Stress Diagnosis Neural Networks

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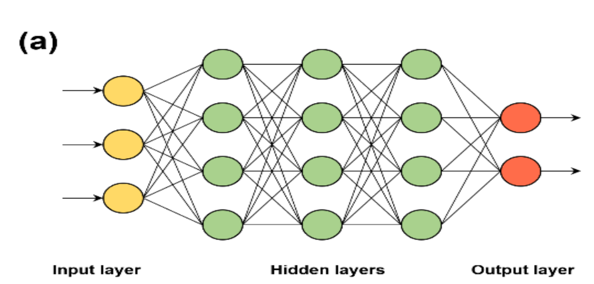
Abstract

Long term stress can cause various problem in human being. There are many physiological indicators of stress that can assist in the diagnosis process, particularly electrocardiogram (ECG) signals and Heart Rate Variability (HRV) ; however, the process can still be difficult due to the limited experts able to diagnose stress in the physiological domain. Additionally, response to stress can be different from individual to individual, therefore interpreting a curve and diagnosing stress levels would be very difficult even for the experts in the field. By constructing a probability model that analyzes the result of pre-processed and extracted HRV wave forms, we can determine the accuracy of diagnosis through DNN and KNN models. Our model aims to better understand stress in real world environments and to see if data presented can be formulated to better detect stress.

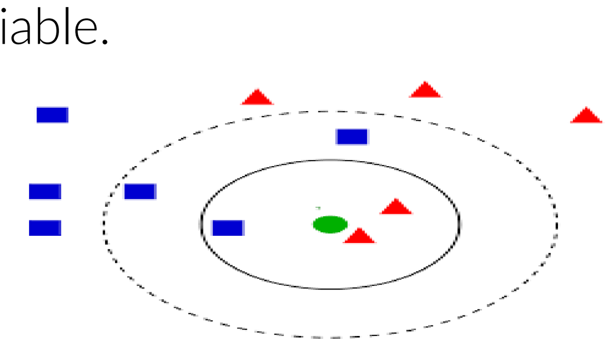
Models

The experiment was conducted on two models:

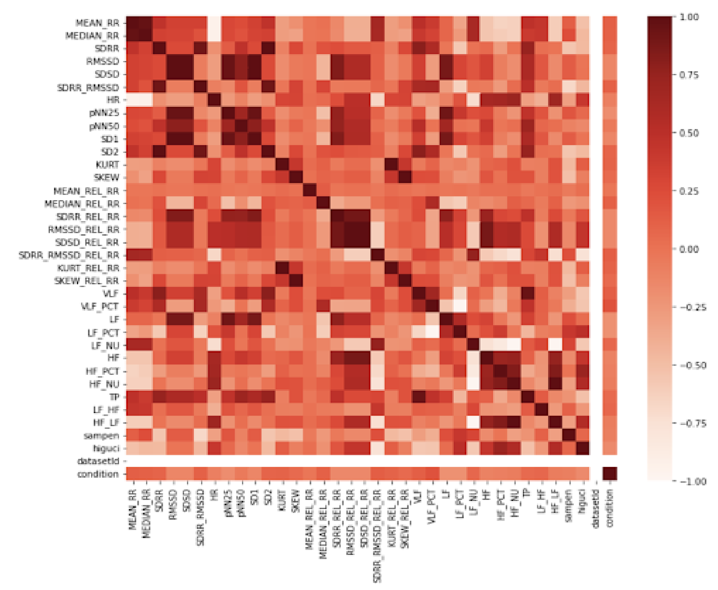
- **Deep Learning Neural Network** consists of numbers of neurons and different hidden layers. The first layer is considered as the input layer where the model gets input and relu activation function is applied to it. Then the result of activation function is passed to second layer as input and the relu activation function is applied to it. It occurs till the last layer and there is iterative forward and backward propagation to adjust weight and bias. Finally, final layer output three classes.



- **KNN** Type of supervised Machine Learning Algorithms which can be used for classification and regression.KNN works by finding the distances between query and all examples of data. Then it classifies most frequent layers. The training data used in the stress level classification comes from eight HRV features in the time domain and four HRV features in the frequency domain. The three HRV features in the time domain used are MEANRR,MEDIANRR. A multi-variable KNN regression analysis could find the outcome between stress and the target variable.



Data



HR	pNN25	pNN50	SD1	...
69.499952	11.133333	0.533333	11.001565	...
64.363150	5.600000	0.000000	9.170129	...
67.450066	13.066667	0.200000	11.533417	...
68.809562	11.800000	0.133333	11.119476	...
74.565728	20.200000	0.200000	13.590641	...
...	...	...	...	...

Figure 1. Left: The heat map shows the weight that each feature has in the interpretation of the model compared to each other.

Figure 2. Right: A fraction of the table to show the features and their qualitative values as an example.

