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Simplistic Simulation for Radar Based Life Signal Detection

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***Abstract*: The radar clutter removal and life signal detection is required when natural or manmade calamities occur and there is need to detect the presence of trapped humans trapped in fallen buildings. This paper contributes in simple experimentation strategy which involves clutter removal and life signal detection starting from radar pulses transmitting and receiving simulation. The simulation is carried out and simple processing aspect is given for analyzing and finalizing the requirements of radar experimentation by considering existing techniques available in the field.**

***Keywords* : RADAR, clutter removal, ICA, power spectral density, life signal**

I. INTRODUCTION

Conventional life identification utilizes a solitary sensor. Ultra Wide Band (UWB) life signal electromagnetic recognition is a propelled life discovery innovation, which uses the reflection standard of electromagnetic waves to identify the miniaturized scale movement brought about by human breathing and heartbeat [1]. Infrared video life identification is utilized to distinguish the living body state around evening time or under high clamor, by gathering temperature dissemination of the living body [1]. The feeble acoustic wave recognition is utilized to recognize and distinguish frail sound sign of a living body, which consistently perform helper salvage forever location [1]. Every sensor has its very own points of interest and impediments, and assumes a significant job in the existence location [6].

The radar assessments each range cell in help searching for a target and appraisals the relative speed between the goal and the radar. A brief span later, the result can be appeared on CRT/LCD contraptions. Radar distinguishing proof of a goal against an establishment of bothersome chaos due to echoes from sea wreckage or land is an issue of excitement for the radar fields [1]. The cognizance and showing of radar chaos is the central in various piece of radar system structure and execution evaluation. The theory of radar disclosure in chaos is agreed to the case, which the untidiness is a complex Gaussian methodology.

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The perfect acknowledgment can be fundamentally executed in all instances of practical interest, let be it clear or non-discerning area. Revelation is the most real limit of a radar system. In the wake of transmitting the electromagnetic waveform, the radar gets the reflected sign. To distinguish the goal, it is essential to perceive the sign reflected from the target, from the sign containing just upheaval. Consequent to recognizing the target, it might be moreover decided the range.

The non-meddlesome distinguishing proof limit of radar sensor structures has starting late expanded much thought among experts. This limit prompts many intriguing employments of the microwave identifying structures, for instance, human administrations watching, protect, security, sharp homes, and alive individual chase and rescue. Without having actual touch with the body, Doppler radar based technology can be used to analyze the human tissues and organs to investigate the diseases related to lungs, heart and vascular systems [1]. The vital basic signs distinguishing system was exhibited through Caro et al. in [2]. This technique was used to analyze the infants. The experiments also showed the significance of the distance that is required to analyze the human body and was considered to be minimum 50 cm for safety essentials. Further advancements were done as per suggestion by various researchers to improve such analysis ideas for medical applications.

II. RELATED WORK

Prosperity watching wraps different activities to be explicit clinical examination, screening tests, symptomatic tests, remedial tests, and individual tests. Picture based tests have quite recently landed at the believability of perceiving molecules in a laboratorial circumstance [2] anyway no one will be surprised if later on sicknesses can be recognized, recognized and immaculately depicted reliant on picture based normal equipment. In the meantime, picture gear reliant on the Doppler Effect using ultrasound have been helping prosperity experts in prosperity watching, either in definite yet also for supporting endless human administrations organizations. In a progressing work, The College of Fellows, American Institute for Medical and Biological Engineering (CF-AIMBE) contemplates that two of the six imperative troubles for remedial and natural structure in the 21st are planning altered human administrations and planning answers for harm and relentless diseases [3]. Altered therapeutic administrations is simply possible if appropriate data on each individual is open. This is the objective of electronic prosperity records (EHRs) [4].

The makers have been managing this subject in Portugal and under a Portuguese financed adventure, are working up a phase for EHR filling, amassing, and search and question.

