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Bitola
Faculty of Information and
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Republic of North Macedonia

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AIIT 2025

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University “St. Kliment Ohridski” Bitola
Faculty of Information and Communication Technology - Bitola
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Introduction

As organizing partners of 15th International Conference on Applied Internet and Information Technologies AIIT 2025, we warmly welcome all participants, researchers, and colleagues joining us from various countries and universities, united by our shared commitment to advancing knowledge in the fields of computer science, applied Internet, and information technologies.

The AIIT conference has become a long-standing tradition of excellence and collaboration, co-organized by the Faculty of Information and Communication Technologies – Bitola, University "St. Kliment Ohridski," and the Technical Faculty "Mihajlo Pupin" – Zrenjanin, University of Novi Sad, Serbia. Over the past fifteen years, this partnership has fostered not only strong academic cooperation but also genuine friendship among our institutions and scholars.

This year's conference proudly continues that tradition, bringing together innovative research, diverse perspectives, and new insights into technologies that are shaping our digital future. The Scientific Program Committee once again faced the demanding task of selecting the highest-quality papers from more than sixty submissions spanning a wide range of topics—including Artificial Intelligence, Immersive Technologies, Mathematical Simulations, Data Science and Big Data Analytics, Knowledge and IT Management, Cybersecurity, Software Engineering, Data Mining, Digital Transformation, Behavioral Economics and Business, Social Engineering, Digital Humanities, Augmented Humanity, and Hybrid Intelligence. This ensures that the program reflects both scientific rigor and creative originality.

We would like to express our sincere gratitude to all reviewers for their dedicated work, as well as to the members of the Organizing Committee for their professionalism, commitment, and enthusiasm in preparing this event.

We are confident that these proceedings will provide an enriching and thought-provoking reading experience.

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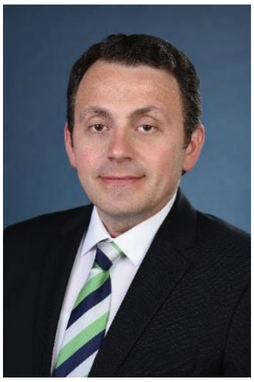

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CONTENT

Comparative Analysis of Text Mining Techniques and Tools

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Abstract:

Rapid progress in digitalisation has generated a vast volume of data, particularly unstructured and semi-structured data. Text mining is a process of extracting useful information from text documents and is a new and challenging research field that aims to address the information overload problem by leveraging techniques from machine learning (ML), natural language processing (NLP), and knowledge management. Text mining tools facilitate the analysis of unstructured textual data by extracting patterns and generating insights through techniques such as classification. In this paper, we have discussed the text mining techniques and compared two platforms: RapidMiner and KNIME.

Keywords:

Text mining, text mining tools, unstructured data, machine learning.

1. Introduction

Data mining is used for finding useful information from a large amount of data. Data mining techniques are employed to address various types of research issues. The research-related subfields in data mining are text mining, web mining, image mining, sequential pattern mining, spatial mining, medical mining, multimedia mining, structure mining, and graph mining [1].

On the other side, text mining is the process of mining useful information from textual documents. It is also called knowledge discovery in text (KDT) or knowledge of intelligent text analysis. Text mining is a technique that extracts information from both structured and unstructured data and also finds and recognizes patterns [1].

Text mining is similar to the data mining process, but they differ in the selected tool. Data mining tools are designed to handle structured data, whereas text mining can deal with unstructured or semi-structured data sets such as emails, HTML files, medical reports, full-text documents, etc. [2]. Text mining is used to find new, previously unidentified information from various written resources [1].

Structured data are data where each element is addressable and is the most organized form of data for easy storage, access, and analysis. This data type is structured into rows and columns and organized within databases and tables. Unstructured data, such as free-form text, images, and social media content, dominates information in the real world [3].

Unlike structured data, unstructured data does not follow a specific format or schema, which makes it more challenging to store and analyze. To overcome these challenges, modern storage solutions have been developed that are capable of handling large volumes and different types of data.

A data lake is a central repository that is highly scalable and can store structured, semi-structured, or unstructured raw and granular data from multiple sources [4].

Within such repositories, semi-structured data plays a particularly important role, as it strikes a balance between structured data's rigidity and unstructured data's flexibility, making it a valuable format for modern businesses looking to work with complex data sources.

The text mining process includes several stages: text pre-processing, feature extraction, text mining techniques, model training and evaluation, interpretation and visualization of results, iteration and refinement, reporting and deployment.

