



A probabilistic approach toward evaluation of Internet rumor on COVID

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Abstract

Several people around the world have died from the coronavirus (COVID-19) disease. With the increase in COVID-19 cases, distribution, and deaths, much has occurred regarding the ban on travel, border closure, curfews, and the disturbance in the supply of services and goods. The world economy was severely affected by the spread of the virus. Every day, new discussions and debates started, and more people were in fear. Occasionally, unconfirmed information is shared on social media sites as if it were accurate information. Sometimes, it becomes viral and disturbs people's emotions and beliefs. Fake news and rumors are widespread forms of unconfirmed and false information. This type of news should be tracked speedily to prevent its negative impact on society. An ideal system is the dire need of modern-day society to evaluate the Internet rumors on COVID. Therefore, the current study has considered a probabilistic approach for evaluating the Internet rumors about COVID. The fuzzy logic tool in MATLAB was used for experimental and simulation purposes. The results revealed the effectiveness of the proposed work.

Keywords Internet rumor · Covid 19 · Covid pandemic · Soft computing · Fuzzy logic

1 Introduction

Coronavirus was first documented at the end of 2019 in the city of Wuhan. Initially, this was called 'severe acute respiratory syndrome coronavirus 2,' later named coronavirus by the World Health Organization (WHO) (Ali 2020). In the first two months, it spread from China to over 143 countries of the world and was declared an epidemic

disease. Several people have died from this disease around the world. With the increase in Covid 19 cases, distribution, and deaths, much have occurred regarding the ban on travel, border closure, curfews, and the disturbance in the supply of services and goods. The world economy was severely affected by the spreading of the virus. Every day new discussions and debates were started, and more people were in fear. These factors were considered productive and made a ground for conspiracy and rumors to go viral. New debates and discussions were spread on social media for detection and prevention purposes. Researchers have considered this as a severe and burning issue, and various approaches were devised from different perspectives. Ming et al. (Li et al. 2021a) presented a deterministic, ODE-based class of rumor spreading model with two different constraining and adjusting methods, as well as corresponding stochastic counterparts, was given and examined from a stability standpoint. Numerical simulations were performed for illustrating, enhancing, and supporting the theoretical analysis.

Hui et al. (2020) have presented a study on how to disseminate rumors on social media platforms. The study looked at education as a way to prevent the spread of rumors. Based on the nonautonomous partial differential

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equation, a new epidemic-like model for defining rumor spread has been proved. The time it took for network users to register was taken into account, and the rumors that propagated were determined by the time and age dimensions. The users were divided into two groups: lower educators and higher educators. The lower class was thought to be more likely to accept and spread rumors, whereas the upper class was thought to be impervious to them. The solution's uniqueness and presence are discussed, and the stability of the approach's steady-state solution is derived. Education of the crowd was considered as an essential factor for the rumors spreading. Control strategies were offered for effectively restraining the propagation of rumors. The approach was validated with numerical simulations.

Li et al. (2021b) have offered a study for developing a rumor refutation effectiveness index to identify the essential factors inducing the rumor refutation effectiveness index and devised decision-making suggestions for the platform of rumor refutation. With the help of natural language processing approaches, the analysis of sentiments of rumor refutation and text characteristics was done. In total, 185,209 pieces of reposts and 298,118 pieces of comments were collected for one year through a web crawler on Sina Weibo. To investigate the link between the rumor refutation efficiency index and contextual elements of rumor refutation microblogs, regression models were applied to the gathered data. The support vector regression model, linear regression model, light gradient boosting machine regression model, and extreme gradient boosting regression model were employed as the algorithms. The light gradient boosting machine regression model has demonstrated promising results among the algorithms. For visualization purpose, the Shapley additive explanations was applied. Finally, decision-making suggestions to a platform of rumor refutation for the organization of rumor refutation microblogs with diverse conditions like the category of rumor, the influence of an author, and the heat of topics were proposed.

Rani et al. (2021) presented a study that offers a complete overview of the various web waves from web 1.0 to web 5.0 and their applications. The categorization provides details of the different continents with malicious information at multiple phases. The study elaborates available datasets, classification features used, and the detection approaches of rumors during the periods of web 1.0 till web 5.0. Future directions and research gaps were demonstrated to make online information more reliable for sharing knowledge and decision-making. Rumor detection aims to identify rumors promptly to prevent rumors and malicious from spreading deceptive or misleading the disrupting and social order of the public. The present text generation and imbalanced learning methods and approaches are

insufficient for dealing with the unbalanced data. The endeavor of the proposed study is given as follows:

- To analyze the existing literature available to the proposed research
- To offer a probabilistic approach for the evaluation purpose of the Internet rumors on Covid.
- To use the fuzzy logic tool in MATLAB for experimental and simulation purposes.
- The experimental results revealed the efficiency and performance of the proposed work.

The paper is organized in this manner: Sect. 2 describes the literature studies associated with the proposed work. The section gives detail of the existing background and approaches for the analysis and evaluation of Covid 19. The proposed scheme in the assessment of Internet rumors is shown in Sect. 5. The results and discussions of the proposed study are given in Sect. 5. The paper is concluded in Sect. 6.

2 Related work

Rumor spreading has an extensive history for which diverse methods and approaches have been developed to detect internet rumors. Cheng et al. (2020) have explored the rumor model based on stochastic. The research has studied the influence of Stratonovich stochastic noise of nonlinear behavior rumor spreading. The critical values for measuring the stochastic and deterministic models are done through mathematical analysis. Numerical simulations were done in order to verify the theoretical results. Ding et al. (2021) have examined the rumor recognition behavior impacting aspects of social media users, and researchers have combined the theories of deterrent and planned behavior. To verify the suggested methodology, the structural equation model method was chosen. The relationships between several elements were examined in order to assess their impact on social media users' rumor recognition behavior in emergency situations. The study's findings revealed that harshness and certainty have significant positive effects on subjective standards. Furthermore, attitude, subjective norms, and perceived behavioral control all influence social media users' awareness of rumors behavior, with participation negatively moderating the relationship between subjective norms and attitude. The creation of insights into rumor control tactics in emergencies is presented based on the experimental investigation. Chen et al. (2021a) have suggested a knowledge-based rumor data augmentation approach that simulates the rumor generating process from the standpoint of knowledge. In order to model the development of erroneous information, the research included knowledge depiction in