For a serious drawn-out period of time the makers moreover share the point of view on the CF-AIMBE in what concerns the noteworthiness of aiding hurt and the relentlessly wiped out. Recollecting that economics and costs lead to times of internment in medicinal centers continuously shorter, it is critical to make courses of action that grant treatment and checking of prosperity both in versatile and at home, both of the patient's family or in nursing homes.

With no sensor joined to the body, radar can remotely perceive the minor physiological improvements due to heartbeat and breathe [1]. The non-contact acknowledgment of basic signs provoked a couple of potential applications, for instance, rest apnea distinguishing proof [1], physiological checking [1], and seismic tremor rescue [1]. Inferable from entrance of micro waves, the advancement in radar are able to distinguish human activities from other sources of signals [1]. In case when subject's signs of presence disappear, the alarm is activated based on which respective activities will be carried out by the guards located on the gates [1]. Radar can be considered as a perfect technique to identify and diagnose the diseases associated with the organs without having any physical interface with human body from any equipment. The wearable device advancements may degrade the performance and also requires to be wired during leisure time and hence idea is not considerable [1]. Other than the social protection applications, it is also fit for recognizing diverse mechanical improvements in a noncontact way [1], which prompts some rising applications, for instance, inhabitance identifying [1] and sign distinguishing for association of human to machine [1]. As per the structure designing, the family of radar is regularly gathered into the going with classes: constant wave (CW) radar [1], repeat managed steady wave (FMCW) radar [1], and inspiration radar [1]. In light of its broadband nature, inspiration radar isn't sure to the extent structure coordination and low-control action. It isn't taking part in the applications of short run backscattering round trip may affect the system along with delays. The concise range deferment needs a staggeringly quick switch and the broadband drive ought to be gotten by an energetic for power easy to-automated converter (ADC) with incredibly quick [32].

Sungwon Yoo et al [2], have given clutter suppression method useful for IR-UWB radar. The adaptive distance based clutter suppression uses Hilbert transform to detect the envelop signal. Due to envelop detection phase shift of signal is neglected and gives better exploiting capability for each scan. The signal to clutter based performance is evaluated.

Ansari et al [3], have given a method for clutter removal which consist of sequential cancellation algorithm, extensive cancellation algorithm and sequential batch cancellation algorithm. After suppression of clutter CLEAN algorithm is used for target detection. The algorithm development consists of optimization for reduction of complexity while processing the signal.

J. W. Choi et al [4], have given a people counting method using IR-UWB radar. The method consists of pattern based signal analysis with respect to number of people present while scanning the radar signals. The data is collected using variations in number of peoples present while performing the radar transmit and receive signal. The cluster based identification is done for each scan to identify the people count. The machine learning based method uses probability density function based people counting.

E. C. Lee et al [5], have given algorithm based on adaptive thresholding for multiple human detection using IR-UWB radar. The threshold level is adjusted using trial and experiment method in which the number of humans were adjusted while recording the received radar signal. The change in distance of receiver with respect to objective human group and change in number of humans were observed while selecting the threshold levels. The variance estimation or correcting the threshold with respect to humans count and distance of the receiver provides better results.

A. Ghaffar et al [6] have given a method for gesture recognition using IR-UWB radar. For extracting action oriented features HOG method is used along with clutter removal on one dimensional signal data. The extracted features are then used to train support vector machine (SVM). The trained SVM is used to classify and detect the gesture of respective human.

Zhao Li et al [7], have given a method to detect the people trapped under ruins. The dual frequency 270 Mhz and 400 MHz is used for developing UWB radar. The two frequency based scanning is done and signal is recorded. The comparative analysis of two signals helps to remove noise parts and recognize the presence exactly when human is present. The power spectral analysis is done to detect the presence of signal based on presence of respiration signal in received radar signal. The two way detection using two simultaneous signals improves the accuracy.

K. Shyu et al [8], have given a method for detection of heart rate and breathing signal. The method makes use of pseudo bi-dimension ensemble empirical mode to detect the energy in recorded signal. The method is capable of detecting heart rate information and breathing information simultaneously. The pseudo layered structure with 5 layer considerations is capable of estimating the signal levels and thereby accurate heart rate and breathing information.