The rest of the paper is structured as follows. Section 2 presents the text mining process, while the subsequent section describes the fundamental techniques of text mining. Sections 4 and 5 present the obtained results of comparative analyses between RapidMiner and KNIME tools. Concluding remarks and directions for further work are given in the last section.

2. Text Mining

Text mining is a systematic sequence of steps used to extract useful information from unstructured text data, as shown in Figure 1. It consists of the following stages:

A. Text preprocessing

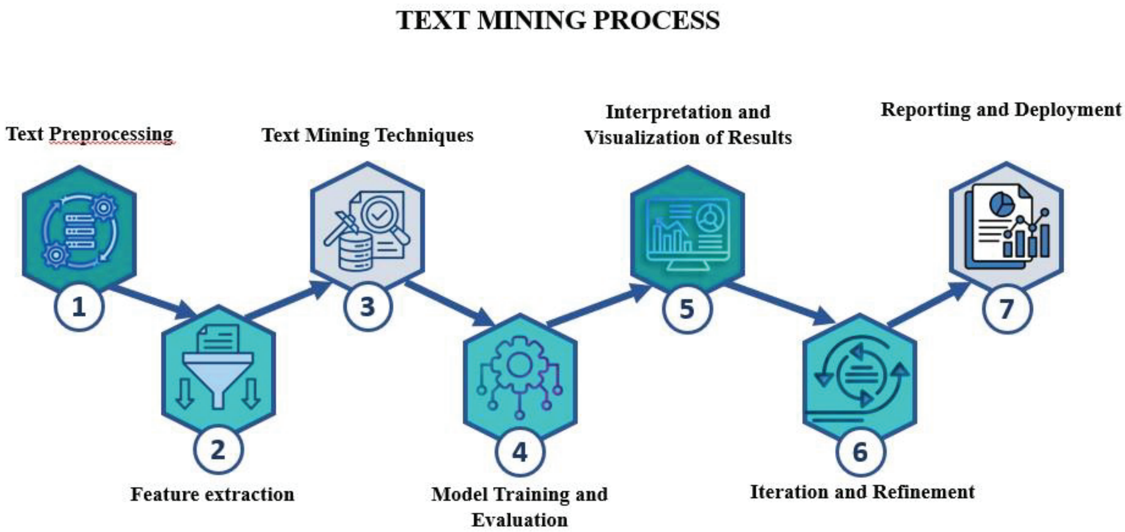


Figure 1. Text Mining Process

Pre-process the raw text data to clean and transform it into a suitable format for analysis. This step includes removing punctuation, converting text to lowercase, tokenization (splitting text into individual words or tokens), removing stop words, and stemming or lemmatization (reducing words to their root form).

B. Feature extraction

Extract attributes from the text data to represent it in a numerical or structured format that can be used for analyses. This step involves techniques such as bag-of-words representation, term frequency-inverse document frequency (TF-IDF), or word embeddings.

C. Text Mining Techniques

Used in various types of research domains like information retrieval, information extraction, natural language processing, categorization, text classification, and text clustering.

D. Model Training and Evaluation

Divide the text into training and evaluation sets using machine learning or statistical models. This step uses techniques like cross-validation or hyperparameter tuning.

E. Interpretation and Visualization of Results

Interpret and analyze results obtained from applied text mining techniques. Visualize results using graphs, charts, or diagrams.

F. Iteration and Refinement:

Analyze the result and iterate on the text mining process as necessary.

G. Reporting and Deployment

Prepare a comprehensive report summarizing the results, insights, and recommendations derived from the text mining.

3. Techniques in Text Mining

In text mining, various techniques are employed to handle unstructured textual data, enabling the discovery of patterns and the extraction of knowledge and actionable insights.

A. Information Retrieval

Information Retrieval (IR) is the process of representing, storing, and querying data collections to enable knowledge discovery based on user requests [5]. This process involves various stages, starting with representing data and ending with returning relevant information to the user. The intermediate stage includes filtering, searching, matching, and ranking operations [5].

B. Information extraction

Information extraction serves as the starting point for analysing unstructured text, where the focus is on recognizing relevant phrases and their interrelations. To accomplish this, pattern-matching methods are applied to locate predefined structures within the text. The information extraction task includes tokenization, identification of named entities, sentence segmentation, and part-of-speech assignment. Firstly, input phrases and sentences are parsed and semantically interpreted, and then the required pieces of information are added to the database. The general information extraction process is shown in Figure 2. The most accurate information extraction systems involve handcrafted language processing modules, and substantial progress has been made in applying data mining techniques to a number of these steps. This technology can be very useful when dealing with large volumes of text [6].

