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Research

A HYBRID DEEP LEARNING APPROACH FOR ONLINE RECRUITMENT FRAUD DETECTION USING BERT, ROBERTA, AND CNN2D

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Abstract: With the increasing rise of digital employment platforms, online recruitment fraud (ORF) has become a critical cyber concern, where fraudsters use phony job advertising to take advantage of job searchers. An improved deep learning-based system that combines transformer models—BERT and RoBERTa—with sophisticated data balancing strategies that employ several SMOTE variants to efficiently handle class imbalance is proposed in this study to address this problem. A Convolutional Neural Network (CNN2D) is also added to the system for better feature extraction, which helps the model recognize intricate textual patterns and boost classification results.

By merging job listings from several sources, a new and updated dataset is created, improving generalization and flexibility to current fraud trends. Metrics including accuracy, precision, recall, and F1-score are used to assess the models' performance after they have been trained and assessed on both original and balanced datasets. A Flask-based web application is also created to offer a user-friendly interface for real-time fraud detection, enabling users to enter job information and get predictions right away. When compared to conventional machine learning techniques, experimental findings show that the suggested hybrid framework greatly increases detection accuracy and resilience, making it a useful tool for spotting fake job listings.

Index terms *- Fraudulent Job Postings, Convolutional Neural Network (Cnn2d), Feature Extraction, Real-Time Fraud Detection*

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1. INTRODUCTION

The hiring process has changed dramatically as a result of the quick development of digital platforms, which allow companies to advertise job openings online and let applicants apply from any location. This change has increased efficiency and accessibility, but it has also increased Online Recruitment Fraud (ORF), in which dishonest people fabricate job advertisements to trick candidates for money or personal benefit. Developing strong and intelligent detection systems is crucial since the likelihood of such fraudulent operations has increased due to the growing reliance on online employment portals, particularly since the COVID-19 epidemic.

Though they frequently fail to grasp the intricate semantic linkages seen in textual job descriptions, traditional machine learning techniques have been widely employed for identifying fraudulent job listings. Recent developments in deep learning, especially transformer-based models like BERT and RoBERTa, have demonstrated better performance in natural language comprehension tests in order to get beyond these restrictions.

These algorithms can enhance classification accuracy in detecting fraudulent job advertisements and efficiently assess contextual information.

Since fraudulent posts usually represent a minority class, class imbalance is still a significant difficulty in ORF detection in addition to model selection. In order to solve this problem, the suggested approach uses a variety of SMOTE variations to balance the dataset and produce synthetic samples, which enhances the model's capacity to identify instances of minority classes. Additionally, the system is expanded by using a Convolutional Neural Network (CNN2D), which improves classification performance by enhancing feature extraction by identifying intricate patterns in the converted textual data.

Additionally, job posts from several sources are combined to create a new and updated dataset that better reflects current fraud patterns. A Flask-based web application is created to make the system useful and easy to use. It allows for real-time job fraud detection via an interactive interface. A complete and effective method for identifying online recruiting fraud with more accuracy and dependability is offered by this integrated strategy, which combines transformer models, data balancing strategies, CNN2D improvement, and web deployment.

2. LITERATURE SURVEY

i) Online fake job advertisement recognition and classification using machine learning

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A large range of data types are handled by machine learning algorithms in real-world smart devices. Due to technology improvements and the extensive utilization of social media platforms, a large number of recruiters and job searchers are now actively engaged online. However, one may be more likely to engage in unsafe activities as a result of data and privacy intrusions. Online job boards are a common tool for scammers and dishonest companies to entice people looking for work. Our objective is to reduce the occurrence of fake and fraudulent efforts by utilizing machine learning to provide predictions. Using a plethora of classification methods, our proposed approach enhances detection. This study also evaluates the performance of several classifiers using various methodologies for real outcomes, with the goal of improving the findings.

ii) Fake Job Detection and Analysis Using Machine Learning and Deep Learning Algorithms

https://revistageintec.net/old/wp-content/uploads/2022/02/1701.pdf

Because of the epidemic, there has been a surge in the number of online job ads on employment websites. But there are shady online jobs out there that take personal information. From a pool of both real and fake job postings, these fictitious positions may be correctly identified and sorted utilizing state-of-the-art deep learning and machine learning classification algorithms. In order to identify fake jobs, this study applies machine learning and deep learning methods. Data cleaning and analysis are suggested as ways to improve the classification system's accuracy and precision in this study. Since data quality affects the performance of ML and DL algorithms, data cleansing is a crucial part of ML initiatives. Therefore, data cleansing and pre-processing are the main points of this article. Precise and accurate categorization and identification of phoney jobs. Consequently, improving accuracy requires using deep learning and machine learning algorithms on cleaned and pre-processed data. Utilizing deep learning neural networks enhances precision. After evaluating all of these models, the one with the highest level of accuracy and precision is identified.

