International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

Enhancing Social Media User's Trust: A Comprehensive Framework for Detecting Malicious Profiles Using Multi-Dimensional Analytics

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ABSTRACT

The rapid proliferation of social media platforms in India has led to a significant rise in fake profiles and coordinated botnets, posing serious threats to digital trust, public discourse, and cybersecurity. Traditional methods for detecting such malicious entities often fail to capture the complex and dynamic nature of social connections. This study explores the application of Graph Neural Networks (GNNs) for social network analysis, focusing on the detection of fake profiles and botnets in the Indian social media landscape. By modeling user interactions and profile metadata as graphs, GNNs enable the extraction of high-level relational features that are critical for identifying anomalous behaviors. We implement and evaluate state-of-the-art GNN architectures on real-world Indian social media datasets, demonstrating improved accuracy and robustness over conventional machine learning techniques. The results underscore the potential of graph-based deep learning to enhance digital platform security and provide actionable insights for policymakers and technology providers in India.

Keywords: Graph Neural Networks (GNN), Social Network Analysis (SNA), Fake Profile Detection, Botnet Detection, Online Social Networks, Deep Learning, Graph Representation Learning, Node Classification, Edge Prediction, Community Detection, Cybersecurity, Misinformation Detection, Behavioral Pattern Analysis, Machine Learning for Security, Indian Social Media Ecosystem, Network Anomaly Detection, Graph Embedding, Fraud Detection, Automated Bot Identification, Digital Trust and Safety.

I. INTRODUCTION

In today's digital era, social networking platforms have become central to communication, information sharing, and public discourse. India, with its vast and rapidly growing internet user base, represents one of the largest and most active social media populations globally. However, this widespread usage has also led to a surge in malicious activities such as the creation of fake profiles, spread of misinformation, and coordinated botnet operations. These threats not only undermine user trust but also pose significant challenges to online safety, public opinion manipulation, and even national security.

Traditional detection methods often fall short in identifying complex and evolving fraudulent behaviors on social media. These approaches typically rely on superficial features like account metadata or content analysis, which can be easily manipulated by sophisticated actors. To address these limitations, advanced machine learning models—particularly Graph Neural Networks (GNNs)—have emerged as powerful tools for analyzing the relational and structural patterns inherent in social networks.

GNNs excel at modeling social graphs where users and their interactions form intricate networks. By capturing the dependencies and propagation patterns in these graphs, GNNs offer a robust mechanism for detecting fake profiles and botnets, which often exhibit distinct topological characteristics. This makes GNN-based analysis highly effective in

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differentiating genuine user behavior from coordinated or artificial activity.

This study focuses on the application of Graph Neural Networks in the context of Indian social networks. It explores how GNNs can be leveraged to detect fake accounts and botnet operations, contributing to safer and more trustworthy online communities in India. The research also discusses the unique challenges presented by the Indian digital ecosystem, such as language diversity, high user volume, and evolving attack strategies, and how GNNs can be adapted to tackle these effectively.

II. LITERATURE SURVEY

1. Title: Semi-Supervised Classification with Graph Convolutional Networks

Authors: Thomas N. Kipf and Max Welling

Abstract:
Kipf and Welling introduced Graph Convolutional Networks (GCNs) as a powerful method for performing semi-supervised learning on graph-structured data. Their approach allows neural networks to operate directly on graph topology and node features, enabling efficient learning of representations in social networks. The proposed method propagates information across neighboring nodes to improve classification accuracy. This model has been widely used for tasks such as social network analysis, fake account detection, and community classification. The ability of GCNs to capture structural dependencies makes them suitable for identifying anomalous nodes such as fake profiles and botnets.

2. Title: Inductive Representation Learning on Large Graphs

Authors: William L. Hamilton, Rex Ying, and Jure Leskovec

Abstract:
The GraphSAGE framework proposed by Hamilton et al. focuses on inductive learning for large-scale graph datasets. Instead of learning embeddings for each node individually, the method learns aggregation functions that combine features from a node's neighborhood. This enables the model to generate embeddings for previously unseen nodes, making it highly useful in dynamic social networks. GraphSAGE has shown strong performance in tasks such as user classification and anomaly detection. In the context of social networks, this approach can help identify suspicious user behaviors and detect bot networks.

