Experimental evaluation of a system for human life detection under debris

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Experimental evaluation of a system for human life detection under debris

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Abstract. It is difficult to for the human beings to be found under debris or behind the walls in case of military applications. Due to which several rescue techniques such as robotic systems, optical devices, and acoustic devices were used. But if victim was unconscious then these rescue system failed. We conducted an experimental analysis on whether the microwaves could detect heart beat and breathing signals of human beings trapped under collapsed debris. For our analysis we used RADAR based on by Doppler shift effect. We calculated the minimum speed that the RADAR could detect. We checked the frequency variation by placing the RADAR at a fixed position and placing the object in motion at different distances. We checked the frequency variation by using objects of different materials as debris behind which the motion was made. The graphs of different analysis were plotted.

1. Introduction

Different ways to detect the human being under the debris are optical devices and acoustic life detectors or rescue robot. The optical devices require expert operators and cannot be used in inaccessible area. The Rescue Robot can search deep into the debris by the use of temperature sensor but they are unable to trap once they go out of range. Acoustical detectors such as geophones are easy to use but need quiet working environments, which is impossible in critical situations. Information about the location of buried person would help to reduce the time of operation also help to save more lives. Hence we need a life detection system which can detect buried victims most efficiently and in less time. These problems could be efficiently solved by using RADAR. In rescue mission and also in some surveillance operations we need to detect life signals also the identify people in a given area. This can be achieved with through the wall surveillance techniques. Detection of human targets and identification of their movements through building is also important in military and security application. Militants are encountered with unknown enemy threats from behind different types of walls or trees. Selection of the frequency of operation depends on the application. Radar can operate at large distances from potential targets and works both during the day and night. It can also function in all-weather conditions. It can distinguish fixed as well as moving target types. Microwaves can be reflected by conducting materials. Received Signal Strength (RSS) is the voltage measured due to the Doppler shift[1-2].

2. Principle

Basic principle of Doppler Effect is that a shift in frequency received by a receiver from a signal source due to relative movement of the source and/or receiver is noted. Doppler theory is used by radar for detection of human beings under debris. We also considered the microwave beam penetration and Doppler shift effect for our analysis. If a human being is alive under debris it will have its own vibration, which will cause a phase change in the incident microwave beam according to Doppler's effect. So, the backscattered microwave beam will have a phase change if there is a presence of human victim alive. The magnitude (μV) of the Doppler Shift is proportional to the reflection of transmitted energy. A high gain low frequency amplifier is usually connected to the IF terminal for amplification. Frequency of Doppler shift is proportional to velocity of motion. A Doppler shift below l00 Hz is generated by humans while walking [3].

$$F_D = 2V (F_T/c) \cos \theta \quad (1)$$

Where
F_D - Doppler frequency, V - Velocity of the target,
F_T - Transmit frequency, c - Speed of light
θ - Angle between the target moving direction and the axis of the module.

3. Materials and methods

3.1. Hardware System
In our experiments a short range Radar which detects motion through Doppler principle is been implemented. It transmits a 10 GHz microwave electromagnetic signal and monitors the shift in frequency signal based on the reflected signal[4].

Features
- Works at 5V power
- Analog output data in range of 0-5V
- Reliable and Continuous output
- Motion Sensing
- Transmits frequency at lo GHz

A digital oscilloscope and a variable DC power supply was used.

An Arduino microcontroller board based on the ATmega328 is used in this work. It has a power jack, l4 digital input/output pin, 6 analog inputs, an ICSP header a l6 MHz crystal oscillator, a USB connection, and a reset button. For display of the reading we used the serial monitor with a baud rate of 9600bps.

4. Block diagram and methodology
We conducted different analysis using the X-Band Radar in order to know its characteristics and to find if it could be used for our application. For the first 5 analysis we used a power supply of 5V

4.1. Analysis 1
We noted the different variations in the output on the CRO for a moving object (random speed) and a stationary random object, when placed at Line of sight (LOS) of the radar.

4.2. Analysis 2
We placed a wooden object at Line of Sight of the Radar. The object was moved to different distances per ft in line of sight up to l0 ft. We noted the frequency shift readings on the CRO per l feet. Next with the same conditions using a DC motor fan as the object at RPM.

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4.3. Analysis 3
We placed a wooden object at Line of Sight of the Radar and a DC motor of 524 RPM behind the object. The object was moved to different distances per feet up to l0 feet and at different angles. We noted the frequency shift readings on the CRO per l feet for different angles

4.4. Analysis 4
We conducted a speed measurement (RPM) analysis of an object using IR detector and then placed it at Line of sight of Radar at lft and noted the frequency shift readings. We used DC motor and PC fan as object.

