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IOT based Cardio resipiratory monitoring System for physically disabled patients

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Abstract--In this project a novel design of an embedded cardio-respiratory monitoring system for wheelchair users is proposed. The entire system is composed of a sensor node, a smartphone, and a cloud server. The sensor node contains two parts of an ultra-wideband pulse radar and the data processing module; the former is used to obtain continuous vital-sign signals, and the latter processes the sampled signals to estimate the heart rate and respiration rate, implemented in an embedded system to achieve a fully integrated radar system. The smartphone functions as the data bridge between the sensor node and the cloud server, which is responsible for sending emergent messages. Experiment results show that the proposed system could work reliably in static and dynamic cases of wheelchairs.

Index Terms—Doppler radar, wheelchair, signal processing, and vital-sign signals.

I. INTRODUCTION

The problem of population aging increases the health care requirement for elderly people and impaired people, particularly in nursing homes or at home. Assistive mobility equipment such as a smart wheelchair, which is used to reduce the burden of caregivers and facilitate the independence of the elderly and impaired people, has been widely discussed in the literature. In general, the major purpose of a smart wheelchair is to increase functionalities or convenience in terms of physiological parameter measurement and human computer interface. Considering that they can be used easily to sense vital-sign signals, non-contact sensing techniques have been developed in the literature. These methods adopt the off-the-shelf UWB radar for car crash prevention or driving environments, and they use backend algorithms to improve the accuracy of breathing and heart rate detection. At present, few studies have proposed the use of noncontact techniques to sense the vital-sign signals of wheelchair users. The work reported in presents a frequency modulated continuous-wave Doppler radar sensor, which allows the monitoring of vital-sign signals for wheelchair users. However, the vital-sign signals are processed on a computer. thereby limiting the utilization of the sensor in real outdoor environments. The work described in presents a real time processing of the biomedical signals obtained by sensors integrated in a wheelchair. However, this approach requires a high-cost digital signal processor. In addition, emergency notification is not addressed in the prior systems. This letter develops an embedded cardio-respiratory monitor system for wheelchair users.

Now a day, UWB radar is a powerful tool for remote target locating and tracking, and an important non-contact monitor of vital signals. Owing to the advantages of low cost and high availability, the UWB has widely chosen for the remote sensing applications. The giant information and communication technology (ICT) manufacturers plan to support the UWB technologies in their released products, such as the UWB chip of Apple mobile phone used for indoor localization, and the Google Soli sensor employed to sense the gesture for the human-computer interaction. Meanwhile, many complex sensor/radar architectures have employed to obtain better- performance , e.g. the multiple transceivers and antennas used for the ranging and detection of multi-targets . The homogeneous (or) heterogeneous multi – sensor fusion is also developed as the networks for object \ locating/tracking. However, in the sensor networks, a information exchanging between the sensor nodes and collaborative signal processing (CSP) between the nodes together target information are usually the performance.

II. Design of Embedded Cardio-Respiratory Monitoring System

The block diagram of the proposed embedded cardio respiratory monitoring system, which is attached to the back side of a wheelchair, is shown in Fig. 1. The proposed system is composed of two major components: the data processing module, which perform the functions of processing, and the UWB pulse radar, which senses the vital-sign signals. The detailed design concept and implementation of each part are provided in the following subsections.

A. UWB Pulse

The Ultra-Wide Band (UWB) regulations have been adopted to allow unlicensed operation in the range of 3.1 and 10.6 GHz. Since the legalization of UWB by the FCC in 2002, UWB technology has awakened great interest in wireless communication and radar sensor applications. UWB sensors detect the macro as well as micro movement inside the human body. The capability of non-invasive measurement of vital sign parameters of the human body is very useful in medical engineering. The deployment of an IR UWB vital measurement system may be used for the trivial vital signs monitoring of patients at home. It may also be helpful for the continuous monitoring of a person while typing on a computer, driving a vehicle or sleeping on a bed. IR UWB technology has many applications due to: its robustness in a harsh environment, high precision ranging at the centimeter level, and its higher penetration capabilities. The main reason for the usefulness of UWB sensors in medical applications is its low power consumption and large spatial resolution. Non-invasive monitoring is much more appropriate in situations where it is difficult to use complicated wired connections, such as ECG monitoring for infants, burn victims or people buried during building collisions. An alternative for the non-invasive detection of vital signs is microwave Doppler radar. However, the Doppler systems have difficulty in penetrating materials and the null point problem. The main advantage of UWB signals over the microwave Doppler radars is good material penetration.

