BU-EEG: EEG-Based Multi-modal Emotion Database

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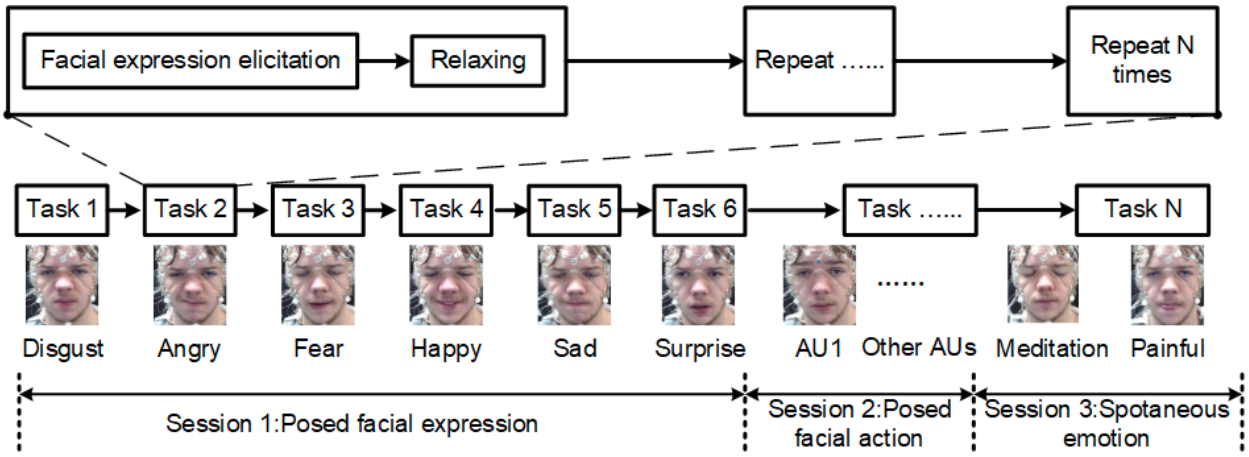
Emotion Elicitation Protocol

BU-EEG contains three sessions in the experiment for simultaneous collection of EEG signals and facial action videos, including posed expressions, action units, and spontaneous emotions, respectively. A total of 2,320 experiment trials were recorded, which is a considerably sized database for research. The tasks these sessions are shown in the table:

Sessions	Task	Activity	Target Expression or Emotion	Trial times
1	1	Imitate the facial expression	Anger	3
	2	Imitate the facial expression	Disgust	3
	3	Imitate the facial expression	Fear	3
	4	Imitate the facial expression	happiness	3
	5	Imitate the facial expression	Sadness	3
	6	Imitate the facial expression	Surprise	3
2	1	Imitate the facial action	AU1: Inner Brow Raiser	5
	2	Imitate the facial action	AU2: Outer Brow Raiser	5
	3	Imitate the facial action	AU4: Brow Lowerer	5
	4	Imitate the facial action	AU5: Upper Lid Raiser	5
	5	Imitate the facial action	AU6: Cheek Raiser	5
	6	Imitate the facial action	AU9: Nose Wrinkle	5
	7	Imitate the facial action	AU12: Lip Corner Puller	5
	8	Imitate the facial action	AU15: Lip Corner Depressor	5
	9	Imitate the facial action	AU17: Chin Raiser	5
	10	Imitate the facial action	AU20: Lip stretcher	5
	11	Imitate the facial action	AU23: Lip Tightener	5
	12	Imitate the facial action	AU25: Lips Apart	5
	13	Imitate the facial action	AU27: Mouth Stretch	5
3	1	Meditation: Close eyes and have a rest	Neutral or relax	1
	2	Cold pressor: Submerge hand into ice water	Physical pain	1

The whole procedure of experiment is shown in the Figure.



Database Organization

In this dataset, we provide (for details of these files, please see next chapter):

Data	Timestamps	Derivatives
EEG raw data	**EEG timestamps**	**EEG features (DE)**
Recorded videos	**Video timestamps**	**Cropped face images**

Note: EEG electrode position file is also provided as the auxiliary file when extracting EEG signal.

EEG Raw Data

The EGI's GTEN™ 100 Research Neuromodulation System has been used for EEG data collection. It has 128 sensors to both record brain electrical activity and modulate it without additional sponge pads or electrodes. EGI's Net Station Acquisition software is designed for the acquisition of dense-array EEG data. We use equipment with 128 sensors to record the EEG signal. The 128 sensors can cover the forehead and cheeks, providing more sensitive and reliable capture ability for facial action analysis.

