Contents

Questions I asked to myself:

- What does a surprise emotion consist of? Does it consist of P300 or it has other components too?
- What makes us believe that surprise must be consisting of other components?
- Will the knowledge of other surprise components, enhance the speed and accuracy of surprise detection process?
- Is Speller the right experiment for finding surprise as a whole? If not, what else need to considered for designing an experiment?
- How can whole surprise be best detected? By linear or non-linear features?

Some theory behind the experiments:

We have a low cost EEG headset by Muse-2. It has electrodes mounted on the *front lobe and temporal lobe (AF7, AF8, TP9, TP10).* Two electrodes are mounted on forehead and another two behind the ears.

As per literature, the *frontal lobes* are responsible for higher cognitive functions such as memory, emotions, impulse control, problem solving, social interaction, and motor function (reference - Frontal Lobe Function, Location in Brain, Damage, More (healthline.com)). The frontal lobes are important for voluntary movement, expressive language and for managing higher level executive functions. Executive functions refer to a collection of cognitive skills including the capacity to plan, organize, initiate, self-monitor and control one's responses in order to achieve a goal (reference - Brain Map Frontal Lobes | Queensland Health).

The *temporal lobes* sit behind the ears and are the second largest lobe. They are most commonly associated with processing auditory information and interact with other structures to create new and
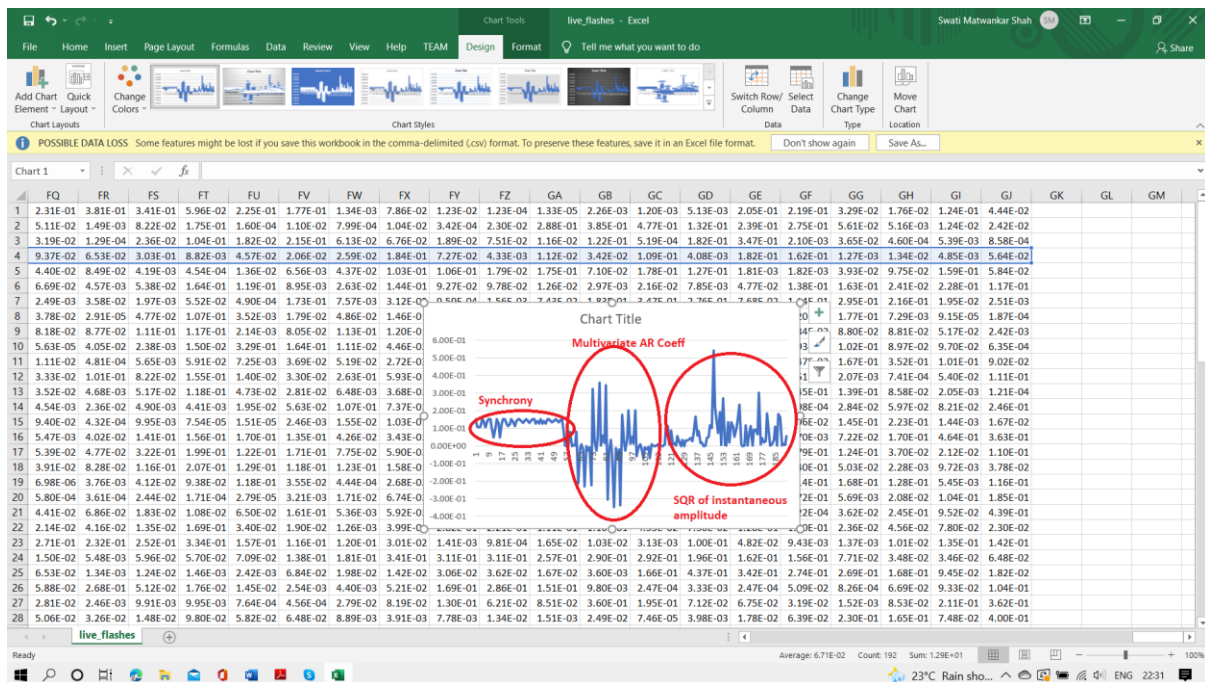
long term memories. (reference - [Temporal lobe: Definition, function, diagrams, and linked conditions (medicalnewstoday.com)](medicalnewstoday.com), https://www.health.qld.gov.au/abios/asp/btemporal_lobes).
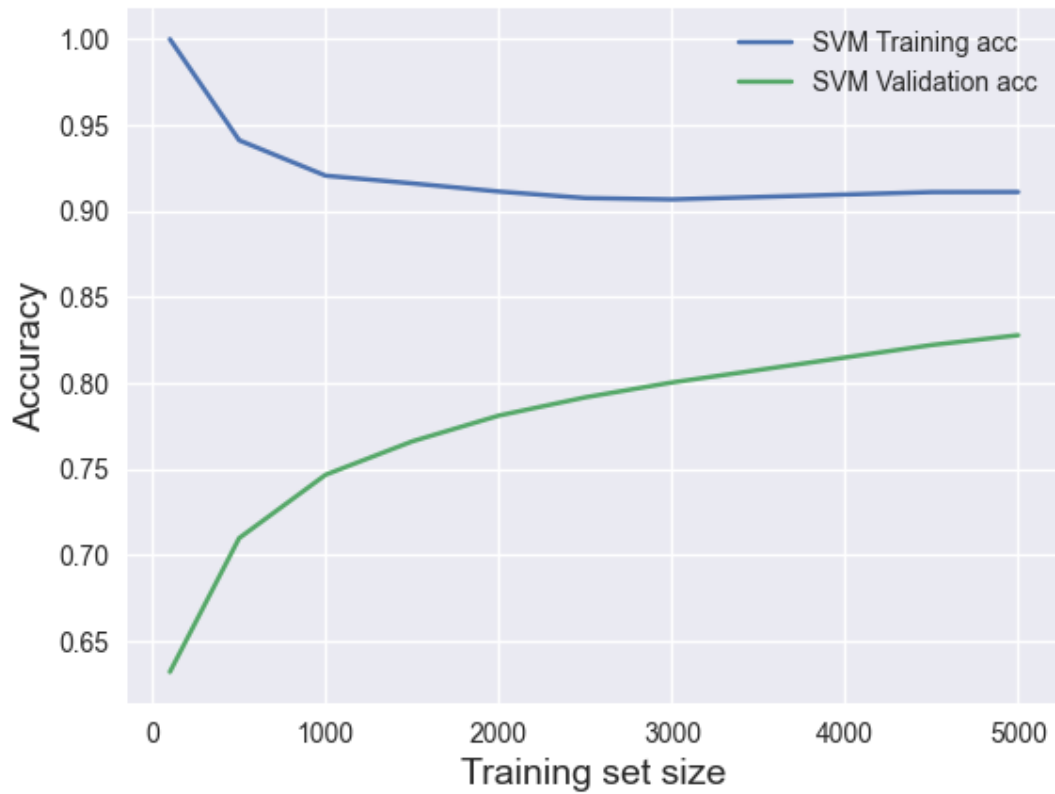
Current Speller Experiment Setup:

