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Calculating Argument Diversity in Online Threads

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Abstract

We propose a method for estimating argument diversity and interactivity in online discussion threads. Using a case study on the subject of Black Pete ("Zwarte Piet") in the Netherlands, the approach for automatic detection of echo chambers is presented. Dynamic thread scoring calculates the status of the discussion on the thread level, while individual messages receive a contribution score reflecting the extent to which the post contributed to the overall interactivity in the thread. We obtain platform-specific results. Gab hosts only echo chambers, while the majority of Reddit threads are balanced in terms of perspectives. Twitter threads cover the whole spectrum of interactivity. While the results based on the case study mirror previous research, this calculation is only the first step towards better understanding and automatic detection of echo effects in online discussions.

2012 ACM Subject Classification Information systems → World Wide Web; Information systems → Sentiment analysis; Human-centered computing → Social media

Keywords and phrases Social Media, Echo Chamber, Interactivity, Argumentation, Stance

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Supplementary Material *Software (Source Code)*: `https://github.com/Cwaterschoot/Interactivity_scoring`; archived at `swh:1:dir:f369c7b7343ace35ad1a916e37708dbae8dd3252`

1 Introduction

No shortage exists in regard to online discussions, whether raging on social media or on other websites including those of media outlets. A substantial amount of work has focused on particular aspects of such debates, such as filter bubbles, the purported consequence of personalization in search and recommendation algorithms [17], and echo chambers, clusters of like-minded individuals amplifying their unison reasoning [7]. What has been sparsely studied, however, is how individual messages contribute to the interactivity of an online discussion thread, either towards an echo chamber or balanced discussion.

This paper presents a method for the automatic scoring of a discussion thread in terms of interactivity and argument diversity, as well as for grading each individual post within the thread on the basis of interactive contribution at the time of posting. The starting point of the analysis is a dataset of messages where each sample has been labelled for the argument it presents. The case study in this paper to illustrate the scoring of discussion threads deals with the "Zwarte Piet" (Black Pete) debate in the Netherlands, a topic with clear "pro" sides, i.e. in favour of the figure, and "con" side against the continued existence of "Zwarte Piet".

First, the literature on online discussions, echo chambers and argument diversity is discussed. Then, the scoring methodology is unpacked. The paper ends by discussing the methodology, limitations and what to focus on in future research.

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2 Background

Echo chambers and social media is a much discussed topic that has received ample attention from different perspectives, whether political, academic or from the media. An echo chamber is understood to be an enclosed, discursive space, online or based on other forms of media, which amplifies the uniform message encapsulated within. This process magnifies the shared opinion within the cluster while insulating it from rebuttal, creating an environment of positive feedback loops [11].

Previous research tends to agree that echo effects exist on social media platforms, even though the concept remains contested [7, 21, 5]. A possible cause for such an echo effect is the fact that social media users have the tendency to discuss matters with like-minded individuals [5]. It has been concluded that this restricted debate increases polarization [1, 20]. However, others have criticised single media studies for echo chamber detection as it does not take into account the "multiple media environment" that we find ourselves in today [6].

The notion of an echo chamber is seen as disadvantageous by dominant conceptions about democracy as well as by stakeholders in media and moderators. Discourse with those holding differing opinions increases understanding of the subject matter and tolerance for those who disagree [16]. This paper aims to contribute to the development of information systems dealing with online discourse, by mapping interactivity of polarized debates.

The automated classification of echo chambers is not a much discussed topic, even though studies have focused on the subject, particularly in the field of politics. One study has outlined that homophily of social media feeds can be determined across groups by assigning users to either Democrats or Republicans [4]. Furthermore, network analysis has shown the online clustering of communities holding similar views regarding climate change [21].

The current model aims to fill the gap and complement the research on echo chamber detection in pro/con-discussions by implementing domain-unspecific calculations based on annotated data, meaning any labelled data can be used, regardless of the debate statement. The unit of analysis is the thread. Such discussions can either be balanced in terms of argumentation or skewed to one perspective. A second indicator is calculated at the message level, as every individual reply in a thread receives a contribution score.

