**Multimodal Dataset of Freezing of Gait in Parkinson's Disease**

**Authors**

Hantao Lib,1, Wei Zhanga,g,h,1, Lipeng Wangj, 1,Yanzhao Weib, Kang Panb, Lin Maa,c,d,e, Huanhuan Fenga,c,d,e, Jing Pana,i

Authors Hantao Li, Wei Zhang, and Lipeng Wang equally contributed to this work.

**Affiliations**

a. Department of Neurobiology, Neurology and Geriatrics, Xuanwu Hospital of Capital Medical University, Beijing Institute of Geriatrics, Beijing, China

b. School of Automation Science and Electrical Engineering, Beihang University, Beijing, China

c. Clinical Center for Parkinson’s Disease, Capital Medical University, Beijing, China

d. Key Laboratory for Neurodegenerative Disease of the Ministry of Education, Beijing Key Laboratory for Parkinson’s Disease, Beijing Institute of Brain Disorders, Collaborative Innovation Center for Brain Disorders, Capital Medical University, Beijing, China.

e. National Clinical Research Center for Geriatric Disorders, Beijing, China

f. Advanced Innovation Center for Human Brain Protection, Capital Medical University, Beijing, China

g. Department of Neurology, The Affiliated Hospital of Xuzhou Medical University, Xuzhou, Jiangsu, China.

h. Jiangsu Key Laboratory of Brain Disease Bioinformation, Xuzhou Medical University, Xuzhou, Jiangsu, China.

i. Department of Neurology, The Second Affiliated Hospital of Inner Mongolia Medical University, Hohhot, China

j. Beijing Institute of Mechanical and Electrical Engineering, Beijing,China

**Corresponding author(s)**

Yuzhu Guo (yuzhuguo@buaa.edu.cn)

Piu Chan (pbchan@hotmail.com)

**Acknowledgments**

Authors YG, HL, LW, YW, and KP gratefully acknowledge the support from the National Natural Science Foundation of China (Grant No. 61876015), the Beijing Natural Science Foundation, China (Grant No. 4202040), and Science and Technology Innovation 2030 Major Program of China (Grant No. 2018AAA001400). Authors WZ, LM, HF, JP and PC acknowledge the partial support from The National Key R&D Program of China (No. 2018YFC1312001, 2017YFC0840105, 2017ZX09304018), Key Realm R&D Program of Guangdong Province (No. 2018B030337001), and The Open Funds of Jiangsu Key Laboratory of Brain Disease Bioinformation (No. XZSYSKF2020011)

**Data Description**

**Overview**: Combined with the standardized experimental paradigm we designed, which can effectively induce FoG, each patient was asked to finish four tasks, including quarter turns, U-turns, and bypass obstacles. EEG, EMG, ECG, skin conductance, and acceleration data were collected during the task. With the video recording, two sophisticated doctors would label the data to indicate whether there have FoG occurred. It is divided into raw data and filtered data. There are 11 sub-folders in each folder, representing the data of 11 different patients (ID:008 have done two experiments, and is divided into 1/2 in its sub-folder).

**Hardware configuration and location of the sensoring system**

|  |  |  |  |
| --- | --- | --- | --- |
| Sensing Type | Sensor system | Number of sensors | Sensor location |
| 28D-EEG | ‘The wireless MOVE’ | 28 | FP1, FP2, F3, F4, C4, C4, P3, P4, O1, O2, F7, F8, P7, P8, Fz, Cz, Pz, FC1, FC2, CP1, CP2, FC5, FC6, CP5, CP6, TP9\*, TP10\*, IO\*\* |
| 3D-EMG | 3 | Gastrocnemius muscle of right leg; Tibialis anterior muscle of left and right legs |
| 3D-accelerometer, 3D-Gyro | MPU6050 | 4\*\*\* | Lateral tibia of left and right legs;  Fifth lumbar spine; Wrist |
| 1D-SC | LM324 | 2 | The second belly of the index finger and middle finger of the left hand |

\*TP9, TP10 (signal of the mastoid process of the temporary bone) were used as reference data in data preprocessing.

\*\*IO (electrooculogram) was given in the dataset without preprocessing.

\*\*\*Some patient only wear two inertial sensors (mounted on left tibia and left wrist, respectively).

**Raw data**: raw data were collected in each experiment, divided into data collected by the ‘MOVE’ system, including EEG/EMG/ECG with the sampling frequency of 1000Hz, and the SC/ACC data collected by MPU6050 and LM324 with the sampling frequency of 500Hz.

Data collected by the ‘MOVE’ system: **[filename.eeg + filename.vhdr + filename.vmrk]**, while the filename is random. These three files are generated directly by the ‘MOVE’ system. EEGLab can read it.

