Fake News Detection: A Comprehensive Survey

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***Abstract* - The growth and increasing use of digital information platforms have dramatically changed the way news is produced, disseminated, and consumed in our society. Fake news can be found everywhere through popular platforms like social media and the internet. Efforts to develop an effective system for identifying fake news are numerous. Artificial intelligent tools are included to address this difficult issue. Fake news appears in different forms based on the features of their content. The aim of this research is to provide a comprehensive understanding of the various techniques within the domain of fake news detection through a systematic literature review of the existing work. This literature will demonstrate the most significant and relevant models to provide orientations in future research.**

Keywords - fake news, machine learning, deep learning

I. INTRODUCTION

Nowadays all over the world, mainly in developing countries, the main source of information where people get the news have become social media platforms on the Internet (Facebook, YouTube, Twitter, etc.). Thus, fake news has become a problem in society, being used to spread false information in order to change people's attitudes. Fake news refers to unrealistic information disguised as authentic news.

Detecting fake news is a difficult and challenging task, as it is associated with a number of characteristics of the news, such as its authenticity, author's intention, content and form.

Mostly fake news is in the categories: satirical news, fraud, completely fabricated news, and government (political) propaganda [1]. But when we talk about the categorization or types of fake news, we encountered different opinions about identifying their types. But looking at their content evaluation on the Internet, there are different types of fake or misleading news that the reader is faced with. A more detailed fake news categorization is as follows:

- Rumor: A rumor is a story or statement that is spread without being verified or confirmed by facts. It can also include innuendos or unverified information.
- Clickbait: these are contents whose main purpose is to attract the attention of visitors to increase their number on websites. To attract attention, they use sensational titles.
- Satire/Parody: fake news published on social media for entertainment, not to cause harm, but have the potential to deceive.
- Propaganda: news that deliberately deceives the audience to give a one-sided view of a certain cause or political agenda.
- Conspiracy Theory: news sources that promote conspiracy theories.
- Manipulated content: real content or images manipulated to deceive.
- Fabricated content: completely fake news created with the purpose of deception and causing harm.
- Hate News: content that actively promotes racism, homophobia, and other forms of discrimination.
- Misinformation: false content spread without malicious intent.
- Dis-information: false content created and distributed with malicious intent. Research in this area is oriented towards the development of automated techniques to discover the credibility of news on social media. Considering the different characteristics of news, according to the researchers of this field, the methods for evaluating fake news are divided in two directions, where the first is content-based, and the second one is social-based. Content-based methods discussed in these papers [2, 3] evaluate fake news by analyzing the textual or visual content of the news, or external data about the news subjects. The authors use these methods to detect fake news at an early stage, but these methods lack mechanisms for modeling important auxiliary data such as the news propagation model presented by Nguyen et al [4] which may limit their performance.

Methods based on social contexts are divided into two categories: stance-based and propagation-based methods. These methods integrate additional data as comments of social network users about certain news given by papers [4, 5], user profiles by Shu et al [6], and user behavior features given by Rajabi et al [7] such as "posting " and "re-posting", and user attitudes given by Van-Hoang et al [8]. Recent studies show that incorporating the structure of news propagation in social networks into the model plays a crucial role in improving the performance of fake news evaluation.

Although methods based on social contexts have shown efficacy in improving accuracy, the best way to improve explainability is unexplored. These methods do not have detailed information about topological connections. This paper presents a systematic review of existing literature, with the aim of understanding different techniques and models based on the domain of fake news, to identify challenges for future research. The rest of the paper is structured as follows: Section II focuses on the

Methodology. Section III presents the result and analysis. And in section IV are presented some conclusions.

II. Research Methodology and Questions

This study conducts a comprehensive search of published research papers investigating the field of automated ML and DL from a computer science perspective on fake news evaluation and the largest databases, such are Google Scholar, IEEE, Springer, ACM, Elsevier, etc., using the strategy based on keywords are used. The target keywords used during the search process are: "fake.", "automated.", "automatic.", "deep learning.", "DL.", "machine learning.", "ML." and "news.". The analyzed articles were selected in such a way that they meet the following condition:

• The analyzed study has a significant number of citations (10 < citations)

• The research paper is written in English.