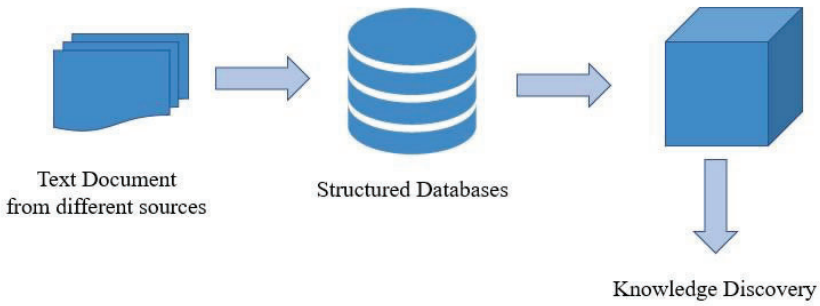


Figure 2. Information extraction [6].

C. Categorization

Categorization represents the mechanism through which entities are identified and differentiated, forming the basis for a structured understanding of ideas and objects. Categorization implies that objects are grouped into categories, usually for some specific purpose. Text categorization becomes a key technology to deal with and organize large numbers of documents. Text representation constitutes a key step in text categorization, ensuring that documents are expressed in a way that supports meaningful classification. A major problem of text representation is the high dimensionality of the feature space. The feature space with a large number of terms is not only unsuitable for neural networks but also easily causes the overfitting problem. Text categorization is the assignment of natural language documents to one or more predefined categories based on their semantic content, and is an important component in many information organization and management tasks [7].

D. Natural Language Processing

Natural language processing (NLP) refers to the automatic processing and analysis of unstructured textual information. It performs different types of analysis, such as Named Entity Recognition (NER) for abbreviation and their synonyms extraction to find the relationships among them [8]. NER identifies all the instances of specified objects from a group of documents. These entities and their instances allow the identification of relationships and other information to attain their key concept. However, this technique lacks a complete dictionary list for all named entities used for identification [8]. Natural Languages (NL) have a lot of complexities, as a text extracted from different sources does not have identical words or abbreviations. There is a need to detect such issues and make rules for their uniform identification [8].

E. Clustering

Clustering is an unsupervised approach used to group the text documents by applying different clustering algorithms. In a cluster, similar terms or patterns are grouped and extracted from various documents. Clustering is performed in a top-down and bottom-up manner. In NLP, various types of mining tools and techniques are applied for the analysis of unstructured text. Different techniques of clustering are hierarchical, distribution, density, centroid, fuzzy c-means, and k-means clustering [9].

F. Summarization

Text summarization techniques aim to generate concise summaries of long texts. It can be done in extractive or abstractive manners. Extractive summarization involves selecting important sentences or phrases from the original text, while abstractive summarization involves generating new sentences to capture the key information.

4. Text Mining Tools (RapidMiner vs KNIME)

Text mining tools can be classified into three categories, as shown in Figure 3.

1) Proprietary Text Mining Tools

These tools are commercial text mining tools owned by a company. To use these tools, a purchase is required. Although demo/trial versions are available free of charge, they have limited functionality.

2) Open-Source Text Mining Tools

These tools are available free of charge, and their source code is available; one can even contribute to their development.

3) Online Text Mining Tools

These tools can be run from the website itself. Only a web browser is required. These tools are generally simple and provide limited functionality [10].

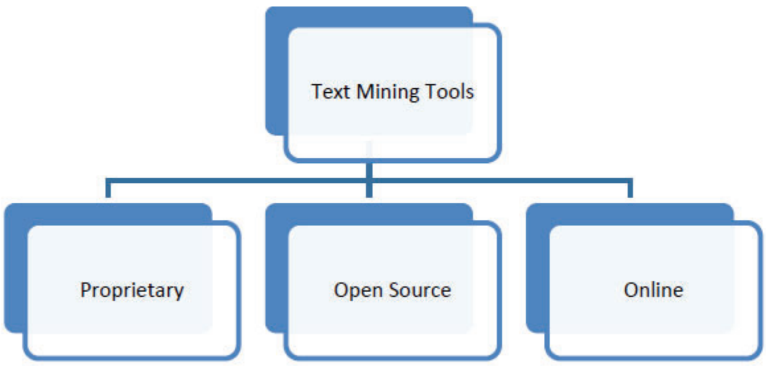


Figure 3. Types of Text Mining Tools.

