

Prediction of Finger Flexion

4th Brain-Computer Interface Data Competition

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The goal of this element of the competition is to predict the flexion of individual fingers from signals recorded from the surface of the brain (electrocorticography (ECoG)). This data set contains brain signals from three subjects, as well as the time courses of the flexion of each of five fingers. The task in this competition is to use the provided flexion information in order to predict finger flexion for a provided test set. The performance of the classifier will be evaluated by calculating the average correlation coefficient r between actual and predicted finger flexion.

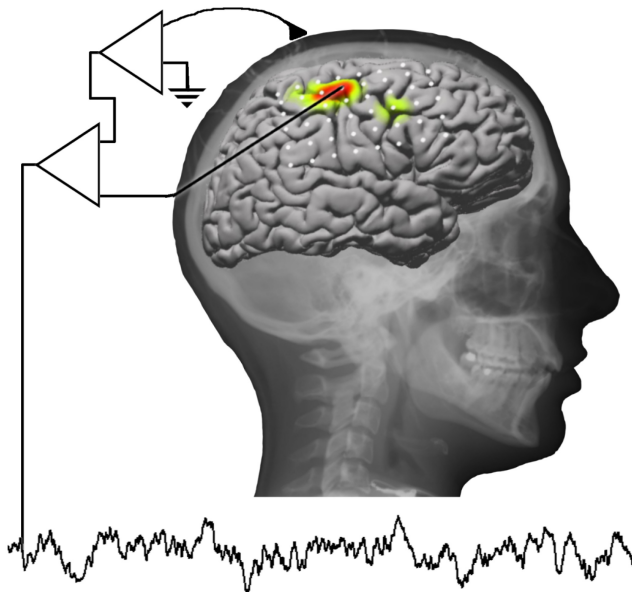


FIG. 1: ECoG signals in `train_data(time,channel)` and `test_data(time,channel)` were acquired from each electrode with respect to a scalp reference and ground before re-referencing with respect to the common average.

I. SUBJECTS

The three subjects in the data set were epileptic patients at Harborview Hospital in Seattle, Washington. Each patient had electrode grids placed subdurally on the surface of the brain for the purpose of extended clinical monitoring and localization of seizure foci. Each subject gave informed consent to participate in this study, which was approved by the internal review board (IRB) of Harborview Hospital. All patient data have been anonymized according to IRB protocol in accordance with HIPAA regulations.

II. RECORDINGS

Signals from the electrode grid were amplified and digitized using Synamps2 amplifiers (Neuroscan, El Paso, TX). The general-purpose BCI system BCI2000 [1] provided visual stimuli to the patient, acquired brain signals from the Synamps2 system, and also recorded the flexion of individual fingers (on the hand contralateral to the implanted grid) using a data glove (Fifth Dimension Technologies, Irvine, CA). BCI2000 stored the brain signals, the timing of stimulus presentation, and the flexion of each of the fingers in a data file. Data files were converted to Matlab format for this competition. Each patient had subdural electrode arrays (Ad-Tech, Racine, WI) implanted. Each array contained 48-64 platinum electrodes that were configured in 8x6 or 8x8 arrangements. The electrodes had a diameter of 4 mm (2.3mm exposed), 1 cm inter-electrode distance, and were embedded in silastic. Electrocorticographic (ECoG) signals (i.e., 62, 48, and 64 channels from subjects 1, 2, and 3, respectively) were acquired with respect to a scalp reference and ground (Fig. 1), band pass filtered between 0.15 to 200 Hz, and sampled at 1000 Hz.

III. EXPERIMENTAL PROTOCOL

The subjects were cued to move a particular finger by displaying the corresponding word (e.g., "thumb") on a computer monitor placed at the bed-side (Fig. 2). Each cue lasted two seconds and was followed by a two-second rest period during which the screen was blank. During each cue, the subjects typically moved the requested finger 3-5 times. This number varied across subjects and fingers. There were 30 movement stimulus cues for each finger (i.e., a total of 150 cue presentations and about 90-150 flexions of each finger); stimulus cues were interleaved randomly. This experiment lasted 10 minutes for each subject.

