Digital Signal processing

VI Semester Report

Title – Sleep Stage Classification Using ECG Signals On SHHS(Sleep Heart Health Study) Dataset [EN]

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Contents

1 Objective

The crust objective of this project is to classify the Polysomnographic data into 6 stages namely [0,1,2,3,4,5].

2 Literature Overview

Sleep is a basic routine of any human on the planet. According to the National Institute of Health (NIH), sleep is classified into 5 stages. Wake, N1, N2, N3, and REM stage. N1 to N3 are classified into NREM (Non-Rapid Eye Movement) with increasing levels of deep sleep. According to NIH, 75% of the time an average human spends during sleep is in NREM, with the majority in the N2 stage. A typical night's sleep consists of 5 sleep cycles with progressive stages as N1, N2, N3, N2, and REM. A complete sleep cycle takes roughly between 90 min to 100 min. For the problem stated in Section 1, we have used SHHS datbase [**?**] to solve the problem, which has tested our approach for 200 subjects of SHHS-1. In the user database, the NREM class is classified into s1,s2,s3, and s4. Sleep stages s3 and s4 combined to form N3 and s1 corresponds to N1 and s2 corresponds to N2, in all NREM consists of N1, N2, and N3 classes.
Sleep stage scoring helps diagnosed to detect various diseases. Usually, EEG signals are used to classify sleep stages but it comes with a catch that it is difficult to detect, and alternative ECG signals of 200 subjects are used to make this report. The features were extracted using Wavelet Scattering and LSTM (Long Short Term Memory) model. A total of 1,51,103 epochs were made for wavelet scattering and a total of 2,04,000 iterations were carried out on 30 epochs for LSTM Model. Then 67% features extracted from the Wavelet scattering method were then fed into several Machine learning Models as a training dataset of Which Fine KNN (k- nearest neighbors) was showing the highest accuracy among all. Then the remaining testing 33% was used for testing model training accuracy of 87.14%. And Then the LSTM model was tested for 85% of data of which the testing accuracy achieved of 71% and training accuracy achieved 69.5%.

3 Methedology

3.1 Through Wavelet Scattering

The ECG signal was divided into 30 seconds epochs length and each epoch was labeled with its respective sleep Stages. In total, 1,51,103 epochs were formed for all the sleep stages and then those sleep stages were labeled with their respective sleep stages.
Then one by one all the epochs were fed into Wavelet Scattering for feature Extraction, since, the number of features extracted for each epoch was not the same therefore, we have to make track of labeling the features also with sleep stages there for in the loop once the features for one epoch is extracted then simultaneously the same were labeled along with it sleep stages.
After all, features were extracted the same were fed into Fine KNN Model, and respectively the Accuracy, precision, Recall, and F1 score were calculated as mentioned in Table 2.

