Recurrent Deep Neural Networks and Natural Language Processing for Sentiment Analysis, Ph.D. Research Proposal

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1 Introduction

In recent years, the increase in the computational capabilities of machines and the enormous rise in the amount of available data have been one the main factors to start a new revolution in big data and AI. Natural language processing is one of the fundamental branches of artificial intelligence known as NLP, where computers cleverly and effectively analyze, comprehend and extrapolate meaning from human language. Sentiment analysis is a subbranch of natural language processing, the main objective is to utilize sentiment analysis and deep recurrent neural networks to process a given human-readable text, by classifying and tagging the sentiment that a writer expresses in a text format.
Empowering the sentiment analysis with the recurrent neural network will enhance the overall performance of sentiment analysis.
Sentiment analysis divides the polarity of a text into negative and positive groups using deep learning algorithms and natural language processing algorithms, thus, It can be used in a variety of ways in business, such as predicting market moves based on opinions stated in news and blogs, determining consumer satisfaction about a product based on reviews posted on websites and social media; therefore, analysis of users data becomes increasingly crucial as the amount of document information produced by users rises quickly. Accordingly, analysis of this data can gather information about customer feedback on products, services, and events which helps businesses and governments to make decisions based on people sentiment analysis. Additionally, it serves as the foundation for various applications, including recommender systems and text-correcting programs[1].
Although there is a lot of research in the field of sentiment analysis and business intelligence, the need for more advanced recurrent neural network architecture to handle the massive amount of data has increased. Therefore, in this study, the proposed model is a novel design of a hybrid recurrent neural network (RNN), which infuses two types of recurrent neural networks, the purposed model infuses the gated recurrent unit and long short memory (GRU and LSTM) in a seq2seq-based architecture. Hence, the purposed model will be able to handle long sentences, In addition, a higher degree of accuracy compared to the recent models is aimed to be achieved by the end of this study[2].

2 Background

The need to improve sentiment analysis for business, decision-making and law enforcement has grown significantly over time. Sentiment analysis has a wide range of applications for the business, for example analyzing the sentiment conditions of customers; therefore, customer sentiments will be monitored continuously to ensure customers' satisfaction and response to their inquiries right away.
Sentiment analysis infers meaningful information from unstructured data. Deep learning models are utilized to boost business efficiency and strategy, this can be done by determining and examining the emotional

tone in client evaluations; thus, an improvement to alter the strategy for a company can be implemented to enhance the sales and services.
In addition, if a business sells items and makes use of a product recommendation system, sentiment analysis better comprehends client wants and makes suggestions that are more useful. Furthermore, to stand out from the competition and grow a business, giving customers a wonderful experience is essential. Therefore, action could be taken to respond right away when one of the consumers reports having a bad experience. Thanks to the technology of sentiment analysis, an enormous amount of client data may be reviewed and classified according to the emotional content, thereby, the bad sentiments can be emphasized and detected immediately. As a result, businesses may take the required steps before losing consumers and monitor bad reviews to prevent reputational damage by utilizing sentiment analysis[3].
Alongside customer satisfaction metrics and tracking the reputation of a brand, another aspect of sentiment analysis is to develop chatbots that are empathetic toward humans. Consumers who have had a bad experience wish their issues to be acknowledged and addressed, accordingly, companies may create a chatbot that is more sympathetic to the sentiments of their consumers by using sentiment analysis.
One more implementation of sentiment analysis is call center sentiment analysis. Businesses employ sentiment analysis to track real-time chat and live phone conversations for their call center representatives with clients[4]. Speech recognition during calls may automatically identify consumer sentiments. Businesses may have a better understanding of how call center services and product variations affect customer satisfaction, thus, based on poor feedback from consumers, evaluating the performance of customer call service enables businesses to examine the effectiveness of the call center and pinpoint the issues in particular departments. Managers may enhance both their training initiatives and customer call service center according to the outcomes obtained from sentiment analysis[5].

3 Proposed Work

The suggested method will study the deep recurrent neural network and natural language processing-based sentiment analysis, the goal is to measure customer satisfaction and increase business profits.
The idea behind measuring consumer satisfaction is to evaluate business efficiency and strategy by utilizing a data-driven approach and more advanced deep learning algorithms[6].

3.1 Aims

As mentioned in the previous sections, most of the research in natural language processing and sentiment analysis is incapable of handling long and complex sequences of human-readable sentences. The core building block for most sentiment analysis and natural language processing models is the sequence-to-sequence(seq2seq)model architecture.The seq2seq model is a unique type of recurrent neural network architecture that is mostly used for language processing problems. By carrying out this study, the aim of this research is to design a novel hybrid recurrent neural network (RNN), that infuses long-short term memory (LSTM) and gated recurrent unit (GRU) to create a hybrid recurrent neural network(RNN) in the form of seq2seq model architecture. After completing this research, the novel hybrid design will extend to fill a gap in the field of sentiment analysis and business intelligence strategy[7].

