© 2016 IJSRST | Volume 2 | Issue 3 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Rescue Robot for Emergency Human Search during Disasters Using Pyrometric Sensor (PIR)

Majid Murtaza Noor, Seema Chawla

Department of Biomedical Engineering, DeenBandhu Chhotu Ram University of Science & Technology, Murthal, Haryana, India

ABSTRACT

This paper presents the designing of rescue robot system with the focus on implementing low cost prototype using the lightweight PIR sensor for the detection of humans in the disasters (man-made as well as natural). This research serves as proof-of concept for human search in catastrophe using pyrometric sensor (PIR) with the high accuracy rate of detection. The wireless sensor network also helps to track the location of the robot by analyzing signal strength. Design and development of the network and the physical robot prototype are described in this paper.
Keywords: Rescue Robot, Wireless network, Disasters, PIR Sensor, Human Detection

I. INTRODUCTION

Nowadays most of the people of a country live in urban centers. As cities grow, their population density increases. The high population density makes any disaster, such as natural or human disaster, much more deadly. Another impact of megacities is the complexity to deploy rescue teams [1]. Indeed a disaster may destroy the critical infrastructures of a city and reduces the effectiveness of the rescue teams greatly. Disaster sites are complex and dangerous. They are a great threat to rescue workers and survivors. In such chaotic scenarios, the rescue workers' lives can be put at risk. In order to avoid unnecessary losses, a rescue robot can be of great help to detect human beings and perform minor medical acts.

Researchers face many flaws in the design of rescue robots. These challenges can be classified in three classes:

- Design and/or conception: Many researchers have proposed single rescue robot [2], [3], [4], [5], [6] that can move in the cluttered environment of disaster sites. These robots use different mechanisms (wheels, legs, tracks and wheeled-legs) to achieve their displacement. However, these robots are not well suited to all disaster environments. The single rescue robot must be carefully chosen in regards to the disaster site. To withstand defaults of single rescue robots, some authors propose to use multiple robots [7], [8], [9]. Each robot can adapt to a precise situation and overcome the defaults of the other ones.

- Positioning: A challenge for rescue robots is to determine their position in a cluttered and unfavorable environment. It is common to use GPS to locate a vehicle or something else. However GPS is not suitable to establish indoor positioning because the GPS signal is highly attenuated and scattered by the rubble from the disaster sites. To localize rescue robots in indoor some authors propose to use the dead reckoning systems of the robot [10], the use of electromagnetic waves for triangulation technique [11], [12] or lasers for scan matching techniques [13]. These proposals offer an accuracy down to a few meters. To monitor the environment efficiently or handle some objects, the positioning system has to be far more accurate. A wise objective would be to obtain a position accuracy of about one or two centimeters, which make it possible to have accurate displacements.

- Human being detection: The main purpose of the rescue robot is to detect human beings. In order to detect human beings, sensors (such as IR sensor, thermal camera, video camera, microphone, ultrasonic sensor,

CO2 sensor…) are mounted on rescue robots [14], [15], [16], [17], [18]. To work conveniently, these technologies require to be in close proximity to the victim.

In this paper, we only focus our interest on the sensor and low cost design. We propose a method to both achieve efficient human being detection as well as to perform an accurate positioning of the rescue robot.

II. METHODS AND MATERIAL

1. Principle

The design on a B-Bot system based on GSM technology to help the people on time which are trapped in natural & man-made calamities like warfare, earthquake, floods etc.

PIR Sensor implemented for detection of victims in the catastrophe and signal strength based on GSM network, can solve the key issue of communication bandwidth, data transmission, real-time detection & so on, The basics of calling feature through GSM with the use of dual tone multiple

2. Solution Chosen for a Human Detection Set of Sensors

With the results of the research obtained above, it can be seen that one sensor is not enough to detect the presence of a victim in a disaster area. We need a set of several sensors which measure different physical human characteristics that can be put on the USAR robot from the DCRUST. Here are the most important criteria for sensor selection for our application:

- Low cost
- Small size
- Low weight
- Simplicity (easy to interface)
- Robustness

Pyroelectric infrared sensor : This is a low-cost sensor which is complementary to the vision and sound chosen before. It is efficient detector for human presence. It is a very cheap and commonly used device in robotics, because the interface with the robot is very easy. With a Fresnel lens it can detect a person several meters away and it is not dependent on external light.

Many pyroelectric sensors which are available have the same characteristics. All of them need an electronic circuit to amplify and filter the signal. A common application is to have a comparator to have a binary output. A very small device with all the electronic parts built in was found by Murata.

