

Study of various forms of polarization on the Reddit network

**Aristeidis Vrazitoulis**

**Diploma Thesis**

Supervisor: Evangelia Pitoura

Ioannina, February 2023

**Τμήμα Μηχ. Η/Υ & Πληροφορικής**

**Πανεπιστήμιο Ιωαννίνων**

**Department of Computer Science & Engineering**

**University of Ioannina**

Thanks to

I would really like to thank my family for supporting me to achieve my dreams and goals, as they always stand by me.

15 Feb 2023

Aristeidis Vrazitoulis

Abstract

In this thesis, we will investigate by how much, an online community of users that interact with each other, tend to form two polarized groups. For the sake of our study, we chose controversial topics of discussion that will likely increase polarity. We consider the formation of two types of polarized groups, namely, groups that barely communicate with each other, and groups that communicate to express disagreement. We call the former *unsigned polarization* and the latter *signed polarization.* We will examine the structure of the graphs of user interaction, for the polarity measurement, both within a community(*intra-polarization)* and across communities(*inter-polarization)*. Also, we will study whether controversial posts are more prone to polarization than non-controversial ones. We exploit the *Random Walk* algorithm to measure unsigned polarity on each graph three variations, as well as the *Random-Eigensign* algorithm to measure signed polarity on each graph with two variations. Our results show evidence of unsigned inter-polarization and that the controversial posts tend to be more polarized than the non-controversial ones.

**Keywords:** Signed Polarization, Unsigned Polarization, Inter-Polarization, Intra-Polarization

Contents

[Chapter 1. Introduction 1](#_Toc124872600)

[Chapter 2. Problem Definition 3](#_Toc124872601)

[Chapter 3. Methodology 4](#_Toc124872602)

[3.1 Choice of the topics 4](#_Toc124872603)

[3.2 Data Collection 4](#_Toc124872604)

[3.3 Comment Tree Creation 5](#_Toc124872605)

[3.4 User Conversation Graph Creation 6](#_Toc124872606)

[3.4.1 Multigraphs 6](#_Toc124872607)

[3.4.2 Unsigned Graphs 7](#_Toc124872608)

# Chapter 1. Introduction

These days, millions of people, all around the world use social media more and more often. They use it for various reasons, one of which is to express their opinion on a topic. It is very likely that some people will express their disagreement to others online, or sometimes even express their hate towards others.

In our study, we focus on *polarization*, where people tend to divide into two opposing groups. More specifically, we will examine the formation of two polarized groups in *Reddit.* Reddit is a famous anonymous social media platform, that people discuss on a large forum. Reddit is subdivided in smaller subcommunities also known as “subreddits” where people make questions or “posts”, or equivalently “submissions” to the subreddit, and some others respond.

In our study, we will consider two types of polarization. Groups that barely communicate with each other, which is the *unsigned polarization* and groups that communicate to express their disagreement, namely, *signed polarization*. For each type of polarization, we will divide them into two cases. *Intra-polarization* and *inter-polarization*. The former, implies the communication within the same subreddit and the latter across different subreddits.

We will measure polarity around specific topics of discussion, which are regarded as controversial topics, so people tend to have different opinions on these topics. We collect all the related submissions and their comments using specific keywords in our search. We build a user conversation graph to perform our experiments based on the interactions among the users. For unsigned polarization, we use the *Random Walk* algorithm, which is already built and further explained on [GMGM18]. We the algorithm for three different variations of each graph. For signed polarization, we use the *Random-Eigensign* algorithm, which is also presented on [BGGO19], to measure signed polarity. We use two variations to determine the sign of the graphs. On the first variation, we exploit the reddit’s score of comments, which is the difference of upvotes and downvotes received from the users, and on the second we do sentiment analysis on a comment to determine its sign.

It is expected that the controversy of a topic would increase the polarity scores. In our experiments, we demonstrate that the set of posts characterized as “controversial” by reddit tend to increase the scores of polarity in unsigned intra-polarization, as they do not have any effect on either intra- or inter- signed polarization. This implies that controversy makes the users to passively disagree with others, namely, encourage them to converse mostly with people of similar opinions and avoid the interaction with others of opposing opinions.

# Chapter 2. Problem Definition

The objective of this thesis is to measure the levels of polarity, in Reddit discussions using various approaches. First, we examine whether polarized groups of users are formed for a specific discussion topic. We have two types of polarity:

* *Unsigned Polarity*: There is unsigned polarity if and only if the users discussing a topic are divided into two disjoint groups that have very low interaction between them.
* *Signed Polarity:* The signed polarity exists if and only if users discussing a topic are divided into two disjoint subgroups, where the users agree mostly with the users of the same group and disagree with the users belonging to the other group.

