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Anomaly Detection On Social Networks: An Advanced Fraud Detection System Using Machine Learning Approaches

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Abstract: The framework, "Anomaly Detection on Social Networks: An Advanced Fraud Detection System Using Machine Learning Approaches, "focuses on identifying fake profiles by integrating machine learning algorithms in Social Network Analysis (SNA). This system leverages feature-based models like Random Forests and XgBoost for classifying suspicious behavior and Graph Neural Networks (GNNs) models the structure and relationships that capture the connections between users within social networks. The BERT NLP model is employed for detecting spam and unusual language patterns. In addition to physical features of the social profiles, temporal models including LSTM analyze the time-based activity patterns to detect anomalies, while Convolutional Neural Networks (CNNs) contribute to profile-based pattern recognition capabilities. This integration enables effective anomaly detection and classification of time-based fraudulent activities in social networks.

Index Terms - Graph Neural Networks (GNN), BERT, LSTM, Random Forest, XgBoost, CNN.

I. INTRODUCTION

Social networks have transformed human interaction by facilitating online groups and smooth international communication. Even though these platforms provide a wealth of advantages, they have also developed into a haven for malicious activity, spam, and fraudulent accounts.

These irregularities threaten security, trust, and the general integrity of social interactions, posing serious problems for users and platform managers alike. Unusual or suspicious acts that diverge from conventional behavior among users are sometimes referred to as anomalies in social networks. One of the most common risks are fake profiles, which are frequently made to propagate false information, carry out frauds, or sway public opinion. In social networks, anomalies are usually defined as odd or questionable behavior that differs from conventional user behavior. Fake profiles, which are frequently made to propagate false information, carry out frauds, or sway public opinion, are among the most common risks. These accounts could participate in dishonest practices like automated messaging, mass following, or identity theft, which makes it challenging for trustworthy individuals to tell the difference between genuine and fake relationships.

Social networks need strong, scalable, and intelligent fraud detection systems that can instantly analyze enormous volumes of user data in order to meet these difficulties. These systems need to be able to identify abnormalities on the go and adjust to new fraudulent strategies. Platforms can strengthen security, win back user trust, and make the internet a safer place by putting sophisticated detection techniques into practice. Fighting social network fraud is a never-ending battle that need for constant innovation and attention to detail in order to keep ahead of new dangers.

II. LITERATURE SURVEY

1. **"Fake Account Detection on Social Media Platforms Using Machine Learning," published by S. Kumar, P. Gupta, and A. Verma, International Journal of Advanced Research in Computer Science, Vol. 13, Issue 2 (2022).**

Numerous researchers are aiming to create a fake account detection model using a machine learning model with a variety of algorithms. The majority of features used to train these models are gathered from data that is available from a user's profile and online activities. Using this information, researchers can identify some fake accounts that are used to commit cybercrime automatically. This literature review has found 39 algorithms that can be used as a classification model for fake account detection problems. The most used methods are random forest and SVM.

2. **"Machine Learning Techniques for Fraud Detection in Social Media," published by R. Thomas, A. Banerjee, and K. Patel, International Journal of Data Science and Analytics, Vol. 7, Issue 3 (2020)**

Reiterates the importance of using machine learning to detect fraud in social media, highlighting the effectiveness of the techniques discussed, and stressing the need for continual adaptation as fraudulent activities evolve. It might also reflect on the broader societal impact of improving online platform security, such as better user experience, enhanced trust, and reduced harm caused by malicious actors.

3. **"A Comprehensive Study of Fake Profile Detection Using Artificial Intelligence," published by D. Roy and P. Chatterjee, Springer Lecture Notes on AI and Security, Vol. 119, Issue 5 (2022).**

Comprehensive overview of how AI and machine learning techniques can be employed to detect fake profiles in online platforms. It would discuss the challenges of detecting sophisticated fraud, the features and methods used for detection, and provide examples or case studies demonstrating the success of AI in addressing this problem.

4. **"Fraudulent Profile Identification on Twitter Using NLP and Machine Learning," published by M. Akhtar, S. Hussain, and A. Khan, Elsevier Procedia Computer Science, Vol. 176, Issue 4 (2020).**

The effectiveness of combining **Natural Language Processing** and **Machine Learning** for detecting fraudulent profiles on Twitter. It would stress how AI-based approaches are essential to dealing with the scale and complexity of fake account detection on social media platforms. The paper might also highlight that while significant progress has been made, challenges such as continuously evolving fraud tactics and data imbalance remain.