In order to focus on our objective, we also proposed few research questions and based on these research questions, all the selected papers were analyzed and as well all the useful insights were extracted. The proposed research questions are as follows:

RQ I: What features influence the evaluation of a news item?

RQ II: Which models can be used in the field of ML and DL in the evaluation of news reliability?

III. Result and Analysis

Evaluation of news reliability could be based on automated solutions provided by artificial intelligence tools with Machine Learning (ML) and Deep Learning (DL) techniques. So having this idea, the following literature review will be based on these tools for reliable news assessment.

A. ML Techniques

Machine learning has found wide use in many areas of everyday life and in solving various problems. Bali et al [9] have applied machine learning algorithms to classify news and to assess their reliability. A stratified 10-fold cross-validation based on linguistic features such as ease of readability and lexical diversity was used to evaluate the model. The characteristics used for the given model are: n-grams Count Feature, TF-IDF which shows how many times a word appears in a certain document, Word Embedding, Sentiment Polarity Score, and linguistic features. Three datasets from Kaggle and GitHub were used to test the model. The used algorithms are Random Forest (RF), Support Vector Classifier (SVC), Gaussian Naive Bayes (GNB), AdaBoost (AB), K-Nearest Neighbor (KNN), Multi-Layer Perceptron (MLP) and Gradient Boosting (XGB). The comparison showed that the lowest average accuracy recorded is 62.5%, 72.54%, and 64.8% when using KNN whereas Gradient Boost (XGB) achieved 87.2%, 92.0%, and 87.3% average accuracy for these used datasets. Pedro et al., in their paper [10] present a model for evaluating news using only textual features which can be generated independently of the news publishing platform regardless of the language used. Authors show that lexical size and sentiment are helpful in all datasets. They used five datasets to obtain test results using four different Natural Language Processing (NLP) techniques. From the conducted experiments, it was shown that the best result was achieved with Random Forest and SVM algorithms, combined with Bag-of-Words (BoW) as a text representation technique with an accuracy of 95% and 94% respectively, for news in the analyzed language groups. Another study in this field, by Ahmed et al [11], presents news evaluation techniques based on the extraction of different text features. Two datasets were used to test them, and it was shown that Passive Aggressive (PA) gives a higher accuracy of 93% while Naive Bayes is 85% and 84% for SVM. While Ott et al., in the paper [12] applying the SVM with LIWC + Bigrams have achieved an accuracy level of up to 89.8%. In the publication [13], the authors have designed a model for automatically identifying fake news based on machine learning. The authors trained several machine learning models suitable for binary classification using textual and graphic features. From the obtained experimental results, the study showed that the highest accuracy of 80% was achieved by SVM. M. E. Tacchini et al., in their paper [14], have used two models based on logistic regression and on Boolean crowdsourcing algorithms. Authors classify the news into hoax or non-hoax based on their features for both classifiers, based on what users liked. The datasets consist of data obtained from the posts of various users on the social platform Facebook. From the evaluation of the models, it results that for the complete dataset, the BLC harmonic algorithm shows better performance and with accuracy above 90%. Another paper, presented by W. Han and V. Mehta [15], presents an assessment and comparison of the different approaches used to classify fake news. They present some traditional machine learning models such as Naive Bayes and advanced deep learning models such as the hybrid CNN and RNN. Evaluation of their performance was done using TF-IDF bi-gram, PCFG, and a combination of both. From the obtained results, authors have shown that the Naive Bayes classifier performs well in fake news detection, but the hybrid model CNN and RNN using TF-IDF results in better performance.

B. DL Techniques

N Ahlem et al., in their paper [16], present a model where CNN and LSTM are combined, which is a type of Recurrent Neural Network as shown in figure 1.

