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A Survey on Algorithms for Life Detection Behind the Wall or Barrier

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Abstract: In this paper survey of different signal processing algorithms for detection of live human behind the wall or barrier is discussed. For all life detection systems, it is difficult to detect the weak life signals from strong echo waves of background noise. The detection signals due to respiratory movement are always weak so that they are easy to be buried by noise, which will increase detection difficulty and even reduce the detection accuracy. Many clutters and noises of system influence seriously. For proper detection of life signals behind wall or barrier, system performance is most important. The performance of system mainly depends upon signal processing algorithm or technique.

Keywords: Life Detection, Signal Processing, Radar Echo, Clutter.

I. INTRODUCTION

An earthquake or other natural disasters cause loss of many lives every year as humans are trapped under collapsed debris or earthquake rubble. A detection of victims can save their life. Nowadays life detection system known as microwave antenna system can be used to search living objects after earthquake and building collapse, to monitor patients in clinic without contacting the human subjects by detecting the respiratory signals. The life detection based on radar techniques has been attracting more attention these years. The system radiates electromagnetic waves to human subjects and receives echo waves modulated by the body surface jiggle caused by their physiological activities. The life parameters such as respiration and heartbeat can be extracted according to frequency or phase variation of the echo waves by applying proper signal; processing techniques or algorithms [1-4]. In this paper different signal processing techniques are discussed.

II. LITERATURE SURVEY

Amer Nezivorvic et al.[5] proposed a detection algorithm designed for detection of periodic motion caused by respiratory motion of victim for low SNCR condition. This algorithm is based on SVD, filtering, DFT, which separates the respiratory motion response from non-stationary clutter and applies a threshold for decision making process. In this paper authors briefly discussed Respiratory Motion Detection Algorithm for use in UWB radar based trapped victim detection. The flow chart for the developed algorithm is shown in Fig.1.

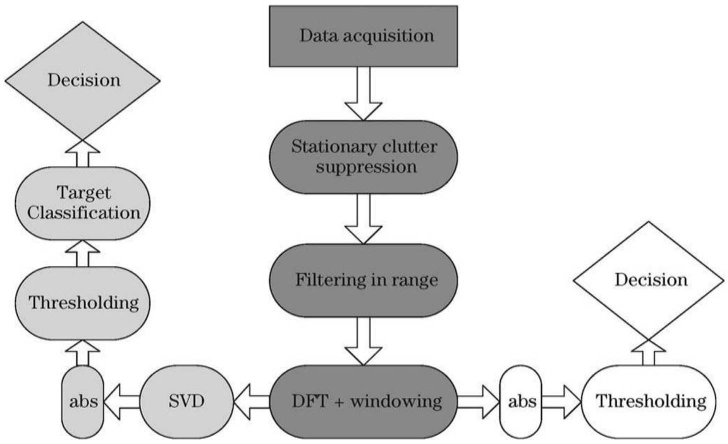

Fig. 1 Flowchart detailing the steps in (center and left side) the developed RMD algorithm and (center and right side) the reference RMD algorithm.

This algorithm separates the respiratory motion response from non-stationary clutter and applies a threshold for decision making process. The performance of this algorithm is assessed both by means of a Monte Carlo simulation as well as on data acquired under realistic conditions using pseudorandom-noise radar. Its performance is compared with

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that of previously reported reference algorithm reference algorithm. The results shows significantly increase in performance of developed algorithm over reference in terms of its de-noising capabilities.

Feng He et al.[6] explained about through the wall life detecting radar prototype. It is a kind of UWB radar using impulse waveform which can penetrate non-metallic wall to detect static and moving targets behind wall. The echo can be expressed as two dimensional function of “fast time” (range dimension) and “slow time” (pulse dimension) d(t,n), where ‘t’ denotes “fast time and ‘n’ denotes “slow time”. The flow chart of signal processing algorithm is shown in Fig.2.

