Lingnan University
Hong Kong

Detecting and Visualizing Echo Chambers in Reddit Vaccine Myths Discussions

CLE9035 Final Project Report

Course Name: Information, Misinformation, and the Media
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PART A - TARGET CONCEPTS

- Echo Chambers
- Misinformation
- Sentiment Analysis

PART B – OVERVIEW

The project was to create a program in Python which analyzes and outputs visualizations demonstrating echo chambers in real life social media communities. This project specifically used text data r/VaccineMyths, which was an available dataset from Kaggle, to search for misinformation and communities within. The project used sentiment analysis, modeling, and network-based community detection to look for existing patterns of homogeneity and thematic clustering that would indicate echo chambers.

For the project, 1602 existing Reddit posts and comments were cleaned and formatted for further processing using VADER and NLTK classifiers in Python to detect emotions/sentiments of users. Additionally, for topic modeling Gensim's LDA was utilized to demonstrate the themes within each community in the data. A similarity network was also built from posts and analyzed using the Louvain algorithm to identify some clusters which showed low variety in sentiment and/or mostly negative sentiment within the posts, which is a characteristic expected of echo chambers. All analysis outputted visualizations which supported interpretation of the analysis, and the work took around 2 weeks. The project only utilized Python as the programming language, focusing on the available libraries (NLTK, VADER, Gensim, NetworkX, scikit-learn)

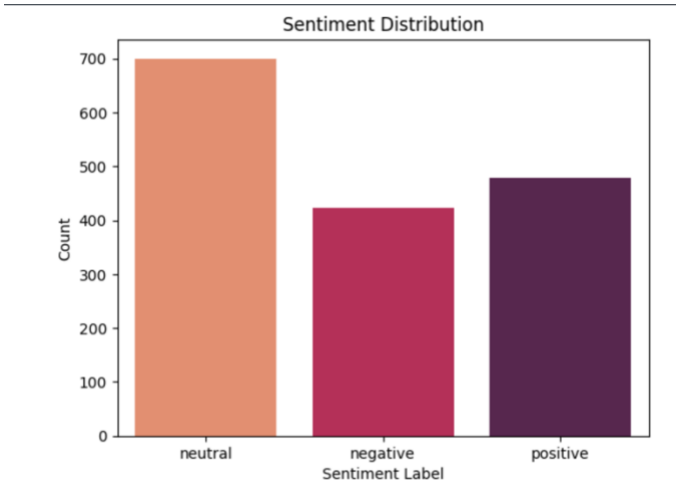
For the given project, the primary goals were to utilize technical data science methods for epistemic theories that are in real life, to see whether algorithms and computers can detect such nuanced human topics. As the technical world is more binary or black and white compared to human emotions, motives and epistemic behavior, the output of the project was very intriguing to explore to see whether it would confirm or deny suspected behavior.

PART C - EXPLANATION

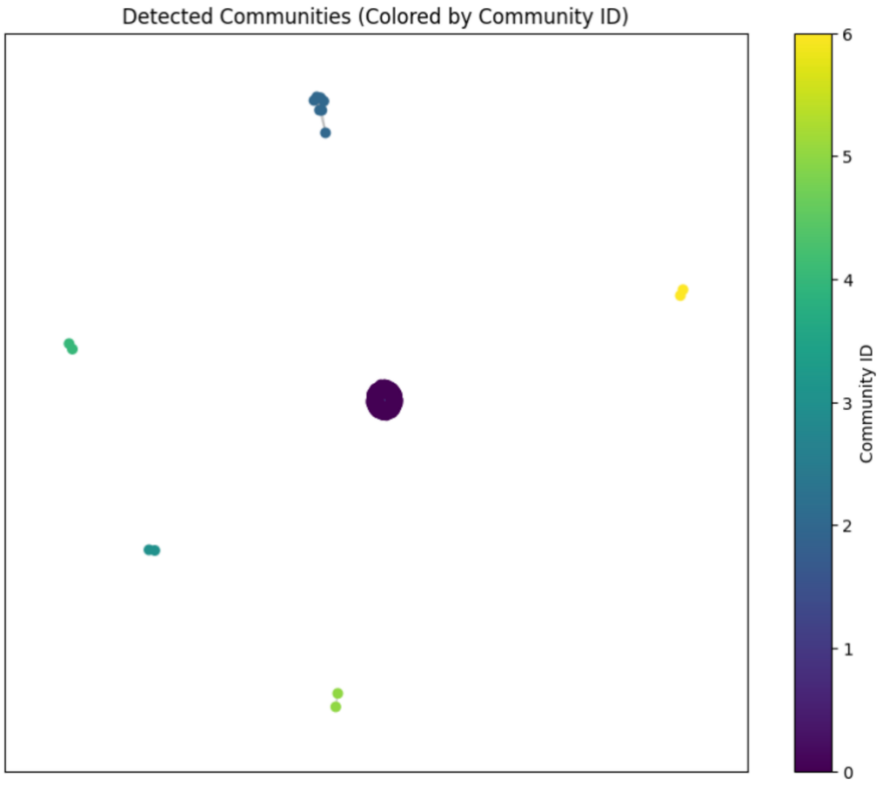
Echo chambers are social structures where outside information is omitted and sources are discredited. Understanding them is essential, especially now, as the internet has amplified their existence and misinformation is spreading faster. The detection of these structures is crucial to prove the commonness of their existence and demonstrate how online communities reinforce these groups. Using content similarity, the created network represented closely related posts. The Louvain algorithm demonstrated though the image below. Communities that exhibited low sentiment variance ($\sigma < 0.2$) and over 50% of post negativity were labeled as echo chambers, which reflected the emotionally uniform groups being resistant to change and opposed information.

