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IOT Based Smart System for Servival Detection in Disasters Zones

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ABSTRACT

Smart systems with high architecture and advance technology has been expected to mitigate losses during disasters especially in earthquake zones. An invention of robotic technology helps to search and rescue the survivals in disasters zones but unable to transmit real time information to base station on-time to expedite the rescue operations. The development of IOT based smart system modernize the survival detection technology to minimize the damages. The proposed system has been tested in controlled environment to evaluate the results and performance of system. The system has been installed in various place between different obstacles to verify and validate the survivals detection frequency and real time information dissemination frequency to its cross pounding base station as well as on handheld devices. Moreover, this research article encompasses various results of respiration, movements and heartbeats of the survival in any natural disaster zones.

Key words: IOT Components, Microcontroller, respiration Module, GSM Module

1. INTRODUCTION

In literature, some researchers suggest and proposed various technologies to identify the survivals from the earthquake disaster zones such as PIR, Microcontroller based GSM technology, power line communication which helped to provide the information about vibration, temperature, ultra-sonic detector as well as IR. These technologies are used to indicate the presence of aliveness of human bodies and communicate that information to remote control rooms [1-2]. The different kinds of radar system have been using by various researcher for evaluating the human bodies' movement during disasters. The frequency-based radar was used to detect the human presences and indicates the human activities. Moreover, the latest radar technology allowed the measurement of regular velocity of person movements [3-4]. Some Ultra-Wide Band radar sensor has a capability to sense the person behind the wall such as during earthquake, survivals can be trapped in collapsed buildings, the sensor were used to locate the survivals locations. The proposed sensor used standard deviation approach to sense through different building materials such as wall, wooden door [5]. Another research approached was based on robot system along with lightweight sensors for the survival detection [6]. It comprises the integrated various biological sensors with radio interface to sense biological data from a survivals body and then sent that information to remote healthcare cloud center via smartphone as an interface. The PIR based robot technology was used to detect the aliveness of humans in debris so the timely help can be possible as soon as possible to the survivals. The robot technology is equipped with passive infrared sensors and robotic arms was used to remove the obstacle in its ways and camera was used to send the image to control station while microcontroller is used to control the activities of robots [7]. A researcher proposed a system with novel concept as arrayed laser image contrast evaluation (Alice) to identify survivals bodies which is based on unique characteristic of human skins. In that system an NIR dot array laser was used to illuminate, and irradiated area detected from the human skins using a near infrared camera [8-9]. Another experiment done by the PANDORA robotic team aims to develop a robotic platform which was used to identify the survivals from any disaster zones [10]. The hybrid radar with wideband Boolean Chaos Code and single phase based Doppler Mode has been developed by the experts to human localization and heartbeat and respiration detection. The signal-based processing technology of the radar system allows working simultaneously on two modes for different aims [11-12]. The 24GHZ Doppler radar network was design for non-contact human respiration detection signal and it also support self-correlation that can be used to increase the quality of the respiration signals. This method minimizes the interference of any moving object around the human body. Another ultra-wide and radar was used to collect eco signal from the stationary and moving statuses of survival bodies. The surveillance robots were also used to collect the aliveness signs of human bodies such as live videos, surrounding area conditions, temperature measurements, humidity, gases volume and vibrations [13-14-15]. The ultra-wideband radar performed key role to locate the victims by detecting respiration and heartbeats signals and rescue the survivals from the disaster's areas [16]. Many other technologies have been proposed by different researcher to rescue the human lives from the disaster's areas such as thermal camera, CO2 sensors, and microphones. These technologies detect the human bodies from the rubbles and high risky areas of disaster zones. The CO2 sensor is used effectively to reduce the disturbed zone, while the thermal camera endorses the accurate location of the object [17]. Nowadays the smartphone technology with embedded sensors is used to locate the motions of earthquake as well as human being motions [18-19]. A researcher developed a seismic network using smartphones which increases traditional networks capabilities to detect the devices, distinguishes earthquakes and human activates. An algorithm was embedded with smartphone technology that effectively differentiates the human activities from the earthquake disaster [20-21-22]. In the researchers have used drone technology to detect the survivals through images and videos, and a PC controlled robot was used to detect the under- surface survivals through PIR and ultrasonic technology [23-24-25]. In, a proposed system of drone captures image sequences through camera to detect the motion of the chest movement of survivors. In UAV has been used for the detection of the survivals and in three types of sensor system have been used to detect the survivals [26-27].

