Machine Learning :

**MEG( Magnetoencephalography Dataset) And Acquisition**

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**2. Abstract**

Magnetoencephalography (MEG) is a powerful neuroimaging technique used to measure the magnetic fields generated by neuronal activity in the brain. The aim of this project is to collect high-quality MEG datasets for the purpose of analyzing brain dynamics associated with cognitive and neurological functions. This report outlines the process of acquiring MEG data from publicly available sources, with a primary focus on ethical, standardized, and reproducible data collection methods.

**3. Dataset 1 :**

* **Dataset Title:** "**A magnetoencephalography dataset for motor and cognitive imagery BCI**"
* **Dataset Link: https://doi.org/10.6084/m9.figshare.c.5101544.v1**  
  [Springer Nature](https://springernature.figshare.com/)

**4. Data Acquisition :**

MEG data were recorded with a 306-channel (102 magnetometers and 204 planar gradiometers) Elekta Neuromag system (Elekta Oy, Helsinki,Finland) located at the Northern Ireland Functional Brain Mapping (NIFBM) Facility of the Intelligent Systems Research Centre, Ulster University. All the participants were screened for any metallic foreign substance e.g. jewelry, coins, keys or any other ferromagnetic material before entering the magnetically shielded room. The standard fiducial landmarks (left and right preauricular points and Nasion), five head position indicator (HPI) coils (placed over scalp), and the additional reference points over the scalp were digitized (Fastrak Polhemus system) to store information about the participant's head position, orientation, and shape. In addition, ocular and cardiac activities were recorded with two sets of bipolar electro-oculogram (EOG) electrodes (horizontal-EOG and vertical-EOG) and one set of electrocardiogram (EKG) electrodes, respectively. Before starting the data acquisition, the complete procedure and the experimental paradigm were described to the participants. All recordings were made with participants seated on a comfortable chair approximately 80 cm away from the projector screen and in upright position of MEG scanner. The MEG signals were filtered at a bandwidth of 0.1-300 Hz (online) and sampled at the rate of 1 kHz during the acquisition itself. Continuous head position estimation was started after 20 s of raw data recording and kept running for rest of the acquisition period.

**5. Dataset 2 :**

* **Dataset Title:** "**A magnetoencephalography dataset for motor and cognitive imagery-based brain–computer interfacing**"
* **Dataset Link:** [**https://doi.org/10.6084/m9.figshare.13561976**](https://doi.org/10.6084/m9.figshare.13561976)  
  [Springer Nature](https://springernature.figshare.com/)

**6. Data Acquisition :**

MEG data were recorded with a 306-channel (102 magnetometers and 204 planar gradiometers) Elekta Neuromag*TM* system (Elekta Oy, Helsinki, Finland) located at the Northern Ireland Functional Brain Mapping (NIFBM) Facility of the Intelligent Systems Research Centre, Ulster University. Elekta Neuromag*TM* system (Elekta Oy, Helsinki, Finland) is installed with MaxShield*TM* system which is a high-performance magnetic shielding system designed and optimised for bioelectromagnetic measurements using Elekta Neuromag*TM*. The system consists of structurally optimal magnetically shielded room with internal active shielding. All the participants were screened for any metallic foreign substance e.g. jewelry, coins, keys or any other ferromagnetic material before entering the magnetically shielded room. The standard fiducial landmarks (left and right pre – auricular points and Nasion), five head position indicator (HPI) coils (placed over scalp), and the additional reference points over the scalp were digitized (Fastrak Polhemus system) to store information about the participant’s head position, orientation, and shape. In addition, ocular and cardiac activities were recorded with two sets of bipolar electro – oculogram (EOG) electrodes (horizontal – EOG and vertical – EOG) and one set of electrocardiogram (EKG) electrodes, respectively. Before starting the data acquisition, the complete procedure and the experimental paradigm were described to the participants. All recordings were made with participants seated on a comfortable chair approximately 80 cm away from the projector screen and in upright position of MEG scanner. The MEG signals were filtered at a bandwidth of 0.01–300 Hz (online) and sampled at the rate of 1 kHz during the acquisition itself. Continuous head position estimation was started after 20 s of raw data recording and kept running for rest of the acquisition period.

**7. Dataset 3 :**

* **Dataset Title:** "**Visual Imagination with MEG**"
* **Dataset Link:** https://www.kaggle.com/datasets/emanuele/visual-imagination-with-meg?resource=download&select=subject\_05.npz

**8. Data Acquisition :**

The Magnetoencephalography (MEG) dataset used in this project was provided in .npz format, a compressed archive used to store multiple NumPy arrays efficiently. This format is highly suitable for storing multidimensional time-series data from neuroimaging studies due to its compact size and compatibility with Python-based scientific computing tools.

The dataset was obtained from [https://www.kaggle.com/datasets/emanuele/visual-imagination-with-meg?resource=download&select=subject\_05.npz], and contains MEG signal recordings from multiple brain regions, sampled at a constant frequency. The .npz file includes the following key components:

* signals: A 2D NumPy array of shape *(n\_channels × n\_timepoints)* containing raw MEG signals.
* fs: The sampling frequency of the signal, in Hertz (Hz).
* channels: A list of MEG sensor/channel names.
* timestamps: A 1D array representing time points for each recorded sample.

