ChamberBreaker Final Report

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Introduction, Background, and Significance

Information segregation is a severe problem. Social psychology studies show that segregation and non-constructive communication may affect the decision-making, organizational practice, and even the mental health of citizens. Extensive research has suggested that information segregation **may** exist inside online communities. With the surge of online activities, the possible side effects are severe, although there is no assertion that those segregation exists on any online community. Hence, designs regarding this problem is needed, which leads to our "ChamberBreaker". Impressed by the definition of echo chamber, **we define the information segregation as "chambers",** which includes echo chamber, filter bubble, and selective exposure due to attention limitation.

Being the No.5 most visited website and one of the biggest social news aggregation, the design of Reddit may overlook the problems of chambers. Firstly, all of the information on Reddit is gathered into subreddits which are dominated by the majority of viewpoints and the curated ranking of posts only place the popular viewpoints to the front. Secondly, being a content-oriented platform, the personalization and recommendation of Reddit is based on users' own preference instead of that from users' friends or followers like user-oriented platforms Facebook or Twitter. Without the corresponding "counter-chambers" design, Reddit may be a big chamber of opinions and information, which may have serious impact on users.

The motivation of "ChamberBreaker" is to discover and mitigate the overlooked chamber problem on Reddit. With the support of quantitive and qualitive results, we aim to provide users with fresh topics and diverse opinions on Reddit.

Related Works

In this section, we review the current “chamber” research and corresponding designs that aim at breaking the chamber. Also, to technically realize our design, we review papers about topic extraction, orientation and sentiment analysis, and content recommendation.

Current “chamber” research

The existence, mechanism, and characteristics of the chamber phenomena, including echo chamber, filter bubble, and selective exposure are extensively investigated. As for the echo chamber effect, some researchers argue that echo chamber, especially echo chamber on political issues widely exists. They explored echo chamber on blogosphere [1], Twitter [2], and Facebook [3] by measuring the URL sharing behavior, quantifying the clustering of political views, and analyzing users’ reactions to posts with different opinions. According to their results, users tend to react and spread information that supports their original stances and thus polarization is created. As for the filter bubble effect, Pariser argued that the personalization of online platforms is dominating and restricting the information users may consume [4]. This phenomenon may exist on a lot of recommendation systems such as the movie recommender system [5]. As for the selective exposure, Zuiderveen et al. argue that the limits of people’s attention may inflict self-personalisation on users [6]. In all, researchers paid lots of efforts on proving the existence of the “chamber” effect online, and Liao and Fu’s work conclude them as “information bubble” which is similar to our definition of “chamber” effect [7].

However, there are still opponents of the existence of the “chamber” effect. Dubois and Blank argue that the echo chamber effect is overstated since the diversity and richness of online information is actually providing enough perspectives [8]. Also, Bakshy et al. argues that the designs of platforms do not create the filter bubble but it is users’ own preferences that create the “chambers” [9]. Hence, this problem is still under development and worth investigating,

especially on the platform Reddit. To the best of our knowledge, the chamber effect on Reddit was rarely investigated except the characterization of conflicts in selected communities with opposing viewpoints [10], [11].

Designs that mitigate chambers

There are noticeable designs on mitigating the chamber effects online. Liao and Fu tested the effects of their design of placing diverse opinions side-by-side, which provides good mitigation on the echo chamber but their information are all pre-selected [12]. In another Liao and Fu's work, they indicated the source position of controversial arguments and quantified how it influences users' selection and reception of diverse opinions [13]. Their research indicates that the diversity of online information reception can be significantly enhanced by simply placing diverse opinions on the webpages. Nagulendra and Vassileva designed a visualization tool of the personalization of online social networks to make users more aware of the filter bubble online [14] but they did not provide new content to users. Moreover, Cambre et al. designed a compact political discussion space for the exchange of diverse opinion to reduce echo chamber effect [15]. Their work not only indicates the importance of providing diverse stances but also indicates the importance of feeding users new information.

Although past design efforts provide us insights on mitigating the chamber effect, there are rare new topics recommendation and opposing opinions on general entities designs existing. One related work about topic extraction design is conducted by Bergstrom and Karahalios [16], but their task is about the topic extraction from speech instead of written languages online. To the best of our knowledge, research works that supplement online social platforms with both fresh topics and diverse opinions are lacking, especially for online news aggregation like Reddit.

How to technically mitigate chambers

Our design includes technical subtasks about topic extraction, sentiment analysis, and content recommendation so related works are briefly reviewed here. As for the topic extraction task, Choi [17] modeled some fundamental algorithms of controversial topic extraction and Addawood [18] did related classification task about extracted topics. Their works gave us an idea about how to extract topics and how to utilize the extracted results. Opinion orientation analysis and sentiment analysis is also a well-developed research field with works about classifying agreement and disagreement online [19] and works about investigating the sentiment and stances during discourse online [20]. To simplify our work, targeted sentiment analysis provided by Google [21] was used, which combines both topic extraction and sentiment analysis.

A lot of research works provide different types of topic recommendation. One work that is closely related to ours is the topic diversification, where they selected more diverse contents based on more diverse and fresh topics [22]. Aside from that, Lu et al. provide a detailed illustration of content recommendation based on similarities of topics [23] and Godin et al. provide hashtag recommendation using LDA model, which connect content with topics [24]. Their principle of recommending topics indicates that the recommendation model can be built using people's sentiment, the popularity of topics, and the similarity between new topics and user's history.