Although there are many text mining tools, such as Weka, Orange, KNIME, RapidMiner, and Tanagra, we have chosen two of them that often come up in discussions: RapidMiner and KNIME. Both are powerful software programs that can help businesses and researchers in text mining and analysing data more efficiently. However, choosing between two can be a daunting task, as each has its strengths and weaknesses, as tabulated in Table 1.

RapidMiner allows users to create data workflows using a drag-and-drop interface. Like KNIME, RapidMiner offers a wide range of pre-built nodes, as well as the ability to create custom nodes using various programming languages. One of the biggest advantages of RapidMiner is its speed. RapidMiner has been designed to efficiently manage large datasets, offering faster data processing performance relative to KNIME. Additionally, RapidMiner offers a wide range of machine-learning algorithms that can be used to build predictive models, such as Naïve Bayes, Decision Tree, Random Forest, Logistic Regression, Support Vector Machine (SVM), K-Nearest Neighbours (KNN), etc.

KNIME (Konstanz Information Miner) is an open-source data analytics platform that allows users to create data workflows, which are essentially a series of interconnected nodes that represent different data processing steps. KNIME offers a wide range of pre-built nodes, as well as the ability to create custom nodes using various programming languages such as Python, R, and Java. One of the biggest advantages of KNIME is its user-friendly interface, which makes it easy for users of all skill levels to create complex data workflows without any programming knowledge. Furthermore, KNIME's community is very active, with a large number of pre-built workflows available for download, which can save users a lot of time.

Table 1: Comparison of features between RapidMiner and KNIME

Feature	RapidMiner	KNIME
Main Feature	Visual workflow	Data integration & manipulation
Strength	User-friendly, extensive pre-built components	Data integration, scripting
Weakness	Can be resource-intensive for complex workflows	Programming skills required for advanced tasks
Cost	Free and Commercial Versions, the free version supports only 10.000 rows	Free
Speed	It demonstrates faster performance when processing large datasets.	It demonstrates slower performance when processing large datasets.
Programming Language	Java	Java
Supported Data Formats	CSV, XML, JSON, others	CSV, TSV, TXT, XLSX, JSON, XML, others
Machine Learning Algorithms	Extensive library	Various, including deep learning
Data Visualization	Basic visualization components	Extensive visualization capabilities
Real-time Data Analysis	Limited support	Some support through extensions
OSs	Windows, macOS, Linux, open source	Windows, macOS, Linux, open source
Quality	Powerful and versatile, with an advantage especially in predictive analytics	The main open data mining tool that predictive analytics has made available to the general public
Techniques supported	Data mining and text analytics, text processing	Text analysis, data I/O, pre-processing and cleaning, modeling, analysis and data mining

5. Experiment

5.1 Research methodology

Besides a comparison of the features between RapidMiner and KNIME, we have conducted a comparative study of the classification algorithm Naïve Bayes on the spam emails dataset, downloaded from Kaggle [11]. The dataset includes two categories: spam and ham. The term spam refers to unsolicited or unwanted messages, typically sent in bulk for advertising or malicious purposes, whereas ham denotes legitimate, non-spam messages. The number of instances is 5572, with two attributes:

- Categories: spam, or ham (not spam).
- Message: email message.

To ensure proper evaluation of the classification models, the dataset was divided into training and test sets using an 80/20 stratified sampling approach. This technique preserved the original class distribution in both subsets, thus avoiding potential bias in the learning process. Out of the total instances, 4825 (86.6%) were labeled as ham and 747 (13.4%) as spam. After the split, the training set contained 4457 messages (3860 ham and 597 spam), while the test set included 1115 messages (965 ham and 150 spam). This distribution allowed the Naïve Bayes classifier to be trained on a representative portion of the data and tested on an independent subset that retained the original characteristics of the dataset.

In RapidMiner for classification, we used the following nodes: Read CSV, Nominal To Text, Set Role, Split Data, Process Document From Data, which contain operators for pre-processing data (Tokenize, Transform Cases, Filter Stop words), Naïve Bayes, Apply Model, and Performance, as shown in Figure 4.