4.5. Analysis 5
We placed objects of different materials (Wood, Concrete, and Metal) at Line of Sight of the Radar and placed the DC motor behind the object. We noted the readings (frequency shift) for different objects.

4.6. Analysis 6
We interfaced the Radar to the Arduino board and observed the readings (frequency shift) on the serial monitor for a moving object and a stationary object[5].

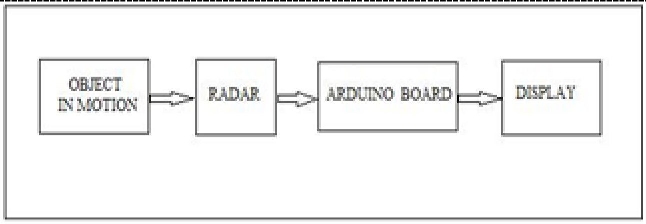

Figure 1. Block diagram of the experimental setup

5. Results and discussions

5.1. Analysis 1

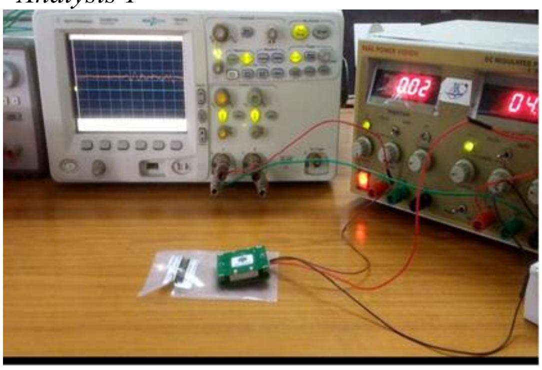

Figure 2.a No moving object in front of the sensor

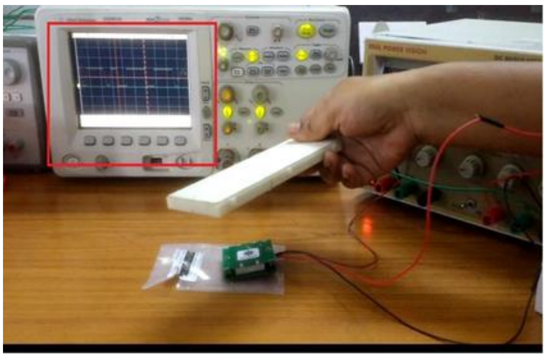

Figure 2.b With a moving object in front of the sensor

5.2. Analysis 2

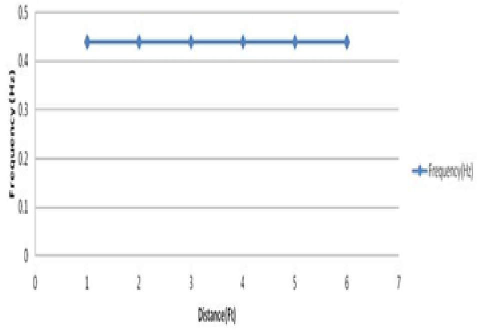

Figure 3.a Stationary object at different distances

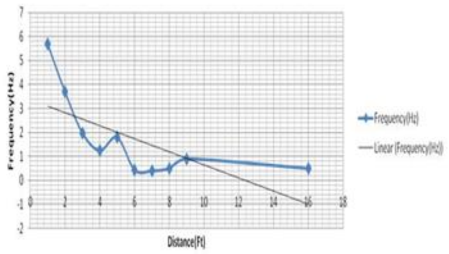

Figure 3.b Moving object at different distances

5.3. Analysis 3

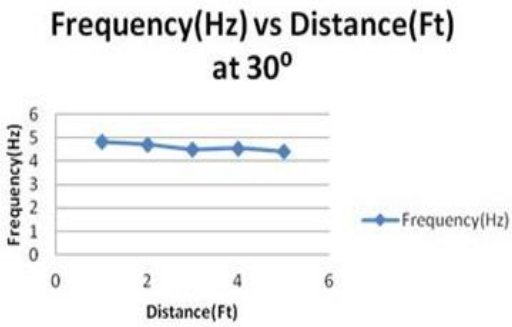

Figure 4.a Frequency Vs Distance at 30 ^{o}

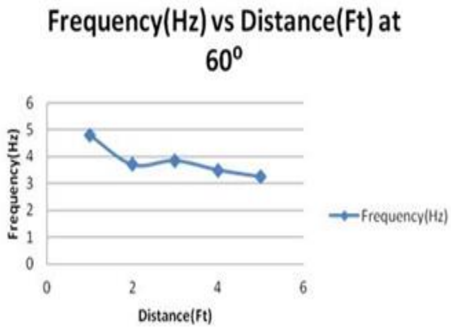

Figure 4.b Frequency Vs Distance at 60 ^{o}

5.4. Analysis 4

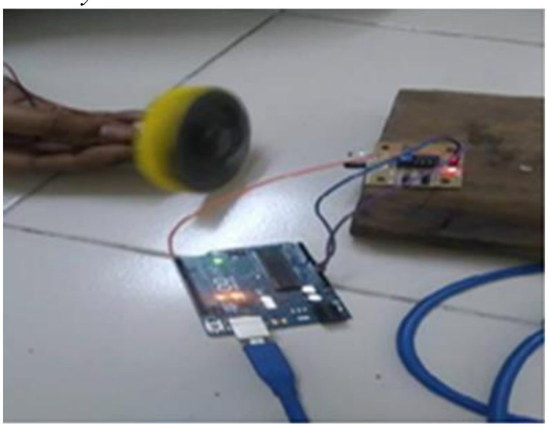

Figure 5.a With IR source

Figure 5.b Fan(RPM=360)

5.5. Analysis 5

Figure 6.a With metal object

Figure 6.b With concrete object

Figure 7.a With wooden object

Figure 7.b With DC fan behind wooden object

Table 1. Observations with PC fan

Object PC-Fan , Fan Speed 350 rpm				
Freq(Hz) / Distance(ft)	Without Obstacle	With wood	With Metal	Debris
0.5	6.00	5.55	5.20	5.01
1	3.77	3.20	2.55	1.78
2	1.47	1.50	1.29	1.09
3	No detection			

Table 2. Observations with DC motor

Object : DC Motor rotating wheel		
Freq(Hz) / Distance(ft)	Without Obstacle	With wood
