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E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

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HIGH PRECISION DIGITIZATION OF PAPER-BASED ECG RECORDS A STEP TOWARD MACHINE LEARNING

Dr.T. Santhosh kumar[1]

B. Pruthviraj[2], **B. Shalini Sumathi**[3], **G. Praneeth Kumar**[4], **J. Sai Kumar**[5]

ABSTRACT:

The advancement of vital sign radar technology has proven to be a useful tool in assessing various physiological dynamics including heartbeat and respiration. There remains several signal processing challenges in this field, which include overcoming the nonlinearities and harmonics that populate the power spectrum. Respiration harmonics distort and overwhelm the measurement of heartbeat due to the large signal amplitude. A supervised machine learning algorithm, the gamma filter, offers an efficient, calibration-free solution to model the time series heartbeat signal given respiration and respiration artifacts. The measured signal is provided by a 5.8-GHz quadrature Doppler radar and a modified ECG signal is used as the ground truth for training the filter. Experimental results show that the heartbeat is independent and separable from respiration and the algorithm can be implemented in real time.

KEYWORDS—Doppler radar vital signs detection, heart rate (HR), noncontact continuous wave (CW), machine learning

INTRODUCTION

Heart rate monitoring devices are becoming increasing popular and more readily available. Yet, most of the devices on the market require continual interaction in order to collect a reading. Namely, the photoplethysmogram (PPG) and the electrocardiogram (ECG) are two of the most popular devices that measure heart activity derived from light and electric potential respectively. However, there are several disadvantages to a contact-restricted device. Accuracy may be degraded due to surface loading effects and the subject is more likely to alter their vital signs knowing their vital signs are being recorded [1]. In contrast, the quadrature Doppler radar is a device that can provide non-contact vital sign detection. For physiological monitoring, Doppler radar has been studied since the 1970s [2]–[7] and remote detection of vital signs has a wide range of utility including searching for survivors in disaster situations, sleeping infant monitoring [8], and detecting breathing abnormalities [1]. Among these various applications of Doppler radar, healthcare draws a significant amount of attention [9]. The principle of detecting motion from a reflected radar signal relies on the

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1. **Assistant Professor, Department of Electronics and Communication Engineering, CMR Institute of Technology, Medchal, Hyderabad.**
2. **Bachelor's Student, Department of Electronics and Communication Engineering, CMR Institute of Technology, Medchal, Hyderabad.**
3. **Bachelor's Student, Department of Electronics and Communication Engineering, CMR Institute of Technology, Medchal, Hyderabad.**
4. **Bachelor's Student, Department of Electronics and Communication Engineering, CMR Institute of Technology, Medchal, Hyderabad.**
5. **Bachelor's Student, Department of Electronics and Communication Engineering, CMR Institute of Technology, Medchal, Hyderabad**

difference in phase between the transmitted signal and the received signal. Tiny physiological movements induced by breathing and heartbeat can be recovered without any sensor attached to the body [1]. The periodic motion of the chest cavity modulates the phase of the incoming signal and is then demodulated to recover the vital signs. This technology has the advantage of neither confining nor inhibiting the target, as other contact-based technologies do. A significant challenge of using Doppler radar to measure heart rate is removing the respiration component. The respiration harmonics, due to the Doppler radar phase modulation and Complex Signal Demodulation (CSD), naturally degrade the accuracy of heart rate detection [10] and must be accounted for when deriving a proper detection method. A number of papers [10]–[15] rely on spectral analysis and various filters to obtain the heart rate. Frequency domain filters require a discrete amount of information to be captured even before vital sign estimation is possible. Windowing functions and overlapping windows like the Short Time Fourier Transform (STFT) and the Continuous Wavelet Transform (CWT) attempt to capture frequency dynamics but are limited in terms of capturing precise time-varying frequencies. These techniques are impractical for the clinical setting, especially for complex physiological analysis. In recent years, there have been several breakthroughs in a new subfield of RF and millimeter-wave radar that apply machine learning architectures to radar including millimeterwave gesture sensing radar [16], Ultra Wide Band (UWB) sleep apnea screening [17], and human activity classification [18]. In these bodies of work, the results highlight radar as a viable technology for many new sensing applications, and show that the combination of radar hardware design and signal processing can yield promising results. Namely, Google's Soli [16], was able to track gestures with up to 92.10% accuracy for 1000 test gestures. This system had sub-millimeter accuracy running 10,000 frames per second on embedded hardware. Ref. [17] achieved an apnea detection accuracy of around 70% by collecting 25 hours of data across 4 subjects as they slept throughout the night. Statistical features of the raw data and a Linear Discriminant classifier was trained for these tests. Finally, Y. Kim and Y. Li [18] exploited the transmission and reflection coefficients found from on-body antennas yielding 98.8% and 97.1% accuracy respectively. A Deep Convolutional Neural Network (DCNN) operated on a spectrogram of the data that exhibited unique time-varying characteristics for different body motion activities. This paper now introduces a machine learning approach to uncover a heart rate waveform using a Doppler radar. The process of training a machine learning model includes selecting a machine learning algorithm and providing data to train on. The training data must hold the solution to the problem in question, which is often referred to as the target. Patterns are found within the training data by mapping similarities in the input data to the target. An effective machine learning model is produced when these patterns are properly captured. The model can then be used to predict new figures for which target data is unknown [19]. For example, consider an input signal is composed of a high frequency target and low frequency noise. A machine learning model would need the mixed data source and the separated high frequency target for comparison. The transformation of the model would look like a highpass filter in this example. The instructions for the data transformation in this study are obtained through the equations highlighted in the following sections. The user-selected training parameters, also referred to as hyperparameters, controls the behavior of the learning algorithm. The mathematical formulation of this process is presented in Section II. The gamma filter is a distinct instance of the generalized feedforward filter. It models an Infinite Impulse Response (IIR) filter with a restricted feedback architecture [20]. Favorable features from both IIR and Finite Impulse Response (FIR) systems are adopted: easy adaptation, trivial stability and an uncoupled region of filter order and impulse response. Since the memory parameter, µ, and filter order, K, are uncoupled, the model requires less coefficients to execute similar filtering results and it provides an increase in performance when modeling low-pass frequency signals [20]. For this reason, vital sign signals are the ideal candidate for testing this algorithm. Previous research suggest the apparent inaccuracies when using a PPG sensor [21] as the ground truth (the reference). The pulse arrival time and variance in sensor specifications suggest that accurate heart rate, for this sensor, is obtained over an average of time in the frequency domain, rather than time domain. A time synchronous ground truth will accelerate convergence time and provide a higher accuracy heart rate measurement for error analysis. So, for this study, a modified ECG sensor is manufactured to overcome the challenges set forth by the PPG device.

