oAFD®—Optical Atrial Fibrillation Detector

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Atrial Fibrillation (AF) is predicted to affect 17.9 million of people by 2060 in Europe. Its early detection is essential as AF is associated with high comorbidities and an increased mortality. Because of their limited recording duration existing solutions – such as ambulatory electrocardiogram (ECG) – do not allow to detect AF in its early stage in large populations. Moreover, 21-50% of patients suffering from AF are asymptomatic, which makes event-triggered-measurement devices unable to detect this arrhythmia. Recent advances in photoplethysmography technology give promise to detect AF in large populations with conveniently small wearable devices at low cost.

While ECG is the gold-standard tool to monitor heart rate in clinical settings, existing tools for ambulatory monitoring are not optimal for an accurate screening of intermittent and asymptomatic AF in large population. Atrial fibrillation has a prevalence of 2.3-3.4% [1], increasing with age up to 10-17% for people 80-year-old and more [2], and is associated with an increased mortality rate. Therefore, an early detection of AF is needed to provide optimal treatment and prevent complications. Recent advances in photoplethysmography (PPG) technology are promising for screening the early paroxysmal stage of AF, as well as its asymptomatic expression. Indeed, PPG can easily be embedded in small and low-cost wearable devices such as smartwatches, which are especially adapted for screening AF in large and elderly populations.

An embedded algorithm was developed to distinguish AF from sinus rhythm (SR) (Figure 1). For this, a recurrent neural network composed of two layers – a gated recurrent unit and a sigmoid – was trained with inter-beat intervals. These inter-beat intervals (Figure 1, red line) were computed from ECG beat labels (obtained from the Long-Term AF Database from Physionet) to predict the nature of the heart rate (AF or SR).

In a recent study [3], this embedded neural network was tested to distinguish AF from SR and regular arrhythmias such as sinus bradycardia, sinus tachycardia and atrial tachycardia based on PPG-derived inter-beat intervals. 21 simultaneous PPG and ECG recordings were obtained during a clinical study conducted in the Service of Cardiology at the University Hospital of Lausanne. A beat detection algorithm was coupled with an artifact detector which identifies inter-beat intervals reflecting poor PPG signal quality. This identification was used to detect AF with two different approaches. In the first one, all data were treated for a continuous prediction while in the second approach, segments of the signal that were affected by motion artifacts or side factors were discarded prior to the RNN predictions.

When all data were given to the RNN, AF was detected with an accuracy of 93%, whereas the selection of good signal quality segments allowed to reach an accuracy of 99%. It is worth noting that the use of ECG data to train the neural network was an interesting approach, considering the large amount of data available.

These results are promising for the screening of AF in large populations. Relatively simple, the selected neural network can be easily embedded in small and light devices especially adapted for detecting AF in elderly population mostly affected by this condition. Furthermore, the reported sensitivity and specificity compare favorably with the values obtained by recently FDA-approved FibriCheck and AliveCor products (specificity of 95% and 64% and sensitivity of 97% and 99%, respectively).

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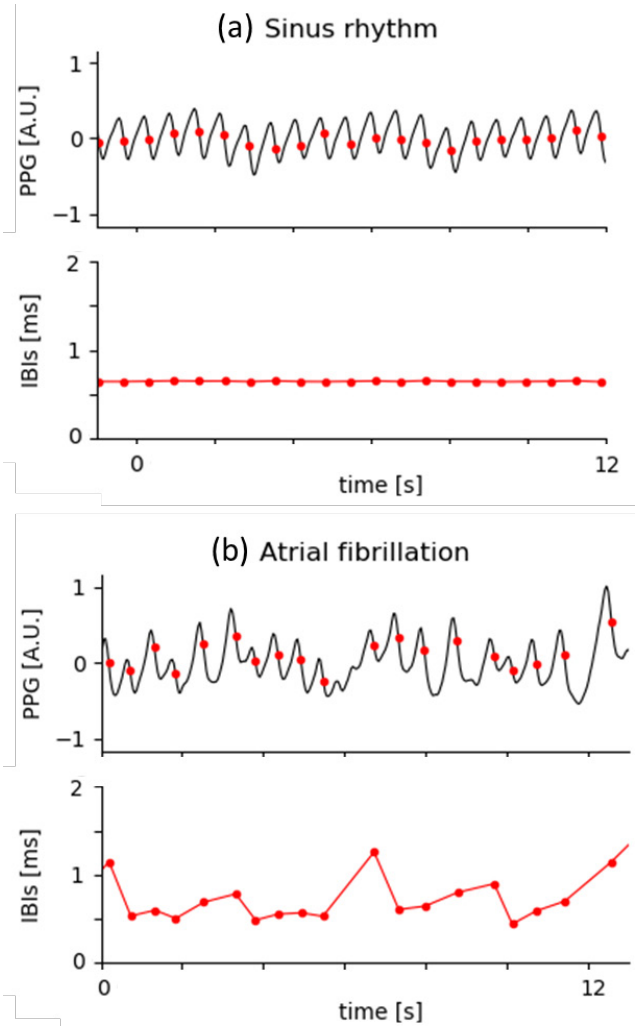

Figure 1: Two examples showing PPG signal (black line) and IBIs (red line) of (a) sinus rhythm and (b) atrial fibrillation. For (a) and (b) each detected heartbeat is noted with red dots.

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