Wireless Heart and Respiration Monitoring for Infants using Passive RFID Tags

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Abstract—A wearable, wireless and battery-free continuous health monitor for infants is described. An RFID tag is used as an On-Off Keying Device to measure the heart rate and the tag’s returned signal strength variations are used to calculate the respiration rate. Machine learning algorithms are employed to determine the health parameters.

I. INTRODUCTION

Healthcare providers are often interested in monitoring an infant's heart and respiration rate. However, babies are usually tethered to lengthy wired devices for continuous monitoring. Besides being uncomfortable, these wired monitors could potentially be hazardous if the baby were to get entangled in them. These monitors are attached to cumbersome battery/mains powered processing units which add to the discomfort caused to the infant. Hence, there is an urgent need for a passive, wireless monitor that can be easily integrated into a comfortable wearable solution for infants.

II. SYSTEM DESCRIPTION

A. Heart Rate Monitoring

An RFID tag is used as an on-off keying device, wherein it is normally transmitting, but turns off every time a heart beat is detected. We have successfully measured heart beats from 30BPM through 300BPM using this system. We have demonstrated that the system is capable of providing accurate heart rate measurements up to a distance of ten feet with a standard deviation of less than one beat per minute without an on-body power source. A detailed description of the system can be found in [1].

B. Respiration Rate Monitoring

We developed a wearable smart-garment device called a Bellyband [2], to be worn about the body of a subject to measure motion artifacts. As the infant’s chest moves, the shape of the fabric antenna changes which causes a change in the Returned Signal Strength Indication (RSSI) from the tag. RSSI values can be monitored to calculate the respiration rate.

III. DATA ANALYTICS

For measuring heart rate, the RFID is disrupted for about 100ms every time the heart beats. Logistic regression model is used to separate true heart beats from erroneously detected heart beats due to noise and unexpected RFID outages. Using the change in timestamp between signals as the primary feature, the transmitted heart beats can be filtered out of the data to facilitate inference of the heart rate.

For respiration rate, RSSI values are collected over time, and a Kalman filter is applied to the collected data to reduce noise artifacts in the wireless signal. The filtered data are then grouped into discrete time windows, and statistical features are extracted from those windows to establish a baseline RSSI during active stretching of the Bellyband (indicating respiratory activity). For the respiratory application, it is not possible to collect non-actuating test data since non-breathing test data is biologically infeasible; therefore, single-class anomaly detection is required. Subsequent new windows of data are compared to the baseline to classify the window as corresponding to an active stretching or resting state. Using a programmable mannequin, a One-Class Support Vector Machine anomaly detector has been shown to perform with classification accuracy just below its two-class counterpart, and the FFT has been shown to accurately extract rate of movement using the Bellyband RFID signal [3].

REFERENCES