Twitter Bot for Activation of Online Discussion and Promotion of Understanding by Providing Related Articles

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Abstract. Twitter has been used in academic conferences and study meetings as a means of debating announcements and sharing information, alongside a real presentation. This paper discusses activating online discussion on a Twitter timeline and promotion of understanding. Accordingly, we developed a Twitter bot which suggests related webpages via tweets. This paper describes the deployments of our bot in two types of meetings: lightning talk format and relaxed group meeting. We report whether it was capable of providing appropriate topics and users' reactions to the bot in these meetings.

Keywords: Twitter bot · Activation of discussion · Keyword extraction from timeline · Documents provision to timeline

1 Introduction

The spread of the Internet means that currently, in academic conferences and study meetings, some participants attend to a presentation while simultaneously looking up questions on the Internet and arguing with other participants online using Social Networking Services (SNS) [1]. However, the meeting or presentation progresses while participants search, and they may lose track of the meaning. If the meeting progresses while participants do not understand, they may not be able to understand the next topic and as a result it is difficult for new discussions to occur.

The purpose of this study is to take the hassle out of searching for more information during meetings, and to activate online discussion by providing participants with new awareness to promote understanding. Therefore, we developed a Twitter bot which provides related information to participants in an online discussion by tweeting in real time. First, the bot analyzes tweets in online discussion, then extracts a keyword which is determined to be at the center of the discussion. After this, the bot searches on websites to which papers have been published, as well as news sites, and finally provides search results for participants in the form of tweets.

Also, we operate this bot in academic conferences and study meetings. We survey how the bot affects online discussion by observing whether the bot tweets

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promote new discussion between participants and users' responses (reply, retweet, like) to the bot tweets.

By introducing this bot into online discussions and providing participants with related webpages in real time, we can enable participants to get more related information without taking time out from attending to presentations to make searches. Furthermore, we hope to see effects such as occurrence of new discussion between participants, resolution of questions, and promotion of understanding.

2 Related Research

2.1 Support of Group Discussion

The purpose of this study is to support group discussion in terms of activating discussion and promoting understanding in online group discussion. Two examples of similar studies are Sumi's "AIDE" [2] and Akagawa's "INGA" [3] systems.

"AIDE" is a real time electronic conference system which has a function for chat via a network. This system is able to promote cooperative thinking among participants by visualizing the interactive structure of discussion.

Also, "INGA" is a system for assisting in activation of research discussion and facilitation of knowledge inheritance among participants. This system uses a microphone to record participants' voices during a conference, and extracts some keywords from the contents of the statements. Participants are then able to check the keywords and search the electronic data of related conference documents. In addition, this system sends some appropriate documents to participants' tablet devices. Participants are able to take notes and share the contents with each other in real time. This system enables participants to cooperate in assessing the electronic data and sharing the knowledge among themselves.

AIDE and INGA are closed systems with limited users. In contrast, our experiment focuses on allowing anyone to easily take part in discussion by using Twitter, which is a generally wide-spread a forum for discussion.

2.2 Information Provision by Agents

In this study, the Twitter bot estimates the key topics of meetings and provides participants with related information. The Kitamura group conducted research on a cooperative information retrieval system [4] and a competitive information recommendation system [5] using multiple character agents, as systems in which agents other than the users provides information for the users. These systems require the learning, via interaction with agents, of information that users need, whereas our study, on the other hand, changes the target of topic estimation from an individual participant to an entire discussion, and provides participants with related information without having to have this information entered intentionally.

2.3 Using Twitter in Meetings

Studies relating to Twitter, a site which anyone can use easily, include "PPTwi" [6], developed by Kurihara, which is an add-in that allows alterations made beforehand in the 'notes' column of a Microsoft Powerpoint presentation to be automatically tweeted, "Vital Atlas" [7], developed by Takeuchi et al., which is a system to visualize the spread of information by recursively clustering tweets displayed in chronological order. Furthermore, there have been studies on visualizing the data on Twitter [8,9].

