An Improved Fake News Detection System using optimized TF-IDF Features with Multi Level Voting Rule

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Abstract: Fake news detection and their analysis is a rapidly growing field of research due to the explosive growth in social media and internet. In artificial intelligence-based modern world, the detection of news reliability is one of the essential tools to extract textual information from massive news data. To the best of our knowledge, the exiting fake news detection system not able to detect the reliability of news with maximum accuracy and need a big improvement. So, in this research article, we designed an Improved Fake News Detection (I-FND) system using the concept of optimized Term Frequency-Inverted Document Frequency (TF-IDF) features with Multi-Level Voting Rule as machine learning technique. To select the best feature set from the extracted TF-IDF features, the concept of Swarm-based Grasshopper Optimization (SGO) technique is used as an optimization algorithm with a novel fitness function. The proposed I-FND system used four steps named as the pre-processing for data normalization, feature extraction using TF-IDF extractor, feature optimization or selection using SGO and classification with multi-level voting as concept of machine learning. The proposed I-FND system outperformed compare to the existing works and to validate the performance of the proposed work parameters such as accuracy, error, precision, recall, f-measure and execution time are computed. Based on the comparison, we founded that the proposed model work effectively in terms of performance parameters and we achieved noteworthy increase in accuracy, precision, recall and f-measure of proposed I-FND system.

Index Terms: Fake News, Textual data, TF-IDF Feature Extraction, SGO, Multi-level voting, Machine learning

I. INTRODUCTION

In recent years, the term "fake news" was popularized due to various reasons like American presidential election, information about corona and many more. Fake news become a common term work word in the public vocabulary due their popularity over the internet as well as the social media platform [1]. While the detection and classification concept of fake news is an old approach but exact detection based on the news content is still a change. The advent of social media and mass information on the Internet has led to fake news taking on a new form compared to its previous iterations [2]. Concerns have been raised especially in the context of the effect which fake news can have on various places such as pandemic, democracy, elections etc. [3]. Another effect of fake news is destabilization where foreign states spread fake news in other states with the purpose of destabilizing democracy. We agree with the fake news is a socio-technical phenomenon that aims to exploit human behavior but relies on technical infrastructures and services in order to spread. The same perspective is Fake news is not a new concern for users as well as research from previous years and media ecosystem of fake news has evolved from newsprint to radio or, television and online news and social media, recently. We can consider the example of India LOKSABHA election 2019, in the election time, multiple users created fake accounts to spread fake news on WhatsApp, YouTube, Twitter, Instagram, Telegram and Facebook to attract people. Furthermore, a considerable amount of misleading and incredible information is generated by the multiple users and display through the social network platform [4]. It also created a latent hazard to multiple communities and had a profoundly negative impact over the users due to the traditional fake news broadcasting [5]. used by who discuss reasons for why users share fake news and provide a social technical model of media effects. The characterization of fake news is shown in the Fig.1

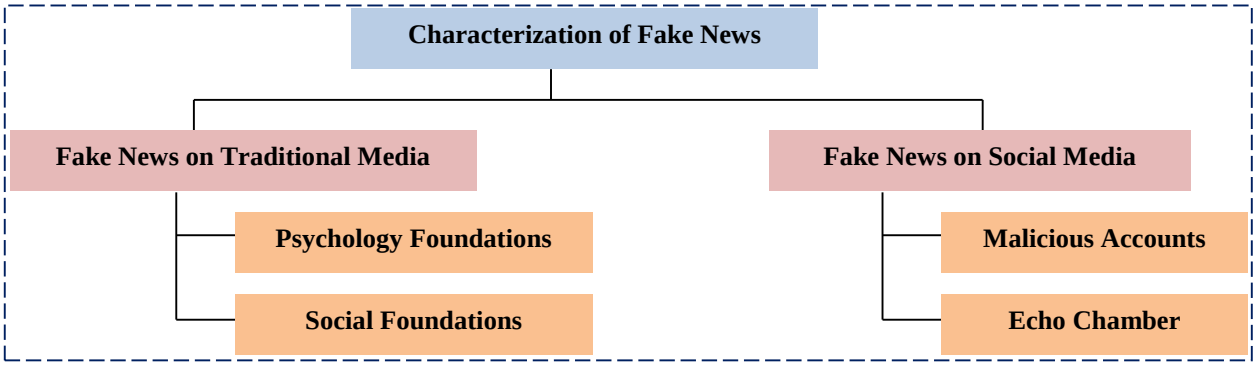

Fig 1: Characterization of Fake News

So, the traditional false news broadcasting is the major issue of fake news before social media has major impact on its development and distribution. After that the researchers have described several psychological and social science foundation's which describe the impact of fake news on the ecosystem of person and social information [6]. The content in the social media platform increases without any verification and everyone easily write and dispersed the fake material over the internet that is depicted through 3V diagram in Fig. 2.

