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**| RESEARCH ARTICLE**

## **A Comprehensive Review of Text Mining Approaches for Predicting Human Behavior using Deep Learning Method**

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**| ABSTRACT**

This article presents a systematic review of research on predicting human behavior through unstructured textual data, employing a comprehensive selection process illustrated in a flow diagram. The review categorizes 82 selected papers into three primary behavioral domains: emotional, social, and cognitive. Each paper undergoes meticulous examination, identifying objectives, algorithms, computational models, and applications. Natural language processing (NLP) emerges as a dominant text mining approach, utilized in over half of the literature, followed by data extraction, report arrangement, and clusterization. The study further employs VOSviewer to visualize the co-occurrence of the term "text mining," revealing prevalent associations and emphasizing the challenges in analyzing unstructured data efficiently. The article contributes to understanding the evolving landscape of behavior analysis through text mining, addressing the need for automated methods in evaluating individuals' attitudes, emotions, or performance.

**| KEYWORDS**

Emotional Domain, Social Domain, Cognitive Domain, Clusterization, VOS viewer.

**| ARTICLE INFORMATION**

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### **1. Introduction**

Understanding and predicting human behavior is a complex and evolving area of research that has witnessed significant advancements with the advent of text-mining techniques. This systematic review delves into the rich landscape of studies aiming to predict human behavior through unstructured textual data. The importance of this endeavor lies in the ability to unravel insights into individuals' attitudes, emotions, and cognitive processes, offering valuable implications for diverse fields such as psychology, sociology, and information technology.

The selection process, illustrated in Figure 01, demonstrates a meticulous approach to identifying and including literature in this meta-analysis. By categorizing 82 selected papers into three primary behavioral domains—emotional, social, and cognitive—the review provides a comprehensive overview of the methodologies, algorithms, and applications employed in this interdisciplinary field.

Table 02 further details the characteristics of the included papers, offering a glimpse into the diversity of research methods utilized, ranging from natural language processing (NLP) and web mining to information extraction and document cauterization. Each paper undergoes a thorough examination, enabling the extraction of crucial insights related to computational models, objectives, and primary applications within the broader context of predicting human behavior.

The sub-classification of publications, as depicted in Figure 02, provides a nuanced understanding of the distribution of papers within the identified behavioral categories. Notably, the dominance of NLP, evidenced in more than half of the reviewed literature, underscores its significance in text mining approaches. The diverse use of other techniques, such as data extraction, report arrangement, clusterization, web mining, and data recovery, highlights the multifaceted nature of the studies contributing to this burgeoning field.

To visualize the co-occurrence of the term "text mining" within the explored literature, Figure 03 employs VOSviewer, offering a graphical representation of associations between terms. This analysis reveals prevalent connections and emphasizes the challenges associated with efficiently analyzing unstructured data, particularly in the context of human behavior.

The dynamic nature of behavior analysis through unstructured texts presents challenges that extend beyond the capabilities of manual analysis by human experts. The review acknowledges the complexities involved, ranging from the continuous monitoring of individual performance to the inherent biases introduced by deep, social, and environmental factors. In response to these challenges, the study explores the contemporary applications of behavior analysis derived from mining unstructured texts, aiming to shed light on both the advancements and persistent challenges in this evolving field.

In essence, this systematic review serves as a comprehensive exploration of the evolving landscape of predicting human behavior through unstructured textual data. By synthesizing findings from diverse studies, the review contributes to the understanding of the role of text mining approaches in deciphering the intricate facets of human behavior, paving the way for automated methods that can enhance our ability to evaluate attitudes, emotions, and performance at an individual level.

## 2. Related Work

Srividya et al. (2018) study proposes the application of diverse machine learning algorithms, including support vector machines, decision trees, naïve Bayes classifier, K-nearest neighbor classifier, and logistic regression, for the identification of mental health states within a specified target group. Responses from the target group were gathered through a designed questionnaire, and they underwent unsupervised learning techniques initially. The obtained cluster labels were validated using the Mean Opinion Score. Subsequently, these validated labels were utilized to construct classifiers for predicting an individual's mental health. The study encompasses populations from various segments, such as high school students, college students, and working professionals. The analysis of applying the mentioned machine learning algorithms to these target groups is presented, along with suggestions for future research directions.