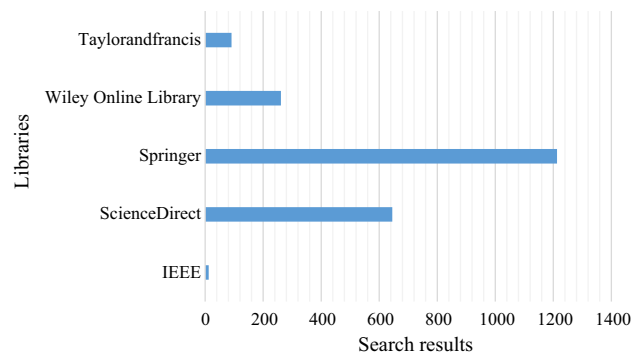
Table 1 Existing approaches associated with the current study

References	Method	Year	Paper type
Abe et al. (2020)	Toilet paper issue during the COVID-19	2020	Conference
Ali (2020)	Sense of rumor and fear in COVID-19 pandemic	2020	Journal
Dai et al. (2020)	Path analysis model on COVID-19 protective behaviors in China	2020	Journal
Dinh and Parulian (2020)	Twitter-based COVID-19 pandemic analysis	2020	Journal
Ito and Chakraborty (2020)	Social media mining with dynamic clustering	2020	Conference
Parker et al. (2020)	COVID-19, public authority and enforcement	2020	Journal
Que et al. (2020)	Suicide deterrence in the COVID-19 pandemic	2020	Journal
Xie et al. (2020)	Analysis of public attention in the early outbreak of COVID-19 in China	2020	Journal
Yang et al. (2020)	Analysis and Insights in the COVID-19 Pandemic	2020	Journal
Adebisi et al. (2021)	COVID-19 pandemic in Nigeria	2021	Journal
Amara et al. (2021)	Tracking COVID-19 trends based on Facebook data analysis	2021	Journal
Bohnet and Rügger (2021)	Refugees and Covid-19	2021	Journal
Cato et al. (2021)	Social media during the COVID-19 pandemic	2021	Journal
Chen et al. (2021b)	Social media during the COVID-19 outbreak in China	2021	Journal
Das and Kolya (2021)	Covid-19 by deep convolutional neural network	2021	Journal
Essam and Abdo (2021)	Arab Tweepsters perceive the COVID-19 pandemic?	2021	Journal
Faour-Klingbeil et al. (2021)	Risk communication during COVID-19 crisis	2021	Journal
Gemenis (2021)	Conspiracy beliefs and skepticism around the COVID-19	2021	Journal
Gesser-Edelsburg (2021)	Health and Risk Communication on social media during COVID-19	2021	Journal
Han et al. (2021)	COVID-19 in the USA	2021	Journal
Lamsal (2021)	Large-scale COVID-19 tweets dataset	2021	Journal
Leng et al. (2021)	Misinformation in the COVID-19 outbreak in China	2021	Journal
Michel et al. (2021)	Social network messages in the COVID-19	2021	Conference

the text generation process. In addition, the study proposes a graph-based rumor text generative model for rumor text production using a generative adversarial network and an attention-based graph convolutional neural network. The experimental results show that the suggested research can generate high-quality murmurs on a variety of topics and can address rumor data imbalance for improved rumor detection performance.

Wu et al. (2020) presented a framework of representation learning, and a strategy for rumor detection was proposed. First, the propagation graph is built using the Twitter post-propagation structure. Then they proposed a gated graph neural network approach that gives each node in the propagation graph the most common representation. The intended method refreshes the representation of nodes on a regular basis by switching overrepresentation between neighboring nodes via the relation path. The Twitter dataset was utilized to illustrate the feasibility of the planned study. When it came to task detection and rumor detection, the model outperformed state-of-the-art techniques. Yuan et al. (2021) have used dilated convolution to create a dilated block design architecture in convolution neural network models to lessen the mutual constraint

between data loss and receptive field growth. The experimentation used the rumor dataset, and the results demonstrated that the suggested model outperforms previous approaches. Various dilated blocks stacks were used in the approach to achieve a large receptive field and automatically extract features from the input with fewer information losses. Zhu et al. (2021) have studied the dynamic behavior of rumor propagation. The study has considered the transmission rates effect between various groups and established 21SR rumor propagation models with time

**Fig. 1** Total search results in the selected libraries

delay and diffusions in heterogeneous and homogeneous networks. Furthermore, some helpful strategies for rumor control were presented. Finally, numerical simulations were displayed, which shows the theories effectiveness.

Huang et al. (2021) modeled the relationship between competitive information dispersion and epidemic spread, and researchers created a two-layer network. The trials were carried out, and the findings showed that knowledge dispersion may effectively reduce both epidemics and rumors. The degree to which knowledge is penetrated into rumor is important. Furthermore, the network topology of the communication layer has a substantial impact on epidemic propagation in the contact layer network. People with more connections in the communication layer network are more likely to distribute knowledge widely. This will help to remove virus and misinformation even more efficiently. Furthermore, when the communication layer network is sparse, a significant degree of knowledge penetration into rumor is necessary to boost knowledge propagation. Parimi and Ranjan Rout (2021) offered a computing model for belief-based precedence value, which allows a user to choose whether or not to dispute a rumor acquired during information propagation. A neighborhood-based propagation strategy was used to investigate the rumor impact and counter-rumor cascades in an online social network. The application's communication overhead is reduced by selecting a small seed set of users for the

counter-rumor recommendation. The problem was solved using a decomposition-based multi-objective genetic algorithm. The system's efficacy was evaluated using real-world datasets. Luo et al. (2021) presented a study that looked into the effects of peer communication and peer condition on Covid-19 fear. Through the urgency impacts of health self-efficacy, the fear of Covid-19 on online rumor sharing behavior. An online survey with 1167 respondents in China was used to test the research method. Peer condition and peer communication induce dread of Covid-19 and fear of Covid-19 in sharing online rumors, according to the results of the experiment.

