

CLAIMS

1. A processor implemented method comprising:
 - extracting in real time a plurality of non-overlapping windows from an input video with a detected face, wherein the non-overlapping windows correspond to time intervals of the input video, each of the time intervals containing an equal number of frames;
 - analyzing each of the non-overlapping windows by:
 - extracting a pulse signal from each of the non-overlapping windows;
 - estimating a first quality measure as a quality of the pulse signal in each of the frames based on out-of-plane movement in a z direction, wherein the first quality measure has $(f-1)$ values for f number of the frames;
 - estimating a second quality measure based on peak signal to noise ratio (PSNR), wherein the second quality measure is a single value for the pulse signal; and
 - post processing the pulse signal, to obtain a modelled pulse signal from each of the non-overlapping windows, by reconstructing the pulse signal at the frames affected by the out-of-plane movements using the remaining frames; and
 - tracking heart rate corresponding to the modelled pulse signal based on a Bayesian decision theory, wherein the step of tracking the heart rate comprises:
 - estimating the heart rate using the Bayesian decision theory by estimating a current heart rate corresponding to a current modelled pulse signal using previous heart rate of a preceding modelled pulse signal and the second quality measure associated with the current and the preceding modelled pulse signals; and
 - analyzing a spectrum associated with the modelled pulse signal from each of the non-overlapping windows to identify frequency of a maximum amplitude corresponding to the heart rate thereof as an HR frequency, and
 - wherein using the Bayesian decision theory comprises:

determining a quality of the previous heart rate estimate by utilizing the second quality measure;

calculating a Gaussian distribution of a prior information pertaining to a previously tracked HR and a likelihood function of a current modelled pulse signal by defining a measure of confidence in the previous heart rate estimate along with the determined quality of the previous heart rate estimate;

estimating the prior information required for current heart rate estimation, wherein the prior information is estimated by finding a normalized sum of the Gaussian distribution of the prior information and a parameter θ defined in the HR frequency ranges of 0.7 Hz to 4 Hz;

estimating the likelihood function for determining the current heart rate estimate, wherein the likelihood function is estimated by normalizing the spectrum of the modelled pulse signal corresponding to a current window;

estimating the posterior probability of heart rate frequency by applying Bayes rule, wherein the posterior probability is estimated based on the prior information and the likelihood function; and

estimating a current heart rate frequency, wherein the current heart rate frequency corresponds to the value at which posterior probability is maximum.

2. The processor implemented method of claim 1, wherein the step of extracting a pulse signal comprises:

identifying a Region of Interest (ROI) corresponding to the detected face in each of the non-overlapping windows, wherein a face area associated with the detected face is divided into non-overlapping square blocks;

performing frame registration between a previous frame and a current frame within each of the non-overlapping windows based on a pre-defined subset of facial landmark points to stabilize location of the ROI in presence of in-plane movement; and

extracting temporal signals from each of the non-overlapping square blocks of the ROI using Eulerian method, wherein the temporal signals correspond to motion or color variations in the detected face across time.

- 5 3. The processor implemented method of claim 1, wherein the step of estimating a first quality measure as a quality of the pulse signal in each of the frames based on out-of-plane movement in a z direction comprises:

10 calculating a deviation introduced by a change of location of pre-defined facial landmark points in the z direction, wherein the deviation is calculated between each pair of consecutive frames in each of the non-overlapping windows;

 estimating the first quality measure by utilizing the pre-defined facial landmark points having a largest deviation in the z direction by:

15 normalizing the deviations in the pre-defined facial landmark points in the z direction to [0,1]; and

 estimating the first quality measure by subtracting the normalized deviations such that low and high deviations result in high and low values for the first quality measure respectively.

20

4. The processor implemented method of claim 1, wherein the post processing of the pulse signal comprises reconstructing the pulse signals at the frames affected by the out-of-plane movements using Fourier basis function based pulse signal modelling, the pulse signal modelling comprising:

25 decomposing the pulse signal at the frames affected by the out-of-plane movements using the Fourier basis function;

 estimating pulse signal modelling parameters by using a weighted least square equation, wherein the pulse signal modelling parameters represent a contribution of the Fourier basis function and weights refer to the first quality measure, wherein solving the weighted least square equation is based on a pseudo inverse equation

30

for minimizing an associated weighted error, and wherein the weighted error is based on the first quality measure and a reconstruction error at each frame; and

obtaining the modelled pulse signal based on the estimated modelling parameters and the Fourier basis function.

