Indoor Fashion Navigation System for RADAR

Nazrin Jahan .N[#1]

Dept. of Electronics and Communication Engineering, Anna University,
Udaya School of Engineering, Vellamodi, South India

[1]nirzan38@gmail.com

***Abstract*—** Patients in bed should be monitored continuously. Because of their tiredness and ill health, they may fall down or may be injured severely by dashing on the walls etc. So a dedicated nurse should watch them day and night. Innovative technology approaches have been increasingly investigated aiming at human-being long-term monitoring. In this project, a complete system for contactless health-monitoring in home environment is presented. It used a Radar technique to monitor the patient. The radar system consists of an IR transducer pair. The signal from the radar will be changed according to the position of the patient. If there is any deviation from normal position, the signal will be different for different actions. According to the signal from the sensors, the software analyses the position of the patient and accordingly the status of the patient. Thus it is very useful to find out the position of the patient without any dedicated nurse inside. Future work is to combine multiple sensors in a wireless sensor network configuration, in order to monitor multiple persons and to increase the accuracy and coverage area, beyond one room.

Index Terms—Fall detection, health monitoring, radar remote sensing, tagless localization.

I. INTRODUCTION

The project mainly focuses on senior citizen population of older than sixty years who are not able to perform any action in case of emergencies has been steadily increasing worldwide. For novel assistive technologies this situation has been resulted in a growing need that enable routine long-term home monitoring [1]. It is used to identify the vital sign monitoring and fall detection of those persons. It may be either a home or hospital environment.

Innovative technology approaches have been increasingly investigated which may be either expensive or health impact or require physical action. So a dedicated nurse should watch them day and night.

Conventional approaches are based on devices attached to the patient's body, involving pressing a button, e.g., worn as a necklace, in emergency situations [2], [3]. However, persons in such situation may already be unconscious or no longer sufficiently reflexive to do so. The ideal solution is therefore a contactless health-monitoring system, avoiding the need for actions by the elderly person. Contactless vital- sign monitoring [4] has mainly focused in the last twenty years. These academic developments are based on radar techniques implemented as a single device sensor, e.g., continuous-wave (CW) Doppler radar [5] or ultra-wideband impulse-radio (UWB- IR) radar [6].

In recent years, health monitoring through remote fall detection has become a primary interest in connection to home environments [7]–[9]. Instances of such investigations are systems based on video cameras [10], floor vibration, and acoustic sensors [11], [12]. Other than privacy concerns, the use of video camera systems have issues related to low light environments, field of view, and image processing, resulting in a success rate of 90% using two cameras [10]. As the result, more than two cameras are required, and it further increases the hardware requirements. Successes in floor vibration are similarly limited due to environmental interference and background noise. Moreover, they are also less effective in detecting cases of "soft" human falls, defined as a fall after the individual collides with an object (e.g., table, chair, or carpet) [11], [12]. Again, this results to place several sensors on the floor thus increasing the cost.

Acoustics sensors should be placed in patients body directly which may cause itching and allergic. Due to the above disadvantages of existing fall-detection technologies, there is a need for further improvement. An approach based on radar techniques has been demonstrated by the authors [13], [14]. The approach is able to detect fall events and to localize a person tagless (without the need for radiofrequency identification (RFID)). First time Uses Radar, Wireless Communication and Data Processing Techniques. This will be very useful to find out the position of the patient without any dedicated nurse inside.

In this work, a full system is proposed enabling indoor, noninvasive fall detection and tagless localization. It combines radar, wireless communications, and data processing techniques. Moreover, it has been designed to satisfy the European and Federal Communications Commission (FCC) UWB spectrum masks, and it can also be potentially connected to medical monitoring personnel to provide a prompt alert in the event of emergencies.

In Section II, the monitoring principle and underlying theory are explained. In Section III, the radar architecture is explained, In section IV, evaluation procedures are discussed and the experimental results are discussed in Section V.