EXISTING SYSTEM:

A number of papers rely on spectral analysis and various filters to obtain the heart rate. Frequency domain filters require a discrete amount of information to be captured even before vital sign estimation is possible. Windowing functions and overlapping windows like the Short Time Fourier Transform (STFT) and the Continuous Wavelet Transform (CWT) attempt to capture frequency dynamics but are limited in terms of capturing precise time-varying frequencies. These techniques are impractical for the clinical setting, especially for complex physiological analysis. In recent years, there have been several breakthroughs in a new subfield of RF and millimeter-wave radar that apply machine learning architectures to radar including millimeter wave gesture sensing radar , Ultra Wide Band (UWB) sleep apnea screening , and human activity classification .

DISADVANTAGES:

- However, there are several disadvantages to a contact-restricted device. Accuracy may be degraded due to surface loading effects and the subject is more likely to alter their vital signs knowing their vital signs are being recorded.
- It should be noted that this is not the only demodulation strategy. Arctangent demodulation is an example that does not generate large harmonics, but it has the disadvantage of complex dc calibration.

LITERATURE SURVEY:

Microwave noncontact motion sensing and analysis:

This book is the first of its kind to detail extremely well the development of a very important technology, namely radar noncontact motion sensing, and has been authored by educators and practitioners, as evidenced by the organization of the chapters. This book can be used by the engineering community and researchers as a reference book, in particular by those interested in microwave components, systems, and subsystems; researchers in healthcare institutes; developers of military and security equipment; and scientists in the field of biomedical engineering. It can also be used as a textbook in seniors, and graduate students, electrical engineering curriculum.

"Noninvasive microwave measurement of respiration,"

A microwave technique for measuring respiratory movements of man and animal is described. The technique is noncontacting and is based on the scattering of continuous wave radiation. Preliminary results are shown for both animal and man, indicating the usefulness of the procedure.

"Automatic clutter-canceler or microwave life-detection systems,"

A microprocessor-controlled automatic clutter-cancellation subsystem, consisting of a programmable microwave attenuator and a programmable microwave phase-shifter controlled by a microprocessor-based control unit, has been developed for a microwave life-detection system (L-band 2 GHz or X-band 10 GHz). This system can remotely sense breathing and heartbeat movements of living subjects. This automatic clutter-cancellation subsystem improves manual clutter-cancellation in microwave systems. A series of experiments have been conducted to demonstrate the applicability of this microwave life-detection system for rescue purposes. The 2-GHz system performs well for remotely detecting human breathing and heartbeat signals through a pile of rubble of up to about three feet thick.

"Microwave sensing of physiological movement and volume change: A review," The ability non-invasively to detect and monitor the movement of tissues and organs from outside the body provides many worthwhile areas of potential biomedical applications. Several non-invasive microwave techniques for contact and remote sensing of circulatory and respiratory movements and volume changes have been developed. In general, these systems consist of a microwave generator, a sampling device, a transmitting-receiving antenna, a set of signal-conditioning and processing devices, and a display unit. They operate at continuous-wave frequencies between 1 and 35 GHz and make use of amplitude and phase information derived from the received signal. The average power density of energy radiated by present systems ranges from approximately 0.001–1.0 mW/cm^2. These systems are capable of registering instantaneous changes in fluid volume, pressure pulse, heart rate, and respiration rate in contact with body surface or at distances greater than 30 m, or behind thick layers of non-conductive walls.

