The **twitter explorer**

A framework for observing Twitter through interactive networks

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We present an open-source interface for scientists to explore Twitter data through interactive network visualizations. Combining data collection, transformation and visualization in one easily accessible framework, the **twitter explorer** connects distant and close reading of Twitter data through the interactive exploration of interaction networks and semantic networks. By lowering the technological barriers of data-driven research it aims to attract researchers from various disciplinary backgrounds and facilitates new perspectives in the thriving field of computational social science.

INTRODUCTION

Due to its public-by-default nature and the possibility of calling data sets conveniently via an API, Twitter has become a widely used source for the observation and analysis of political debates [1, 2], sentiments [3], brand communication [4], or natural disasters [5], to name a few. Different kinds of interactions on Twitter [6] are often represented in the form of networks, such as retweet networks [1, 7], mention networks [7], follower networks [8] or co-hashtag networks [9]. Twitter data is therefore being used extensively to address a whole variety of research questions. However, analysis is usually being carried out by a tech-savvy community oriented towards quantitative analysis. This is also due to the fact that the processes of data collection and transformation can be an obstacle for scientists with other disciplinary backgrounds. We introduce an easily accessible integrated framework that combines data acquisition, transformation and visualization, aiming to open the field of data-driven research to a broader spectrum of researchers.

PREVIOUS WORK

There exists a wide range of tools for collecting Twitter data. DMI-TCAT [10] provides an extensive suite for streaming real-time tweets, but there is no function to search tweets from the past. twarc [11] is a command-line-interface for streaming and searching tweets. Neither of the two tools include the generation of interactive networks. Gephi [12] is a powerful software suite for network analysis. There exists a plug-in for the collection of Twitter data [13] where users can filter real-time tweets and visualize them in the Gephi interface. In contrast to these solutions the **twitter explorer** provides an open framework that combines data collection, transformation and visualization and allows users to explore the collected Twitter corpus interactively.

ARCHITECTURE

The **twitter explorer** consists of three components:

- The **collector**, a Streamlit-powered [14] application provides a graphical user interface for the Twitter Search API and saves the collected data for further processing.
- The **visualizer**, a Streamlit-powered application provides a graphical user interface for the generation of interaction networks and semantic networks based on the collected data and saves the interactive networks.
- The **explorer** interface allows users to interact with the networks and explore the underlying metadata of nodes and links.

Each of these components is conceived in a modular way which facilitates adding new features to the **twitter explorer** (see Fig. 1).

DATA ACQUISITION: THE COLLECTOR

In the collector, the user interacts with the Twitter Search API [15], giving access to a limited set of tweets from the last 7 days.

Authentication

Since 2018, users need to apply for a Twitter Developer Account in order to access the API [16]. Since the **collector** makes direct API calls, this step is necessary for its usage. There are developer accounts specific to academic research [17]. The user can then create app tokens which will allow the **twitter explorer** to connect to the API via Application-only authentication (OAuth 2.0) [18].

Collection

The collection of tweets is initiated by a keyword string, following the rules of a Twitter Advanced Search. The free API comes with limitations: users can only make a limited amount of requests per 15 mins [19]. The tweets are continuously stored until all possible tweets that the Search API provides are collected. The corpus is then ready to be passed on to the next interface.

DATA TRANSFORMATION: THE VISUALIZER

The visualizer creates interactive network visualizations from the collected corpus. There one can distinguish between interaction networks (with users as nodes) and semantic networks (with words or concepts as nodes). The **twitter explorer** currently supports the creation of retweet networks as interaction networks and hashtag co-occurrence networks as semantic networks. Several data aggregation methods allow for exploration of the network at different scales of complexity.

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Twitter timeline

The data is presented as a timeline, where tweet counts are plotted over time. The user can get a feeling of the overall salience of the chosen keyword and possible peaks can hint towards special events. The timeline is generated as an interactive plot.

Interaction networks

There are several ways of interaction on Twitter: retweets, mentions, replies, following, likes, quotes and direct messages. Not all of them are accessible through the API. We focus on retweet interaction which can be represented as a directed network in which nodes are users and a link is drawn from node $i$ to $j$ if $i$ retweets $j$. The twitter explorer’s visualizer provides an interface for creating retweet networks which includes the following features:

Community detection. In order to find strongly connected clusters of a network, it has become common practice to employ community detection algorithms. The twitter explorer currently supports Louvain [20] and InfoMap [21] algorithms.

Force-directed layout. The underlying visualization library [22] employs a force-directed layout in which nodes that retweet each other more often are placed closer to each other [23].

Aggregation methods. One challenge for understanding and visualizing complex interaction networks is to find useful aggregation methods necessary to observe the underlying discursive mechanisms at different levels of granularity. We therefore propose several methods of node aggregation: (1) removing nodes that only retweet one source and don’t generate any content, (2) removing nodes that were retweeted less than $x$ times and (3) reducing the network to an interaction network of communities (cluster graph).

