RFID-based Vital Sign Monitoring

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***Abstract*—With the rapid development of the IoT, the concept of smart healthcare has been proposed to provide advanced and mobile healthcare service by exploiting IoT technologies. As important indicators, vital signs can provide useful clues for human's health condition. It would be useful to monitor vital signs for patients in their daily life as enabled by smart health systems. However, traditional vital sign monitoring technologies are usually costly and hard to deploy for long-term vital sign monitoring. Several wireless technology based motoring systems have been proposed for flexible, low-cost, and long-term vital sign monitoring. Among the various wireless technologies, the low-cost and light-weight Radio Frequency Identification (RFID) tags have many advantages and have been proposed as a promising approach for vital sign monitoring. However, there are many challenges in RFID based vital sign monitoring, such as the channel hopping offset, noisy data, and interference from the environment. In this paper, we examine these challenges and introduce several solutions, including mitigating the frequency hopping offsets by using a reference channel and estimating the offset each time when the reader hops to a new channel, using tensor completion for data imputation, and leveraging phase difference and tensor decomposition to detect the weak vital sign signal from strong interference.**

I. Preliminaries

Among the various wireless technologies, the low-cost and light-weight RFID tags have many advantages for vital sign monitoring [1-3]. Historically, the RFID technique is mainly focused on identification applications, as the name suggests, such as authentication, vehicle parking monitoring, road toll system, and supply chain management. These traditional applications are mainly based on communicating the Electronic Product Code (EPC) the tag carries to the reader, which is a universal identifier providing a unique identity for every physical object anywhere in the world. Beyond the traditional applications, there has been great interest in RFID based sensing techniques in recent years. The characteristics in the RFID wireless channel, such as the radio frequency (RF) phase angle, Doppler frequency, and received signal strength indicator (RSSI), have been leveraged for RFID based sensing [4]. Among such channel state information, the measured phase data has been used because it is indicative of the changes in the distance between the RFID tag and the reader antenna. When the tags are attached to the human body, such as chest and abdomen, the respiration will cause the tags to move, which will be captured by variations in the sampled RFID phase. An effective technique is needed to translate the measured RFID phase data to tag-reader distance, from which the respiration signal can be restored.

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II. Challenges and Solutions

There are several challenges to be addressed first for such a scheme to work. First, following the FCC regulations, the RFIC reader should adopt channel hopping when interrogating the tags, which introduces considerable noises in the measured RFID phase data. Moreover, the phase data also suffers from phase distortion and missing samples. Finally, the interference from the environment could be considerable. For example, when the system is applied in a noisy driving environment, the vehicle vibration and the driver's body movements will cause severe interference to the weak vital sign signal. When there are moving objects nearby, they will also introduce interference that is much stronger than the chest movement.

To address these challenges, several effective solutions have been proposed in recent works. For example, the Autotag system was proposed to measure the patient's respiration rate and detect abnormal breathing patterns. The system effectively mitigates the influence of the channel hopping by using a reference channel and estimating the phase offset when hopping to a new channel [5]. To deal with the sparse RFID phase data, a High Accuracy Low Rank Tensor Completion (HaLRTC) based technique was proposed in [5] to estimate the missing samples. An effective solution to combat the interference from unstable environment was also proposed in [6], which first mitigates the environment interference with phase difference calculated between a pair of tags, and then detects the weak respiration signal with tensor decomposition.

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