server, and has proceeded with most well-known since April 1996. In 2009, it turned into the primary web server programming to accomplish more than 100 million sites. It was delivered and maintained by an open group of engineers under the sponsorships of the Apache Software Foundation. The most approximately connected on a Unix like framework (typically Linux), the product is likewise accessible for an expansive variety of working frameworks other than Unix, including eComStation, Microsoft Windows, NetWare, OpenVMS, OS/2, and TPF. Apache is free and open-source programming discharged under the Apache License. Apache was assessed to serve half of every single dynamic site and 37% of the best servers over all domains for the year 2015.

13. FINAL OUTPUT

The final output will be location with respect to system sent to the mobile robot and if detected any human, live photographs of it would be uploaded on a hosted server so that the info and analysis is accessible to all.

14. RESULTS AND DISCUSSION

The final product was hence created and tested against different situations whose results have been compiled in Project Demonstration. The system proved efficient in many different conditions as well as working temperatures, however the robustness is compromised for above 37-degree Celsius environment, solely because of its similarity to human body temperature. Although the error is temporary pertaining to the cheaper alternative of thermal camera. With suggested equipment and model prototype devices, the system is extrapolated to work in every possible condition. The techniques used for motion detection were selected keeping in mind that the system might be placed on a moving rover. For a camera on moving rover, everything with respect to the rover is moving, hence it will trigger a lot of false detections. That's why optical flow recognition algorithm was used so that the system not only identifies motion but also the speed, and direction of motion which can be normalized with the rover's speed and hence reduced false detections.

The system is expected to help rescue teams in conducting their operation by utilizing high end processing techniques and compiling results within seconds. For future works, the skin and motion detection data can be re-analyzed to make the prototype completely independent and autonomous. Based on percentage of event trigger the rover can move towards the trigger with an implemented control system and provide more data of a single

trigger giving detailed information. In addition, with a tradeoff to navigation, the rover could be equipped with mechanical tools and first aid boxes so that people who are still in their senses could use them. More research can be done on the use of microwave sensors that penetrate through rocks but fail to refract through shiny metal pieces. This thing could be overcome by the use of high powered waves like X-rays, but the limit he mobility of the system. Once established these rays could make the work much easier, faster and will be able to provide with more and detailed information about the disaster scene.

Figure 3 Test image for skin detection with image only

Figure 4 YCBCR format image of test image

Figure 5 Skin detected output – skin highlighted by blue pixels

Figure 6 Skin detection with video output-Real time I **Figure 7** Skin detection with video output-Real Time II

Figure 8 Motion detected video in comparison with original video

15. CONCLUSIONS

In this paper, an automated sensing system to aid rescue team and their operations after an earthquake is presented. The main objective is to furnish a safeguard robot with the capacity to enable save to group and to accomplish great execution in exploring and investigating a fiasco scene to discover however many casualties as could reasonably be expected. This empowers a human administrator to profit by the robot's ability to distinguish the casualties in different conditions. With the suggested equipment and model prototype devices, the system is extrapolated to work in every possible condition. The system constitutes monitoring sensors and equipment for studying the conditions of human body and transmit the data to server. These portable robots make localization tracking to communicate over wireless sensor networks. The techniques used for motion detection were selected keeping in mind that the system might be placed on a moving rover.

REFERENCES

[1]   Burion, Steve, Casper, J., Amerada, Yams, Igarashit, &Matsunos, and Cappello, C., etal Human Detection for Robotic Urban Search and Rescue Carnegie Mellon University, Institute of Production Robotique (IPR) LSRO2 – VRAI-Group, Micro technique, February 2004.

[2]   Chou Wusheng. Wang Tianmiao, You Song, Sensor-based autonomous Control for tele-robotic system, Proceedings of the 4th World Congress On Intelligent Control and Automation, vol.3, pp. 2430 – 2434, 2002.

