Poster Abstract: Accurately Measuring Heart Rate Using Smart Watch

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ABSTRACT

Smart watches are increasingly being used in various applications to monitor heart rate for exercise and health care purposes. It is crucial that the readings from these devices are accurate so that users can take proper actions according to the intensity of the heart rate. Taking actions from inaccurate readings can negatively impact the health of the user. In this work, we run a preliminary study that verifies the accuracy of wearable platforms by comparing the measurements with a clinically-grade device.

1. INTRODUCTION

With the advancement of low-power electronics and wireless communications, over the last decade, we have seen a dramatic increase in the number of devices that we carry around. Nowadays, not only do we carry around smartphones, as a means of ubiquitous communication, many also "wear" smart devices. An example of such a wearable device is a smartwatch. Smartwatches, not only provide a new interface for users to access the functionalities of a smartphone, but are also capable of capturing new sensing information close to a human body. Specifically, most smartwatches in the market provide additional sensing capabilities such as an additional accelerometer for the wrist and a heart rate sensor to accurately measure user activity / exercise levels. However, smartwatch vendors, themselves, admit that the accuracy of such heart rate readings may not be accurate [1]. Nevertheless, many studies suggest that using these "always-monitorable" devices can revolutionize the way we approach healthcare or clinical-care applications. This work targets to validate this possibility.

We started this study to understand the limitations and the possibility to utilize healthcare sensors on smartwatches for clinical applications. While it is well known that motion artifacts can complicate sensor readings from a mobile user, we target this study to identify accelerometer reading patterns that suggest the ineffectiveness of heart rate sensor readings. Specifically, using this knowledge, we can design autonomous signal processing software to filter out heart rate readings that may be misleading, leaving only the ones that are clinically useful. In this work, we compare the readings from two different smartphone manufacturers (i.e., Apple Watch and LG Urbane) with a different ground truth readings from a (FDA approved) Zephyr BioHarness wearable chest strap. Our results provide evidence that the accuracy of these wearable platforms does not follow the standards of a clinical-grade device.

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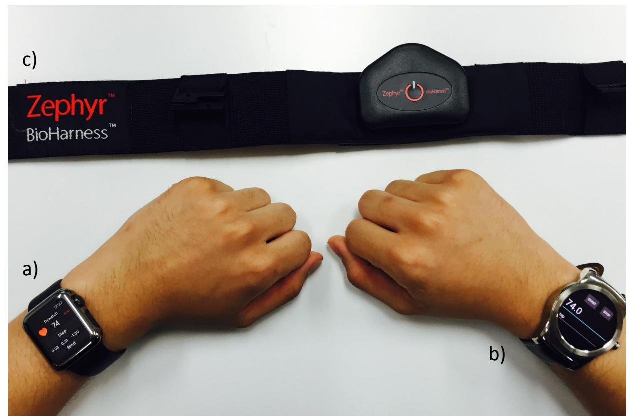

Figure 1: Heart rate readings from (a) Apple Watch and (b) LG Urbane is compared with ground truth data from (c) Zephyr BioHarness.

2. PRELIMINARY STUDY

We run our evaluation on two existing smart watches, the Apple Watch (WatchOS) and LG Urbane (Android wear), as shown in Figure 1a and Figure 1b. Both of these devices use a sensing technique called Photoplethysmography (PPG), which uses a combination of green, red, or infrared (IR) LED emitters and optical sensor to measure heart beat. BioHarness wearable chest strap, as shown in Figure 1c, is used to measure ground truth data. This device is a compact physiological monitoring module that provides clinically approved accurate heart rate readings by utilizing smart fabric technology. Note that we have also test readings from Philips IntelliVueMP70 bedside biosignal monitor to use it as an alternative ground truth device. However, we refrain from using the device since it is designed for stationary monitoring.

As a preliminary study, we conduct a two-part evaluation.

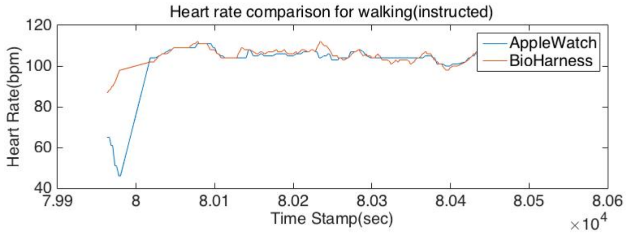

Figure 4: Heart rate data comparison between the Apple Watch and the BioHarness after calibration of the Apple Watch.