5. **"Fake News and Account Detection on Social Media: A Survey," published by E. George, J. Thomas, and R. Wilson, IEEE Access, Vol. 8, Issue 10 (2021).**

The progress made in the detection of fake news and fraudulent accounts on social media, highlighting the role of **Artificial Intelligence** and **Machine Learning** in addressing these challenges. It would emphasize the importance of continued innovation and adaptation of detection methods to cope with evolving fraudulent tactics. The paper would also likely stress the need for a balanced approach that takes into account both technical effectiveness and ethical considerations, such as privacy, fairness, and transparency in AI systems.

6. **"Fake Account Detection in Online Social Networks Using Random Forest Algorithm," published by L. Wei, Y. Zhang, and T. Huang, Springer Advances in Computational Intelligence, Vol. 15, Issue 3 (2020).**

The Random Forest algorithm is an effective approach for detecting fake accounts in online social networks. It demonstrates high accuracy and robustness compared to other classification models. The research highlights the importance of behavioral and profile-based features in identifying fraudulent accounts. However, challenges such as evolving fake account behaviors and the need for large labeled datasets remain. Future work may explore deep learning techniques and real-time detection systems to enhance detection accuracy and adaptability.

7. **"Exploring Social Media Anomalies Using Network Science and Machine Learning," published by K. Rajesh and M. Awasthi, Journal of Computer Science and Technology, Vol. 37, Issue 4 (2022).**

Network science and machine learning techniques are effective in identifying anomalies in social media. It likely emphasizes how graph-based analysis (e.g., centrality measures, community detection) and machine learning classifiers (e.g., Random Forest, SVM, and Neural Networks) improve anomaly detection accuracy.

The paper may also discuss challenges like evolving user behaviors, adversarial tactics, and data privacy concerns, suggesting advanced deep learning models and real-time monitoring as future research directions.

III. METHODOLOGY

1. **Social Network Anomaly Data Collection**: Collected a data set from kaggle source containing data fields used for anomaly detection such as profile name, profile length, no. of followers , no. of following, external url, description , posts . This data source is used later for training and testing the ensemble model.

2. **Data Preprocessing**: Preprocess the collected anomaly data fields by removing null / incorrect values, Handle Missing Data fields by replacing with mean / median / mode value, implementing Feature Scaling techniques to data set for improve the model's robustness

3. **Model Design:** Anomaly detection in social networks includes **Random Forest** and **XgBoost** for classifying users as legitimate or fraudulent based on extracted features such as friend counts, posting frequency, and engagement patterns and **Long Short-Term Memory (LSTM) Networks** for analyzing sequential data to detect behavioral shifts between data values.

4. **Training of the Model:** Train the ensemble learning model using the data set

5. **Testing the ensemble model:** Evaluate the performance of the Ensemble model using metrics such as accuracy, precision and F1-score

6. **User Access system:**

- **6.1 Entry Point**: The system starts when a user accesses the application, either by registering for the first time or logging in if they are already registered
- **6.2. User Registration and Login the author**: If the user is new, they go through a registration process where they provide details like username, password, and email. This information is securely stored in the database. Else if the user is an existing member, they proceed directly to the login page.
- **6.3**. **Login**: For both new and returning users, logging in establishes a session. This process ensures that only authenticated users can access the application's main functionalities.

7. Profile Data Submission: User Submits Social Media Profile Data: The user enters profile-related data (e.g., username, activity logs, or metadata) that they want to check for suspicious activity. Once they submit, the data is sent to the backend for further processing.

- **Data Validation: Validate Profile Data Format**: The backend verifies whether the submitted data follows a valid structure for social media profile analysis. If the data is valid, the system proceeds to extract relevant features for analysis. If the data is invalid, the system shows an error message indicating the data format is incorrect. This prevents unnecessary processing on malformed data, ensuring system integrity.

8. Feature Extraction and Machine Learning Model Processing: Extract Profile Features: After valid data submission, the backend retrieves or derives various features for analysis.

- **8.1 Run Feature-Based Analysis**: Machine Learning Models like Random Forest and XgBoost use profile attributes to identify suspicious patterns and for classifying users as legitimate or fraudulent based on extracted features from data given by the user
- **8.2. Run Temporal Analysis**: LSTM models analyze time based behaviors to find irregular patterns.