WSNs are self-awareness networks. They have wide applications in battlefield observation, healthcare, weather forecasting and disaster detection.Generally, WSNs are made of the base station (or sink), countless hubs and tiny devices are known as sensor nodes which comprise lesser sensor devices, radio transceiver, restricted battery, memory and microcontroller module which involves Controller Processor Unit (CPU) and Digital Signal Processor (DSP) chipsets. These sensors are densely deployed and distributed to monitor many ecological conditions, like relative humidity, pressure, temperature, motion, sound pollutants or vibration at different locations.All the aggregated data are transferred to the sink node where valuable data are sorted for managing the vital application. The battery-operated sensors organize themselves according to a certain topology and transmission range for transferring data packets from the source node to traverse multiple hops before they reach terminal. Through WSN communication, thousands of nodes sense the massive volume of data and convey it to a number of hubs. The issue of the huge bulk of datasets produced by these sensors forms a very serious challenge. Data communication in WSN consumes a significant amount of energy and occupies a large volume of memory, further there are dissemination failure may happen through communication. Data diffusion may produce erroneous observed values that may degrade the reliability of the network due to its non-accuracy. Also, the aggregated data often suffer from some inaccuracies and incompleteness. Inaccurate/imperfect measurements in WSN data are often referred to as WSN abnormalities. Abnormalities are defined as the observations that do not correspond to well-defined normal behavior.

This paper introduces an algorithm for detecting the presence of walking humans in an urban environment populated by other moving objects such as cars and trucks. Our particular motivation is the problem of providing pedestrian safety in the presence of moving vehicles. More generally, the problem of detecting and localizing human presence has been a widely studied problem due to its potential military, safety, security, and entertainment applications. A number of technologies can be used to detect human signatures. Computer vision has limited ability to detect humans in poor visibility conditions (e.g., at night, haze, fog, rain, and smoke, etc.). Similarly, the performance of infrared detectors varies with the ambient temperature conditions. Human detection using RF, microwave, and mm-wave radar has been previously studied in controlled environments. However, the problem of human detection in real complex environment has been less well addressed. In this paper, we use UWB human scattering properties and human biometric information to develop a UWB monostatic radar-based human detection algorithm. Compared with narrowband radar, UWB radar has many potential advantages for detecting human presence. The target's frequency response over the radar signal's wide bandwidth may provide useful detection and discrimination information.

This paper introduces an algorithm for Ultra-Wideband (UWB) radar-based human presence detection and tracking. Our particular motivation is the problem of outdoor surveillance and intruder detection by a mobile robot. The robot must be able to discern humans from other non-human objects, e.g., small animals. More generally, the problem of detecting and localizing human presence has been a widely studied problem due to its potential military, safety, security, and entertainment applications. A number of technologies can be used to detect human signatures and/or track human. However, computer vision has limited ability to detect humans in poor visibility conditions (e.g., at night, haze, fog, rain, and smoke, etc.). Similarly, the performance of infrared detectors varies with the ambient temperature conditions The block diagram of the embedded cardio-respiratory monitor system.