From here on out, an *echo chamber* will refer to a thread in which the argumentative position presented in the parent message – the contribution starting the thread to which others have replied – is continued throughout the thread, per calculation. The opposite, in which the contrasting argumentative camp, whether pro or con, is the dominant presence in the thread, will be called an *opposition flood*. Equal presence of pro and con messaging results in a *balanced* discussion. A thread can be interpreted as a string of messages portraying an argument belonging to either the pro or con camp where all replies comment on the parent message. Simplified examples are as follows in the form $\{firstpost \rightarrow replypost \rightarrow replypost \rightarrow ...\}$:

$$Echo\ chamber := X_{pro} \rightarrow Y_{pro} \rightarrow X_{pro} \rightarrow X_{pro}$$
$$Opposition\ flood := X_{pro} \rightarrow Z_{con} \rightarrow L_{con} \rightarrow M_{con}$$
$$Balanced := X_{pro} \rightarrow Z_{con} \rightarrow Y_{pro} \rightarrow M_{con}$$

2.1 Case study

To illustrate the approach, an annotated dataset containing online threads discussing the controversial blackface figure of Black Pete in the Netherlands was created. This discussion has a clear pro/con divide. Those in favour of the figure, a component of the Dutch Sinterklaas festivities, argue that Black Pete ought to remain as it was celebrated throughout the last decades. The camp opposing the festivities assert that the character is a racist stereotype portraying people of colour and should not be celebrated. This debate ought to be seen more broadly in the discussion on racism in Dutch society [2]. These threads were collected from Twitter (using the keyword "Zwarte Piet"), Reddit, by scraping the subreddit r/thenetherlands with "Zwarte Piet", and finally Gab, also scraped using the hashtag "zwartepiet" (Table 1).

Table 1 Threads and messages included, sorted by platform.

Platform	Total Threads	Total Messages
Twitter	21	125
Reddit	7	39
Gab	7	22

Manual labelling with regard to the included arguments was performed, based on the outline presented in previous research (see e.g. [18, 2, 10, 9] and Table 2). Stance labelling of social media data is a challenging task and therefore, it is done at the level of argumentation presented in the literature [13, 12].

Table 2 Arguments (Labels) in the Zwarte Piet discussion.

Level1 (l1)	Level2 (l2)
Pro	Dutch tradition, Christian tradition, Innocent, Intention, Pre-christian, Oriental
Con	Racial stereotype: historical, Racial stereotype: contemporary

Each post in the data was labelled for the dominant argument (level2) that it presents in regard to the "Zwarte Piet" discussion (Table 2). These labels have been derived from the extensive literature outlining this particular debate in The Netherlands. To test whether such argumentation can be clearly detected in online contributions, multiple annotators were employed to label all gathered posts. The annotators were familiarized with the discussion and arguments using the existing literature (see e.g. [18, 2, 10, 9]). Furthermore, a sheet with all possible labels alongside a brief explanation was provided to guide the labelling process. A Krippendorff's alpha of 0.745 was calculated, indicating that inter-rater agreement exists.

3 Methodology

We propose a calculation method for estimating indicators of interactivity in threads. A first indicator applies to the thread level; a second indicator relates to single messages.

The model created in this paper makes certain assumptions in order to compute interactivity. First, each post contributes at least one argument in the discussion. Second, each argument can be assigned to a position in the discussion, whether it be "pro" or "con". Additionally, it is assumed that the more an argument is repeated, the smaller the contribution a new repetition will make in terms of diversity/interactivity on the individual message level. However, when calculating the state of the thread as a whole, a new repetition will weigh greater towards the extremes of echo chamber/opposition flood, i.e. constant repeating of identical reasoning will result in an echo chamber or opposition flooding faster.

3.1 Thread Interactivity Score

The thread as a whole receives a single score based on the interactivity and diversity detected in the posts. This real-valued indicator provides information on whether the presented collection of arguments constitutes an echo chamber, opposition flood or a balanced discussion. To compute the overall thread interactivity score, each message receives a cumulative log operator, which increases as an identical argument is repeated within the thread. Using this factor, repetition of a single reasoning weighs heavier towards the extremes, either echo chamber or opposition flood.

Calculating the log operator for both the echo and opposition scores requires the cumulative count of the argument (denoted as j) in each message at that point in time. Simply put, this variable equals the nth iteration of the particular argument represented in the sample at the order given in the data. To calculate the actual log operator, $log_{10}(j)$ is substracted. Dividing the log operator by the total number of messages in the thread (N) results in the message share. Per the assumptions, each argument can be assigned to either the "pro" or "con" side, which is notated as $l1$ of an argument, the deciding factor whether the share is negative or positive (denoted as multiplication by -1). The specific argument as presented in the case study is decoded as $l2$. The Thread Interactivity Score (TIS) is sum of all shares in thread T. An exception exists for replies where the specific argument is identical to the parent message. In this case, the share is multiplied by a weight and added to the parent message share that is not weighed down, with the result that a parent repetition impacts the echo score to a larger degree.