3.2 Objectives

during this study, many objectives as the following will be carried out to achieve the final aim of the purposed work.

1. Applying data mining techniques to gather, sort, visualize and evaluate data .
2. Consulting professionals from the business domain to figure out important features regarding the collected data.
3. Applying statistical and data pre-processing methods to prepare the collected data to be fed to the purposed hybrid neural network model.

4. Create a theoretical foundation for a seq2seq model-based sentiment analysis system.
5. Designing LSTM and GRU models to be implemented as encoder/decoder models respectively in the form of seq2seq model.
6. Testing, evaluating and optimizing the hyperparameters of the purposed hybrid model.
7. Comparing the metric results of the purposed model with the most recently published models.

3.3 Rationale

Sentiment analysis, also known as opinion mining, is a field of natural language processing that involves using computational techniques to identify and extract subjective information from textual data. In business, sentiment analysis can be used to understand the attitudes, opinions, and emotions of customers, employees, and other stakeholders toward a company, its products, services, or brand[8].
There are several reasons why sentiment analysis can be valuable in business analysis. First, customer sentiment is a key driver of customer loyalty and retention, and it can be a strong predictor of future purchasing behavior. By monitoring and analyzing customer sentiment, businesses can identify opportunities to improve customer satisfaction, resolve customer issues, and enhance their overall customer experience.
Second, sentiment analysis can help businesses track and measure the effectiveness of their marketing campaigns, public relations efforts, and customer service. By analyzing the sentiment of social media posts, online reviews, and other forms of customer feedback, businesses can drive conclusions regarding their performance.
Third, sentiment analysis can provide valuable insights into employee sentiment, which can be an indicator of employee engagement, satisfaction, and retention. By analyzing employee sentiment, businesses can identify potential issues or areas for improvement in their workplace culture and HR policies.
Overall, the use of sentiment analysis in business analysis can help organizations gain a deeper understanding of their customers, employees, and other stakeholders, and make informed decisions that can drive business growth and success[9].

4 Methodology

To achieve the aim of this study, it is essential to carefully design and examine the relationships between the various components in the purposed model. The Ph.D. candidate will employ statistical methods to measure and analyze the research outcomes. Depending on how the study is going, the Ph.D. candidate may also be required to complete mandatory surveys.
The study will start by reviewing the most recent research in sentiment analysis and natural language processing.The study will then provide theoretical and practical answers for sentiment analysis applications[10]. Furthermore, the accessible APIs will be used to retrieve and mine the required dataset. Following data retrieval, initially, data pre-processing steps is done, such as lowering the case of the letters, eliminating non-alphabets, converting alphabets to uni-codes, removing URLs, word lemmatization, eliminating unnecessary words to reduce noise and applying part-of-speech (POS) tagging. After performing the necessary pre-processing operations, feature extraction is carried out to get the most significant characteristics in the dataset, thus, the pre-processed data will be ready to be used as input tensors into the purposed network model. Furthermore, the model classifies human speech into different sentiment categories(negative, neutral and positive sentiments)[11]. The model will be trained using a seq2seq model architecture and back propagation neural network validation technique, hence, 15-fold cross-validation and feed-forward neural network will be implemented during the training phase. Validation is carried out to prevent the model from overfitting[12].
In the final stage of this study, evaluation metrics such as accuracy, recall, F1 score and precision will be utilized to evaluate the performance of the proposed hybrid neural network, therefore, The findings of the statistical analysis and the evaluation metrics will be used to compare and drive conclusions.

5 Programme of Work

In this part, the work packages to conduct this research will be fully explained. To fulfill the aims and objectives, the following work package will be employed.

1. **Literature review:** The Ph.D. candidate will conduct a comprehensive review of the most recent research publications and studies, with an emphasis on sentiment analysis algorithms, learning methodologies, and mapping out a route for the study. Furthermore, this section will address the primary goal of studying sentiment analysis, its applications and advantages in business.

2. **Data collection:** Determine the source of the data that is to be collected. This could be social media posts, online reviews, survey responses, or any other type of textual data. In addition, utilizing a tool such as SQL to scrape or access the data for the chosen source.

3. **Prototype design:** The basic model of the system will be built. At this point, the perfect neural network topology will be chosen and assessed. Furthermore, the structure of the seq2seq model will be designed in the form of an encoder/decoder network.

4. **Optimization and hyperparameters fine-tuning** Based on prior knowledge, experimentation and hyperparameter fine-tuning, the hyperparameter of the purposed hybrid design of LSTM and GRU neural networks will be tuned and optimized. In order to choose the hyperparameters' ideal values and optimization algorithm, the topology of the LSTM and GRU will be considered, hence a more logical trial-and-error approach will be adopted to further enhance the performance of the model.