Yang et al. (2021) have developed the first Chinese dataset of Covid-19 misinformation called CHECKED. The dataset contains a total of 2104 confirmed microblogs associated with Covid-19 from December 2019 to August 2020. The dataset has 1,185,702 comments, 1,868,175 reposts, and 56,852,736 likes which revealed the verification of microblogs are reacted and spread on Weibo. Yao et al. (2021) presented a study for measuring one person's influence on others. Considering the cost, most people are finding with the smallest credibility but can gain maximum effect. Minimal credibility was considered as the focus of the study at a given time for clarifying rumors. They proposed the longest effective hops algorithm for solving the problem. The effectiveness of the study was shown with the experimental results in terms of performance and time.

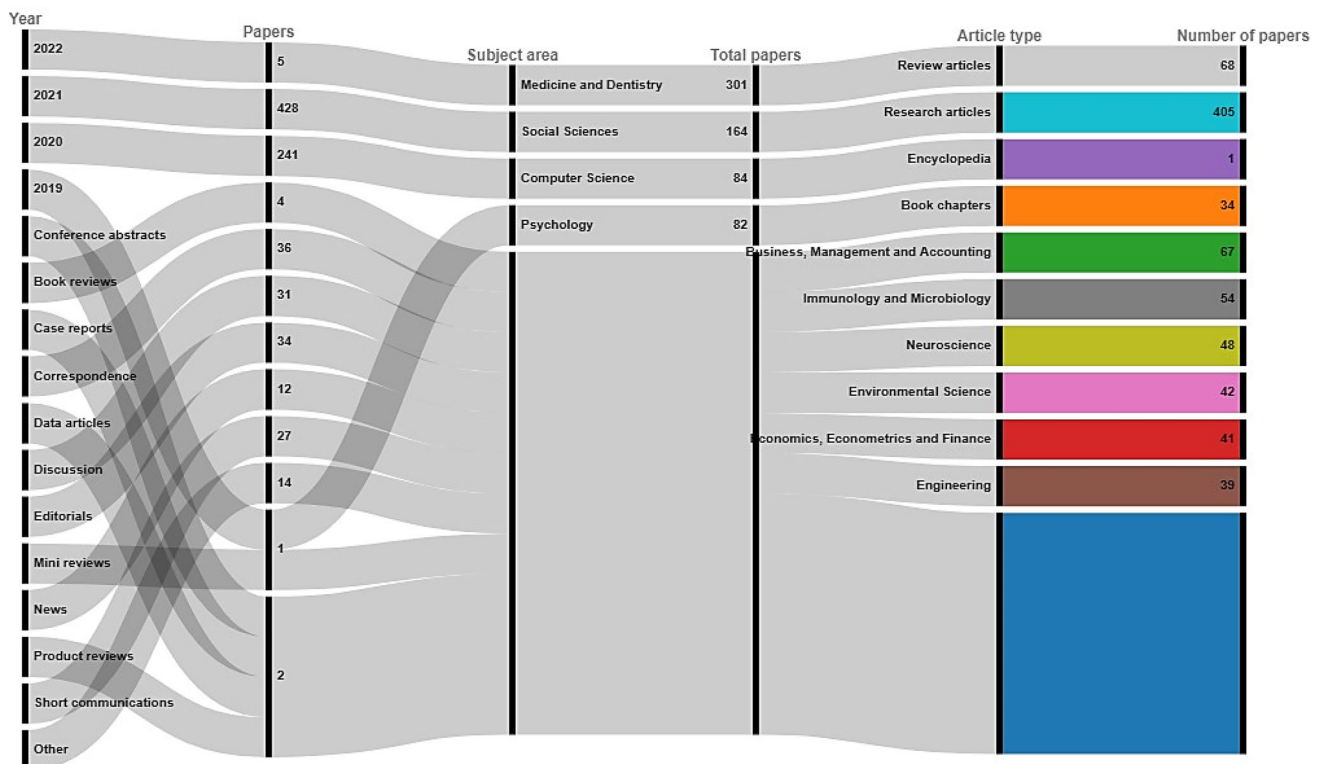
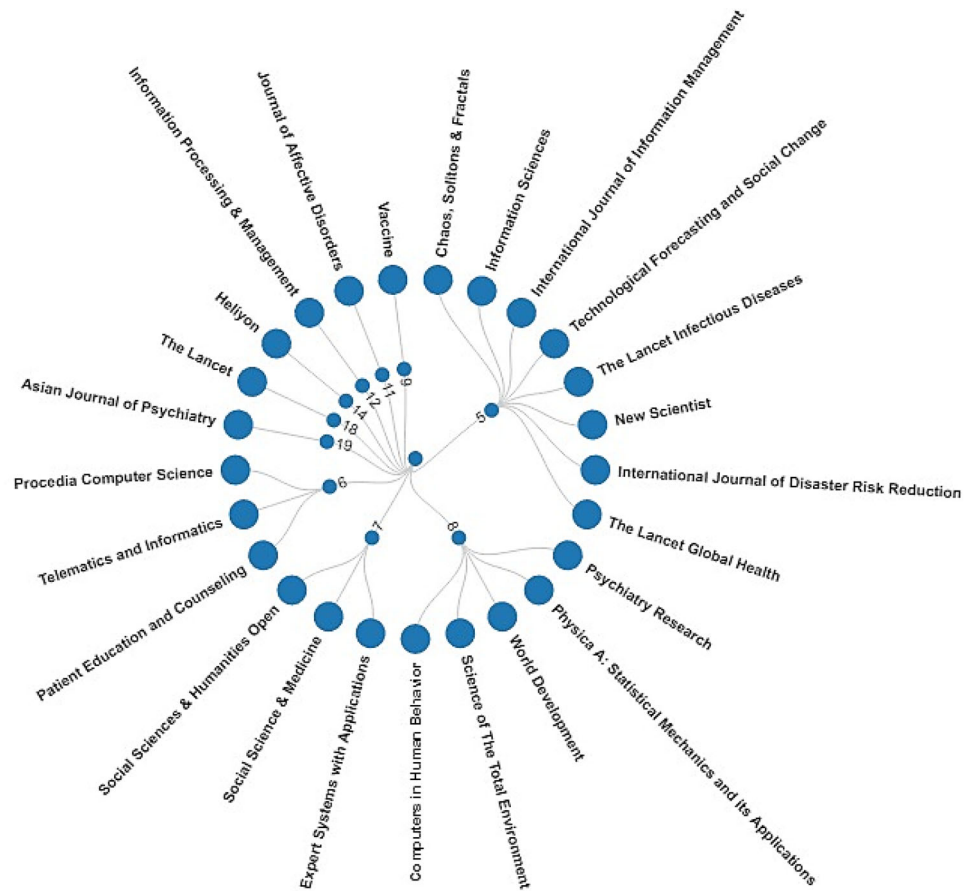


