Measuring Mental Workload Using FNIRS

(Data Analysis and Preprocessing)

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INTRODUCTION

Functional near-infrared spectroscopy (fNIRS) is an imaging technique that measures hemodynamic processes in the brain. It provides insight into activation patterns identical to functional magnetic resonance imaging (fMRI). Mental workload classification has always been considered the most important task in the literature related to brain memory. We have done data analysis and preprocessing of FNIRS data in order to propose a model to classify mental work load. We have done our work to propose a model using the publicly available large-scale open-access dataset which consists of 68 participants performing n-back tasks where increased n represents the intensity of the mental workload. We are also determined to implement BCI which can evaluate users in real time.

METHODOLOGY

**To do statistical analysis and graph plotting of FNIRs data we have followed below methodology:**
- Selected the raw data in FNIRs data.
- In raw data there are 68 subjects.
- Each subjects contains
  - Fnirs_init.csv (Initial)
  - Fnirs_train.csv (Training)
  - Fnirs_test.csv (Testing)
- Concatenated each 68 subjects init, test, and train FNIRs data into a single data frame respectively.
- Calculated mean, median, mode and standard deviation for each init, test, train FNIRs data frame.
- Plotted different types of graph for each described init, test, train FNIRS data frame.
- Printed Correlation matrix for each FNIRS data frame.
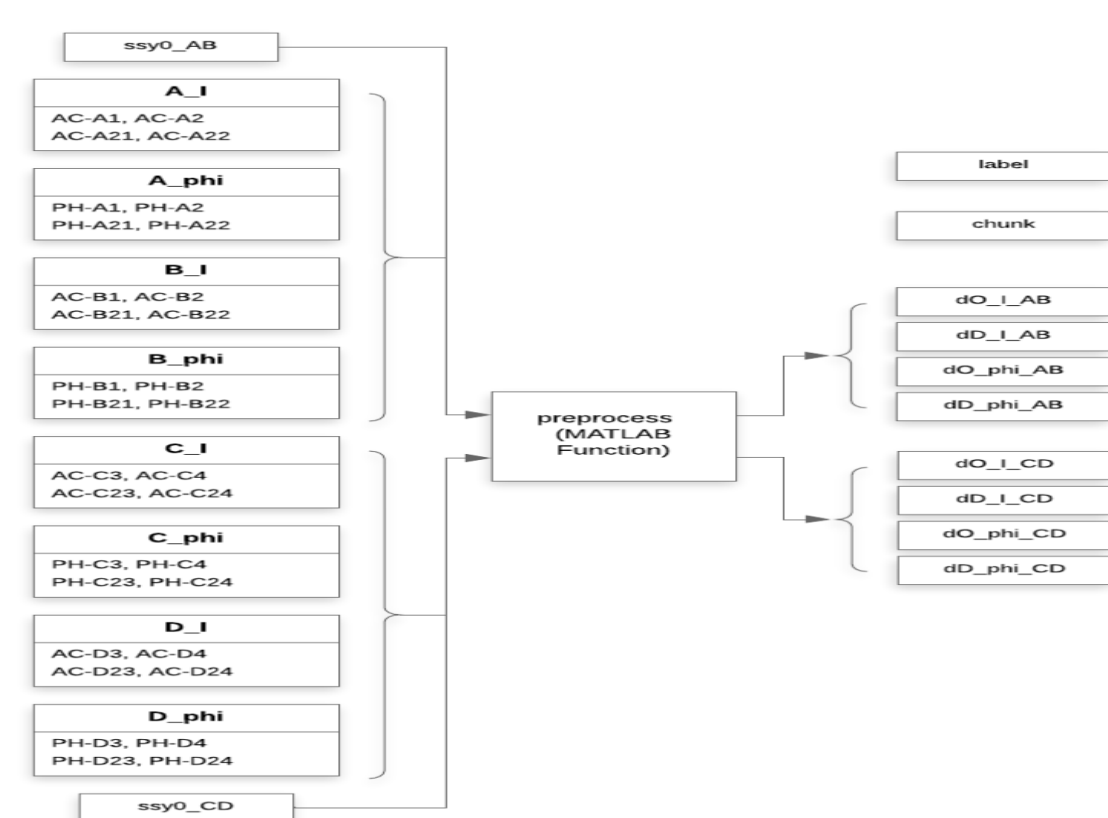
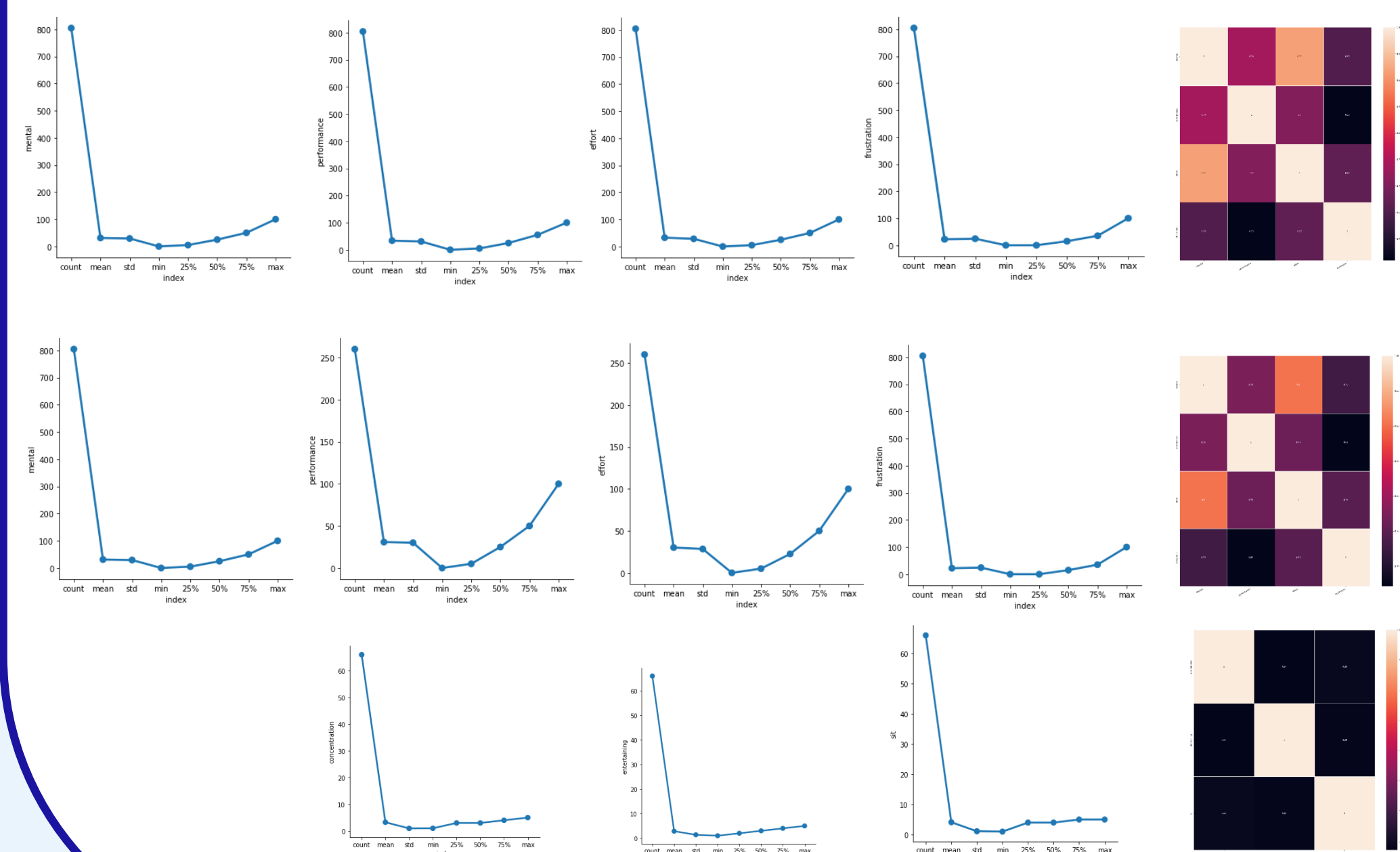**To do statistical analysis and graph plotting of FNIRs data To do statistical analysis and graph plotting of nasa-tlx data we have followed below methodology:**