iii) Online Recruitment Fraud Detection using ANN

https://ieeexplore.ieee.org/abstract/document/9636978

People looking for work may find many opportunities online and apply for them quickly. Furthermore, it enhances the hiring process by assisting recruiters in locating qualified candidates. The incidence of fraud in the workplace is on the rise. It is possible for job ads to be legitimate or not. In order to detect fraudulent job postings, this research introduces a technique based on artificial neural networks. For text preparation purposes, the proposed model may be trained and evaluated using the publicly accessible Employment Scam Aegean Dataset (EMSCAD). The f-measure, recall, and accuracy of our model are 93.88%, 96.02%, and 91.84%, correspondingly. In terms of detecting fraudulent employment, the results show that the ANN-based model performs better than competing algorithms.

iv) Classification of Genuinity in Job Posting Using Machine Learning

https://www.academia.edu/68038151/Classification_of_Genuinity_in_Job_Posting_Using_Machine_Learning

We help candidates remain watchful and make smart decisions by using machine learning (ML) to predict the possibility that a job is fake. This, in turn, decreases the amount of fake job ads on the internet. The model extracts features using the TF-IDF vectorizer and using natural language processing to analyze trends and attitudes in job postings. With the help of Random Forest and SMOTE, the balanced data will be accurately categorized. It prevents overfitting and improves model accuracy even with big datasets. The final algorithm will find out if the job is real or not by looking at the details of the listing.

v) A Comparative Study on Fake Job Post Prediction Using Different Data mining Techniques

https://ieeexplore.ieee.org/abstract/document/9331230

Advertising open positions has grown ubiquitous in the age of social media and online tools. This means that erroneous forecasts in job postings will be a major concern for everyone. Similar to earlier classification efforts, false job posing prediction has several flaws. If you want to spot phoney job postings, this research recommends employing a combination of data mining algorithms and techniques including KNN, decision trees, and support vector machines. In the EMSCAD Employment Scam Aegean Dataset, we examined 18,000 cases. Classifiers trained using deep neural networks are quite good at this. This classifier for deep neural networks is made up of three thick layers. The trained classifier achieves a 98% success rate in predicting DNN fraud job postings.

3. METHODOLOGY

i) Proposed Work:

The suggested approach uses sophisticated transformer models, data balancing methods, and convolutional neural networks to identify Online Recruitment Fraud (ORF) via deep learning. To better cover modern fraud practices, job advertisements from several sources are combined to create a new dataset. BERT and RoBERTa models turn work descriptions into contextually semantic numerical vector representations after preprocessing the textual job data. Multiple SMOTE versions create synthetic minority (fraudulent) class samples to balance training data. CNN2D deep feature extraction identifies complicated data patterns and correlations to improve balanced feature representations. The model can better discriminate between real and fake job advertisements using this hybrid method.

The processed dataset is used to train and test BERT, RoBERTa, and the expanded CNN2D-

based architecture. Model efficacy is measured by accuracy, precision, recall, and F1-score. Finally, the best-performing model is incorporated into a Flask-based web application for real-time job fraud detection, allowing users to input job information and obtain predictions.

ii) System Architecture:

The proposed method detects fraudulent job advertisements on recruiting websites by using Convolutional Neural Networks (CNN2D). Although transformer-based models, such as BERT and RoBERTa, have demonstrated potential in identifying fraudulent job advertisements, they frequently struggle to adequately capture intricate patterns in the data. The method tackles this by fusing the sophisticated skills of CNN2D, which is renowned for its capacity to identify complex patterns in datasets, with the advantages of these transformer models. In order to extract more subtle information from job ads and increase the model's overall accuracy and efficiency in differentiating between genuine and fraudulent listings, the CNN2D model uses 2D convolutional layers.

The system's initial stage is compiling an extensive dataset from several sources that contains both legitimate and fraudulent job postings. This enlarged dataset guarantees that the system stays current with the most recent trends in job postings and helps overcome the shortcomings of the old benchmark datasets. Following data collection, the CNN2D model is used to analyze and extract important characteristics, improving the system's ability to identify intricate patterns that could point to fraudulent activity. This hybrid technique, when combined with BERT and RoBERTa, makes use of CNN2D's feature extraction skills as well as the transformer models' language understanding capabilities.

