The Polarization of Information on the Web, September 3, 2018

Project Type: Multi-institution/Multi-disciplinary Teams:
Total Funds Requested: $6000

Student Co-PI's:

Pamela Bilo Thomas, (Advisor: Dr. Tim Weninger, Notre Dame)
pthomas4@nd.edu,
Department of Computer Science and Engineering,
Notre Dame

Ram Hari Dahal, (Advisor: Dr. Legand Burge, Howard University)
ramhari.dahal1@gmail.com,
Department of Computer Science,
Howard University

Prajjwal Dangal, (Advisor: Dr. Gedare Bloom, Howard University)
prajjwal.dangal@bison.howard.edu,
Department of Electrical Engineering and Computer Science,
Howard University

Charles Dickens, (Advisor: Dr. Narayana Prasad Santhanam, University of Hawaii Manoa)
dickcnsc@hawaii.edu,
Department of Electrical Engineering,
University of Hawaii Manoa

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dickensc@hawaii.edu,
Department of Electrical Engineering,
University of Hawaii Manoa

Problem Statement:

Popular microblogs such as Twitter have become sources of information as well as an incubator for emerging schools of thought. Twitter encourages users to share their opinions and information about current issues and events no matter how contrarian, and access to such a variety of viewpoints has the potential to foster awareness. However, it seems groups of society are forming increasingly polarized opinions on topics, leading to disagreements over even factual details. This concerning observation has been a common topic of conversation as of late, but an accepted method for quantifying the polarization between camps on a topic to topic basis has yet to be developed, leaving the dialogue and, as a result, the proposed solutions subjective and difficult to act upon.

The research team's initial focus will be on analyzing the network of information and opinions on Twitter, with the intention of creating a model that is scalable and extensible for the inclusion of a variety of types of data, such as news articles and other popular social networks like Facebook. This decision was primarily made to expedite the development of the methodology. Twitter maintains a fantastic API for developers and researchers which provides an easy to use access point for data and useful functionality.

Retrieving Relevant Information and Opinions: The first task is to collect a sample of sources which are disseminating information about a specific topic within a specified time frame. The Twitter API allows us to search for, or follow in realtime, a provided set of phrases. A first order approach would be to query the search data endpoint using a single phrase which is intuitively related to the topic. However, downstream analysis relies on the sample being a good representative of the population as a whole, and some camps may use different phrases to refer to the same topic. This problem is inherently subjective and will be a topic of discussion and refinement for the team of researchers.

One solution would be to begin with an intuitive set of phrases to query the data endpoints that is felt to capture most of the existing ideologies, then, using the results of the search, dynamically create a new set of phrases by analyzing the *hashtags* of the retrieved tweets for another query.

"A hashtag—written with a # symbol—is used to index keywords or topics on Twitter. This function was created on Twitter, and allows people to easily follow topics they are interested in." [1]

Hashtags are essentially metadata allowing users to easily find tweets related to a certain topic. It may be argued though that some hashtags are intentionally vague and simply used to boost a user's presence and may result in collecting tweets that seem unrelated, but these tweets may actually be seen as a bridge between communities.

This methodology could be scaled to identify relevant news articles by using state of the art auto tagging algorithms to extract keywords and phrases in the same way hashtags can be used to collect relevant tweets.

Modeling the Network: Once the relevant sources are sampled, the next task is to build a weighted network summarizing the relations between the tweets. This network will be used as input to a state of the art community detection algorithm [2]. Tweets will be modeled as nodes in the network and an edge between 2 nodes, call them A and B, are weighted to reflect how many of the same users are exposed to both tweets. There are many features to consider to capture this idea, for example whether the user who tweeted A follows the user

who tweeted B and vice versa, the number of shared hashtags, the number of similar likes between tweeters, etc. State of the art methods used by recommender systems (methods which contribute to the polarization which is being studied) can be adapted to aggregate these features into a single weight [3].

Community Detection: The weighted network model of the collected tweets will be input to a community detection algorithm developed in previous work from the University of Hawai'i Big Data Lab (Paravi and Santhanam, 2015)[2]. This particular algorithm captures an intuitive understanding of modern day information collection by modeling the idea that a user will follow information with a probability reflecting their predispositions. Also, this algorithm makes no assumptions on the number of communities present in a network and in fact provides potential clusterings at different granularities.

Polarity Calculations: Lastly, once the network clusters are identified, the final task is to quantify the polarity between the individual communities and among the graph as a whole. The team will be working with the definition of *polarity*, in the context of social networks, as the state of two communities having contradictory tendencies and little interaction.

Common metrics for calculating the polarity between network communities such as cluster conductance and modularity can be used but only consider the structural properties of the graph. Other interesting factors to consider is the sentiment of the tweets, if there are tweets with contrasting sentiment in the same cluster then that is an implication that contrasting ideologies are being exposed to similar content and interacting, therefore low polarity. The convergence rate of the community detection algorithm itself can be used to measure the polarity: from the way the algorithm works it can be inferred that slower convergence indicates higher polarity and faster convergence indicates lower polarity.

Similar work has been done on this topic, most closely is the work by Conover et al. (2011) [4]. This project differs primarily since they only considered Left and Right wings parties and examined tweets during a specific timeline, regardless of the topic. Other work related to the Polarization of Information on the web includes that of Lai et al. (2015) [5], which analyzed the discourse of a single topic but was a soley Hashtag driven approach, ignoring other features which may be relevant.

Intellectual Merit & Broader Impacts:

While many American citizens would probably successfully point to media polarization as a problem currently facing the country, few could quantify their experience. A goal of the project is to develop a way to measure this polarization, which will be useful as researchers and consumers of media to find ways to appropriately describe the current state of discourse on the Internet.