"Fast accurate measurement of phase and amplitude using em microprocessor-based zero-balance system,"

Non-contact vital signs monitoring system based on Doppler radar has been becoming more and more attractive in the field of health care. In this paper, a non-contact wireless health monitoring system is presented. The monitoring system is capable of separating the mixed multi-person respiration signals without physically contacting them by using a continuous wave (CW) Doppler radar system. Experimental results show that the mixed respiration signals are successfully separated by the means of Blind Source Separation processing, and the estimation of respiration rates are very close to the actual values. The system can be used to monitor the respiration and calculate the respiration rates of elderly people when they fall ill or sleep at home.

PROPOSED SYSTEM:

Once the Mean Squared Error (MSE) converges, a solution is found. Then, the model is applied to a new dataset with different HR and respiration features. Choosing a proper ground truth for machine learning algorithm's training target is found non-trivial. Recording blood oxygenation has been proposed as an effective method to derive an accurate time series heart rate. There have also been claims that the pulse waveforms produced by the PPG is more practicable than measuring the R-R intervals produced by the ECG. However, the PPG is not an accurate time-precise representation of the heartbeat signal and hence, making it harder to train on. As many methods suggest, the PPG, as it relates to heart rate, should be taken as an average. In contrast, the ECG is a non-invasive and widely available device that can accurately measure the interval between successive heartbeats with the cost of some discomfort and extra wires.

ADVANTAGES:

- To achieve this effect, the ECG is put though a modified practical integrator to take advantage of the bimodal nature of the wave function. What is produced, is a smooth oscillation of a PPG like signal (referred to as ECG-based blip wave), as shown in with the original ECG signal.
- In the spectral domain, we have the advantage of averaging the missed heartbeats with the rest of the discrete transformation; but, we lose some time localization depending on the window.
- The advantage of the gamma filter as a regression problem is that we can choose how we interpret the signal since it was trained in the time domain.

MODULES:

Photoplethy smogram:

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Complex signal demodulation:

The respiration harmonics, due to the Doppler radar phase modulation and Complex Signal Demodulation (CSD), naturally degrade the accuracy of heart rate detection and must be accounted for when deriving a proper detection method. A number of papers rely on spectral analysis and various filters to obtain the heart rate. Frequency domain filters require a discrete amount of information to be captured even before vital sign estimation is possible. Windowing functions and overlapping windows like the Short Time Fourier Transform (STFT) and the Continuous Wavelet Transform (CWT) attempt to capture frequency dynamics but are limited in terms of capturing precise time-varying frequencies. These techniques are impractical for the clinical setting, especially for complex physiological analysis.

Ultra wide band:

In recent years, there have been several breakthroughs in a new subfield of RF and millimeter-wave radar that apply machine learning architectures to radar including millimeter wave gesture sensing radar, Ultra Wide Band (UWB) sleep apnea screening , and human activity classification. In these bodies of work, the results highlight radar as a viable technology for many new sensing applications, and show that the combination of radar hardware design and signal processing can yield promising results. Namely, Google's Soli , was able to track gestures with up to 92.10% accuracy for 1000 test gestures. This system had sub-millimeter accuracy running 10,000 frames per second on embedded hardware.

Infinite impulse response:

The gamma filter is a distinct instance of the generalized Feed forward filter. It models an Infinite Impulse Response (IIR) filter with a restricted feedback architecture. Favorable features from both IIR and Finite Impulse Response (FIR) systems are adopted: easy adaptation, trivial stability and an uncoupled region of filter order and impulse response. Since the memory parameter, μ, and filter order, K, are uncoupled, the model requires less coefficients to execute similar filtering results and it provides an increase in performance when modeling low-pass frequency signals. For this reason, vital sign signals are the ideal candidate for testing this algorithm. Previous research suggest the apparent inaccuracies when using a PPG sensor as the ground truth (the reference). The pulse arrival time and variance in sensor specifications suggest that accurate heart rate, for this sensor, is obtained over an average of time in the frequency domain, rather than time domain.

CONCLUSION:

The adaptive gamma filter has been proposed and evaluated for removing respiration and its harmonics from radar measured vital sign signals. There is a strong correlation between the tested ground truth and the estimated target signal. A practical and timely solution has been found for leaning individual heartbeat time series. These results have shown that there is no need for multiple optimization schemes, tuning steps, and intermediate signal processing steps for static observation of vital sign radar. Further areas to explore are varying types of noise in body movements. If there is induced body motion, for example, the algorithm would attempt to filter this noise out. However, the signal might be overcrowded with a poor signal-to-noise ratio to the extent that a recoverable.

REFERENCES

1. User Interfaces in C#: Windows Forms and Custom Controls by Matthew MacDonald.
2. Applied Microsoft® .NET Framework Programming (Pro-Developer) by Jeffrey Richter.
3. Practical .Net2 and C#2: Harness the Platform, the Language, and the Framework by Patrick Smacchia.
4. Data Communications and Networking, by Behrouz A Forouzan.
5. Computer Networking: A Top-Down Approach, by James F. Kurose.
6. Operating System Concepts, by Abraham Silberschatz.