II. OPERATIONAL PRINCIPLE

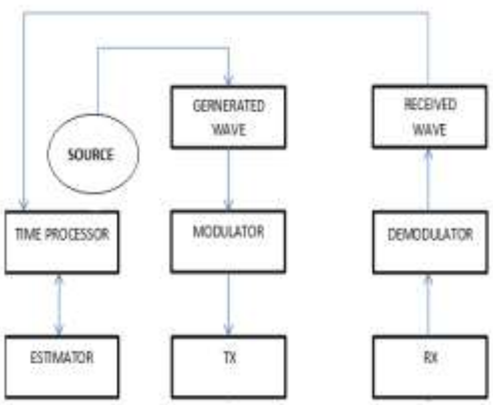


Fig.1. Block diagram of the fashion.

Fig. 1 shows a simplified block diagram of the proposed system. It consists of a modulator, demodulator, generated wave, received signal, time processor, estimator and the source.

Waves are generated from the source and those generated wave generate the high frequency waves and further given to the modulator block. Carrier signal be added with the waves in the modulator block. Then the modulated signal is transmitted through the transmitter.

The receiver receives the modulated signal. Then the modulated signal is given to demodulator block. Demodulator removes the carrier signal and then it receives the original signal

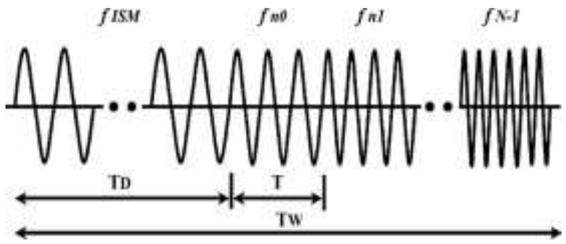


Fig. 2. Designed radar waveform.

Consider CW radar that transmits the following waveform at frequency f_0:

$$S(t) = A \sin(2\pi f_0 t)$$

The received signal from a target at range R is

$$S_r(t) = Ar \sin(2\pi f_0 t - \phi)$$

Doubling the number of receiver filters increases distance performance by about 20%. Maximum distance performance is achieved when receiver filter size is equal to the maximum FM noise riding on the transmit signal. Reducing receiver filter size below average amount of FM transmit noise will not improve range performance. This type of radar was selected due to its relatively waveform, i.e. the signal waveform that the radar transmits and processes in order to calculate the distance.

The step frequency radar utilizes continuous wave sinusoids of different frequencies i.e., during each measurement, a sinusoid of only one frequency is transmitted, received and processed thus greatly simplifying the signal generation, reception and digitization.

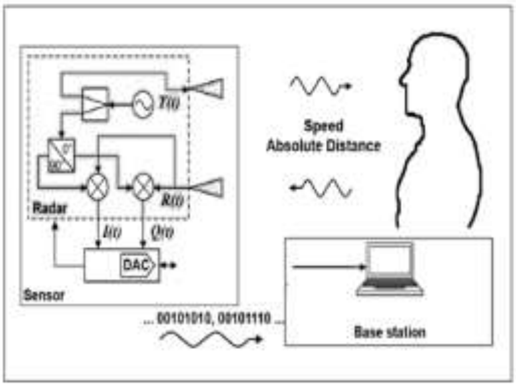


Fig 3: Simplified block diagram of the Health-monitoring system

Fig.3. shows a simplified block diagram of the proposed health monitoring system. It consists of a sensor, combining both radar and wireless communications and a base station for data processing. A radar waveform is generated and sent to the target.

The reflected signal contains speed and absolute distance information which is further collected by the receiver. The resulting signals which we collected in the receiver are digitized and transmitted to a base station (personal computer) by wireless to determine remotely the target's absolute distance and to distinguish a fall event from normal movements. Sensor does not perform data processing in order to avoid complex processor on board and also to reduce costs, size energy consumption. The spectral analysis waveform is explained here followed by wave form design.

A. Spectral Analysis

Initial amplitudes are neglected and the transmitted waveform can be expressed as

$$T_s(t) = \cos[2\pi f_{ISM}t + \phi_{ISM}(t)] \quad (1)$$

for $0 \le t \le T_D$ and

$$T_{SFCW}(t) = \cos[2\pi f_o + n\,\Delta f)t + \phi_n(t)] \quad (2)$$

for $T_D \le t \le 0$, with $o \le n \le N$.