Objectives, Goals and Outcomes

Our main objective in designing the "ChamberBreaker" is to ***help users understand more fresh and diverse information on Reddit.*** Aside from that, we also aim to illustrate the possible existence of "chambers" on Reddit via quantitative and qualitative research.

Our expected outcomes consist of two parts. Firstly, we expect our research results can demonstrate that the current design of Reddit makes users lack of fresh and diverse

information. That is to say, the design of Reddit does not mitigate the “chamber” effect but may overlook or reinforce it. Secondly, we expect to design a tool that can help users “break the chamber” by receiving more fresh and diverse information, which breaks the chamber of users’ own preference and breaks the chamber of majorities’ viewpoints respectively.

Our research and design results fit our expected outcomes. Firstly, via user interviews, the calculation and visualization of user entropy, and the calculation of polarization inside subreddits, we argue that the “chamber” effect on Reddit does exist in at least the two subreddits we investigated. Secondly, we developed a tool that supplements the original Reddit platform. According to the user evaluation results, we mitigated the “chamber” problem on Reddit.

Dataset

We selected and crawled subreddit data and Reddit user data from Reddit via the Reddit API. As for the subreddit dataset, we selected two subreddits: /r/SelfDrivingCars and /r/apple. As for the Reddit user dataset, we selected 360 users who once appeared on the posts section or the comment section of the subreddit /r/SelfDrivingCars.

The rationale for us to choose these two subreddits includes three parts. Firstly, we want subreddits with concrete entities. Hence, a lot of subreddits like /r/pics are excluded since they do not have many concrete entities and may cause runtime error when using Google NLP API. Secondly, we want subreddits with general information except direct opinion polarization. By investigating subreddits with seemingly non-controversial topics, we want to argue that the “chamber” effect exist even inside normal online communities. Hence, subreddits like /r/politics are excluded. Thirdly, we aim to find one mid-size community and one large-size community separately. This is from the intuition that mid-size subreddit may have more severe “chamber” effects since there may exist closer user connections and stricter moderators. Hence, we used a

bigger subreddit to illustrate that the chamber effect exist even in large subreddits in the following works. Also, the comparison between mid-size community and large-size community may give us a better understanding of ordinary users' behaviors. To finalize our choice, we browsed news reports such as "Nine technology trends in 2019" [25] and selected the topic of "automatic driving" and the topic of "Apple press conference" as our research subjects. Hence, /r/SelfDrivingCars and /r/apple are selected.

We used the Reddit API to collect our subreddit data. Reddit API has the limitation that one can only gather one thousand posts for each subreddit, and thus we collected the top one thousand posts from two subreddits separately. From the two thousand posts, we selected 200 high-quality posts with more than seven comments and 300 high-quality posts with more than fifteen comments from /r/SelfDrivingCars and /r/apple respectively. The basic statistical information of two subreddits and the posts we collected are listed in Table 1. All of the comments and posts collected are processed into Google NLP API separately and we got their corresponding entities extraction results and sentiment analysis results.

Subreddits	Subreddit Statistics					Collected Dataset Statistics	
	Subscribers		Comments		Posts	Ave_comments	Unique users
SelfDrivingCars	~4000	50K	~3000	~70	7	5	368/1151
apple	~200	1200K	~400	~700	37	21	535/7862

Table 1: *Subreddit Statistics are calculated based on data from 9-1 to 11-30 (duration of 3 months) and Collected Dataset Statistics are calculated based on the one thousand posts we crawled. Subscribers contains the ranking and number of subscribers respectively; Comments contains the ranking and the number of comments respectively, posts is the approximate number of new posts per day. Ave_comments is the average number of comments, and Unique users contains the unique users in posts and unique users in both posts and comments separately.*

To quantify the chamber effect within users, we also selected 360 unique users and crawled their whole user histories via the Reddit API and 360 unique user ids from /r/SelfDrivingCars. The rationale of our selection is that we need user id seeds which can be either collected from

overall top posts' authors on Reddit or from top posts' authors of our crawled subreddits. Our concern of the former choice is that the overall top posts of Reddit may only contain users from certain biggest subreddits, which may give a bias of our dataset. Hence, we collected users from /r/SelfDrivingCars and crawled all of their user history including comments, posts, and subreddits they subscribed separately.

The basic statistics for our users are that: they have an average of 595 pieces of activity history, an average of 65 subreddits subscription, and an average user history of 40 months. Notably, the user with the longest user history have a history of 162 months.

Approach and Result

(I) Echo Chamber Demonstration

We used mixed methods to demonstrate why echo chamber is a problem we want to solve. User interview helps us quickly understand there's user needs for breaking echo chamber. And data visualization helps us use data to demonstrate echo chamber do exist on Reddit.

1. User Interview

Initially our project focus on user similarity. To quickly identify which topic has the most user needs in this area, we conducted **5 user interviews, 30 mins for each**. To begin with, we listed 4 potential objectives within user similarity and then we listed interview questions for each objective around how they achieve that task right now and what's their expectations.

For the interview session, one limitation is that we only conducted 5 user interviews which is a small number. Also users are mainly college students which is not diverse enough. So we try to mitigate the limitation by recruiting users with at least 2 years of Reddit experience so that we can get more insights from one person.

Table 2 summarized our interview questions and results of user interviews. There are two highlights: "Users mainly focus on the content instead of users". (P1)(P2)(P3)(P5) and 'Users

would love to know diverse information' (P1)(P2)(P3)(P4). Based on these, we demonstrated users do have the needs to understand diverse opinions which become our objective.