1	9.37	8
3	3.4	3.2
5	2.9	2.5
10	1	0.7

Table 3. Observations with DC motor rotating wheels

Object PC-Fan , Fan Speed 350 rpm				
Freq(Hz) / Distance(ft)	Without Obstacle	With wood	With Metal	Debris
1	9.37	8.00	5.20	5.01
3	3.40	3.20	2.95	1.78
5	2.90	2.50	2.29	1.09
10	1.00	0.70	0.61	0

5.6. Analysis 6

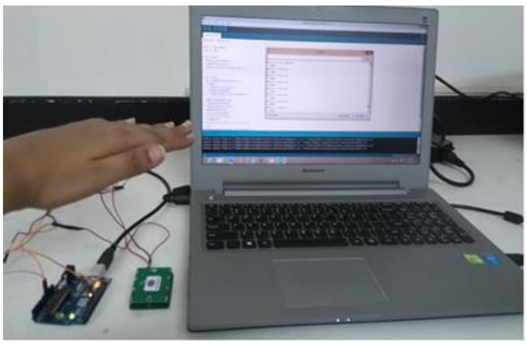

Figure 8.a Interfacing Radar with Arduino board with random moving object

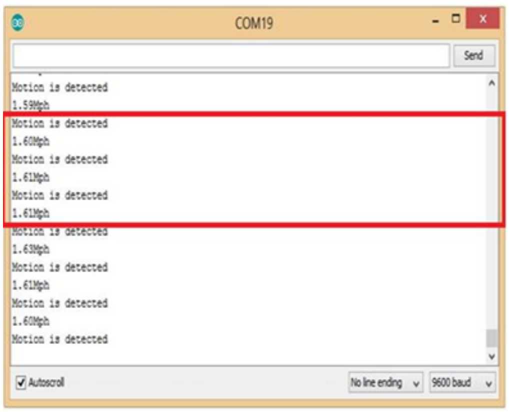

Figure 8.b Terminal window showing the object motion detected

6. Conclusions

From the various analyses we could conclude the following: We proved a property that radar can distinguish fixed as well as moving target types. We could find the range of radar in real time application. Also the variation of frequency shift with distances [6,7]. We could find the beam spread. Also the human being under debris need not be in the line of sight of the device though the maximum frequency shift was at Line of Sight. Considering the real time scenarios we found the minimum RPM that could be detected is 300 rpm. We found that the frequency shift is maximum when the material of debris is wood and the minimum for concrete which implies penetration of microwave is maximum when material is wood. In order to make the system simple and cost effective we tried interfacing Radar with Arduino and wrote a code for finding the frequency shift due to the motion of the object.

7. Future Scope

L-Band radar with better penetration characteristic could be used. Characteristic of radars under water could be studied and compared. An alert system with the coordinates of the location of the human being could be implemented.

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