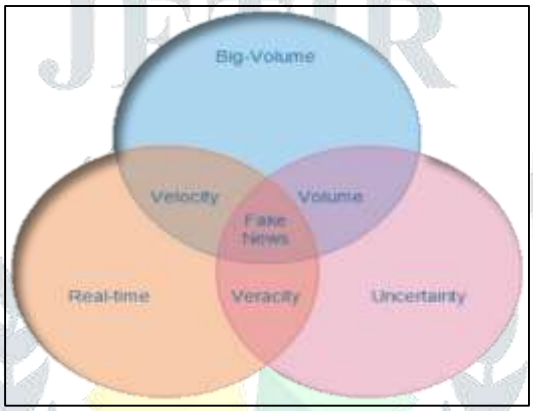

Fig 2: 3-V Diagram of Fake News

In this research, a model is designed to detect fake news from internet database that is known as an Improved Fake News Detection (I-FND) system using optimized Term Frequency-Inverted Document Frequency (TF-IDF) Features with Multi-Level Voting Rule. Here, the concept of Swarm-based Grasshopper Optimization (SGO) technique is used as an optimization algorithm with the concept of TF-IDF to analyze the feature of news data [7]. The main contributions in this research is listed as:

- ❖ We design a technique of pre-processing on the raw news data to find out the better feature using the TF-IDF feature extraction [8].
- ❖ Here, lots of irrelevant features are included in the set of feature that decrease the system accuracy [9]. So, to select the optimal features, SGO technique is used as a feature selection approach with a novel objective or fitness function to discard the irrelevant features from the news data feature set.
- ❖ To provide better training to the proposed IFND system, the concept of multi-level voting rule is used as machine learning approach to detect fake and reliable news data [10].
- ❖ At the last a comparison of simulation results are done to validate the proposed IFND system. Here, quantities based performance parameters like Precision, Recall, F-measure, Execution Time, Error and Accuracy is considered to compare with existing related works [11].

In this section, we describe the brief introduction about work and the rest research article for IFND system is organized as: Sect. 2 presents an overview regarding the existing fake news detection or classification. The methodology of IFND system is discussed in the Sect. 3 and their experimental results are given in Sect. 4 of article. Finally, the model conclusion with its future works is presented in the Sect. 5.