5. **Outcomes evaluation and comparison** Evaluating the performance of the model on an unseen dataset is essential to test the generalization ability of the purposed model, using appropriate evaluation metrics such as accuracy, precision, recall, and F1 score to conclude comprehensive results and diagnosis. Afterward, the results of the purposed model will be compared to those of other deep learning models that took place in similar research topics in sentiment analysis.

6. **Evaluation of results and sharing of findings** The last stage of the project will involve a comprehensive review of the framework created earlier, as well as the creation of a final report. The results will be published in academic journals. This phase will also identify any potential areas for further study.

6 Professional, Legal, and Ethical issues

In recent years, big data and AI are two new technologies that have raised some ethical questions about how to treat people's personal information and data.
It is ethical and legal to mine some types of data, such as meteorological data, however, care must be taken while mining other types of data, such as customer behavior or health information. Scraping publicly available data from social media networks is permitted and lawful. Thus, It must be aware that the obtained data can contain personal information must not be shared publicly or sold to a third party.

7 Research Management Plan

This study requires a research management strategy as a crucial element. This is due to the fact that the project's completion timeline and any possible dangers will be taken into account. The Ph.D. applicant will be tasked with this project, which has a 3-year completion deadline, under the supervision of academic staff. The Ph.D. candidate will meet with their supervisor every 10 days to go over the status of their work and make any improvements that need to be made before moving to the next stage. Furthermore, risk management should be considered during the years of study, any unexpected issue or drawback that could face the candidate can cause a delay or a failure to conduct responsibilities on time, therefore, to avoid this kind of situation it is suggested to be self-discipline and ahead of the working schedule.

8 Relevance to Beneficiaries

The current development of deep learning techniques and AI algorithms has made it very convenient to build and develop sentiment analysis systems. The creation of the newly purposed model helps stakeholders and companies to grow their business and increase profits, in addition to that participation in academic literature will be added by filling a gap and extending the research in the field of sentiment analysis. Furthermore, the proposed neural network model can be extended beyond sentiment analysis, therefore, it can be used for other purposes such as foreign language translation and autonomous vehicles.

9 Justification of Resources

The Ph.D. candidate will require experience in cloud computing, deep neural networks, math and programming to successfully finish the study. Furthermore, the Ph.D. thesis supervisor must be a qualified expert in natural language processing.
A Ph.D. candidate who is interested in natural language processing is supposed to be familiar with the framework of sentiment analysis. In addition, the applicant should be capable of using Python programming proficiently, as well as platforms and libraries used in natural language processing, such as TensorFlow, Pytorch, and Google Colab. Lastly, it is essential to create user-friendly GUIs and commercial applications that utilize the purposed model to enhance business.The hardware of machines running Windows 10 is adequate to conduct this study.

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10 Project Work Plan

Task	Description	Deliverables	Period (Months)
1	Research and Literature Review	Presentation and Report	4
2	Prototype Design and Development	Software implementation, Models report	8
3	Prototype Test and Analysis	Software implementation, Simulation	6
4	Model optimization	Report	6
5	Feedback and Model Modifications	Report, Analysis	4
6	Models comparison and Full report submit	Report, Presentation	8

Table 1: Project Work Plan

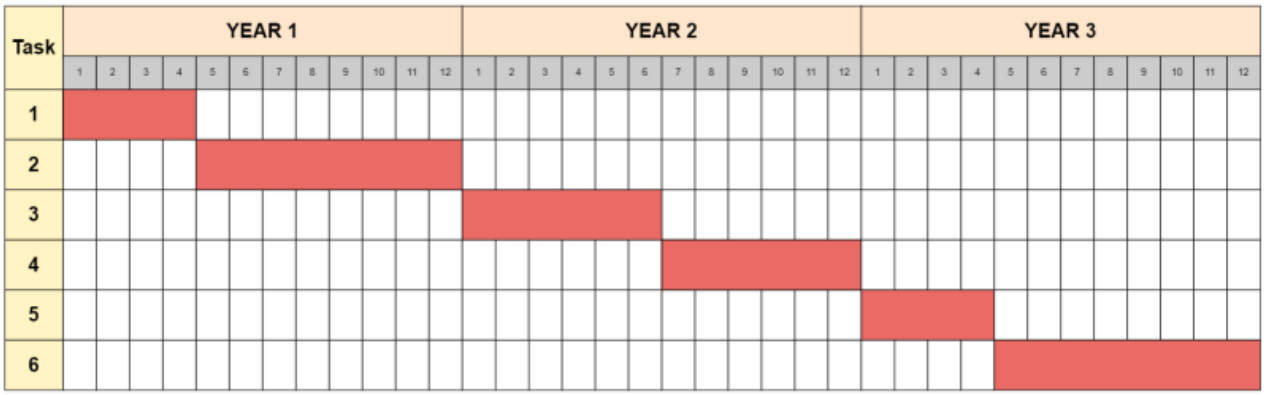

Figure 1: Diagrammatic Work Plan