2. X2M200 RESPIRATION MODULE DETECTION TECHNIQUE

The objective of logical architecture of sensor based detection techniques is to allow the field operators to monitor the activities in disaster zones. The proposed architecture helps to develop a coordination among affected earthquake zones, field offices and core management to provide the assistance to the victims and survivals of affected area. The logical architecture of sensor based detection methods has various components to provide a resilient network communication to float the information from the disaster zones as shown in figure 1.The architecture components are following as, National Disaster Management Authority, Quick Disaster Management Response Cell ,Central Disaster Management cell and Resilient ICT Networks.

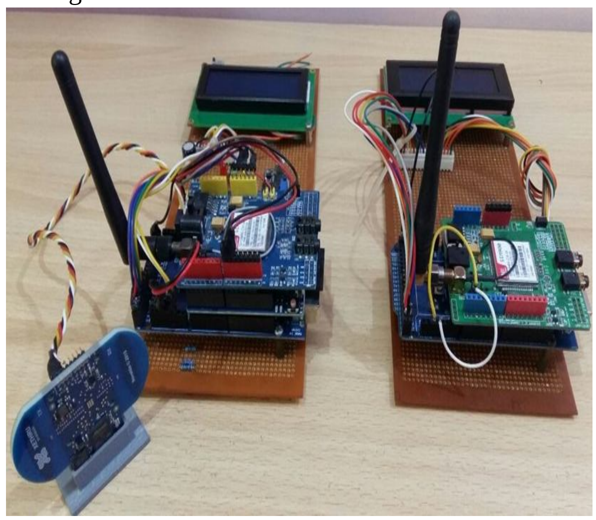

Figure 1. Respiration Detection Modules

3. OPERATIONAL COMPONENT OF PROPOSED SYSTEM

It is the main component of the proposed system and it consists of X2M200 respiration module and mega 2560 micro conroller aurdino module as shwn in figure 2. It is placed in the controllrd environment in different location and test it to get the movment and respiration rates of the people with in detection zone.

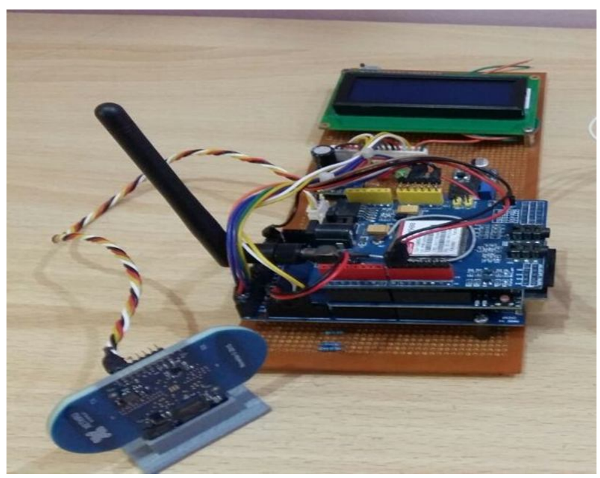

Figure 2. Operational unit of prototype in earthquake disaster zone

3.1 Remote Device

The cell phone component is the most important part of the proposed system and this is used for the flow of real time information through the operational area componet and also the cell phone connected to the system that is the remote location. The purpose of using the cell phone is to mointor the information as received from the base station. The figure 3 shows the received information from the base station.

Figure 3. Remote Device

4. ALIVENESS DETECTION MECHANISM

The process of aliveness detection technique can illustrate in the following figure 4. The designed system will initialize first and then starts searching different aliveness detection techniques (movement, breathing and respiration per minutes (RPM)).

The system constantly working and searching for the detection of the survivals location, moment, breathing and RPM respectively.