II. RELATED WORK

In this section, we presents a brief survey related to the many fake news detection techniques developed recently. To getting idea about the proposed research work, this is an essential step for accurate detection of fake news on online social media is discussed. A user-friendly fake news detection module was designed by ***S. Kaur et al. (2019)*** to classify the news as fake or real on real-time social media platforms such as Facebook, Instagram, Twitter and WhatsApp using the concept of multi-level voting rule. Motivated by the need for automated detection of fake news, the goal is to find out which classification model identifies phony features accurately using three feature extraction techniques, TF–IDF. Authors in this research, designed a novel multi-level voting ensemble model for three datasets using twelve classifiers. The performance metrics, whereas the proposed model outperforms the Passive Aggressive model by 0.8%, Logistic Regression model by 1.3%, Linear-SVM (Support Vector Machine) based model by 0.4% using the concept of TF-IDF respectively. The proposed system can also be used to predict the fake content (textual form) from online social media websites. But, the concept of GUI is not consider to make a user-friendly fake news detection system for three different dataset like News Trends, Kaggle and Reuter's repository [12]. ***Kaliyar et al. (2020)*** proposed a network for fake news detection (FND-Net) using the concept of a deep Convolutional Neural Network (CNN). In this research, various machine learning algorithm as well as deep learning algorithm was used for the detection of the fake news. GloVe a pre-trained word engine used as a unidirectional training of the data. After the simulation result shows that the proposed FND-Net model performed a state of art for the result with 94.31% accuracy as compared to traditional machine learning model as well as the deep learning model. For example, the previous Naive Bayes (NB) model which has 89.97% accuracy [13]. ***Readdy et al. (2020)*** proposed a combination of style-metric feature and text-based vector representations through ensemble method for the detection of the fake news. Different classification algorithms such as SVM, Random Forest (RF), and Naïve Bayes (NB) were used for the classification. Author demonstrated that, the performance of the proposed work perform well with accuracy between 75-95%, precession 0.85, recall 0.79 and the F1 score is 0.72 while using random forest classifier [14]. ***Mahabub et al. (2020)*** proposed a unique classification based Ensemble Voting classification technique for deciding both real and fake news. In the proposed work, different traditional Machine Learning classification algorithm has been used for the detection the real one among different news and also reduces the reddened of the news. After the simulation result shows that the proposed work have better performance with 98.21% accuracy, 0.85 precision and 0.9 recall [15]. ***Kaur et al. (2020)*** proposed a novel two phase hybrid CNN-LSTM model for the detection of the fake news. The proposed work used GloVe, a pre-trained word engine used as a unidirectional training of the data. Bi-term Topic Model (BTM) was used as a classification model and different type of click-bait were used such as Reasoning, Number and Hypothesis. Result shows that the proposed approach has accuracy for 3 dataset are 95.8%, 89.44% and 94.21% respectively [16]. ***Wu et al. (2020)*** proposed a novel model based on Adversarial Networks and inspirited by the Shared-Private model (ANSP) which aims at reducing common, irrelevant features from the extracted features for information credibility evaluation. Adversarial network guided by the reinforcement learning and KL diversity was used for the better enhancement of the work. For the simulation, three different mechanisms such as LIAR, Weibo and Twitter16 were used with 0.75, 0.72 and 0.71 accuracy [17]. ***Shu et al. (2019)*** proposed a model for fake news understanding and detection named Fake News Tracker that can automatically collect data for news pieces and social context, which benefits further research of understanding and predicting fake news with effective visualization techniques. Result shows that the accuracy of the proposed work is about .074, precision is 0.77, recall is 0.5 and the F1-score is about 0.68 for the detection of the Buzz feed news [18]. ***Li et al. (2019)*** proposed multi-level CNN, which uses the combination of local convolutional features as well as the global semantics features, to effectively capture semantic information from article texts which can be used to classify the news as fake or not. The proposed work employed a method of calculating the weight of sensitive words, which has shown their stronger importance with their fake or true labels. After the simulation, result shows that the outcome of the proposed work is a state-of-art in terms of accuracy 0.92 and effectiveness 0.96 [19]. ***Zhang et al. (2019)*** proposes e a novel analytics-driven framework for detecting fake news named Fake News Detection (FEND). The proposed model uses double layered approach for the classification and the detection of the fake news. First layered perform fake topic detection and the second layer perform the fake event detection. Cluster based k-mean technique was proposed in the model for the enhanced outcomes. Result shows that the proposed model has the accuracy about 92-94%, precision 85-93%, recall 91.3-98.4% and the F-score 88-95% [20].

Based on the above survey of existing research, we motivated to design an IFND system using optimized TF-IDF features with multi-level voting rule with SGO as an optimization algorithm. These days, fake news detection is frequently used from social sites but there is a problem that occurred during the classification of fake and real news using accessible feature extraction techniques. The major causes of the problem in fake news detection system are the extraction of best and appropriate feature sets from the sample of fake and real news document. To minimize these types of problems from an improved fake news detection system, there are many options but SGO is the finest searching algorithm according to the survey. At the last of fake news detection system, the performance metrics of proposed work is to be calculated and compared with the existing work.

III. MATERIAL AND METHOD

In this section of research paper, we explain the architecture of the proposed IFND system based on their flowchart. The architecture of proposed IFND system using the TF-IFD with SGO and multi-level voting rule in shown in the Fig. 3.

