README for MR-NIRP Car Dataset release

MERL-Rice Near-Infrared Pulse (MR-NIRP) Car Dataset for Camera-Based Vital Signs Estimation in Narrow-Band Near-Infrared During Driving

Please cite the following paper when using the dataset:

Ewa M. Nowara, Tim K. Marks, Hassan Mansour, and Ashok Veeraraghavan, "Near-Infrared Imaging Photoplethysmography During Driving *IEEE Transactions on Intelligent Transportation Systems* (2020)

Dataset

We release the first dataset of face videos for imaging photoplethysmography (iPPG) during driving that were collected simultaneously in broadband RGB (with a standard color camera) and narrow-band NIR (near-infrared), with pulse oximeter recordings as ground truth of the vital signs. This dataset gives researchers the ability to understand the difficulties of and evaluate systems' performance on estimation of vital signs during realistic driving.

Organization of Files

The dataset contains a separate directory for each of the 18 subjects. Each subject's directory contains 10 subdirectories corresponding to each of 10 driving experiments (i.e., 10 conditions for data collection), listed below. Each of these 10 subdirectories itself has 3 subdirectories:

1. NIR contains the images recorded with the NIR camera.
2. *PulseOX* contains the pulse oximeter recordings, saved as the Matlab data file pulseOx.mat.
3. RGB contains the raw images captured with RGB camera.

The two cameras and pulse oximeter recordings were synchronized during data collection, so the frame numbers in each directory are in correspondence.

Note that although there were 18 subjects, there are 19 subject folders. Subject 2 and Subject 16 are the same person recorded during the day and at night, respectively. Therefore, Subject 16 does not contain the garage experiments, since they would duplicate those of Subject 2. When

including Subject 2 or Subject 16 in a test set, the other one should not be in the training set. For leave-one-subject-out cross validation, we treated subject 2 and subject 16 as the same subject and included them in the same validation splits.

Data Collection and Hardware Details

We recorded videos in a car of 18 healthy subjects (2 female), aged 20–60 years old, with varying skin tones (Indian, Caucasian, Asian). Of the 16 male subjects, 4 had facial hair. To decouple the effects of motion and ambient light variations on the quality of the iPPG signals, we recorded videos in the car in two different driving conditions: inside the garage, and city driving. Inside the garage, the engine was running but the car was parked. During the driving scenario, we drove around the block in the city, where we often had to stop at traffic lights. All the recordings captured inside the garage were 2 minutes long; the recordings captured during driving ranged from 2–5 minutes in duration, depending on how long it took us to drive around the block due to the traffic. In all of the conditions, the subject sat in the front passenger seat.

We simultaneously recorded videos with an RGB camera and an NIR camera. We used the RGB FLIR Grasshopper3 GS3-PGE-23S6C-C (sensor format: 'rggb'), and an NIR monochrome camera, Point Grey Grasshopper GS3-U3-41C6NIR-C, fitted with either (1) a narrow-band 940 nm bandpass filter with 10 nm passband, or (2) a 975 nm bandpass filter with 50 nm passband. The lenses we used had focal length 8mm for the NIR camera and 4.5 mm for the RGB camera. We used four Bosch EX12LED-3BD-9W illuminators. Each illuminator was fitted with both the 95˚ diffuser in the vertical direction and the 80˚ diffuser in the horizontal direction, to widen the beam in order to more uniformly illuminate the face. We did not provide additional light in the visible spectrum, so the RGB camera used whatever ambient light was (or was not) available. We used a CMS 50D+ finger pulse oximeter to obtain a ground-truth PPG waveform recorded at 60 fps. The raw 10-bit images were recorded with 640 × 640 resolution at 30 fps. When the images were well exposed, we always set the gain to zero, and when it was very dark, we increased the gain until the face region was sufficiently bright.

List of the 8 experiments (8 data collection conditions)*:

1. *driving_still_940*: Driving with passenger trying to sit still (*minimal head motion* condition), recorded with 940 nm filter
2. *driving_still_975*: Driving with passenger trying to sit still (*minimal head motion* condition), recorded with 975 nm filter
3. *driving_small_motion_940*: Driving with additional head motion (*additional head motion* condition), recorded with 940 nm filter
4. *driving_small_motion_975*: Driving with additional head motion (*additional head motion* condition), recorded with 975 nm filter
5. *driving_large_motion_975*: Driving with large head motion (*not reported in the paper due to large errors*), recorded with 975 nm filter
6. *garage_still_940*: Inside the garage and parked car with passenger sitting still (*minimal head motion* condition), recorded with 940 nm filter
7. *garage_still_975:* Inside the garage and parked car with passenger sitting still (*minimal head motion* condition), recorded with 975 nm filter

8. *garage_small_motion_940*: Inside the garage and parked car with head motion (*additional head motion* condition), recorded with 940 nm filter
9. *garage_small_motion_975*: Inside the garage and parked car with head motion (*additional head motion* condition), recorded with 975 nm filter
10. *garage_large_motion_975*: Inside the garage and parked car with head motion (*not reported in the paper due to large errors*), recorded with 975 nm filter

Still (*minimal head motion*) conditions: The participants were asked to sit as still as possible and did not talk during these experiments. However, even though the subjects tried to sit still, they still moved significantly during driving because of the motion of the car (acceleration, deceleration, and turning). Therefore, even the still conditions were very challenging during driving.

Small_motion (*additional head motion*) conditions: The participants were asked to move their heads naturally, e.g., look at rear-view and side-view mirrors and talk. However, the participants were instructed to avoid large, sudden movements and avoid large out-of-plane rotations of the head.

Large_motion (*not reported in the paper due to large errors*) conditions: The participants were asked to significantly and suddenly move their heads out of plane.

* The experiments with "*still"* in the file name are referred to as "minimal head motion" in the paper, and those with "*small_motion"* in the file name are referred to as "additional head motion" in the paper. The experiments with "large_motion" in the file name were not reported in the paper due to large errors.