External dimension: 20 x 13 x 8 mm

- supply voltage : 2.6 – 5.5 V
- Current consumption : 45 µA (ready period) 85 µA (active period)
- Output: analog or digital
- Wavelength Range: 5 – 14 µm
- Detection length : 1 m (without lens), 5 m (with Fresnel lens)
- Field of view : 104° x 30° with Fresnel lens (not specified without lens)

The advantages of this device are its whole built-in electronic package, small size and the ease of interface with its digital output.

3. Robot Configuration

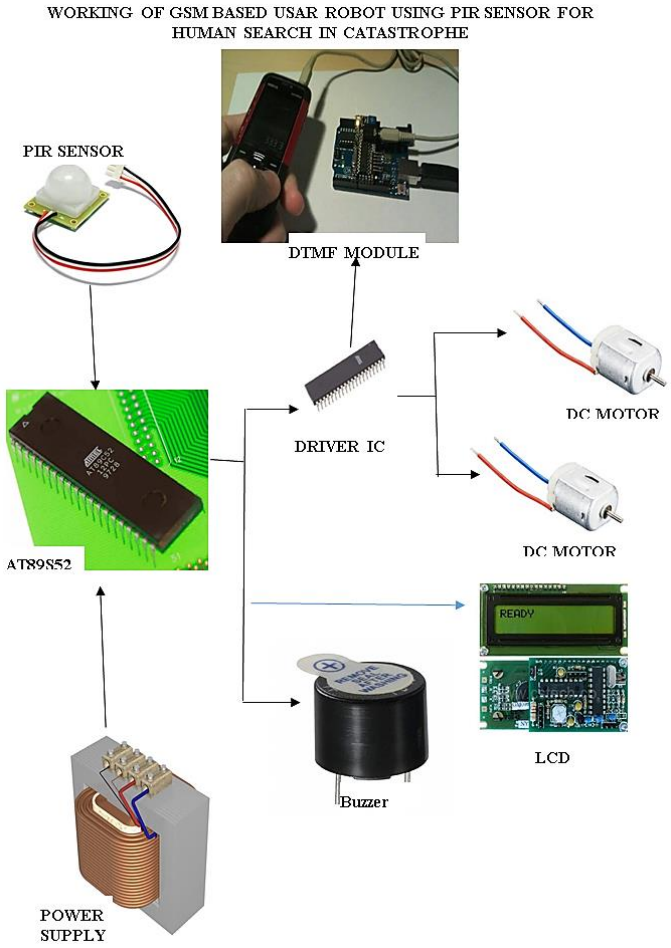

Figure 1: Operation and Structure of design strategy

In this work the robot is connected to GSM mobile (using DTMF technology) which is controlled by user mobile phone. With the help of commands we can move the robot in desired direction as per our requirement. Since the DTMF technology which is incorporated in robotic system for controlling the movement by pressing the corresponding digit on the keypad for the displacement of USAR robot to carry out the operation. The remote control technologies have been used in the fields like factory automation, space exploration, in places where human access is difficult or risky. As the mobile phone enables us to connect with the outside devices via mobile communication network regardless of time and space, the mobile phone is a suitable device to control domestic systems.

Internally it consists of PIR sensors, which are used to sense the live persons. All the above system is controlled by the microcontroller AT89S50.

III. RESULT AND DISCUSSION

1. Results

Different kinds of experiments are done to determine the sensitivity of this sensor.

First the sensor is placed on the robot in a fixed position and the robot remained in place. A human stand in different places in the field of view of the sensor and gestures.

According to Figure 2, the human is nearly always detected in the sensor field of view. Sometimes the detection distance is longer than the specifications because the sensor detects movement at more than 5 meters.

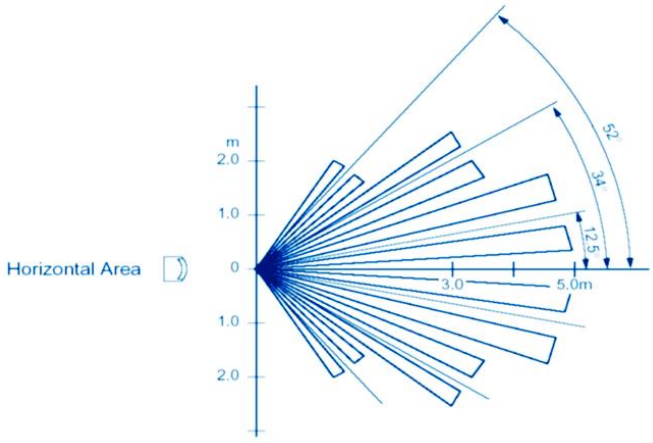

Figure 2: Pyroelectric sensor field of view

In 30 readings 16 readings detected a human. Since the false positive result are, almost the one-third. Actually, these kinds of measures are strongly dependent of the environmental condition (heat reflection, artificial heat). Results table (number of measurements):