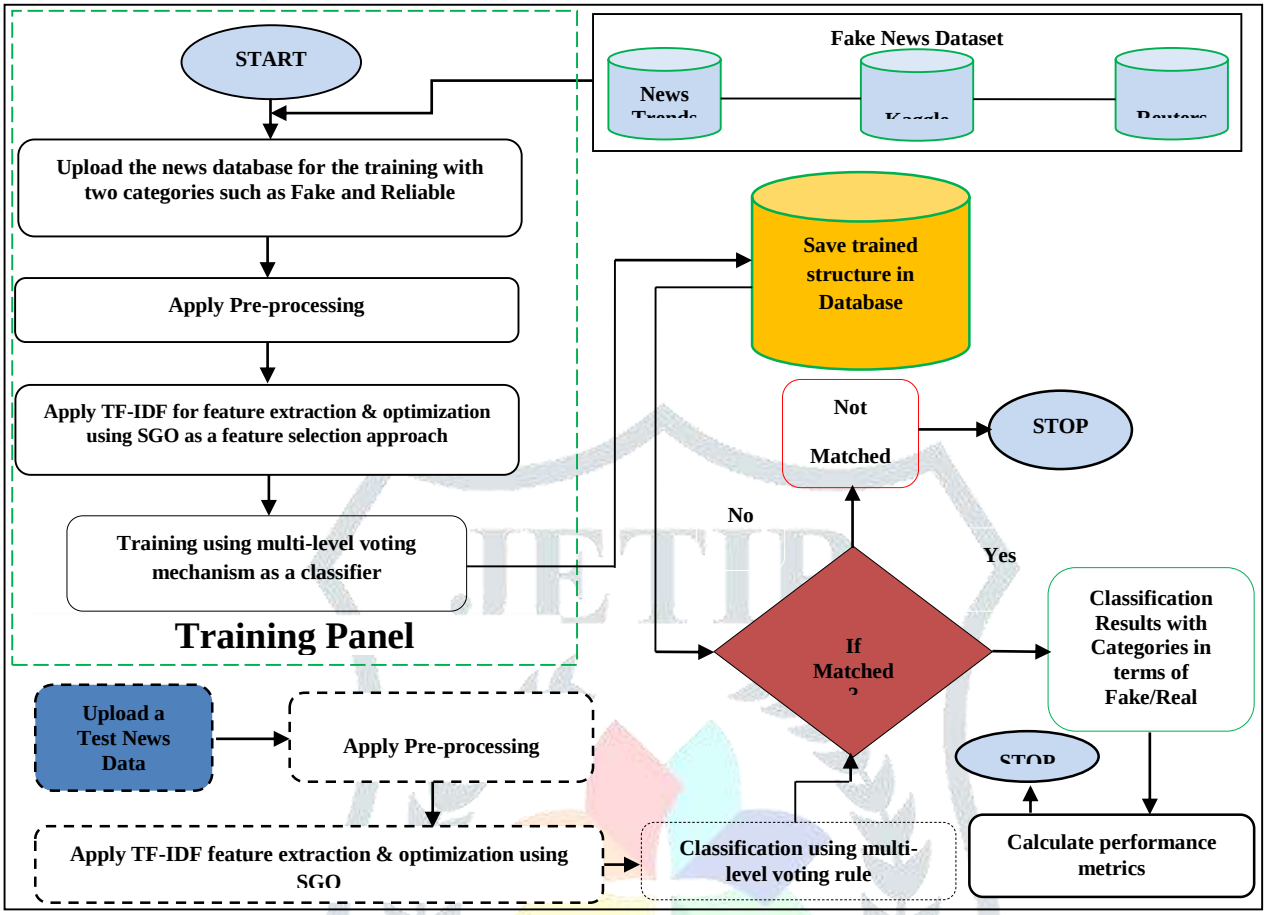

Fig 3: IFND System Flowchart

To train the proposed IFND system, a combination of three different news dataset have been collected from three different publicly available datasets such as News Trends, Kaggle and Reuters websites. Fake news detection involves lots of steps like data acquisition, pre-processing of raw data, feature extraction, selection of a set of unique features using the optimization algorithm and then training of model with classification process to classify the news reliability. To design and develop a framework for the simulation of proposed IFND system using optimized TF-IDF features with multi-level voting rule, some basic steps according to the flowchart is given as:

Step 1: Design a framework and upload text news data with different types like fake and real for Training and Testing of proposed an IFND system.