These systems merely present information that has been entered in advance or analyze tweets on a timeline, whereas our study aims to analyze tweets in real time and provide optimal contents for discussion participants.

Also, it is important for the promotion of discussion and understanding that Twitter bots provide related information to participants directly. Regarding research on Twitter bots, Yamada developed a Twitter bot called "Ronbutter" [10]. This system regularly searches CiNii for papers with relevant content, on the basis of trend information on Twitter, then tweets the search results to general users.

However, this system is not able to narrow down the subject of discussion because the information provided is trend information for the entirety of Twitter. In contrast, our study is limits the target of discussion to conferences and study meetings currently being conducted, extracts a central topic, and provides information suitable for that specific discussion.

2.4 Keyword Extraction in Online Meetings

In our study, it is necessary to extract an appropriate keyword from participants' tweets in order to select webpages strongly related to the contents of the discussion.

There are several techniques for extracting keywords from text. To take some existing algorithms, there are TF-IDF [11], Key Graph [12], machine learning by SVM [13], LDA [14], and DTM [15]. Also, there are studies which assume that a word with a high instantaneous burst degree is important [16]. Other studies use a web-page ranking algorithm [17] to determine the importance of words [18], and estimate a main topic [19]. Also, there has been a study on summarizing single documents by using lexical chains [20]. Based on this study, Hatori et al. use lexical chains to extract key sentences and topics from corpuses [21]. However, these techniques require other texts (corpuses), besides the text from which keywords are to be extracted, or are not suitable for operation in real-time. For this reason, these techniques are not suitable for our research, which requires the successive extraction of keywords from tweets.

3 A Bot to Support Discussion on Twitter

This chapter describes the flow of our system and the techniques used in the development. Figure 1 is a concept diagram of our system.

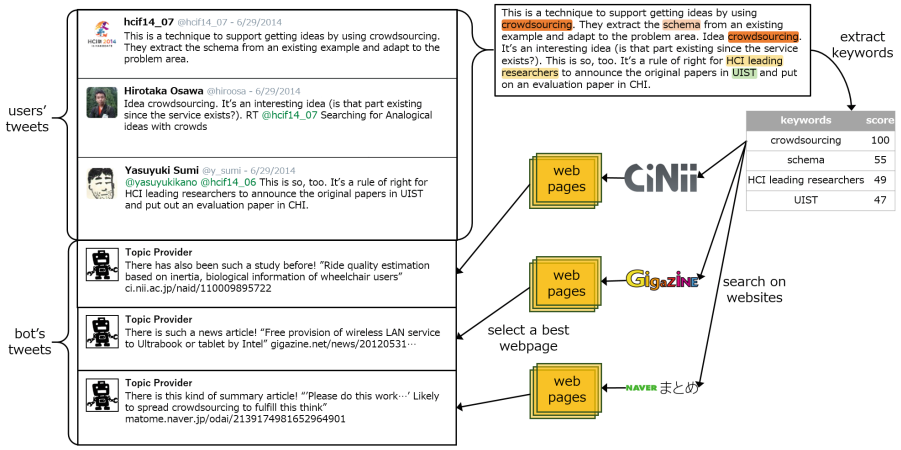

Fig. 1. Conceptual diagram

3.1 Overview of the Twitter Bot

In a meeting, Twitter is generally used with specific hash tags created for the meeting. Accordingly, the bot first searches Twitter for tweets which contain these hash tags, then stores the tweets in sequence. When a sufficient number of tweets have been saved, or a specified amount of time has passed, the bot extracts one keyword which is considered to be closely related to the meeting. Next, the bot uses the keyword to search within some websites to which papers are published, then finally tweets the titles and URLs of the webpages obtained as a result of the search, accompanied by the meeting-specific hash tags.