In Iyortsuun et al. (2013) research, a total of 33 articles focusing on the diagnosis of schizophrenia, depression, anxiety, bipolar disorder, post-traumatic stress disorder (PTSD), anorexia nervosa, and attention deficit hyperactivity disorder (ADHD) were gathered from different search databases utilizing the preferred reporting items for systematic reviews and meta-analysis (PRISMA) review methodology. The selection of these publications was based on their utilization of machine learning and deep learning technologies. Each article was individually evaluated, and the methodologies they recommended were categorized according to the specific disorders covered in this investigation. Furthermore, the challenges faced by researchers are deliberated upon, and a compilation of publicly available datasets is presented.

Ehiabhi et al. (2023) research provides an extensive overview of current trends and the latest developments in mental health analysis, specifically focusing on the application of machine-learning techniques for analyzing multi-variate/multi-channel multi-modal biometric signals. The study delves into the examination of prominent mental health biosensors such as polysomnography (PSG), electroencephalogram (EEG), electro-oculogram (EOG), electromyogram (EMG), and electrocardiogram (ECG). Additionally, it outlines the procedures involved in data acquisition, data cleaning, feature extraction, machine-learning modeling, and performance evaluation. The review emphasizes the thorough exploration of support-vector-machine and deep-learning techniques in the existing literature. Following the analysis of more than 200 papers, the research also addresses the current challenges and opportunities within this domain.

Rahman et al. (2020) investigation conducted a review of articles available in major databases spanning the years 2007 to 2018, utilizing keyword searches as the primary method. Screening of articles occurred based on titles and abstracts, followed by a thorough examination of full texts. The coding process involved categorizing articles by data set characteristics (e.g., data sources, keywords, geographical locations), data analysis methods, application of machine learning or deep learning techniques, classifier

performance, and feature extraction methods. From a total of 2770 articles, 22 were selected for detailed review. Recognizing the considerable potential of Online Social Networks (OSNs) as a data source for early detection of mental health issues, many researchers focused on text analysis of new datasets extracted from diverse OSN sources. Statistical analysis or machine learning techniques were commonly employed to examine the extracted data. Additionally, some studies adopted multimethod approaches involving the distribution of questionnaires with explicit consent to access and extract information from respondents' OSN accounts. The utilization of big data in OSNs emerged as a valuable contributor to the detection of mental health problems. This approach presents an alternative to traditional strategies, such as data collection through questionnaires or devices and sensors, which are often time-consuming and costly.

**3. Methodology**

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines are followed in this evaluation. The orderly writing survey is organized around research requests obtained from the goals illustrated in the theoretical of the flow study. These inquiries are (a) the Most relevant examination recorded in the logical writing concerning the acknowledgment of human ways of behaving through text mining. (b) The way existing logical strategies for estimating the human way of behaving from unstructured literary information can be classified. Considerable rules were: English written documents, peer-inspected papers, papers containing diagrams, graphs, and conditions, as well as tables outlining text mining procedures basically centered around the investigation of conduct from a mental stance.

On the other hand, the models for prohibition were papers not written in English, papers considered, upon evaluation, to be immaterial to the exploration questions. Furthermore, suppositions, letters, and articles. An orderly inquiry methodology was utilized for this research to pinpoint papers pertinent to tending to the exploration questions. The scope of the search and the criteria for evaluating and selecting relevant literature were both outlined in this strategy. Recent and influential text mining literature, such as journal articles, textbooks, proceedings, and grey literature, were important sources for this study. Outfitted with a far-reaching comprehension of the topic and drawing motivation from widely referred to articles. We figured out a bunch of catchphrases. Following testing in different web search tools, this underlying set was refined to 15 catchphrases, as point by point in Table 1. Consequently, we utilized this refined set to inquire about different data sets, including EBSCOhost, Compendex, IEEE Xplore, Google Researcher, and ProQuest. This technique worked with the smoothing out of the center pursuit boundaries, zeroing in on key components impacting the expectation and perception of human conduct through text mining.

