HELO GUIDES

AFIB

Atrial Fibrillation Detection by HELO Wearable Devices

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Abstract

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia, associated with significant mortality and morbidity through association of risk of death, stroke, heart failure and coronary artery disease, etc. Improving detection of AF can therefore help consumers be aware of AF episodes and consult with a doctor as needed. However, AF detection remains problematic because it may be episodic. Electrocardiogram (ECG) is typically used to diagnose AF, but this is most frequently done reactively, rather than proactively. Photoplethysmography (PPG) via wearable device, such as a smartwatch, can provide continuous measurement and AF detection. In harmony with the findings of researchers, Helo wearable devices provide consumers with convenient and accurate AF detection through PPG reading and algorithmic classification.

Understanding Atrial Fibrillation

Normal sinus rhythm (NSR) is the term given to the cardiac cycles of normal resting hearts because the depolarisation of the cardiac muscle begins at the sinus node, a group of cells located in the wall of the right atrium of the heart. This rhythm produces the familiar pattern of P wave, QRS complex, and T wave. Deviations from NSR are considered cardiac arrhythmia.

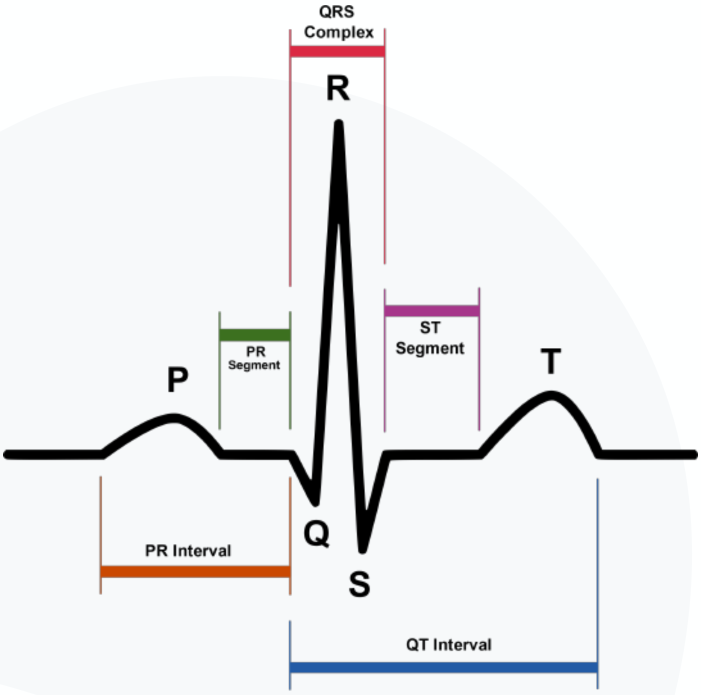


***Fig. 1**: Normal sinus rhythm of a human heart, as displayed by ECG.*[1]

Among all arrythmias, atrial fibrillation (AF) is the most common. "AF simply refers to irregularly irregular heart rate. In other words, AF is a random sequence of heart beat intervals with increased beat-to-beat variability and complexity."[2]

Detecting and Identifying AF with Consumer Devices

Given the distinct differences between NSR and AF, AF is not difficult to identify. The challenge is capturing an AF incidence, which can be difficult even with long-term electrocardiographic (ECG) monitoring due to the paroxysmal nature of AF.[3]

One research team observed, "technical options to detect atrial fibrillation have significantly improved within the past decade. However, they carry the burden of a lack of comfort, invasiveness, and costs."[4] These concerns are echoed by another team, which succinctly noted, "there is a need for a reliable, cost effective, convenient and easy-to-apply, long-term AF screening device."[5]

Researchers have therefore examined the practicality and accuracy of detecting AF via smartphone and smartwatch, given the ubiquity of such devices. If they can help solve this challenge and make AF detection easier to achieve, it would be a great benefit to anyone who has to live with this form of arrhythmia or help those who don't know they have it be aware of it.