3.2 Keyword Extraction from Tweets

The first stage in this process is to obtain all the tweets which contain the specified hash tags, by using Streaming API. Streaming API is a form of API that can obtain tweets in real time via continuous HTTP connection. The second stage in the process is to continue storing tweets as text data, while removing excess information such as hash tags or URLs, until a certain amount has been stored. The final stage is to analyze the stored tweets and extract a keyword.

An appropriate timing for keyword extraction must be set depending on factors such as the number of participants and the presentation style of the meetings in which this system is used. For example, if a meeting is divided into a series of sessions, the bot will be set to select one keyword from all the tweets made during a single session and tweet the result at the end of the session. In other situations keyword extraction could be set to occur when a specified criterion is met, such as a certain period of time having passed, a certain number of characters having been used, or a certain number of tweets having been made.

Also, our system uses a text analysis API provided by Yahoo! JAPAN to extract a keyword. Using this API it is possible to analyze given texts and

extract characteristic expressions (key-phrases) and their corresponding degrees of importance (score).

However, when using this API it is not uncommon for unknown words containing symbols or similar to be selected, leading to the extraction of a useless keyword. To avoid this, our system selects only the highest scoring keyword from among those that exist as titles of Japanese Wikipedia articles. A list of titles from Japanese Wikipedia is summarized and stored in the database in advance. Key-phrases are checked in order of score, beginning with the highest, until one is found that exists in the database.

3.3 Searching on Websites, and Tweets

Our Twitter bot searches on three websites: CiNii, Gigazine and NAVER matome. CiNii is an academic information database, Gigazine is a news site in blog format, and NAVER matome is a CGM-type web curation service. We decided these three websites to provide relevant past research papers from CiNii, and recent related topics from Gigazine or NAVER matome. When searching, the API provided by each website is used, or in the case of there being no provided API, the Bing Search API provided by Microsoft Azure is used.

Search results can be considered in order of relevance or date, but it is not guaranteed that the highest ranked website will be related to the content of the meeting. To resolve this issue, our system obtains a maximum of ten search results from each website in order of date, and selects the best webpage by using tf-idf [11] and cosine similarity estimation method [22] to determine the degree of similarity between the content of tweets made at the time of keyword extraction and the content of the webpages. The webpage with the highest degree of similarity is chosen as the best. By taking this approach, it is possible to select a webpage which is closer to the contents of the discussion, as this method does not depend solely on the highest scoring keyword, but also considers words which were not chosen as keywords yet which are nonetheless distinctive and relevant to the meeting.

After the webpages have been selected, the Twitter bot provides tweets including the titles and URLs of obtained webpages for users taking part in online discussion. This bot provides one tweet per website. If there are no search results, the bot does not tweet about the website. Also, if a useful keyword cannot be obtained, no search is carried out and the bot does not tweet.

4 Operational Experiment Conducted at a Lightning Talk Format Study Meeting, and Corresponding Considerations

We operated the Twitter Bot at “CHI study meeting 2015” which was held on June 27, 2015. This chapter describes the overview of the experiment, the results, and our considerations.

4.1 About "CHI Study Meeting 2015"

"CHI study meeting 2015" was a study meeting in which 485 papers presented at an academic conference, CHI 2015, were introduced in presentations of 30 seconds per paper. About 150 people participated in this meeting, and 49 people used Twitter during this meeting. Figure 2 is the overview of this meeting. This meeting was divided into 114 sessions consisting of three to six papers, and one person was responsible for one session and presented. This meeting was carried out at DMM.make AKIBA in Tokyo and Hokkaido University in Hokkaido. When a presentation was being made in one of the venues, the audio from the presentation, and the slides that were being used, were broadcast online in the another venue. Also, when each paper was presented, the title of the paper and an introduction of the contents, prepared by the presenter beforehand, were tweeted to a Twitter account specially created for the provision of information in this meeting.

Thus, we assumed that many of the participants used Twitter during the meeting, because the meeting was held in two different venues and Twitter was used to introduce papers.