Objective	Interview Questions	Results Summary
Help users understand the diverse of opinions	Do you want to know different opinions for certain topics right now and how?	**Users would love to know diverse opinions and would like to have a quick status of different opinions. e.g. Within each post, each comment can** clearly separate opinion levels. (P1)(P2)(P3)(P4)
Help users quickly find the post they want to read	How do you choose what post to read now?	Most cases users just browse all the posts in hot topics / favorite SubReddits. And pick the one looks funny. (P1) Sometimes if they've specific goals, they'll go to one SubReddit. (P1)
	Do you care about whether opinions is similar to you or not?	Users do sometimes care about other users when we provide a whole picture of users. e.g. "If can see 70% photography, 20% politics, probably will go to their profile." (P1)(P4)
User similarity: Help users quickly understand each other better	Have you interact with users before? When and how?	The time I'm interacting with others is when someone is seeking for help / I disagree with that and I'll write a comment. And we'll talk. (P1)(P2) Generally I'm care about the comment instead of the user.
	For a user new to you (don't have online interaction before), will you interest in sometimes and want to learn more? What do you want to know and how?	**"Reddit is not a platform to make friends. I mainly focus on the content instead of users".** (P1)(P2)(P3)(P5)
User recommendations (similar users, unsimilar users)	Do you want to know similar users?	Reddit is a solo experience. (P1)(P2)(P3)
	Do you want to know users who hold opposite opinions about you?	Wouldn't really want to know who opposite about me.(P2)

Table 2: *Interview Questions and Interview Results*

2. Chamber Visualization

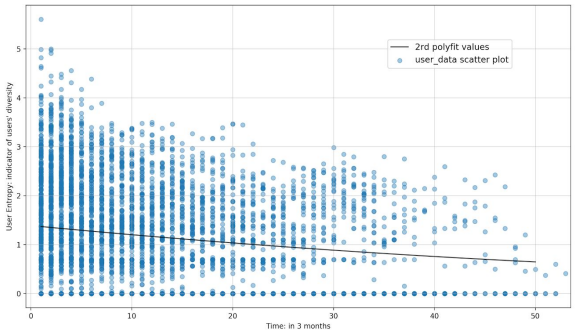


Figure 1: *User entropy plot. Scatter plot is the entropy value of 3 months of user's history versus time. The black line is a 2nd order polynomial the average of their entropy during a certain time.*

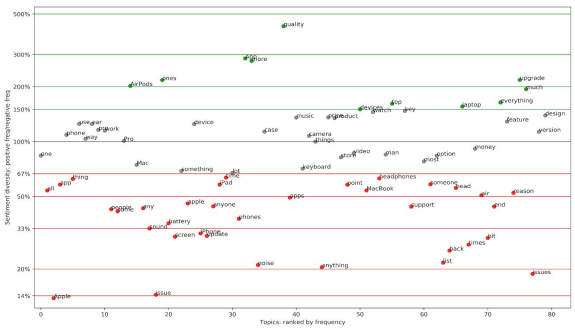


Figure 2: *Subreddit polarization plot. Scatter plot is the ratio of the number of positive sentiment to the number of negative sentiment towards entities versus topic popularity. Green, red dots are entities that are strongly advocated and criticized.*

We used two figures to visualize the chamber effect, one is about the user diversity and another is about subreddit polarization. To measure the diversity of information gathered by user, we used entropy which is a widely used measurement quantity of biodiversity. The equation for calculating the entropy is $E_{user} = -\Sigma_{s_i} p_{s_i} log p_{s_i}$, where s_i is all of the subreddit user is subscribing, p_{s_i} is the possibility of having activities within the subreddit s_i, and the E_{user} is the entropy of user. User history is divided into 3 months and their entropy is calculated and plotted in figure 1, where 3-month history with zero activity is removed. Although the 360 users we collected have an average of 65 subreddit subscription, they only have primary user activities in around three subreddits in 3 months on average. Also, with the increase of users' time staying on Reddit (user history), users' average entropy drops, which indicates that the longer the user stays, the less diverse information are gathered.

In addition, we calculated the overall sentiments polarization towards the entities we extracted in subreddits as in figure 2. At least for the top eighty topics extracted, users'

sentiment towards then is highly biased: over fifty percent of topics have polarized opinion inside the subreddit /r/apple. The polarization here is defined as the ratio of supporters and opponents is over 150% or below 67%.

(II) Implementation of topic modeling and topic recommendation

The process of the topic modeling is illustrated in Table 3. For all of the subreddits' dataset and user dataset, entities are extracted and their corresponding sentiment and sentiment magnitude are analyzed for all posts and comments via the Google NLP API (values extracted as #1# and #3#). For user history and threads, the entities are combined and aggregated to have a new set of entities, sentiments, magnitudes, and frequencies (values extracted as #2# and #4#). Combining entities similarity analysis and entities popularity analysis, a recommendation system was built to recommend users fresh topics and posts with fresh topics. For fresh topics, entities that do not overlap between user history (#4#) and threads (#2#) are recommended. For threads with fresh topics and diverse threads, ranking is calculated based on the product of fresh topics and their frequency and the product of sentiment and magnitude respectively.