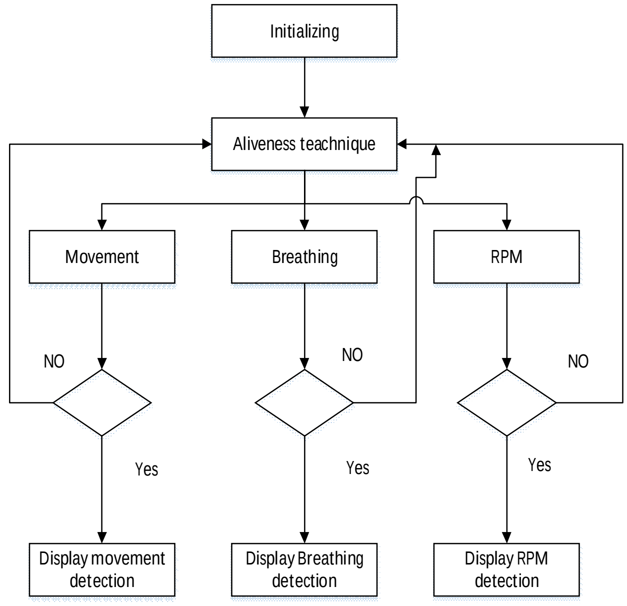

Figure 4. Aliveness Detection flow mechanism

5. OPERATIONAL COMPONENT OF PROTOTYPE SYSTEM

The figure 5 shows the operational component of the desgin system. it is the main components which is used to detect the survivals from the earthquake afftected areas. The operational components has aliveness sensing module which is used to detect the movement, breathing and RPM of survivals and store that information on external storage module. Moreover, when the components collect the information from the disaster zone at the same time it transfer that information on operator mobile phone as well as base-station components through GSM communication protocol.

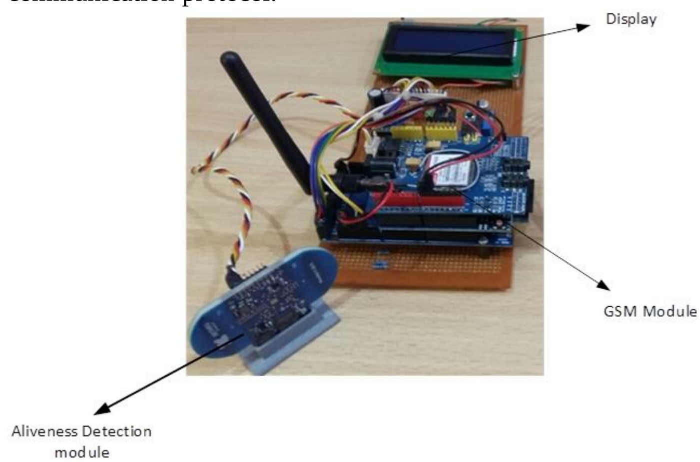

Figure 5. Operational unit of prototype at disaster zone

5.1 Disaster Information Respondents Cell Phone

This is the remote component of system where the operational components transfer the disaster information for quick rescue operations. The mobile phone component of the system mainly hold by the field operators as well as central response management cell personnel's. The figure 6 depicts the operator mobile phone component of the system.

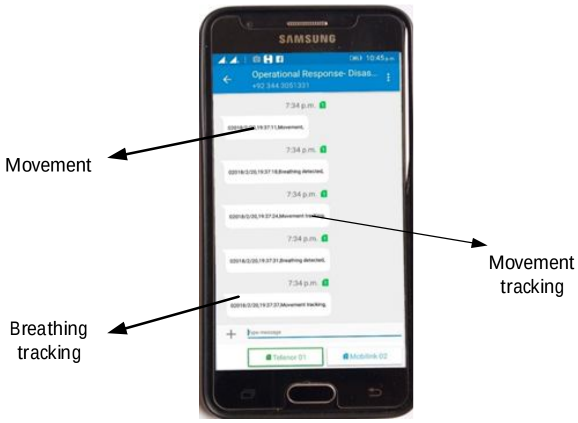

Figure 6. Respondents Device

5.2 Base-Station Components of the System

The third component of prototype system is called as base-station component. The base-station components receive the information from the operational components and communicate that information to the field operators to lunch speedy rescue activities in disaster affected zones. Moreover, the base-station also has information of available repaid response networks for quick activation. The figure 7 shows the base-station component of the Smart system.