Fig. 2. Overview of lightning talk format study meeting, "CHI study meeting 2015"

4.2 Overview of the Experiment

In this experiment, tweets made over the course of one session were treated as one text, and analyzed, and a keyword was extracted. Next, a search was carried out in CiNii, Gigazine and NAVER matome. Finally, the Twitter bot tweeted at

the end of each session. Besides this, participants took notes and tweeted their opinions on Twitter using a common hash tag.

Incidentally, it was stated in Sect. 3 that only the highest scoring keyword that existed as the title of a Japanese Wikipedia article would be selected, but this was not implemented in this particular experiment. We used the obtained keyword directly. Additionally, it was previously explained that the best webpage was selected by determining the degree of similarity to tweet content using tf-idf and cosine similarity estimation method, but this also was not implemented. The top-ranking webpage from among the search results was automatically selected.

4.3 Results of the Experiment

One of 114 sessions, we were able to extract a keyword in 100 sessions by excluding the sessions in which participants did not tweet. Also, out of those 100 sessions, we were able to obtain a keyword that could be considered useful in 47 sessions. In other sessions, common words such as "user" or "display", and words containing symbols were extracted.

Example of when appropriate webpages were provided. Table 1 shows an example of when the bot successfully extracted a useful keyword and provided appropriate webpages to participants in the meeting. "hcihokkaido" was an account created in order to provide the information of each paper's title and introduction of content, and "bot" was the Twitter bot that we made. Incidentally, all tweets contained a hash tag in the meeting, but it is omitted from the table, partly because it was not used to extract a keyword and also for the purpose of simplification.

In this section of the meeting, a finger-mounted device called "FingerReader", which assists visually impaired people to read sentences, was being presented. A keyword, "active reading", was successfully extracted and two related webpages provided.

Results obtained through the study meeting. We anticipated that participants would "like" some of the bot tweets and "re-tweet" them, or that new discussion would be generated as a result of the tweets. However, participants displayed almost no reaction to the bot during the meeting. Out of 233 bot tweets, only 7 tweets were reacted to by participants. Analysis of the timeline of the meeting reveals that out of a total of 342 tweets made by participants, only 18 tweets were replies to other participants or reference tweets. Figure 3 shows the tendency of the user's tweets.

4.4 Considerations

Regarding keyword extraction, less than half of all keywords selected could be considered useful. Accordingly, it is thought necessary not to simply use the Yahoo! JAPAN text analysis API, but also to contrive other methods of keyword extraction.

Table 1. Example of when appropriate information was provided (part of timeline of study meeting, translated from Japanese)

Username	Tweet
user01	UI of a belt is like “007”
hcihokkaido	RegionSpeak: Quick Comprehensive Spatial Descriptions of Complex Images for Blind Users http://t.co/OS6FVB0C2S
user02	I want to experience. https://t.co/rkSmh1G6eq
hcihokkaido	FingerReader: A Wearable Device to Explore Printed Text on the Go http://t.co/Cmec3onksU
hcihokkaido	Collaborative Accessibility: How Blind and Sighted Companions Co-CreateAccessible Home Spaces http://t.co/nQ9sFbakwQ
user03	@hcihokkaido Device to strengthen an active reading. It’s good idea
bot	I search “active reading” in CiNii. Result: “On the Ambiguity of Sentences with Natural Language Quantifiers” http://t.co/ywcZX7y2fI
bot	I search “active reading” in Gigazine. Result: “Scientists revealed how brain wor···” http://t.co/qhKdBTOBSA

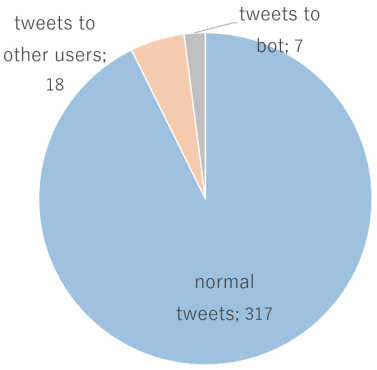

Fig. 3. Tendency of users’ tweets

Furthermore, no significant participant reactions to the Twitter bot were observed in the lightning talk format study meeting. However, from analysis of the timeline it is evident that participants’ purpose of using Twitter was to make memos rather than to hold discussion. It is thought that the reason for this may be that participants found it difficult to enter directly into online discussion with other participants who they did not know.

