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Quality Controlled Compression Technique for Photoplethysmogram Monitoring Applications

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Abstract- Computerized acquisition and analysis of Photoplethysmogram (PPG) can provide vital information on various cardiovascular functions. In this paper, we introduce a quality controlled PPG compression technique using principal component analysis to keep the local and global distortion of the reconstructed data within pre-specified limits. To achieve this, optimum number of eigenvectors (EV) and principal components (PC) along with their quantization level (Q) were selected for compression. The technique was validated with pre-recorded 2 min and 10 min PPG data collected from 35 healthy volunteers (N) and 35 cardiovascular patients (CVP) under fully resting condition. At limiting PRD of 5% and absolute error of 8%, for N group (CVP group) an average compression ratio (CR), PRD and MAE of 5.65 (6.76), 2.41% (3.33%) and 6.1% (7.3%) were obtained respectively. Relaxing the control criteria up to clinically acceptable limits, a CR of 13.28 for N and 13.31 for CVP group were achieved. Most of the clinical features had an average deviation of less that 6% from their original values. The method yielded lower CR, PRDN and MAE with noisy (motion artifact and Gaussian noise) PPG. With two different stress levels, the compression parameters were found to vary. The reconstruction results were clinically validated by experts. A successful real-time data streaming in computer proved the usefulness of the technique for continuous monitoring applications.

Keywords—Compression, Error Measure, Photoplethysmogram, Principal Components, PRD, Quality control.

1. Introduction

The Photoplethysmogram (PPG) is an important medical signal that can provide information on cardiovascular, respiratory function and general healthiness of an individual. Photoplethysmography employs a matched pair of LED-photodiode combination attached to peripheral body sites (typically finger tip, wrist, toe, and earlobe) to capture the light intensity passed through microvascular bed of tissue. A PPG sensor operates either in reflective or transmission mode, based on the principle that a momentary increase in pulsatile blood volume in the artery increases absorption of light and consequently decreases the transmitted or reflected light intensity in the receiving photodiode [1]. For transmission type (reflection mode) probing, infrared (IR) region 0.8-1 µm (green-yellow region of the spectrum, 0.5-0.6 µm) wavelength is used. The increasing interests in PPG in recent years by the biomedical research community is primarily due to its non-invasive, fast and easy acquisition, and capability to derive many surrogate physiological parameters [2].

In the last decade, PPG has been extensively used in various cardiovascular measurements, like heart rate, blood pressure (BP), respiration, arterial compliance, endothelial function, cardiac outputs (CO). Automatic blood pressure measurement and monitoring is one of the prominent areas of contemporary biomedical research [3]-[4]. Since the arterial blood pressure waveform closely resembles that of the PPG waveform, in many of the reported works, the researchers used pulse transit time (PTT) or pulse arrival time (PAT) followed by regression analysis to estimate systolic and diastolic blood pressures [5]-[7]. For continuous monitoring of BP using PPG, new sensor designs are proposed [8]-[10]. Heart rate monitoring is another area where PPG has been used. A novel sensor based on PPG is described to monitor heart rate from a mattress [11]. It has been shown that respiration has a strong correlation with the PPG signal [12]. For respiration and heart rate monitoring in children and neonatal babies, PPG seems to provide better choice over the ECG [13]-[14]. CO is another important parameter which is required to be monitored in intensive care units and exercise tests. Application of PPG for CO measurement is described in [15]-[16].