Raw SC/ACC data: .csv files name with the location of the sensor. For example, **LShank.csv** contains the raw acceleration data collected from the left shank. For eight columns in each CSV file, the order of data is ‘timestamps, accelerometer-x, accelerometer-y, accelerometer-z, Gyro-x, Gyro-y, Gyro-z, NC/SC.’ The eighth column of the **LShank.csv, RShank.csv, Waist.csv** is NC, which is invalid data; the eighth column of the **Arm.csv** is skin conductance.

**Filtered data**: data that has been labeled, sliced, and preprocessed. The processing method is given in ‘Experimental Design, Materials and Methods.’ The nth task’s data file of each experiment is named **task\_ n.txt**; in the .txt file array, the vertical axis represents the time with the sampling frequency of 500Hz; there are 60 columns on the horizontal axis, which represents:

1 column of Time-stamps, which begins from 0; **[1]**

25 columns of EEG signals: FP1, FP2, F3, F4, C4, C4, P3, P4, O1, O2, F7, F8, P7, P8, FZ, CZ, PZ, FC1, FC2, CP1, CP2, FC5, FC6, CP5, CP6; **[2-26]**

5 columns of EMG/ECG/Electrooculogram signals, the order of each subject is given in the ‘**Order of 27-31 columns**’; **[27-31]**

7\*4 columns of Acceleration data on left shank, right shank, waist, and arm. Some patients only wear two inertial sensors (mounted on the left tibia and left wrist, respectively), whose data will be 0 on the location without the sensor. For every 7 columns, the order of data is ‘accelerometer-x, accelerometer-y, accelerometer-z, Gyro-x, Gyro-y, Gyro-z, NC/SC.’ The seventh column of the first three is NC, which is invalid data; the seventh column of the fourth is SC (because SC is collected by the sensor on the arm only); **[32-59]**

1 column of Labels. Label 1 indicates the presence of FoG, and 0 indicates the FoG-free. **[60]**

Please download raw data from another data repository: Li, Hantao (2021), “Multimodal Dataset of Freezing of Gait in Parkinson's Disease”, Mendeley Data, V1, doi: 10.17632/r8gmbtv7w2.1

http://dx.doi.org/10.17632/r8gmbtv7w2.1

**Data Filtering**

After the data has been aligned and unified to 500Hz, two qualified physicians from the Department of Neurology, Beijing Xuanwu Hospital labeled the time points when a FOG started and ended in the video, respectively. Subsequently, the labels will be assigned to the multimodal data and attain a standard Parkinson's FOG database with expert labels.

Each of the sensing data was preprocessed separately. The EEG data were preprocessed using EEGLab. The artifacts of Electrooculogram (EOG) were removed by independent component analysis (ICA) with the average signal of the mastoid process of the temporal bone (TP9, TP10) as the reference. The data was then filtered by a band-pass filter of 0.5-100Hz.

The EMG data were filtered by a band-pass filter of 10Hz-500Hz, and the ACC were filtered by a low-pass filter with stop frequency 16Hz. All the data above filtered out the 50 Hz noise by a notch filter and normalized in the preprocessing process. After the filtering, the ‘Filtered Data’ was obtained.

**Data source location**

Institution: Xuanwu Hospital; City/Town/Region: Beijing; Country: China

Latitude and longitude: 39°53′25.80″N, 116°21′43.51″E; GPS coordinates: 39.8905, 116.3621

**Order of 27-31 columns**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Patient ID | 27(EMG-1) | 28(EMG-2) | 29 | 30(EMG-3) | 31(EMG-4) |
| 001 | R-TA | L-TA | IO | ECG | R-GS |
| 002 | R-TA | L-TA | ECG | R-GS |
| 003 | L-TA | R-TA | ECG | R-GS |
| 004 | L-TA | R-TA | ECG | R-GS |
| 005 | L-TA | R-TA | ECG | R-GS |
| 006 | R-TA | L-TA | ECG | R-GS |
| 007 | R-TA | L-TA | ECG | R-GS |
| 008-1 | R-TA | L-TA | ECG | R-GS |
| 008-2 | R-TA | R-GS | ECG | L-TA |
| 009 | L-TA | R-TA | R-GS | ECG |
| 010 | L-TA | R-TA | ECG | R-GS |
| 011 | L-TA | R-TA | ECG | R-GS |
| 012 | L-TA | R-TA | ECG | R-GS |

\* R-TA => EMG of Tibialis anterior muscle of right leg

1. GS => EMG of Gastrocnemius muscle of right leg
2. TA => EMG of Tibialis anterior muscle of left leg

IO => Electrooculogram