Concerning the reason that almost no reactions to the bot were observed, this is probably also because participants did not use Twitter to discuss with other participants but to take notes. Besides this, the bot tweets were monotonous,

containing only titles and URLs. Evidently it is necessary to devise a way to make the wording of these tweets less monotonous.

5 Operational Experiment in Group Meetings

Taking into account the results from the lightning talk format study meeting, we devised new methods of keyword extraction and webpage selection, and operated the Twitter bot in study meetings in a laboratory. This chapter presents an overview of the experiment and some characteristic results.

5.1 Overview of the Experiment

In this experiment, 15 university students, 7 fourth-year students and 8 third-year students, participated in a meeting in which 4 of the fourth-year students made presentations to the other participants. The contents of the presentations were an overview of their current research, achievements and future prospects. The 15 participants all used Twitter to take notes and discuss, which compensated for the fact there was insufficient time taken for the question-and-answer session. One presenter was assigned 10 min to speak, and the meeting was held over approximately 40 min.

5.2 Results of the Experiment

The bot tweeted ten times, and five tweets were reacted (liked) to by users. This section presents some characteristic results along with the corresponding timelines.

Example of provision of appropriate webpages. Table 2 shows an example of when the bot successfully provided appropriate webpages for participants in this study meeting.

During the time that the tweets in Table 2 were being made, a study on activation of library usage through introducing a prisoner's base game was being presented. Figure 4 depicts the overview of the study meeting. The Twitter bot provided two webpages, one of which was a research paper about gamification in libraries, similar to the work being presented. This research paper was closely related to the contents of the meeting. Also, the presenter did not know of this paper and stated in the post-meeting questionnaire that it would be very useful as a piece of related research. This confirms that the bot was able to provide useful related information.

Table 3 shows the results of keyword extraction using the text analysis API provided by Yahoo! JAPAN. The highest scoring word was "gamification", and this word existed as the title of a Japanese Wikipedia article. Therefore, this word was selected as a keyword.

Also, Table 4 shows the results of searching for "gamification" within CiNii, and the calculation result of the cosine similarity between the webpages found

Table 2. Example of when appropriate information was provided (part of timeline of group meeting, translated from Japanese)

Username	Tweet
user12	This is a study about activation of library usage through gamification
user12	He wants people to use real-world libraries more
user12	By using prisoner's base game
user14	Using gamification to entice people in?
user03	Using library ⇔ Gamification
user04	'A chance encounter with books' has a nice ring to it doesn't it
user08	A study posting photos already exists
user12	At first users' objective is to play the game, but gradually, going to the library becomes their objective
user10	There is also this previous research. I didn't know about it
bot	There has also been such a study before! "Possibility of Gamification as an'escape game' in a university library" ci.nii.ac.jp/naid/120005588···
bot	There is this kind of summary article! "#Gamification Geeks 2015.12.08 :: iglobe Inc." matome.naver.jp/odai/214494283···
user01	The literature about escape games and library usage looks interesting!
user15	@user01 Is there such literature?
user01	@user15 It was shown a moment ago
user14	@user15 @user01 The provider tweeted it