Also, we investigate two different types of polarization, intra- and inter-polarization.

* *Intra-polarization*: examines the formation of polarized groups discussing a specific topic within a single community(subreddit).
* *Inter*-*polarization:* examines the formation of polarized groups discussing a specific topic across two communities(subreddits).

**QUESTIONS:**

* Is there any evidence of signed or unsigned or intra- or inter- polarization?
* Do controversial posts increase the scores of polarity?

# Chapter 3. Methodology

In this chapter we explain the whole methodology and preprocessing of transforming the data in the needed form, to perform our experiments. Firstly, we explain the way and the tools we use to collect the data. Secondly, we demonstrate, how we build the comment trees, based on the collected posts. And, thirdly, how we create each variation for each type of polarity that we want to examine.

## Choice of the topics

It is more likely to find higher scores of polarity in communities that discuss controversial and contradictory topics. We navigated through reddit and ended up in four topics of discussion. We examined the topics of Covid-19 Vaccines, the patriarchy, gay rights, and the moon landing. For each topic we chose at least two subreddits that were likely opposing to each other, using specific keywords. We can visualize it with the following table:

|  |  |  |
| --- | --- | --- |
| **Topic** | **Keywords** | **Subreddits** |
| Covid-19 Vaccines | covid, coronavirus, vaccin | Coronavirus, conspiracy, science |
| Patriarchy | patriarchy | WitchesVsPatriarchy, MensRights |
| Gay Rights | gay, rights, homo | lgbt, Conservative |
| Moon landing | moon landing | conspiracy, space |

Table 1: Data Collection, Topics of discussions, with the corresponding keywords and subreddits

We took care of choosing famous subreddits with plenty of posts and data. After the above choice of topics and subreddits, we can start collecting the data from Reddit.

## Data Collection

Now we can start crawling in Reddit and start collecting the data. We use Python(3.6) language to achieve both the preprocessing phase and the algorithms for our study. With the help of Reddit’s API we can bring our data in our programming language. To make our lives easier, we use a python module named *PRAW,* which is a wrapper of the Reddit’s API. Our goal is to collect as many related post ids as possible. The more data we collect, the more sense our experiments will make. For each topic, we chose a couple of subreddits and from each subreddit we collect and divide our data in three *categories*. *Non-Controversial, Controversial, Both.* With the PRAW module, we collect the non-controversial post ids with the filter ‘Top’ provided by the API. Top posts are considered the posts with the highest upvote rate. More specifically, we use the Reddit’s method *search,* where we pass the desired keywords and we sort the posts by ‘top’ and the time filter ‘all-time’ which means it searches chronologically from the subreddit’s birth. For the controversial posts, we use the method *controversial* again provided by reddit, but it does not provide a parameter for keywords, so we must search for these keywords manually. And the ‘both’ category is the controversial and non-controversial posts combined. We can summarize the collection in the following table:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Subreddits | NC | | C | | B | |
| *#Comments* | *#Posts* | *#Comments* | *#Posts* | *#Comments* | *#Posts* |
| Coronavirus | 143116 | 222 | 3395 | 117 | 146511 | 339 |
| conspiracy | 118139 | 216 | 14939 | 58 | 132278 | 273 |
| science | 68068 | 139 | 1897 | 15 | 69965 | 154 |
| MensRights | 25051 | 222 | 2024 | 23 | 27075 | 245 |
| WitchesVsPatriarchy | 31543 | 241 | 1841 | 49 | 32613 | 285 |
| lgbt | 15731 | 246 | 5164 | 137 | 20895 | 383 |
| Conservative | 19795 | 237 | 1202 | 4 | 20180 | 238 |
| conspiracy | 13526 | 215 | 1269 | 4 | 14795 | 219 |
| space | 13042 | 236 | 2171 | 58 | 15205 | 293 |

Table 2: The amount of data we collected. The number of posts and comments for each category of the subreddits. NC: Non Controversial, C: Controversial, B: Both

In that point we would like to note that the reddit API has a limit of the amount of posts that it can return. The limit is 250 posts for each request and unfortunately, we cannot make another request to get the next 250 posts.

## Comment Tree Creation

We collected all the necessary data, so we can start building our Comment Trees(*CT*). A Comment Tree is a tree that represents the structure of all the comment replies to a Reddit’s post. A node represents a comment and an edge that connects two nodes creates a hierarchy where the parent is a comment, and the child is the reply to that comment. The root of the tree is the title and the text of a post. For each node we save the text and the score of the comment, as well as the user id that posted it. We create a Comment Tree for each post. We use a python module for the tree creation, named *treelib.* For each subreddit and category we save a set of trees in a json file. So, for each subreddit we have three json files. The json file has for example the following structure:

{

“post\_id1”:{

“user1” : {“children” : [“user2”:{..} , “user3”:{..},…],

“data”: {“body”: “comment\_text”, “score”: 2}

},

“post\_id2”:{..}

}

## User Conversation Graph Creation

We have transformed our data to our desired form and are saved on json files. We use the json files to start creating the graphs. For that purpose, we use the *NetworkX* python module, to create, process and save our graphs.

