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Sensor Web for Public Safety

Sarang Ardhapurkar,S. Sai Manjula and Y. Meena Kasturi

K L University,
Vijayawada, India

***Abstract* — The purpose of this project is to introduce a sensor web based application for public safety. We have heard of many incidents of stampedes and fire accidents taking place that result in a huge death toll. So it is becoming essential to find a viable solution to these incidents.**
This project aims at solving this problem by estimating the capacity of a room or a large open area. Object Detection Sensors are used detect the movement of people in and out of the site. This data is then sent to a remote server where some calculations take place and the exact count of people present in the room is determined. This value is then compared with the threshold value and if exceeded, a notification is sent to the authorities present at the site who can then take required action.

Keywords:Sensor Web, Human Detection System, Human Safety

I. INTRODUCTION

It uses the combination of wireless sensor networks and the web for providing public safety at large gatherings and/or public places like railway stations, bus stands, etc.

A. Purpose

We have heard a lot about many people succumbing to injuries caused by stampedes. The headline reading "Stampede kills" has become a pretty common line in the newspapers for the past few years. Scores of people have lost their lives in stampedes.

In India alone, 415 deaths have been reported in the past 4 years [1].

Fig. 1 Pictures of a few tragic events

Here's a list of few of the tragic events that took place in the last 4 years.

1) *Feb 10, 2013:* During the Hindu festival Kumbh Mela, a stampede broke out at the train station in Allahabad, Uttar Pradesh, India, killing 36 people including 26 women and injuring at least 39.

2) *Jan 14, 2012:* At least 10 people, including six women were crushed to death in the middle of the night when a stampede broke out at a religious shrine in central India.

3) *Jan 14, 2011:* This took place at Sabarimala in Kerala, India. It broke out during an annual pilgrimage, killing 106 pilgrims and injuring about 100 more.

4) Mar 4, 2010: Thousands of villagers who came to a popular ashram in northern India for a free meal on Thursday were caught in a stampede, which left more than 60 dead.

5) *Aug 3, 2008:* A human stampede at the Hindu temple of Naina Devi occurred on 3 August 2008 in the Indian state of Himachal Pradesh. 162 people died when they were crushed, trampled, or forced over the side of a ravine by the movement of a large panicking crowd.

B. Aim

To build a Sensor Web with whose help the number of people that are present in a gathering/building can be determined and when this count exceeds the threshold value, the application designed will notify the local authorities present there so that they could then provide proper crowd control and ensure the safety of all the people present there and minimize the damages.

C. Assumptions

1) The same gate could be used for both entrance and exit.

2) There can be any number of gates

3) The area of the ground is based on the documentation of that area.

4) The estimated capacity of the ground is a rough figure for safety purpose.

The terms Mote (Technical) and Sensor (General) will be used as per the situation but in actuality mean the same.

D. System Structure

Consider an open ground with many entrances and exits. The area of this ground is taken from the available records. Now we calculate the rough capacity of that area by using the formula.

$$\text{Ground Capacity} = \frac{\text{Area of ground}}{\text{Area occupied by one person}}$$

This calculated value is taken as the threshold value. And the "area occupied by one person" is considered as constant and that constant being "1" sq. ft.

This would only be a rough estimate. But for accurate or near accurate estimation follow the local Govt. guidelines.

This document also can help in providing for a good estimate [2].

There will be two sensors placed at every gate of the ground. One sensor will record the number of people entering the premise and the other will record the number of people leaving it.

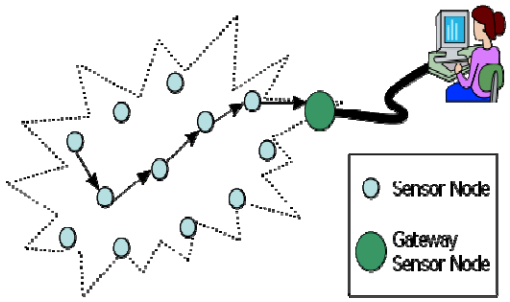

Fig. 2 Structure of the proposed WSN

There will be a series of such sensor nodes which will be coordinated by a gateway sensor node. This gateway acts as the bridge between the sensor data and the computer just as in Fig 2.

The data is thus received by a computer via the gateway which makes the transition of signals into system language. The data from all the sensor nodes is collected and analyzed. The server gathers all the data and then calculates the exact number of people present at this site. This count is then compared with the threshold value. This data is monitored by an administrator present at the server location.

If the administrator notices that the data has exceeded the threshold value then he notifies the authorities present at the site for evasive action. He does this by using a web application available to him where he can log in and send messages to the authorities present at the site. The web app comes with an embedded feature where all this is possible.

The administrator can also view all the data which is stored in the server. He can analyze the rate at which people are entering and leaving and all that is required based on his purpos**e.** There can be many possible uses of this data. It can turn out to be very useful for analysts and statisticians who want to record events of historical importance.

II. IMPLEMENTATION

A. Hardware requirements

1) Object Sensing Sensor (Mote): These are used to detect objects coming towards the Sensor using a wide range of sensors like Infrared, Acoustic, Temperature and Visual Light.