Z. Liu et al [9] have given application of Hilbert Huang transform for the detection of life signal using UWB radar. The 1GHZ based signal is used to detect the life signal which provides sufficient accuracy during simulation experiments as the life signal being present at 02 to 04 GHz range with 1 to 1.2 Hz frequency range. The simulated data is similar to practical applicability and hence the method is best suitable for practical UWB radar applications for life signal detection along with Hilbert Huang transform for envelop based signal analysis.

Branka Jokanovic et al [10], have given study of fall detector using deep neural network based estimation using radar signals.

The time frequency analysis while estimating fall detectors performance is important and more accurate. The signal processing in particular presentation format have significant impact on the results and hence wavelet based presentation techniques are used for analysis in the work.

Kohei Yamamoto et al [11], have given a method that shows the use of Doppler analysis based radar signal processing for drowsiness detection. The heartbeat and eye blinking is estimated using radar signal processing. The sort time Fourier transform (STFT) based heartbeat signal analysis and band pass filter based blink peaks analysis along with noise suppression are used to estimate diastole and systole of heart and blinks of eyes. The spectrogram based analysis of Doppler shifts in radar receiver shows better accuracy for heartbeat and blink detection when signals are observed by firing them on chest or face respectively.

Luis Ramirez Rivera et al [12], given a method for fall detection suing STFT analysis of radar received signals. The time frequency analysis is used to segment the desired set of frequencies. The feature extraction and fusion method is used to obtain exact differentiating signals from which frequency is estimated for life signal detection. The experimental setup consist of conditions with fall and non-fall cases in which trial and experiment approach is used while fusion and feature analyzing stages.

Qisong Wu et al [13], have given a method of fall detection using radar signals. The feature extraction and fusion is done using spectral analysis method in which exact fall cases are evaluated with respect to experimentation strategies. The SVM classifier is used to identify the fall conditions by extracting suitable features. The results are satisfactory in terms of detection accuracy.

F. R. Morales et al [14], have given a method of measuring thickness of snow cover using radar. The radar frequency chosen is within 2-18 GHz. The differentiating snow-ice interfaces and snow air interfaces patterns are used to analyze the characteristic differences between the two. The respective measurements are applied to check different levels of thickness of snow on ice surfaces. The method provides good results for detection of snow thickness in areas where periodic snow falls happen. The experimentation makes use of feature measurements by scaling the observatory screen which shows layered difference at different interfaces of different mediums.

Xin Liu et al [15], have given a method for m-sequencing the radar signals with the help of multiple antennas. The multiple antenna transmitted and multiple antenna received signal are combined to for a sequential signal using which the movement pattern of the object behind the wall can be observed. The moving human body is used during the experimental setup and analysis. The analysis is also been done by experimentation in which radar is kept outside and near the wall of first room and readings of first second and third room are taken by keeping moving object in each room at a time respectively. The performance evaluation shows the third room which is at longer distance form radar observer, gives almost noisy signals from which identifying the objects is very difficult but as object is near to observer and in room second or first, the received signals contain information from which presence of human objects can be identified.

Byeong Jae Seo et al [16], have given designing strategy of the radar circuitry using single chip and onboard antenna. The frequency considered for the UWB radar design lies within 7-9 GHz. The radar design shows simplistic design approach with better noise immunity and size of antenna is also small making it suitable for portable device manufacturing. The device has sensing range upto 6m and hence can be used during emergency investigations applications with battery operated circuit.

Zhao Li et al [17], have given human detection method using dual frequency IR-UWB radar. The radar operates at two different frequencies such that 270 MHz and 400 MHz frequency are used to transmit the signals. The received two channel signal is then used to process and extract the information. The cross correlation is used to check the presence of the human behind the wall. The Linear trend subtraction method is used to remove the clutter from the signal and then power spectral analysis is performed to extract the heart beat signals. Radar operation using two frequencies improves reliability of detection process.