$$Share_i \begin{cases} \frac{j(x_i)-1-log_{10}(j(x_i)-1)}{N} * (-w) + \frac{1}{N} & \text{if } l2(x_i) = l2(x_0) \\ \frac{j(x_i)-log_{10}(j(x_i)}{N} & \text{if } l2(x_i) \neq l2(x_0) \wedge l1(x_i) \neq l1(x_0) \\ \frac{j(x_i)-log_{10}(j(x_i)}{N} * (-1) & \text{if } l2(x_i) \neq l2(x_0) \wedge l1(x_i) = l1(x_0) \\ 0 & \text{if } i = 1 \end{cases} \tag{1}$$

$$TIS_T = \sum_{i=1}^{N} share_i$$

A perfectly balanced discussion will have a TIS of 0, indicating that both the echo share and opposition are equal. An echo chamber is defined as a thread with a TIS below -0.5. Dipping below this threshold means that the share of echo posts is more than double that of the opposition posts. Threads with a TIS above 0.5 are overflooded with opposition messaging.

The opposition score is defined as the sum of shares of all messages from the opposite side of the parent argument on $level1$ (l1), while the echo score is the result of summing the shares in absolute value of all messages where $level1$ equals that of the parent.

To detect when a thread turns into an echo chamber or opposition flood, the TIS is calculated at each new posting in an iterative manner. Thus, it combines the log operator from the TIS with a time-dependent factor. This approach might enable future research to study trends in online discussions in regard to echo chamber prediction. The result is a matrix of message shares, calculated at each new posting in the thread at that point in time. Dynamic scoring follows the TIS equation(1) in which thread size N equals message index i at the point of calculation.

3.2 Message Interactivity Contribution

Alongside the indicators calculated at the thread level, individual posts receive a diversity score representing the extent to which this post at the time of posting contributed to the thread in terms of interactivity. Simply put, if the new post presents an argument that has not been part of the discussion, it contributes more to the thread compared to when perspectives are repeated. Subsequent repetition of identical arguments are downgraded by the individual log operator, which decreases the more an already presented argument is added. The message contribution of reply i is calculated as follows:

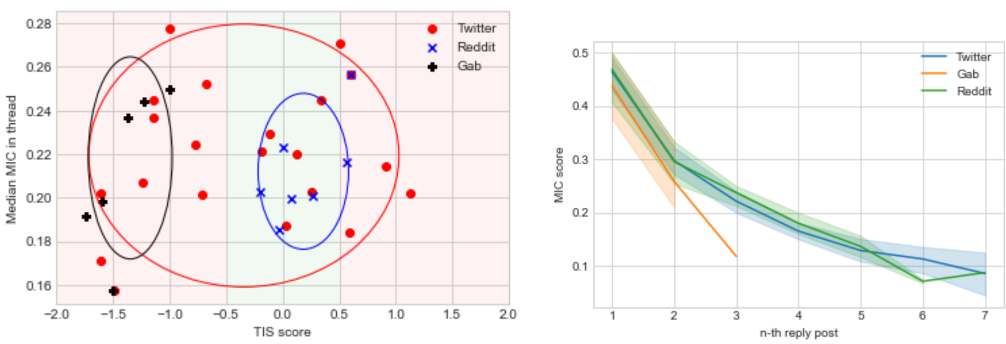
$$MIC_i \begin{cases} \frac{1-log_{10}(j(x_i))}{i} * w^{-1} & \text{if } l2(x_i) = l2(x_0) \\ \frac{(1-log_{10}(j(x_i))}{i} & \text{if } l2(x_i) \neq l2(x_0) \\ 0 & \text{if } i = 0 \end{cases}$$

To derive this MIC indicator, the message share at that point in time is calculated using the individual log operator, which decreases if an argument was already prevalent in the discussion. This share equals one minus the log of the cumulative count of the argument, i.e. j, divided by the number of arguments in the thread at the point in time of the message (i). The first post of a thread always receives MIC equal to zero, as it is not a reply and due to the thread score remaining zero at that point in time. When the parent argument is repeated, the contribution is downgraded by the inverse of the weight. Large MIC values indicate greater contribution to the argument diversity within the thread. Following Equation 3.2, the MIC in a thread converges to zero as the thread size grows.