[3]   Miyama, S.; Imai, M.; Anzai, Y.; Rescue robot under disaster Situation: position acquisition with Omni-directional Intelligent Robots and Systems, 2003.(IROS 2003), 27-31, , vol.3, pp. 3132 – 3137 , Oct. 2003.

[4] Donoso-Aguirre, F. et al. Mobile robot localization using the Hausdorff Distance, Robotic A, Cambridge University Press, Vol. 26, No.2, March 2008.

[5] Dhariwal, A. and Sukhatme, S.G. Experiments in robotic boat Localization, Internsational Conference on Intelligent Robots and Systems, IEEE, 2007.

[6] Chou Wusheng. Wang Tianmiao, You Song, Sensor-based autonomous Control for telerobotic system, Proceedings of the 4th World Congress On Intelligent Control and Automation, vol.3, pp. 2430 - 2434, 2002.

[7] B. Doroodgar, Y. Liu, and G. Nejat, A learning-based semi-autonomous controller for robotic exploration of unknown disaster scenes while searching for victims, IEEE Transactions on Cybernetics, Vol.44, No.12, Dec. 2014.

[8] T. Lupton and S. Sukkarieh, Visual-Inertial-Aided Navigation for High-Dynamic Motion in Built Environments Without Initial Conditions, IEEE Transactions on Robotics,Vol.28, No.1,Feb. 2012.

[9] B. Mobedi and G. Nejat, 3-D Active Sensing in Time-Critical Urban Search and Rescue Missions," IEEE/ASME Transactions on Mechatronics, Vol. 17, No.6, Dec. 2012.

[10] Brendon Rhys Le Comte, Gourab Sen Gupta, Moi Tin Chew Distributed sensors for hazard detection in an urban search and rescue operation, Instrumentation and Measurement Technology Conference (I2MTC), 2012.

[11] George C. Pallis, Wireless transmission of vital signs of entrapped victims during search and rescue operations in collapsed buildings, EAI 4th International conference on Wireless mobile communication and Healthcare, 2014.

[12] Trupti B. Bhondvel, Prof. R. Satyanarayan, Prof. Moresh Mukhedkar, Mobile rescue robot for human body detection in rescue operation of disaster, IJAREEIE, Vol.3, No.6, June 2014.

[13] Geetha Bharathi.V.S, Dr.S.Sudha, Alive Human Detection in Disaster Zones using Manually Controlled Robots,Vol.3, No.2, March 2015.

[14] Sandeep Bhatia, Hardeep Singh Dhillon, Nitin Kumar, Alive human body detection system using an autonomous mobile rescue robot, Indicon, 2011.

[15] Miyama, S, Imai, M, Anzai, Y, Rescue robot under disaster Situation: position acquisition with Omni-directional Intelligent Robots and Systems, 2003. (IROS 2003), vol.3, pp. 3132 – 3137, Oct. 2003.

[16] Albert KO and Henry Y. K. Lau, Robot Assisted Emergency Search and Rescue System with a Wireless Sensor Network, International Journal of Advanced Science and Technology Vol. 3, February, 2009.

[17] B. Ramyaa Sree and SS. Asadi A Remote Sensing and GIS Based Critical Evaluation of Change Detection Study in Thimmaipally Watershed for Land Resources Management, International Journal of Civil Engineering and Technology, 8(4), 2017, pp. 2110-2124.

[18] Ramandeep Kaur and Sakshi Sharma, A Research on Non Cooperative Hybrid Spectrum Sensing Technique, International Journal of Electronics and Communication Engineering and Technology, 8(1), 2017, pp. 67–78

[19] P.Lakshmi, SS. Asadi, P.Polu Raju, and D.Sathish Chandra, An Integrated Approach For Site Selection By Using Remote Sensing And Design Of Group Houses In And Around Vijayawada: A Model Study. International Journal of Civil Engineering and Technology, 8(3), 2017, pp. 806–815.

[20] J. Bhattacharjee, Study of OMRF and SMRF Structures for Different Earthquake Zones of India, International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 5, May 2017, pp.968-983