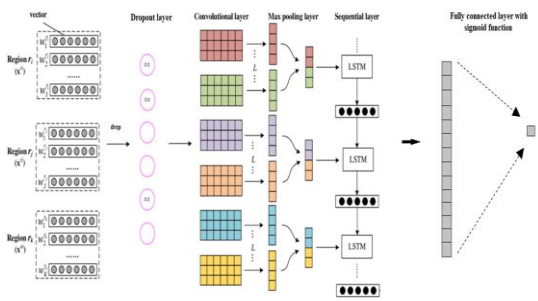

Figure 1. The architecture of the proposed fake news detection model Ahlem et al [16]

The first layer represents each statement (text) as a series of vectors. Then drop-out layers are added to reduce overfitting and to determine the probabilities of the vectored data during the training phase. Then comes the CNN layer that serves to extract features from local inputs. Some of the features used are total words, characters per word, frequency of large words, unique words, number of followers, number of tweets, etc. The LSTM layer measures the long-term dependencies of feature sequences. The outputs from this layer are merged and passed to a fully connected layer which converts the array into a single output in the range {0,1} using the sigmoid function. The overall performance of the CNN-LSTM model is much better than the baselines in terms of accuracy. What is evident is that this model is more efficient to apply to a large dataset to improve the detection of fake news compared to small datasets. Gallego et al., in the paper [17], present some techniques based on ML and DL for evaluating news in the Spanish language. For comparison purposes, in the case of ML were used the techniques of Support Vector Machine (SVM), Random Forest (RF), Gradient Boosting Tree (GBT), and Multi-Layer Perceptron (MLP) while for the DL were used LSTM-RNN using a many-to-one architecture and CNN. For testing, two datasets, in Spanish and English, that correspond to fake and real data for both languages were used. Accuracy was used as the meter parameter and it resulted that the highest accuracy, up to 80%, for DL was achieved using the LSTM model with 25 epochs. Where in the group of ML techniques, RF has shown the best performance getting an accuracy of 80%, using TF-IDF, and a rough accuracy has shown the SVM. What was noticed was that the application of these techniques to the automatically translated dataset had a significant decrease in accuracy. There were also no significant differences in model performance when applying Stemming or removing stop-words.

The authors, in the paper [18], present a hybrid model for evaluating different news. The proposed model called CSI consists of three modules: Capture, Score, and Integrate. The model uses three characteristics of news such as: the content of an article, the response of the users who receive and the source user who distributes it. The first module analyzes the response and the text, while it uses a Neural Recurrent Network to analyze the user activity. The second module learns the characteristic of the source based on user behaviors and then integrates with the third module for news classification. For the comparison and testing of the model are used two datasets that were obtained from the social networks Twitter and Weibo. From the obtained results the proposed model performs better than the others respectively with an accuracy of 89.2% and an F-score of 89.4% for Twitter, and accuracy of 95.3%, and an F-score of 95.4% for Weibo. As the text representation technique used, the paper shows the benefit of using doc2vec over simple TF-IDF.

Another study in this field is presented in the research work [19], where the authors present an ensemble-based deep learning model for news evaluation. LIAR datasets were used to test and evaluate the model. For the statement attributes, NLP techniques like tokenization, lemmatization, and stop word removal are applied. The first model is built with 9 neural network layers, while the second model, was designed with 10 fully connected dense layers and with 9 feature variables as input data. The obtained results of this research, show an accuracy of 89.8% using the statement feature. Another work in this area that uses neural networks is given in research [20], where the proposed model accurately predicts the attitude between headlines and the body of a given article. The FNC-I datasets are used to test and evaluate the model which includes the body and the headline of the news article, and the label for relatedness (stance) of an article and headline. The preprocessing techniques used are Stop Word Removal, Punctuation Removal, and Stemming. Bag of Words and TF-IDF techniques are applied to transform the raw text and extract the features. The presented model estimates the relative importance of a word present in article-title pairs locally (importance of that word for that specific headline-article pair) and globally (how often that specific word is found in relation to all words in the corpus). For the similarity measure between the headline and article pair the Cosine similarity between Headline- Article TF-IDF pairs are calculated. Authors have tested three different architectures: TF-IDF Vectors with Dense Neural Network, Bag of Words Vector with Dense Neural Network, and Pre-trained word embedding with Neural Networks. The architecture with the use of a fine-tuned TF-IDF - Dense neural network (DNN) has shown the best result with 94.21% accuracy. K. Kaliyar et al., in research [21], present a Deep Hybrid Neural Network (DeepNet) model for evaluating fake news using the BuzzFeed and Fakeddit datasets. Initially, they present a model based on the Artificial Neural Network (ANN) with four dense hidden layers and activation function Leaky ReLU and Adam optimizer. The implemented Deep Hybrid Neural Network architecture, whereas the first layer has an embedding layer that accepts the input as a vector and continues with three convolutional layers where the vector is transformed and passed to the LSTM layer responsible to handle the nature of sequential data. After the LSTM layer are implemented seven dense layers. The proposed model uses a combination of content and context features. From the obtained results, DeepNet outperformed existing fake news detection methods with an accuracy of 95.2% for BuzzFeed and 86.4% for Fakeddit.

