Empatica Embrace Plus Specifications (Physiological Tracking)

Which features can be collected and extracted with this device?

Empatica EmbracePlus is a wearable device designed for continuous physiological monitoring. It is marked as a medical device according to MDD 93/42/EEC.

It is primarily used to collect and extract data related to the following features:

- Optical PPG (Photoplethysmogram) for Pulse Rate (PR) and Pulse Rate Variability (PRV) measurements
- Oxygen Saturation
- Electrodermal activity (Ventral EDA sensor)
    - Detects subtle changes in electrical conductance at the surface of the skin
- Accelerometer and Gyroscope
    - Raw accelerometry data and motion intensity detection
- Digital temperature sensor
    - Reads peripheral skin temperature
- Inter-beat interval [IBI] (Systolic peaks)
- Rest
    - Sleep patterns, including the duration and quality of sleep.
- Steps and activity
    - Tracks physical activity, including steps taken, distance traveled, and calories burned
- It also senses the wearing detection.

The Empatica Health Monitoring Platform uses two formats of files, Avro[1] and CSV and it provides three types of data:

- Raw data is the high-frequency data recorded by the EmbracePlus sensors.

Raw data is stored in Avro files. EmbracePlus creates a new Avro file about every 15 minutes of data collected. A single Avro file contains a continuous portion of

[1] Avro is an open-source project that provides data serialization and data exchange services. It provides a compact, fast, binary data format, allowing a significant reduction in the size of the stored data files. Avro data format is platform-independent, and it offers an official API for Phyton, Java, C, C#, and C++, and also supported by the MATLAB interface.

data, meaning that in case of any gap (e.g., because of a charging period) a new file is created.

- Digital Biomarkers are pre-processed data by Empatica's proprietary algorithms. They can be:
  - eda
  - movement-intensity
  - prv
  - pulse-rate
  - respiratory-rate
  - sleep-detection
  - spo2
  - temperature
  - wearing-detection

- Reports are data summaries for a group of participants that provide an overview of different physiological and behavioral metrics. They can be:
  - wearing-detection-report
  - autonomic-arousal-report
  - physical-activity-report
  - sleep-report

Physiological Parameters measurement			
	Range	Resolution	Accuracy
Pulse Rate	24 - 240 bpm	1 bpm	Accuracy (no motion): 3 bpm A_{rms} Accuracy (motion): 5 bpm A_{rms}
PRV - RMSSD	Typical range: 0 - 300 ms	0.01 ms	98% of positive agreement, with respect to the ECG. Absolute relative error < 10%. The comparison was made on recordings of healthy subjects in still conditions.
Respiration Rate	6 - 60 rpm	1 rpm	3 rpm A_{rms}

Temperature	0°C - +50°C	0.1°C	± 0.1°C within 30.0°C - 45.0°C range
Electrodermal Activity	0.01 µSiemens – 100 µSiemens	1 digit ~ 900 pSiemens	N/A
Rest Detection	0 - 400 (0-99: wake epoch; 100-299: rest epoch; 300-399: rest interruption epoch; 400: for future use)	N/A	The Rest detection algorithm did not miss any of the 46 PSG-derived sleep periods (Sensitivity = 100%). On average, the Rest detection algorithm detected an earlier sleep onset and a later sleep offset, with an overall longer sleep period duration compared to PSG.
SpO_2	70% - 100%	1 %	3% A_{rms}

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How are such features related to arousal and valence?

Physiological tracking is closely related to arousal and valence, which are two dimensions of affect that reflect the intensity and pleasantness/unpleasantness of an emotional experience.

Arousal refers to the level of physiological activation associated with an emotional experience, such as increased heart rate, respiration rate, and skin conductance. High levels of arousal are typically associated with emotions such as fear, excitement, or anger, while low levels of arousal are associated with emotions such as calmness or relaxation.

Valence, refers to the pleasantness or unpleasantness of an emotional experience. Positive emotions, such as happiness or joy, are associated with high valence, while negative emotions, such as sadness or fear, are associated with low valence.

By monitoring these physiological signals, researchers can gain insight into how different learning experiences or interventions affect learners' emotional states, and how these emotional states are related to learning outcomes. This information can be used to develop more effective learning interventions that are tailored to learners' emotional needs, and to better understand the complex interplay between emotion and learning.

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How could we relate such features to learning?

There are multiple studies in the literature which relate physiological tracking, with devices such as the Empatica embrace plus, to different learning activities and environments. Such studies seek to analyze physiological signals to gain a deeper understanding on:

- Stress detection
- Dynamic changes of EDA
- Classification of learning styles
- Sleep and memory consolidation
- Physical activity
- Attention

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How to cite this document

Morán-Mirabal, L.F., Favaroni-Avila M., L.E., Ruiz-Ramirez, J.A. *Empatica Embrace Plus Specifications (Physiological Tracking). https://hdl.handle.net/112867656561476*

Document Change Control

Date	Version	Description of Change	Made By
09/Dec/2022	1.0	Document Creation	Moran, L.
05/Apr/2024	2.0	The document handle link is included	Ruiz, A.