Misinformation is information that is false or misleading information spread in communities unintentionally or intentionally. In this project's case, it affects public's attitude and decisions about public health. As vaccines are crucial to help individuals, vaccine related misinformation is incredibly dangerous. This project chose this topic to show how misinformation correlates with echo chambers and the topics within. Using LDA models to uncover topics within the posts, identifying myths, conspiracy theories, and vaccine safety concerns that were dominant in some communities. By correlating the topic with the community's overall sentiment, the project could associate misinformation themes to polarized echo chambers, illustrating how concentrated themes reinforce false beliefs in echo chambers.

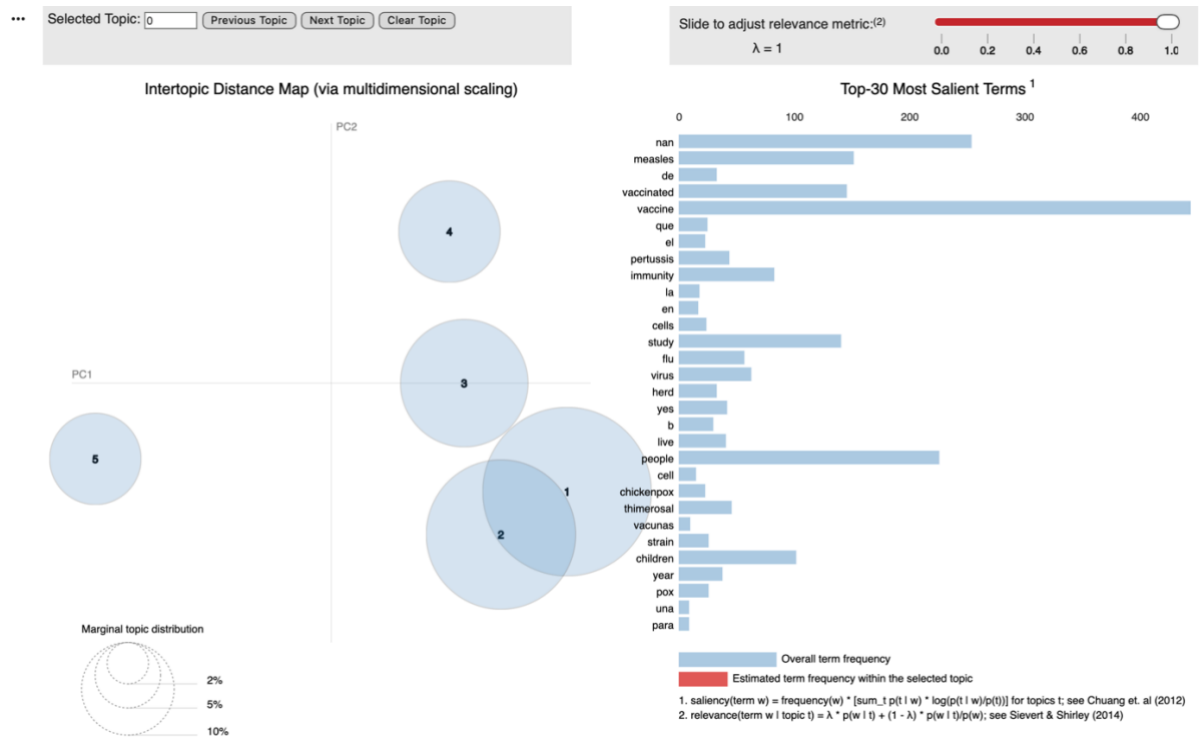
Sentiment analysis is a type of analysis where the emotional tone of a given text is assessed by a person/algorithm. In this particular project, the sentimental value of each post was already available in the free dataset from Kaggle. Emotional value is significant for the computer to have a way to categorize comments/texts, as misinformation, especially about vaccine myths, often carries a negative connotation, which is extremely dangerous. Additionally, if the sentiment of a user stays relatively constant, then it further supports the theory of their placement in an echo chamber, as echo chamber participants are unlikely to change their attitudes towards foreign/outside information. Therefore, assessing sentiment is one of the foundations of this project, which makes further analysis possible. Posts were further processed using VADER and NLTK libraries, to improve the sensitivity of the algorithms and the sentiments, to achieve more accurate results. Sentiment was categorized as positive, neutral, and negative, with distributions analyzed for each community. These metrics showed emotional uniformity in some communities which were suspected of being echo chambers that supported the emotional uniformity theory



