Overcoming The Vanishing Gradient Problem Of Recurrent Neural Networks In The Iso 9001 Quality Management Audit Reports Classification

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Abstract: Deep neural networks specifically the Recurrent Neural Networks (RNN) generally suffer from the vanishing gradient problem. However, with proper implementation of hyper parameters, activation functions and appropriate choose of text representation models which purposely fit for the recurrent neural networks it can optimize and stabilize the gradient and prevent it from being vanish. This paper, focus to resolve the issue of the vanishing gradient problem of the recurrent neural network models while also improving the quality audit procedures through the application of data mining and deep learning models that’s automatically classify an audit reports based on the ISO 9001 Quality Management System Requirements. A total of ninety (90) recurrent neural networks were developed to investigate the influence of the combined word representation model, combined activation functions and implementation of dropouts’ method on the learning ability of the Long Short-Term Memory (LSTM) and Bidirectional-LSTM recurrent neural networks. The highest average classification accuracy of LSTM is 85.27% while the highest average classification accuracy of the BLSTM is 88.01%

Index Terms: Artificial Intelligence; Audit Reports; Quality Management System; Recurrent Neural Networks (RNN); Vanishing Gradient Problem;

1 INTRODUCTION

Hidden layers plays a significant role for the training of deep neural networks, it recognize complex patterns on the data and helps the deep learning model to discover more hidden patterns, factors and states of the data which leads to a better understanding on the content and depth of the data. It plays a crucial role for big data processing, data mining and data feature modeling. [1], [2] However, the addition of hidden layers in the neural networks may also lead to a negative outcome. When the neural network becomes too deep, the more the network becomes hard to train and the worst case scenario is the network will not finish its training process. [3], [4] this is called “The Vanishing Gradient Descent Problem” and it is a common problem when building a deep neural network. Especially the recurrent neural networks (RNN) generally suffer from this type of problem. When the network becomes deeper and more hidden layers had been added, the value of the gradients is gradually decreasing and it directly affecting the training and the learning outcomes of the deep learning model. [5], [6] Also, the training speed becomes slow and the classification accuracy becomes low. To resolve this issue, the authors proposed an innovative method by combining the word encoding and word embedding layer to pre-process the data and used the dropout’s method to optimize and stabilize the gradients of the deep neural networks. In recent years, several techniques had already been proposed to improve the performance of the deep learning models in order to overcome the vanishing gradient problem. Such as batch normalization and combination of two different algorithms and activation functions.

However, only few had explored to combined two different text representation model and evaluate its classification accuracy based on the methods used to overcome the vanishing gradient problem such as dropouts and activation functions. [2], [6], [12] This paper focus to resolve the issue of the vanishing gradient problem of the recurrent neural network models while also improving the quality audit procedures through the application of data mining and deep learning models that’s automatically classify an audit reports based on the ISO 9001 Quality Management System Requirements. In addition, this paper also aims to investigate the influence of the combined word representation model, combined activation functions and implementation of dropouts’ method on the learning ability of the LSTM and BLSTM recurrent neural networks.

2 RELATED WORKS

The researchers conducted an initial study on the automatic classification of the ISO 9001 Quality Management Audit Reports. In the initial study, the authors noticed that the adding of more hidden layers has directly affected the performance of the recurrent neural network models. The models suffer from slow training process and sudden decrease in the classification accuracy. The researchers found out that the cause of this phenomenon is due to the vanishing gradient problem of recurrent neural networks. [7] Similar papers were published regarding on the automatic classification of the quality management system audit reports and auditors opinions using deep neural networks. Based from their experiments during the building of their Deep Neural Networks model they experienced difficulty of adjusting the weights during the backpropagation process.[8],[9]The authors noticed, that their deep neural networks is difficult to train when hidden layers are been added. They concluded, that determining a number of hidden neurons is not an easy task, and mostly done on a trial and error basis. As the number of hidden layers increases, the learning ability of the networks becomes slow as the training set increases. The authors advised that the researchers should make fair balance and constantly assess the networks learning ability for this specific type of classification problem. [10], [11]
METHODODOLOGY

A total of 5,172 Audit Reports was extracted from the online quality assurance department of the academic sector. 70% of the data was used to train the RNN models and 15% was used to test the model and the remaining 15% was used to validate the actual deep learning models. The authors used the MATLAB version 2018 software to train and built an artificial neural network from the collected dataset. The “Adam optimizer” was used to stabilize the training process. A total of ninety (90) recurrent neural networks (RNN) models where developed and investigate the effects of the following methods applied in this type of text classification problem. Forty-five (45) Long Short Term Memory (LSTM) models and Forty-Five (45) Bidirectional-LSTM models were trained and built as classifiers and applied the following methods: (see Fig. 3 & 4)

RESULTS AND DISCUSSIONS

The deep learning models were evaluated by comparing the classification accuracy results of the RNN models according on the type of word representation models and methods used in optimizing and stabilizing the gradients of the deep neural networks. The results of the experiments have achieved the goals of this research. It able to determine, which method is the best to use, to improve the performance of the recurrent neural networks models and overcome the vanishing gradient problem in the ISO Quality Management Audit Reports Dataset.
It was observed in Table 1, using the word encoding method. The RNN models have achieved 50% of classification accuracy. This means, half of the audit reports were misclassified. Based on the results, the accuracy of the RNN models was drastically dropped. As the networks continue to become deeper, the performance of the deep neural networks also became poorer. In this type of experiment the dropout method outperformed the most common two methods in regularizing and optimizing the gradients of the deep neural networks. While the LSTM models outperformed the BLSTM model having the average classification accuracy of 69.06%.

Table 2 shows the results of using a combined word representation model to pre-process the data and integrate it to the three different approaches to optimize the gradients to improve the training process of the RNN models. Based from the results, the performance of the deep learning models was satisfactory, compared to the results of the first two methods. The average classification accuracy is about 72.81%. While the combined activation function outperformed the performance of the single activation function. Hence, the dropout approach surprisingly improved the learning ability of the RNN models and still outperformed the activation functions approach and lastly, in this approach the BLSTM models beat the LSTM model having the average classification accuracy of 88.01%.

Fig. 5. Results of automatic classification of audit reports using deep learning. The RNN models automatically classified the audit reports documents. The documents contains seven classes: Context of the Organization, Improvement, Leadership, Operation, Performance Evaluation, Planning and Support.

Table 3.

Table 2.

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Table 2: Results of classification accuracy using word embedding only.

Table 2: Results of classification accuracy using word embedding only.

Table 3: Results of classification accuracy using word encoding with word embedding.

Table 3: Results of classification accuracy using word encoding with word embedding.

Table 3: Results of classification accuracy using word encoding with word embedding.

Fig. 6. Design of the ISO Quality Management Audit Report Classification System.
5 CONCLUSIONS

Based from the results of the experiments, the word representation model has a significant influence on the learning ability of the recurrent neural networks. The proper choice of a word representation model is an important element or factor to be considered when training a deep neural network. The combination of two text processing models drastically increased the performance of the RNN models. The single layer LSTM and BLSTM both achieved a 97% of classification accuracy. While the five layers BLSTM with a combined word representation model and dropout's method able to overcome the vanishing gradient problem and achieved a classification accuracy of 81.20%. Meanwhile the combination of two activation functions with a combined word representation model also shows stability and satisfactory results. The experiments prove that, the proper implementation of hyperparameters and activation functions and proper choice of text representation model can improve the learning ability of the recurrent neural networks and overcome the vanishing gradient problem.

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7 REFERENCES