22 Listening carefully to your heart beat

Cardiohemodynamical analysis based on stethoscopic sounds

Abstract

A variety of sounds are constantly emitted from the human body as a result of life activities. By listening to and analyzing those sounds, we can obtain useful information about the function and condition of the body, which is called auscultation. In this research, we are focusing on heart sounds to estimate the function and condition of the heart and blood vessels based on the observation of acoustic signals. In our system, multiple microphones are attached to several places, such as the chest, to detect heart activity. Based on the captured sound, it estimates the degree of normality as a score and generates an explanatory statement as a sentence. We have confirmed that the normality estimation and description generation with a specified degree of detail work effectively for test data. We aim to realize an "AI stethoscope" that contributes to the prevention and early detection of diseases in many people, as skilled doctors can accurately understand and explain the condition through auscultation.

Concept of AI Stethoscope

- Multiple small microphones are attached to your body to collect useful information and visualize it in various ways.
- By our machine learning techniques, advanced media conversion such as text generation from audio [1] is possible, in addition to abnormality detection or pattern classification.
- The system will be extended to a visualizing and analyzing tool for heart activity and hemodynamics, which is a part of the "digital twin computing" concept that we are pursuing.

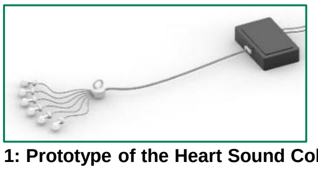

Figure 1: Prototype of the Heart Sound Collector

Generation of Explanatory Text and Score

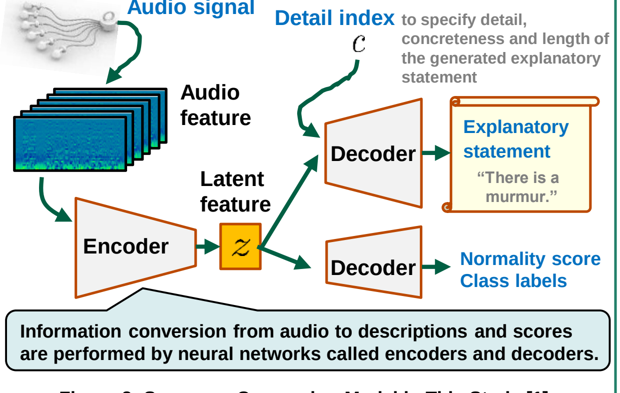

Figure 2: Sequence Conversion Model in This Study [1]

Working Example of Prototype

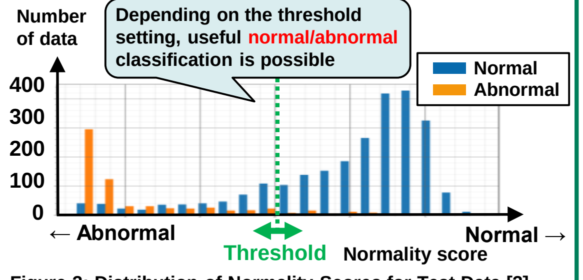

Figure 3: Distribution of Normality Scores for Test Data [3]

Table 1: Generated Description Examples

Depending on the specified level of detail, useful description is generated.

C index	Example of generated text
20	Your heart sounds are abnormal.
40	There is a systolic murmur in the heart sound.
60	There is a systolic murmur in the heart sound, and it may be a sign of cardiomyopathy.

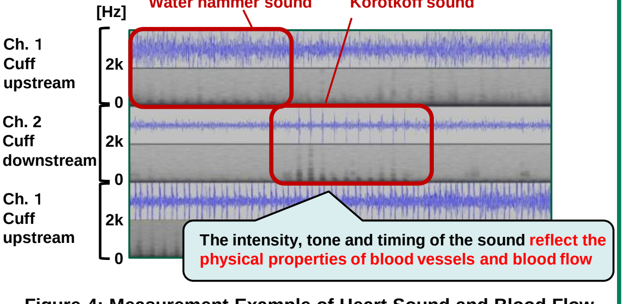

Figure 4: Measurement Example of Heart Sound and Blood Flow Sound during Blood Pressure Measurement in the Left Upper Arm
(Each Ch. Top: Sound signal waveform, Bottom: Sound spectrogram)

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References

[1] S. Ikawa, K. Kashino, "Neural audio captioning based on conditional sequence-to-sequence model," In *Proc. DCASE 2019 Workshop*, 2019.
[2] M. Nakano, R. Shibue, K. Kashino, S. Tsukada, H. Tomoike, "Gaussian process with physical laws for 3D cardiac modeling," under review.
[3] The PhysioNet Computing in Cardiology Challenge, *http://physionet.org/content/challenge-2016/1.0.0/*, 2016.

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