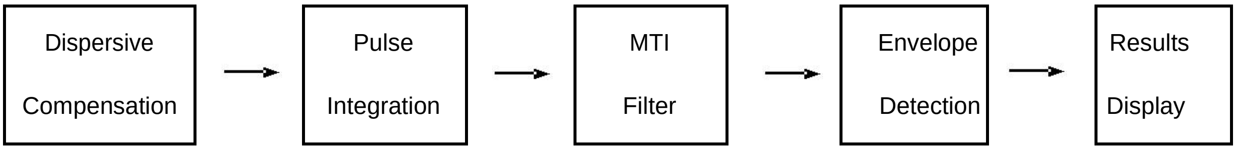

Fig. 2 The flow chart of signal processing.

Due to the large relative bandwidth, antennas are subjected to the dispersive effect, so it is necessary to compensate echoes first. Pulse integrations are carried out to improve the signal to noise ratio (SNR). Here, the data after dispersive compensations and pulse integrations are still denoted as $d(t, n)$. A MTI filter is applied so as to reject responses those are time invariant, such as antenna coupling, impedance mismatch and static clutter. Two methods are used to carry out MTI filter, due to as target is a person who moves micro-motions or macro-motions. One is averaging accumulative background subtraction for micro-motions, and the other is pulse canceller for macro-motions.

If background signal is denoted by $b(t, n)$,

$$b(t, n)= d(t, n)/n + b(t, n-1)\,(n-1)/n \qquad (1)$$

then

$$s(t, n)= d(t, n) - b(t, n) \qquad (2)$$

where $s(t, n)$ is the signal after background subtraction.

The simplest implementation of pulse cancellation method is the two pulse canceller (also known as the first order canceller). Higher order cancellers are more stable with better SNR, but they are less sensitive to target motions. If $z(t$, n) denotes the signal after cancellation, then,

$$Z(t, n) = d(t, n) – d(t, n-1) \qquad (3)$$

After extracting envelope signatures, the results are showed as range-time history, where x-axis is time and y-axis is range. Some preliminary experiments are shown considering barrier is a concrete wall about 30 cm. thick.

Zhang Zhen et al.[7] presented wavelet analysis technique in the signal de-noising of life sign detection as radar echo signal is very weak and hard to extract. It is stated that performance of the system is determined by signal processing technique used. As the Doppler frequency shift of life signal is very weak and traditional Fourier Transform signal processing has poor localization in the time domain, it is difficult to locate the signal. Wavelet transform has good time-frequency localize properties in signal processing and characteristic of multi-resolution analysis ,so it can extract transient information from non-stationary signal effectively and extract required life signal better.Wavelet threshold de-noising method in life signal detection is discussed along with working principle of life detection radar. As the SNR of signal received by life detection radar is very small ,high frequency coefficients generated in wavelet transform, including life signal and noise signal, constitutes high frequency coefficient vector of the signal. The high frequency part in life signal will be removed as noise signal in general threshold selection method. Simulation results of wavelet de-noising method are shown in the Fig.3-6.

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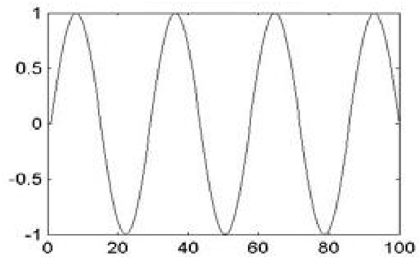