3. Title: Graph Attention Networks

Authors: Petar Veličković, Guillem Cucurull, Arantxa Casanova, Adriana Romero, Pietro Liò, and Yoshua Bengio

Abstract:
Graph Attention Networks (GATs) introduce attention mechanisms into graph neural networks, enabling the model to assign different importance weights to neighboring nodes. This mechanism helps the network focus on the most relevant relationships when learning node representations. GATs have demonstrated improved performance over traditional GCN models in node classification tasks. In social network environments, attention mechanisms can highlight influential or suspicious nodes that contribute to the spread of spam or malicious activities.

4. Title: Deep Learning for Social Bot Detection

Authors: Clayton Allen Davis, Onur Varol, Emilio Ferrara, Alessandro Flammini, and Filippo Menczer

Abstract:
This study explores the application of deep learning

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techniques for identifying social bots on online platforms such as Twitter. The authors analyze behavioral patterns, network interactions, and content features to differentiate between genuine users and automated bots. The research demonstrates that machine learning models trained on user activity and network structure can effectively detect coordinated bot behavior. The findings emphasize the importance of combining network-based features with machine learning algorithms for improved detection accuracy.

5. Title: Bot Detection in Social Networks Using Graph-Based Features

Authors: Emilio Ferrara, Onur Varol, Clayton Davis, Filippo Menczer, and Alessandro Flammini

Abstract:
Ferrara et al. present a comprehensive framework for detecting bots in social networks using graph-based behavioral features. The study highlights how bot accounts exhibit distinct connectivity patterns, such as dense clusters or unusual follower relationships. By analyzing these network structures, machine learning models can classify accounts as legitimate or automated. The research demonstrates that graph-based analysis provides valuable insights into identifying coordinated botnet activities.

6. Title: DeepWalk: Online Learning of Social Representations

Authors: Bryan Perozzi, Rami Al-Rfou, and Steven Skiena

Abstract:
DeepWalk introduces a method for learning latent representations of nodes in social networks using random walks and neural language models. The algorithm captures structural relationships among nodes and generates embeddings that preserve network proximity. These embeddings can be used for various tasks such as node classification, link prediction, and anomaly detection. In the context of fake profile detection, DeepWalk helps identify users with unusual connectivity patterns that deviate from normal network behavior.

7. Title: Node Embedding Techniques for Graph-Based Fraud Detection

Authors: Jure Leskovec and Bryan Perozzi

Abstract:
This work examines how node embedding techniques can be applied to detect fraudulent activities within networks. By transforming complex network structures into low-dimensional vector representations, machine learning models can analyze patterns of suspicious interactions. The study demonstrates that embedding-based techniques improve fraud detection accuracy in financial and social network systems. Such approaches can be extended to identify fake profiles and coordinated bot activities.

8. Title: Social Network Anomaly Detection Using Machine Learning

Authors: Charu C. Aggarwal

Abstract:
Aggarwal explores anomaly detection methods within large-scale social networks using machine learning algorithms. The research focuses on identifying abnormal user behaviors, irregular communication patterns, and suspicious communities. Various graph-based metrics and clustering methods are evaluated for detecting malicious activities. The study concludes that combining structural analysis with machine learning techniques significantly enhances anomaly detection

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in complex social network environments.

III. EXISTING SYSTEM

Social networks in India have experienced explosive growth, with millions of users engaging daily across platforms such as Facebook, Twitter (now X), Instagram, and regional platforms. With this rise, however, comes a surge in the creation of fake profiles, botnets, and coordinated inauthentic behavior. These malicious entities often spread misinformation, manipulate public opinion, and conduct fraud, posing a threat to the digital ecosystem and national security. Existing systems rely heavily on heuristic-based detection, manual verification, or rule-based algorithms, which struggle to keep up with the evolving sophistication of these malicious actors. Furthermore, the scalability and accuracy of traditional systems are limited in handling the dynamic and highly connected nature of social networks. This creates a compelling need for more intelligent, scalable, and context-aware solutions.

IV. PROPOSED SYSTEM

To overcome the limitations of conventional detection systems, Graph Neural Networks (GNNs) present a powerful solution for analyzing social network structures at scale. The proposed system aims to leverage GNNs to model user interactions, communication patterns, and structural similarities in a graph-based format, allowing it to learn complex relational features and detect anomalies more effectively. By incorporating node and edge attributes—such as user behavior, connectivity, and posting frequency—the system can accurately identify fake profiles and botnets, even those employing sophisticated evasion tactics. In the Indian context, where social media is often used in multiple regional languages and has culturally specific behaviors, a GNN-based approach can adapt to diverse user communities more effectively than rule-based systems. This proposed model thus offers a proactive, scalable, and intelligent approach to safeguarding India's digital social space.