If the waveform is reflected by a target at a distance, the received signal will then be represented as

$$R_s(t) = \cos[2\pi f_{ISM}t\text{-}2D/c + \phi_{ISM}(t\text{-}2D/c)] \quad (3)$$

and

$$R_{SFCW}(t) = \cos[2\pi f_o + n\,\Delta f)(t\text{-}2D/c) + \phi_n(t\text{-}2D/c)] \quad (4)$$

For a quadrature sampling, it is given as

$$e^{-j\varphi i} = I(t) + jQ(t) \quad (5)$$

$$\varphi i = \varphi s = 2\pi f_{ISM}\, 2D/c + \theta_{ISM} + \Delta_{ISM}(t) \quad (6)$$

for a single tone,

$$\varphi i = \varphi n = 2\pi(f_o + n\,\Delta f)2Dn/c + \theta_n + \Delta\phi_n(t) \quad (7)$$

for SFCW signal,

$$\Delta\phi_n(t) = \phi(t) - \phi(t\text{-}2D/c) \quad (8)$$

Only one sample for pulse width has been considered, In the case of a moving target, the range D can be written as

$$D = D_{ISM} + v(t)\,t \quad (9)$$

for $0 \le t \le T_D$ and

$$D_n = D_0 + v(t_n)\,nT \quad (10)$$

for $T_D \le t \le T_w$

Combining the equations to find out the values of φs and φ_n

$$\varphi s = 2\pi f_{ISM}\, 2D_{IMS}/c + 2\pi.\, 2f_{ISM}\, v(t)/c.\ t + \theta_{ISM} \quad (11)$$

$$\varphi_n = 4\,\pi f_0 D_0/c + 2\pi.\ \Delta f/T.2D_0/c.\ nT + 2\pi\, 2v(t_n)f_0/c.\ nT + 2\pi.\ 2v(t_n)n\Delta f/c.\ nT + \theta_n \quad (12)$$

For data processing, the last two equations are essential in the waveform design. The signal is proportional to the target's speed which can be identified from the equation (11) and its sampling rate also dictates. The target's absolute distance is determined in the equation (12).

The equation represents a constant phase shift, rate of frequency change, signal round-trip time, distance information, Doppler frequency shift due to target motion and the interaction of the frequency varying step waveform.

B. Waveform Design

Authors in [15] said that the hybrid approach supports the radar waveform. The signal which we are generating is ISM band alternate with stepped frequency CW (SFCW) waveform working in the UWB band .It contains a single tone and lasts 1 s. The frequency range in the ISM band is 5.8GHz. The waveform consists of frequency and the time measurements. The frequencies of which are increased from pulse to pulse by a fixed increment Δf=50MHz and the total number of coherent pulses are N=80 also called as burst. Each pulse is T=100μs long, resulting in a burst duration N.T of 8 ms and its total band N.Δf is 4 GHz. In order to design waveform, we need certain parameters T,T_D and T_W. The waveform has been designed to monitor continuously the speed of the target and to determine its absolute distance.T_D = 2 s.

The values are defined considering the Nyquist theorem and equations (5) and (11).where frequency f=5.8 GHz. However, a sample rate of 8 ms has been chosen providing a sufficient margin to detect movements of humans with different weights.

C. Data Processing

With the help of MATLAB, the digitized I/Q baseband signals are processed remotely in the base station. The samples are first collected and then split according to processed category separately i.e., whether to find out the speed or the distance.

During a fall or a normal movement there will be a change in the speed. While in fall, in fact the speed continuously increases until the sudden moment when the fall stops abruptly and the Doppler signal experiences a controlled movement in a normal movement. When a person is sitting or moving forward or backward the speed first gradually increases and then decreases to a smooth stop. During a walk, instead, the speed is quite constant over time.

III. RADAR ARCHITECTURE

The electronic principle on which radar operates is very similar to the principle of sound-wave reflection. If we shout in the direction of a sound-reflecting object, we will hear an echo. If we know the speed of sound in air, we can then estimate the distance and general direction of the object.

The time required for an echo to return can be roughly converted to distance if the speed of sound is known. Radar uses electromagnetic energy pulses in much the same way, as shown in Figure 4.