After recovering the articles, a fastidious determination process was applied to recognize important papers. In the EBSCOhost data set, the pursuit terms used were: "information mining" [MeSH terms] OR "text mining"[all fields] AND ("humans"[MeSH terms] OR "humans"[all fields]) AND ("behavior"[all fields] OR "behavior"[MeSH terms] OR "behavior"[all fields]) AND (("1998/01/01"[PDAT]: " 2019/12/31"[PDAT]) AND "humans"[MeSH terms] AND English[lang]).

| <b>Text Mining</b>                       | <b>Cognitive Behavior</b>   | <b>Behavioral Markers</b> |
|--|-----------------------------|---------------------------|
| Information Extraction                   | Emotional Behavior          | Lone Wolf Behavior        |
| Linguistic inquiry and word count (LIWC) | Natural Language Processing | Computational Linguistics |
| Human Behavior                           | Social Behavior             | Linguistic Markers        |
| Opinion Mining                           | Sentiment Analysis          | Behavioral Profiling      |

Table 01: Keywords used for searching selected databases.

To assess the gamble of predisposition in the current review, the Cochrane Chance of Predisposition Device was filled in as a supporting instrument. Applicable papers were arranged across different predisposition areas, including succession age (strategies utilized for information assortment), assignment disguise (whether information allotments could be expected previously or during assortment), blinding of members (people answerable for creating the text), blinding results (those producing text information without information on the outcomes), fragmented result information (whether the papers exhibited fulfillment of results in their outcomes), and particular result revealing (whether creators uncovered result detailing and what was found). The majority of the papers in each of these categories have a low risk of bias. The use of the Cochrane Instrument empowered the distinguishing proof and moderation of likely inclinations, in this way upgrading the general quality and dependability of the survey's decisions.

The evaluation of predisposition risk implied emotional decisions (arranged as high, low, or muddled) concerning the singular components inside the spaces. After the not entirely set in stone, a rate gauge was processed for these decisions. Overall, the different spaces showed around 58% generally safe, 23% hazy gamble, and 18% high gamble of inclination. This method offered

insights into the overall reliability of the findings by providing a quantitative representation of the distribution of bias risk across the various study components.

**4. Result and Discussion**

Figure 01 illustrates the selection procedure, along with the quantities of papers chosen at different stages of the selection process, to comprehend the evolution of research on predicting human behavior from unstructured textual data.