The above bar charts demonstrated the sentiment distribution amongst the comments in the dataset, where the negative count is around 450, which is where we expect to find the echo chamber clusters.



The above visual demonstrates communities in the dataset. However, it is important to note that these communities are not necessarily echo chambers, the visual only illustrates size of the communities and identifies them.



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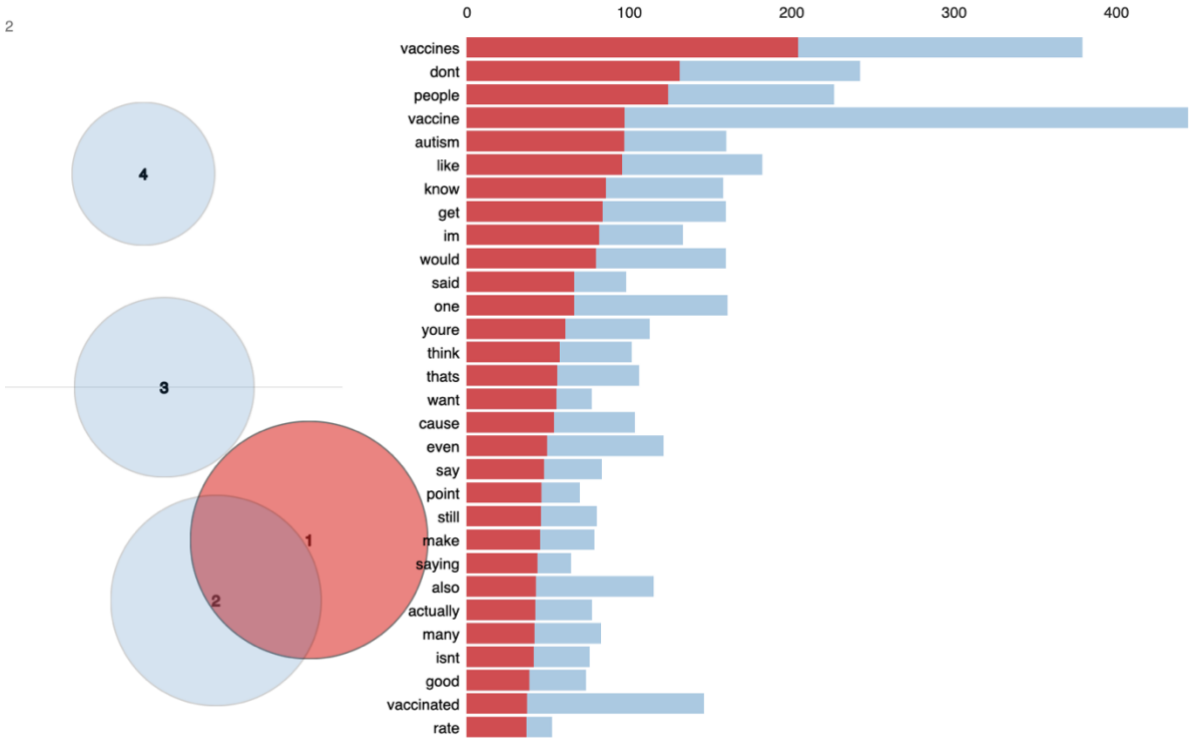
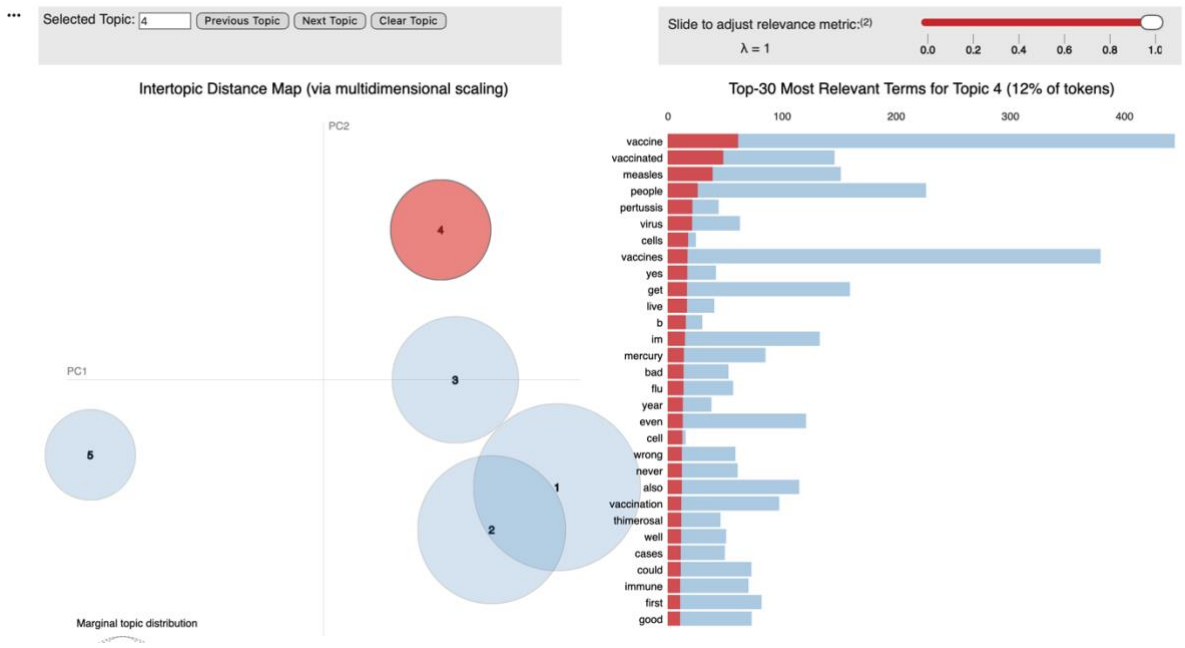
This last visual shows the communities and their word averages, since this visual is originally an interactive window, it is not fully possible to show everything. However, upon further analysis, we receive this:

```
Community sentiment averages:

community

 4   -0.077200

 0    0.000000

 6    0.000000

 1    0.000000

-1    0.006122

 5    0.264300

 3    0.391350

 2    0.421500
```

These values show us that community 1 and 4 is the most likely to be an echo chamber. The following visual demonstrates the word usage of said community.