In the research [22], Singhal et al., present a model called SpotFake - a multi-modal framework for the classification of fake news. This model evaluates fake news based on the textual and visual features of an article. It uses the BERT to extract text features and VGG-19 to extract image features pre-trained on the ImageNet dataset. The proposed model consists of three sub-modules. The first sub-module is the extraction of textual features composed of 12 encoding layers, where the vectors of these features are marked as Tf. The second sub-module serves to extract visual features from VGG-

19 pre-trained and implemented through Vf vectors. The third sub-module serves to join two feature vectors obtained through different modes Tf and Vf fused together using a simple concatenation technique to form the news. The authors have compared the performance of SpotFake with the models presented in EANN [3] and MVAE [23] tested with the same datasets and the results are shown in the following table (Table1).

TABLE I. PERFORMANCE COMPARISON OF EANN, MVAE WITH SPOTFAKE

	Accuracy %	
Model	***Twitter***	***Weibo***
EANN	71.5	82.7
MVAE	74.5	82.4
SpotFake	77.77	89.23

The model SpotFake proposed by Singhal et al [22] performs better compared with both above mentioned models on Twitter and Weibo datasets.

Farokhian, M. et al., in the research [24], present a model where parallel BERT deep neural networks are used. The proposed model is named MWPBert and uses two parallel BERT networks, where the first one is used to encode news headlines, and the second on to encode news bodies. As an algorithm for fact-checking, they used the MaxWorth algorithm, by which it is possible to get the most valuable part of the news text. The outputs from the two BERT networks are encoded into a single output network to classify the news. To evaluate the model, they used Fakenewsnet datasets. To show the effectiveness of using two BERT networks, the result is compared with the result of MWBERT model, which uses only one BERT. From the obtained results, it appears that MWBERT shows an accuracy of approximately 84.7% while MWPBert is 85.4%. Thus, the MWPBert model, with parallelization, shows that the use of two parallel BERTs was beneficial.

C. Answer of the research questions

By analyzing the above research, we came up with the following answers to the above-mentioned questions.

RQ I: What features influence the evaluation of a news item?

Considering the different characteristics of news, the methods for evaluating fake news can be divided into two main categories, content-based, and social-based features.

Content-based methods evaluate fake news by analyzing the textual or visual content of the news, or external data about the news subjects. The set of features used captures the structure of the article, the similarity between the headline and the body of the news, and readability. Features from these data are grouped into stylometric, semantic, and syntactic. Some stylometric features that are used in techniques for detecting fake news are the average number of words, characters, punctuation marks, and the number of words, sentences, and unique words used. Semantic features are anger, anxiety, feelings, polarity, and informality. Syntactic features can be: word impact, certainty, inconsistencies in the text, self-references, questions, disfluencies, numbers, and tentative language use.

Social-based methods are categorized into two subtypes: stance-based and propagation-based methods. These methods, for detecting fake news, integrate additional data used in social media, such as extracted features about social network users' comments on a given news and user profiles. Other features used are the number of words in a user's self-description, posts, likes, shares, replies, followers–followees, and the time difference between the source tweet's post time and my retweet.