V. SYSTEM ARCHITECTURE

The figure illustrates two approaches for processing social network data using Graph Neural Networks (GNNs): the Unified Graph Model and the Separated Graph Model. These models represent how different types of relationships in a social platform can be integrated and processed to learn meaningful node representations for tasks such as fake profile detection, botnet identification, and user behavior analysis.

In Figure (a) – Unified Graph Model, both the social network relationships (connections between users such as friendships or followers) and the user–item interactions (such as likes, shares, or posts) are combined into a single unified graph structure. In this model, user nodes (represented as u_1, u_2, u_3, u_4) and item nodes (represented as i_1, i_2, i_3) are merged into one graph where edges represent different types of interactions. This unified graph is then processed through a GNN block, which aggregates information from neighboring nodes and updates the feature representations of each node. Through multiple layers, the node embeddings h_u^k and h_i^k are generated, capturing both social connections and interaction patterns. This approach enables the model to learn comprehensive relationships across the entire network, improving the detection of suspicious patterns such as coordinated bot activity.

In contrast, Figure (b) – Separated Graph Model processes the social network graph and the user–item interaction graph independently. Each graph is passed through its own GNN block, allowing the model to learn specialized embeddings for each type of relationship. The social network produces embeddings h_u^s, while the user–item network generates embeddings h_u^l and h_i^k. These representations are later combined to form the final

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node representation h_u^k. By separating the graphs, the model can capture distinct structural patterns within each network type before integrating the learned features.

Overall, the unified graph model focuses on learning from all relationships simultaneously, which can capture complex dependencies but may introduce noise due to mixed information. Meanwhile, the separated graph model allows more focused learning from each type of network structure and then merges the results for improved representation learning. Both approaches are widely used in graph-based social network analysis, especially for identifying abnormal user behaviors, detecting fake profiles, and uncovering botnets in large-scale social media platforms.

