the Telepathy Guide Book for Dummy

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1 Abstract

Telepathy, as coined word used to be popular in Gothic imagination and psycho-analysis, is misused by recent scholars and converted into ideas such as *implicit interaction* or *silent speech*. This paper rediscover the concept of telepathy and discuss the possible implement of telepathy in modern Brain-computer Interface (BCI) context.

This paper describe design and implement of two telepathy applications based on two popular BCI paradigms respectively: ERP(Event-Related Potentials) and ERD/ERS (Event-Related De/Synchronizations). The first one typically involves the immediate potential change after the stimulation of certain frequency of flash light, which could be decoded into binary signal for text-based communication. The second one could be feeded into machine learning model to regress measure a mid-term emotional state for emotion sharing.

2 Introduction

The word telepathy, coined in 1882 by poet Frederic Myers, is initially defined as *forms of occult relation or communication between people at distance.*[1] Historically, it is a fancy topic strongly connected with Gothic imagination, woman's hyper-sensitivity and psycho-analysis.[2]

the coin of telepathy

Sympathetic resonance in John Tyndall's Sound

an oxymoronic of intimacy tele- and touch -pathos

Forms of occult relation or communication between people at distance. An ancient concept in many cultures.

There are two major paradigm of adopting EEG signals: Event-Related Potentials(ERP) and Event-Related De/Synchronizations(ERD/ERS).[3]

Event-Related potential generally involves the change of electrical potential after sensory stimulation. Based on stimulation type, scholars cut them into subcategories such as Auditory Evoked Potentials (AEP), Visual Evoked

1. Roger Luckhurst et al., *The invention of telepathy, 1870-1901* (Oxford University Press on Demand, 2002).

2. Sigmund Freud, "Dreams and telepathy," in *The Standard Edition of the Complete Psychological Works of Sigmund Freud, Volume XVIII (1920-1922): Beyond the Pleasure Principle, Group Psychology and Other Works* (1955), 195–220.

3. Soraia M Alarcao and Manuel J Fonseca, "Emotions recognition using EEG signals: A survey," *IEEE Transactions on Affective Computing*, 2017,

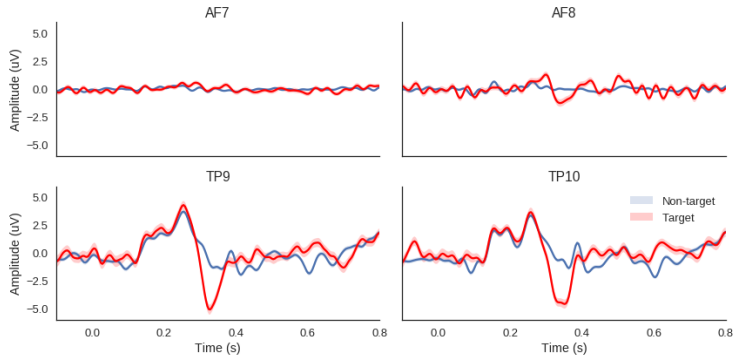

Figure 1: An example of P300 signal from Dr. Alexandre Barachant

Potentials (VEP) and Somatosensory Evoked Potentials (SsEP).[4] VEP is typically implemented by giving a flash light or flash pattern on monitor to produce change of electrical potential on different electrodes location. VEP is elicited by a tone stimulus through earphones and SsEP by a direct electrical stimulation of nerve system. The ERP could provide high temporal resolution about the immediate influence of a brief stimuli. Among which P300, the positive deflection in voltage with a latency of roughly 250 to 500 ms is the most common signal used for VEP.

ERD/ERS, on the other hand analysis the power change within certain frequency band of across electrodes. The increase of band power is defined as ERS while decrease as ERD. The ERD/ERS approach is commonly used for measuring the existing reaction to affection related communication, such as the emotion state of people or motion imaginary.

3 Binary Communication Approach based on ERP

4 Emotional Sharing Approach based on ERD/ERS

4.1 Design Consideration

- **Reader**: The hardware of mind reader is an Emotiv Epoch 16-Channel EEG headset. It captures the raw EEG data at 240HZ and sends raw EEG to **Server** by Bluetooth.