Dataset	subreddit dataset		user dataset	
data type	#1# posts & comments	#2# threads	#3# posts & comments	#4# user history
values extracted	entity: [sentiment, magnitude]	entity: [sentiment, magnitude, frequency]	entity: [sentiment, magnitude]	entity: [sentiment, magnitude, frequency]

Table 3: *The implementation of topic modeling and topic recommendation process.*

(III) Tools to help users understand diverse information on Reddit

1. **Brainstorming. Wireframe. Hi-fi Design**

Before design, we set 3 design goals first based on our objectives and user interview results to guide our design:

- Diversity: Design should provide diverse topics / posts instead of just top ones
- Efficiency: Design should provide quickly overview of topics / posts
- Transparency: Design should be transparent enough to help users understand how does information generated.

And then we started design. We went through brainstorming, wireframe, and hi-fi design and we refined ideas at each stage. **Figure 3** illustrates how our dashboard iterate through different stages. At brainstorming stage, we provided a dashboard with many visualizations - wordCloud + imageCloud + treemap. It provides great overview and fancy visuals, but could users understand immediately what the visualization is about? So considering the heavy cognitive effort, we lightened the dashboard to make it easy to understand in wireframe stage. And at the hi-fi stage, we added more explanations to increase the transparency of the design.

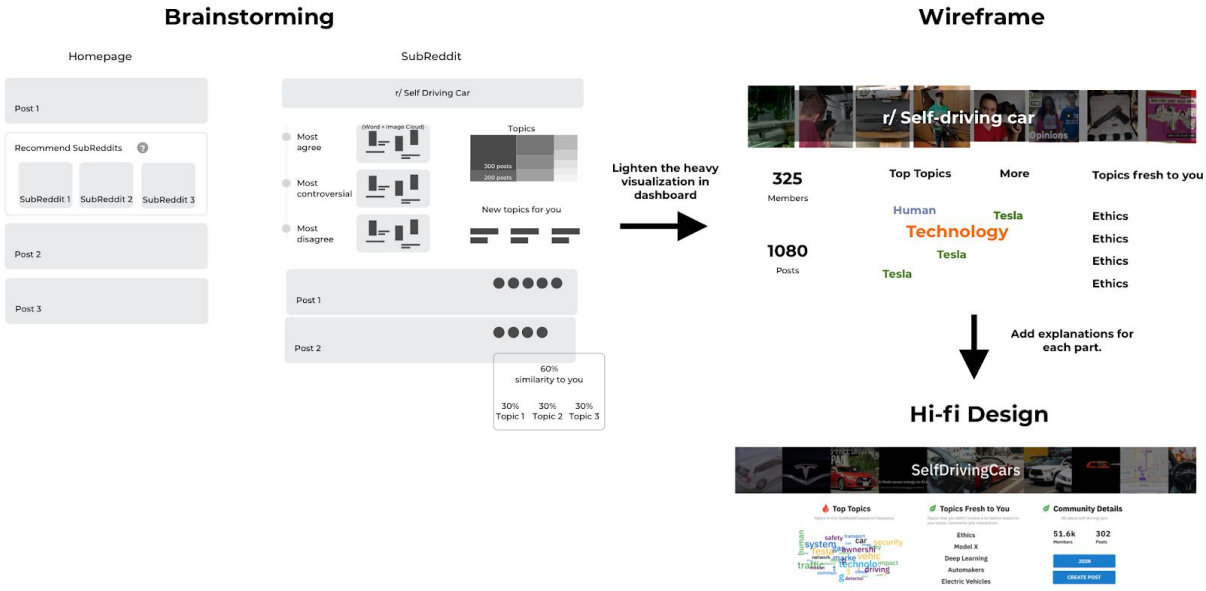
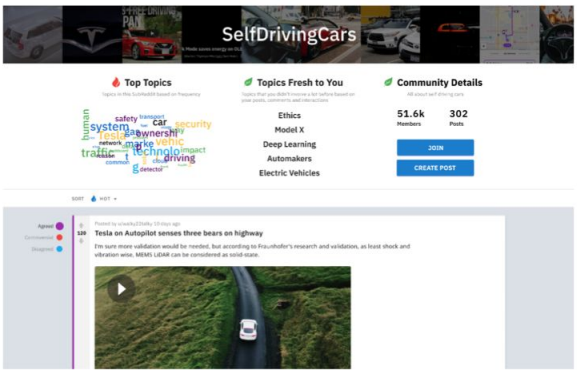
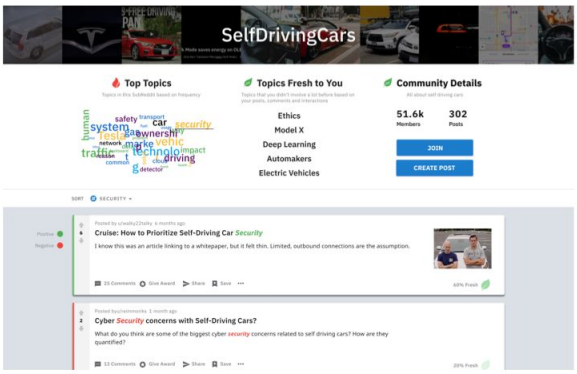