Terence Jerome Daim et al [18], have given a method of IR-UWB radar based indoor positioning system. The received signal strength, angle of arrival, time of arrival and time difference of arrival parameters are used to estimate the position in 2D space scenarios. The experimentation is done in a room of dimension 50x50x10 size and the results are satisfactory.

Xin Liu et al [19], have given a method of through the wall positioning system using UWB radar. The radar uses the kalmaan filtering method by obtaining signals from two different signals. The Kalmaan filtering based positioning accuracy is obtained. The static clutter removal method is used similar to MTI system. The interference caused to each other in two radar experimental setup is removed by using interferometer principle. The results obtained are satisfactory.

III. PROPOSED WORK

In this paper, we have presented first phase of a life signal detection using UWB radar. The conventional method indicated consists of clutter removal from received signal and life signal extraction. The details of work are presented in Figure 1.

Life signal detection using UWB radar:

Expression for chest movement due to respiration and heart beat:

$$d(t) = d0 + mb\text{Sin}2\pi fbt + mh\text{Sin}2\pi fht \qquad (1)$$

where d0 is the nominal distance of the subject and radar, mb and mh are amplitude multiplying coefficients.

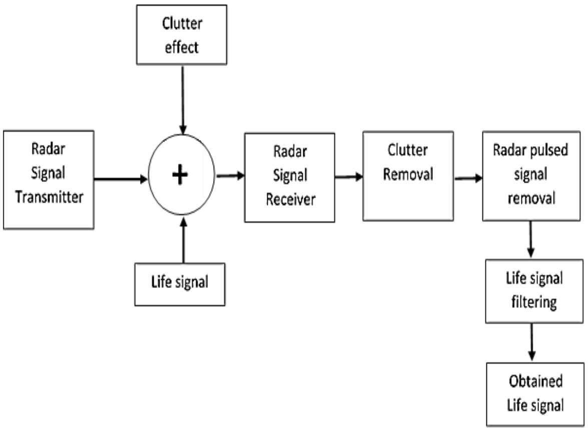

Figure 1: Proposed experimentation system block diagram

The channel impulse response for steady state environment,

$$h(t,\tau) = \sum_{l_0}^{L}\sum_{k_0}^{K} \alpha_{k,l}\delta(\tau - T_l - \tau_{k,l}) + A\delta(\tau - \tau_d(t)) \quad (2)$$

where δ(.) is Dirac-delta function. Tl is delay of lth cluster and r (k,l) is delay of kth multipath component with respect to lth cluster arrival time Tl. r and t are the fast-time and slow-time components which are in the order of nanoseconds and seconds respectively. The right most term in equation (2) indicates the human chest position and its variations with respect to respiration activity.

Now as signal has to travel the distance d twice as a function of time, the delay of the received pulse from the transmitted time,

rd = 2d(t)/c (3)

Where, c is velocity of light.

Hence received signal can be written as,

$$r(\tau) = \sum_{L}\sum_{K} \alpha_{k,l}p(\tau - T_l - \tau_{k,l}) + Ap(\tau - \tau_d(t)) \quad (4)$$

Where, p(r) is transmitted pulse.

Equation (4) represents only impact of respiratory signal and heart beat signal as an addition of term. Here effect of clutter has to be added if Human being is behind the wall.

In a static environment, the clutter map may change with the measurement. Without losing generality, each clutter measurement rie can be modeled by a rescaling factor αi and a shifted bias ci as,

$$r_e^i = \alpha^i r_c + c^i \quad (5)$$

Where, rc represents clutter vector, and ci represents bias vector which is constant. Hence, equation (4) can be updated by adding re from equation (5) for effect of wall clutter.

Therefore,

$$r(\tau) = \sum_{L}\sum_{K} \alpha_{k,l}p(\tau - T_l - \tau_{k,l}) + Ap(\tau - \tau_d(t)) + r_e \quad (6)$$

The clutter from received signals for each pulsed wave can be extracted by subtracting each time received signal from that of transmitted signal and finally taking the average phase shift from the all subtraction obtained answers. This process will lead to separation and identification of clutter signals. The side effect of this method of clutter estimation is removal of intended signal which is human respiration and heart beat signal. Hence there is need to consider the method in which clutter and respiratory along with heartbeat will be separated without affecting each other. Also, here in this case the complete removal of clutter will provide the intended signal which is actually information we need to estimate for human being respiratory and heartbeat related information.

