PRELIMINARY RESULTS ON COMPUTERIZED ANALYSIS OF BOWEL SOUNDS CAPTURED FROM A NOVEL WEARABLE DEVICE

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Abstract

Bowel sounds (BS), the noises produced by the movement of fluids and gas during the peristaltic movement of intestines, are useful in clinical practice as their auscultation constitutes a traditional technique for identifying gastrointestinal (GI) health status. Assessing patients with GI disturbances presents many challenges for a health professional. In this direction, there are research efforts that focus on computerized BS analysis systems in order to detect GI motility problems.

The aim of this work is to present an alternative technique to process BS, captured by a novel comfortable wearable device, namely smart belt, that captures 3-channel BS recordings at up to 3KHz sampling frequency, during a soda tolerance test (STT). The processing pipeline is applied separately on each sound channel and consists of two steps. At Step 1, the BS recordings are adaptively denoised via a wavelet transform-based stationary non-stationary filter (WTST-NST) [1] that separates sound events of interest (SEOI) from background noise. By applying the WTST-NST filter, the coherent structure of bowel sounds or other similar sound events (non-stationary) is revealed and separated from the superimposed interfering background noise (stationary). The output of Step 1 is subjected to time-frequency analysis based on the Continuous Wavelet Transform using the Morlet wavelet. The target is to identify the frequency content of each candidate bowel sound event and characterize it as bowel sound or artefact [2]. In this context, the output of this process is a bowel sound mask signal per channel with non-zero values that correspond to the positions of bowel sound events. Finally, three GI mobility indices are calculated, i.e., BS per minute (BSPM), sound-to-sound interval (SSI) and mean BS duration (BSD).

The above analysis pipeline was evaluated on a dataset consisting of BS recordings from 7 adult subjects during an STT, along with expert-based BS annotations as the ground truth. The performance is evaluated via the measures of the true positive rate (TPR) and sensitivity. In overall, the TPR is 40-80%, implying that in many cases there are a lot of false positive events, whereas the highest TPR of each subject, produced by a single channel, ranges between 60-80%. The relatively high number of false positives may be caused by the way the expert evaluated the abdominal sound recordings, i.e., by listening to a single three-channel audio file rather than three separate single audio files. In this way, the expert may have missed or misinterpreted bowel sounds that appear on a single channel and are suppressed by the superposition of the other two. Sensitivity, in overall, ranges from 50% to 98% while the best performance by a single channel for each subject is higher than 70% in most cases. The results of the motility indices calculation validate the expected behaviour, i.e., BSPM increase and SSI decrease during the SST. However, this was not the case for BSD that slightly decreased instead of the opposite. This may be due to increased segmentation of long BS events to shorter ones by the processing algorithm. To conclude, the BS recordings acquired by the smart belt along with the proposed pipeline are capable to identify the bowel motility alteration during the STT and pave the way for computerized evaluation of GI disturbances.

References

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Bowel sounds, Computer analysis, Wavelet transform

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