Monitoring Lung Disease Using Electronic Stethoscope Arrays

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This paper presents the design and prototype testing of a novel medical instrument able to measure changes in the distribution of lung fluid and lung tissue density. Potential applications for this instrument include: monitoring of patients with unstable pulmonary status resulting in accumulation of lung fluid and/or collapse of lung tissue, and providing a physician with an index rating the effectiveness of treatments such as pills, puffers, supplemental oxygen, etc. The apparatus consisting of an array of 4 electronic stethoscopes linked together via a fully adjustable harness provides physicians with two major pieces of information: 1) spatial information of pulmonary obstructions and 2) an index rating the effectiveness of an administered treatment based on changes in lung tissue density. This information is obtained using the Normalized Least Mean Squares (NLMS) algorithm to develop a transfer function based the propagation characteristics of a White Gaussian Noise (WGN) signal inputted into the patient's trachea and measured on the chest surface. Changes to the transfer function as a treatment is administered are analyzed based on propagation delay, speed of sound, and Mean Squared Error (MSE). Furthermore, the system uses the advantage of an array of stethoscopes to eliminate breath variability between auscultation points and does not rely on differences between the auditory training of physicians. The system was calibrated to account for delays in the signal acquisition equipment and verified using a lung phantom model where it was discovered that as the volume of fluid in the lungs increases, the sound propagation delay decreases exponentially until the lungs are saturated with fluid. It is hoped that the system will lead to an improved overall sense of reliability for stethoscope auscultation.