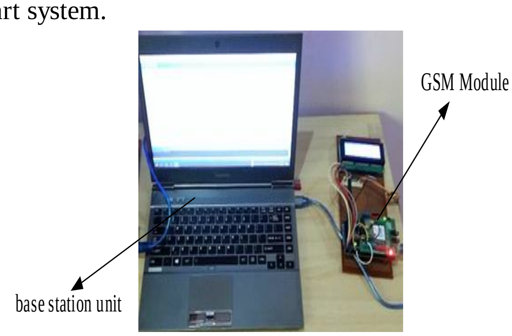

Figure 7. Base-Station

6. RESULTS AND DISCUSSION

The results of prototype hardware module based on different scenarios. The smart system has been placed in various building structured material to detect the location, movement, breathing and respiration patterns of survivals. Table 1 shows the prototype system results. It started to detect the movement at 12:37:37 pm, 12:38:15 pm and again the system is tested to track the movement at 12:38:28 pm and at the same time the system detects the breathing on 12:38:41 pm .Moreover, system manages to detect its 1st respiration per minute RPM that was 12.34 as shown in the figure 8. Then again tracking movement and breathing at 12:38:54, 12:39:6 pm respectively. The 2nd RPM 26.15 was detected at 12:39:19 pm. The 3rd RPM 17.35 was detected by the system at 12:39:58, movement tracking at 12:40:10 pm and at 12:41:32 pm the breathing was detected. On 12:41:45 pm 4th RPM 21.5 was detected by the system respectively.

Table 1. Aliveness detection by Prototype system

Time	**Aliveness feature Detection**
12:37:37	Movement
12:37:50	Movement tracking
12:38:02	Movement
12:38:15	Movement tracking
12:38:28	Breathing
12:38:41	12.34 RPM
12:38:54	Movement
12:39:06	Breathing tracking
12:39:19	26.15 RPM
12:39:32	Movement tracking
12:39:45	Breathing
12:39:58	17.35 RPM
12:40:10	Movement tracking
12:41:32	Breathing detected
12:41:45	21.5 RPM

6.1 Concrete Structure

The system was install on concrete material and tested the signal penetration rate as well detection rate. The figure 8 shows the concrete material with prototype system.

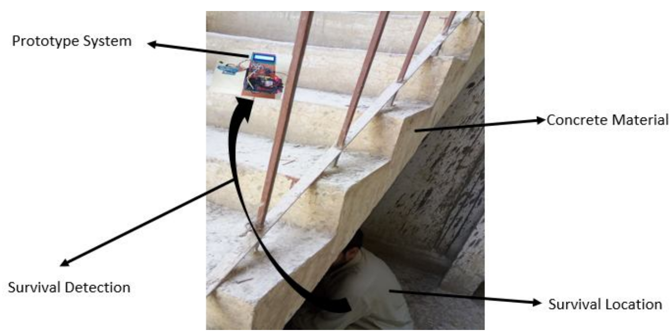

Figure 8. Aliveness detection through Concrete structured

In the table 2. Shows that concrete structure was used for hardware result shown in figure 8, that the breathing was detected at 13:2:44 pm, 13:2:45 pm, and 13:2:45 pm. The first rpm was detected at 13:2:46 pm which was 14.7 RPM. Then the system starts movement detecting at 13:3:1 pm, breathing detection at 13:3:7 pm, movement at 13:3:1 pm, breathing detection at 13:3:20 pm and breathing detection at 13:3:27 pm respectively. 2nd RPM 10.25 was detected at 13:3:27 pm. Then the system again starts breathing detection at 13:3:28 pm, and movement detection at 13:3:29 pm. Breathing detections at 13:3:38 pm, 13:3:44 pm and 13:3:45 pm.

Table 2. Aliveness detection through Concrete structure

Time	**Aliveness feature Detection**
13:02:44	Breathing
13:02:45	Breathing
13:02:45	Breathing
13:02:46	14.7 RPM
13:03:01	Movement tracking
13:03:07	Breathing
13:03:14	Movement
13:03:20	Breathing
13:03:27	Breathing
13:03:27	10.25 RPM
13:03:28	Breathing
13:03:28	Breathing
13:03:29	Movement
13:03:38	Breathing
13:03:44	Breathing

6.2 Stone Structure

The design system has been install behind the stone walls and check the detection ability of system as shown by figure 9.

Figure 9. Aliveness detection through Stone structure

By using Stone wall as discussed in the figure 9 various results are collected in Table 3. The Hardware Result shows that the breathing was detected at 13:10:50 pm, 13:10:51 pm, and 13:10:52 pm. The first rpm was detected at 13:10:53 pm which was 11.6 rpm. Then the system starts movement detecting at 13:11:2 pm, breathing detection at 13:11:8 pm, and at 13:11:15 pm. 2nd rpm 21.5 was detected at 13:11:16 pm. Then the system again starts movement detection at 13:11:17 pm, and movement tracking at 13:11:26 pm. Breathing detections at 13:11:34 pm, and 13:11:41 pm.