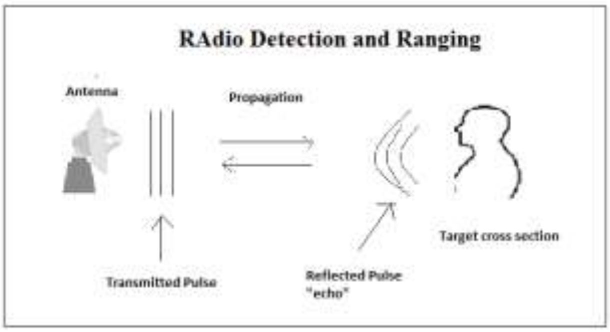


Fig.4. RADAR Principle

The radio-frequency (rf) energy is transmitted to and reflected from the reflecting object. A small portion of the reflected energy returns to the radar set. This returned energy is called an ECHO, just as it is in sound terminology. Radar sets use the echo to determine the speed and distance of the reflecting object. The electromagnetic waves are reflected if they meet an electrically leading surface. If these reflected waves are received again at the place of their origin, then that means an obstacle is in the propagation direction. Electromagnetic energy travels through air at a constant speed, at approximately the speed of light.

The energy normally travels through space in a straight line, and will vary only slightly because of atmospheric and weather conditions. By using of special radar antennas this energy can be focused into a desired direction. Thus the direction of the reflecting objects can be measured.

It refers to electronic equipment that detects the presence of objects by using reflected electromagnetic energy. Under some conditions a radar system can measure the direction, height, distance, course and speed of these objects.

The frequency of electromagnetic energy used for radar is unaffected by darkness and also penetrates fog and clouds. This permits radar systems to determine the position of airplanes, ships, or other obstacles that are invisible to the naked eye because of distance, darkness, or weather.

Modern radar can extract widely more information from a target's echo signal than its range. But the calculating of the range by measuring the delay time is one of its most important functions. The range is just a distance. The radio waves travel at the speed of light is

(v = c = 300,000 km/sec)
range = c•time/2

A. Sensor

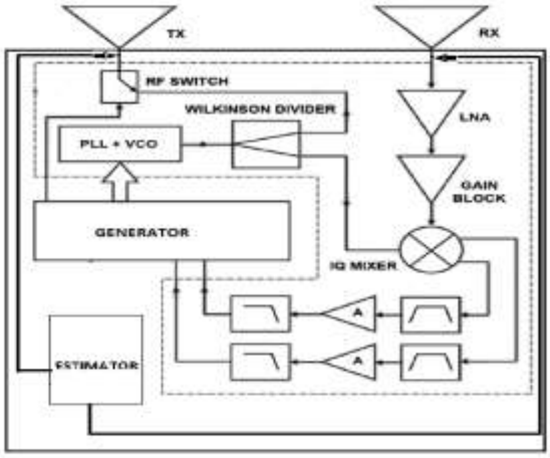


Fig.5. Block diagram of the sensor.

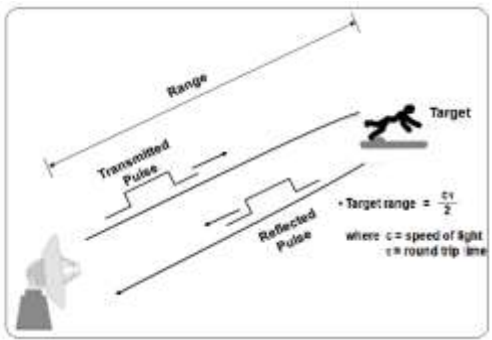
A sensor converts a physical parameter to an electric output. A transducer is a device that converts energy from one form to another an actuator converts an electric signal to a physical output. An electric output from the sensor is normally desirable because of the advantages it gives in further signal processing.

The overall sensor block is shown in fig.5.which consists of radar module, generator and estimator. The two element dual band antennas are combined with this sensor block to reduce the Backscattering and crosstalk effects. To deal with such challenges no off-the-shelf antennas are used. To represent a more compact solution, A wideband circulator with one antenna could be used. . This effect cannot be reduced below a practical value (i.e., 30 dB) in the whole radar bandwidth, as it was possible with the cross talk in the case of two antennas. The radar module contains PLL with a wideband voltage-controlled oscillator (VCO), Wilkinson power divider, an RF switch, a low-noise amplifier (LNA), a gain block, an in-phase and quadrature (IQ) mixer, and baseband filters and amplifiers. The sensor requires approximately 30 µs to generate a new frequency. In which the PLL occupied first 20 µs. VCO take 8 µs to maximum settling time.