Fig. 2 Search results based on article type and subject area in the ScienceDirect library

Fig. 3 Search results based on publication title in the ScienceDirect library



3 Approaches for the analysis and evaluation of Covid 19

Researches have been carried out to efficiently detection the rumor of Covid-19. Cheng et al. (2021) proposed an enhanced rumor spreading model to explore the novel features of the rumor spreading process. First, the threshold of rumor spreading extinction is calculated, and the dynamic behavior of the delay spreading model was studied. Control strategies were considered like popular science education, deleting rumor posts, immunotherapy, and so on and then suggested an enhanced control problem for minimizing the control cost of rumors and spread scale. Mathematical analyses were done for the calculation of optimal conditions and optimal control problems. Numerical simulations were done for the verification of the theoretical results. Finally, the optimal control, the influence of time delay, and the media network on rumor spreading are compared. Table 1 describes the available approaches associated with the current study.

Li et al. (2021) suggested a deep reinforcement learning-based ensemble model for tracking rumors. The research amassed several components through weight tuning policy networks and employed particular social features to

improve performance. Public datasets were used for experimental purposes, and the results have revealed the efficiency of the proposed research work. Vardanjani et al. (2020) performed a comprehensive study associated with the pandemic of Covid-19 in southern Iran. Different participants were selected for conducting the survey. The online questionnaire was distributed, contacting 29 items evaluating diverse perspectives of rumors and recommendations affecting Persian medicine associated with the pandemic of Covid-19. Shehzad et al. (2020) presented that the Covid-19 has impacted Japan and US market returns, according to the Asymmetric power GARCH model.. Chen et al. (2021c) proposed a novel framework of participant-level rumor detection. It incorporates different fine-grained user representations such as susceptibility, user influence, and temporal information of all participants through deep representation learning. Real-world datasets were used for experimental purposes. The results showed a significant accuracy enhancement of the research. The operative usage of analytics for social information and data science were contributed theoretically. The results can be considered for enhancing the rumor detection services quality for social platforms.

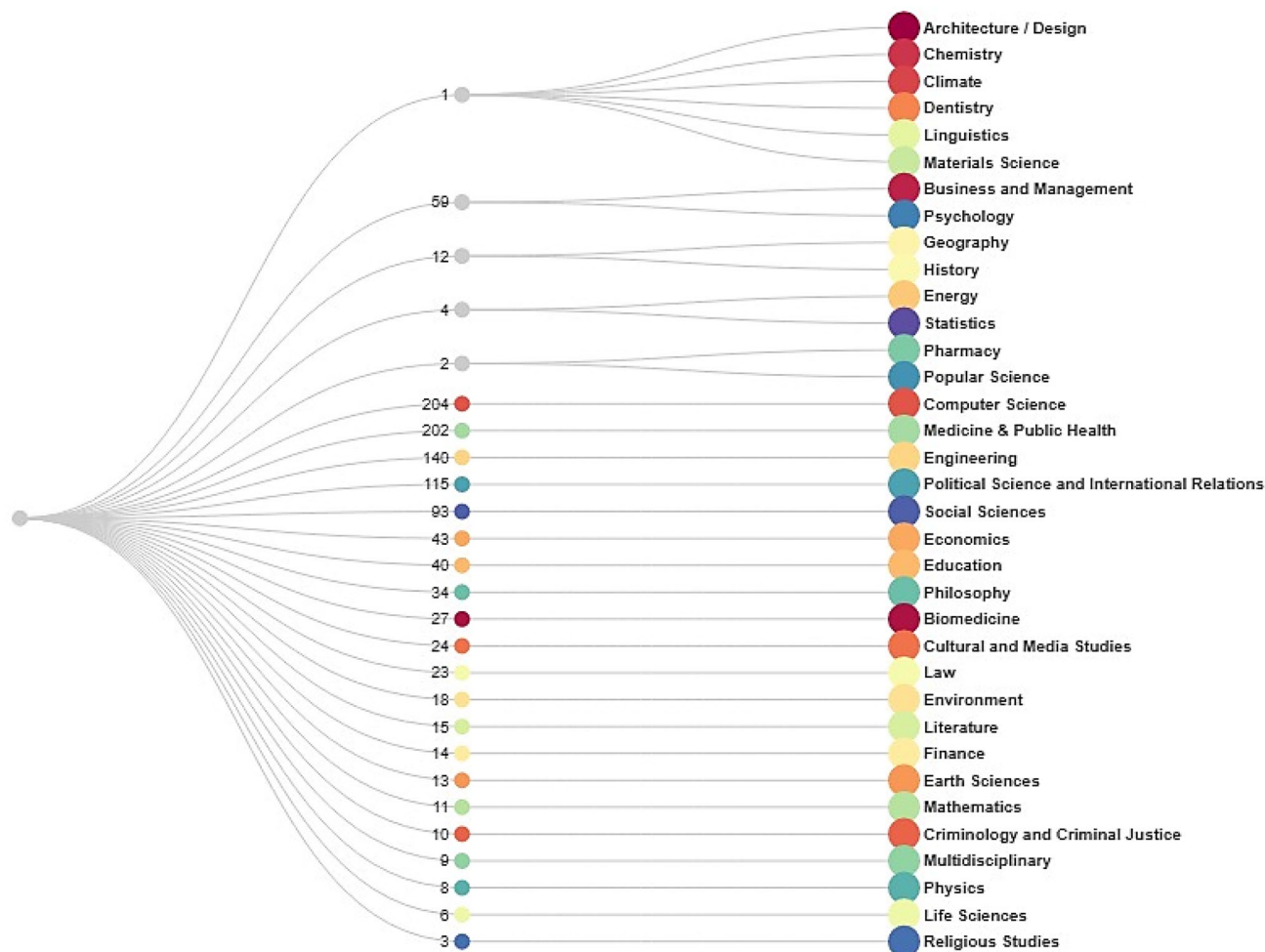


Fig. 4 Search results based on discipline in the Springer library

For the purpose of finding the associated materials to the proposed study, various popular libraries were studied. These libraries include ScienceDirect, IEEE, Springer, Taylor & Frances, and Wiley Online. The search process are given in Fig. 1. The keywords ‘internet rumor’ or ‘rumor on Covid-19’ were considered for the search process. Once the search results obtained then from different analysis facility available in the libraries, the statistics of the search query were achieved. Some associated analysis were done manually in the excel software.

