Summary -paper 1
Lung and Heart Sounds Analysis: State-of-the-Art and Future Trends

In this article, we review the research conducted during the last six years on lung and heart sounds, instrumentation and data sources (sensors and databases), technological advances, and perspectives in processing and data analysis.The World Health Organization (WHO) reports that an estimated Approximately one in every four deaths (700,000) annually in North America are the result of heart disease.In the United States, heart disease is the leading cause of death in both men and women, but more than half of heart disease deaths in 2009 occurred in men. Coronary heart disease (CHD) is the most common type of heart disease, resulting in more than 400,000 deaths annually in North America. Every year, ~800,000 Americans suffer a heart attack. Of these, 550,000 have their first heart attack, and 250,000 have already had at least one.

Someone diagnosed with heart disease has a poor prognosis. Its presence commonly signals the final phase of many processes, and one of the most noticeable is ischemic heart disease. Mortality associated with heart disease is comparable to that due to common cancers, with a survival rate of < 49% during a span of 4 yr. Despite this data, current technology in treatment has brought improved quality of life and survival to heart-failure patients. On the other hand, improved survival and the many co-morbidities are accompanied by additional health problems. Recent studies show that a substantial number of heart-failure patients die from causes other than the cardiac disease, in particular, events due to malignancies, respiratory problems, and septicemias.

HEART SOUND CHARACTERISTICS

A.Heart Sounds

Some of the common mechanisms by which heart

sounds are generated include:

(1) opening or closing heart valves

(2) flow of blood through the valve orifice,

(3) flow of blood into the ventricular chambers,

(4) rubbing of cardiac surfaces.

AUSCULTATION

Auscultation usually is performed with a stethoscope, an acoustic medical instrument invented by Laennec.The modern stethoscope is much different from the first model,more recent stethoscopes can record and send the recorded sounds to a personal computer for processing and analysis.Research conducted by Abella et al. showed that amplification at low frequencies in stethoscopes occurs below 112 Hz, the point at which heart sounds can be heard; however, in this range, the human ear loses sensitivity.34 This represents a major problem for diagnosis.

Such disadvantages regarding auscultation have been overcome by means of computerized analysis of recorded lung and heart sounds.Computerized analysis enables a systematic approach to the diagnosis of different respiratory or cardiac diseases.

OVERVIEW OF SOUND DATABASES

A.Heart Sound Databases

heart sound databases have been developed as learning tools and enhance problem-solving skills in the area of respiratory medicine.The effort needed to document data for storage and sharing in a semi permanent manner is rarely available at the close of a research project.Some of the most relevant databases are described below.

01. Before the PhysioNet/CinC Challenge 2016, only three public, heart sound databases were available: (1) A database from the University of Michigan Heart Sound and MurmurLibrary (MHSDB), (2) the PASCAL database,and (3) the Cardiac Auscultation of Heart Murmurs Database, summarized as follows:
    - The MHSDB, provided by the University of Michigan Health System, includes only 24 heart sound recordings with a total time length of 1500 s.
    - Recordings last from 1 to 29 s but have a limited frequency range below 200 Hz, due to the applied low-pass filter that removes many of the useful heart sound components for clinical diagnosis.
    - The Cardiac Auscultation of Heart Murmurs database, provided by eGeneral Medical Inc.,includes 65 recordings. It is not open and thus requires paid access.

Toward Mobile Signal Acquisition

the development of mobile technology has significantly evolved and is often used by clinicians for data acquisition and diagnosis.These researchers used

two smartphones with different operating systems(Android and Apple iPhone operating system). The reference signal was acquired by a spirometer, and results showed a high correlation between the signal acquired with both smartphone devices and the signal acquired by the spirometer.In other studies, smartphones, including their camera and flash, have been used to obtain respiratory rate estimation at normal breathing rates.Because breathing rate and heart rate can be measured directly by a finger's pulsatile flows,148 a fingertip was placed in the lens of the smartphone to obtain the pulse signal.suggests that medical apps in clinical practice will significantly contribute to accessible and evidence-based health care and to improve practical clinical skills in medical education. Much work is needed by physicians, hospitals, and healthcare centers to establish appropriate regulatory procedures that ensure patient safety when a mHealth app is used.

Feature extraction and machine-learning algorithms are applied to the signals online. Once these signals are analyzed, results of the analysis are sent to a medical record server that will be reviewed by specialist doctors and then sent to the global database. This database will include data recordings from other parts of the world to help refine the diagnosis through algorithms based on pattern recognition and artificial intelligence.Subsequently, results of analyses are sent to the mobile device to provide a diagnosis of a patient's pathology. Owing to the availability of global positioning system (GPS) technology on mobile devices, the patient can potentially receive immediate medical assistance, for example in case of a medical emergency. This will benefit those living in rural areas. Figure 8 presents an overview of the proposed system. Other considerations include patient privacy and deployment of sensors, camera, GPS technology, internet access, and a team of specialist physicians who can validate the information and results that are received from the big database.Often, methods that health-care professionals use to analyze, process, and interpret data remain basic. Cutting-edge technology including machine learning algorithms, natural language processing,and cognitive

computing are needed to better understand human behavior. A large database system with GPS is proposed herein.