DEPARTMENT OF ELECTRICAL ENGINEERING

PHD DISSERTATION DEFENSE

Noninvasive Electromagnetic Sensor Array for Continuous Monitoring of Human Vital Signs and Assessment of Lung Fluid Content

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Location: Holmes Hall 389

Abstract

Early detection and continuous assessment of lung fluid content or abnormal fluid buildup in the lungs, is the foundation to the management and treatment of life threatening diseases such as heart failure (HF), and other cardiopulmonary related illnesses. However, measurement of lung fluid content is difficult and available modalities are either invasive and/or not suitable for continuous monitoring. The Cardiopulmonary Stethoscope (CPS) system, aims to address this need. The CPS system is a noninvasive, portable, low-cost device, capable of monitoring vital signs (VS) such as heart rate (HR), respiratory rate (RR), and most importantly, detect changes in lung fluid content. This study is related to the development of the system and its use in clinical trials.

Contributions of this dissertation included the following: (1) A textile based sensor for remote monitoring and wearable applications was developed and clinically validated for HR and RR measurements on healthy patients. (2) Specific Absorption Rate (SAR) measurements were conducted with the DASY4 system using safety compliance guidelines set forth by the FCC. With 32 mW input power, the measured SAR was 0.4 W/kg which is only 1/4th of the FCC limit of 1.6 W/kg for 1g avg. (3) HR and RR measurements were clinically validated on ten healthy participants at rest and during exercise. Measured differences between the CPS device and standard hemodynamic devices were all within the limits of agreement which were calculated using Bland-Altman analysis. (4) In collaboration with the Queen's Medical Center, sensitivity to changes in lung fluid content was also clinically validated with twelve heart failure (HF) and eight hemodialysis (HD) patients. Polynomial regression fit of the overall changes in phase was generally in good agreement with the trend of the pulmonary arterial pressure measurements from the HF patients and fluid removed during hemodialysis treatment. HR and RR measurements also showed significant correlation. (5) Detailed 3D simulation and phantom experiments were conducted to examine the effect of the sensor position on the human body to accurately monitor different parameters across the thorax.