We enhanced OpenViBE Speller experiment to include following non-linear features.

1. Phase Synchrony
2. Auto-Regressive Coefficients of Multivariate Time Series (corresponding to each of 4 channels)
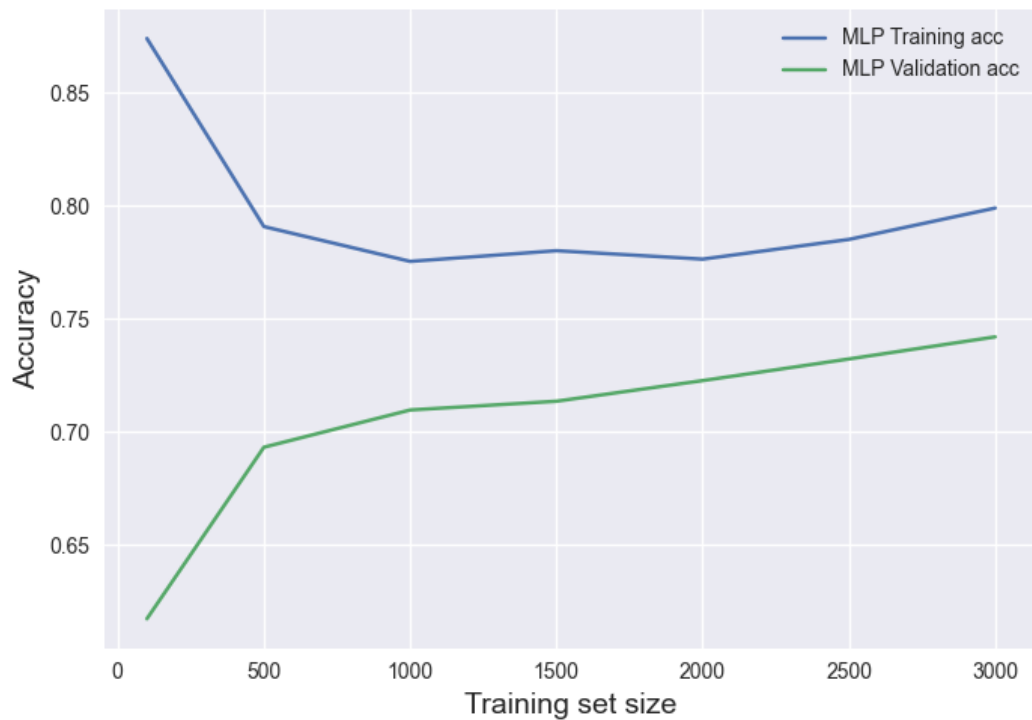3. Square of instantaneous amplitude of the EEG signal from each channel