The raw data is in **/BU-EEG/EEG_rawdata**, there are 29 .mat files which are corresponding to 29 subjects, all experimental trials of each subject are included in one .mat file. We set the sample frequency at 1000 Hz or 250 Hz (for details, please refer to the EEG timestamps file) and

chose the cut-off frequency for the Net Amps high-pass filter, with a 0.1 Hz cutoff by default. For how to extract the corresponding EEG meta-data of each trial, please refer to the **EEG Timestamps and Video Timestamps**.

Recorded Videos

For each subject **/BU-EEG/Recorded_videos**, there are 29 .mov videos corresponding 29 subjects, all experimental trials of each subject are included in one .mov file. Here we provide the cropped videos which focus the head area of the participants. The videos have a frame rate of 24fps and the resolution is 250x350. These videos are used to record the facial actions during the data collection. For how to extract the corresponding face images of each trial, please refer to the **EEG Timestamps and Video Timestamps**.

EEG Timestamps and Video Timestamps

System synchronization is a critical process for data collection from multi-modality sensors. Both of the EEG recording system and video recording software can generate timestamps when starting and ending the recording process. Due to the booting delay of EEG device, there is relatively a time offset for the recording time of EEG signal and frontal face video. The time offset of 29 subjects are different, but the same for all the trials from one subject. By comparing and calculating the timestamps of starting time from different sensors, we can obtain the synchronized signal accurately.

The timestamps of the starting time and ending time for every trial are recorded in the file **/BU-EEG/EEG_timestamps/EEG_timestamps.csv** and **/BU-EEG /Video_timestamps /Video_timestamps.csv**. By using the timestamps information, user can easily navigate when we start and end the experiment in both EEG file and video file.

About how to get a well-synchronized meta-data from both modalities, we provide an example to extract the facial images and EEG signal of first trial for subject one's happy expression imitation:

- Step one: Use a software and library e.g. python and openCV to load and read the video file.
- Step two: Load the **Video_timestamps.csv**, and get the starting time and ending time for the exact trial you need. In this case, we can cut the sequence from 267s to 273s. See the figure below:

	A	B	C	D	E	F	G	H
1	Subject_ID	Gender	Capture rate	Time interval with EEG(Earlier than EEG)(Second)	Anger(Duration of each trail)(Second)	Disgust(Duration of each trail)(Second)	Fear(Duration of each trail)(Second)	Happiness(Duration of each trail)(Second)
2	Sub_1	Male	24	53	34.0 38.0||73.0 81.0||93.0 100.0	118.0 124.0||142.0 147.0||153.0 158.0	188.0 193.0||211.0 218.0||233.0 238.0	267.0 273.0||287.0 292.0||303.0 308.0
3	Sub_2	Male	24	50	36.0 38.0||55.0 57.0||97.0 99.0	120.0 123.0||137.0 139.0||164.0 167.0	220.0 223.0||245.0 249.0||195.0 199.0	270.0 274.0||290.0 294.0||316.0 319.0
4	Sub_3	Male	24	69	23.0 28.0||42.0 47.0||72.0 77.0	100.0 104.0||126.0 131.0||152.0 157.0	180.0 185.0||199.0 204.0||223.0 227.0	244.0 247.0||269.0 274.0||292.0 297.0
5	Sub_4	Male	24	64	33.0 35.0||70.0 74.0||97.0 102.0	124.0 127.0||150.0 155.0||173.0 177.0	128.0 135.0||219.0 224.0||241.0 248.0	272.0 282.0||297.0 305.0||318.0 328.0
6	Sub_5	Male	24	70	40.0 45.0||66.0 70.0||92.0 98.0	118.0 122.0||142.0 147.0||164.0 168.0	190.0 193.0||217.0 220.0||240.0 245.0	268.0 271.0||293.0 296.0||315.0 320.0
7	Sub_6	Male	24	70	29.0 34.0||56.0 60.0||81.0 86.0	114.0 118.0||137.0 141.0||166.0 170.0	200.0 204.0||227.0 230.0||260.0 263.0	296.0 300.0||329.0 331.0||354.0 358.0
8	Sub_7	Male	24	12	69.0 74.0||84.0 89.0||98.0 102.0	111.0 116.0||138.0 144.0||157.0 163.0	187.0 194.0||206.0 213.0||224.0 230.0	254.0 260.0||270.0 276.0||288.0 295.0
9	Sub_8	Male	24	13	58.0 62.0||67.0 70.0||78.0 82.0	92.0 98.0||105.0 111.0||117.0 123.0	140.0 144.0||151.0 155.0||162.0 166.0	177.0 182.0||188.0 191.0||199.0 204.0
10	Sub_9	Male	24	48	33.0 38.0||52.0 56.0||70.0 75.0	87.0 92.0||101.0 106.0||118.0 123.0	134.0 140.0||151.0 154.0||166.0 171.0	181.0 187.0||196.0 202.0||215.0 220.0

- Step three: Check the capture rate and output the face images frame by frame according to the timestamps. To make the face images clearer, user can utilize some cropping tools to reach it.