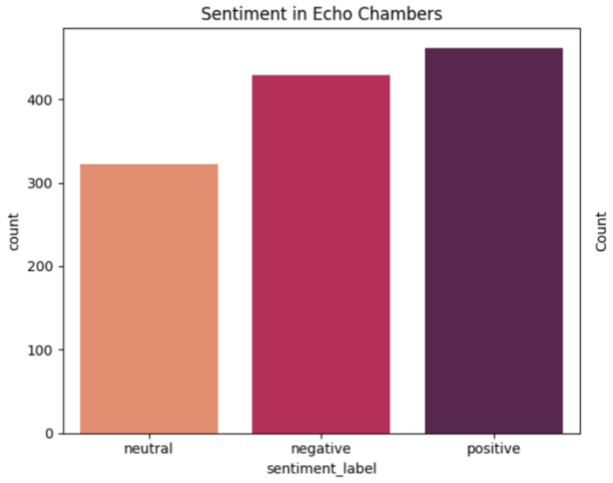




Subsequently, the 1st and 4th communities require more inspection and investigation, which is why community specific algorithm and methods were used to track users, their sentiment, and the communities themselves.

```
Original df shape: (1602, 12), Valid df shape after filtering NaN/empty 'body': (1226, 12)
All communities (before echo chamber filter): 6
   community  size  total_comms  sentiment_std  avg_comms
0         -1  1211         1105       0.492602   0.912469
1          2     7            0       0.000000   0.000000
2          3     2            0       0.042639   0.000000
3          4     2            0       0.000000   0.000000
4          5     2            0       0.373777   0.000000
Overall Modularity: 0.004 (Higher = more isolated communities)
Detected Echo Chamber Communities (2 out of 6):
   community  sentiment_mean  neg_ratio  avg_comms  total_comms  size
0         -1        0.006122   0.354253   0.912469         1105  1211
5          6        0.000000   0.000000   0.500000            1     2
/tmp/ipython-input-878875109.py:54: FutureWarning:
```

The output above, further shows that community 4 can be disregarded, as it only has 2 members, and with error correction, is not considered an echo chamber. However, community 1, has 1211 comments, with a high negative interaction ratio of 0.35.



This echo chamber sentiment bar chart allows us to see that in echo chambers the number of negative and positive interactions are higher than neutral, which tracks with the philosophical theory.

```
Post Proxy Sentiment Trends (Initial, Final, Change):
        initial_sentiment  final_sentiment  change
id
1vofc7           -0.53275        -0.53275       0
1y0s0k            0.19370         0.19370       0
22bkdv            0.74300         0.74300       0
238hku           -0.63525        -0.63525       0
26f34p           -0.29600        -0.29600       0
```

This output shows us some quantified sentiment vales of users, and whether they changed or not. Of course, as the data was limited, it is possible that the representation and the interpretation is lacking. However, according to this output all of these users, saw no change in sentiment, which supports the theory that the given community is an echo chamber.

```
Word: 'autism' (Freq: 182) | Avg Sentiment: -0.16 (Negative (anti-
vaccine))

    Example: 'See my comment above, this probably is a error on the
part of the cdc, but isn't a reason not to vac...' | Sentiment: -0.40

    Example: 'And you're still wrong--it's not an error. The estimate
is actually 1-2 per 1000 which derived from ...' | Sentiment: -0.72

  Word: 'know' (Freq: 181) | Avg Sentiment: -0.09 (Negative (anti-
vaccine))

    Example: 'What is thimerosal? I know it's a compound, but what's in
it? What's it made of?...' | Sentiment: 0.00

    Example: 'I sure am, which is how I know there is mercury in
vaccines when doctors have told me and millions o...' | Sentiment: -
0.01
```

Lastly, the output above are examples of negative interactions from community 1, our echo chamber.

PART D – REFLECTION

This project helped me understand echo chambers better by allowing me to observe them from real life examples from an online platform as Reddit. Additionally, it allowed me to use practical skills from my major and apply them onto the philosophical concepts from this course. Moreover, observing echo chambers' presence and the prevalence of misinformation in our society, especially in crucial topics like health, further convinced me to put more effort in becoming a better epistemological agent.

Majority of our population has grown skeptical of the world, especially in the age of deepfakes. Which is why I believe many either wouldn't believe in echo chambers or would only think that they are in cults and there is no possible way for them to be in an echo chamber themselves. Nevertheless, this project utilizes data from one of the most popular social media platforms and demonstrates how individuals like you and me can easily be members of an echo chamber or contribute to the spread of misinformation.

There was only one big challenge this project faced, which was to as accurately as possible to identify and represent real life complex social structures (echo chambers) from existent online material that is by itself nuanced with human emotions. There were issues of how to develop an algorithm as a data science student that can actually accurately categorize users, where words and sentiment cannot be used to determine alone, as human interaction is complex and layered, its chaos, especially online. Which is why, the program is not perfect, there is an error rate, but it functions well given the timeframe and skill set.

The goals were met well in demonstrating analysis techniques and uncovering echo chamber sentiment homogeneity. Connections between topics and misinformation were partly shown but could be further refined with a richer extensive database and a more complex structured program.

Future work might include employing transformer-based sentiment models for finer emotional granularity, dynamic network analysis for evolution tracking over time, and integrating user-level data to analyze influence patterns. Additional interactive visualizations could improve accessibility and educational impact.