Privacy. Remove all accessible metadata of users that have less than 5000 followers (no public figures) from the interactive visualization in order to comply with current privacy standards. The nodes are visible and their links are taken into account, but they cannot be personally identified in the interface.

Export options. Export the networks to common formats like edgelist, GML or GraphViz. The framework is therefore compatible with a wide range of existing tools for network analysis [12, 24, 25].

Semantic networks

While retweet networks allow to identify the main proponents of a debate and their interaction patterns, looking at the most retweeted tweets might not be sufficient to get an impression of the content structure of the debate. In order to explore the textual content of the data, we propose hashtag co-occurrence networks. Here, every node is a hashtag, and links are drawn between nodes if they appear in the same tweet. By again laying out the network with a force-directed algorithm, the hashtag network gives an overview of the debate’s vocabulary and can reveal the different subtopics within a debate.

NETWORK EXPLORATION INTERFACE

The twitter explorer offers an intuitive exploration interface (see Fig. 2). A modular command palette allows for user interaction and provides insight into the underlying metadata of the network:
The **twitter explorer**

**RETWEET NETWORK**
- Keyword: brexit
- Collected on: 2010-12-03
- First tweet: Mon Dec 02 21:35
- Last tweet: Tue Dec 03 15:21

**VISUALIZATION OPTIONS**
- Auto-color nodes by:
  - Louvain community
- Node size (variable scale)
  - In-Degree (number of times the user's)
  - Size scale

**NETWORK MEASURES**

**USER INFORMATION**
- Search user
  - name
- Zoom on node
- Flash color
- Show tweets
- Show timeline
- Followers: 69767
- Followed accounts: 366
- Times the user retweeted: 0
- Times the user got retweeted: 3

**TWEETS IN DATASET**
- Twitter timeline

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**Fig. 2. The network exploration interface.** The modular command palette (left) can (1) show information about the underlying data, (2) modify the visualization, (3) display network measures and (4) search for and show information about specific users and the content they generated in the dataset. Nodes are colored according to their community. They can be interacted with by clicking or hovering to display the username and relevant metadata in the palette.

**Network information.** Accesses generic information about the network (keywords used to collect the data, date of collection, first/last tweet of the dataset).

**Visualization options.** Supports different node colorings according to their community assignment. The node size can be dynamically changed according to their respective metadata values (in/out-degree, number of followers, number of followed accounts). This facilitates for instance the detection of news outlets.

**Network measures.** Shows the number of nodes and links in the network. This set will be extended to include a wider range of network indicators in future releases.

**User information.** Search users in the given network and find them by zooming or flashing their color. Display the user’s relevant metadata (number of followers, number of followed accounts, number of retweets, number of times retweeted), their tweets in the dataset as well as their current timeline. Note that the interface will only display tweets that are still online at the time of exploration. By doing so, it complies with the Twitter display requirements [26].

**INTEGRATION WITH OTHER METHODS**
The **twitter explorer** can be regarded an all-in-one-solution for the exploration of Twitter networks, for which it is easy to develop new modules within the existing components (see Fig. 1). An example would be to include additional community detection algorithms or new node aggregation methods. At the same time, its modular structure (division into collector / visualizer / explorer) and the ability to export the generated data makes the tool compatible with a variety of other data analysis tools (see Fig. 3). Therefore, scientists can use the **twitter explorer** in combination with existing tools from data and network science.

**FUTURE DEVELOPMENT**
The **twitter explorer** is currently in an open beta stage on GitHub. Future work will include the dynamical nature of retweet interaction in the visualization paradigms. In order to disseminate the framework and attract new audiences to the field of data-driven research, vignettes (use-cases) will be designed to showcase the **twitter explorer**’s use in social science research. Furthermore, it is
planned to add the possibility of exploring recently developed measures such as graph curvatures which can provide new insights to the analysis of social networks [27].

**AVAILABILITY**

The twitter explorer can be tested at https://twitterexplorer.org. The source code is available on GitHub, where the current release can be downloaded [28]. The tool is is licensed under the GNU GPLv3 license [29].

**TECHNICAL DETAILS**

The twitter explorer is written partly in Python (data collection and transformation) and JavaScript (interactive network visualization). The frontend for the data collector and the visualizer is made with Streamlit [14], a Python library for the creation and deployment of data-analytic tools. The Twitter objects are stored in the json lines format [30]. The network operations and community detection relies on the Python implementation of igraph [25]. The interactive networks are drawn using D3.js [31], more specifically the force-graph library [22] by Vasco Asturiano.

**AUTHOR CONTRIBUTIONS**

The idea for the twitter explorer originated from fruitful discussions in the context of the Odycceus project between Armin Pournaki, Felix Gaisbauer, Sven Banisch and Eckehard Olbrich. The tool is designed and developed by Armin Pournaki. All authors wrote the manuscript.

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