Overview

With the burgeoning of wearable devices and passive body/brain-computer interfaces (B/BCIs), automated stress monitoring in everyday settings has gained significant attention recently, with applications ranging from serious games to clinical monitoring. With mobile users, however, challenges arise due to other overlapping (and potentially confounding) physiological responses (e.g., due to physical activity) that may mask the effects of stress, as well as movement artifacts that can be introduced in the measured signals. For example, the classical increase in heart rate can no longer be attributed solely to stress and could be caused by the activity itself. This makes the development of mobile passive B/BCIs challenging. In this paper, we introduce PASS, a multimodal database of Physical Activity and StresS collected from 48 participants. Participants performed tasks of varying stress levels at three different activity levels and provided quantitative ratings of their perceived stress and fatigue levels. To manipulate stress, two video games (i.e., a calm exploration game and a survival game) were used. Peripheral physical activity (electrocardiography, electrodermal activity, breathing, skin temperature) as well as cerebral activity (electroencephalography) were measured throughout the experiment. A complete description of the experimental protocol is provided and preliminary analyses are performed to investigate the physiological reactions to stress in the presence of physical activity.

The PASS database, including raw data and subjective ratings has been made available to the research community at https://musaelab.ca/pass-raw-dataset/. It is hoped that this database will help advance mobile passive B/BCIs for use in everyday settings.

Data organization

The data is separated in directories containing the data for each subject. Each of these directories contains 5 files (4 for each device and 1 for key logging). Some folders might contain more files if logging was interrupted and restarted. Devices files are in csv format and can be parsed using this matlab parser.

Notice that in the case of Bioharness3 and Empatica E4, more than one modality was simultaneously recorded. The following table presents a summary of the modalities monitored by each device (i.e. can be found in the .csv file), along with the respective sampling rate used during the collection.

	Modality	Sampling rate (Hz)
Muse	EEG	220
Empatica E4	Skin temperature	4
	Galvanic skin response	4
	Blood volume pulse	64
	Acceleration	32
Bioharness3	ECG	250
	Breathing rate	25
	3-axis acceleration	18

The data contains markers to indicate the start and end of each experimental condition. However, a corrected and valid version of these markers can be found in the file "correctedMarker.csv". The counterbalance table can be accessed here. The following table summarizes the experimental conditions.

Experimental condition	Condition start code	Condition end code
Practice (0)	10	20
Timeframe (1)	11	21
Timeframe (2)	12	22
Timeframe (3)	13	23
Outlast (4)	14	24
Outlast (5)	15	25
Outlast (6)	16	26

The file PASS_Subjective_Database.csv contains the NASA-TLX ratings and the BORG scale ratings.

Feature database

A simplified version of the dataset can be accessed at https://musaelab.ca/pass-database/. This version hosts a single mat file. This file contains a table with metadata and with over 1000 neurophysiological features computed over epochs of 5 minutes.

Loading the data

After downloading the four parts of the database, run the following bash commands (from your Downloads folder) to have all subfolders in a single directory.

```
# Moving all subfolders to a single directory
mkdir PASS_dataset
mv ./PASS_dataset1/* ./PASS_dataset
mv ./PASS_dataset2/* ./PASS_dataset
mv ./PASS_dataset3/* ./PASS_dataset

# Removing empty directories
rm PASS_dataset1
rm PASS_dataset2
rm PASS_dataset3
```

Citing the database

In case you use our database in your research, please cite our manuscript published by Frontiers in Neuroscience using the following BibTeX entry:

```
@article{parent2020pass,
  title={PASS: A Multimodal Database of Physical Activity and Stress for Mobile Passive Body/Brain-Computer Interface Research},
  author={Parent, Mark and Albuquerque, Isabela and Tiwari, Abhishek and Cassani, Raymundo and Gagnon, Jean-Fran{\c{c}}ois and Lafond, Daniel and Tremblay, S{\'e}bastien and Falk, Tiago H},
  journal={Frontiers in Neuroscience},
  volume={14},
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  year={2020},
  publisher={Frontiers}
}
```