Hardware is only part of the solution. Deciphering the recorded heart rhythm data and accurately and consistently identifying AF is the other element. To that end, researchers are developing and deploying algorithms that can accurately differentiate between NSR and AF based on smartphone or smartwatch readings.

Heart Readings by PPG to Detect AF

Photoplethysmography is an optically obtained plethysmogram that can be used to detect blood volume changes in the microvascular tissue beds and is often obtained by using a pulse oximeter which illuminates the skin to measure changes in light absorption and correlate them to the arterial hemoglobin's saturation.[6] Several studies have shown PPG to be an effective means of detecting AF. Specifically, Brasier et al state, "PPG signal analysis constitute a promising, non-invasive and cost-effective option for AF screening."[7]

This study "validated the performance of a PPG-based automated algorithm in differentiating between AF and SR." Study participants used an internet-enabled ECG (iECG) for a one-minute recording "for later analysis by at least two board-certified cardiologists" for reference.

For the PPG reading, participants placed "the smartphone camera … on an index fingertip for 5-min pulse wave recording."[8]

This team found that the Heartbeats algorithm, proprietary to Preventicus of Germany, "achieved a specificity of 99.1% and a sensitivity of 89.9% for cohesive 1-min PPG segments." Using longer segments did not significantly improve results, and in fact "led to a significant signal quality decrease in analysable files."

This led the team to conclude, "PPG-based, hardware-independent algorithms for AF detection represent a promising alternative to other established technologies, and enable convenient AF screening given that smartphones and health apps are already widely used around the globe."[9]

While McManus et al admit “the 12-lead ECG remains the gold-standard diagnostic test for AF,”[10] this team also utilized the camera from a smartphone with LED light (not specifically mentioned in the Brasier study) to detect irregular pulse using PPG (Figure 2).

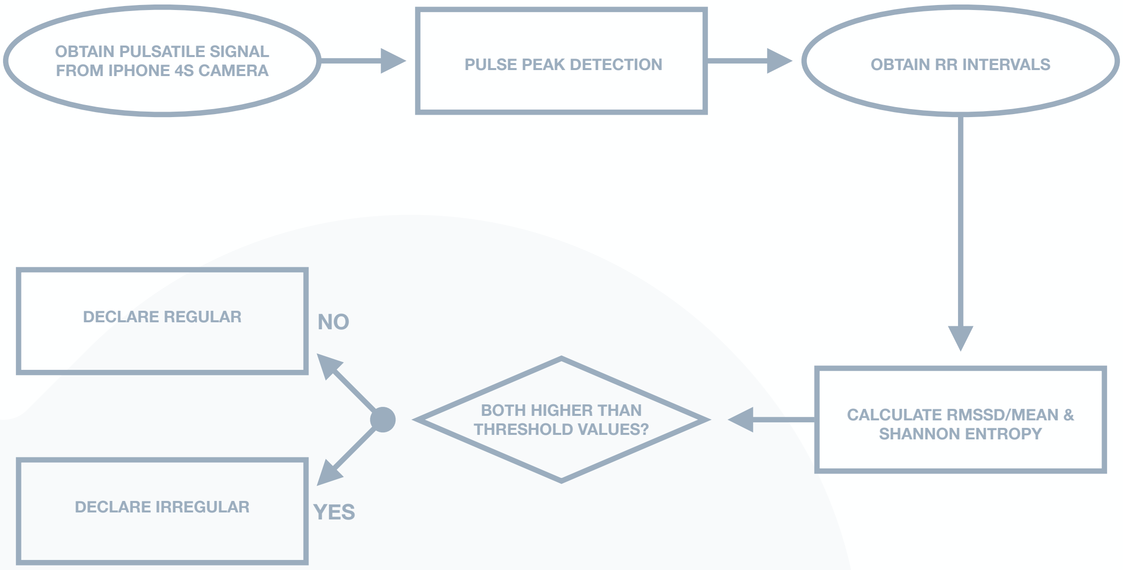


Fig. 2*: A flowchart of the pulse waveform analysis algorithm.*
RMSSD/mean = root mean square of successive RR difference.[11]