Step 2: Apply pre-processing on uploaded text news data in both section of an improved fake news detection system. In the pre-processing several basic steps are involved to make a data according to the requirements. The pre-processing steps which are applied on uploaded data to generate a compatible data for proposed work are given as:

Data normalization	Stop words removal
Punctuation removal	Tokenization of data

Uploaded Data	Normalized Data
2017 Fantasy Football Team Defense Rankings – Week 5 % of readers think this story is Fact. Add your two cents. (Before It's News).Here are the 2017 Lester's Legends Week 5 team defense rankings.	2017 fantasy football team defense rankings – week 5 % of readers think this story is fact. add your two cents. (before it's news). here are the 2017 lester's legends week 5 team defense rankings.

Removed Punctuation	Removed Stop Words
2017 fantasy football team defense rankings week 5 of readers think this story is fact add your two cents before its news here are the 2017 lesters legends week 5 team defense rankings	2017 fantasy football team defense rankings 5 readers think story fact add cents news 2017 lesters legends 5 team defense rankings bye atlanta denver new orleans washington 1 minnesota vikings 2 seattle seahawks 3 philadelphia eagles 4 pittsburgh steelers 5

Featutes of Data		
8.89921	8.89921	5.27478
8.89921	11.9007	5.27478
8.89921	5.27478	5.27478
8.89921	5.27478	8.89921
11.9007	5.27478	8.89921

Fig 4: Pre-processing in IFND System

Step 3: Pre-processing have been applied in both training and testing section. After that, feature extraction technique will be applied on the pre-processed data to extract the feature sets from fake or real textual news data using the TF-IDF.

Step 4: The used dataset taken from three different source named as News Trends, Kaggle and Reuters repository. The algorithm of used TF-IDF based feature extraction is written as:

Algorithm 1: Feature Extractor TF-IDF

Input: NTD→Pre-processed of News Text Data
Output: TF-IDF FS→Feature set of NTD

Start feature extraction
Record = 0
Output = 1
Calculate size of Pre-processed data (R, C)
For i = 1→ R
  For j = 1 → C
    If is empty (find (Record == NTD (i, j)))
      Count=numel (find (NTD == NTD (i, j)))
      TF=Count/numel (NTD)
      Output (i, j) = TF × log (numel (NTD)/Count)
    End – If
  Record (i, j) =NTD (i, j)
  TF-IDF FS=Output (find (Output>0)) × 100
  End – For
End – For
Return: TF-IDF FS as a feature set
End – Algorithm

Step 5: To achieve better accuracy of proposed automatic improved fake news detection system, feature optimization is a major approach which is used to remove the unwanted features from the TF-IDF feature set using the novel objective function. As a feature optimization or selection, Swarm-based Grasshopper Optimization (SGO) will be used and it select only fit or optimal features.

Algorithm 2: SGO-based Selection

Input: TF-IDF FS → Feature set of News Text Data
FF → Fitness function of SGO
Output: OFS → Optimized Feature Set

Start feature selection
To optimized the TF-IDF FS, SGO is used
Set up basic parameters of SGO: Grasshopper size ($G_{\text{TF-IDF FS Data}}$) = Total TF-IDF FS Data
Define Fitness function for the selection best TF-IDF FS Data,
Fitness Function: $F(f) = \begin{cases} True; & if\ S_G < A_G \\ False; & Otherwise \end{cases}$
In the fitness function,
S_G Selected feature in terms of selected grasshopper
A_G Average feature and known as adult grasshopper
Calculate Length of TF-IDF FS Data in terms of Row and Column, [Row, Column] = Size (FS)
Set, OFS = [] // Initiate an empty variable to store selected data
For i = 1→ Row
  For j = 1→ Column
    S_G = TF-IDF FS Data (i, j)
    $A_G = \frac{\sum_{i=1}^{Row}\sum_{j=1}^{Column} E_{P-Data}(i,j)}{Row \times Column}$
    $F(f) = Fit\ Fun\ (S_G, A_G)$
    OFS = SGO (F (f), TF-IDF FS Data (i, j))
  End – For
End – For
Check the index of OFS
If OFS (index) = True
  OFS = Select (FS
Else
  OFS = Reject (FS)
End – If
Returns: OFS as an Optimized Feature Set
End – Algorithm