Table 3. Aliveness detection through Stone Material

Time	**Aliveness feature Detection**
13:10:50	Breathing
13:10:50	Breathing
13:10:51	Breathing
13:10:52	Breathing
13:10:53	11.6 RPM
13:11:02	Movement
13:11:08	Breathing
13:11:15	Breathing
13:11:16	21.5 RPM
13:11:17	Movement
13:11:26	Movement tracking
13:11:34	Breathing
13:11:41	Breathing

6.3 Bricks Structure

Another practical scenarios of the system was the bricks material as shown in figure 10. The system successfully detect the survival movement, breathing and RPM under-surface of bricks material.

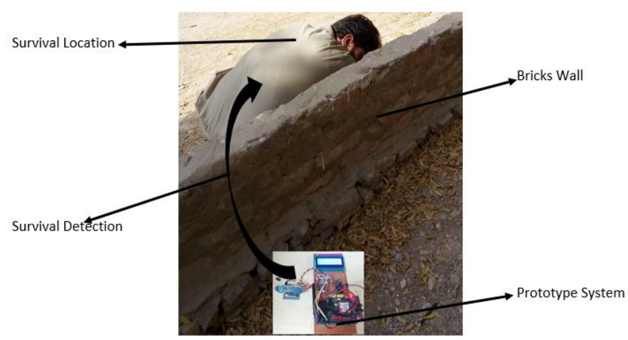

Figure 10. Aliveness detection through brick

Table 4 shows the breathing was detected at 13:7:55 pm, 13:7:56 pm, and 13:7:57 pm. The first rpm was detected at 13:7:57 pm which was 11.8 rpm. Then the system starts movement detecting at 13:8:7 pm, breathing detection at 13:8:13 pm, movement at 13:3:20 pm, movement tracking detection at 13:3:28 and breathing detection at 13:8:34 pm respectively. Then the system once again starts movement at 13:8:40 pm and breathing detection at 13:8:48 pm. The second rpm 12.37 at 13:8:50 pm.

Table 4. Aliveness detection through Brick structure

Time	Aliveness feature Detection
13:07:55	Breathing
13:07:56	Breathing
13:07:56	Breathing
13:07:57	11.8 RPM
13:08:07	Movement
13:08:13	Breathing
13:08:20	Movement
13:08:27	Movement
13:08:28	Movement tracking
13:08:34	Breathing
13:08:40	Movement
13:08:48	Breathing
13:08:50	12.37 RPM

6.4 Blocks Structure

The blocks wall testing is another testing scenario of design system. Where the hardware system was placed behind the blocks wall and checked the detection ability of system. The acquire results validated the system detection results. Figure 11 depicts the blocks scenario.

Figure 11. Block structure Material System Testing

Block wall used to combine results in Table 5.the breathing was detected at 13:5:25 pm, 13:5:26 pm, and 13:2:45 pm. The first rpm was detected at 13:5:26 pm which was 15.1 rpm. Then the system starts breathing detecting at 13:5:37 pm, at 13:5:36 pm, and at 13:5:39 pm respectively. 2nd rpm 15.7 was detected at 13:3:39 pm. Then the system again starts movement detection at 13:6:57 pm and Breathing detection at 13:7:4 pm. The last movement was detected at 13:7:10 pm by the system.

Table 5. Aliveness detection through Block Material

Time	Aliveness feature Detection
13:05:25	Breathing
13:05:26	Breathing
13:05:26	Breathing
13:05:26	RPM 15.1
13:05:37	Breathing
13:05:37	Breathing
13:05:38	Breathing
13:05:38	Breathing
13:05:39	Breathing
13:05:39	RPM 15.7
13:06:57	Movement
13:07:04	Breathing
13:07:10	Movement

6.5 Wooden Structure.

The system detection abilities has been tested through wood materials against the movement tracking, RPM and breathing detection. Figure 12 shows system testing scenario on wood door material.