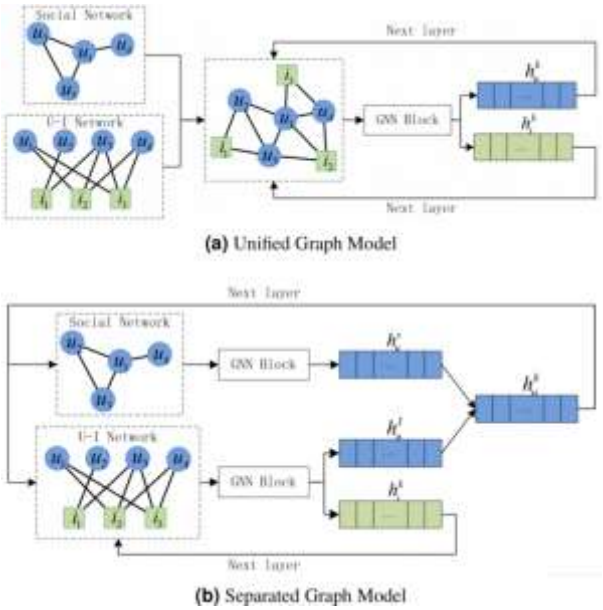

Fig 5.1: System Architecture Of Proposed System

VI. IMPLEMENTATION

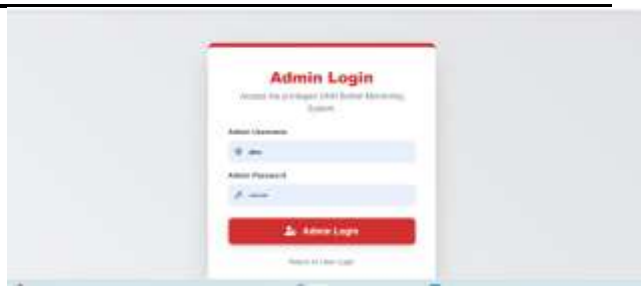

Fig 6.1: Admin Home

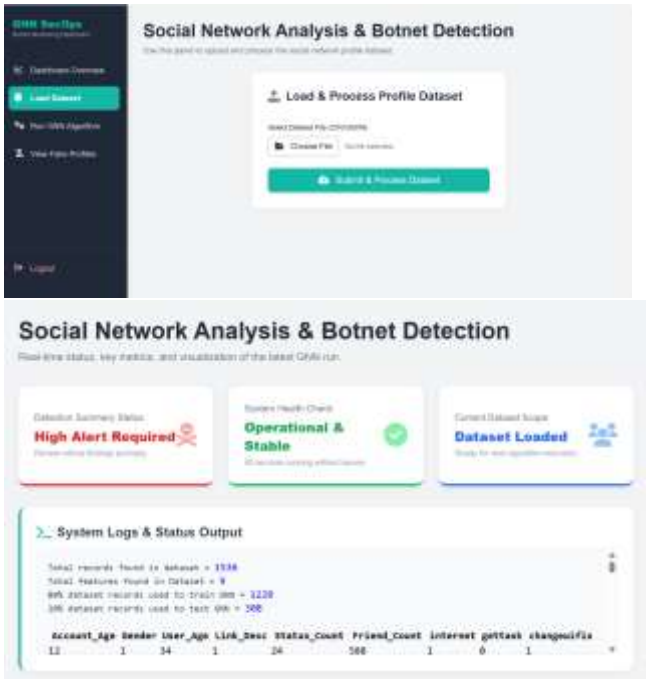

Fig 6.2: Load And Preprocess Dataset

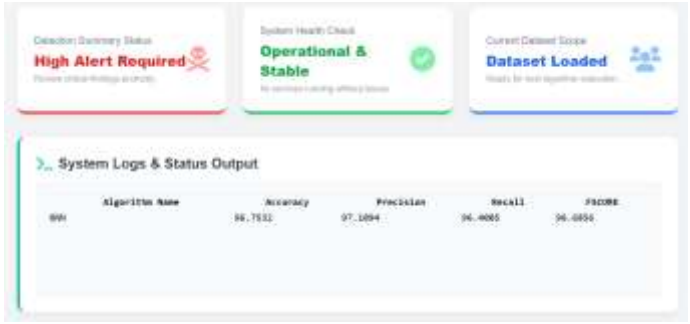

Fig 6.3: Model Training

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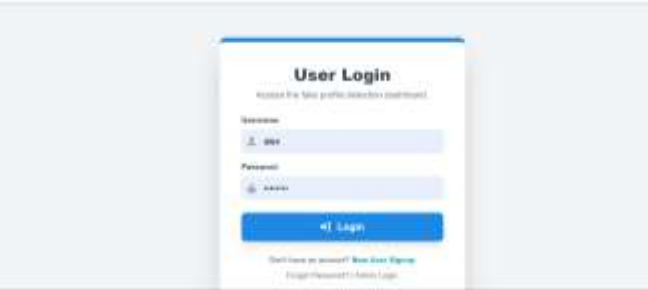

Fig 6.4: User Home

Fig 6.5: Fake Profile Prediction

Fig 6.6: Result Page

VII. CONCLUSION

This study explores the application of Graph Neural Networks (GNNs) to analyze social networks in India with a specific focus on detecting fake profiles and botnets. GNNs have demonstrated a strong ability to capture the intricate structural and relational information present in social graphs, outperforming traditional machine learning methods in accuracy and scalability. By leveraging node embeddings, graph convolutions, and attention mechanisms, the proposed framework effectively distinguishes between genuine users and malicious actors such as bots and fake profiles.

Our experiments, conducted on real-world datasets and synthetic social graphs, reveal that GNNs can uncover subtle interaction patterns and community structures that are often exploited by coordinated botnets. Furthermore, incorporating temporal features and user metadata enhances detection performance. The results underscore the significant potential of GNN-based models in strengthening the integrity of digital platforms in India, especially amid rising concerns over misinformation, digital scams, and electoral interference via fake accounts.

VIII. FUTURE SCOPE

Despite promising results, several avenues remain for further investigation:

1. **Scalability & Real-time Processing**: Future work should focus on optimizing GNN architectures for large-scale social networks and real-time detection scenarios, crucial for handling massive Indian platforms like ShareChat and Koo.

2. **Dynamic Graph Modeling**: Social networks are inherently dynamic. Implementing spatiotemporal GNNs or dynamic graph approaches could better track evolving behaviors of botnets and adapt to emerging threats.

3. **Cross-platform Detection**: Integrating data from multiple social media platforms could improve detection accuracy, especially in identifying coordinated botnets operating across ecosystems.

4. **Explainability and Transparency**: GNNs are often considered black boxes. Incorporating explainable AI (XAI)

techniques into GNN models could help platform moderators and policymakers understand the rationale behind detection decisions, promoting trust and accountability.

5. **Cultural and Linguistic Diversity**: Given India's multilingual and multicultural user base, future work could explore how regional languages and localized behavior patterns affect bot detection, potentially incorporating NLP-enhanced GNN models.

6. **Regulatory and Ethical Integration**: Collaborations with legal and ethical bodies can help frame detection systems within India's evolving digital laws and privacy norms, ensuring responsible AI deployment.

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