- Step four: Use a software and library e.g. MATLAB and EEGLAB to load and read the EEG .mat file. Then load the **EEG_timestamps.csv** to find the corresponding time slot recording. Check the capture rate and output the EEG data. Finally, we can get a well-synchronized meta-data from two modalities.

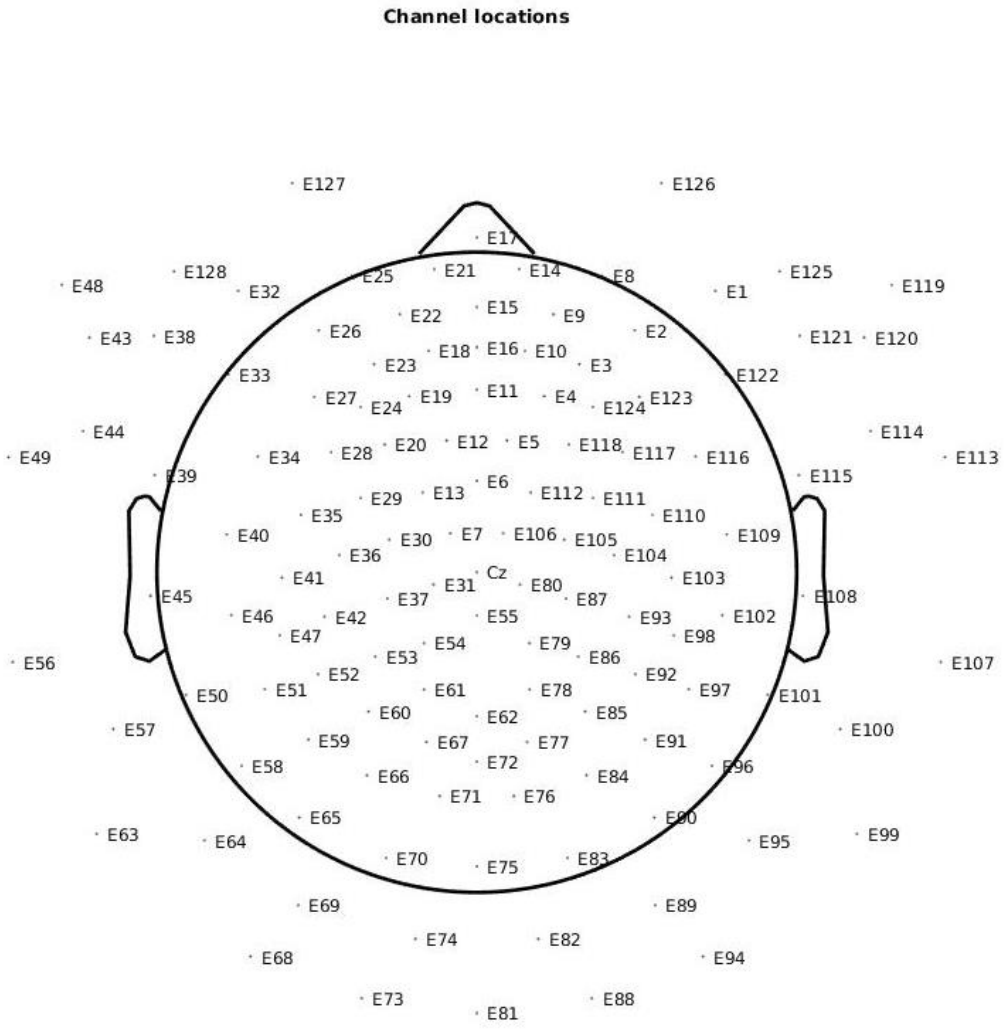
Note: The timestamps are accurate to second-level, if users find any redundant data is generated or important sequences are missing when using it to do the data extraction, you can consider adjust the timestamps to a more detailed time level by observing corresponding videos.

We also remove some of the trials if any inevitable noise is introduced when collecting the data. We leave a blank in the timestamps file to indicate that the corresponding trials no longer exist.