5. A system comprising:

one or more processors; and

one or more internal data storage devices operatively coupled to the

one or more processors for storing instructions configured for execution by the one or more processors, the instructions being comprised in:

a window extractor module configured to:

extract in real time a plurality of non-overlapping windows from an input video with a detected face, wherein the non-overlapping windows correspond to time intervals of the input video, each of the time intervals containing an equal number of frames;

a window analyzer module configured to:

extract a pulse signal from each of the non-overlapping windows;

estimate a first quality measure as a quality of the pulse signal in each of the frames based on out-of-plane movement in a z direction, wherein the first quality measure has $(f-1)$ values for f number of the frames;

estimate a second quality measure based on peak signal to noise ratio (PSNR), wherein the second quality measure is a single value for the pulse signal; and

post process the pulse signal by reconstructing the pulse signal at the frames affected by the out-of-plane movements using the remaining frames to obtain modelled pulse signals; and

a heart rate (HR) tracker module configured to:

5 track heart rate corresponding to the modelled pulse signal from each of the non-overlapping windows based on a Bayesian decision theory, wherein the heart rate (HR) tracker module is further configured to track the heart rate by:

10 estimating the heart rate using the Bayesian decision theory by estimating a current heart rate corresponding to a current modelled pulse signal using previous heart rate of a preceding modelled pulse signal and the second quality measure associated with the current and the preceding modelled pulse signals; and

15 analyzing a spectrum associated with the modelled pulse signal from each of the non-overlapping windows to identify frequency of a maximum amplitude corresponding to the heart rate thereof as an HR frequency, and wherein the heart rate (HR) tracker module is further configured to use the Bayesian decision theory by:

20 determining a quality of the previous heart rate estimate by utilizing the second quality measure;

25 calculating a Gaussian distribution of a prior information pertaining to a previously tracked HR and a likelihood function of a current modelled pulse signal by defining a measure of confidence in the previous heart rate estimate along with the determined quality of the previous heart rate estimate;

30 estimating the prior information required for current heart rate estimation, wherein the prior information is estimated by finding a normalized sum of the Gaussian distribution of the prior information and a parameter θ defined in the HR frequency ranges of 0.7 Hz to 4 Hz;

- estimating the likelihood function for determining the current heart rate estimate, wherein the likelihood function is estimated by normalizing the spectrum of the modelled pulse signal corresponding to a current window;
- 5 estimating the posterior probability of heart rate frequency by applying Bayes rule, wherein the posterior probability is estimated based on the prior information and the likelihood function; and
- 10 estimating a current heart rate frequency, wherein the current heart rate frequency corresponds to the value at which posterior probability is maximum.
6. The system of claim 5, wherein the window analyzer module is further configured to extract the pulse signal by:
- 15 identifying a Region of Interest (ROI) corresponding to the detected face in each of the non-overlapping windows, wherein a face area associated with the detected face is divided into non-overlapping square blocks;
- performing frame registration between a previous frame and a current frame within each of the non-overlapping windows based on a pre-
- 20 defined subset of facial landmark points to stabilize location of the ROI in presence of in-plane movement; and
- extracting temporal signals from each of the non-overlapping square blocks of the ROI using Eulerian method, wherein the temporal signals correspond to motion or color variations in the detected face across time.
- 25 7. The system of claim 5, wherein the window analyzer module is further configured to estimate a first quality measure as a quality of the pulse signal in each of the frames based on out-of-plane movement in a z direction by:
- calculating a deviation introduced by a change of location of pre-
- 30 defined facial landmark points in the z direction, wherein the deviation is

calculated between each pair of consecutive frames in each of the non-overlapping windows;

estimating the first quality measure by utilizing the pre-defined facial landmark points having a largest deviation in the z direction by:

5 normalizing the deviations in the pre-defined facial landmark points in the z direction to [0,1]; and

 estimating the first quality measure by subtracting the normalized deviations such that low and high deviations result in high and low values for the first quality measure
10 respectively.

8. The system of claim 5, wherein the window analyzer module is further configured to post process the pulse signal by reconstructing the pulse signals at the frames affected by the out-of-plane movements using Fourier basis function based pulse signal modelling, wherein the pulse signal modelling comprises:
15

 decomposing the pulse signal at the frames affected by the out-of-plane movements using the Fourier basis function;

 estimating pulse signal modelling parameters by using a weighted least square equation, wherein the pulse signal modelling parameters represent a contribution of the Fourier basis function and weights refer to the first quality measure, wherein solving the weighted least square equation is based on a pseudo inverse equation for minimizing an associated weighted error, and wherein the weighted error is based on the first quality measure and a reconstruction error at each frame; and
20
25

 obtaining the modelled pulse signal based on the estimated modelling parameters and the Fourier basis function.