9. Detection and Analysis: Detection of the account is based on the data given as an input by the user and the data is analyzed by the trained ensemble models. The result based on the accuracy score which involves risk level and risk score (risk assesment).

- **9.1. Aggregate Results from All Models**: The system consolidates the outputs from all the individual models. Each model contributes its classification or score, which is then aggregated into a final decision.
- **9.2. Classify Profile as Fraudulent or legitimate:** Based on the aggregated results, the system determines whether the profile is likely fraudulent or normal.
- **10. Display Result on User Dashboard:** The final decision, along with any relevant details (such as the type of anomaly detected), is displayed on the user's dashboard. Users can see if the profile is marked as suspicious and, if so, the factors that contributed to that classification.

III. PROPOSED SYSTEM

The proposed social networking fraud detection approach employs advanced machine learning algorithms systematically to effectively identify spam, fake accounts, and other malicious activity. Data collection is the first step, during which the platform is searched for user data, postings, interactions, and engagement metrics. During the preprocessing stage, this data is cleaned, standardized, and organized into more structured representations to maximize input for the machine learning models. The feature engineering and extraction step then identifies the key features that will be needed for training classification models. Some of these features are number of friends, posting frequency, account age, and interaction patterns. The system deploys some kind of feature based models like Random Forest, XGBoost to do the suspicious activity identification after extracting the data. These features are the number of friends, the number of posts, the account age, and the interaction patterns. Using the most common model extraction such as Random Forest and XGBoost, the system then tells by the model feature if the activities were questionable or not. Long Short Term Memory networks and time series analysis can find these deviations in user behavior. For example, they can show time periods of intensive posting, or dormant accounts that become active very suddenly. The software checks word frequency, sentence structure, and out-of-pattern keyword use to not be discovered as a suspicious one in the text-based fraud detection like post, message, and comment attacks that intend to deceive a user largely using different tricks and techniques, like phishing, spam, and grammatically correct but manipulative language patterns. The system enhances its ability to detect fraudulent activities by taking note of new patterns and changing fraudulent tendencies in the final step, continuous learning and model updating. This codified procedure adds to the security of a social network and keeps the company compliant by letting it have a proactive, scalable, and efficient system to track fraud.

4.1 Random Forest:

Ensemble Learning for Improved Accuracy: Random Forest is an ensemble learning technique that builds multiple decision trees and combines their predictions to improve overall accuracy. Each tree in the forest is trained on a random subset of the training data and features, which helps reduce overfitting and variance in the predictions. By aggregating the predictions of multiple trees, Random Forest can provide more robust and accurate crop recommendations compared to individual decision trees.

4.2 XgBoost:

XGBoost (Extreme Gradient Boosting) is an advanced machine learning algorithm based on decision trees designed for efficiency and scalability. It builds a strong predictive model by iteratively combining the outputs of weaker models (decision trees) in a gradient boosting framework.

4.3 LSTM:

Long Short-Term Memory (LSTM) is a type of recurrent neural network (RNN) architecture specifically designed to address the vanishing and exploding gradient problems in sequence modeling. Its ability to capture long-term dependencies in sequential data makes it highly effective for tasks like time-series forecasting, text generation, and speech recognition.

4.4 GNN:

Graph Neural Networks (GNNs) in this project analyze user relationships and interactions in social networks to detect fraudulent behavior. Instead of relying only on individual user attributes, GNNs construct a social graph where users are nodes and their interactions (likes, follows, messages) are edges. The model learns patterns in these connections to distinguish legitimate users from fake accounts, which often form clusters, show low engagement, or exhibit unusual connection patterns.