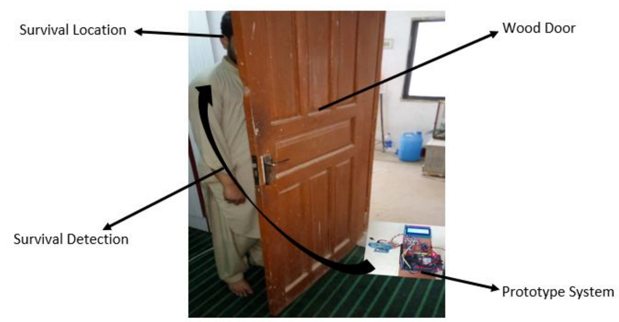

Figure 12. Aliveness detection through Brick structure

The table 6 shows result of the movement was detected at 13:26:39 pm, breathing detection at 13:26:40 pm, and the first rpm was detected at 13:26:41 pm which was 12.8 RPM. Then the system starts movement tracking at 13:26:50 pm, breathing detection at 13:26:57 pm, movement tracking at 13:27:3 pm, movement at 13:27:12 breathing detection at 13:27:31, movement at 13:27:50 pm and breathing detection at 13:27:57 pm respectively. 2nd 12.51 RPM was detected at 13:28:1 pm. Then the system again starts breathing detection at 13:28:3 pm, and at 13:28:4 pm.

Table 6. Aliveness detection through Wooden Structure

Time	Aliveness feature Detection
13:26:39	Movement
13:26:40	Breathing detected
13:26:41	12.8 RPM
13:26:50	Movement tracking
13:26:57	Breathing detected
13:27:03	Movement tracking
13:27:12	Movement
13:27:24	Movement tracking
13:27:31	Breathing detected
13:27:37	Movement tracking
13:27:44	Breathing detected
13:27:50	Movement
13:27:57	Breathing detected
13:28:01	21.51 RPM
13:28:03	Breathing detected
13:28:04	Breathing detected

6.6 Plywood Structure

Plywood door material testing is another practical experiment of design system to validate the system performances. The figure 13 shows testing plywood testing scenario.

Figure 13.Aliveness detection through Plywood structure

Table 7. Hardware Result shows taken from the Plywood material as shown in 6 figure 13 that the Movement was detected at 13:30:8 pm, and breathing at 13:30:9 pm. The first RPM was detected at 13:30:12 pm which was 12.5 RPM. Then the system starts breathing detections at 13:30:15, 13:30:17 pm, 13:30:20 pm, 13:30:23 pm, 13:30:25pm, 13:30:26 pm, and at 13:30:29 pm respectively. 2nd RPM 11.6 was detected at 13:30:32 pm. Then the system again starts movement tracking detection at 13:30:34 pm, and movement detection at 13:30:40 pm, 13:30:53 and at 13:31:6 pm separately and Breathing detections at 13:31:19 pm.

Table 7. Aliveness detection through Plywood Material

Time	Aliveness feature Detection
13:30:08	Movement detected
13:30:09	Breathing detected
13:30:12	12.5 RPM
13:30:15	Breathing detected
13:30:17	Breathing detected
13:30:20	Breathing detected
13:30:23	Breathing detected
13:30:25	Breathing detected
13:30:26	Breathing detected
13:30:29	Breathing detected
13:30:32	11.6 RPM
13:30:34	Movement tracking
13:30:40	Movement
13:30:53	Movement
13:31:06	Movement
13:31:19	Breathing detected

6.7 Glass Structure

Glass material testing was another scenario for hardware prototype system. The system successfully detect the movement, breathing and RPM of survival undersurface of glass material. Figure 14 refer the testing scenario of glass material.

Figure 14. Aliveness detection behind glass structure

In the Table 8 Result taken from Glass material shown in figure 14 that the breathing was detected at 15:35:0 pm and 15:35:5 pm. The first rpm was detected at 15:2:46 pm which was 8.8 rpm. Then the system starts breathing detection at 15:35:11 pm, movement detection at 15:35:12 pm, and breathing detection at 15:35:19 pm respectively. 2nd rpm 28.0 was detected at 13:3:27 pm. Then the system again starts movement detection at 15:35:25 pm, and breathing detections at 15:35:26 pm, 15:35:27 pm, and 15:35:28 pm respectively. 3rd rpm 11.58 was detected at 15:35:29 pm. Then the system again process and Breathing tracking detections at 15:35:30 pm, 15:35:31 pm and 15:35:32 pm were noted.

Table 8. Aliveness detection through Glass Material

Time	Aliveness feature Detection
15:35:00	Breathing
15:35:05	Breathing
15:35:08	RPM 8.8
15:35:11	Breathing
15:35:12	Movement
15:35:19	Breathing
15:35:23	RPM 28.0
15:35:25	Movement
15:35:26	Breathing
15:35:27	Breathing
15:35:28	Breathing
15:35:29	RPM 11.58
15:35:30	Breathing tracking
15:35:31	Breathing tracking
15:35:32	Breathing tracking

6.8 Paper Bundles

Paper bundles testing scenario was carried out as shown by figure 15 the system is able to detect the survivals behind the paper materials.