Figure 3: *An example of brainstorming, wireframe, hi-fi design*

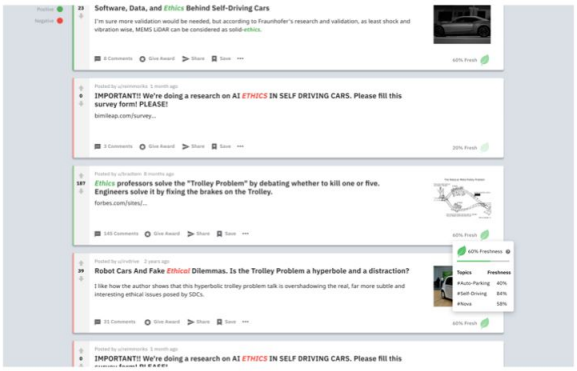
As for the result of hi-fi design, **figure 4** are some key features which aligned with objectives:



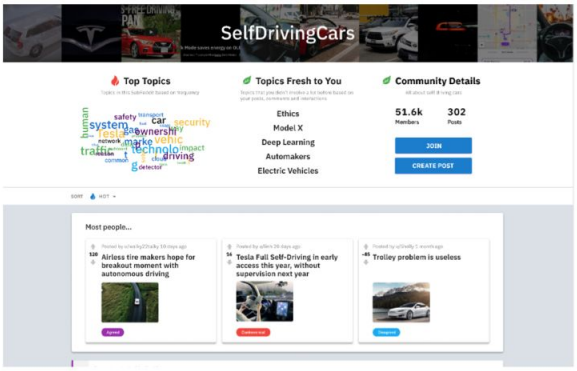
Top topics and fresh topics



Diverse opinions for each topic



Fresh posts



Diverse opinions of most people

Figure 4: *Key features of hi-fi design*

2. Evaluation

To verify whether we achieve our objectives, we conducted **comparable task based benchmark testing**. We used **think aloud method** which requires users speaking out their thoughts while conducting tasks and explaining ‘why’ for each score they measured. For the preparation work, we designed 5 tasks from our key features and listed 3 criterias as measurement which are our design objectives. For each criteria, we measured it through 7-point rating scale (1 - strongly disagree, 7 - strongly agree):

The procedure is as follows: We started from a brief introduction of our project to provide a general idea of what's our project about. And then we collected some background information to learn about their Reddit frequency usage, Reddit usage habit, etc. Then users start to evaluate the 5 tasks we designed. Firstly, they conduct the task using existing Reddit and evaluate the efficiency and diversity of tasks. Then we walked them through them our prototype and let them evaluate those measurement again.

For the result summarization, we calculated the measurement as quantitative result and summarized insights we gathered from think aloud as qualitative result. We had **9 participants** for total. Several insights we want to highlight:

- All scores of our tool are higher than existing Reddit. It demonstrates at least our tool has less echo chamber problem than existing Reddit.
- Users gave almost full score for task 1, 2, which corresponds to top topics and fresh topics in dashboard. With the current Reddit, users mainly just browse to go through posts, which is troublesome, as it's hard for them to get a quick overview of topics, posts.
- Users are really satisfied with task 5 which is to provide diverse opinions of majority people. The reason being, the curated ranking of posts of the current Reddit make users tend to focus on the one most people agree with. On the other hand, our tool additionally provides users the threads which are controversial and the threads most people disagree with, and helps them easily navigate between different sessions.
- Task 3 has the lowest score in general, because users are a little bit concerned about the diversity because of the clear cut between positive and negative opinions. And machine decisions seem more polarized than users' upvote and downvote.

Tasks	**Criteria**	**Existing Reddi**	**Our Tool**	**Qualitative Result**	**Design Iteration**

		t			
Task 1	Efficiency	4.6	6.57	It's efficient to know many keywords. But not sure wordCloud is the best way, as vertical ones or really small one is hard to see (P1, P2, P3, P4, P6, P7)	Change wordCloud to all horizontal ones
	Diversity	5.4	7	Users all give highest score for this. One thing could consider is to use trending topics instead of topics for all (P3, P4)	
	Transparency	N/A	5.86	Description is good but too small to notice at the beginning. Users not sure if they can click it (P1, P6)	Enlarge the descriptions.
Task 2	Efficiency	5	7	Really efficient	
	Diversity	5.3	6.67	Efficiency and diversity all pretty good. One suggestion is to provide both interested topics and new topics which could also provide reason behind why these are new topics. (P4, P5)	
	Transparency	N/A	6.14	Still, description is too small to notice. Also probably change the wording to "topics you might be interested in based on your previous comments,../" (P1, P3, P4, P7)	Enlarge the descriptions.
Task 3	Efficiency	5	6.71	Pretty efficient now (P1, P3, P4)	
	Diversity	5.3	5.67	Users are a little bit concerned about the diversity because of the clear cut between positive and negative. Will there be polarization? What if it's neutral? Probably can consider scale instead of binary. But still, machine decision feels less objective than upvote and downvote (P1, P4, P7)	Lighten the sentiment and only shows a banner like task 5.

	Transparency	N/A	6	What is the agree and disagree about? With security? With majority? With the post? With me? (P4, P5, P7)	Add annotation of what agree and disagree with.
Task 4	Efficiency	5.14	6	Probably only care about whether it's a fresh one or not instead of the number. The different measurement of from sentiment, to you, from upvote / downvote is a little confused. (P2, P3, P7)	Instead of show the percentage of freshness for each posts, only show top 10 fresh posts
	Diversity	5.286	6.29	N/A	
	Transparency	N/A	5.43	Freshness is to majority (new post) or to users or to topics? How freshness based on? If I upvote it means I agree with, then probably more objective. (P3, P4, P5, P6, P7)	
Task 5	Efficiency	4.3	6.71	Pretty efficient	
	Diversity	4	6.86	Users like the diversity as previously disagree and controversial one will be hidden because of downvote. Also users like it shown randomly. But need to consider what if disagree one are most shit stuff. (P1, P3, P4, P5, P7)	
	Transparency	N/A	6	"Agree / disagree with me or majority?" (P1, P2, P4, P5, P6)	Add annotation of what agree and disagree with.

