Advanced Text Document Classification Techniques: Enhancing Accuracy and Efficiency in Real-World Applications

Bachelorarbeit

zur Erlangung des akademischen Grades

Bachelor of Science in Engineering (B.Sc.)

Eingereicht bei:

Fachhochschule Kufstein Tirol Bildungs GmbH

Web Business & Technology

Verfasser/in:

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Gutachter : Prof. (FH) Dr. Michael Kohlegger

Abgabedatum:

19. May 2024

Eidesstattliche Erklärung

Ich erkläre hiermit, dass ich die vorliegende Bachelorarbeit selbständig und ohne fremde Hilfe verfasst und in der Bearbeitung und Abfassung keine anderen als die angegebenen Quellen oder Hilfsmittel benutzt sowie wörtliche und sinngemäße Zitate als solche gekennzeichnet habe. Die vorliegende Bachelorarbeit wurde noch nicht anderweitig für Prüfungszwecke vorgelegt.

Kufstein, 19. May 2024

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Jesse Lang

Sperrvermerk

Ich habe die Sperrung meiner Bachelorarbeit beantragt, welche von der Studiengangsleitung genehmigt wurde.

Kufstein, 19. May 2024

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Jesse Lang

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Author: Jesse Lang
First reviewer: Prof. (FH) Dr. Michael Kohlegger

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Verfasser: Jesse Lang
Gutachter: Prof. (FH) Dr. Michael Kohlegger

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1. Introduction

The classification of text documents is essential across various applications. It demands a high accuracy and efficiency, in order to be beneficial. Traditional approaches often struggle with the diversity and complexity of modern textual data, emphasising the need for advanced techniques. Leveraging natural language processing (NLP), data mining and machine learning (ML) techniques holds promise in overcoming these challenges by enabling automated categorisation of textual documents based on their content, context and semantics. These procedures contain numerous obstacles, including defining accurate annotation of documents, the implementation of dimensionality reduction techniques to address complexities, utilizing appropriate classifier functions to obtain robust generalisation while avoiding overfitting (Aurangzeb et al., 2010).

One of the main sources for textual documents these days is the web, the amount that is available to us is constantly increasing. Unstructured textual formats, such as reports, emails, opinions, and news stories, are thought to contain approximately 80% or more of an organization's information. Studies indicate that unstructured formats contain almost 90% of the world's data. There's a clear necessity for the automatic extraction of valuable insights from vast amounts of textual data to aid human analysis (Aurangzeb et al., 2010).

This study aims to investigate how these advanced classification techniques, can enhance the accuracy and efficiency of categorizing diverse textual docu-

ments. Libraries, such as scikit-learn (Scikit-Learn, 2024), NLTK (NLTK, 2024) and Keras (Keras, 2024) and their broad spectrum of algorithms will be used to implement different approaches and exploring the interactions between these techniques. With the use of a BBC text document dataset with a ".csv" format does the research seeks to gain insights into optimizing classification performance in real-world applications.

The following research question arises from the objective: "How can advanced text document classification techniques, incorporating machine learning and natural language processing, be effectively employed to improve the accuracy and efficiency of categorizing diverse textual documents, and what factors influence the performance of such classification models in real- world applications?"

1.1 Motivation

The current state of research in text document classification techniques, with ML and NLP, showcases significant progresses towards enhancing efficiency and accuracy. Recent developments have seen the emergence of sophisticated deep learning architectures, such as CNNs and RNNs, which excel in processing complex textual data. Furthermore, has the integration of pre-trained language models like GPT and BERT revolutionized feature representation, allowing models to capture difficult semantic nuances. This dynamic landscape reflects ongoing efforts to refine classification models, making them increasingly adept at real-world applications.

2. Theory

The theoretical basis of this thesis provides the necessary background to comprehend the research discussed in the following chapters. Through an insight of relevant development in the field, various models, preprocessing methodologies, and evaluation metrics, this chapter aims to construct a theoretical framework for the thesis. Its objective is to empower the reader with the requisite understanding to contextualize the research outcomes and their significance.