Figure 15. Aliveness detection under paper bundle

The Paper bundle box as shown in figure 15 were used to extract results in the Table 9. It shows Hardware Result that the breathing was detected at 19:4:54 pm and the first rpm was detected at 19:4:57 pm which was 9.3 RPM. Then the system starts breathing detection at 19:5:3 pm, 19:5:4 pm and at 19:5:5 pm respectively. 2nd RPM 13.2 was detected at 19:5:9 pm. Then the system again starts breathing detection at 19:5:12 pm, 19:5:16 pm, and at 19:5:17 pm. Then the system again detects the movement detection at 19:5:18 pm, 19:5:30 pm, 19:5:38 and at 19:5:38 pm. Movement tracking was detected at 19:5:41 pm and the breathing detections at 19:5:45 pm.

Table 9. Aliveness detection through Paper Material

Time	Aliveness feature Detection
19:04:54	Breathing detected
19:04:57	RPM 9.3
19:05:03	Breathing detected
19:05:04	Breathing detected
19:05:05	Breathing detected
19:05:06	Breathing detected
19:05:09	RPM 13.2
19:05:12	Breathing detected
19:05:16	Breathing detected
19:05:17	Breathing detected
19:05:18	Movement
19:05:30	Movement
19:05:38	Movement
19:05:39	Movement
19:05:41	Movement tracking
19:05:45	Breathing detected

7. Comparison between Prototype System and Existing ICT Networks For Survival Finding

After all results and their analysis the results of proposed research smart system has been compared between Existing ICT Networks for Survival Finding. The table 10. Shows different features of the proposed advance technologies have been used to track the survivals from any kind of disaster zones. The Integration of multiple technologies makes system capable to detect the, over surface detection, under surface / behind the wall detection, location tracking of survivals, Respiration detection of survivals and movement detection.

Table 10: Comparison between Existing ICT Networks for Survival Finding and developed System

Systems	Integration with Multiple Networks	Over surface Detection	Under surface Detection	Location Tracking of survivals	Respiration Detection of survivals Under surface	Movement Detection of survivals Under surface	GSM based Alerts
Proposed System	√	√	√	×	√	√	√
GIS	√	√	×	√	×	×	×
WAN	√	×	×	×	×	×	×
Social Networks	√	×	×	×	×	×	×
Multi-WSN	√	√	√	√	×	√	×
HAP	√	√	×	√	×	×	×
FANET	√	√	×	√	×	×	×
UAV	√	√	×	√	×	×	×
Drones	√	√	×	√	×	×	×

8. CONCLUSION

In this research, an IOT based smart system has been designed, tested and implemented to detect the disaster survivals in different circumstances. The prototype system has capability to detect the survivals movement, movement tracking, breath detection and identify the respiration patterns. The system is integrated with different sensing devices such as aliveness detecting sensors, respiration and GSM communication module. The prototype system is used to locate and identify the human bodies from upper and under surface of disaster zones. Once the infrastructure is established, it can be used for efficient disaster management other than the earthquakes. The IOT based smart system is wireless communication network which has an important role to restore communication in earthquake zone after the earthquake disaster. Moreover, an efficient and reliable resilient network can be established by using the available wireless technologies such as Drones, UAV (Un-armed vehicle), MAV (Move-able Vehicle), MANET (Mobile ad hoc Networks), FANET (Flying ad hoc Networks), HAP (High amplitude Platform) and GIS (Geographic Information Services) to accomplish the future requirements. The networks can be linked together with broadband services which will be activated just after earthquake occurrence and create a communication links with earthquake survivals.

In this paper, an IOT based Smart system for earthquake zones has been introduced. To implement IOT based smart system. The proposed system has been used to detect the under-surface alive survivals through aliveness sensing techniques and the earthquake survivals can also be detected through their movements, breathing and respiration patterns. Moreover, the system collects the information from disaster zone and sent that information among the system components such as responders' cell phones, base-station unit and relevant quick disaster management response cell. In addition, the designed system performance has been evaluated through different environments such as proteus simulation, laboratory based and open air based environments.

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