- Selected the nasa-tlx data in Post Experiment.
- In nasa-tlx data there are 68 subjects.
- Each subjects contains
  - serial_feedbacktest.csv
  - serial_feedbacktrain.csv
  - Questionnaire_rating.csv
  - questionnaire_like_and_dont_like.csv
- Concatenated each 68 subject serial_feedbacktest.csv, serial_feedbacktrain.csv, questionnaire_rating.csv, questionnaire_like_and_dont_like.csv data into a single data frame respectively.
- Calculated mean, median, mode and standard deviation for each serial_feedbacktest.csv, serial_feedbacktrain.csv, questionnaire_rating.csv, questionnaire_like_and_dont_like.csv data frame.
- Plotted different types of graph for each described serial_feedbacktest.csv, questionnaire_rating.csv, questionnaire_like_and_dont_like.csv data frame.
- Printed Correlation matrix for each above data frame.
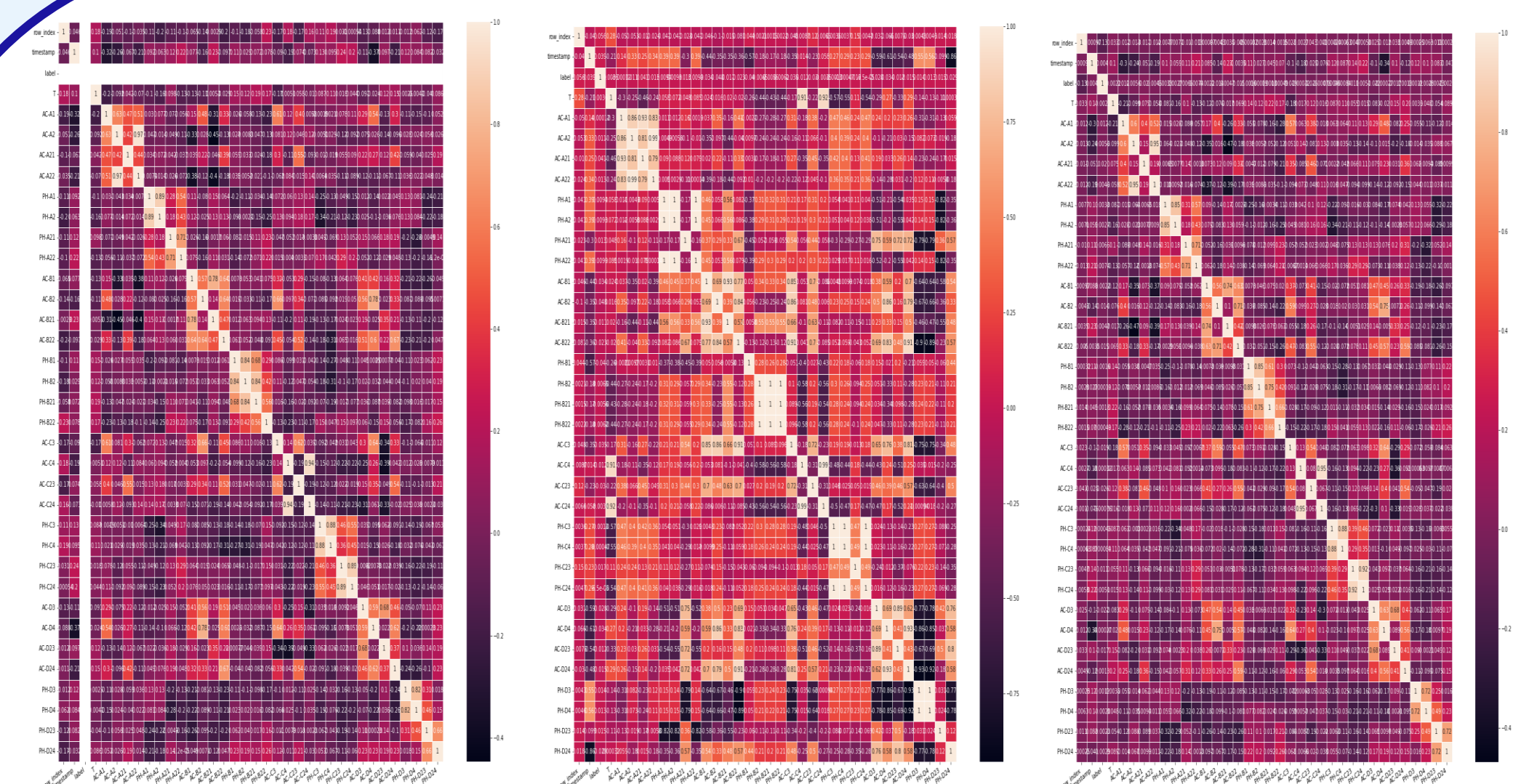
DATA DESCRIPTION