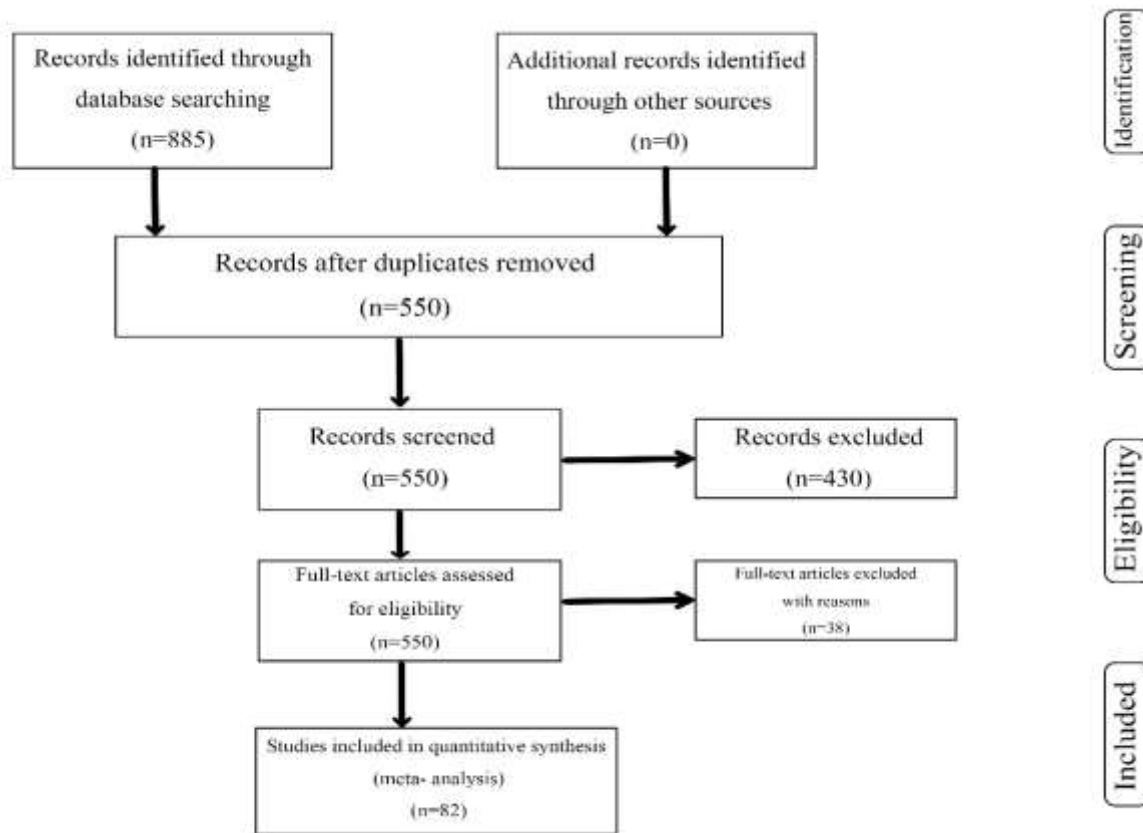


Fig 01: Flow diagram and selection process for including literature in the meta-analysis

After that, we divided the review into these categories after identifying categories in the literature review. When a class was laid out, we deliberately recognized the essential message mining approaches and key bits of knowledge from each examined work. The attributes of the included papers are itemized in Table 2.

| <b>Reference</b> | <b>Title</b>   | <b>Research Method</b>      | <b>Category</b>         |
|------------------|--|-----------------------------|-------------------------|
| [6]              | Modeling Public Mood and Emotion: Twitter Sentiment and Socio-Economic Phenomena                             | Natural language processing | Emotional               |
| [7]              | A Survey of Text Mining in Social Media: Facebook and Twitter Perspectives                                   | Web mining                  | Emotional               |
| [8]              | Thumbs Up or Thumbs Down? Semantic Orientation Applied to Unsupervised Classification of Reviews             | Document clusterization     | Emotional               |
| [9]              | Using causal models in heterogeneous information fusion to detect terrorists                                 | Natural language processing | Emotional and social    |
| [10]             | Assessing Bipolar Episodes Using Speech Cues Derived from Phone Calls  | Information retrieval       | Emotional and social    |
| [11]             | Language-based personality: a new approach to personality in a digital world                                 | Natural language processing | Emotional and cognition |
| [12]             | The Development and Psychometric Properties of LIWC2015  | Natural language processing | Emotional and theory    |
| [13]             | Mining the peanut gallery: opinion extraction and semantic classification of product reviews                 | Information extraction      | Social                  |
| [14]             | A mutually beneficial integration of data mining and information extraction                                  | Information extraction      | Social                  |
| [15]             | A Generic Architecture for a Social Network Monitoring and Analysis System                                   | Document classification     | Social                  |
| [16]             | Class Diagram Extraction from Textual Requirements Using Natural Language Processing (NLP) Techniques        | Information extraction      | Social and theory       |
| [17]             | Analysis of unstructured data: Applications of text analytics and sentiment mining                           | Information extraction      | Others/theory           |
| [18]             | Emotion correlation mining through deep learning models on natural language text                             | Natural language processing | Emotional               |
| [19]             | Study of coronavirus impact on parisian population from April to June using Twitter and text mining approach | Information extraction      | Emotional               |
| [20]             | An Exploration about the Last Mile Logistic Efficiency in Indian E-Commerce Sector- A Text Mining Approach   | Natural language processing | Cognition               |

Table 02: Characteristics of the included papers.

The selected articles, chosen based on criteria such as publication date, relevance, and content, underwent classification into three primary behavioral categories: emotional, social, and cognitive. Each paper was meticulously examined to identify its objectives, algorithms/techniques, models of computational aims, and main applications. Subsequently, each included paper was further sub classified according to the categories illustrated in Figure 02. In total, this review identified and retrieved a combination of 82 relevant papers, each uniquely identified by its respective subcategory.