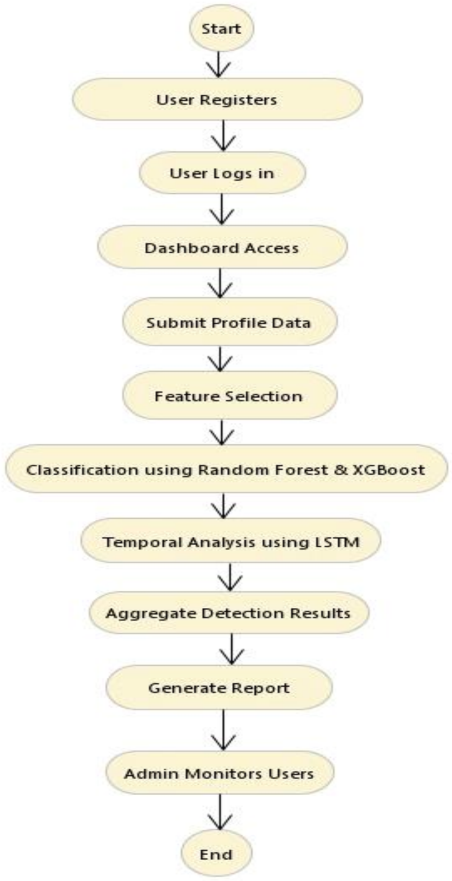


Fig: flow of the model

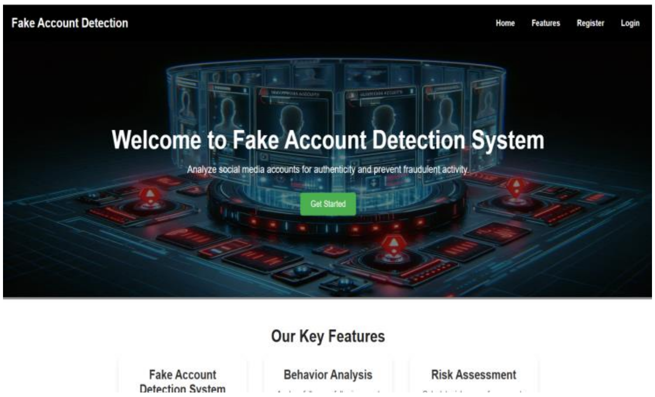
IV. MODEL DESCRIPTION

The machine learning model is interfacing both a supervised and a deep learning engine, i.e., a random forest and an XGBoost is used to detect the anomalous data in the social network. The structured data is well-processed by analyzer around previous suspicious engagement patterns, using the Random Forest and XGBoost algorithms. LSTM works through time to detect suspicious patterns or deviations. The complex reality is that sometimes the measurement of the real situation such a fraud is hard to be exactly predicted. However as it has been stated so far the procedures regarding machine remember, it may not provide the details of fraud attempt. But it can be an efficient measure that will trace criminals and thus will enable us to intercept them before a crime is committed. Nonetheless, the model opts to hypothesize over this. The data mining methods nowadays are built with the capability where the model can update itself according to the new acquired data. The fraud detection system which is self-adapting, it is not only efficient but also can be effective in detecting the fraud sooner.

V. IMPLEMENTATION

For a web-based anomaly detection system, the implementation uses a structured format that combines LSTM, Flask, and machine learning (Random Forest, XGBoost).The very first step is to cover data collection, cleaning, feature engineering (numerical, temporal, graph, text) and normalization for model fit. Tabular data would be Random Forest and XGBoost; temporal sequences is LSTM. So, ensemble techniques are used to combine the model outputs. Developed a Flask app to render a user dashboard to submit user profile information as well as an admin dashboard to monitor the information for anomalies by utilizing API endpoints registering user (/register), user login (/login), submit data (/submit data), and admin dashboard (/admin_dashboard) and storing it in a MySQL database.

VI. RESULTS



Fake Account Detection

Home Features Register Login

Welcome to Fake Account Detection System

Analyze social media accounts for authenticity and prevent fraudulent activity

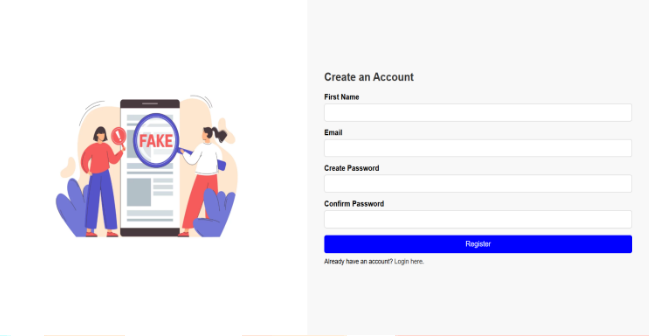
Get Started

Our Key Features

Fake Account Detection System | Behavior Analysis | Risk Assessment

Fig-1: landing screen for anomaly detection

The landing page for the Fake Account Detection System effectively introduces the platform's purpose of analyzing social media accounts to detect fraudulent activity.