The data set contains the following records acquired during the 30-60 min experimental session:

fNIRS recordings: Multivariate time series representing brain activity during a session. It is recorded by a sensor probe placed on the forehead and secured with a headband. At each time step, two measured concentration changes (oxygenated and deoxygenated hemoglobin), two optical data types, and one for each combination of two spatial locations on the forehead, 8 Record one real-valued measurement. The units for each measurement are micromoles of hemoglobin per litre of tissue.

Activity labels: Comments about experimental task activities performed by subjects during the session, such as instructions, breaks, and active experimental segments. Each segment of the active experiment is shown as one of four possible intensity levels of n-back working memory. Increased intensity levels are said to induce increased cognitive workload.

Demographics: Participants' age, handedness, gender, race, and other attributes.

Activity performance: Accuracy of participants' task performance on working memory.

After Preprocessing

There are 8 measurement columns, which we use as features for machine learning classifiers: AB_I_O, AB_PHI_O, AB_I_DO, AB_PHI_DO, CD_I_O, CD_PHI_O, CD_I_DO and CD_PHI_DO
Where
AB or CD which sensor location on the forehead was used
I = intensity, PHI= phase
O = oxygenated haemoglobin
DO = deoxygenated haemoglobin

RESULTS AND DISCUSSION

- ❖ Correlation matrix of init_dataframe
- ❖ Correlation matrix of train_dataframe
- ❖ Correlation matrix of test_dataframe respectively.

- ❖ Statistical analysis and Correlation matrix of serial_feedbacktest

- ❖ Statistical analysis and Correlation matrix of serial_feedbacktrain

- ❖ Statistical analysis and Correlation matrix of Questionnaire_rating

CONCLUSION

This work is done to build an effective model to detect mental workload using publicly available fNIRS datasets containing 68 participants' sensor signals. We have done data analysis of FNIRs data to build an effective model using 3D CNN and with some other algorithms to compare and achieve better accuracy. We have also done behavioral analysis of nasa-tlx data so that we can correctly build the system in order to satisfy real world users. There are different applications in different areas such as health apps and stress monitor apps to monitor your mental state and take appropriate actions to improve your daily life.

FUTURE DIRECTION

There are several challenges in order to build effective systems to capture mental intensity levels. However, discerning fine-level intensities is very difficult. Therefore, there is room for further research to differentiate mental workload intensity levels.