Fig. 3 Heartbeat signal simulation

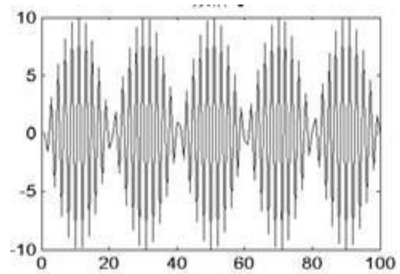

Fig. 4 Background noise simulation

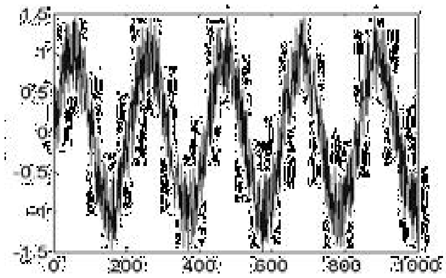

Fig. 5 Heartbeat signal simulation

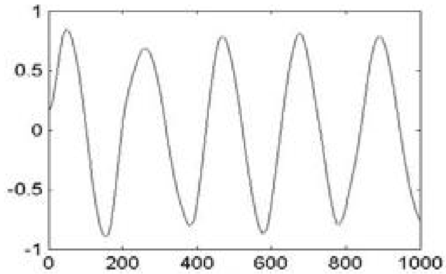

Fig. 6 Heartbeat signal simulation

Jing Li et al.[8] proposed complex environment model of two human subjects trapped in the earthquake ruins and apply Finite Difference time domain method to simulate the model response. Signal processing techniques as correlation analysis and curvelet transform are applied first to decompose background signal, then used singular value decomposition to remove noise in the life signals. Then FFT and ensemble empirical mode decomposition combines with HHT are used to separate and extract breathing signal and heartbeat ,also locate the target's position.

Xiaoyanmg li et al.[9] presented a method for through –wall human detection based on the singular values decomposition of the measurements matrices. The sparsity of the measurement matrix using CLEAN algorithm is demonstrated. The sparse SVD algorithm is used for target detection. Analysis of singular values of matrices constructed by difference square techniques for different types of walls is presented. The results of CLEAN and SVD algorithm for gypsum wall are shown in the Fig.7-8. A variant of the CLEAN algorithm is applied to extract channel impulse response, shown in Fig.7. Sparse SVD result for target detection is shown in Fig.8.

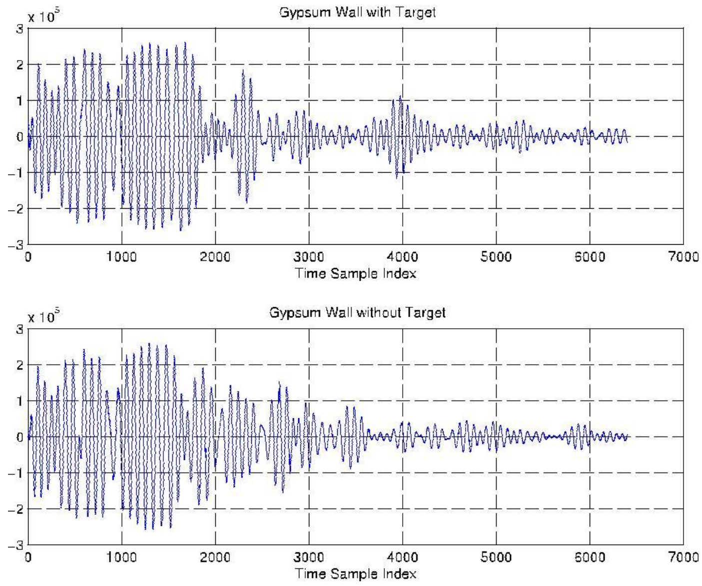

Fig. 7 Single scan for gypsum wall

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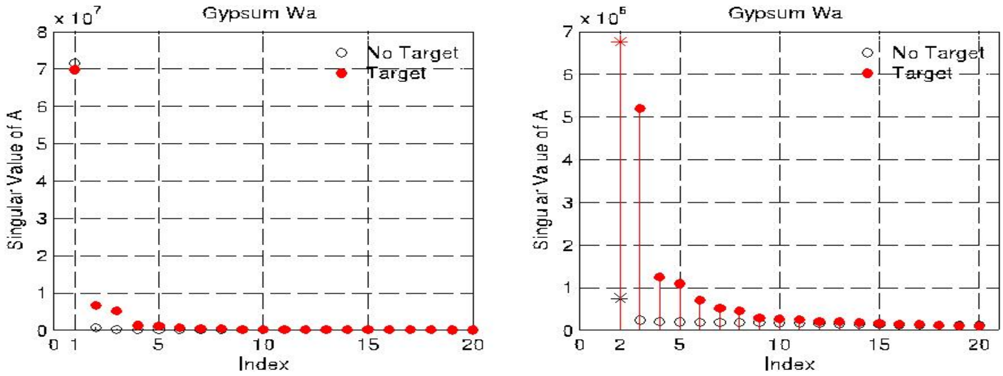

Fig. 8 Singular value of matrix for gypsum wall

Quichi jian et al.[10] proposed development of simple UWB radar system and signal processing algorithms for detecting human breathing and heartbeat. Different signal processing techniques including band-pass filtering, empirical mode decomposition, wavelet packets are used. Experimental setup, flow chart of signal processing for breath detection and heartbeat detection, signal extracted for movement detection are shown in the Fig.9-12.