- **Server**: The server is a Thinkpad X1 Carbon with Win 10 Pro running the software. The software would first filter the data, remove artifacts such as eye movement or acceleration[5] 4. Then the cleaned data would go through Fast Fourier Transformation mapping into band power. The band power would be send to a pre-trained **Model**: A Random Forest based emotion classifier. For each class, a score would be scaled to 0-9. A regression is conducted first and then converted into binary value on 3

4. Alarcao and Fonseca, "Emotions recognition using EEG signals: A survey."
5. Tan Thi Thai Le et al., *Method and system for detecting and classifying the mental state of a subject*, US Patent 7,865,235, January 2011.

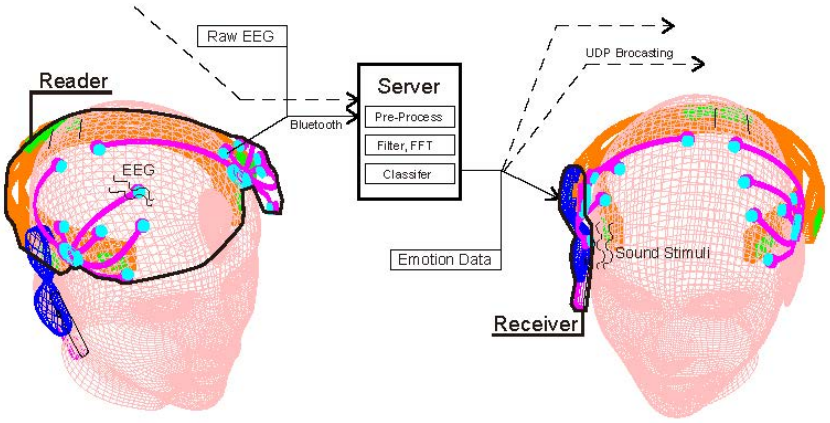

Figure 2: The Composition and data flow of Emotional Sharing Approach

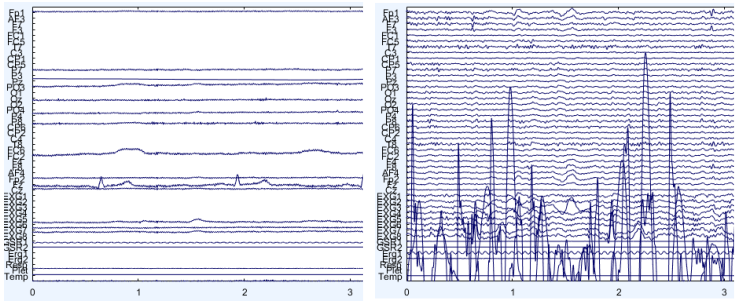

Figure 3: A sample of unfiltered (left) and filtered (right) data

dimensional, which contains [high/low arousal, high/low valence, high/low dominance]. The three bool information would be then converted to one of the eight emotions [Excitement: HHH, Joy: LHH, Contempt: LHL, Surprise: HHL, Anger: HLH, Distress: HLL, Fear: LLH, Shame: LLL] would be passed through Speech Synthesis and send to the **Receiver**.

- **Receiver**: The actuator is as simple as a wireless earpod receiving the synthesized sound from **Server** and play the sound to people wearing it.

When put on and connected to the Server, the device would iterative send EEG data to the server. The server would estimate the distance between users by Bluetooth signal strength. When two users are close enough, the server would send the synthesized sound containing her emotion state description to each other iterative.

In this way, the emotion condition could be shared between people involuntarily.