The selected libraries were then analyzed individually. The process of the search process and its results are given in Fig. 2. The figure contains details of the search results based on article type and subject area in the ScienceDirect library.

The search results based on publication title in the ScienceDirect library are given in Fig. 3.

Various approaches have been devised, and researchers have tried to propose methods that can automatically identify rumors. Features engineering has been considered

in the traditional techniques, which require more human actions and are tough to generalize. The Springer library was considered as part of the search process. Figure 4 depicts the search results based on discipline in the Springer library.

The search results based on the content type in the Springer library are presented in Fig. 5.

Shi et al. (2020) have attempted to solve the issues of detecting rumors on the social media associated with the Covid-19. In the initial stage, characteristics of texts are extracted, user-related features are defined, interaction-based features are given, and emotion-based features are derived from the Covid-19 associated spread message. Next, an intelligent rumor detection model based on these four features is modeled with ensemble learning. In the last phase, several experiments were performed on the data collected from Weibo. The experimental results described that the proposed approach has considerably enhanced the rumor detection accuracy. The details of the search results

Fig. 5 Search results based on the content type in the Springer library

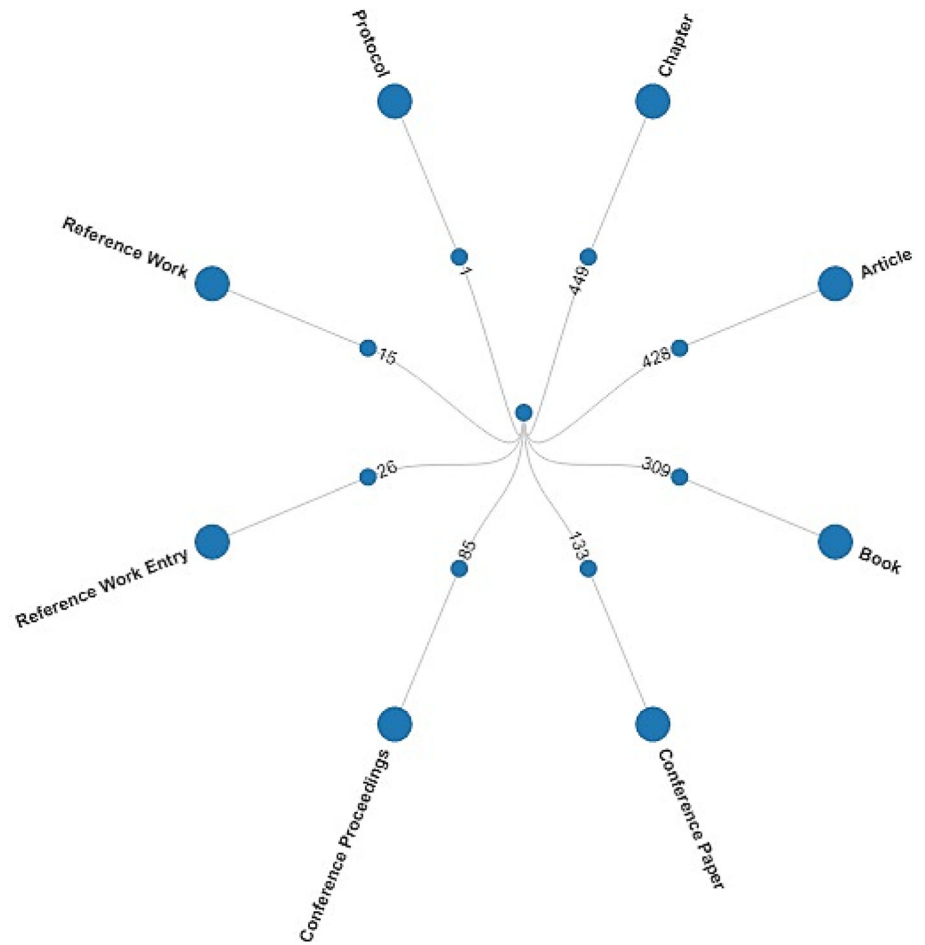
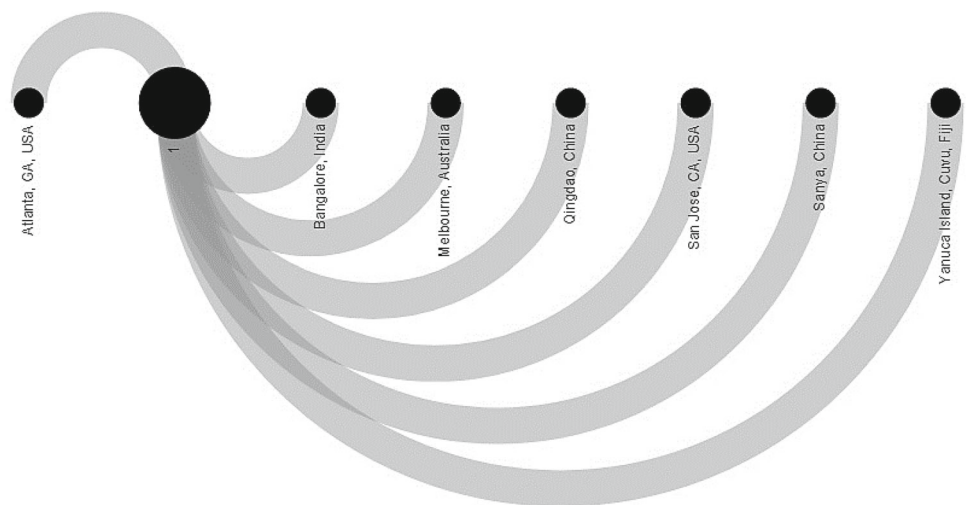


Fig. 6 Search results based on conference location in the IEEE library



based on conference location in the IEEE library are shown in Figs. 6 and 7

The search results based on article type in the IEEE library are given in Fig. 8.

In last, the Wiley online library was searched for identification of the associated studies to the proposed research.

