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UNCONSTRAINED SYSTOLIC BLOOD PRESSURE ESTIMATION METHOD CONSIDERING THE ULTRADIAN RHYTHM TIME DYNAMICS OF THE BLOOD PRESSURE DURING THE NIGHT

Abstract:

Hypertension is a very common disease in the modern world. It requires daily measurements of blood pressure to reduce the risk of developing other associated diseases. It is especially difficult to measure blood pressure at night because the present measurement method requires compressing the patient's arm using a cuff, which cannot be performed during sleep. In this study, we propose an unconstrained systolic blood pressure estimation method that considers time dynamics of blood pressure change during sleep on the basis of a transfer function model.

In the proposed method, 12 features that relate to stroke volume, heart rate, blood vessel diameter, and vascular hardness are calculated in an unconstrained manner from the heartbeat signal measured by the pneumatic method. Taking time dynamics into account, a transfer function is constructed using the 12 features calculated from the heartbeat signal as inputs to estimate blood pressure at the current time. The features are measured for the past 70 minutes considering the ultradian rhythm.

We conducted a validation experiment in six healthy subjects. The subjects were asked to sleep during the night on an ordinary bed equipped with a pneumatic bio-signal measurement system. To obtain the true systolic blood pressure as a reference, the subjects wore the cuff of an automatic sphygmomanometer around the left arm. True systolic blood pressure was measured every 10-minutes. The heartbeat signal of the subject was obtained by applying a band-pass filter with a range of 0.8–6 Hz to the output signal from the pneumatic method. The 12 features were then calculated from the heartbeat signal. To obtain the transfer function model, we performed subspace identification with the 12 measured features as input signals, and one output signal corresponding to blood pressure. Leave-one-subject-out cross-validation was applied to evaluate the accuracy of the proposed method; i.e. the transfer function was identified using five subjects' heartbeat signal data, and the blood pressure of the left-out-subject was estimated by the transfer function. Finally, we

calculated the correlation coefficient between all estimated blood pressure and true blood pressure measurements. The correlation coefficient between the systolic blood pressure estimated by the proposed method and the true blood pressure measured by the sphygmomanometer was 0.81. This shows that systolic blood pressure estimated by our method is comparable to true measures of blood pressure using a sphygmomanometer. This method may be useful for monitoring blood pressure at night without disturbing sleeping patients.

Keywords:

Systolic Blood Pressure, Unconstrained bio-signal measurement, pneumatic method, sleep, ultradian rhythm

JEL Classification: I19