Create an Account

First Name

Email

Create Password

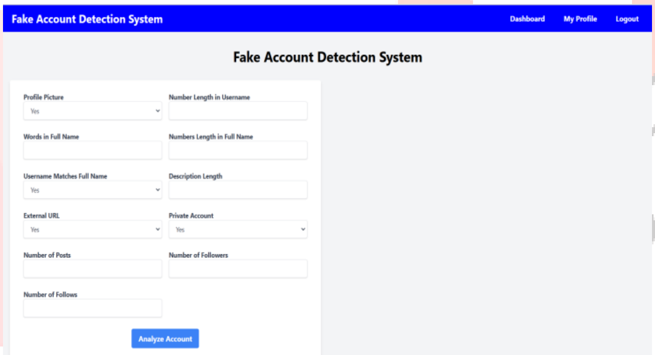
Confirm Password

Register

Already have an account? Login here.

Fig-2: registration screen for anomaly detection

The registration page for the Fake Account Detection System provides a simple and user-friendly interface for new users to create an account.



Fake Account Detection System   Dashboard My Profile Logout

Fake Account Detection System

Profile Picture: Yes

Number Length in Username:

Words in Full Name:

Numbers Length in Full Name:

Username Matches Full Name: Yes

Description Length:

External URL: Yes

Private Account: Yes

Number of Posts:

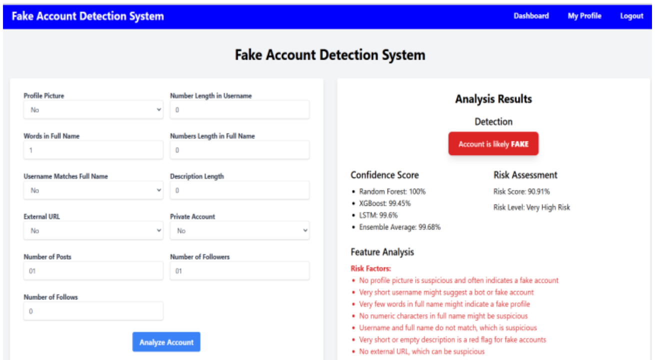
Number of Followers:

Number of Follows:

Analyze Account

Fig-3: screen for anomaly detection input

This input screen is part of a Fake Account Detection System designed to analyze social profiles and determine their authenticity.



Fake Account Detection System   Dashboard My Profile Logout

Fake Account Detection System

Profile Picture: No

Number Length in Username: 0

Words in Full Name: 1

Numbers Length in Full Name: 0

Username Matches Full Name: No

Description Length: 0

External URL: No

Private Account: No

Number of Posts: 01

Number of Followers: 01

Number of Follows: 0

Analyze Account

Analysis Results

Detection

Account is likely **FAKE**

Confidence Score

- Random Forest: 100%
- XGBoost: 99.45%
- LSTM: 99.6%
- Ensemble Average: 99.68%

Risk Assessment

Risk Score: 90.91%

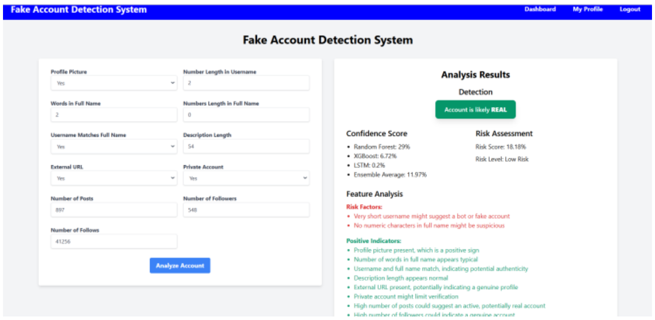
Risk Level: Very High Risk

Feature Analysis

Risk Factors:

- No profile picture is suspicious and often indicates a fake account
- Very short username might suggest a bot or fake account
- Very few words in full name might indicate a fake profile
- No numeric characters in full name might be suspicious
- Username and full name do not match, which is suspicious
- Very short or empty description is a red flag for fake accounts
- No external URL, which can be suspicious