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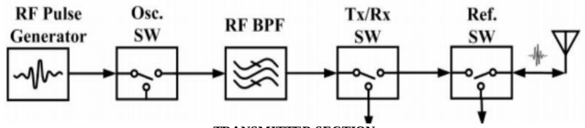
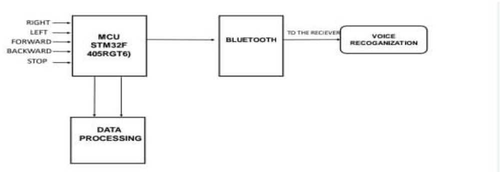
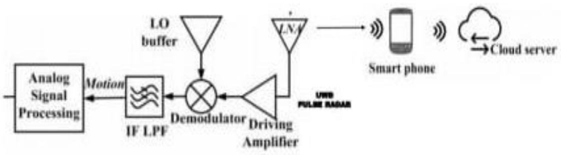


TRANSMITTER SECTION



Processing unit



Receiver Section

Data Processing Module and Smartphone

The block diagram of data processing module and smartphone. The data processing module comprises one MCU and one Bluetooth (BT) module, where the former aims to process the digital signals and the latter is responsible for communicating with the smartphone users. I In system has three operation modes for wheelchair users or caregivers. Mode 1 is designed to transmit the raw data of vital-sign signals from the UWB radar. Modes 2 and 3 are designed to transmit the estimated respiration rate and heart rate, respectively. The vital-sign signals are digitized at a speed of 20 Hz/s with a 12-bit resolution analog-to-digital converter in all modes. In Mode 1, the sampled raw data are directly transmitted to the smartphone through the BT module. In Modes 2 and 3, the sampled raw data are further fed into a sequel of signal processing, including digital filter, power spectral density (PSD), and peak detection. All filters are constructed in direct form, which can be implemented in a difference equation2. The digital filter designed for Mode 2 is an LPF with a cutoff frequency of 0.5 Hz and 62 taps

III. EXPERIMENTS AND RESULTS

A. Implementation of Radar Module and smart phone The printed circuit board of the proposed system is shown in Fig. 4(a) and 4(b). The size of circuit board is 10 × 5 cm2 . STM32F405RGT6 and HC02 are used as the core MCU and BT module, respectively. The HC02 is connected to the MCU through UART. STM32F405RGT6 is the ARM CortexM4 32-bit MCU with a maximum frequency of 168 MHz. The adopted operation modes of the MCU in the proposed systems are run and sleep modes, which have current consumptions of 238 uA/MHz and 280 uA, respectively. The proposed systems operates at a maximum frequency of 168MHz for the run mode, which means that the total current consumption is 40 mA (i.e., 168·238 uA = 40mA). The power supply is 3.3 V dc, indicating a power consumption of 0.132 watt (i.e., 3.3 V·40 mA = 0.132 watt).

Static case	Respiration Rate(Hz)	Reference(Hz)	Accuracy(%)	Heart Rate(Hz)	Reference(Hz)	Accuracy(%)
subject 1	0.38	0.38	100	1.33	1.35	98.52
subject 2	0.41	0.43	95.35	1.43	1.47	97.28
subject 3	0.36	0.34	94.44	1.23	1.21	98.37
subject 4	0.38	0.39	97.43	1.36	1.38	98.55
Dynamic case	Respiration Rate(Hz)	Reference(Hz)	Accuracy(%)	Heart Rate(Hz)	Reference(Hz)	Accuracy(%)
subject 1	0.43	0.42	97.67	1.36	1.32	97.05
subject 2	0.39	0.38	97.43	1.41	1.38	97.87
subject 3	0.34	0.36	94.44	1.32	1.34	98.05
subject 4	0.41	0.39	95.12	1.38	1.39	99.28

Similarly, the power consumption of the sleep mode is 0.132 watt (i.e. 3.3 V·280 uA = 9.24·10−4 watt). Moreover,

the current consumption and power consumption of analog signal processing circuit are the 100 mA. If we choose a battery with a capacity of 3000 mAh, we could estimate the battery life as 3000/140 = 21.43 hours. According to test results,the calculations of (6), (7), and (8) take 4.82, 1.98, and The estimation accuracies of heart rate and respiration rate are more than 94%. Emergency notifications of abnormal respiration and ECG are verified by using the LINE notification system, illustrated in Fig. 4 (f), which help caregivers monitor the subject’s abnormal vital conditions immediately.

