Classification of Wrist Pulse Blood Flow Signal Using Time Warp Edit Distance

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Abstract. The blood flow signals can be used to examine a person's health status and have been widely used in the study of the clinical diagnosis of cardiovascular diseases. According to the pulse diagnosis theory of traditional chinese, the pathological changes of certain organs could be reflected on the wrist pulse signals. In this paper, we use Doppler ultrasonic device to collect the wrist pulse blood flow signals from patients with pancreatitis (P), duodenal bulb ulcer (DBU), appendicitis (A) and acute appendicitis (AA) as well as healthy persons. After extracting the envelopes of ultrasonic pulse contour, the wrist pulse blood flow signals are pre-processed using wavelet transform. Finally, we adopted a recent time series matching method, time warp edit distance (TWED), on the pre-processed data for classification of wrist pulse blood flow signals. The proposed approach is tested on the wrist blood flow signal dataset, and achieves higher classification accuracy than several classical time series matching approaches, such as Euclidean distance (ED), dynamic time warping (DTW), and edit distance with real penalty (ERP).

Keywords: Wrist blood flow diagnosis; time series; time warp edit distance.

1 Introduction

Pulse diagnosis, one of the most important diagnostic methods in traditional Chinese medicine (TCM), has been used in disease examination and in guiding medicine selection for thousands of years. In pulse diagnosis, wrist pulse signal carries vital information and can reflect the pathological changes of the body condition. By feeling the pulse, although the practitioners could examine the person's health conditions, the diagnostic results, however, sincerely depend on the practitioner's subjective analysis and sometimes may be unreliable and inconsistent. Therefore, with the help of modern computer techniques, it is necessary to develop computerized pulse signal analysis techniques to make pulse diagnosis quantitative and objective [1, 2, 3, 4]. For example, Chen et al. [5, 6] developed several models to extract features from the wrist pulse blood flow signals, and use support vector machine (SVM) and fuzzy C-means (FCM) for classification. Using linear discriminant classifier, other researchers [7, 8] have also shown the effectiveness of identifying human sub-health status based on pulse signals. Most recently, Zhang et al. [9, 10] used the Hilbert-Huang transform and the wavelet method to extract pulse features including wavelet powers, wavelet packet powers, and other Doppler ultrasonic diagnostic parameters.

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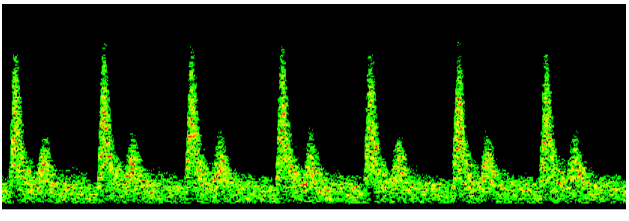
In this paper, we adopt a recently developed time series matching method, time warp edit distance (TWED) [11], for classification of the wrist pulse blood flow signals. In order to test the classification performance of TWED, experiments are carried out on the wrist blood flow signal dataset [12] which contains 100 healthy people, 54 patients with pancreatitis (P), 77 with duodenal bulb ulcer (DBU), 35 with appendicitis (A), and 54 with acute appendicitis (AA).

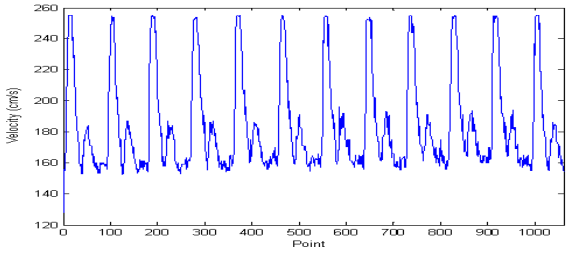
The reminder of the paper is organized as follows. Section 2 describes the pre-processing method of the Doppler ultrasonic signals. Section 3 introduces the time warp edit distance method. Section 4 provides the experimental results and Section 5 concludes the paper.

2 The Pre-Processing of the Wrist Pulse Blood Flow Signals

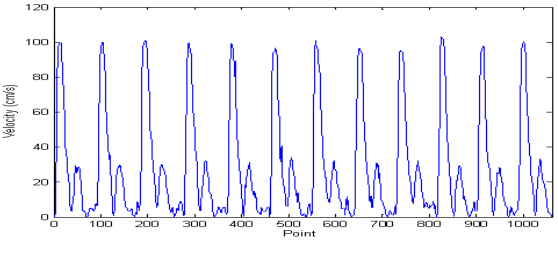
In our scheme, blood flow signals of the wrist radial artery are collected by a Doppler ultrasonic acquisition device. At the beginning of signal acquisition, operator uses



(a) A typical pulse Doppler spectrogram



(b) The maximum velocity envelop of the wrist blood flow Signal



(c) The wrist blood flow signal after de-noising and drift removal

Fig. 1. The pre-processing of the wrist pulse blood flow signal. (a) A typical pulse Doppler spectrogram, (b) the maximum velocity envelop of the wrist blood flow signal, and (c) the wrist blood flow signal after de-noising and drift removal.