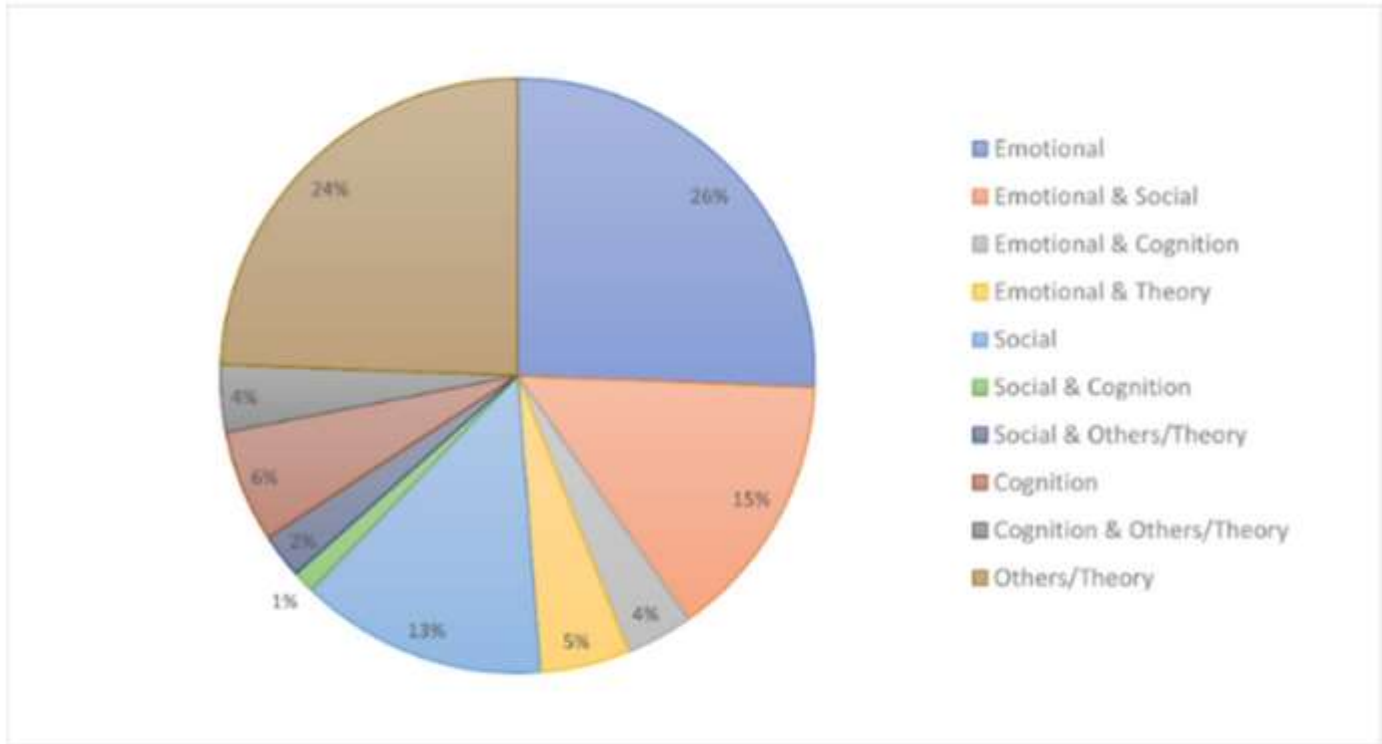


Fig 02: Sub classification of publications.

The rates for every one of the analyzed text mining approaches are portrayed. The results show that natural language processing (NLP) was used in more than half of the reviewed literature. Data extraction followed firmly, adding to 25% of the writing, while report arrangement and clusterization represented 23%. Also, web mining, data recovery, and synopsis aggregately made up 30% of the looked into writing. These outcomes feature the pervasiveness and meaning of NLP as a main text mining approach in the dissected examinations.

A co-event guide of the expression "text mining" in the title and unique of the explored writing. The planning was directed utilizing VOSviewer programming, accessible at <https://www.vosviewer.com/> (got to on 10 June 2021). This product was utilized to envision bibliometric information as an organization and create watchword co-event maps.