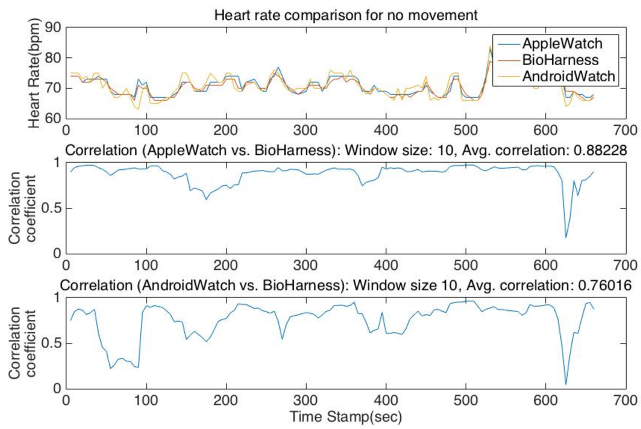

Figure 2: Similarity comparison of the Apple Watch, LG Urbane, and BioHarness while staying still.

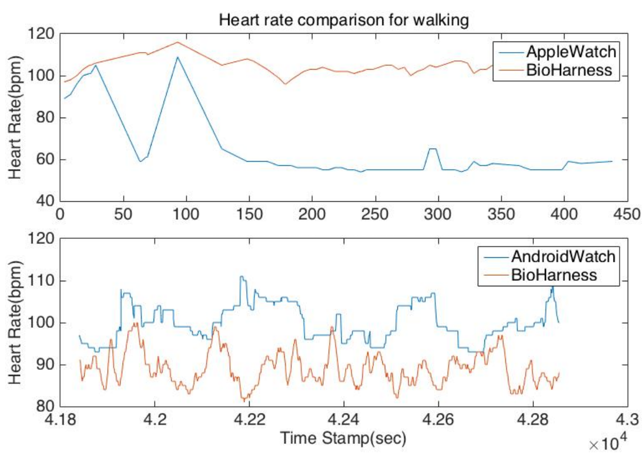

Figure 3: Heart rate data comparison of the Apple Watch, LG Urbane, and BioHarness while walking.

For the first evaluation, we test the performance on both of the watches while the participant sits on a chair and show no movement for 12 minutes. We ask the participant to wear the BioHarness on the chest while wearing the Apple watch on one of the arm and the LG Urbane on other. For the second evaluation, we test walking activity for 15 minutes. Again, the participant is instructed to wear the BioHarness on the chest. However, this time we run the experiment in two sets, separately testing each of the watches since each arm project different swinging patterns while walking.

Correlation coefficient is used to measure the similarity between heart rate samples. For every 10 samples, we compute the correlation coefficient and average the entire value to see the overall similarity. Moreover, due to different time clock set on each of these three devices, we synchronize the time on the sampled data by shifting the entire sample until the maximum average correlation coefficient is found.

As shown in Figure 2, heart rate readings for both of the watches while staying still are closely following the trend of the ground truth device. The average correlation coefficient for the Apple Watch is 0.88 and for the LG Urbane is 0.76. In contrast, on the second evaluation, both of the watches project readings that are far different from the readings of the BioHarness when the subject is moving, as shown in Figure 3. The average correlation coefficient is 0.58 for the Apple watch and 0.39 for the LG Urbane.

When monitoring heart rate data, Apple suggests that irregular movement needs to be avoided and 20 minutes walking or running calibration is necessary to measure accurate readings. We test this with the Apple Watch by first walking in a repetitive pattern for 20 minutes, so that the watch can calibrate, and then start walking again for another 20 minutes. Figure 4 shows much better results than that of the second testing. Nevertheless, repetitive movement and calibration is always necessary for accurate monitoring, and limits the users to be involved in diverse activities and restraints them from measuring accurate heart rate during short time periods.

3. FUTURE WORK

As part of our future work, we plan to further strengthen our observations by surveying medical doctors to confirm the clinical validness of the correlation between wearable platforms and clinical-grade devices. While motion artifacts heavily impacts heart rate sensor readings from wearable devices, classification of ineffective data using accelerometer readings is another direction of research we plan to seek. We believe that designing an application-level filter of incoming heart rate samples can benefit the use of these sensor components in a variety of clinical applications.

4. ACKNOWLEDGMENTS

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