Table 4: *Benchmark testing quantitative and qualitative results and design iterations: Green are the one over 6.5 and red are the one below 6 which we need to improve*

3. Design Iteration

We identified areas to improve based on **table 4.** We prioritized which feature to iterate on considering both quantitative score and number of qualitative feedback we get. **Figure 5 and figure 6** listed 2 top features we need to iterate on. The first one is about diverse opinions for each topic. As mentioned before, users are a little bit concerned about the diversity because of the clear cut between positive and negative opinions. And machine decisions seem more polarized than users' upvote and downvote. So we lightened this feature and only show more when users are interested in.

The second feature we iterated was fresh posts. There was many features in the previous design, such as posts different from you, posts different majorities. It is hard for users to understand the difference between each features. Therefore, it is a great opportunity to lighten some cognitive effort as users will only care what are recommended instead of how.

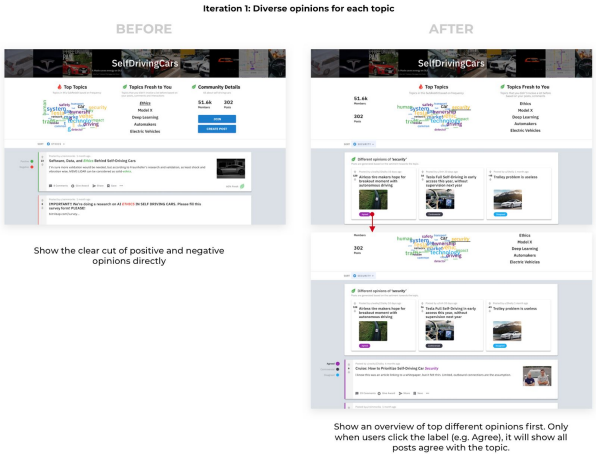


Figure 5: *Design Iteration of Diverse Opinions for each Topic Feature*

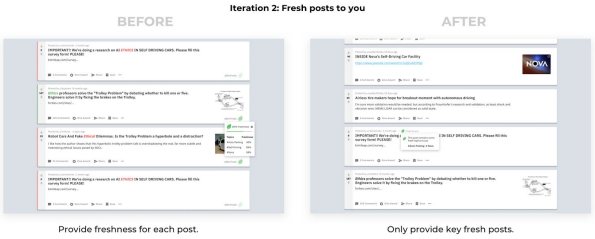


Figure 6: *Design Iteration of Fresh posts to you Feature*

In addition, we solved some usability issues, like "change wordCloud to all horizontal", 'enlarge the font size of descriptions', 'add annotation of what agree and disagree with'.

4. Implementation

After the design phase, we implement the prototype using Python, PHP, HTML, Javascript and CSS. We build our tool based on **Simpleddit** project [27] - an open source Reddit browser.

For the front end, we used jQuery as the Javascript framework, and Handlebars as the templating engine for our front end GUI. The Overview of all topics word cloud is generated using the d3 data visualization framework. Our backend is implemented using PHP and Python. Python is used to implement the natural language processing pipeline, which uses Google Natural Language library, and the real-time Reddit data crawler and processor, which uses Pandas and PRAW. PHP is used to implement the hosting of the website and the middleware between the website and the Python pipeline. Figure 7 shows the architecture of our prototype.

The workflow of our prototype is as following. First, the user would enter their Reddit username. Then, our realtime data crawler and processor would crawl their Reddit data, perform sentiment analysis and entities extraction (Figure 9). After, the analysis completes, our recommendation engine would use the analysis data to recommend posts and generate recommended topics for the users. After the recommendation complete, the user can use our tool to browse the subreddit data and receive the recommendation topics. Our prototype support operations to navigate the sentiment analysis data i.e: selecting, highlighting and filtering (Figure 10). User also receive the recommended posts that contains diverse and fresh topics (Figure 8)..

Our tool shows a possible implementation and design of Reddit that can promote the diversity and freshness of Reddit user's ideas and opinions about a certain topic. While our tool only works on a pre-download dataset of a subreddit, it can extend to any other subreddit dataset. This means that given enough resources, we can build a complete Reddit browser that can

implement topics recommendation seamlessly into the browsing experience of a Reddit users, similar to Facebook news feed.