Fig-4.1 fake account detection screen for anomaly detection



Fake Account Detection System

Profile Picture: Yes
Number Length in Username: 2
Words in Full Name: 2
Numbers Length in Full Name: 0
Username Matches Full Name: Yes
Description Length: 54
External URL: Yes
Private Account: Yes
Number of Posts: 897
Number of Followers: 548
Number of Follows: 41256

Analysis Results

Detection

Account is likely **REAL**

Confidence Score

- Random Forest: 29%
- XGBoost: 6.72%
- LSTM: 0.2%
- Ensemble Average: 11.97%

Risk Assessment

Risk Score: 18.18%

Risk Level: Low Risk

Feature Analysis

Risk Factors:

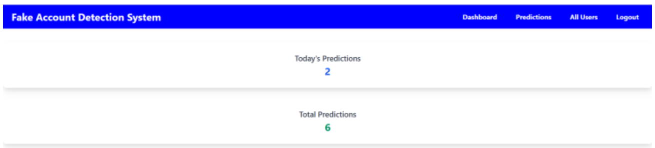
- Very short username might suggest a bot or fake account
- No numeric characters in full name might be suspicious

Positive Indicators:

- Profile picture present, which is a positive sign
- Number of words in full name appears typical
- Username and full name match, indicating potential authenticity
- Description length appears normal
- External URL present, potentially indicating a genuine profile
- Private account might limit verification
- High number of posts could suggest an active, potentially real account
- High number of followers could indicate a genuine account

Fig-4.2 real account detection screen for anomaly detection

Fig(s)-4: These pages are the result screen of a Fake Account Detection System, where the system analyzes the input data and provides an assessment of whether an account is real or fake.

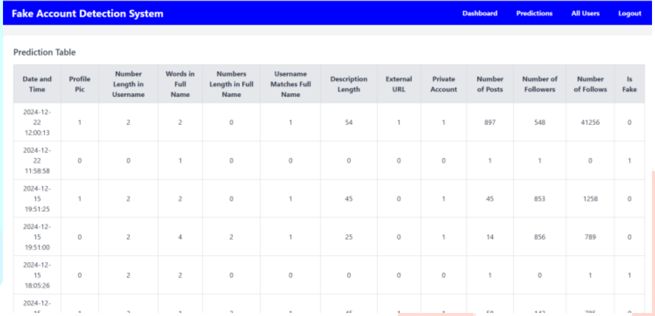


Today's Predictions
2

Total Predictions
6

Fig-5: admin screen for anomaly detection

The Admin Screen for Anomaly detection shows an admin dashboard for a Fake Account Detection System. The dashboard displays key metrics related to the system's performance.



Prediction Table

Date and Time	Profile Pic	Number Length in Username	Words in Full Name	Numbers Length in Full Name	Username Matches Full Name	Description Length	External URL	Private Account	Number of Posts	Number of Followers	Number of Follows	Is Fake
2024-12-22 12:00:13	1	2	2	0	1	54	1	1	897	548	41256	0
2024-12-22 11:58:58	0	0	1	0	0	0	0	0	1	1	0	1
2024-12-15 19:51:25	1	2	2	0	1	45	0	1	45	853	1258	0
2024-12-15 19:51:00	0	2	4	2	1	25	0	1	14	856	789	0
2024-12-15 18:05:26	0	2	2	0	0	0	0	0	1	0	1	1
2024-12-												

Fig-6: prediction screen for anomaly detection

The Screen shows a Prediction Table within the Fake Account Detection System. The table displays details about recent predictions made by the system.

VII. CONCLUSION

The Fake Account Detection System is an address that is comprehensive and robust solution designed to the growing issue of fraudulent activities on social networks. The system uses advanced machine learning algorithms, as well as an intuitive user interface, to allow people to detect fake accounts using the analysis of social media data for profile anomalies. However, this project has given both individual users and social media platforms with the tools to mitigate the risks that fake profiles represent and the potential of artificial intelligence in enhancing digital security, provided both.

VIII. FUTURE SCOPE

Integration with Multiple Social Media Platforms: The system can be extended to work with APIs from various social media platforms, enabling real-time detection of fake accounts across multiple networks.

Integration of Biometric Verification: The system could be integrated with biometric authentication methods, such as face or voice recognition, to identify and validate genuine account holders.

Real-Time Monitoring and Alerts: Introducing real-time monitoring features with instant alerts for suspicious activities can provide proactive security for users and businesses.

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