Photoplethysmogram Sensor Arrays for the Detection of Early Signs of Cardiac Disease

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Photoplethysmogram (PPG) sensor arrays are devices used to measure the volume of blood flowing through an organ. The device uses OLEDs to create an AC-Modulated light signal and then captures the signal data from beneath the skin non intrusively. Using inexpensive flat panel screens bonded to a flexible backing the device can be miniaturized and attached to the users skin so that it is not cumbersome. Data will then be used in machine learning algorithms to detect age related cardiac disease.

I. INTRODUCTION

Photoplethysmogram (PPG) Sensor Arrays are devices used to measure the volume of blood by recovering refracted or reflected light emitted from an led. PPG sensors rest on the outer layer of skin and can noninvasively display many early signs of cardiac disease. Current wearable technology is bulky and noticeable to the user. Also, current technology is noisy and not clinically relevant. Our goal is to use flexible and inexpensive organic light emitting diode (OLED) technology in a device that can clinically monitor early signs of cardiac disease. Flat panel OLED displays are readily available and inexpensive for less than 10 cents/cm [1]. This new technology will allow for multiple LEDs to be used in an array to improve the accuracy of the device.

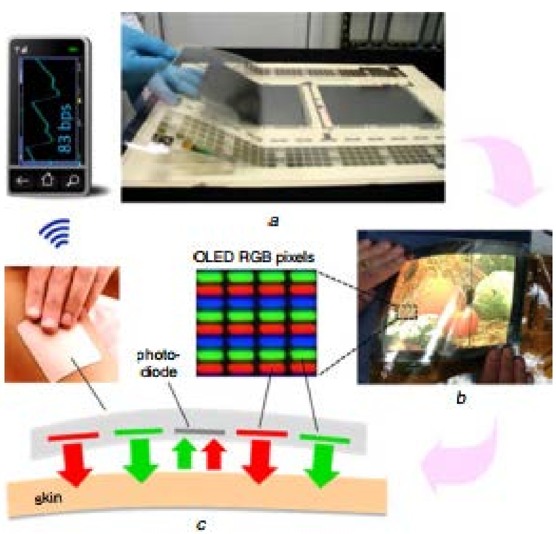

Fig. 1. PPG flexible display with oled sensors
(Fig 1.a) Manufacturing of 7.4 inch diagonal full-colour exible OLED. display at ASU Flexible Electronics and Display Center (Fig 1.b) Concept for Bluetooth connected display with alternating red and green OLEDs in an array (Fi 1.c) Example of sensor array contouring to a patient's skin

Noise reduction is a critical step to produce accurate feature extraction in PPG signals. Movement artifacts is a large source of limiting noise for PPG sensor arrays which limits their functionality. To reduce this and other noise from hardware, the signal will be run through a high pass filter which will be done in Matlab. After removing noise, feature extraction is now possible. The time period is a measure of the speed that the heart is beating at. This feature is commonly used to help determine arrhythmias in the data. Other features include the distance between the systolic and diastolic peaks which measure the hardening of the arteries which is known as arteriosclerosis. After extracting the features from the data, principal component analysis is used to compress feature space by removing features with high variance.

Training data that was preprocessed was obtained from forty different young and healthy subjects has been obtained. The data will be used to compare different subjects between the ages of 18 to 39 as “young” and ages seventy plus as “old”. This data will be used to detect the cardiac risk of individuals due to common ageing problems. While the support vector machine is commonly used, we used Matlab’s internal machine learning algorithm tester we will explore many different algorithms and compare their accuracy to find which is the best for our data set. After training, our algorithm will be able to detect the difference between a heartbeat with some form of cardiac disease and one without.

The initial testing of the sensor hardware yielded good results. The sensor could clearly show the diastolic and systolic peaks in the graph. After trying to use the sensor over other parts of the body, the strongest signal was obtained over the volar forearm. To reduce the risk of misplacing a single OLED, an array of sensors is used so that at least one will be placed in an adequate position to obtain good data. For future testing, different patterns of OLEDs can be used to decrease the dependence on position and increase the sensor's accuracy.

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