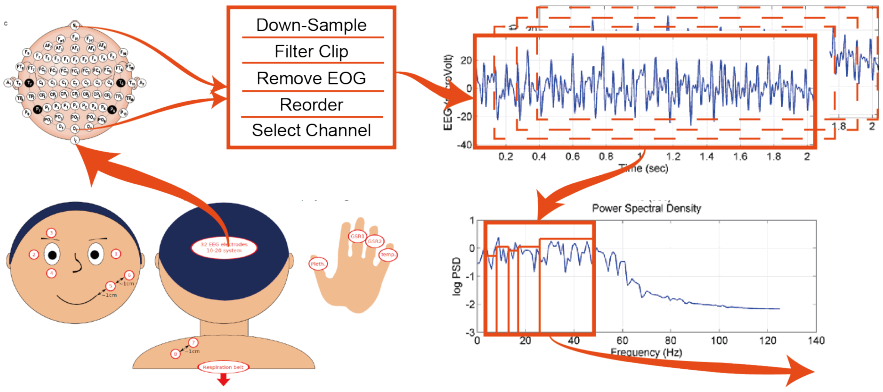

Figure 4: The pre-processing procedure diagram

4.2 Data Pre-processing

The DEAP dataset[6] is preprocessed in Matlab with EEGLab with following procedure: down-sampled from 512Hz to 128Hz, EOG artifacts remove by ICA, a bandpass filter [4.0-45.0] Hz applies, and reorders with Subject ID from 1-32. Each subject is asked to perform 40-trails, each trail is composed of a 2 sec informative screen, a 5 sec baseline, a 1 minute display of video and a self-assessment score sheet. The sheet from subjects are regarded as ground truth, this include a a discrete 9-point scale for valence, arousal, dominance and like and a 5-point scale for familiarity for each video.

After data filtering and matching, a Fast Fourier Transformation(FFT) is performed in Python with PyEEG to calculate band powers. The band powers are selected as follows: [4-8]Hz theta band, [8-12]Hz alpha band, [12-16]Hz low beta band, [16-25]Hz high beta band and [25-45]Hz gamma band. To satisfy the standard of Emotiv, the channel chosen from 10-20 system is [AF3, F3, F7, FC5, T7, P7, O1, AF4, F4, F8, FC6, T8, P8, O2].

4.3 Model Selection and Training

Some researchers[??] convert directly from the 0-9 score to 0/1 binary category and then conduct classification. This is an intuitive approach however lose the ranking information of each user toward each video. In this paper, the raw score is adopted directly and feed into regression model instead of classification model, and later the regression result is converted into binary category.

Several popular regression algorithm are selected such as Support Vector Regressor, Random Forest Regeressor, AdaBoost Regressor and Artificial Neural Network. As tested, the Random Forest generally out perform other model with minimal training time and light weight. An random forest with Minimum Number of Sample Leaf = 2 and Number of Estimator = 512 is chosen for best performance, and the model performs fair on all three categories. For binary classification, [Arousal = 82.7 %, Valence = 83.7%, Dominance = 81.8%, Liking

6. Sander Koelstra et al., "Deap: A database for emotion analysis; using physiological signals," *IEEE Transactions on Affective Computing* 3, no. 1 (2012): 18–31.

	SVM	RF	Ada	ANN 500	ANN 3000
Accuracy H/L Valence	60.5%	**83.7%**	61.5%	59.1%	81.4%
Regression Error	1.62	**1.09**	1.92	1.76	1.35

Table 1: Cross Model Comparsion: SVM: Support Vector Machine, RF: Random Forest, Ada: AdaBoost, ANN 500: Artificial Neural Network epoch = 500

	N Es 10	N Es 100	N Es 250	N Es 512	N Es 750
Min Leaf 2	77.4%	81.5%	83.0%	**83.7 %**	82.1%
Min Leaf 10	-	76.2%	-	-	-
Min Leaf 50	-	68.2%	-	-	-

Table 2: Random Forest Regression Parameter Tuning: N Es: Number of Estimator, Min Leaf: Minimum Number of Sample Leaf

= 85.1%].

4.4 Conclusion

4.5 Discussion

References

Alarcao, Soraia M, and Manuel J Fonseca. "Emotions recognition using EEG signals: A survey." *IEEE Transactions on Affective Computing*, 2017.

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Le, Tan Thi Thai, Nam Hoai Do, William Andrew King, Hai Ha Pham, Johnson Thie, and Emir Delic. *Method and system for detecting and classifying the mental state of a subject.* US Patent 7,865,235, January 2011.

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