Social Network Analysis of Twitter Bots

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1 Introduction

In the current historical moment, the widespread diffusion of AI systems designed to simulate human behaviour is increasingly evident. Our project aims to evaluate the effectiveness of these systems in the context of bot detection on Twitter, seeking to identify behavioural patterns that differentiate automated users (aka *bots*) from human ones. To this end, we make use of Social Network Analysis techniques.

2 Problem and Motivation

What are the problems you want to address? Why are those problems important (impact, theoretical and/or practical needs, etc.)? What are the main contributions of the project?

3 Datasets

What tools did you use 1) to handle (store, manipulate) the data and 2) to compute measures on the data?

We conducted our analysis using the TwiBot-22 dataset [2], which is publicly available on GitHub[1]. Since the dataset is already digitized, there was no need for any manual data collection or processing.

TwiBot-22 is a comprehensive, graph-based benchmark for Twitter bot detection, featuring the largest dataset available up to date. It offers a diverse range of entities and relationships within the Twitter network, and boasts significantly improved annotation quality compared to previous datasets.

Given the large size of the dataset, significant preprocessing was necessary. This involved splitting the .json files containing the tweets and the .csv file with the edges into smaller chunks, allowing for faster and more efficient manipulation of the data.

3.1 Adopted tools

networkx networkit

[1] https://github.com/LuoUndergradXJTU/TwiBot-22

3.2 Analyzed networks

- Large → Ukraine, Ai, Covid
- Medium → Nato, Deeplearning, Nftcommunity
- Small → Ruleoflaw, Feminist, Agenda2030

4 Validity and Reliability

As discussed in the dataset official paper [2], the TwiBot-22 dataset was created trying to address and mitigate known problems of previous datasets, such as poor annotation quality and low dataset scale. This led to the construction of a large social graph with real word tweets, relationships between entities and metadata. This design allows the results to be statistically relevant and it accurately reflects Twitter's social dynamics. Moreover, the dataset benefits from a strong annotation pipeline, which guarantees reliability and consistency, and reproducibility for a wide range of bot detection and behaviour analysis studies. It is also easily accessible and freely available.

In our work, we exploited the dataset focusing only on *follower-following* relationships between users. Additionally, we experimented with applying the same analytical measures to the full graph and to subgraphs based on shared hashtags, in order to introduce a topical dimension to our analysis. This approach maintains the dataset's validity, as both follower links and shared hashtag activity represent authentic user behaviours and capture meaningful patterns within Twitter's social structure. Our results are also fully reproducible and reliable, as we provide a detailed description of the preprocessing pipeline used to tailor the dataset to our specific research goals.

5 Measures and Results

What measures did you apply (brief explanation of how they work)? How do they relate to the intent of the study? Why are they relevant? What is the connection among the gathered data, the applied measures, and the properties found?

- **Centrality**:
  1. Degree centrality
  2. Betweenness centrality
  3. Eigenvector centrality
  4. PageRank
  5. Reputation [1].
- **Groups**:
  1.
- **Clustering**:

1.

- **Redundancy**:
  1.
- **Equivalences**:
  1. Structural equivalence
  2. Regular equivalence
- **Homophily**:
  1.
- **Small-worldness**:
  1.
- **Scale freedom**:
  1.
- **Cohesion**:
  1.
- **Connectedness**:
  1.
- **Compactness**:
  1.
- **Triad census**:
- **Core-periphery**:
  1.

The experiments were conducted on an NVIDIA GeForce RTX 3090 GPU (24GB VRAM).

6 Conclusion

Qualitative analysis of the quantitative findings of the study.

7 Critique

Do you think your work solves the problem presented above? To which extent (completely, what parts)? Why? What could you have done differently to answer your research problems (e.g., gather data with additional information, build your model differently, apply alternative measures)?

The *follower* and *following* connections may not represent meaningful relations for bot detection, as the TwiBot-22 dataset lacks a clear separation between human and bot accounts in this aspect.

References

[1] David M. Beskow and Kathleen M. Carley. You are known by your friends: Leveraging network metrics for bot detection in twitter. In Babak Akhgar, Hamid R. Arabnia, and Petra Saskia Bayerl, editors, *Open Source Intelligence and Cyber Crime*, pages 53–88. Springer, 2020.

[2] Shangbin Feng, Zhaoxuan Tan, Herun Wan, Ningnan Wang, Zilong Chen, Binchi Zhang, Qinghua Zheng, Wenqian Zhang, Zhenyu Lei, Shujie Yang, Xinshun Feng, Qingyue Zhang, Hongrui Wang, Yuhan Liu, Yuyang Bai, Heng Wang, Zijian Cai, Yanbo Wang, Lijing Zheng, Zihan Ma, Jundong Li, and Minnan Luo. Twibot-22: Towards graph-based twitter bot detection, 2022.