Comparisons of Detection Accuracy of Heart Rate and Respiration Rate.

IV. CONCLUSIONS

An embedded cardio-respiratory monitoring system is developed for wheelchair users, where a commercial MCU is employed to handle digital signal processing to meet the lowcost requirement. Accordingly, a fully customized UWB radar is implemented to wirelessly detect real-time physiological data. Emergent event notifications for monitoring are also incorporated in the system. The proposed system has been used in a hospital in Taiwan.

V. REFERENCES

[1] R. C. Simpson, “Smart wheelchairs: A literature review,” *Journal of rehabilitation research and development*, vol. 42, no. 4, p. 423-436, Jul. 2005.
[2] O. A. Postolache, P. M. B. Silva Girao, J. Mendes, E. C. Pinheiro, and G. Postolache, “Physiological parameters measurement based on wheelchair embedded sensors and advanced signal processing,” *IEEE Trans. Instru. and Measu.*, vol. 59, no. 10, pp. 2564-2574, Oct. 2010.
[3] Y. Li, “A EOG-based switch and its application for start/stop control of a wheelchair,” *Neurocomputing*, vol. 275, no. 1, pp. 1350-1357, Jan. 2018.
[4] F. Khan and S. H. Cho, “A detailed algorithm for vital sign monitoring of a stationary/non-Stationary human through IR-UWB radar,” *Sensors*, vol. 17, no. 2, pp. 1-15, Feb. 2017.

 ISBN: 978-81-910765-1-6

[5] S. K. Leem, F. Khan and S. H. Cho, "Vital sign monitoring and mobile phone usage detection using IR-UWB radar for intended use in car crash prevention," *Sensors*, vol. 17, no. 6, pp. 1-25, Jun. 2017.

[6] K. K Shyu, L. J. Chiu, P. L. Lee, and L. H. Lee, "UWB simultaneous breathing and heart rate detections in driving scenario using multi-feature alignment two-layer EEMD method," *IEEE Sensors J.*, vol. 20, no. 17, pp. 10251-10266, Sept. 2020.

[7] O. Postolache, P. S. Girao, G. Postolache, and J. Gabriel, "Cardio respiratory and daily activity monitor based on FMCW Doppler radar embedded in a wheelchair," in *Proc. 2011 Annual International Confer ence of the IEEE Engineering in Medicine and Biology Society*, Sept. 2011, pp. 1917-1920.

[8] A. Abdolalipour, O. Postolache, and P. S. Girao, "DSP based real time adaptive vital signals extraction algorithm using CW-Radar for wheelchair users," in *Proc. 2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Oct. 2012, pp. 620-623.

[9] W. M. Elsayed, H. M. El-Bakry, and S. M. El-Sayed, "Data reduction using integrated adaptive filters for energy-efficient in the clusters of wireless sensor networks," *IEEE Embedd. Syste. Lett.*, vol. 11, no. 4, pp. 119-122, Dec. 2019.

[10] Kuo-Kai Shyu **YEAR:**2020 UWB Simultaneous Breathing and Heart Rate Detection In Driving Scenario Using Multi-feature AlignmentTwo-layer EEMD Method

[11] Yuanqing Li, Shenghong He **YEAR:**2017 A EOG-based Switch and Its Application for "Start/Stop" Control of a Wheelchair

[12] Faheem Khan and Sung Ho Cho **YEAR:**2016 A Detailed Algorithm for Vital Sign Monitoring of a Stationary/Non-Stationary Human through IR-UWB Radar

[13] SeongKyuLeem , Faheem Khan **YEAR:**2017 Vital Sign Monitoring and Mobile Phone Usage Detection Using IR-UWB Radar for Intended Use in Car Crash Prevention.