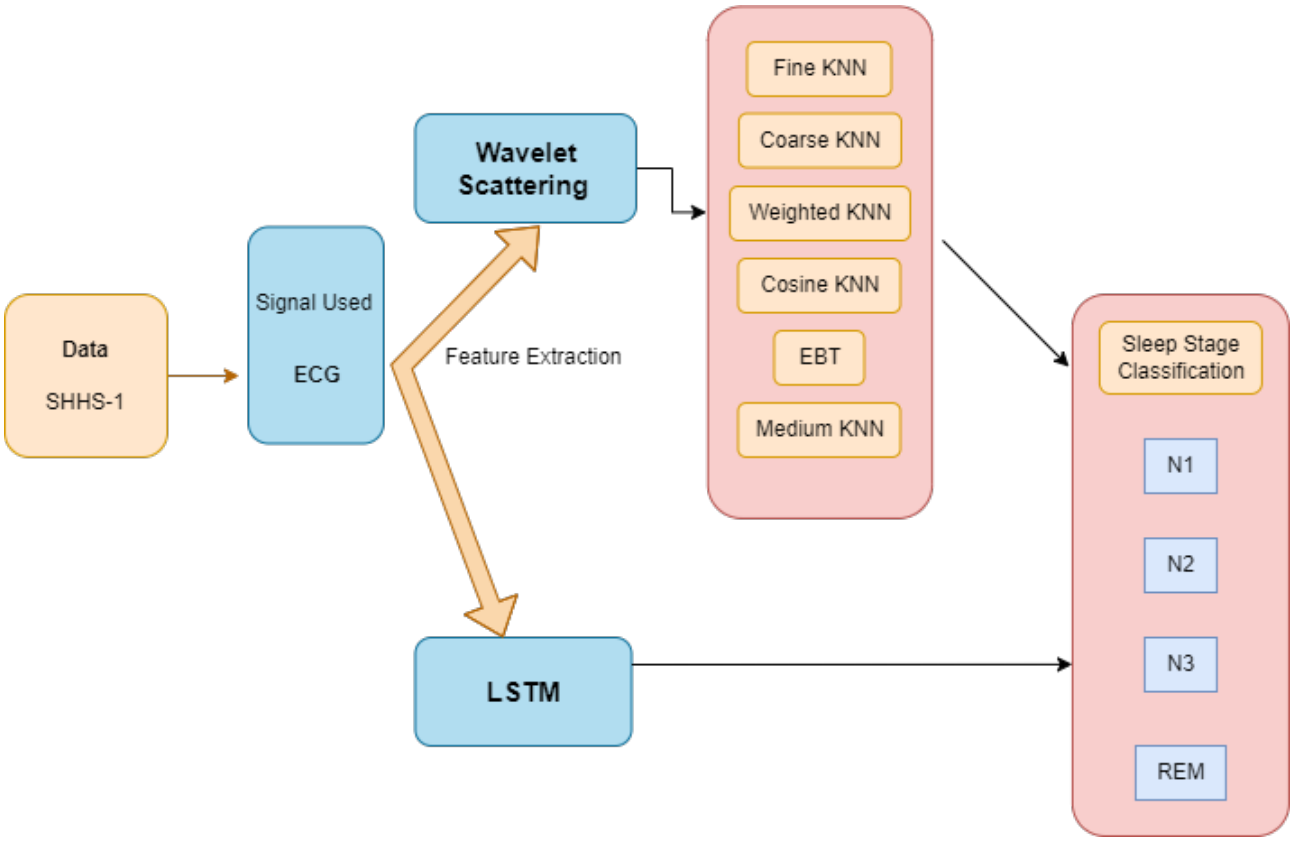

Figure 1: Methodology of proposed Work

3.2 Through LSTM Model

While working on the LSTM model the Raw data were firstly categorized and then the feature Amp was fed into the LSTM Model as shown in Fig 4,.

4 Results

The Validation of the model is signified using results below, in fig 2.
The model accuracy,precision, F1 score are calculated within 1234

$$Accuracy_{measure} = (T_p + T_n)/(T_p + T_n + F_p + F_n) \tag{1}$$

$$Precision = (T_p)/(T_p + F_p) \tag{2}$$

$$Recall = (T_p)/(T_p + F_n) \tag{3}$$

$$F1_{score} = 2 * ((Precision * Recall)/Precision + Recall) \tag{4}$$

4.1 Validation Figures

A ROC curve (receiver operating characteristic curve) is a graph showing the performance of a classification model at all classification thresholds. This curve plots two parameters:

True Positive Rate

False Positive Rate

Figure 3 shows the ROC curve for the Model KNN, with True Positive Rate = 0.93, and False Positive Rate = 0.02.
AUC: AUC measures the entire two-dimensional area underneath the entire ROC curve (think integral calculus) from (0,0) to (1,1).
AUC provides an aggregate measure of performance across all possible classification thresholds. In our case the AUC is 0.95. Now, in Fig 4, the training accuracy and loss for the LSTM model are shown with the training accuracy of 69% and losses of less than 1 after 20,40,000 iterations .