### Multigraphs

We start to build our graphs, by making multigraphs first. For each json file that we created, we make a multi directed-graph, where each node represents a user and each edge indicates the interaction between two users. The direction of the edge denotes that a user has responded to the user that the edge points. Therefore, between two users there may be many edges, meaning that they have responded to each other multiple times. The text of each comment does not need to be transferred on these graphs.

Similarly, we save each multi directed-graph in a text file, in the form of edge-list, where each line of the file has two user ids, symbolizing a directed edge, with source the first user id and destination the second user id.

For each subreddit we have three text files with the corresponding (multi directed) graphs. A graph made by non-controversial posts, a graph made by controversial posts and a graph made by the combination of these two. We have the following graph statistics:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Subreddits | NC | | C | | B | |
| #V | #E | #V | #E | #V | #E |
| Coronavirus | 81267 | 149557 | 2031 | 3256 | 82586 | 152803 |
| conspiracy | 48592 | 121050 | 8029 | 21938 | 53675 | 211338 |
| science | 77872 | 108919 | 1034 | 884 | 78757 | 110604 |
| MensRights | 10359 | 24709 | 827 | 1999 | 10974 | 26707 |
| WitchesVsPatriarchy | 15628 | 31275 | 1186 | 1800 | 15957 | 32307 |
| lgbt | 8913 | 15476 | 2659 | 5017 | 11431 | 20493 |
| Conservative | 10201 | 19350 | 697 | 1198 | 10337 | 19734 |
| conspiracy | 5676 | 13246 | 864 | 1265 | 6423 | 14510 |
| space | 9371 | 12839 | 1342 | 2119 | 10557 | 14949 |

Table 3: Amount of nodes and edges for each category, #V: Number of users, #E: Number of edges

There is a slight problem with that, there is a chance that some of these graphs are not connected. We need to get the largest connected component. It does not have to be strongly connected component, so we get the largest weakly connected component of each graph, always with the help of NetworkX. We, finally save the following graphs:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Subreddits | NC | | C | | B | |
| #V | #E | #V | #E | #V | #E |
| Coronavirus | 81267 | 149557 | 1923 | 3127 | 82554 | 152780 |
| conspiracy | 48592 | 121050 | 8029 | 21938 | 53675 | 211338 |
| science | 77872 | 108919 | 604 | 1341 | 78757 | 110604 |
| MensRights | 10359 | 24709 | 827 | 1999 | 10974 | 26707 |
| WitchesVsPatriarchy | 15621 | 31267 | 1048 | 1605 | 15957 | 32273 |
| lgbt | 8882 | 15445 | 2034 | 3996 | 11265 | 20277 |
| Conservative | 10201 | 19350 | 697 | 1198 | 10337 | 19734 |
| conspiracy | 5665 | 13235 | 443 | 664 | 6416 | 14502 |
| space | 9182 | 12655 | 1118 | 1847 | 10304 | 14683 |

Table 4: Largest weakly connected components of each multigraph the updated version.

In Table 4, we report the graphs that were not fully connected and we show off the new values in the blue color of the largest connected component. Now, the graphs are connected and saved on the disk.

### Unsigned Graphs

The unsigned graphs are the graphs that we do not care about the sign of the edges. On these graphs we will perform the *Random-Walk* algorithm. All the experiments will be conducted on undirected graphs. We mentioned that, in unsigned polarization we will be using three variations. We will explain these in more depth.

#### Variation 1 – Simple Graphs

In this variation we simply convert the multi directed graphs in undirected graphs. For intra-polarization we have the Table 5:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Subreddits* | NC | | C | | B | |
| #V | #E | #V | #E | #V | #E |
| Coronavirus | 81267 | 132066 | 1923 | 2488 | 82554 | 134614 |
| conspiracy | 48592 | 95555 | 8029 | 10987 | 53675 | 105820 |
| science | 77872 | 96411 | 604 | 672 | 78757 | 97632 |
| MensRights | 10359 | 16727 | 827 | 1035 | 10974 | 17761 |
| WitchesVsPatriarchy | 15621 | 24848 | 1048 | 1186 | 15957 | 25497 |
| lgbt | 8882 | 12554 | 2034 | 2637 | 11265 | 15751 |
| Conservative | 10201 | 15999 | 697 | 850 | 10337 | 16225 |
| conspiracy | 5665 | 8322 | 443 | 563 | 6416 | 9359 |
| space | 9182 | 10905 | 1118 | 1342 | 10304 | 12394 |

