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Continuous mental state estimation using EEG band power time series predictions.

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Introduction: Long Short-Term Memory network (LSTM) [1] can be used as a prediction model that reproduces time series dynamics based on training data. Here, LSTM was used to predict changes on EEG band power time series (BPts) trained with data from two different mental tasks, assuming that BPts dynamics should differ between the two tasks. Prediction error was used as a single feature to identify mental state continuously.

Methods: The EEG signals were obtained using Mental Calculation paradigm (15 subjects) over the frontal, parietal, occipital, central, and anterior-frontal regions (10-20 system) [2]. Three sessions on different days were carried out. The experimentation consisted in the alternated realization of basic arithmetic mental calculations and resting periods [3]. BPts was calculated using Power Spectral Density (PSD) over the β ([14–35] Hz) and γ([35–100] Hz) bands, assessed using the Welch periodogram method over 18 channels. Two LSTM were trained independently with BPts derived from EEG mental calculation sections ($BPts_{ac}$), and EEG rest sections ($BPts_{rest}$). Thereby, two prediction models feeding with test BPts data, produce two error signals, calculated by Mean Absolute Error (MAE). Training data was made with all information available in two of three sessions and tested over the remaining session. Area under ROC curve was used to evaluate mental state estimation.

Results: Mean population shows: the model trained with $BPts_{ac}$ over β band achieved **0.602 ± 0.025** AUROC values, whereas $BPts_{rest}$ model achieved **0.548 ± 0.022**, where 88 of 114 realizations had AUROC values below 0.5. Fig. 1 shows an example of error series and the correlation index between predictions and test BPts.

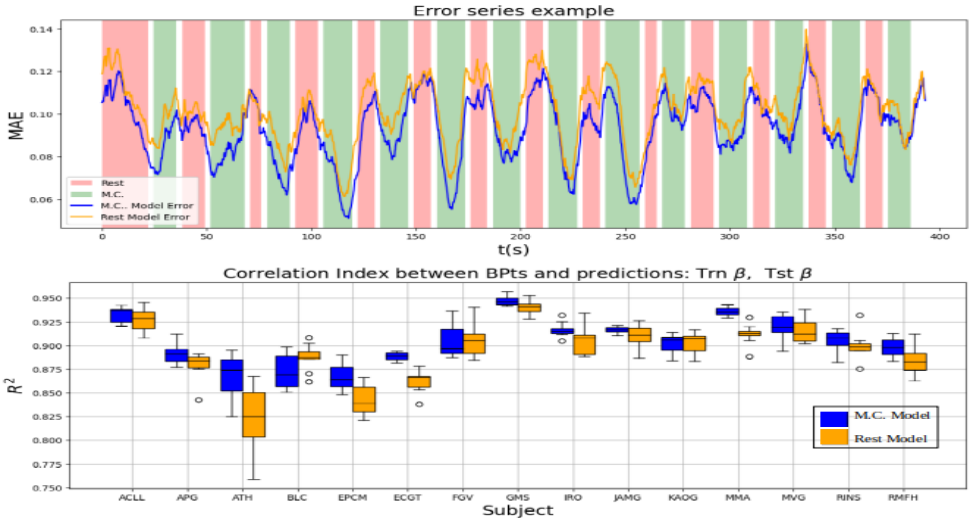

Figure 1.. *Top: Error series, where green bands are Mental Calculation (M.C.) sections, and red bands correspond to Rest sections. Blue line is M.C. model error; orange line is Rest model error. Bottom: Correlation Index (R^2) between test BPts and predictions*

Discussion: Results suggest that LSTM prediction models could work for identifying mental state training with $BPts_{ac}$. Nevertheless, more tests are needed to find ideal LSTM parameters, channels and bands combinations. The model trained with $BPts_{Rest}$, shows a similar dynamic than $BPts_{ac}$ model, so, the error series seems to be non effective for Rest periods estimation (produced improper ROCs), but it's still useful for a binary decision. One possible explanation for this issue is that the Rest state on M.C. paradigm is not stable, that is to say, there is no explicit task in those periods, hence EEG activity does not have the same characteristics in every Rest section.

References

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