To determine whether a message is an interactive contribution to the thread in terms of argument diversity, the current MIC value of post i is compared to that one of the previous post $i-1$. Replies with a greater MIC score than the previous post are deemed interactive contributions. In case the first reply post contains identical argumentation to the original post, it cannot be seen as a contribution in terms of interactivity.

4 Results

The first obtained indicator is the Thread Interactivity Score (TIS), the overall score as a whole, plotted alongside the median MIC score in the thread (Figure 1a). TIS informs you whether the thread is an echo chamber, balanced debate or opposition flood. Balanced discussion is found when the TIS falls within the interval $[-0.5, 0.5]$, indicating a somewhat equal distribution of arguments. Threads with a score below -0.5 are deemed echo chambers, above 0.5 as opposition floods where the parent argument is overflooded by opposing messages. For this particular illustration, the weight for *punishing* repetition of the parent post was kept at 1.1.



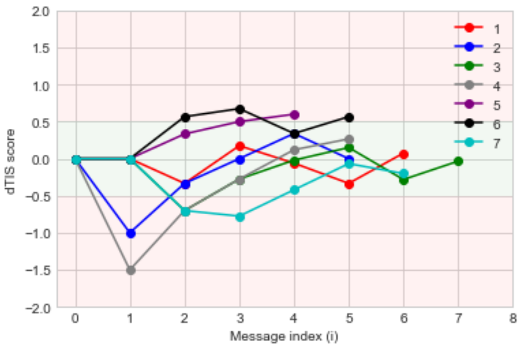
(a) Dynamic TIS. **(b)** Average MIC at the n-th reply, 95% ci.

Figure 1 Dynamic TIS & MIC scores, Black Pete case study, by platform.

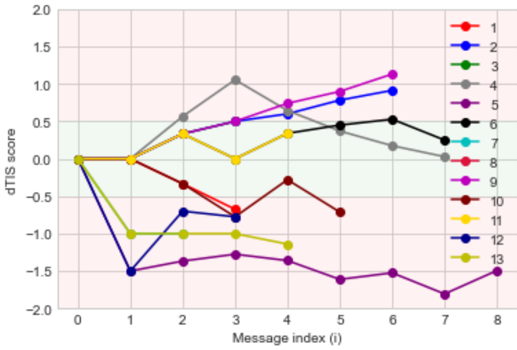
The three online platforms showcase different characteristics in regard to overall thread status, at least in this dataset (Figure 1a). Gab appears to exclusively host echo chambers, confirming previous research [14]. The “Zwarte Piet” discussion on Reddit, however, results in balanced discussion with the exception of two threads. Finally, the TIS result indicates that one finds variability on Twitter regarding the thread status, with both echo chambers, balanced discussion and opposition flooding found in this dataset (Figure 1a). That being said, the 21 Twitter threads plotted here do collectively shift slightly towards echo chambers.

The dynamic TIS (dTIS) informs how a thread developed in terms of argument diversity and interactivity. Figure 2 visualizes threads from all included platforms. One can infer from the dTIS when a thread becomes an echo chamber (dipping below -0.5) or if it returns into the green zone, indicating a balanced discussion.

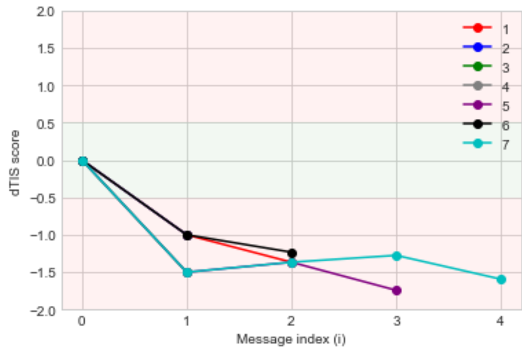
Figure 2 indicates that Gab lacks any argumentation from one side of the aisle, resulting in direct echo chambers. Secondly, threads on Reddit bounce back towards balanced discussion even when the first replies pull the thread towards an echo chamber. Furthermore, the variability in thread structure on Twitter are once again visible. Some discussions are echo chambers from the first reply onwards, never experiencing opposite messaging (e.g. thread 5, thread 13), others bounce back and forth between balanced and echo chamber (thread 10). On the other side of the spectrum, threads steadily grow towards opposition flood, meaning that every new reply to the thread argued against the parent message (thread 2, thread 9).



(a) Reddit, n=7.



(b) Twitter, first 14 threads.



(c) Gab, n=7.

Figure 2 Dynamic TIS scores per platform, balanced discussion in $[-0.5, 0.5]$.