Table 5: Undirected graphs for intra-polarization – Variation 1

In fact, only the number of edges reduced, as it is indicated at the Table 5 with the blue colors. As for the inter-polarization, we can simply merge two graphs with the NetworkX module:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 2-subreddits | NC | | C | | B | |
| #V | #E | #V | #E | #V | #E |
| Coron. & consp. | 128088 | 227621 | 9943 | 13475 | 134345 | 240434 |
| science & consp. | 124826 | 191965 | 8626 | 11659 | 130699 | 203451 |
| WvP & MR | 25957 | 41575 | 1874 | 2221 | 26907 | 43258 |
| lgbt & Cons. | 19077 | 28553 | - | - | 21592 | 31976 |
| consp. & space | 14807 | 19227 | - | - | 16677 | 21753 |

Table 6: Statistics of graphs of Inter-Polarization.

The ‘-‘ symbol indicates that there was no intersection at the process of merging the graphs.

#### Variation 2 – Modified Graphs

In the second variation we modify the Comment Tree structure. We load the trees that we saved and perform some changes. On every tree root we want to make all his offspring as his children. More specifically, for every root, we make all his grandchildren, grand grandchildren and so on, his children. This process can be better explained with the following picture:

A picture containing diagram

Description automatically generatedA picture containing chart

Description automatically generated

Figure 1: Second Variation, all the offspring of the root becomes his children.

This concept was presented at [GMGM18]. This structure denotes that all of the replies are addressing to the root, this may have an impact on our algorithm. The number of users stays the same, only the number of edges changes:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Subreddits* | NC | | C | | B | |
| #V | #E | #V | #E | #V | #E |
| Coronavirus | 81267 | 115981 | 1923 | 2212 | 82554 | 118235 |
| conspiracy | 48592 | 79555 | 8029 | 9177 | 53675 | 88119 |
| science | 77872 | 85985 | 604 | 609 | 78757 | 87030 |
| MensRights | 10359 | 14033 | 827 | 878 | 10974 | 14911 |
| WitchesVsPatriarchy | 15621 | 22156 | 1048 | 1089 | 15957 | 22775 |
| lgbt | 8882 | 11595 | 2034 | 2280 | 11265 | 14376 |
| Conservative | 10201 | 13769 | 697 | 702 | 10337 | 13967 |
| conspiracy | 5665 | 6890 | 443 | 443 | 6416 | 7757 |
| space | 9182 | 9822 | 1118 | 1157 | 10304 | 11122 |

Table 7: Modified Graphs – Variation 2 for intra-polarization

Similarly, we merge the above graphs, to make the graphs for inter-polarization:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 2-subreddits | NC | | C | | B | |
| #V | #E | #V | #E | #V | #E |
| Coron. & consp. | 128088 | 195536 | 9943 | 11389 | 134345 | 206354 |
| science & consp. | 124826 | 165540 | 8626 | 9786 | 130699 | 175149 |
| WvP & MR | 25957 | 36189 | 1874 | 1967 | 26907 | 37686 |
| lgbt & Cons. | 19077 | 25364 | - | - | 21592 | 28343 |
| consp. & space | 14807 | 16712 | - | - | 16677 | 18879 |

Table 8: Modified Inter Polarization – Variation 2

The number of edges has decreased. It is interesting to see how this variation would visually be.

A picture containing scatter chart

Description automatically generated

A picture containing mold

Description automatically generated

1. Space community (b) conspiracy community

A picture containing nature, sky, rain, outdoor

Description automatically generated

(c) space-conspiracy community

Figure 2 Variation 2 visualized, on the moon landing topic

It is obvious how the second variation is gathering multiple nodes around one, in multiple place in the graph. Also, in the Figure 2 (c) we notice how two groups have been formed and probably we are going to see high levels of polarization on that graph.

#### Variation 3 – Weighted Graphs

Appendix

|  |  |
| --- | --- |
| [GMGM18] | Garimella, K.; Morales, G. D. F.; Gionis, A.; and Mathioudakis, M. 2018. Quantifying controversy on social media. ACM Transactions on Social Computing 1(1): 1–27. |
| [BGGO19] | Bonchi, F.; Galimberti, E.; Gionis, A.; Ordozgoiti, B.; and Ruffo, G. 2019. Discovering polarized communities in signed networks. In Proceedings of the 28th ACM International Conference on Information and Knowledge Management, 961–970. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |