

CLAIMS:

1. A processor implemented method, comprising:
 - 5 obtaining by one or more hardware processors, instantaneous HR from a resampled time series of RR intervals of an ECG signal specific to user, wherein the instantaneous HR is obtained for a plurality of time windows from the resampled time series;
computing by the one or more hardware processors, for each time window
10 of the plurality of time windows, a measured average heart rate (a measured $\overline{HR}$) from the instantaneous HR specific to the user;
inputting by the one or more hardware processors, to a Kalman Filter, the measured average heart rate (the measured $\overline{HR}$) and an initial estimate of an ideal $\overline{HR}$, wherein the Kalman Filter comprises a state space model that is designed
15 based on baseline dynamics of an average heart rate ($\overline{HR}$);
for each time window until a last time window of the plurality of time windows, performing:
estimating by the one or more hardware processors, an apriori state based on a last instance of an aposteriori state being initialized,
20 wherein the initialized aposteriori state is based on the initial estimate of the ideal $\overline{HR}$ fed to the Kalman filter;
determining by the one or more hardware processors, using the apriori state, an observation of the state space model of the Kalman filter;
estimating by the one or more hardware processors, an error based
25 on the observation and the measured average heart rate (the measured $\overline{HR}$), and normalizing the error thereof;
performing by the one or more hardware processors, a comparison of the normalized error with a pre-defined threshold; and
continually monitoring by the one or more hardware processors,
30 an arousal of the user based on the comparison to obtain an arousal trend; wherein the processor implemented method further comprises:

determining by the one or more hardware processors, for each time window of the plurality of time windows, a measurement noise of the state space model of the Kalman Filter based on a change in the arousal;

5 estimating by the one or more hardware processors, a Kalman gain of the Kalman Filter using the measurement noise, wherein the measurement noise is adjusted to a value based on the arousal detected, wherein the measurement noise models variations in the average heart rate associated with sinus rhythm and wherein the state space model of the Kalman filter infers the arousal trend by increasing variance of the measurement noise when a change in arousal is detected, and wherein deviation of the measured ($\overline{HR}$) from the baseline value estimated adaptively by the state space model of the Kalman filter is used to infer the arousal trend;

10 performing window-wise averaging operation for smoothing over a normal heart rate variability and wherein the measured ($\overline{HR}$) performs a slow-varying heart rate trend; and

15 updating by the one or more hardware processors, for each time window of the plurality of time windows, the aposteriori state using the Kalman gain.

20 2. The processor implemented method of claim 1, wherein the resampled time series is obtained by:

25 receiving the ECG signal pertaining to the user, the ECG signal is captured for a pre-defined time interval;

 detecting a plurality of R peaks from the ECG signal;

 determining a time series of the RR intervals based on a difference between the positions of consecutive R peaks from the plurality of R peaks;

30 filtering outliers from the time series of the RR intervals to obtain a corrected time series of RR intervals; and

resampling, at a predefined sampling rate, the corrected time series of RR intervals using a cubic spline interpolation technique.

3. A system, comprising:

- 5 a memory storing instructions;
 - one or more communication interfaces; and
 - one or more hardware processors coupled to the memory via the one or more communication interfaces, wherein the one or more hardware processors are configured by the instructions to:
- 10 obtain instantaneous HR from a resampled time series of RR intervals of an ECG signal specific to user, wherein the instantaneous HR is obtained for a plurality of time windows from the resampled time series;
 - compute, for each time window of the plurality of time windows, a measured average heart rate (a measured $\overline{HR}$) from the instantaneous HR specific
 - 15 to the user;
 - input, to a Kalman Filter, the measured $\overline{HR}$ and an initial estimate of an ideal $\overline{HR}$, wherein the Kalman Filter comprises a state space model that is designed based on baseline dynamics of an average heart rate ($\overline{HR}$);
 - estimate, for each time window until a last time window of the plurality of
 - 20 time windows, an apriori state based on a last instance of an aposteriori state being initialized, wherein the initialized aposteriori state is based on the initial estimate of the ideal $\overline{HR}$ fed to the Kalman filter;
 - determine for each time window until a last time window of the plurality of time windows, using the apriori state, an observation of the state space model
 - 25 of the Kalman filter;
 - estimate, for each time window until a last time window of the plurality of time windows, an error based on the observation and the measured $\overline{HR}$, and normalizing the error thereof;