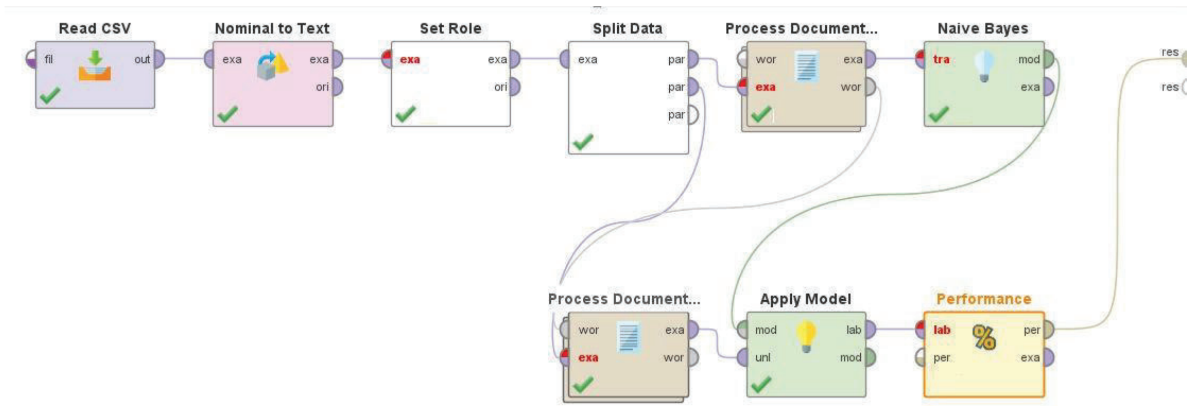


Figure 4. Classification in RapidMiner.

For the classification in KNIME, we have employed the following nodes: CSV Reader, String to Document, Nodes for Pre-processing Data (Punctuation Erasure, Number Filter, Stop Words Filter), Bags of Words Creator, Term to String, TF, Partitioning, Naïve Bayes Learner, Naïve Bayes Predictor, and Scores shown in Figure 5.

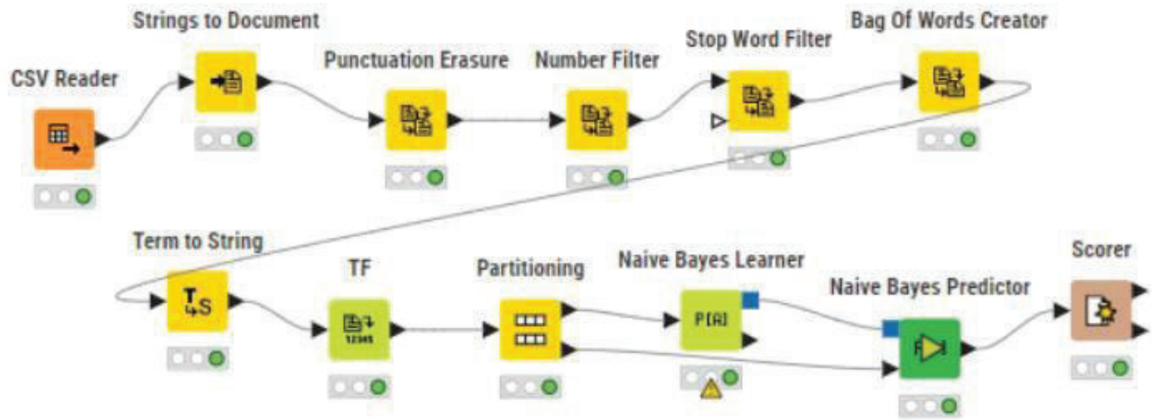
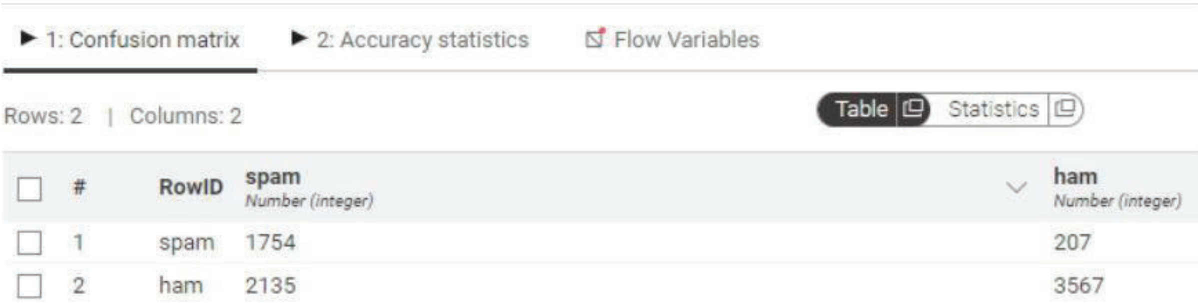


Figure 5. Classification in KNIME.