Besides that, the information like subject ID, gender, capture frequency rate and time interval of data synchronization are also contained in the timestamps files.

EEG electrode position

This .sfp records the distribution of all electrodes position when capturing the EEG activity of all participants. User can use the file to navigate the specific electrode channel by using library like EEGLAB. For more details, see the figure below.



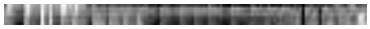
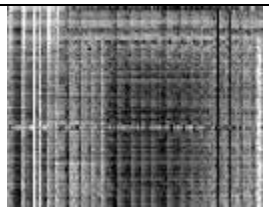
EEG features (DE)

The folder structure of the EEG features is BU-EEG -> EEG_features -> Feature_*type* -> Sub_*number* -> *Task_name* -> Trial_*number*. For instance, **/BU-EEG /EEG_features /Feature_A/Sub_001/Anger/Trial_1** shows that you are visiting the EEG feature A, the subject number is 001, the task name is Anger, the trial number is 1. Under each /Trial_*number* folder, there are several sequential frames (.jpeg files) of the extracted EEG feature maps, which are named of 0001 to xxxx.

Directory **/BU-EEG/EEG_features** contains three handcrafted features extracted from EEG raw data. After applying the band-pass filter, we use the short-term Fourier transform (STFT) to extract Power spectral density (PSD) features, and calculate the Differential Entropy (DE). We apply a 1 s time window without overlap in meditation and pain tasks. Considering these two

tasks are long-time period, to balance the data for each task, we set the same time window but with 0.9s overlap in the other tasks.

The three types handcrafted features are separately in three folders **/Feature_A**, **/Feature_B**, **/Feature_C**. Feature A is derived by the DE feature from 5 frequency bands (Delta:0.1~4 Hz, Theta:4~8 Hz, Alpha:8~14 Hz, Beta:14~31 Hz, and Gamma:31~50 Hz). Feature B is derived by 7 frequency bands (0.1~4 Hz, 4~8, 8~14 Hz, 14~31 Hz, 31~50 Hz, 50~75 Hz, and 75~100 Hz). And Feature C is same as the extracted DE feature with 100 frequency bands. Combining with 128 location channels, the three feature maps are in size of 5x128(feature A), 7x128(feature B), and 100x128(feature C), respectively. For details, please refer to the paper we list at the end of this user guide. For the visualization images of the 3 types of features, see the table below:

Feature A	Feature B	Feature C
		

Cropped face images

The folder structure of the cropped face is BU-EEG -> EEG_features -> Cropped_face -> Sub_*number* -> Task_*type* -> Trial_*number*. For instance, **/BU-EEG /Cropped_face /Sub_001/Anger/Trial_1/** shows that you are visiting the cropped face data, the subject number is 001, the task name is Anger, the trial number is 1. Under each /Trial_*number* folder, there are several sequential frames (.jpeg files) of the cropped face images, which are named of 0001 to xxxx.

We record a video of every subject from a frontal camera with 24 frames per second. During the data processing, we extract all frames corresponding to the selected EEG data. We then crop the faces and resize them by 120x120 using the OpenCV face detector and landmark detector.

Note: Due to the difference of the frequency rate for EEG device and camera, we can not map each EEG feature frame to each cropped face frame one by one. Here we provide a brief table to show how the EEG feature frame maps to the corresponding cropped face frame.

Task name	Cropped face frames per second	EEG features per second
Tasks in Session 1 and 2	10	24

Tasks in Session 3	1	24

User can decide which EEG feature frame is matched with which cropped face frame according to this table. For example, if you try to map the frames of Session 1or 2 from different modalities, considering that we have 10 frames of cropped face per second and 24 frames of EEG feature per second, user can make it in this way: cropped face frame 1 -> EEG feature frame 2, cropped face frame 2 -> EEG feature frame 4, cropped face frame 3 -> EEG feature frame 6, cropped face frame 4 -> EEG feature frame 8, cropped face frame 5 -> EEG feature frame 10…..cropped face frame 10 -> EEG feature frame 20, then ignore the rest frames of EEG feature.

Citation

- Xiaotian Li, Xiang Zhang, Huiyuan Yang, Xing Zhang, Wenna Duan, Weiying Dai and Lijun Yin. “An EEG-Based Multi-Modal Emotion Database with Both Posed and Authentic Facial Actions for Emotion Analysis” In *IEEE International Conference on Automatic Face and Gesture Recognition*. 2020.