2.1 Natural Language Processing

Natural Language Processing (NLP) is a branch of computer science and artificial intelligence, that deals with the interaction between human language and computers. Its aim is to enable machines to generate human language, process and understand it. Through employing a variety of techniques and different approaches, such as deep learning, rule-based systems, and statistical methods, is NLP capable to tackle different language-related tasks. The usage of it can be found in numerous areas, including machine translation, chatbots, text classification, and speech recognition (Helland, 2023).

2.2   Machine Learning

Machine learning refers to the development of computer programs that are learning from experience to complete and solve a certain task. The measurement of the performance is calculated by the ability to do so. A training dataset represents the "experience" that is acquired by machine learning models, which contains output and input pairs. From the analysis of these examples can the model recognize and generalise the patterns to new, unseen data. To simplify, can it be reflected to the process of human learning and adaption to new scenarios. Common applications include fraud detection, self-driving cars and personalised recommendations (Helland, 2023).

2.3   Deep Learning

Deep learning is a method that uses non-linear modules to transform the data at multiple levels of abstraction, allowing models to find patterns in the raw data. This suggests that deep learning models are discovering and learning different data features without the need for human interaction. Because of its universal learning, generalization potential, robustness, and scalability advantages, this can be used in a variety of applications without the need for precise feature engineering (Helland, 2023).

2.4   Evaluation Metrics

A machine learning model's performance is assessed using metrics. They are employed to evaluate the accuracy of the made predictions, to analyze the output of various models, and to fine-tune them for optimal performance. Different types of machine learning issues have various types of metrics avail-

able. The model selection process, the optimization procedure, and the overall understanding of the model's capabilities can all be impacted by the metrics chosen. Selecting the incorrect metrics might also result in a biased model, which aligns differently with the project's objectives (Helland, 2023).

2.4.1 Accuracy

One popular assessment metric for classification problems is accuracy. Out of all the samples in the prediction, it calculates the proportion of correctly classified samples.

Accuracy = Number of correctly classified instances/ Total number of instances

For balanced datasets, accuracy works well since it presents a realistic picture of the model's capabilities and performance. When datasets are unbalanced, accuracy might be misleading and more difficult to interpret. This may be due to a single label in the dataset that accounts for the majority of the samples; therefore, reasonable accuracy can still be obtained by projecting all samples to the dominant label. This does not imply that the model is good because it ignores the less common but no less significant labels. Accuracy in multi-label classification only takes into account samples where every label is correctly classified. Because of this, using accuracy as a multi-label classification metric to evaluate the performance of multi-label models is more strict, less informative, and less desirable (Helland, 2023).

3. Methodology

The methods used to address the research topics raised in this thesis are described in this chapter. To obtain the results that will be presented, this chapter aims to give a thorough description of the data collection and preprocessing, feature extraction, and model selection. To ensure reproducibility and provide the reader with a fair basis for evaluating the employment of models on text categorization tasks, this section should detail the techniques.

3.1 Data Collection and Preprocessing

The collection of data is a crucial step that lays the foundation for later analyses and model development. It involves gathering textual data from various sources, which could include websites, databases, or specialized datasets for the specific domain of interest. It is important to collect a sufficiently diverse amount of data to capture the variability present in real-world text data (OpenAI, 2024). This thesis uses a BBC news dataset containing 2225 text data and five categories of documents (Text Document Classification Dataset, 2024).

3.2   Text preprocessing

Preprocessing methods are an essential step for text mining techniques and applications. The data and its columns need to be analyzed and inspected since it is often necessary to generate a new column combining the various features. Through the joint column, a better, more comprehensive, and more accurate analysis can take place. The three essential preprocessing steps — extraction, stop word removal, stemming, and TF/IDF algorithms — are covered in this study (Figure 1).

3.2.1   Extraction / Tokenization

Tokenization is the process of splitting sentences into individual words, characters, and punctuation, which are referred to as tokens. The split function uses white spaces or punctuations as dividing criteria. These generated tokens are often stored in a list afterward. In later processing phases, this step aids in removing unnecessary terms (Tabassum & Patil, 2020).

For example:

"This is an example sentence for the showcase of tokenization!"

Will be split into:

"This", "is", "an", "example", "sentence", "for", "the", "showcase", "of", "tokenization", "!"

4. Results

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5. Discussion

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Bibliography

A. List of Interview Partners

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B. Code Table

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