It is expected that over the course of the research, communities commonly isolated and polarizing will be identified. The causes of polarization can then be narrowed and those involved may be found responsible for pushing polarizing narratives. Today, many online social media companies rely on algorithms to give users information that they will be more likely to interact with. While there are algorithms designed to increase user engagement with social media sites, an unintended consequence is that people are exposed dominantly to information that is in line with their predispositions. As a result, social media users may be more susceptible to propaganda from malicious users. Any work that can be done to help

understand this is interesting from a research perspective as people try to understand how polarization spreads.

The research will lead to a new way of finding common ideas that exist between the polarized groups. In identifying these common ideas, a bridge of communication between the groups can be promoted using these "middle ground" ideas. By speaking to the ideas that are shared by both groups, users can be broken out of the confined regions of the internet they have found themselves in. Furthermore, politicians may use these commonalities to properly represent their constituents and make bipartisan progress. It is important for democracy to ensure that the electorate is informed and can work together to solve problems.

Proposed activity:

The team of researchers will meet once per week to discuss progress using the telecommunication application Skype. Additionally, the team will meet once in person at the Center's NSF site visit to present a poster about the project in December 2018 at Purdue University. It is the teams goal to have the collaborative efforts result in the team co-presenting at a leading conference, and to develop a user friendly containerized application to determine the polarity of a provided topic.

The team will use Python 3.x as to automate the analysis and interaction with the Twitter API. The study will incorporate data analysis techniques from recommender systems, statistics, community detection, natural language processing, and graph theory to develop network models and extract information. These activities directly align the project with the Knowledge Extraction thrust from CSol, and more specifically Learning and Inference in Networks.

Goals and Outcomes:

The goals for the project include

Short Term

- Develop a well-defined method for comparing the polarization of existing communities of thought regarding specific topics and time frames
- Improved methods for recommender systems to suggest information sources outside of the user's typical community
- Improved methods for identifying good representatives of the social network communities that can be used to classify the schools of thought

Long Term

- Collaborations result in team co-presenting results at an influential conference
- Develop a user friendly containerized application to provide a polarity score for a provided topic

Proposed work statement:

The team will organize work and create a clear timeline to complete goals by maintaining the already existing *Polarization of Information* repository on the team's *GitHub* organization page. *GitHub* supports an effective workflow of creating projects with a collection of

issues to complete which may be assigned to collaborators. The team will meet weekly over texitSkype to keep everyone updated on the current state of the project as well as plan the next week of work by creating and assigning *GitHub* issues. This workflow will keep everything the team has accomplished and discovered well documented while also keeping the entire team up to date on the latest progress and challenges.

The team of researchers consists of the following individuals who will contribute to and benefit from the project as listed below.

- Charles Dickens Undergraduate Degree in Electrical Engineering UH Manoa
  - Contribute as team leader, organizing meetings, workflow, and team's direction
  - Contribute knowledge of software development and data science
  - This project provides valuable research and collaboration experience, a great benefit to prepare for future PhD work
- Pamela Bilo Thomas, PhD in Computer Science and Engineering, Notre Dame
  - Knowledge of graph theory and networks
  - Contribute knowledge of software development and data science
  - Experience in the research process
- Prajjwal Dangal, PhD in Electrical Engineering and Computer Science, Howard University
  - Knowledge of pattern recognition techniques and programming
  - Contribute knowledge of software development and data science
  - Research experience
- Ram Hari Dahal, Master's in Computer Science, Howard University
  - Knowledge of software development, algorithms, and graph visualizations
  - Research experience in NLP and graph theory

Diversity Statement:

A mission of this project is to foster awareness of the existing communities of thought and encourage discourse between those communities. The team is fully committed to celebrating diversity and valuing opinions.

Furthermore, the team realizes that many groups are underrepresented in the field of information science. For example, out of the 64,405 postsecondary degrees awarded in the field of computer and information sciences in year 2015-16, only 12,072 were awarded to female students. (NCES, 2017) This makes for 18.74% of the total population of the field. The research team for this project however comprises of students of different backgrounds to form a diverse group of individuals, it consists of 25% women, 50% US citizens, 50% Asians.

Budget and Justification:

The team plans to meet at least once in person and present at a prominent machine learning or data science conference. A rough estimate of the expenses associated with the proposed activities is summarized as follows:

- Four team members attend and co-present project: $4,500
  - Registration fee for conference (will vary depending on conference): $\$400 \times 4 = \$1,600$
  - Flight: $\$1,700$
    - Charles: $500
    - Pamela, Prajjwal, Ram: $\$400 \times 3 = \$1200$
  - Lodging: $300 * 4 =$1,200
- In person meeting in Washington, DC: $1,500
  - Flight $800
    - Prajjwal, Ram: $0
    - Charles: $500
    - Pamela: $300
  - Lodging $700
    - Prajjwal, Ram: $0
    - Charles, Pamela: $\$350 \times 2 = \$700$

References

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[2] Torghabeh, Ramezan Paravi, and Narayana Prasad Santhanam. "Community Detection Using Slow Mixing Markov Models." 2015, pp. 1-11.

[3] L. A. Hassanieh, C. A. Jaoudeh, J. B. Abdo and J. Demerjian, "Similarity measures for collaborative filtering recommender systems." 2018 IEEE Middle East and North Africa Communications Conference (MENACOMM), Jounieh, 2018, pp. 1-5.

[4] M. Conover, J. Ratkiewicz, M. Francisco, B. Goncalves, A. Flammini, and F. Menczer, "Political Polarization on Twitter." 2011 Fifth International AAAI Conference on Weblogs and Social Media, Barcelona, 2011, pp. 1-8.

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