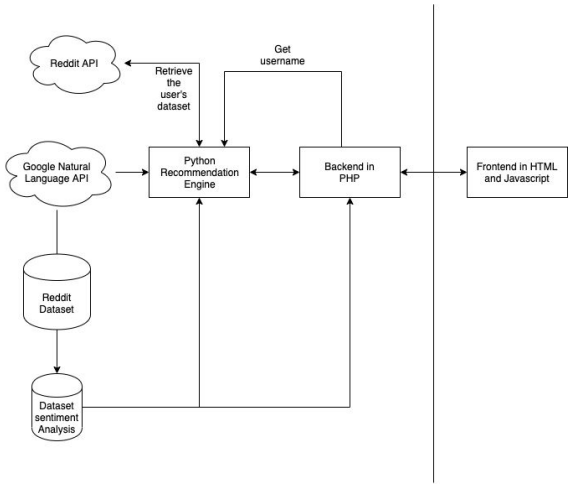


Figure 7: *The architecture of our prototype*

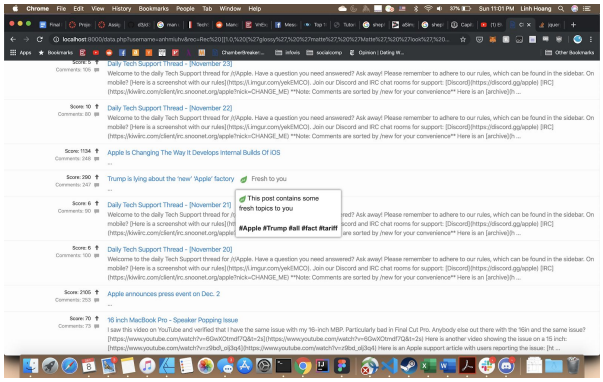


Figure 8*: Our tool recommends a post*

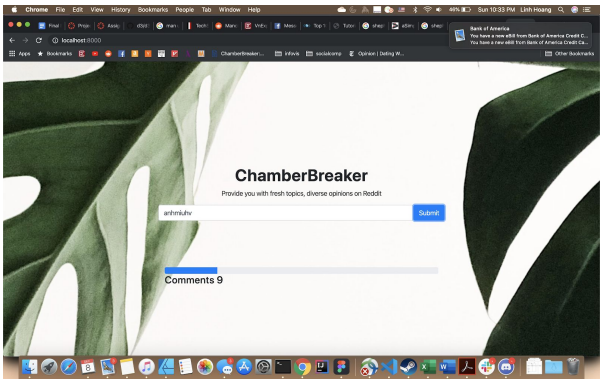


Figure 9: *Realtime data crawler and processor is gathering and processing the data*

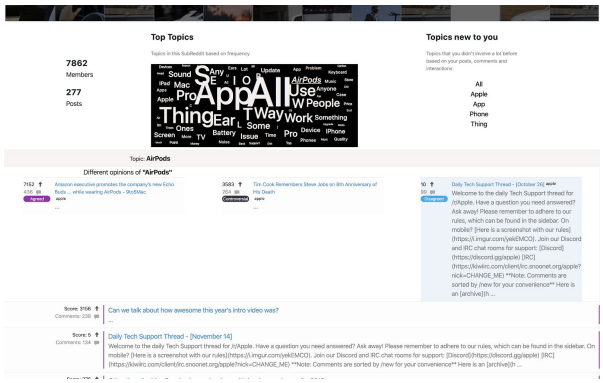


Figure 10*: Real implementation of the design. The user is currently selecting the "Airpods" and filters for the positive sentiment of that topics.*

Discussion

"Why chambers problem exists"

Some sub communities on Reddit are known to have chamber problems (r/incels [26]). In our project, we also find out the chambers of opinions in /r/apple and /r/SelfDrivingCars by analysing the sentiment of their contents. As stated in our related work, any large and popular social computing platforms seem to contain some forms of chambers. It is a widely acknowledged problem; however, it is a difficult problem to solve and there is little incentive for social media companies to solve it. Most of social media companies make money proportionally to the amount of time users to stay on their platforms; so by recommending contents that are outside of users' comfort zone, social media companies actually risk losing users. Most social media, therfore, recommend new content by picking the posts which people are most likely to read; for examples, Reddit's upvote system. From our interview, we observed while some users are concerned with the chambers problems, they still tend to read and interact with the topics and opinions that they are familiar with as it takes additional efforts to consume contents which you don't find comfortable or agree with. Therefore, a tool, which lessens the efforts by the users, is needed to break the chamber of users own opinion and majority people's opinion.

"Reddit users mainly focus on the content instead of users"

Our initial project topic focuses on user similarity. We think it would be a great opportunity for users to have a better understanding of other users and interact with them. However from our user interview, most users especially for users who have already stayed in the platform for a long time (e.g. more than 2 years), they have strong perception that Reddit is a platform mainly for content. So instead of focusing on users, we find opportunities to provide users diverse information, which becomes our final objective.

"Machine computation itself is a polarization"

Initially we try to provide users as enrich features as possible. We involved many computations inside, to calculate different opinion orientations for each topic, top different opinion orientations

for whole subreddit, fresh topics for users, fresh posts for users. But what we find from evaluation testing, users feel a lot of computations going on and become intimidated, fearing that our algorithms are trying to create polarization. So instead of visually showing all computation results right upfront, We'll design the UI the show these computation result to require low cognitive effort, and users able to learn more about how we generate the results if they're interested. In addition, we try to make our design more consistent across different features in our tool. For example, for posts different from majority people, whether it's to one topic or the whole subreddit, we used the same style so that users only need to learn once of what ‘‘agree with' or 'disagree with' are about.

"Echo chamber problem is hard to solve but our tool is a great way to start"

Although still some features are not perfect, our solution may not be the most direct solution when we thought about to solve echo chamber problem, but we tried to provide the most usable and appropriate solution based on our design goal at the beginning. From the evaluation testing, we find there are two types of users. Some users still not interested in fresh topics / posts, they still tend to see information they want to see. But another type of users who care about echo chamber actually provide us a lot of support and confidence. "It's good to have those at the top of the page so that people can notice. Even they probably still want to see things similar to them, it's a good start" (P5). "Echo chamber is not easy to solve, but I'm glad you guys start." (P4) With these feedback we got, we know breaking echo chamber is still a long way to go but we also glad we start.