Moving on from the thread scoring, the MIC score reflects how much the post in question contributed to the argument diversity at that point in time. Figure 1b summarizes this scoring by averaging the MIC score at each subsequent reply across platforms in the dataset.

In the case of Gab, where maximum thread size is four, it is clear that, due to the absence of diversity in arguments, replies quickly diminish in terms of contribution. Due to the linear MIC decline in the scraped threads, no reply posts can be deemed beneficial contributions in terms of argument diversity.

However, this cannot be said for the threads scraped from Twitter and Reddit (Figure 1b). The decline in message contribution is less steep compared to Gab. Furthermore, on Reddit, 14 replies were deemed interactive, meaning that the MIC was larger than the previous message. In the case of Twitter, 30 replies were found to be interactive, accounting for about a quarter of included comments.

In the case of the "Zwarte Piet" dataset used for this calculation, one could infer that the most diverse debate in terms of argumentation is found on Reddit, due to the fact that a larger share of comments are deemed interactive, combined with the absence of a field dominated by echo chambers. However, this dataset is limited both in scope and size. While these indicators can be used to explore online discussions, in this instance it is a mere illustration of the calculation and variables.

5 Discussion & conclusion

This short paper presented a calculation procedure for two metrics for estimating echo chamber effects in online discussion threads. The case study, focusing on the "Zwarte Piet" discussion in the Netherlands, illustrated how the debate exists on different online platforms. Threads belonging to the right-wing network Gab exclusively fall into the echo chamber category, in line with the literature [14, 23]. In this specific dataset, the discussion around the "Zwarte Piet" figure on subreddit r/thenetherlands falls mostly within the balanced category. Previous research put forward varied results in terms of echo chambers on Reddit depending on the subreddit in question [15]. Concerning the valuation of replies, the Reddit threads hold a larger share of interactive comments compared to Twitter. Furthermore, the discussion on Twitter experiences wide variability with a slight collective shift towards echo chambers. This divergence in thread status is reflected in previous research on the social media platform, as studies report a variety in results regarding bias and homophily on Twitter feeds [3, 21, 19]. Political studies as well as studies focussing on climate change tend to point towards echo effects on Twitter [8, 22].

Posts deemed interactive by MIC calculation can be valuable for stakeholders. Journalists and moderators aim to have engaging forum discussions on their platform with a large number of participants. Academics might look at interactive posts to map out discussions, understand echo chambers and what effects they have on deliberative debate.

While the discussed indicators do confirm previous research, the approach is not without its limitations. First, for the approach to provide valid and qualitatively sound scoring, an annotated dataset is needed. This data ought to be labelled for the specific argument or debate stance put forward in the message. Without substantiated labelling, the scoring loses value and interpretability. However, as illustrated by the case study, when threads are well-annotated, the scoring yields understandable results.

The TIS and MIC scoring informs about the status of a thread and contribution of a message in the discussion in terms of argument diversity and interaction across argumentative camps. However, what it lacks is any indication on the quality of the interaction taking place. Understandably, a wide variety exists in terms of constructive communication among posters on internet platforms and social media. This approach operates at the coarse pro/con and basic argumentative levels, ignoring further depth of the communicative discourse.

Further research is needed to address these limitations. The current study is small in scope and size. A larger case is needed to rigidly map out echo chambers on online platforms with the goal of being independent of topic, platform or language. Different weights for parent argument repetition ought to be included as well in order to pinpoint the effect. Additionally, the concept of interaction in online discussion needs to be unpacked in further detail by developing estimators for qualitative features of interaction. By introducing gradation in terms of discursive quality in the process of valuating reply contribution, the depth of such interaction can be included. Studies to come will pinpoint just that aspect of online threads in order to fill this gap. Moreover, future work will focus on the automatic labelling of online posts in regard to presented argumentation. While in this proof-of-concept study this was done manually, the automatic annotation of pro- and con-statements allows for a computational pipeline for echo chamber detection from the ground up. Upcoming research will address just that, using the "Zwarte Piet" case as well as other discussion cases to include broader topics that do not showcase such strong binary distinction between pro- and con-groups.

The concrete necessity to better outline and understand online discourse and echo chambers becomes more urgent as social media and other online platforms acquire dominance in societal conversation. As this trend progresses, so does the need for research to follow that path and develop automated methods that help detecting adverse and toxic discourse and communication. The presented calculation aims to contribute to this challenge by expanding the computational possibilities for forum and discussion moderation.

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