By using the Synthetic Minority Oversampling Technique (SMOTE), the system addresses the prevalent problem of class imbalance in the dataset and improves the model's performance even further. Many SMOTE implementations create phony, fraudulent job adverts in order to train the algorithm on a more balanced sample. This enhances the system's capacity to identify fake ads, particularly when there are fewer phony jobs than genuine ones.

Additionally, the system has an easy-to-use interface that was created with the Flask framework, giving administrators a simple approach to handle job posts. Administrators can upload job postings using this interface to identify fraud in real time. These postings are promptly processed by the system, which then determines if they are authentic or counterfeit and offers useful information. Deep learning algorithms, when paired with an easy-to-use interface, can effectively and accurately identify fake job advertisements, ensuring the security of online recruiting platforms.

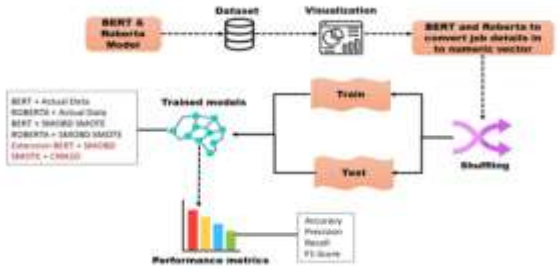


Fig.1. Proposed Architecture

iii) MODULES:

a. **Load BERT & RoBERTa Model**: The Hugging Face library's pre-trained BERT and RoBERTa models are imported into this module. When analyzing job descriptions and extracting contextual embeddings, these models function as potent text encoders.

b. **Exploring the Dataset**: In this module, the dataset is examined for structure, content, and potential issues. Key statistics such as class distribution, missing values, and sample entries are analyzed to understand the data.

c. **Visualization**: This module utilizes visualization libraries to create graphs and

charts, showcasing insights into the dataset. Visualizations help identify trends, relationships, and anomalies in job postings, enhancing understanding.

d. **BERT and RoBERTa for Vectorization**: Here, BERT and RoBERTa convert job details into numerical vectors. The models tokenize and encode the text, transforming it into dense representations suitable for classification tasks in the subsequent steps.

e. **Shuffling**: This module randomizes the order of data entries to ensure that the training process is unbiased and independent of the input order. Shuffling enhances model robustness and generalization.

f. **Split the data into train & test**: In this module, the dataset is divided into training and testing subsets, typically using an 80-20 split. This separation allows for effective training of the model and evaluation of its performance.

g. **Model generation:** Model building – BERT + Actual Data, ROBERTA + Actual Data, BERT + SMOBD SMOTE, ROBERTA + SMOBD SMOTE, Extension BERT + SMOBD SMOTE + CNN2D. Performance evaluation metrics for each algorithm is calculated.

h. **Admin login**: In this module, admin can login into the application.

i. **Predict Fraud Job**: In this module user can upload the input data.

j. **Logout**: User can logout after the completion of all activities.

iv) ALGORITHMS:

i. **BERT + Actual Data:** This algorithm applies BERT to convert raw job postings into numerical vectors, leveraging its deep bidirectional context understanding for accurate language representation. By processing actual data without oversampling, BERT helps in capturing genuine patterns and features in job descriptions, aiding in identifying indicators of fraud effectively.

ii. ***RoBERTa + Actual Data:*** RoBERTa enhances BERT by utilizing optimized pre-training techniques and extensive training data to encode job details. It provides deeper contextual representations and improves detection accuracy on actual data. RoBERTa's enhanced language modeling helps distinguish subtle linguistic cues that may indicate fraudulent or deceptive job postings.

iii. **BERT + SMOBD SMOTE:** With BERT embeddings enhanced by SMOBD SMOTE, this approach addresses class imbalance in the dataset by oversampling minority class samples. This combination improves detection accuracy for underrepresented fraudulent postings, ensuring the model effectively captures the distinguishing features of rare fraudulent postings.

iv. **RoBERTa + SMOBD SMOTE:** By combining RoBERTa with SMOBD SMOTE, this approach leverages RoBERTa's robust feature extraction and SMOTE's balancing capabilities. This pairing improves model resilience against imbalance, enhancing the system's ability to detect nuanced indicators of fraudulent postings within an imbalanced dataset.

v. **Extension BERT + SMOBD SMOTE + CNN2D:** This extended model combines BERT embeddings with SMOBD SMOTE balancing and CNN2D for classification, enhancing feature extraction through spatial patterns. The CNN2D layer adds a deeper level of pattern recognition, improving the system's classification performance and yielding a higher accuracy for fraud detection.

4. EXPERIMENTAL RESULTS

The model was able to reasonably accurately categorize job posts as legitimate or false by using the Basic Neural Network technique with features from BERT and ROBERTA. Nevertheless, the accuracy greatly increased when CNN2D was used. The CNN2D layers improved feature optimization and classification performance by assisting the model in identifying more intricate patterns in the data.