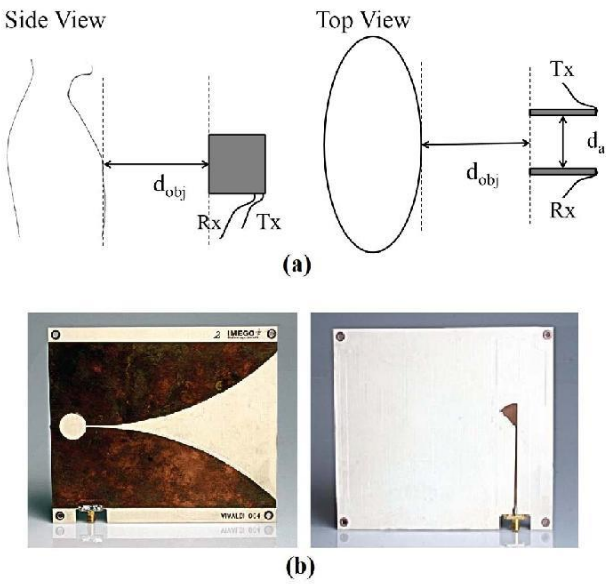

Fig. 9 Experimental setup of breath detection (upper) and the Vivaldi antenna (lower).

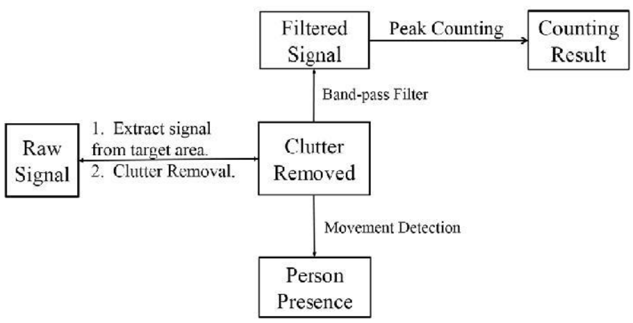

Fig. 10 Signal processing procedure diagram for breath detection.

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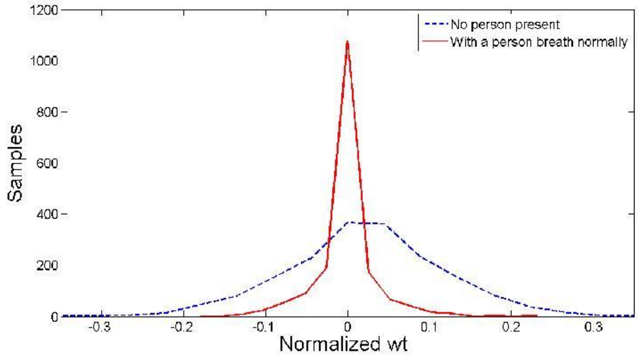

Fig. 11 Signal extracted for movement detection.

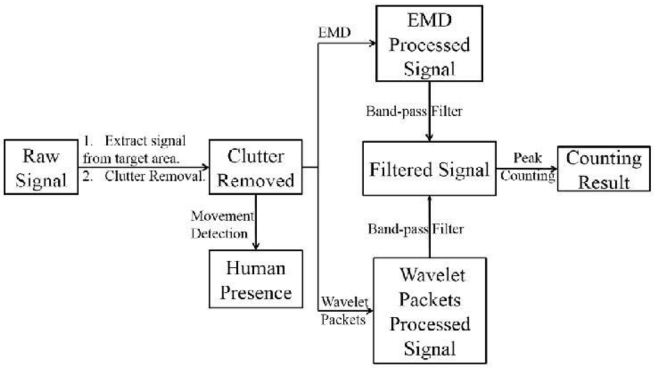

Fig. 12 Signal processing procedure diagram for heartbeat detection

It is stated that by combining different signal processing methods the system can achieve effective measurement both off line and in real time with less power and smaller antennas. Still higher SNR and better resolution could be achieved.

III. CONCLUSION

For detection of live human behind the wall various algorithms are reported in this paper. Still for proper detection of life signals such as heartbeat and breathing and for better resolution a novel signal processing algorithm is to be proposed.

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