**9. Dataset 4 :**

* **Dataset Title:** " **A geometric shape regularity effect in the human brain: MEG dataset**"
* **Dataset Link:** [**doi:10.18112/openneuro.ds006012.v1.0.1**](https://doi.org/10.18112/openneuro.ds006012.v1.0.1)
* **Dataset Link:** [**doi:10.18112/openneuro.ds006035.v1.0.0**](https://doi.org/10.18112/openneuro.ds006035.v1.0.0)
* **Dataset Link:** [**doi:10.18112/openneuro.ds005810.v1.0.4**](https://doi.org/10.18112/openneuro.ds005810.v1.0.4)

**10. Data Acquisition :**

The MEG dataset used in this study is titled “A geometric shape regularity effect in the human brain”, publicly available through the OpenNeuro platform. This dataset adheres to the BIDS (Brain Imaging Data Structure) format, which includes accompanying metadata and tab-separated values (.tsv) files for event information, channel metadata, and participant details.

Dataset Structure

The dataset contains:

* Raw MEG recordings in FIF format
* Event annotations in .tsv files (e.g., \*\_events.tsv)
* Channel information in \*\_channels.tsv
* Participant demographics in participants.tsv

These .tsv files provide structured tabular data critical for preprocessing and analysis. For example:

* events.tsv: Contains trial-by-trial information such as stimulus onset time, duration, and condition labels.
* channels.tsv: Includes metadata about each MEG sensor, such as type, status, and coordinates.
* participants.tsv: Lists subject-level data including age and sex.

**11. Dataset 5 :**

* **Dataset Title:** "**A multi-subject, multi-modal human neuroimaging dataset**"
* **Dataset Link:** https://openneuro.org/datasets/ds002718

**12. Data Acquisition :**

Both the MEG and EEG were measured in a light magnetically shielded room using an Elekta Neuromag Vectorview 306 system (Helsinki, FI). Five head-position indicator (HPI) coils were attached to the EEG cap and stimulated with sinusoidal currents at 293, 307, 314, 321, and 328 Hz. A 70 channel Easycap EEG cap (based on EC80 system here: [http://www.easycap.de/easycap/e/products/products.htm#15](http://www.easycap.de/easycap/e/products/products.htm%2315)) was used to record the EEG data simultaneously, with electrode layout conforming to the extended 10–10% system. A 3D digitizer (Fastrak Polhemus Inc., Colchester, VA, USA) was used to record the locations of the EEG electrodes, the HPI coils and approximately 50–100 ‘head points’ along the scalp, relative to three anatomical fiducials (the nasion and left and right pre-auricular points). The EEG location was digitized by inserting the digitizer pen into the paste in the middle of the donut-shaped electrodes until the pen touched the scalp.

Following the practice, stimuli were presented in six, 7.5 min runs. Data were acquired at an 1100 Hz sampling rate with a lowpass filter at 350 Hz and no highpass filter.

The EEG reference electrode was placed on the nose, and the common ground electrode was placed at the left collar bone. Two sets of bipolar electrodes were used to measure vertical (left eye) and horizontal electro-oculograms (VEOG and HEOG), and another set was used to measure the electro-cardiogram (ECG): left lower rib and right collarbone (due to a problem with the acquisition software, these three channels are not properly labelled in the fif files: EEG061=HEOG; EEG062=VEOG; EEG063=ECG). Twenty seconds of data without continuous HPI were collected at the start of each run prior to beginning the stimulus program. A fixed 34 ms delay exists between the appearance of a trigger in the MEG file (on channel STI101) and the appearance of the stimulus on the screen.

A small number of empty-room recordings acquired around the same dates as the participants’ data are also available with the dataset (these can be used to estimate characteristics of the environmental noise in the MEG sensors).

After the M/EEG acquisition, participants saw each of the 300 faces again, but now used three buttons to indicate whether (1) they had not seen the face before the experiment, (2) the face looked familiar, but they could not remember from where, or (3) they knew the face, i.e. could remember definite fact about them, such as their job, a movie they were in, their name etc. On average across participants, 73% of famous faces were given a rating of 2–3, and 86% of nonfamous faces were given a rating of 1. These debriefing data could be used to further refine familiarity of each participant with each face, and are available on request, but were not used in the current validation.

**13. References**

* NOD-fMRI: doi:10.18112/openneuro.ds004496.v2.1.2
* **Rathee, D., Cecotti, H. & Prasad, G. Single-**trial effective brain connectivity patterns enhance discriminability of mental imagery tasks. *Journal of neural engineering* **14**, 056005 (2017).
* **Wang, Y., Sprague, T. C., Serences, J. T. (2020).**  
  *A geometric shape regularity effect in the human brain: MEG dataset.*  
  OpenNeuro.

**14. GitHub Repository**

* **GitHub Link: https://github.com/kritheeshsaravanan/Machine-Learning-Project.git**