FacePulseRate: A Suite of Features to Use with iPhys Toolbox

Calculate frame-by-frame blood volume pulse (BVP) and windows of pulse rate from a face present within an input video. FacePulseRate is designed to supply output from the four (as of November, 2019) pulse-rate algorithms provided by iPhys Toolbox (McDuff & Blackford, 2019). Additionally, FacePulseRate ...

- Breaks down pulse rate into windows, permitting pulse rate to vary across time.
- Automically positions a face ROI for each frame.
- Provides enhanced skin segmentation.
- Provides separate versions of each of the four algorithms while controlled for variation in luminance across frames (see Madan et al., 2018). This is in addition to providing the four versions without controlling for luminance.
- Provides verification of ROI placement and skin-segmentation by providing an annotated output video. Arguments are available to make adjustments to ROI placement and skin-segmentation based upon inspection of the output video.

Treatment of Pulse Rate Variations Across Time

The method in iPhys Toolbox for deriving pulse rate derives BVP from a span of time, the limitation of which is that changes in pulse rate across this span are not calculated. Although methods exist to derive a continuous measure of pulse rate from BVP as calculated from a sensor attached directly to the body, these methods do not appear to be appropriate for BVP captured from a video because of the additional noise present in the video. To provide a somewhat continuous measure of pulse rate while retaining the method used in iPhys Toolbox, the current function breaks the video into windows (the duration of which can be specified by PulseRateWindowDurationSec) and applies the method used in iPhys Toolbox to each.

Input

Color Videos.

Supported file extensions include ...

- .mp4
- .avi

Other file extensions may be supported.

For additional discussion and recommendations, see "Video and Recording Environment Recommendations.pdf".

Output

The BVP and pulse rate results are provided, along with additional information, as output tables. Included among the additional information are the input video timestamps and means from the red, green, and blue color channels of an ROI from each frame; these two components of the data are the basis for the BVP. These tables are also written to CSV files. As previously mentioned, an output video is provided to facilitate corrections to ROI placement and skin segmentation. Examples of corrections are provided in file Example_Script.mlx.

Use of Pretests

When planning a study, pretests should be conducted where video as well as traditional measures of pulse rate (e.g., PPG, ECG) are recorded. The traditional measures of pulse rate should be used to validate the use of video-derived pulse rate for expected behavioral tendencies. This is because the accuracy of video-derived pulse rate is highly dependent on the degree of facial movement, where greater movement tends to result in video-derived pulse rate that is less accurate. The four pulse-rate algorithms may vary in accuracy depending on the degree of movement. The pulse-rate algorithm with greatest accuracy in a given context should be used. For a detailed discussion of the key features and technical implementation, see the description in function FacePulseRate.

System Requirements

- 64-bit Windows

Currently, 64-bit macOS has not been implemented or tested.

Software Requirements

- Matlab. FacePulseRate has been tested on Matlab versions 2020a and 2020b. Matlab can often be acquired without cost through a university affiliation.

The following Matlab toolboxes are also required. Note that these toolboxes require corresponding licenses from Matlab. However, these can often be acquired without cost through

a university affiliation. These are the toolbox names as of Matlab release 2020b; toolboxes are occassionally renamed.

- Statistics and Machine Learning Toolbox
- Computer Vision System Toolbox
- Image Processing Toolbox
- Signal Processing Toolbox
- DSP System Toolbox
- Optimization Toolbox

Instructions

Most of the features of FacePulseRate occur automatically, so few lines of code need to be used to return results under default options. For example, once the required toolboxes have been installed and FacePulseRate Toolbox is placed on Matlab's path, entering the following line in Matlab is all that is needed to return results:

```
FacePulseRate(<\...\MyInputVideo.mp4>);
```

Setup

1. Install Matlab on a Windows 64-bit computer. Matlab version 2020a or later is recommended. Matlab is often provided at no cost through a university affiliation.

2. Install the following Matlab toolboxes. As of Matlab version 2020b, Matlab toolboxes can be installed in the Matlab environment through Apps > Install App. The following toolboxes are often provided at no cost when using an academic license.

- Statistics and Machine Learning Toolbox
- Computer Vision System Toolbox
- Image Processing Toolbox
- Signal Processing Toolbox
- DSP System Toolbox
- Optimization Toolbox

3. Download the folder that contains the functions for FacePulseRate. This folder is named 'FacePulseRate'. As of October 2020, FacePulseRate can be found on Github.com under the username 'dpmagill' as a fork to McDuff and Blackford's (2019) iPhys Toolbox.

General Instructions

See file "Examples_General_Instructions.mlx".

This script is aimed at users with no previous experience with Matlab and introductory experience with programming languages.

Note: .mlx files can only be displayed in the Matlab Environment.

Corrections to ROI Placement or Skin Segmentation

See "Examples_Correct_ROIs_and_Skin_Segmentation.mlx".

Note: .mlx files can only be displayed in the Matlab Environment.

Implementation

For a detailed discussion on the implmentation of FacePulseRate, see file FacePulseRate.m. Additional discussion is included in the helper files to FacePulseRate.m.

License and Third-Party Software Acknowledgements

GNU General Public License, Version 2

code concerned.

RAIL License

In addition to the aforementioned GNU General Public License, this program is licensed under the terms of the Responsible AI License (RAIL).

Third-Party Software Acknowledgements

FacePulseRate is only possible through the use of third-party open-source software. The author is grateful for its use.

See an acknowledgement of third-party software in file 'FacePulseRate/License/Third-Party Software Acknowledgements.txt'.

References

Madan, C. R., Harrison, T., & Mathewson, K. E. (2018). Noncontact measurement of emotional and physiological changes in heart rate from a webcam. Psychophysiology, 55(4), e13005.

McDuff, D., & Blackford, E. (2019). iphys: An open non-contact imaging-based physiological measurement toolbox. In 2019 Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 6521-6524.