2) Gateway: Used to transmit the data received by the Mote to the Base Station.

3) *Base Station:* Any regular Desktop PC equipped with all the required software like Cygwin, NesC, Java based Web Application.

4) *Cables:* To connect the Sensors with the Base Station via Gateway.

Additional Equipment can be cameras for surveillance purpose and a public announcement system.

B. Software Requirements

1) Operating System: Required for the base station. Preferably TinyOS.

2) *NesC Editor and Compiler:* It is an editor and compiler to configure the sensors.

3) *Packet Analyser:* To analyze the packets and record the raw data.

4) *Cygwin:* To configure the WSN.

5) *JDK:* Required to run the java based web application.

6) Java Application: To view the sensor data and derive conclusions.

7) MySQL: Required by the Java Application to store and manage the sensor data.

C. Human Detection System

We used the human detection algorithm proposed in [3]. In this proposed algorithm a sensor is used to collect the raw data from the environment. This sensor comes with an application that will analyse this raw data and will then determine the presence of a human in the environment. This application used to recognize a human is programmed using Java. The application collects the data from the network via the gateway and then analyses the collected data to detect the presence of human. A gateway acts as a bridge between the sensor network and the base station. Gateway collects the data from the network. Node in the network consists of a mote powered by battery and a sensor board which is mounted on the mote.

To recognize a human, an application was developed which runs on the base station. This application collects the data from the network and analyzes the collected data to detect the presence of human. PIR sensor is used to collect the data from the environment. Data is collected from the environment initially and a threshold value is set when no human is present. Later if human comes in the vicinity of sensor it compares the current collected value from the network with threshold value and makes decision of human presence. The whole setup is as shown in Fig 3.

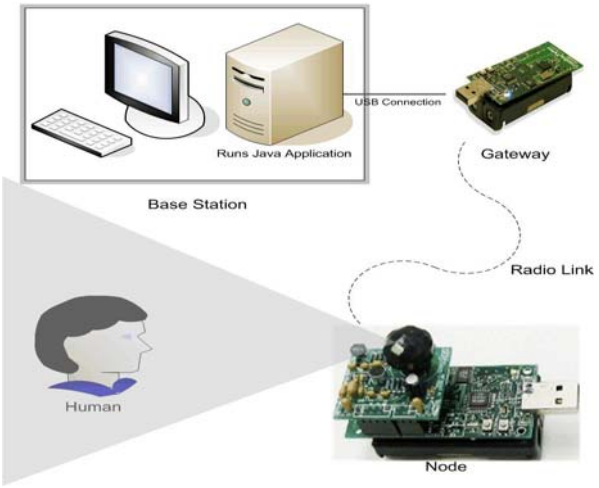

Fig. 3 Design of the WSN for Detecting Human Presence

Our application initially fetches the data from the environment in absence of any object. Once the application starts fetching the data with less variation or constant data a threshold value is set. Application continuously receives data from network if collected value is greater than threshold value it indicates that object is detected.

An algorithm was also developed to do these calculations.

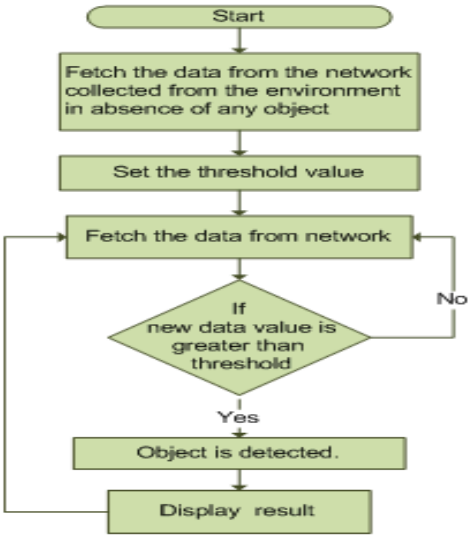

Fig. 4 Flowchart of Java Application

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D. Wireless Sensor Board Design

The Wireless Sensor Board used is a low power, flexible sensor board with multiple sensor modalities (visual light, infrared, acoustic, temperature, dual-axis magnetometer and dual-axis accelerometer) that is specifically designed to be plugged into wireless motes for use in sensor networks, data fusion, rapid application prototyping and monitoring applications.

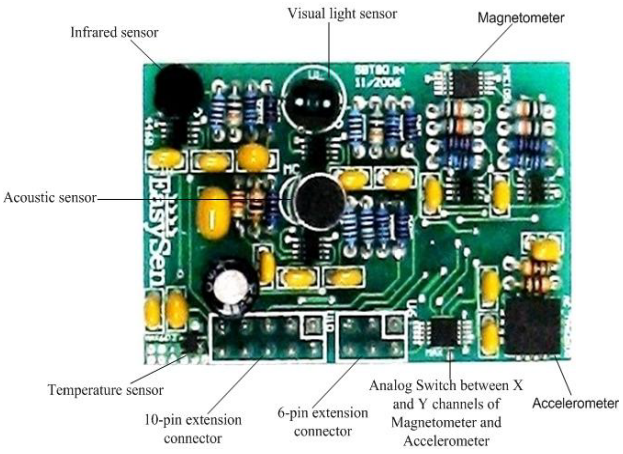

Fig. 5 View of the Sensor Board

The board of this Wireless Sensor Board is as in Fig 5. The various sensors on it are used in combination to determine the presence of an object. This is a very widely used sensor board.