RQ II: Which models can be used in the field of ML and DL in the evaluation of news reliability?

There are various methods and techniques based on deep learning and machine learning, used to design, and implement different models for fake news detection, where we mention, and

ML techniques: Logistic Regression (LR) [13, 14], Gaussian Naive Bayes (GNB) [11, 12, 15], Gradient Boosting [2,9, 13, 17], Random Forest (RF) [9, 13, 17], Passive Aggressive (PA) [11], K-Nearest Neighbor (KNN) [9], and Support Vector Machine (SVM) [9, 11, 12, 13, 17], and

DL techniques: Convolutional Neural Network (C.N.N.) [3, 15, 16, 17], Recurrent Neural Network (R.N.N.) [15, 17, 18], Long Short-Term Memory (L.S.T.M.) [16, 17, 21] and Transformer (BERT, ALBERT) [22, 23, 24].

From the analyzed research papers, we collected some data, regarding the techniques used, the features analyzed and the relevant datasets to evaluate the performance of the algorithms used. This is shown in the below table (Table 2).

As can be seen from the table, different techniques give different performances depending on the features analyzed and on the datasets used for model evaluation.

TABLE II. PERFORMANCE COMPARISON OF SOME WORKS BASED ON ML AND DL TECHNIQUES

Reference	***Dataset***	***Classifier***	***Represen-tation technique***	***Features***	***Accuracy Metrics***
Pedro et al [10]	*5 datasets*	*RF*	*Bag-of-Words (BoW)*	*text features*	*95%*
Ahmed et al [11]	*Kagle datasets*	*PA/SVM*	*tf-idf*	*text features*	*93% / 84%*
Ott et al [12]	*spam detected*	*SVM*	*LIWC+ Bigrams*	*text features*	*89.8%*
Janze et al [13]	*BuzzFeed*	*SVM*	*binary classify-cation*	*textual and graphic*	*80%*
Gallego et al [17]	*four open datasets*	*LSTM-RNN/RF*	*tf-idf*	*Text Norma-lization*	*80%*
Ruchansky et al [18]	*Twitter/ Weibo*	*CSI*	*doc2vec*	*textual features*	*89,2% / 95,3%*
Aslam et al [19]	*LIAR*	*Bi-LSTM-GRU*	*Adam" optimizer*	*statement feature*	*89.8%*
Thota et al [20]	*FNC-I*	*Dense neural network (DNN)*	*Bag of Words and TF-IDF*	*text features*	*94.21%*
Kaliyar et al [21]	*BuzzFeed and Fakeddit*	*CNN-LSTM*	*Adam optimizer*	*content and context*	*95.2% / 86.4%*
Farokhian et al [24]	*Fake-newsnet*	*parallel BERT*	*MaxWorth*	*text-based features*	*0.855 %*

IV. CONCLUSION

This study has tried to collect and analyse different ML and DL methods used in model design for fake news detection. The research found that fake news can be spread in different forms and ways. Some of the categories encountered may be in the form of rumor, clickbait, satire/parody, propaganda, manipulated content, or news that is purposely fabricated for various benefits such as economic, political, etc. Based on the analyzed features, the news is divided into content-based and social-based categories.

Content-based methods evaluate fake news by analyzing the textual or visual content of the news. Social-based methods are categorized into two subtypes: stance-based and propagation-based methods. Based on the algorithms used for ML mention Logistic Regression (LR), Gaussian Naive Bayes (GNB), Random Forest (RF), K-Nearest Neighbor (KNN), and Support Vector Machine (SVM), while for DL techniques are used Convolutional Neural Network (C.N.N.), Recurrent Neural Network (R.N.N.), Long Short-Term Memory (L.S.T.M.) and recently Transformer (BERT, ALBERT) are also being used, leading to an increase in the accuracy of the models implemented for detecting fake news. The implementation of deep learning models overcame the limitation of machine learning models since the implementations by use of ML technique perform weakly when there is a large dataset. The techniques for identifying fake news are always in development since the methods for spreading fake news have a dynamic spread.

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