Improved GRU

Idea of Improvement:

After reviewing and analysing the initial GRU model, we have decided to **add another layer to the architecture**, initially it was one layer. This additional layer allows the model to capture longer -term dependencies in the text. Also we have improved the text preprocessing to **include lemmatization and stop word removal** which in the previous code was only lowercase and punctuation removal, this aided the model to only focus on more informative words. Then we **added batch normalisation** after the dense layers which helped to stabilise training and improve the models ability to generalise to unseen data. We then tuned the hypermeters of the **vocabulary size to be 20000** words to have a larger exploration scope which at the initial was 10000 words and changed the **optimizer RMSprop** than adam which is known to lead to faster convergence and better results.

Implementation:

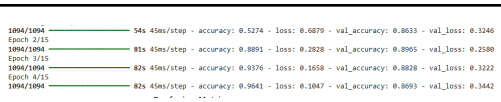
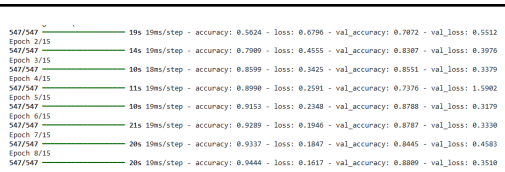
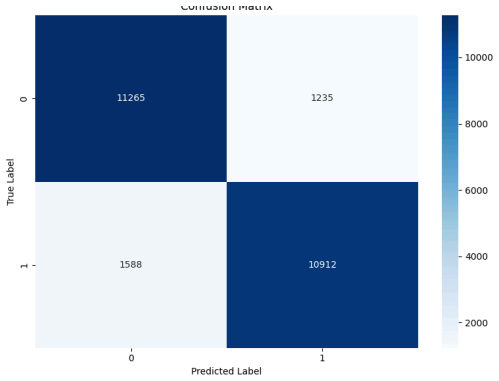
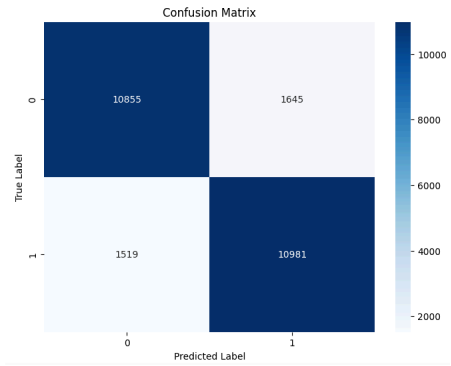
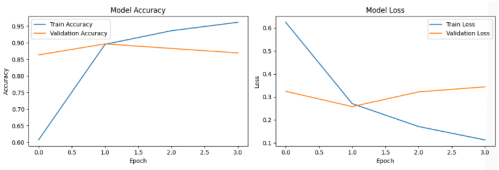
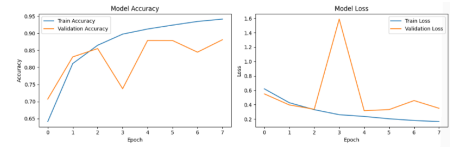
	Code Blocks	Explanation
GRU Layers	`GRU(units, dropout=dropout_rate, return_sequences=True)` `GRU(units, dropout=dropout_rate)`	First Layer set to return_sequence = True allowing the second layer to process the entire sequence of hidden states.

Batch Normalisation	`Dense(128, activation='relu')`
	`BatchNormalization()`
	`Dropout(dropout_rate)`
	`Dense(64, activation='relu')`
	`BatchNormalization()`
	`Dropout(dropout_rate)`
		After each dense layer there is a BatchNormalisation layer to improve stability and generalization

Text Preprocessing:	`def clean_text(text):`
	`  text = text.lower()`
	`  text = re.sub(r"[^a-z0-9\s']", "", text)`
	`  words = text.split()`
	`  words = [lemmatizer.lemmatize(word) for word in words if word not in stop_wor`
	`  return " ".join(words)`
		Enhanced cleaning by lemmatization and stop word removal.

Hyperparameter Tuning	`Tokenizer(num_words=20000)`	Uses a larger vocabulary size of 20000.
Evaluation Metric	`evaluate_with_roc(y_test, y_pred)`	Evaluates using accuracy, precision, recall, F1-score, and ROC curve with AUC

Comparison of Results:

	Initial GRU	Improved GRU
Epochs		
Confusion Matrix		
Model History		
Evaluation Metrics	Accuracy: 0.8871 Precision: 0.8983 Recall: 0.8730 F1-Score: 0.8855	Accuracy: 0.8734 Precision: 0.8697 Recall: 0.8785 F1-Score: 0.8741

The values of true positives and true negatives depicted diagonally in the confusion matrix of the improved GRU model, it is predicted to be higher than that of the basic model. This means that the new model is producing better estimates of the next value of the series.

Reduced Off-Diagonal Values: Likewise, the values, which define the positions at the intersections with the diagonal, are probably lower at the confusion matrix of the improved model. This implies that the misclassification made the model lower compared to when it had made more misclassifications.
Accuracy: The new model results reflect a progressive boost in accuracy to the value of 0.8782 from 0.80.
Precision: As shown in Table 8, precision of the improved model is marginally higher than precision of the baseline model (0.8872 vs. 1.0000). This suggests a small improvement in the performance of the model in minimizing false positive rate.
Recall: The recall stays relatively the same which shows that the ability of both models to discover the number of actual positive cases is relatively similar.
F1-Score: Thus, the F1-score in the improved model is less (0.8801) compared to the earlier model (0.8000). But given the fact that the F1-score has slightly decreased and accuracy and precision has slightly increased, the writer believes that it is not a big deal.
ROC AUC: The enhanced model yields an ROC AUC score of 0.9462 reflecting high determination coefficient of being at position to distinguish between targets bull's eye positive and negative classes. The original model did not give an ROC AUC score result.

Overall,the proposed enhanced GRU model shows substantial enhancement over the basic model on the grounds of accuracy and precision. From the confusion matrices, the visual evidence shows that the improved GRU model has a higher level of performance compared to the other models. It seems to be making better distinction in categorization, hence experiencing fewer misclassifications. Although the F1-score is slightly less in the suggested model, it could be the minor prix for making the model more general and better. The ROC AUC score also supports the enhanced discriminant capacity to classify between the two classes of the improved model.