Clutter Removal

Wavelet disintegration is likewise a useful asset for mess concealment from radar got signal. Multi-goals attributes improve the examination for various frequencies. Higher recurrence parts have preferable time goals over recurrence resolution, whereas low recurrence parts give preferable recurrence goals over time. Wavelet partitions signal into set of premise or mother capacities named „wavelets", which features properties of the sign. Here a Daubechies wavelet is consider as mother wavelet. It is ideal appropriate wavelet for removing pertinent development data. Fifth request mother wavelet used to break down every radar return. The blind source separation problem can be solved using ICA. ICA partitions information into factually autonomous segments while different procedures, for example, PCA or FA speaks to information into uncorrelated segments. In this manner, PCA or FA can't separate flag effectively on account of non-associated isn't sufficient. Measurable autonomy is essential which mulls over higher request minutes which are more grounded factual properties than decorrelation. Subsequently, ICA is broadly utilized in numerous applications, for example, include extraction and clamor decrease from the pictures, discovering concealed variables from money related information and for the most part utilized in media communications for isolating the first source signal from meddling sign. In ICA model, it is expected that the watched information X have been created from source information S through a straight procedure X = AS, where both the sources S and blending grid An are obscure. ICA calculations can appraise both the sources S and blending lattice A from the watched information X with not many suppositions

In process of clutter removal using ICA technique, a rectangular matrix Xij is used to represent B-scan data the , having dimensions MxN (i = 1; 2; : : : ;M; j =1; 2; : : : ;N). Here, the time index is denoted by i, and the antenna position index is denoted by j. xi is a linear combination of each sj in ICA processing, given by,

$$x_i = \sum_{j=1}^{N} a_{ij}s_j \quad (7)$$

j = 1; 2; 3; : : : ;N or in the matrix notation.X = AS (8)

Here, the basis transformation or mixing matrix is given by matrix A with dimensions M x N, and for holding the N independent source signals in rows of N samples the matrix is given by S. A full rank separation matrix W can be used to find the ICA of matrix X in which the output signal matrix can be calculated by Y = WX. Finally the approximation of signal from source can be given by

$$y_i = \sum_{j=1}^{N} w_{ij} x_j \quad (9)$$

j = 1; 2; 3; : : : ;N or in the matrix notation where, W is a N x M matrix. The output S is obtained from X which is sensor signal with independence as possible which makes the outputs S from the linear transformation. Formulation of ICA can be done in two steps. Initial one is to plan a differentiation work G(y) that gauges the degree of factual autonomy between the segments of y, other one is the streamlining of complexity work that empowers the computation of autonomous segments. Complexity capacity assesses the degree of factual autonomy between the segments of y i.e., improvement of difference capacity give the free parts. While applying ICA, there is need of preprocessing. The most important preprocessing is process of subtracting each B-examine lattice from lattice X for focusing. The next step of preprocessing is brightening. In this process the new signal X is obtained which is white. i.e., its parts are un-related, and their difference is equivalent to solidarity. Here we have utilized the FASTICA calculation which is fixed point emphasis based calculation to ascertain the isolating framework W by finding a limit of non-Gaussian of WTX: After processing the isolating grid W, blending network A can be registered by taking reverse of it i.e., A = Wi1.

Since blending lattice is known, comparing free segment S grid can be determined utilizing above condition. In the wake of applying ICA on test information, we can get the quantity of free segments as much the quantity of sources or A-filters.

Xtarget = Atarget Starget (10)

Here Xtarget represents the respiratory signal and heart beat signal.

From equation (10) and (4), it should be noted that,

$$X_{target} = Ap\left(\tau - \tau_d(t)\right) \quad (11)$$

Which is expression for received life signal in terms of respiration and heartbeat.