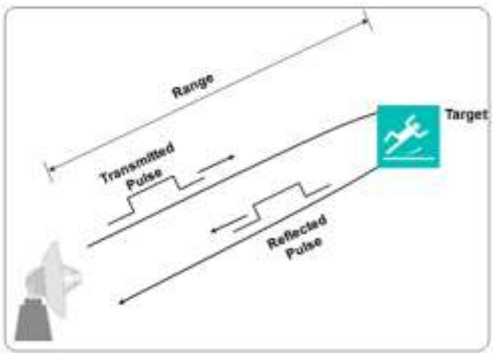
To avoid saturation of the gain block, the combined LNA and gain block is chosen to provide a total gain. The outputs of the mixer are band pass filtered and amplified. The low-pass filter serves both as an antialiasing filter and as a charge reservoir. Immediately after the SFCW waveform, the 5.8-GHz tone is generated. The first I/Q speed samples are acquired after about 2 ms after the acquisition of the last burst samples. This is done to hold the 4-ms speed sampling time as a constant.

IV. EVALUATION

A dedicated home or hospital environment with limited space is provided for the senior citizens. The sensor is placed at a fixed place. It uses a Radar technique to monitor the patient. The radar system consists of an IR transducer pair. The signal from the radar will be changed according to the position of the patient. The patient is sleeping, gets up, walking, running etc; the signal will be different for different actions.



a) Forward Position



b) Backward Position

Fig.6.Patient Position Detection

According to the signal from the radar, the system analyses the position of the patient and accordingly the status of the patient. When the patient falls forward the radar distance value is suddenly decreases from the starting point. So easily find the patient position be forward. It is shown in fig.6a

When the patient falls reverse the radar distance value is suddenly increases from the starting point. So easily find the patient position is backward. It is shown in fig.6b

The patient gets up the radar detects the distance. When the patient fall down suddenly the radar value reach zero. Thus our system detects the fall position.

V. EXPERIMENTAL RESULTS

Experimental results have conducted by generating signals from the source. Only a Simple sensor needed and it is fixed to the wall at a height of 1.5 m for hardware projects. It is an automated monitoring System.

Load the transmitted and received signal using MATLAB functions and compare the signal according to the position of the patient. No RFID is required and there is no contact with human body. When we send one signal it gets reflected and as received signal. Comparing with the positions of the patient along with speed and distance we can identify the position or status of the patients.

VI. CONCLUSION AND FUTURE WORKS

The full system combining radar, wireless communications, and data-processing techniques has been analyzed and described. A radar-based system has been proposed as a new approach for contactless fall detection and tagless localization in an indoor environment.

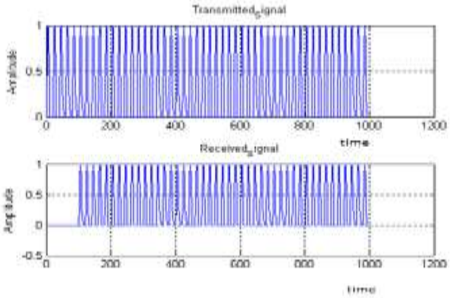


Fig.7a) Input signal generation

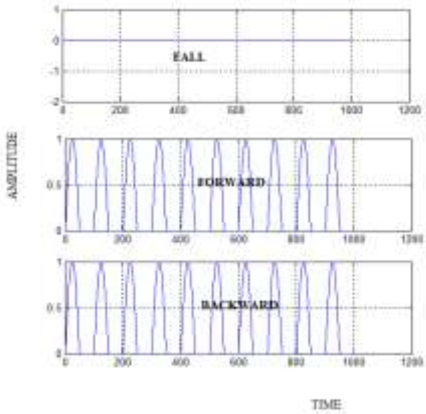


Fig.7b) Output signals

The next step is to mount a sensor on a motor in a wireless sensor network configuration, in order to monitor multiple persons and to increase the accuracy and coverage area, beyond one room.

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