	Human	*No Human*
Human Detected	16 (TP)	9 (FP)
Nothing Detected	1 (FN)	14 (TN)

Table 1: Pyro sensor results of measurements

TP = true positive FP = false positive
FN = false negative TN = true negative
If these results are expressed in a probabilistic way and if H means “there is a human”, NH “there is no human”, D “human detected” and ND “nothing detected”, the following results can be established:

$$P\left(\frac{D}{H}\right) = \frac{TP}{TP+FN} = 0.941 \qquad P\left(\frac{ND}{NH}\right) = \frac{TN}{TN+FP} = 0.608$$

	Human	*No Human*
Human Detected	94.1%	39.2%
Nothing Detected	5.9%	60.8%

Table 2 : PIR Sensor results in Percentage

Accuracy: $A = \frac{TP+TN}{TP+TN+FP+FN} = 0.75$
(ideally =1)

As the sensor has less false positives, it is very reliable and its accuracy value is high. But the Table 2, shows that if the sensor does not sense anything, we can almost be sure that there is no human presence. The opposite way is not true.

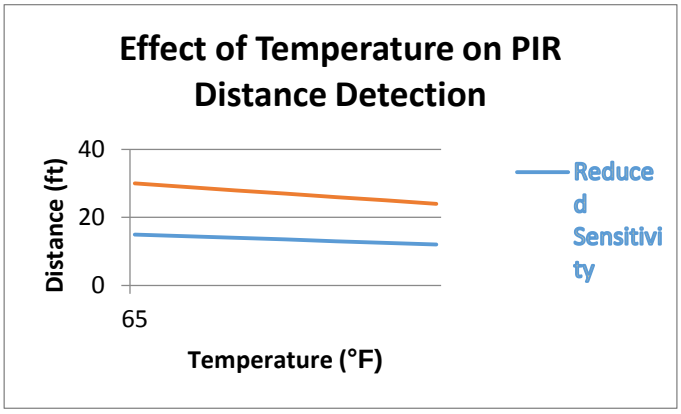

Figure 3 : Effects of temperature on PIR Sensor

Over most of the temperature range, a PIR sensor works consistently in detecting the temperature difference but at high temperatures, close to body temperature at about 99 degrees F, there is a small range of outside temperatures where a PIR sensor range will reduce.

2. Test

The prototype of the robot was successfully experimented with the detection of human using pyrometric sensor (PIR) with automatic alarm and with the capability to call the rescue operator or team for the emergency help to save the victim. The LCD in the figure 3 displays the message while detecting the human alive in the test phase.

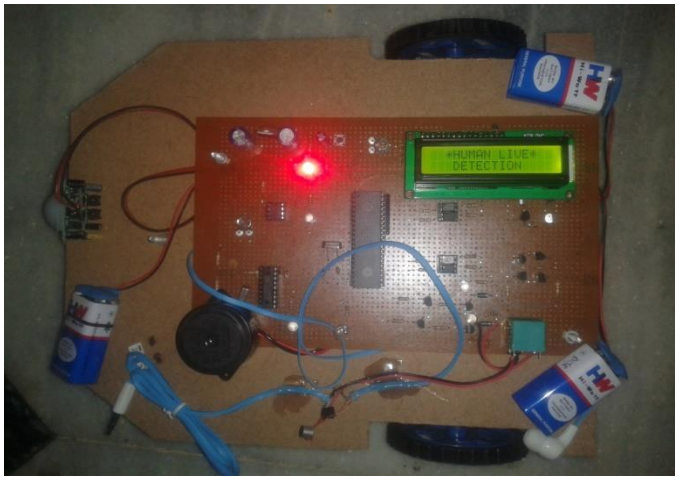

Figure 4: Tested design of the prototype

IV. CONCLUSION

The results obtained from the tests described in this work were very promising. In the test set used throughout the experimentation, the combined detection system performed better than any single detector and achieved a detection rate of 94.1 % and overall average detection accuracy 75% for all experiments and environments tested.

The hardware presented in this work is designed to be efficient for real-time applications. It is not easy to predict how well the robotic system would work in an actual disaster scenario, however, the tests have shown that the system is well capable of detecting humans, thereby promises to save lives of humans in the catastrophe.