Step 6: After the feature optimization, multi-level voting rule as classifier will be used to train the system based on optimized data.
Step 7: After that in the training of proposed improved fake news detection system, classification of fake news based on their textual features is performed according to the trained structure of improved fake news detection system as a classifier and the algorithm is written as:

Algorithm 3: Multi Level Voting

Input: OFS → Optimized Feature Set
Class → Fake and Real News
Output: Train-Net → Trained multi-level voting mechanism structure with Results

Start training
For i = 1 → Size (OFS)
  If OFS (i) ε fake (Data belongs to 1st class)
    G (1) = Feature from Fake News
  Else
    G (2) = Feature from Real News
  End – If
End – For
Trained-Net = Train (FND-Net, OFS, G)
Start classification
Test Output = Simulate (Train-Net, Test News Data)
If Test Output = 1st Class

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   Results = Type of news is Fake
Else
   Results = Types of news is Real
End – If
Return: Train-Net with Results
End – Algorithm
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Step 8: At last of module, performance parameters of proposed improved fake news detection system like Precision, Recall, F-measure, Execution Time, Error and Accuracy will be calculated and compare with existing works. Above flowchart and algorithms are shows procedural steps of proposed an IFND system that is tested on three different dataset such as News Trends, Kaggle and Reuters repository. The sample of used dataset is given in the Table I.

Table I: Used Dataset Sample

Uploaded Text Data	JetNation FanDuel League: Week 4 % of readers think this story is Fact. Add your two cents. (Before It's News) Our FanDuel league is back again this week. Here are the details: $900 in total prize money. $250 to the winner. $10 to enter. Remember this is a one week league, pick your lineup against the salary cap and next week if you want to play again you can pick a completely different lineup if you want. Click this link to enter — http://fanduel.com/JetNation
Normalized Data	jetnation fanduel league: week 4 % of readers think this story is fact. add your two cents. (before it's news) our fanduel league is back again this week. here are the details: $900 in total prize money. $250 to the winner. $10 to enter. remember this is a one week league, pick your lineup against the salary cap and next week if you want to play again you can pick a completely different lineup if you want. click this link to enter — http://fanduel.com/jetnation
Punctuation Free Data	jetnation fanduel league week 4 of readers think this story is fact add your two cents before its news our fanduel league is back again this week here are the details 900 in total prize money 250 to the winner 10 to enter remember this is a one week league pick your lineup against the salary cap and next week if you want to play again you can pick a completely different lineup if you want click this link to enter httpfanduelcomjetnation
Stop words Free Data	jetnation fanduel league 4 readers think story fact add cents news fanduel league details 900 total prize money 250 winner 10 enter remember league pick lineup salary cap want play pick completely different lineup want click link enter httpfanduelcomjetnation discuss ny jets fans jet nation message board visit facebook source httpwwwjetnationcom20170927jetnationfanduelleagueweek4

The simulation results of proposed an IFND system using optimized TF-IDF features with multi-level voting rule as a machine learning algorithm and SGO technique as a feature selection is described in the below section of paper.

IV. RESULTS AND ANALYSIS

We have shown the result of proposed IFND system using the TF-IDF features based multi-level voting rule as a machine learning algorithm on the basis of available information in news data. The results of proposed system with multi-level voting classifier is expressed in terms of Precision, Recall, F-measure, Execution Time, Error and Accuracy will be calculated and compare with existing work presents by ***S. Kaur et al.*** [12]. Below Table II represents the classification results for the proposed an IFND system using the TF-IDF feature with SGO and multi-level voting as machine learning algorithm and ten sample of news data is used for evaluation.

Table II: Performance Parameters of Proposed IFND System

No. of Samples	Precision	Recall	F-measure	Accuracy (%)	Error (%)	Execution Time (s)
Data-1	0.9864	0.978	0.98218	99.684	0.316	1.715
Data-2	0.9758	0.925	0.94972	98.876	1.124	2.402
Data-3	0.9641	0.919	0.94101	99.765	0.235	1.218
Data-4	0.9285	0.967	0.94738	97.988	2.012	1.013
Data-5	0.9608	0.905	0.93206	98.589	1.411	2.195
Data-6	0.9843	0.986	0.98514	99.567	0.433	2.319
Data-7	0.9579	0.965	0.96143	98.981	1.019	2.16
Data-8	0.9456	0.973	0.95910	98.991	1.009	2.82
Data-9	0.9765	0.963	0.96970	99.673	0.327	2.272
Data-10	0.9742	0.981	0.97758	98.467	1.533	2.051