Reference

[1] Adamic, L. A., & Glance, N. (2005, August). The political blogosphere and the 2004 US election: divided they blog. In Proceedings of the 3rd international workshop on Link discovery (pp. 36-43). ACM.

[2] Gruzd, A., & Roy, J. (2014). Investigating political polarization on Twitter: A Canadian perspective. Policy & Internet, 6(1), 28-45.

[3] Quattrociocchi, W., Scala, A., & Sunstein, C. R. (2016). Echo chambers on Facebook. Available at SSRN 2795110.

[4] Pariser, E. (2011). The filter bubble: How the new personalized web is changing what we read and how we think. Penguin.

[5] Nguyen, T. T., Hui, P. M., Harper, F. M., Terveen, L., & Konstan, J. A. (2014, April). Exploring the filter bubble: the effect of using recommender systems on content diversity. In Proceedings of the 23rd international conference on World wide web (pp. 677-686). ACM.

[6] Zuiderveen Borgesius, F., Trilling, D., Möller, J., Bodó, B., De Vreese, C. H., & Helberger, N. (2016). Should we worry about filter bubbles?. Internet Policy Review. Journal on Internet Regulation, 5(1).

[7] Liao, Q. V., & Fu, W. T. (2013, April). Beyond the filter bubble: interactive effects of perceived threat and topic involvement on selective exposure to information. In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 2359-2368). ACM.

[8] Dubois, E., & Blank, G. (2018). The echo chamber is overstated: the moderating effect of political interest and diverse media. Information, Communication & Society, 21(5), 729-745.

[9] Bakshy, E., Messing, S., & Adamic, L. A. (2015). Exposure to ideologically diverse news and opinion on Facebook. Science, 348(6239), 1130-1132.

[10] Mills, R. A. (2018). Pop-up political advocacy communities on Reddit. com: SandersForPresident and The Donald. AI & SOCIETY, 33(1), 39-54.

[11] Kumar, S., & Shah, N. (2018). False information on web and social media: A survey. arXiv preprint arXiv:1804.08559.

[12] Liao, Q. V., & Fu, W. T. (2013, April). Beyond the filter bubble: interactive effects of perceived threat and topic involvement on selective exposure to information. In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 2359-2368). ACM.

[13] Liao, Q. V., & Fu, W. T. (2014, February). Can you hear me now?: mitigating the echo chamber effect by source position indicators. In Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing (pp. 184-196). ACM.

[14] Nagulendra, S., & Vassileva, J. (2014, September). Understanding and controlling the filter bubble through interactive visualization: a user study. In Proceedings of the 25th ACM conference on Hypertext and social media (pp. 107-115). ACM.

[15] Cambre, J., Klemmer, S. R., & Kulkarni, C. (2017, May). Escaping the echo chamber: ideologically and geographically diverse discussions about politics. In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (pp. 2423-2428). ACM.

[16] Bergstrom, T., & Karahalios, K. (2008, April). Conversation clusters: human-computer dialog for topic extraction. In CHI'08 Extended Abstracts on Human Factors in Computing Systems (pp. 2829-2834). ACM.

[17] Choi, Y., Jung, Y., & Myaeng, S. H. (2010, June). Identifying controversial issues and their sub-topics in news articles. In Pacific-Asia Workshop on Intelligence and Security Informatics (pp. 140-153). Springer, Berlin, Heidelberg.

[18] Addawood, A., Rezapour, R., Abdar, O., & Diesner, J. (2017, August). Telling apart tweets associated with controversial versus non-controversial topics. In Proceedings of the Second Workshop on NLP and Computational Social Science (pp. 32-41).

[19] Wang, L., & Cardie, C. (2016). A piece of my mind: A sentiment analysis approach for online dispute detection. arXiv preprint arXiv:1606.05704.

[20] Mejova, Y., Zhang, A. X., Diakopoulos, N., & Castillo, C. (2014). Controversy and sentiment in online news. arXiv preprint arXiv:1409.8152.

[21] Godbole, N., Skiena, S., & Srinivasaiah, M. (2011). U.S. Patent No. 7,996,210. Washington, DC: U.S. Patent and Trademark Office.

[22] Ziegler, C. N., McNee, S. M., Konstan, J. A., & Lausen, G. (2005, May). Improving recommendation lists through topic diversification. In Proceedings of the 14th international conference on World Wide Web (pp. 22-32). ACM.

[23] Lu, Z., Dou, Z., Lian, J., Xie, X., & Yang, Q. (2015, February). Content-based collaborative filtering for news topic recommendation. In Twenty-ninth AAAI conference on artificial intelligence.

[24] Godin, F., Slavkovikj, V., De Neve, W., Schrauwen, B., & Van de Walle, R. (2013, May). Using topic models for twitter hashtag recommendation. In Proceedings of the 22nd International Conference on World Wide Web (pp. 593-596). ACM.

[25] https://www.bbva.com/en/nine-technology-trends-in-2019/

[26] Taub, Amanda. “On Social Media's Fringes, Growing Extremism Targets Women.” The New York Times, The New York Times, 9 May 2018, www.nytimes.com/2018/05/09/world/americas/incels-toronto-attack.html.

[27] “a Simple Reddit Browser.” Simpleddit, www.simpleddit.com/.