Figure 9 depicts the search results based on article type in the Wiley Online Library.

The search results based on publication date in the Wiley Online Library is presented in Fig. 10.

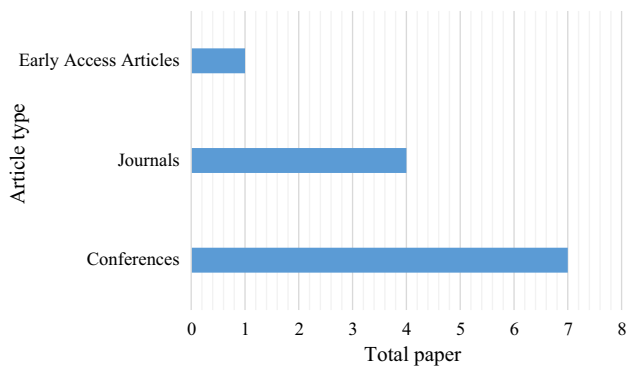
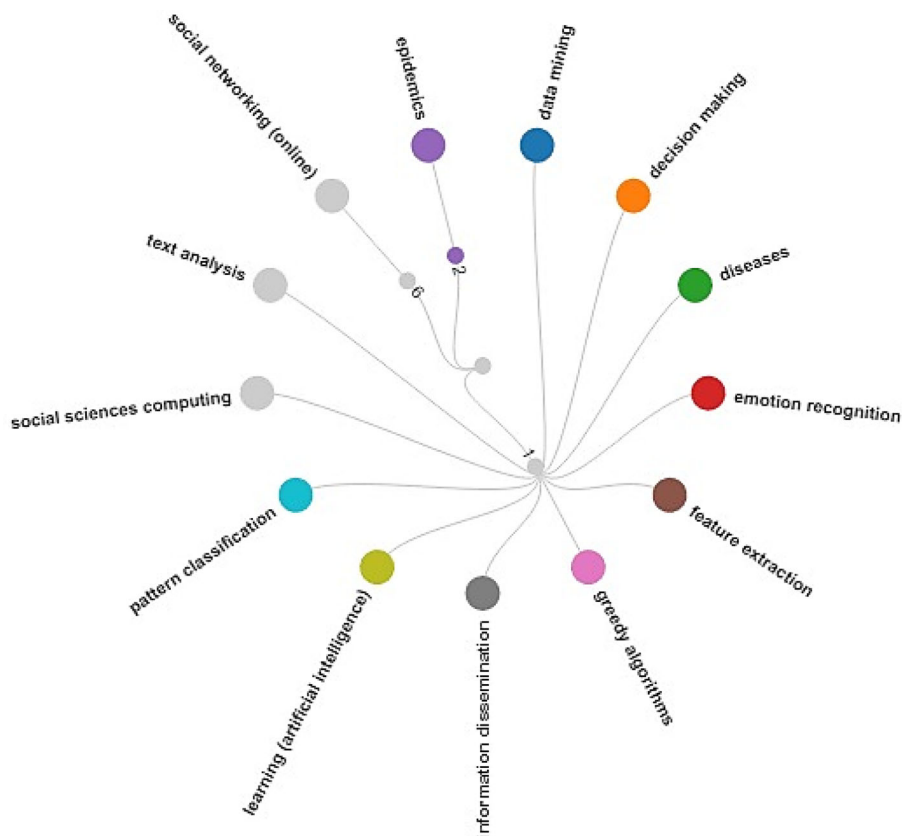


Fig. 7 Search results based on article type in the IEEE library

4 Methodology

Extensive consideration has been given to the pandemic of COVID-19, which has brought a significant loss to healthcare. COVID-19 has caused health crises globally, and more people have died from this pandemic disease. Various types of information are spread on social media, some of which create fear among people. This information is sometimes not reliable and fake, which causes further threat and fear to people, especially those infected by COVID-19. Only authentic and reliable information has more value to the authorities and public, which can be well

Fig. 8 Search results based on publication topics in the IEEE library



thought out for consideration. Keeping in view the issue of rumor, the proposed research has considered the probabilistic approach and used fuzzy logic for the evaluation of Internet rumors on COVID-19. Fuzzy logic has different applications in various areas of research (Xiao et al. 2021; Nazir et al. 2012, 2015; Liao et al. 2020). The study under consideration used the tool MATLAB, and the experimental work has been carried out using the same tool. Figure 11 shows the graphical representation of the process of the proposed system.

For the proposed research work process, initially, the inputs were considered from the literature (Rani et al. 2021). After this, the membership functions were defined for each input. For understanding purposes, membership for a single input is given in Fig. 12.

The same membership functions were defined for the rest of the inputs. Based on these membership functions, the rules were designed for the modeling of the proposed system. Figure 13 describes the model design from the membership functions and rules.