perform, for each time window until a last time window of the plurality of time windows, a comparison of the normalized error with a pre-defined threshold; and

continually monitor, for each time window until a last time window of the plurality of time windows, an arousal of the user based on the comparison to obtain an arousal trend; wherein the one or more hardware processors are further configured by the instructions to:

determine for each time window until a last time window of the plurality of time windows, based on the estimated arousal trend, a measurement noise of the state space model;

estimate a Kalman gain of the Kalman Filter using the measurement noise, wherein the measurement noise is adjusted to a value based on the arousal detected, wherein the measurement noise models variations in the average heart rate associated with sinus rhythm and wherein the state space model of the Kalman filter infers the arousal trend by increasing variance of the measurement noise when a change in arousal is detected, and wherein deviation of the measured ($\overline{HR}$) from the baseline value estimated adaptively by the state space model of the Kalman filter is used to infer the arousal trend;

perform window-wise averaging operation for smoothing over a normal heart rate variability and wherein the measured ($\overline{HR}$) performs a slow-varying heart rate trend; and

update for each time window of the plurality of time windows, the aposteriori state using the Kalman gain.

4. The system of claim 3, wherein the resampled time series is obtained by:

receiving the ECG signal pertaining to the user, the ECG signal is captured for a pre-defined time interval;

detecting a plurality of R peaks from the ECG signal;

determining a time series of the RR intervals based on a difference between positions of consecutive R peaks from the plurality of R peaks detected;

filtering outliers from the time series of the RR intervals to obtain a corrected time series of RR intervals; and

resampling, at a predefined sampling rate, the corrected time series of RR intervals using a cubic spline interpolation technique.

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5. One or more non-transitory machine readable information storage mediums comprising one or more instructions which when executed by one or more hardware processors cause:

obtaining instantaneous HR from a resampled time series of RR intervals of an ECG signal specific to user, wherein the instantaneous HR is obtained for a plurality of time windows from the resampled time series;

computing, for each time window of the plurality of time windows, a measured average heart rate (a measured $\overline{HR}$) from the instantaneous HR specific to the user;

15 inputting, to a Kalman Filter, the measured average heart rate (the measured $\overline{HR}$) and an initial estimate of an ideal $\overline{HR}$, wherein the Kalman Filter comprises a state space model that is designed based on baseline dynamics of an average heart rate ($\overline{HR}$);

for each time window until a last time window of the plurality of time windows, performing:

estimating an apriori state based on a last instance of an aposteriori state being initialized, wherein the initialized aposteriori state is based on the initial estimate of the ideal $\overline{HR}$ fed to the Kalman filter;

25 determining, using the apriori state, an observation of the state space model of the Kalman filter;

estimating an error based on the observation and the measured average heart rate (the measured $\overline{HR}$), and normalizing the error thereof;

performing a comparison of the normalized error with a pre-defined threshold; and

continually monitoring an arousal of the user based on the comparison to obtain an arousal trend; wherein the instructions further cause:

5 determining for each time window of the plurality of time windows, a measurement noise of the state space model of the Kalman Filter based on a change in the arousal;

10 estimating a Kalman gain of the Kalman Filter using the measurement noise, wherein the measurement noise is adjusted to a value based on the arousal detected, wherein the measurement noise models variations in the average heart rate associated with sinus rhythm and wherein the state space model of the Kalman filter infers the arousal trend by increasing variance of the measurement noise when a change in arousal is detected, and wherein deviation of the measured ($\overline{HR}$) from the baseline value estimated adaptively by the state space model of the
15 Kalman filter is used to infer the arousal trend;

performing window-wise averaging operation for smoothing over a normal heart rate variability and wherein the measured ($\overline{HR}$) performs a slow-varying heart rate trend; and

20 updating for each time window of the plurality of time windows, the a posteriori state using the Kalman gain.

6. The one or more non-transitory machine readable information storage mediums of claim 5, wherein the resampled time series is obtained by:

25 receiving the ECG signal pertaining to the user, the ECG signal is captured for a pre-defined time interval;

detecting a plurality of R peaks from the ECG signal;

determining a time series of the RR intervals based on a difference between the positions of consecutive R peaks from the plurality of R peaks;

30 filtering outliers from the time series of the RR intervals to obtain a corrected time series of RR intervals; and

resampling, at a predefined sampling rate, the corrected time series of RR intervals using a cubic spline interpolation technique.