V. APPLICATIONS

- ✓ In disaster zones for rescue operations, whether it natural or man-made disaster.
- ✓ In defense applications for security purpose and other allied areas.
- ✓ In addition, technologies and methods that can help to setup the system quickly for emergency application and medico-robotic studies are another important area's to make the system truly applicable.

VI. REFERENCES

[1] J. Casper and R. Murphy, "Human-robot interactions during the robot assisted urban search and rescue response at the World Trade Center",IEEE Trans. On Systems, Man and Cybernetics-part B, vol. 33, pp. 367-385, 2003.

[2] M. Eich, F. Grimminger and F. Kirchner, "Proprioceptive control of a hybrid legged-wheeled robot", Proc. IEEE Int. Conf. on Robotics and Biometrics, pp. 774-779, Feb. 2009.

[3] Y. Fukuoka and H. Kimura, "Adaptive dynamic walking of a quadruped robot on irregular terrain based on biological concepts", International Journal of Robotics Research, vol. 22, pp. 187-202, 2003.

[4] M. Ohira, R. Chatterjee and T. Kamegawa, "Development of three legged modular robots and demonstration of collaborative task execution", IEEE International Conference on Robotics and Automation, pp. 3895-3900, April 2008.

[5] H. Tsukagoshi, M. Sasaki, A. Kitagawa and T. Tanaka, "Design of a higher jumping rescue robot

with the optimized pneumatic drive", Proc. IEEE Int. Conf. on Robotics and Automation, pp. 1276-1283, April 2005.

[6] M. Suzuki, S. Kitai and S. Hirose, Basic systematic experiments and new type child unit of anchor climber: swarm type wall climbing robot system", Proc. IEEE Int. Conf. on Robotics and Automation, pp. 3034-3039, May 2008.

[7] T. Kamegawa, K. Saikai and A. Gofuku, "Development of grouped rescue robot platform for information collection in damaged buildings", The University Electro-Communications, pp. 1642-1647, Aug. 2008.

[8] K. Nagatani, K. Yoshida and K. Kiyokawa, "Development of a networked robotic system for disaster mitigation", Proc. Field and Service Robotics, pp. 453-462, Aug. 2008.

[9] Y. Yang, G. Xu, X. Wu, H. Feng and Y. Xu, "Parent-child robot system for rescue missions", IEEE Int. Conf. on Robotics and Biomimetics, pp. 1427-1432, Dec. 2009.

[10] Z. Hu, "Localization system of rescue robot based on multi-sensor fusion", IEEE Int. Conf. on Computing, Control and Industrial Engineering, Aug. 2011.

[11] S. Miyama, M. Imai and Y. Anzai, "Rescue robot under disaster situation: Position acquisition with omni-directional sensor", IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, Oct. 2003.

[12] D. P. Stormont and A. Kutiyanawala, "Localization using triangulation in swarms of autonomous rescue robots", IEEE Int. Work. on Safety, Security and Rescue Robotics, Sept. 2007.

[13] J. Li, J. Bao and Y. Yu, "Study on localization for rescue robots based on NDT scan matching", IEEE Int. Conf. on Information and Automation, June 2010.

[14] B. Schiele, M. Andriluka, N. Majer, S. Roth and C. Wojek, "Visual people detection: Different models, comparison and discussion", ICRA Workshop People Detection and Tracking, 2009.

[15] J. Serrano-Cuerda, M. Lopez and A. Fernandez Caballero, "Robust human detection and tracking in intelligent environments by information fusion of color and infrared video", Int. Conf. on Intelligent Environments, 2011

[16] A. Himoto, H. Aoyama, O. Fuchiwaki, D. Misaki and T. Sumrall, "Development of micro rescue robot – human detection", IEEE Int. Conf. on Mechatronics, 2005.

[17] S. Bhatia, H. S. Dhillon and N. Kumar, "Alive human body detection system using an autonomous mobile rescue robot", IEEE India Conference, Dec 2011.

[18] H. Sun, P. Yang, Z. Liu, L. Zu and Q. Xu, "Microphone array based auditory localization for rescue robot", Control and Decision Conference, May 2011.

AUTHORS

Majid Murtaza Noor

Majid Murtaza Noor is presently pursuing MTech in the Department of Biomedical Engineering DCRUST Haryana India. His research interests are Surgical Robotics, Medical Imaging Systems, Haptics, Biomechanics, Tissue Regeneration, Artificial Intelligence and Designing.

Er Seema Chawla

She is presently working as Assistant professor in the Department of Biomedical Engineering DCRUST Haryana. Her field of interests are robotics, Bioinstrumentation, Haptics