To interpret and categorize the recorded data, this team employed two statistical methods:

- Normalized root mean square of successive difference of RR intervals (nRMSSD). Quantifies variability; expected to be higher in patients with AF.
- Shannon entropy (ShE). Quantifies complexity; expected to be higher in patients with AF.[12]

Their study showed, “an algorithm combining the two statistical methods demonstrated excellent sensitivity (0.962), specificity (0.975), and accuracy (0.968) for beat-to-beat discrimination of an irregular pulse during AF from sinus rhythm.”

Krivoshei et al followed this same smartphone camera methodology to capture PPG pulse wave signals. In addition to the nRMSSD and ShE statistical methods deployed by McManus et al to analyze data, the team used Poincaré plot analysis (PPA). This is "a visual tool to characterize time series fluctuations where BBIn is plotted against BBIn−1. The index SD1/SD2 represents the ratio of the standard deviation of short-term BBI variability (axis vertical to the line of identity, SD1) to the standard deviation of the long-term BBI variability (axis along the line of identity, SD2)"[13] (Figure 3).

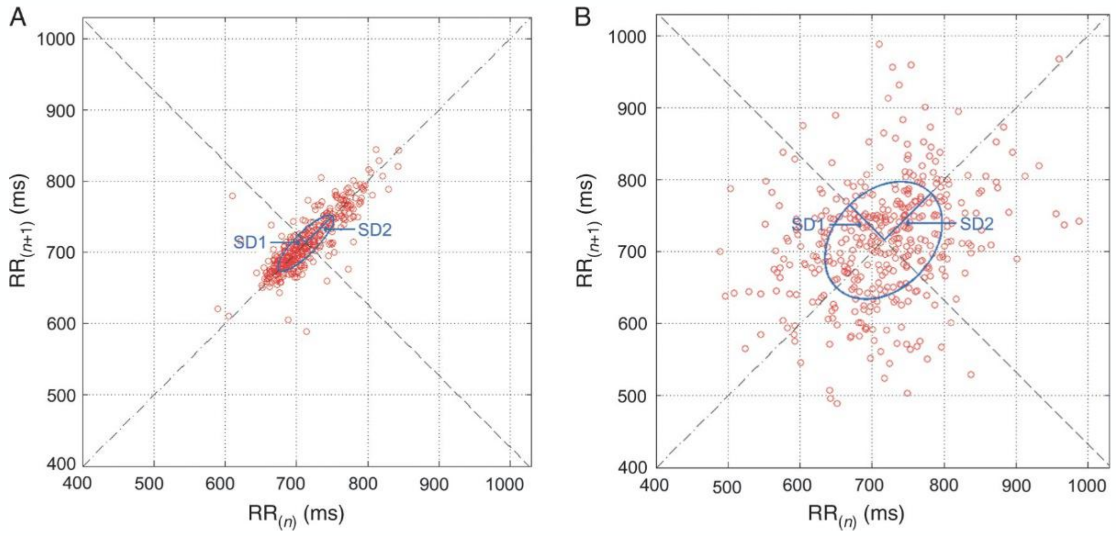
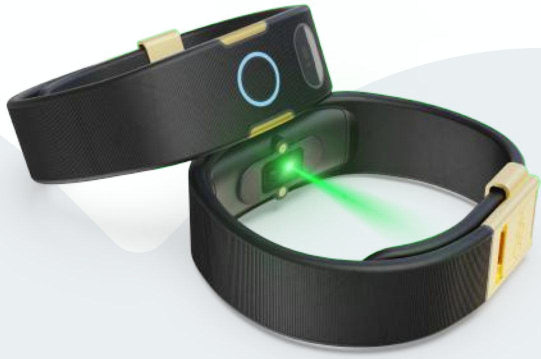