5.2 Results

In this step, we evaluate the performance of the classification algorithm using the confusion matrix, a table that reveals true versus predicted values and the performance of the classification model on the basis of accuracy, as shown in Figures 6, 7, and 8.



▶ 1: Confusion matrix ▶ 2: Accuracy statistics Flow Variables

Rows: 2 | Columns: 2 Table Statistics

#	RowID	spam Number (integer)	ham Number (integer)
1	spam	1754	207
2	ham	2135	3567

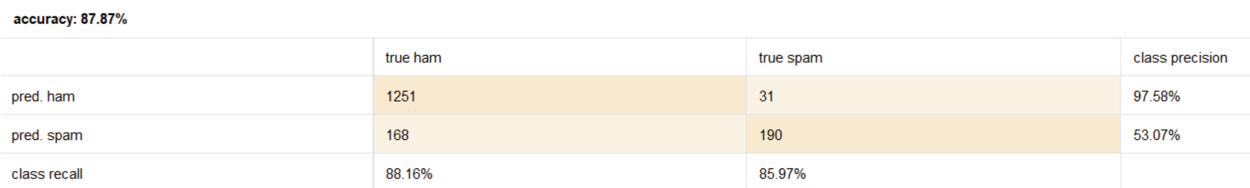
Figure 6. Confusion Matrix in KNIME.

▶ 1: Confusion matrix ▶ 2: Accuracy statistics Flow Variables

Rows: 3 | Columns: 11 Table Statistics

#	RowID	TruePositives Number (integer)	FalsePositives Number (integer)	TrueNegatives Number (integer)	FalseNegativ... Number (integer)	Recall Number (double)	Precision Number (double)	Sensitivity Number (double)	Specificity Number (double)	F-measure Number (double)	Accuracy Number (double)	Cohen's kappa Number (double)
1	spam	1754	2135	3567	207	0.894	0.451	0.894	0.626	0.6	?	?
2	ham	3567	207	1754	2135	0.626	0.945	0.626	0.894	0.753	?	?
3	Overall	?	?	?	?	?	?	?	?	?	0.694	0.393

Figure 7. Accuracy in KNIME.



accuracy: 87.87%

	true ham	true spam	class precision
pred. ham	1251	31	97.58%
pred. spam	168	190	53.07%
class recall	88.16%	85.97%	

Figure 8. Confusion Matrix and Accuracy in RapidMiner.

Table 2:
Results of classification

	Accuracy	Class Precision		Class Recall	
		predicted ham	predicted spam	ham	spam
RapidMiner	87.87 %	97.58 %	53.07 %	88.16 %	85.97 %
KNIME	69.40 %	94.50 %	45.10 %	62.60 %	89.40 %

As shown in Table 2, the accuracy value in RapidMiner is 87.87%, and in KNIME, that value is 69.4%. When we compare class precision in RapidMiner for predicted ham, which is 97.58% and for predicted spam, which is 53.07% versus class precision in KNIME for predicted ham, which is 94.5% and for predicted spam, which is 45.1%. Also, class recall in RapidMiner for ham is 88.16% and for spam is 85.97%, versus class recall in KNIME for ham is 62.6% and for spam is 89.4%.

6. Conclusion

Business decision-making relies on structured, unstructured, and semi-structured data being processed through every step of the text mining process. Text mining techniques help to improve the text mining process. Selecting the text mining technique is an important part of obtaining the most reliable results. Similarly, selecting the appropriate text mining tools is essential. Now there are a large number of tools that are available to users, which we have already classified into three categories and compared some of the features of RapidMiner and KNIME.

To conclude, RapidMiner and KNIME are powerful platforms for text mining, offering a comprehensive set of features and functionalities. When we compare them according to the obtained results, we can say that RapidMiner has better accuracy, class precision, and class recall than KNIME on the dataset that we have chosen. But choosing between the two ultimately depends on your specific needs, datasets, models, and algorithms. Regardless of which tool is selected, both RapidMiner and KNIME can help to analyze the data more efficiently and effectively.

Future work could expand the analysis by incorporating additional machine learning algorithms such as Support Vector Machines, Random Forests, Gradient Boosted Trees, or even deep learning approaches. A broader evaluation across multiple models would provide deeper insights into performance trade-offs and enhance the robustness of the findings.

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