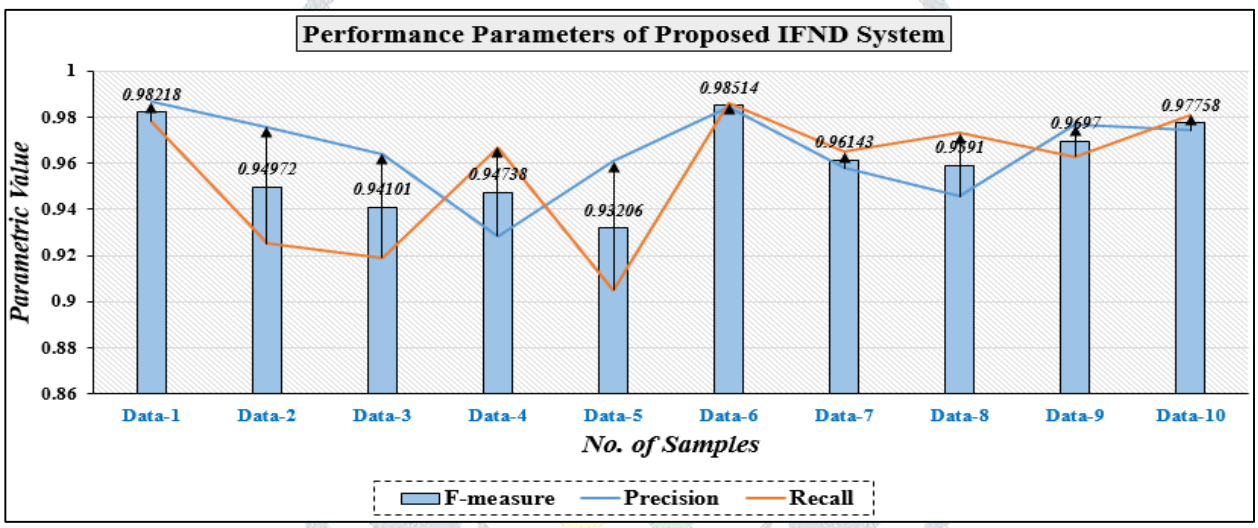

Fig 4: Performance Parameters of Proposed IFND System

The computed parameters values are shown in Fig. 4 for the proposed an IFND system using the multi-level voting mechanism as a classifier. From the graph of combined precision, recall and f-measure, it is clearly observed that the achieved results are maximum for ten sample of data collected from the three different dataset named as News Trends, Kaggle and Reuters repository. The average values for ten sample news data is near to 0.9654, 0.9562, and 0.9605 for precision, recall and f-measure separately. To calculate these values, we used the quantities approach where:

True classified feature counts from test data,

A = TP → True Positive

False classified feature counts from test data,

B = FP → False Positive

Dissimilar feature counts from training data,

C = TN → True Negative

Similar feature counts from training data,

D = FN → False Negative

Based on these counts, we calculate all parameters and the formula of precision is written as:

$$Precision = \frac{A}{A + B}$$

Recall is the factor used to know the actually positively predicted fake news among the labelled fake news data during the classification and the formula of recall is calculated using the formula given below.

$$Recall = \frac{A}{A + D}$$

The F-measure of the proposed IFND system represents the arithmetic means of the precision and recall, and the formula of F-measure is represented by the following equation:

$$F - measure = \frac{2 * Precision * Recall}{Precision + Recall}$$

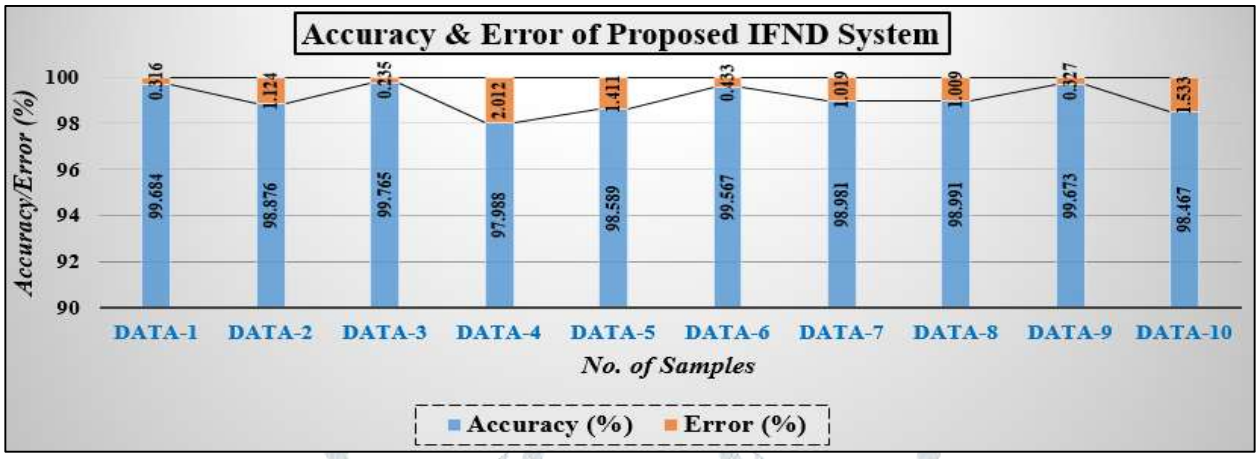

Fig 5: Accuracy and Error of Proposed IFND System

In Fig. 5, the accuracy and error of the proposed IFND system is shown and the average value of accuracy is near to 99.06% whereas, the system error is very less and bear to the 0.94%. To calculate the accuracy of system, the given formula is used:

$$Accuarcy = \frac{A + C}{A + B + C + D}$$

And, $Error = 100 - Accuarcy$

The simulate time of proposed model is improved by utilizing the concept of the SGO as an optimization technique and the average execution time is noted as 2.01 seconds.

Comparative Analysis: To validate the proposed IFND system, we need to compare the efficiency of system with existing work and a comparison has been done with the past work performed by ***S Kaur et al.,*** [12]. The comparison is given the in Table III.

Table III: Comparison-based on Performance

Parameters	Proposed	*S. Kaur et al.* [12]
Accuracy (%)	99.06	94.70
Error (%)	00.94	05.30
Precision (%)	96.54	95.65
Recall (%)	95.62	93.82
F-Measure (%)	96.05	94.78

Above Table III shows the comparison of proposed IFND system with fake news detection system by ***S Kaur et al.,*** in 2019. The effectiveness of proposed system is clearly shown in the table and for better representation, their graphs are shown in the Fig. 6.

Fig 6: Comparison-based on the performance parameters of proposed IFND System with Existing Work

Above Fig. 6 represents the comparison of proposed IFND system and with ***S Kaur et al.*** [13] on the basis of performance parameters. The significant increase in accuracy, precision, recall and f-measure of proposed work is recorded from existing work and it is 5.17%, 0.89%, 1.8% and 1.27% respectively. The conclusion of the proposed work is given in the below section of this article.

V. CONCLUSION AND FUTURE WORK

In this paper, we have proposed an IFND system using the concept of TF-IDF feature extraction technique along with the SGO algorithm as a feature selection or optimization technique on the three different dataset named as News Trends, Kaggle and Reuters repository. Here, multi-level voting mechanism is used as machine learning technique to analyze the reliability of news on the social media platform or network. The working of IFND system is based on the concept of TF-IDF extractor to analyze the written text news by editor in order to find out the reliability of news from the text data. The swarm-based optimization algorithm named as SGO is used to select a set of better TF-IDF feature using a fitness functions and to train the IFND system, multi-level voting rule is used that helps to distinguish fake and real news. Previously various authothr presented lots of related work that is survey in the second section of this article and the proposed an IFND system, to validate the model, we evaluate and compare the performance parameters in terms of accuracy, error, precision, recall, f-measure and execution time. A noteworthy increase in accuracy, precision, recall and f-measure of proposed work is recorded from existing work by ***S Kaur et al.*** and it is 5.17%, 0.89%, 1.8% and 1.27% respectively. In future, we can enhance the feature extraction process by utilizing the other approaches, and try to design an audio and visual format to fake news detection from the way of speech and facial expressions.

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