Combining BERT and ROBERTA with the SMOTE SMOBD method (to balance the dataset) allowed them to detect phony job listings with remarkable accuracy, with BERT outperforming ROBERTA. Because it was more efficient than a simple neural network at extracting and processing information, the CNN2D extension significantly increased accuracy.

All datasets can be downloaded from below URL

https://www.kaggle.com/datasets/shivamb/real-or-fake-fake-jobposting-prediction

https://www.kaggle.com/datasets/promptcloud/indeed-job-posting-dataset

https://www.kaggle.com/datasets/zusmani/pakistans-job-market

Accuracy: The ability of a test to differentiate between healthy and sick instances is a measure of its accuracy. Find the proportion of analysed cases with true positives and true negatives to get a sense of the test's accuracy. Based on the calculations:

Accuracy = TP + TN /(TP + TN + FP + FN)

$$Accuracy = \frac{(TN + TP)}{T}$$

Precision: The accuracy rate of a classification or number of positive cases is known as precision. Accuracy is determined by applying the following formula:

Precision = True positives/ (True positives + False positives) = TP/(TP + FP)

$$\Pr e\,cision = \frac{TP}{(TP + FP)}$$

Recall: The recall of a model is a measure of its capacity to identify all occurrences of a relevant machine learning class. A model's ability to detect class instances is shown by the ratio of correctly predicted positive observations to the total number of positives.

$$Recall = \frac{TP}{(FN + TP)}$$

mAP: One ranking quality statistic is Mean Average Precision (MAP). It takes into account the quantity of pertinent suggestions and where they are on the list. The arithmetic mean of the Average Precision (AP) at K for each user or query is used to compute MAP at K.

$$mAP = \frac{1}{n}\sum_{k=1}^{k=n} AP_k$$

$$AP_k = \text{the AP of class } k$$

$$n = \text{the number of classes}$$

F1-Score: A high F1 score indicates that a machine learning model is accurate. Improving model accuracy by integrating recall and precision. How often a model gets a dataset prediction right is measured by the accuracy statistic..

$$F1 = 2 \cdot \frac{(Recall \cdot \Pr e\,cision)}{(Recall + \Pr e\,cision)}$$

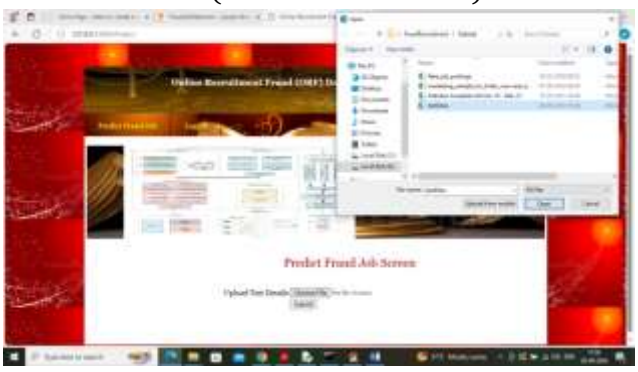


Fig.2. upload test file



Fig.3. dataset analysis



Fig.4. algorithm performance in tabular format



Fig.5. algorithm performance graph

5. CONCLUSION

This work presents an enhanced framework for Online Recruitment Fraud (ORF) detection by integrating transformer-based models (BERT and RoBERTa), SMOTE-based data balancing techniques, and a CNN2D model for improved feature extraction. The combination of these advanced methods enables the system to effectively capture contextual semantics and complex patterns in job postings, resulting in higher detection accuracy and robustness compared to traditional approaches. The use of an updated and combined dataset further improves the system's ability to identify modern fraud trends.

Additionally, the deployment of the model through a Flask-based web application ensures practical usability by providing real-time fraud detection with a user-friendly interface. The experimental outcomes demonstrate that the hybrid approach significantly enhances performance metrics such as accuracy, precision, and recall. Overall, the proposed system offers a reliable and scalable solution for detecting fraudulent job postings and can be further extended to other text-based fraud detection applications in the future.

6. FUTURE SCOPE

The suggested system may be further enhanced by adding multimodal aspects like metadata and corporate facts for improved fraud detection, as well as sophisticated transformer models like DistilBERT or ALBERT to increase efficiency and lower computing complexity. Using real-time job portal data to update the model continuously can aid in adapting to changing fraud trends. Furthermore, using explainable AI approaches and implementing the system as a mobile or cloud-based application can enhance user confidence, scalability, and accessibility, strengthening the system's resilience and broad applicability.

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