Subsequent offline analysis showed that ring (4th) fin-

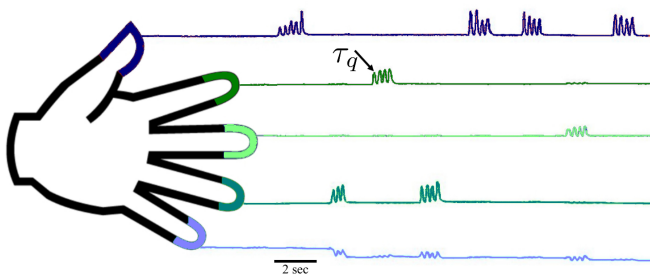


FIG. 2: Capturing individual finger flexion: each subject moved a finger several times in response to a visual cue. Finger flexion was recorded using a dataglove. The task in this competition is to use the provided ECoG signals to predict the flexion of each finger during the last 1/3 of the experiment.

ger movements were correlated with either middle (3^{rd}) or little (5^{th}) finger movements. Thus, while this ring (4^{th}) finger position is included with the training data, it will not be used for evaluation purposes.

IV. DATA STRUCTURE

The data for each subject are contained in a separate MATLAB file that is named “*subX_comp.mat*” where “*X*” denotes the subject number. Each file contains three variables:

- “*train_data*” - this variable, in $time \times channels$, gives the first 2/3 (6 min, 40s) of recorded ECoG signals (400,000 samples at 1kHz sampling rate per channel) from the specified experiment, for every channel.
- “*train_dg*” - this variable, in $time \times finger$ is the first 2/3 (6 min, 40s) of recorded finger position (thumb - index - middle - ring - little; 400,000 samples (super-sampled to 1 kHz) per finger) for the associated experiment.
- “*test_data*” - this variable, in $time \times channels$, gives the last 1/3 (3 min, 20s) of recorded ECoG signals (200,000 samples at 1kHz sampling rate per channel) from the specified experiment, for every channel. These data will be used to predict the final 1/3 (3 min, 20s) of recorded finger position (thumb - index - middle - ring - little) for the associated experiment.

Please note that the channel order has been scrambled.

V. EVALUATION CRITERIA

Each participating group will submit three files titled “*sub1_eval*”, “*sub2_eval*”, and “*sub3_eval*”, corresponding to subjects 1-3, respectively. Each of these will contain a single variable, “*eval_dg*,” with dimensions $200,000 \times 5$:

- “*eval_dg*” - this variable, in $time \times channels$, shall give the last 1/3 (3 min, 20s) of predicted finger flexion for each of the five fingers (thumb - index - middle - ring - little) for the associated experiment (200,000 samples per finger).

The evaluation criteria will be as follows: for each subject, the received variable “*eval_dg*” will be compared with the actual finger positions in “*test_dg*,” which we have retained. We will calculate the correlation coefficient r between the actual and the predicted finger flexions for each subject and finger. We will not calculate the correlation coefficient for the 4^{th} (ring) finger, because the flexion of this finger was typically correlated with the flexion of the 3^{rd} (middle) or 5^{th} (little) finger. The variable for predicted position should still be of dimension $200,000 \times 5$ (i.e., the 4^{th} column will not be used for evaluation). The final score will be calculated as the arithmetic mean of the 12 correlation coefficients (4 per subject, 3 subjects). The submission with the highest score wins the competition.

VI. SOME THINGS TO KEEP IN MIND...

- The lag between the dataglove position measurement recording and the amplifier measurement is 37ms (± 3 ms, SEM). This is of the same order of granularity in the dataglove position (which was sampled at 25Hz - every 40ms).
- There is a characteristic delay between brain activity and resulting finger movement. You may want to take this into account.
- Please cite [2] when you use this dataset in a publication.

[1] Schalk, G., McFarland, D.J., Hinterberger, T., Birbaumer, N., and Wolpaw, J.R. BCI2000: a general-purpose brain-computer interface (BCI) system, *IEEE Trans Biomed Eng*, 51(6): 1034-1043, 2004.
 [2] Schalk, G., Kubanek, J., Miller, K.J., Anderson, N.R.,

Leuthardt, E.C., Ojemann, J.G., Limbrick, D., Moran, D.W., Gerhardt, L.A., and Wolpaw, J.R. Decoding Two-Dimensional Movement Trajectories Using Electrocorticographic Signals in Humans, *J Neural Eng*, 4: 264-275, 2007.