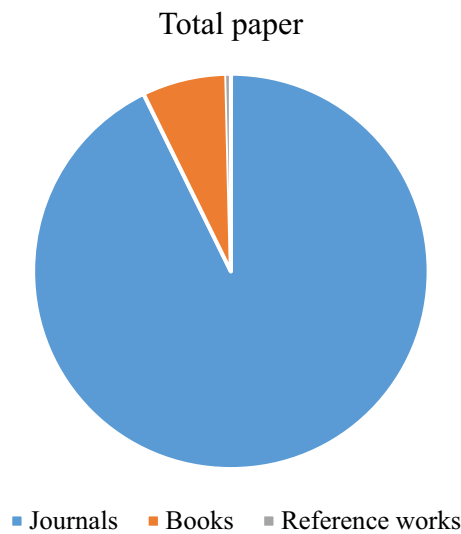


Fig. 9 Search results based on article type in the Wiley Online Library

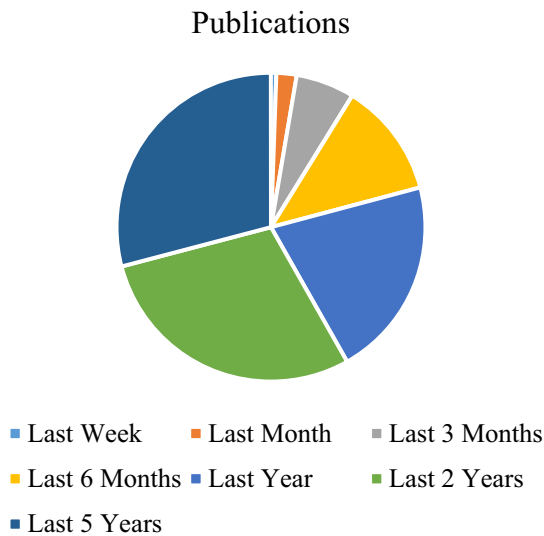


Fig. 10 Search results based on publication date in the Wiley Online Library

5 Results and discussions

Detection of rumors on social media has always remained an important issue, specifically during Covid-19, which has hugely caused danger to social security. Various research works have been carried out to timely and effectively detect rumors that have raised much interest in both industry and academia. Currently, the prevailing approaches detect rumors based entirely on linguistic information without bearing in mind the propagation patterns and temporal dynamics. Once the proposed system is developed from the membership functions and rules, the model is generated to pass out the input from it and decide the decision regarding the inputs given. Figure 14 shows the inputs' 'long-standing' and 'breaking news and the output.

The inputs 'bogy rumors' and 'breaking news along with the output are shown in Fig. 15.

The inputs 'pipe dream' and 'breaking news' with output are depicted in Fig. 16.

The input 'breaking news' and 'wedge driving' along with the output is given in Fig. 17.

After this process, the input was passed from the proposed system. The following are some of the inputs which were passed from the designed system.

```

Input 1
evalfis([0.2 0.5 0.7 0.3 0.2], a)
ans = 0.5000
Input 2
>> evalfis([0.8 0.6 0.7 0.8 0.6], a)
ans = 0.5000
Input 3
>> evalfis([0.8 0.7 0.7 0.8 0.8], a)
ans = 0.6398
Input 4
>> evalfis([0.9 0.8 0.8 0.9 0.9], a)
ans = 0.8470
Input 5
>> evalfis([1 1 1 1 1], a)
ans = 0.8700
    
```

So from the above inputs and outputs, one can decide the Internet rumor on Covid-19.

Fig. 11 Representation of the process of the proposed research

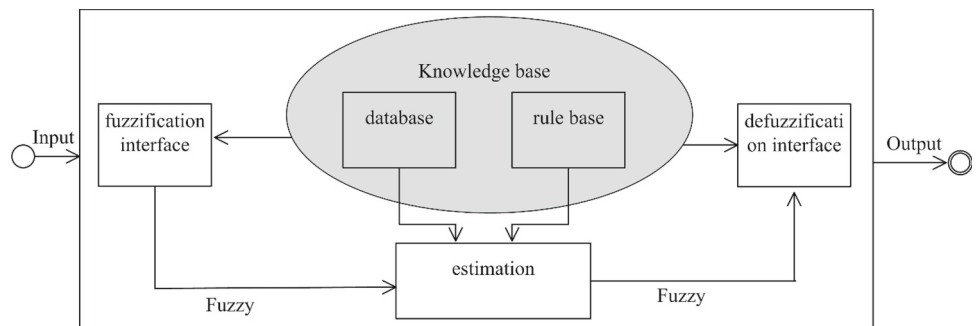


Fig. 12 Membership function for single input

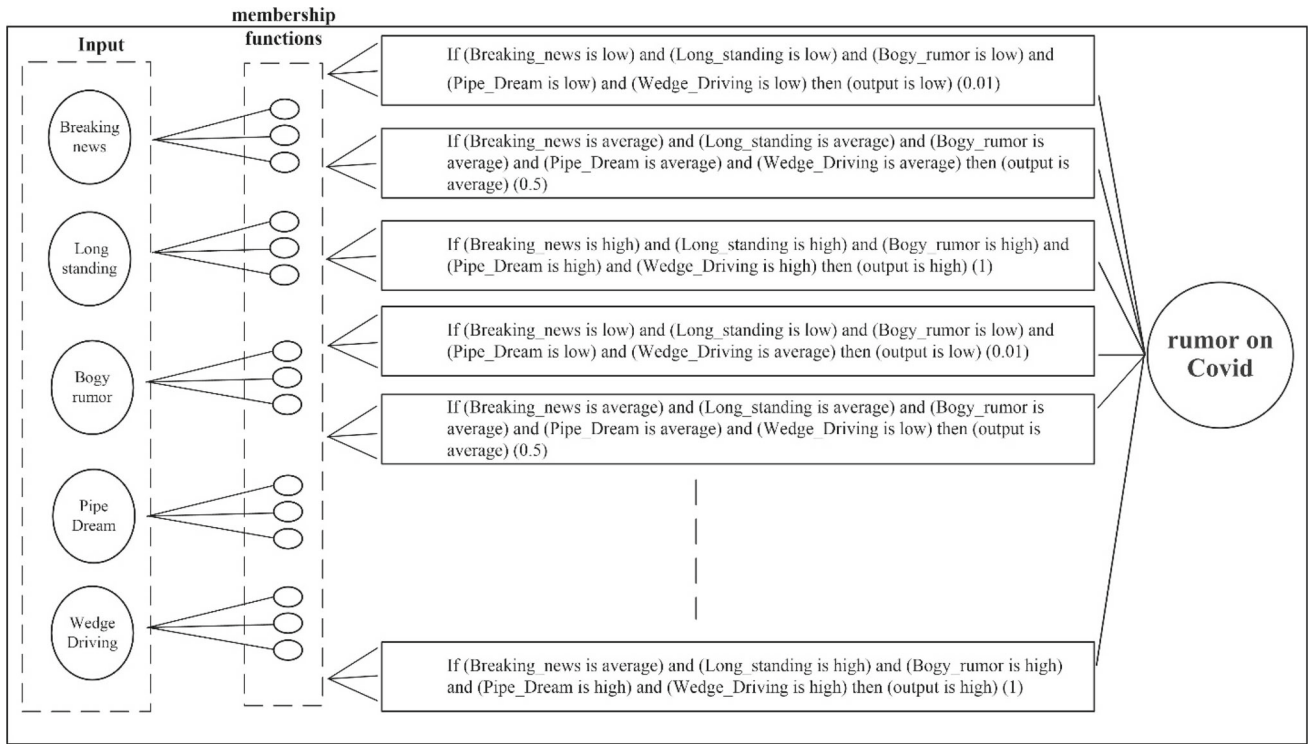
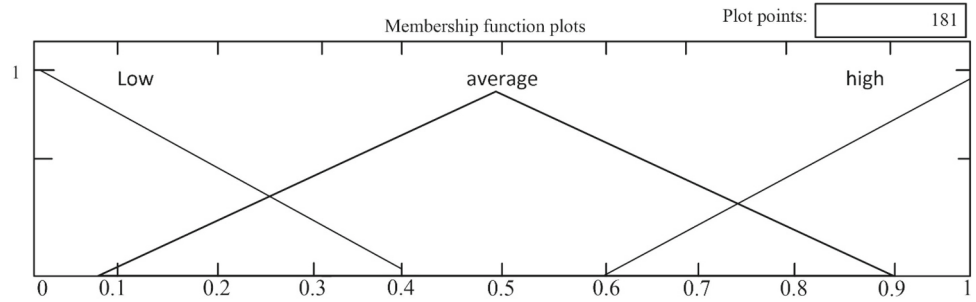