Algorithm:

1. Send pulsed signal using radar transmitter configuration
2. Apply channel characteristics in terms of decay and noise to simulate actual radar scenario
3. Receive pulses
4. Apply ICA to remove clutter
5. Remove radar carrier pulses
6. Perform frequency analysis using power spectral density and apply filter to remove unwanted signal parts.
7. Plot the result with detected life signal

The work discussed in section III is implemented using MATLAB. The simulated results are shown in following figures.

1. Received radar signal

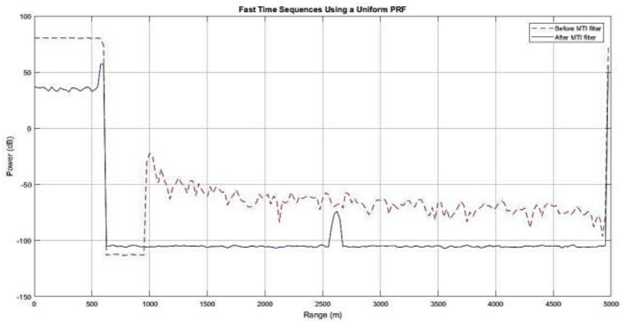

Figure 2: Received radar signal

2. Extracted heartbeat signal

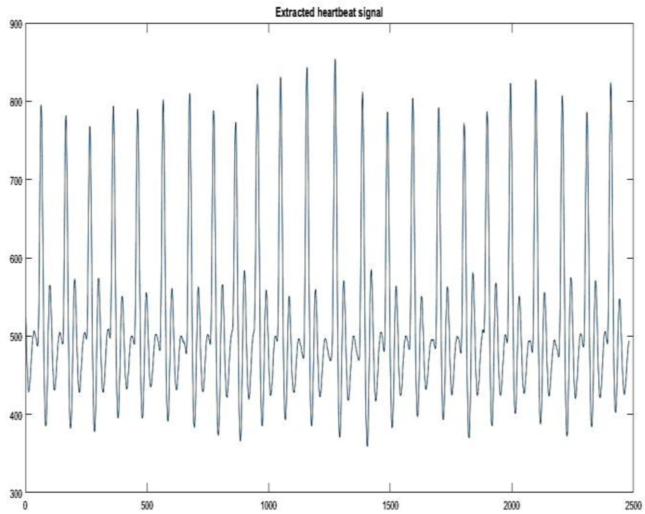

Figure 3: Extracted heartbeat signal

3. Spectral analysis of heartbeat signal

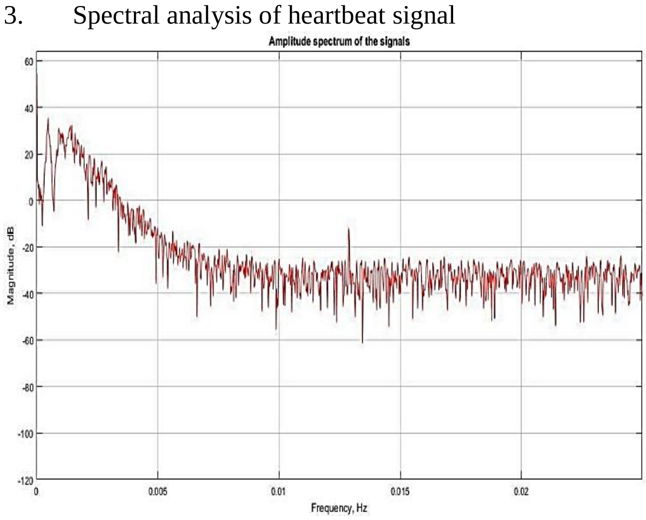

Figure 4: Spectral analysis of heartbeat signal

IV. CONCLUSION

The results obtained in this paper shows better applicability of radar for detection of life signals from behind the wall. In this paper a method is provided for simple experimentation strategy for life detection using UWB radar. The paper forms the platform of signal separation from radar received signals for analyzing the life signals and detection of presence of human behind the wall. The process may become helpful for the researchers in the field working for life detection using radar.

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