4.2 Tabular Comparisons

Table 1: The Statistical Measures of input Data Signals classified as Sleep Stages

Variable	mean	std	max	min	Epochs
Wake	0.3559	0.0012	1.25	-1.2402	46645
Stage-1	0.0088	0.1642	1.25	-1.2402	4757
Stage-2	-0.0001513	0.168	1.25	-1.2402	61232
Stage-3	0.0128	1.1514	1.25	-1.2402	118117
Stage-4	-0.0087	0.1491	1.25	-1.2402	1247
REM	0.0107	0.1621	1.25	-1.2402	19098

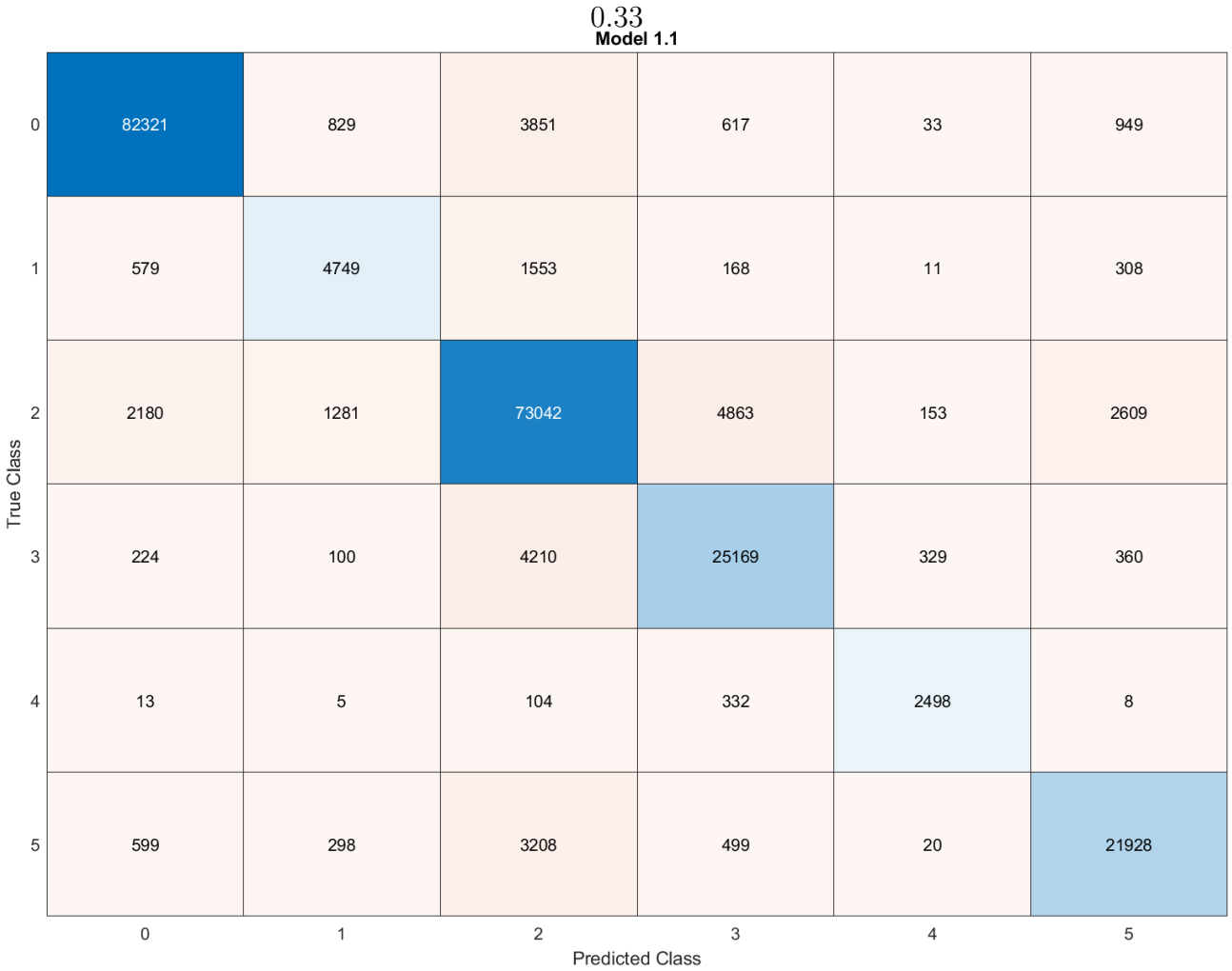