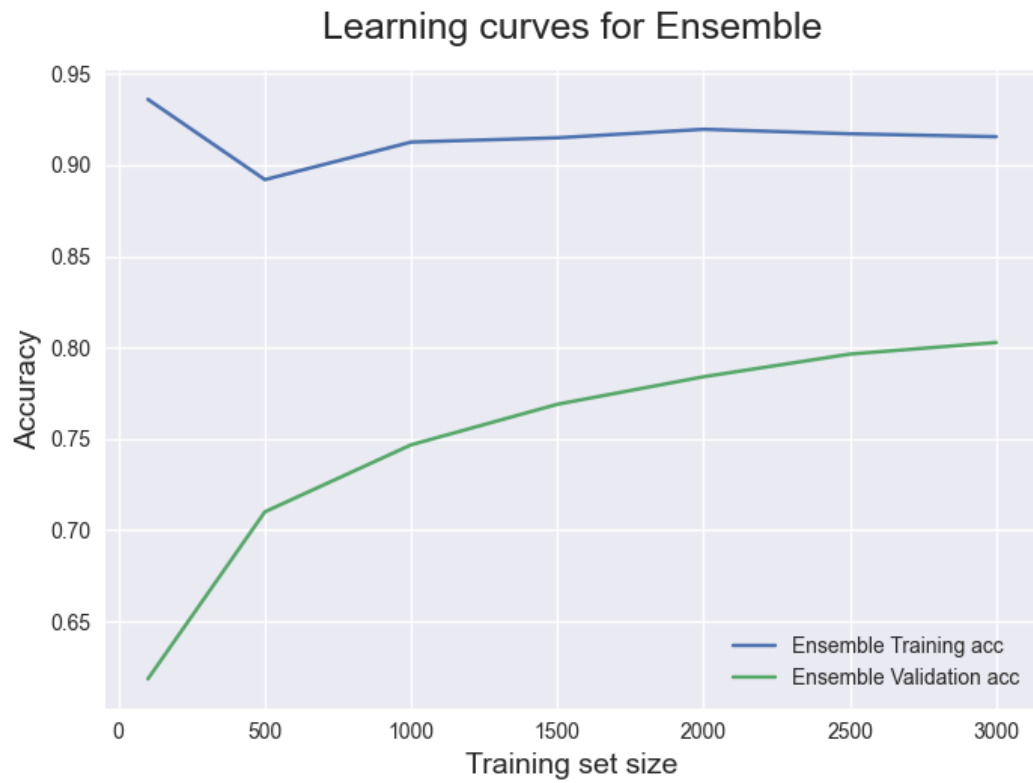The combined normalized feature vector looks like below.

We got feature vectors for 120 characters. This data is then balanced and augmented with Python APIs. It is then fed to an ensemble. The ensemble is a stacking classifier which stacks a Support Vector Machine (SVM) and Multi Layer Perceptron (MLP). The final estimator for the stacking ensemble is Logistic Regression. The training data is 70% of the whole data. It turns out to be 20160 feature samples. The testing data is 30% of the whole data. It turns out to be 8640 feature samples. The learning curves of the two classifiers and the ensemble, with increase in training samples, are given below.