Fig. 13 Inputs, membership functions, and rules to obtain proposed system

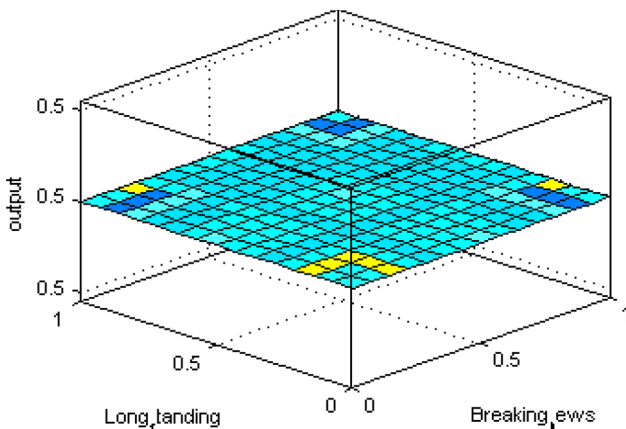


Fig. 14 Representation of the inputs 'long standing' and 'breaking news' with output

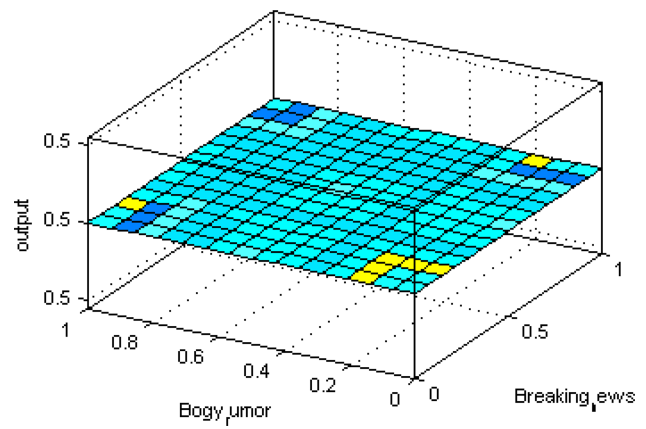


Fig. 15 Representation of the inputs 'bogy rumors' and 'breaking news' with output

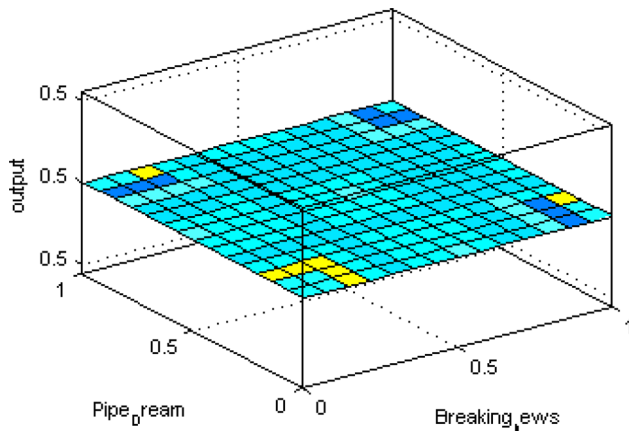


Fig. 16 Representation of inputs ‘pipe dream’ and ‘breaking news’ with output

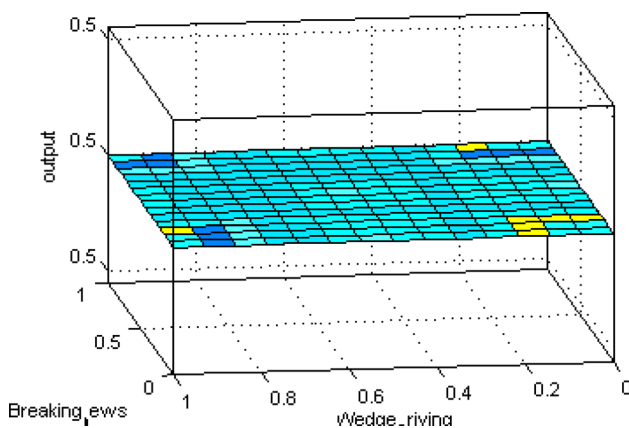


Fig. 17 Representation of input ‘breaking news’ and ‘wedge driving’ with the output

6 Conclusion

Rumor detection aims to detect rumors appropriately to avoid malicious dissemination of rumors and rumors from being misrepresented or misrepresented, thus disrupting the social order of the public. The existing methods and approaches for text generation and imbalanced learning are insufficient for dealing with the imbalanced data. The high use of platforms in social media has resulted in the broader and quicker propagation of not only genuine information but also rumors. The dissemination of rumors may reduce productivity and cause mental stress in society. Wide-ranging attention has been given to the pandemic of COVID-19, which is a significant threat to healthcare. COVID-19 has caused health crises globally, and more people have died from this pandemic disease. Various types of information are spread on social media, some of which create fear among people. Keeping in view the severity of information reliability, the proposed study has considered a probabilistic approach for assessing the

Internet rumors on COVID. The fuzzy logic tool in MATLAB was used for experimental and simulation purposes. The results revealed the effectiveness of the proposed work.

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Data availability Enquiries about data availability should be directed to the authors.

Declarations

Conflict of interest The authors have declared that they have no conflict of interest regarding this paper.

Ethical approval The paper does not deal with any ethical problems.

Informed consent We declare that all the authors have informed consent.

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