**Code description**

**Initial step to read signatures from text file:-**

1. First we are reading text file which has json data of forgery signatures and genuine signatures of each user.
2. We are splitting this json data using train\_test\_split function.
3. We are storing json data of each user that has both forgery and genuine signatures in test\_data and train\_data.

**Building &Training TARNN model:-**

1. The function dtw\_distance is calculating dynamic time warping between two signatures using fastdtw library.
2. The function prepare\_data prepares the input data for the neural network. It computes the DTW distance between each pair of genuine signatures and forged ones, pads the sequences to have the same length (using pad\_sequences from keras.preprocessing.sequence), and creates labels for the data (1 for genuine pairs, 0 for genuine-forged pairs). This function is used to prepare both training and testing data.
3. The max sequence length across all signatures in the training and test data is found. This will be used for padding the sequences to the same length.
4. The build\_model function builds a model with attention mechanism. This model takes three inputs: the DTW distance and two sequences of signature data. It processes the signature data with a Bidirectional LSTM and attention mechanism, then processes the output with another LSTM and a dropout layer, and finally a dense layer with sigmoid activation (since this is a binary classification problem).
5. Inputs for the model are prepared by taking the appropriate slices from X\_train and X\_test.
6. The model is trained using the Adam optimizer, binary cross entropy loss (since this is a binary classification problem), and accuracy as the metric.
7. The trained model is evaluated on the test data.
8. Finally, the test accuracy is printed out.

**Calculating EER ( Equal Error Rate):-**

1. The model predicts the probability of each test example being positive (genuine signature). These probabilities are stored in y\_pred\_probs\_test.
2. The Receiver Operating Characteristic (ROC) curve is calculated using the true labels (y\_test) and predicted probabilities. This curve plots the true positive rate (TPR, or sensitivity) against the false positive rate (FPR, or 1-specificity) at various threshold settings. The roc\_curve function returns the FPR (fpr), TPR (tpr), and thresholds (thresholds) used.
3. The False Acceptance Rate (FAR, equivalent to FPR) is calculated as far = fpr. The False Rejection Rate (FRR, equivalent to 1-TPR) is calculated as frr = 1 - tpr.
4. The EER is the point where FAR equals FRR. It's calculated by finding the index of the threshold that minimizes the absolute difference between FAR and FRR (eer\_threshold\_index). The corresponding threshold (eer\_threshold) and EER (eer) are then extracted.
5. Finally the EER is printed.

**Predicting TARNN model:-**

1. To ensure that the input signatures have the same length as the ones the model was trained on, padding is added to the input signatures using the pad\_sequences function. The padding is added at the end ('post') of the sequences.
2. The DTW distance between the two signatures is calculated using the dtw\_distance function.
3. The model makes a prediction using these inputs. The output is a probability that the pair of signatures is genuine.
4. If the output probability is greater than 0.5, the function returns 1, indicating that the pair of signatures is predicted to be genuine. Otherwise, it returns 0, indicating that the pair of signatures is predicted to be a forgery.

**References:-**

1. [Recurrent Neural Networks (RNN) with Keras  |  TensorFlow Core](https://www.tensorflow.org/guide/keras/rnn)
2. [A Guide to Bidirectional RNNs With Keras | Paperspace Blog](https://blog.paperspace.com/bidirectional-rnn-keras/#:~:text=To%20enable%20straight%20%28past%29%20and%20reverse%20traversal%20of,beginning%20from%20the%20end%20of%20the%20data%20sequence.)
3. [matplotlib - How to plot ROC curve in Python - Stack Overflow](https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python)
4. [How to Plot a ROC Curve in Python (Step-by-Step) - Statology](https://www.statology.org/plot-roc-curve-python/)