Methods

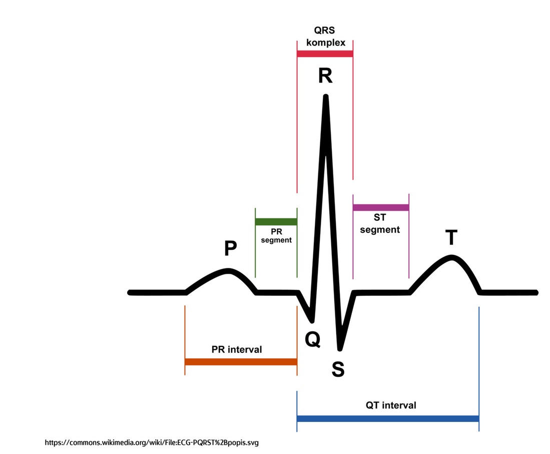


Figure 3. Shows the standard wave of an ECG. For pre-processing, one must make sure they can detect the R-peaks of each beat, the beginning, and the end. This detection *must* be a start for processing

- Models
  - DNN: A discriminative model with a basis in weight training through Neural networks.
  - kNN: A recursive neural network focused reverse nearest-neighbors.
- Though both are deep-network models, they will have results that vary when placed to time-series data.

- Pre-processing
  - We had a data set that pre-processed the ECG signals we were looking for already, but the process is represented by these steps:
    - Find the HRV (heart rate variability.) This is the deviation each 5 minute interval peak has from one another. It allows us to see the difference in rates to measure the states of the subject
    - split the signal into 5 minute interval IBI arrays.

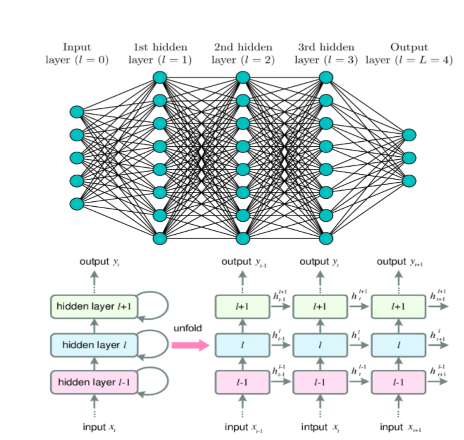
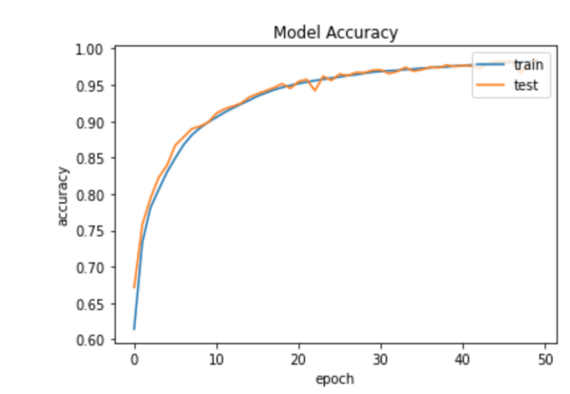


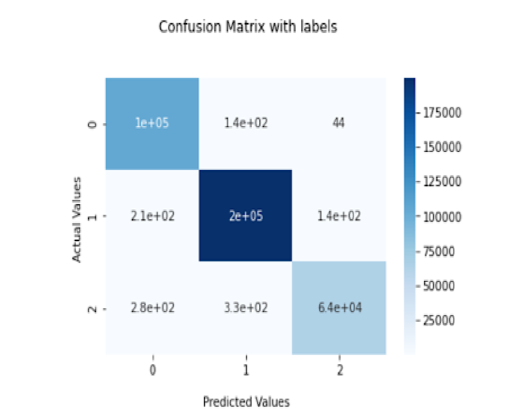
Figure 4. Above: Representation of a KNN architecture.

Figure 5. Below: representation of a DNN architecture

Results and Analysis

We conducted our experiment on Deep Learning Neural Network model and we were able to get 98.53 percent accuracy on validation set and 98.57 percent accuracy on test set. We also conducted our experiment using KNN model and we were able to get accuracy score of 99 percent.
This represents that time-pressured has the best accuracy when looking at the confusion matrix model. Both models networks performance exhibited a significant improvement over past methods that analyzed physiological signal for 3-class stress classification.





Conclusion

Our aim was to design and implement DNN and KNN models that are able to assess the user stress level through HRV signals. Our proposed architectures—one being simple and with low memory footprint, and the other being deeper with greater model capacity—met that goal by yielding state-of-the-art accuracy on the Swell data set both for the multi-class stress classification task. Specifically, our architectures and data processing techniques reported an accuracy of 98.53 percent and 98.57 percent, respectively. Finally, we explored a open-access data sets and provided insights regarding their problems and limitations.
Accuracy decreases if features are misidentified. That is why are DNN model and KNN model collects data in 2 different ways. First by using a neural network that classifies stress in 3 different stages. Then using a KNN model that uses multi layer perception neural network to classify if it has stress. KNN model has shown to be more effective when classifying stress.

References

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2. K.Nkurikiyeyezu, K. Shoji, A. Yokokubo, abd G. Lopez, " Thermal Comfort and Stress Recognition in Office Environment. "Prague Czech: SCITEPRESS- Science and Technology Publications,2019.