Learning curves for a SVM model

Learning curves for MLP
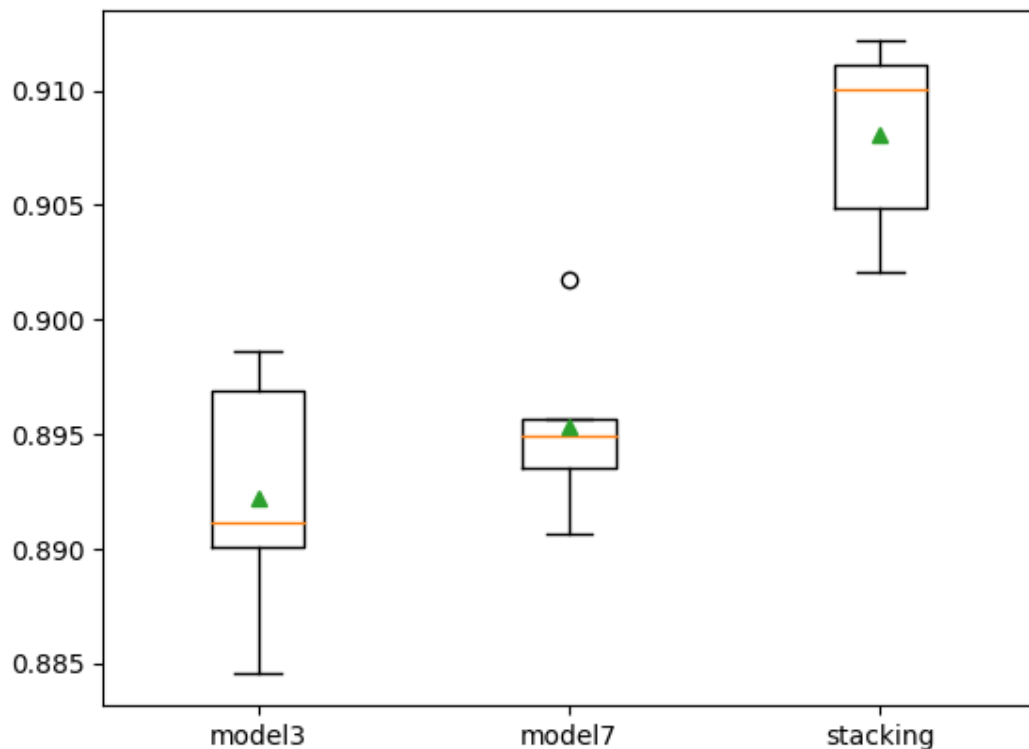
Learning curves for Ensemble

The below box plot shows the mean and standard deviation of accuracy of the below models:

Model3 is an MLP model

Model7 is an SVM model

Stacking is an ensemble

Results

Call me "crazy" but …. I observed the following.

I have experimented with myself as a subject so far. I conducted multiple online experiments with the above ensemble model. In each experiment I kept 10 characters to be focused on.

Expectation: Whichever character is focused on, should turn GREEN.

Reality:

1. The character does not turn GREEN, just by focusing on visual cues.
2. It turns GREEN when my brain experiences intense emotions and thoughts. Few of the incidences are
   a. During the experiment, I am thinking … I am not prepared with tomorrow's plan. What am I going to do? (fear).
   b. During the experiment, I am annoyed by auditory distraction (anger).
   c. During the experiment, I am trying to recollect something from the past (memory).
3. All of the above thoughts are "sudden/unconscious/unexpected" thoughts which I could remember, when the character turned GREEN. They are not planned. Many of the thoughts I do not remember.
4. It looks like the model reflects a combined Audio/visual/emotional wholistic impact
5. Since it is related to "sudden" deep thinking process, the results are not reproducible. (Or it is sheer coincidence? But coincidence cannot repeat itself multiple times …)

Tests

- Each stimulation/flash is mapped to its corresponding features Or is there any mismatch?
  - o I tested it with the help of logs and spreadsheet data
- Is the Loss and Accuracy curve proper?
  - o I checked with the OpenViBE's speller test data (which is kept on their website) with my features. They too have the similar loss number and accuracy curve
- Tested the data normalization by visually inspecting the spreadsheet

OpenViBE (OV) Feature Enhancements

- Implemented python classifier by extending the interface which OV provided
- Implemented python predictor by extending the interface which OV provided
- Separated the data collection and model creation process
- Dumped the classifier data into a spreadsheet, which enables us to visualize the training/test data

Future Work

- Make multiple subjects to go through the same experiment.
- In the current state, my model which is trained with non-linear features, activates for any kind of emotions. For Example: Anger, Fear etc. I need to make it "surprise only".
- I need to simulate the intense thoughts, unexpected events for getting surprise emotion.

References

The Cognitive-Evolutionary Model of Surprise: A Review of the Evidence - Rainer Reisenzein,a Gernot Horstmann,b Achim Sch€utzwohl