Its full specifications can be found in [4]

E. Cygwin Software

This software is used to connect the wireless sensor board i.e the sensors and the motes to the base station via the gateway and also to decode the reading of the sensor into human understandable language.

This also helps in programming the Sensors to read and detect the presence of an object. This reading is taken by the Web Application which then sums up the readings of all the motes that are present.

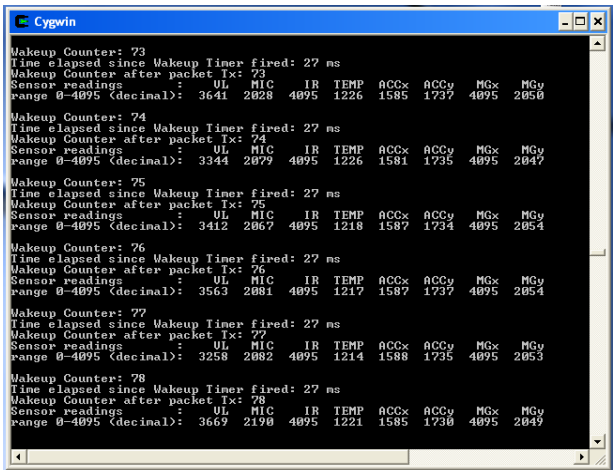

Fig. 6 Sensor readings on PC

The readings of all the sensors are displayed as in the above figure, Fig 6.

Depending on these readings and the pre-determined threshold value during setup, the presence of an object is detected as in Fig 7.

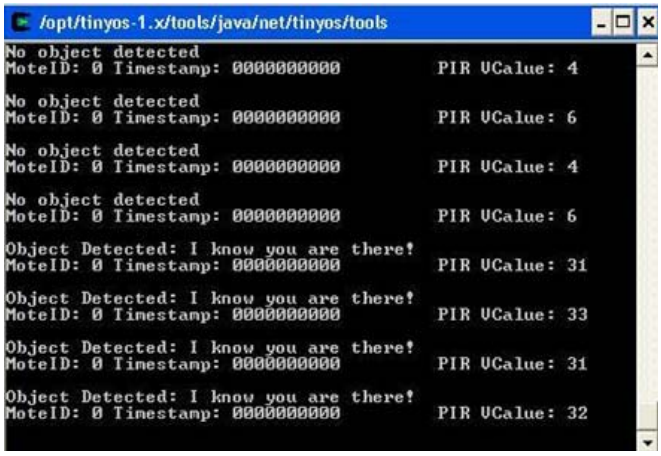

Fig. 7 Sample Output of Java Application

The Java Application takes the input of the Cygwin S/W and then decides on the presence of an object. Above is a screen showing the sample output of the application.

F. Java based Web Application

This is built on top the java application used to program the sensors. This is a web application with a log on screen as its homepage, with access only to the administrator. He can view the results, analyse them and also record all the information.

The administrator could also grant privileges to other users and determine their view.

This application summarizes the data collected from all the motes. It also gets us the exact count of the number of people present at the site. This is then compared with the site capacity. If it exceeds this value then the administrator is notified by the application with a warning message. He can then use the same application to notify the authorities by sending messages to the mobile phones of the authorities present at the site, who can then take the necessary desired action.

This application is designed using HTML and JSP. It has a MySQL database as its backend.

III. Applications and Advantages

1) The main purpose of this being crowd control and easy evacuation and management of people. It can be used at large crowd gathering or public meetings.

2) This idea can be extended and implemented at places like the temples, hospitals and schools.

3) It can be used in minimizing the death toll that occurs during stampedes due to large crowds.

4) *We* can also monitor the people leaving and entering the building without any kind of extra man power.

5) This can also be used to determine the number of people inside a building in case of calamities to help the authorities in giving them the exact count.

IV. Future scope

This idea is still in the development stages. It has been implemented in a closed area only that is a room. It can be extended to a large open area.

It can also be implemented in office buildings, schools and hospitals where the flow of people can be monitored. This information can be vital at the time of any calamity like fire-accident whence the people can be safely exited from the building instead of crowding up either one of the exits.

V. Conclusion

This idea deals with solving the problem of over-crowding. With the help of a few sensors and a Java Application one can easily solve this major social issue.

This is a very novel idea in order to avoid some major accidents. It can help immensely in aiding the police authorities on managing the crowd and in evacuating them safely out of the area.

The only issue being, it still in the development phase. It is yet to be completely tested out in the open. Although it has only been successfully tested in a closed room, a real time test is essential to prove its acceptance.

So there is a lot of scope for improvement and development in this field. But it's a start.

VI. References

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