Fig. 3. *Poincaré plots of 5 min recordings from patients in NSR (A) and patients in AF (B).*[14]

"The highest sensitivity and specificity was achieved using the combination of the indices nRMSSD and SD1/SD2 .... By prolonging the analyzed interval from 2 to 5 min, we reached a sensitivity and specificity of 95%."[15]

Based on these findings, they conclude, "We have successfully tested an algorithm that reliably discriminated between SR and AF in individual patients based on pulse wave signals derived from a smartphone camera. Implementation of this algorithm into a smartwatch is the next logical step."[16]

Chiang et al took this next logical step in a 2019 study. This team developed a wearable smart watch "and evaluated its accuracy to differentiate AF from sinus rhythm."[17] The watch extracted pulse wave data from the green light spectrum, with simultaneous ECG recording.



> *Pulse-to-pulse intervals (PPI) were automatically identified.… The correlation between R-to-R interval on ECG and PPI were excellent, with a correlation coefficient R >0.99 (p<0.05). An entropy-based algorithm which combined Shannon entropy of successive difference of PPI and sample entropy of PPI was used to discriminate between AF and sinus rhythm. This method had high sensitivity and specificity (96% and 98%, respectively).*[18]

AF Detection with Helo Wearable Device

Helo is convinced smartwatches can accurately capture heart rhythm data and, using tried and tested algorithms on intelligent networks, detect AF, as substantiated in the findings outlined above.

The heart's four chambers operate in a coordinated dance to circulate blood to the body. This steady rhythm of heartbeats keeps oxygen moving to cells, keeping the body alive and ready for action. If this rhythm is disrupted, such as through AF, the body can struggle, such as heart palpitations, fainting, lightheadedness, dizziness, shortness of breath, and chest pain.

With AF detection on Helo wearable devices, users can be more aware of their heart health and take appropriate action under the guidance of a medical professional.

Conclusion

Photoplethysmography (PPG) by smartphone or smartwatch is an accurate and effective way to detect atrial fibrillation. While ECG remains, in the words of one research team, “the gold standard,” PPG has been shown to be not only convenient, but also accurate. Given the episodic nature of AF, detection by Helo wearable device even provides continual monitoring benefits over ECG that can help people who didn’t even know they had an AF issue.

Legal Disclaimer

Unless otherwise specified, Helo devices and related services are not medical devices and are not intended to diagnose, treat, cure, or prevent any disease. With regard to accuracy, Helo has developed products and services to track certain wellness information as accurately as reasonably possible. The accuracy of Helo’s products and services is not intended to be equivalent to medical devices or scientific measurement devices.

Consult your doctor before use if you have any pre-existing conditions that might be affected by your use of any Helo product or service.

Useful Terms

Atrial Fibrillation (AF): A heart arrhythmia in which the heartbeat is randomly irregular. Tends to be episodic, making detection difficult.

Photoplethysmography (PPG): An optical way to measure blood volume changes in a bed of tissue, such as a finger or earlobe. Obtained by illuminating the skin and measuring light absorption.

Electrocardiogram (ECG): Used to measure and analyze electrical activity of the heart to detect abnormalities or heart arrhythmias. Components of an ECG are outlined in the following terms.

P wave: The P wave represents depolarization of the atria. Atrial depolarization spreads from the SA node towards the AV node, and from the right atrium to the left atrium.

PR interval: The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. This interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node.

R wave: A measure of the arterial ability to expand and contract with cardiac pulsation and relaxation.

QRS complex: The QRS complex represents the rapid depolarization of the right and left ventricles. The ventricles have a large muscle mass compared to the atria, so the QRS complex usually has a much larger amplitude than the P wave.

Reference

(1) By Agateller (Anthony Atkielski), converted to svg by atom. - SinusRhythmLabels.png, Public Domain, 1 https://commons.wikimedia.org/w/index.php?curid=1560893

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