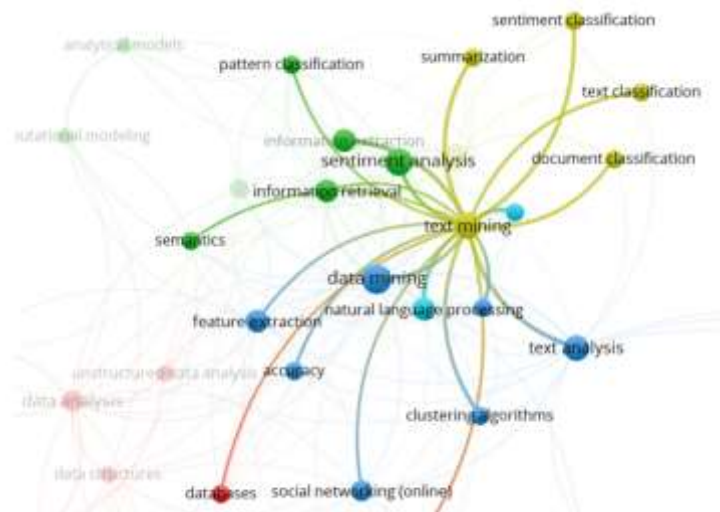


Fig 03: The map of the co-occurrence of the "text mining" term.

Here, the associations between the "text mining" hub and different hubs mean the co-event of terms, and their sizes mirror the recurrence of the event. The test of proficiently breaking down unstructured data connected with people makes ceaseless observing of a singular's presentation or learning adequacy, especially testing. This challenge highlights the developing requirement for mechanized methods equipped for examining and applying labels related to human conduct marks and execution. Performing such an errand physically by a human master could require weeks or even months, particularly when the outcomes are inclined to predisposition due to profound, social, and natural elements. The current review dives into the cutting edge in the uses of conduct examination obtained from mining unstructured texts. To shed light on the advancements and challenges in this ever-evolving field, this analysis aims to evaluate individuals' attitudes, emotions, or performance at the individual level.

## **6. Conclusion and Future Work**

In conclusion, this systematic review provides a comprehensive exploration of the evolving landscape in predicting human behavior through unstructured textual data. The meticulous selection process, illustrated in Figure 01, resulted in the categorization of 82 papers into three primary behavioral domains: emotional, social, and cognitive. The thorough examination of each paper unveiled diverse methodologies, algorithms, and applications, with natural language processing (NLP) emerging as a dominant text mining approach. The sub-classification of publications, as depicted in Figure 02, highlighted the prevalence of NLP, showcasing its significance in this interdisciplinary field. The results indicated that more than half of the reviewed literature employed NLP, emphasizing its role in behavior analysis. Other techniques, including data extraction, report arrangement, clusterization, web mining, and data recovery, contributed to the multifaceted nature of studies within this domain.

The co-occurrence map in Figure 03, generated using VOSviewer, visually represents the associations between terms, particularly focusing on "text mining." This analysis not only reveals prevalent connections but also underscores the challenges associated with efficiently analyzing unstructured data, especially in the context of human behavior. The discussion delves into the implications of the findings and the broader context of behavior analysis through text mining. The dominant role of NLP suggests its effectiveness in extracting meaningful insights from unstructured textual data. However, the challenges highlighted in the co-occurrence map emphasize the need for continued advancements in automated methods to analyze and apply tags related to human behavior and performance. The diverse set of papers, as outlined in Table 02, reflects the interdisciplinary nature of the field, with studies ranging from modeling public mood on Twitter to assessing bipolar episodes using speech cues. These applications showcase the versatility of text mining approaches in addressing various aspects of human behavior. The inclusion of related work in Section 2 expands the scope of the review by presenting studies that focus on mental health analysis using machine-learning techniques. This broader context offers insights into the potential applications of text mining in understanding and addressing mental health issues.

The methodology, following PRISMA guidelines, ensures the systematic selection of relevant literature. The risk of bias assessment, using the Cochrane Risk of Bias Tool, enhances the credibility of the review by identifying and mitigating potential biases in the selected studies. In summary, this systematic review not only contributes to the understanding of the evolving landscape of predicting human behavior through unstructured textual data but also emphasizes the significance of NLP as a dominant approach. The challenges outlined pave the way for future research endeavors to refine automated methods and advance our ability to evaluate attitudes, emotions, and performance at an individual level in the dynamic realm of human behavior analysis.

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