Figure 2: Methodology of proposed Work

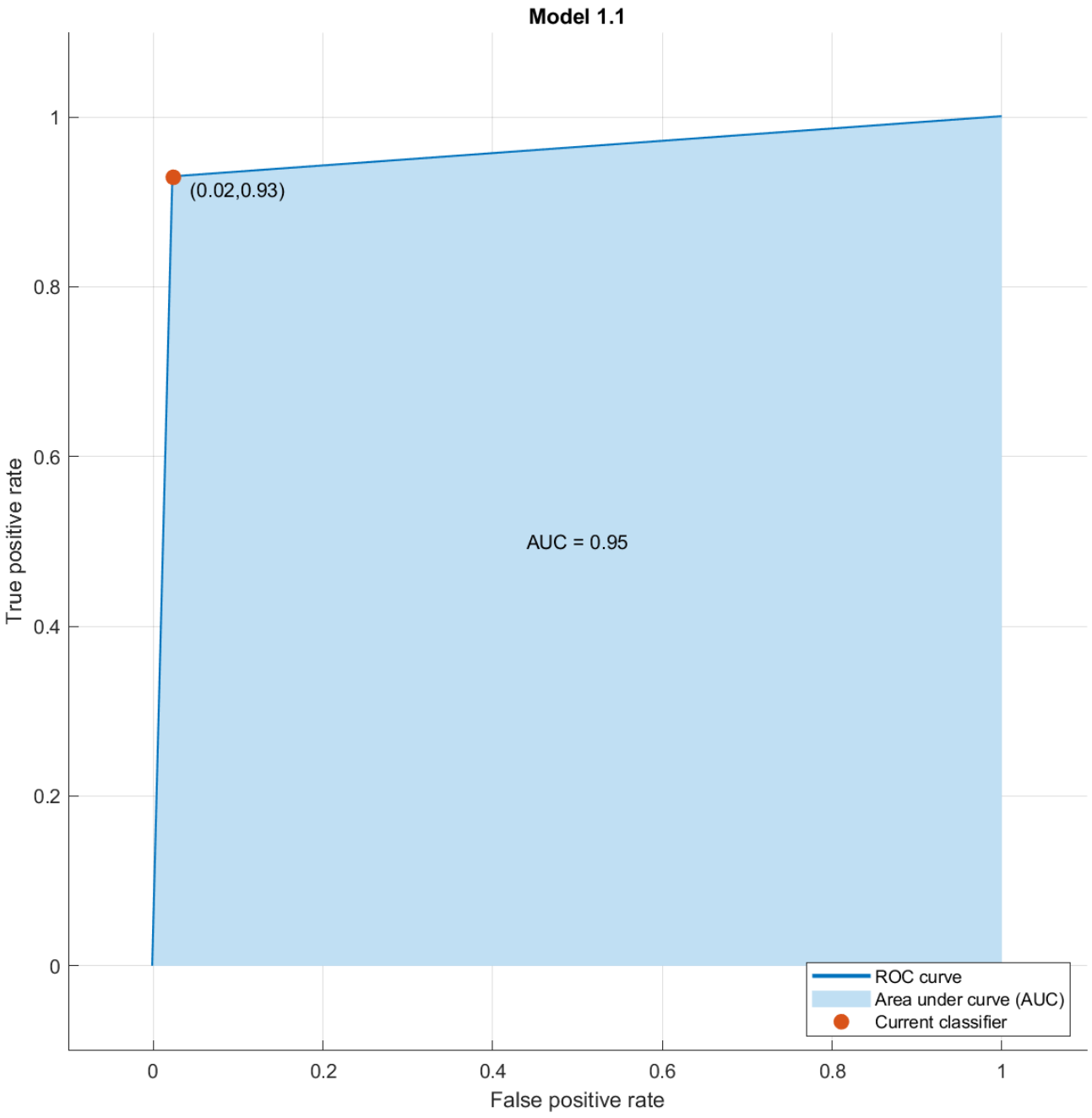

Figure 3: Methodology of proposed Work

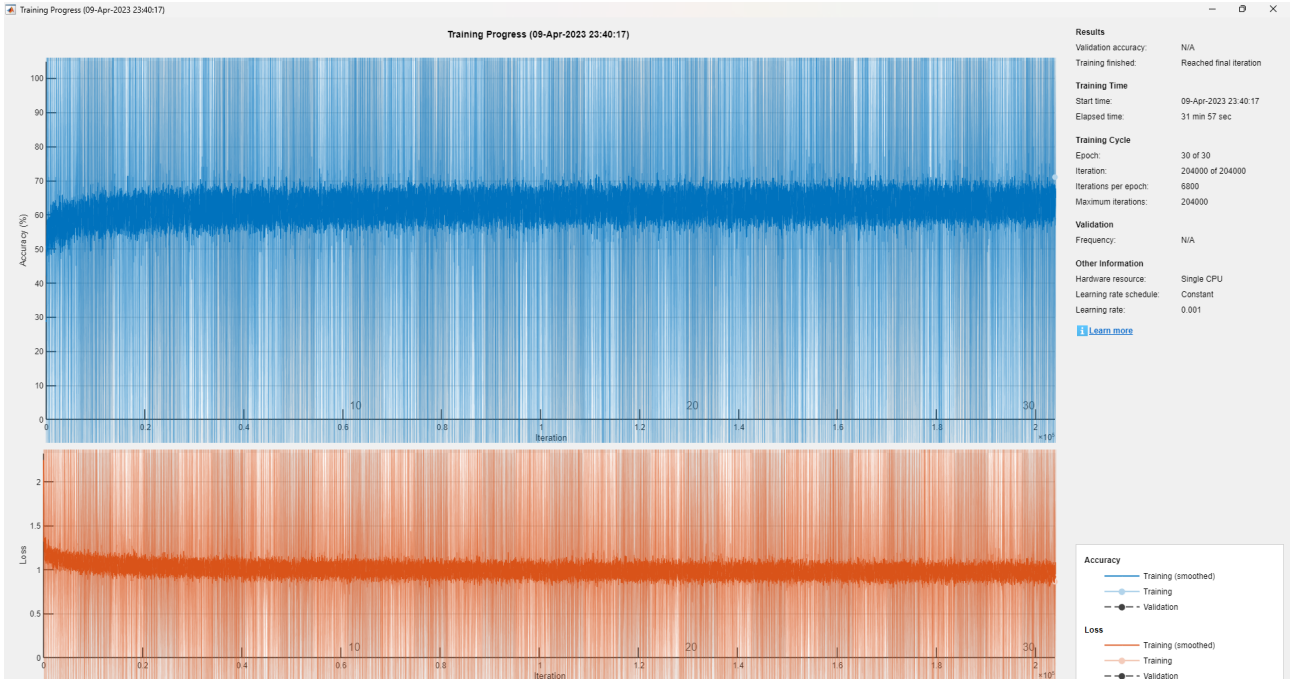

Figure 4: LSTM Model for classification

Table 2: Tabular Representation of Models classification Accuracy, Precision, Recall, F1 Score

Variable	TP	TN	FP	FN	Accuracy	Precision	recall	F1
Wake	82321	147755	6279	3595	0.9588	0.9291	0.9581	0.9434
Stage-1	4749	232738	2619	2513	0.9788	0.6445	0.6539	0.6492
Stage-2	79042	229947	11086	12929	0.9265	0.8682	0,8496	0.8588
Stage-3	25169	208352	5223	6449	0.9523	0.8281	0.7960	0.8117
Stage-4	2498	236127	462	546	0.9957	0.8439	0.8206	0.8321
REM	21928	209214	4624	4234	0.9630	0.8258	0.8381	0.8319

5 Conclusion

From the results obtained one can conclusively say that wavelet scattering along with FINE Knn has performed better in comparison to LSTM Model, with an accuracy of 87.4%.