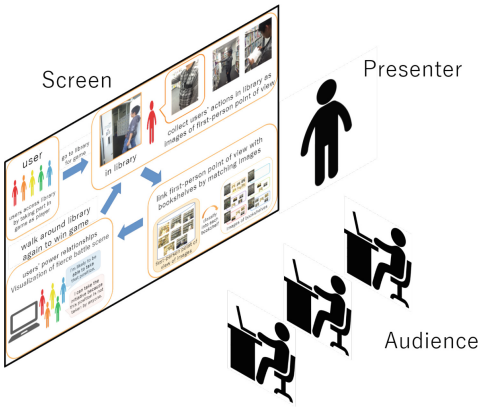

Fig. 4. Overview of group meeting, Example slide of work on "Library usage and Gamification"

Table 3. Results of keyword extraction (translated from Japanese)

Keyword	Score
Gamification	100
Library usage ⇔ gamification	44
Real-world	40
Prisoner's base	31
Game	26
Purpose	24
Previous research	22

Table 4. Results of search for "gamification" in CiNii and Cosine similarity between tweets and webpages (translated from Japanese)

Article Title	Cosine similarity
Design for W-DIARY, a diary-style-application for English word learning, with existing photos	0.0847
Demonstration of Character Rearing Game Application in Delay Tolerant Networks	0.057
Communication Support with Game-like Methods	0.0544
The possibilities of using gamification in information literacy education: examples from overseas libraries	0.0444
Effects of Gamification-Based Teaching Materials Designed for Japanese First Graders on Classrooms	0.0365
From NTT Data Technology using gamification and verification in the business field	0.0134
Possibility of Gamification as an 'escape game' in a university library	0.2426
Active Learning through Disoassion and Negotiation: Using University Education as Materials	0.012
Development and Practice of Gamified Coursework Design Framework (Paper on Educational Practice Research)	0.0509
Effects of Presenting Rank Order Generated from Subsets	0.0089

and the contents of tweets. From among 10 webpages obtained by searching, the bot was able to select a very closely related webpage about gamification in libraries. Therefore, it can be considered that calculating cosine similarity of content is a useful webpage selection technique.

Many participants were interested in this tweet, and five participants "liked" it. Besides this, several participants referred to the CiNii article and were able to obtain additional information, including the presenter ("user15"). Therefore, the result was useful in terms of providing new knowledge.

Example of failure to provide appropriate webpages. Table 5 shows an example of when the bot was not able to provide appropriate webpages.

Table 5. Example of when the bot failed to provide information (translated from Japanese)

Username	Tweet
user09	It looks interesting
user12	It's a book search based on individuals' reading experience
user03	Speaking of the universe... ☆
user12	Association is different for each person, so it refers to that
user06	The images are cute
user14	Apparently it's possible to obtain specialized search terms from the dictionary of a scholar in a specific field...
user08	This is good. It looks useful for when you don't have keyword to search by
user12	You can look at not only abstract but also professional ones
user05	I'd never have come up with that word...!
user15	I have heard of String theory, but what actually is it?
bot	There has also been such a study before! "Evolutionary learning of hysteresis neural networks" ci.nii.ac.jp/naid/400205244···
bot	There is such a news article! "'The steak at that time was delicious...' Greasy foods have..." gigazine.net/news/20090502···
user07	I want to eat steak

During the time when these tweets were being made, a presentation was being made about research on making associative dictionaries based on individuals' associations, and applying this to book searching. The keyword "association" was extracted. From CiNii the bot provided a paper about an evolutionary learning algorithm for hysteresis associative memory, based on greedy algorithm. On the other hand, from Gigazine the bot provided a useless article about the relationship between long-term memory and meals containing lipids. As these results demonstrate, even if a useful keyword is obtained the provided webpages will not necessarily be appropriate.

5.3 Considerations

The results of this experiment showed that participants discussed with each other freely in a study meeting among acquaintances. Also, that the method of webpage selection by calculating cosine similarity was a useful technique.

However, in the current method the bot tweeted about useless webpages, thus it is necessary to find methods to prevent the bot from tweeting in the case of a useless result, such as introducing a threshold of cosine similarity.

6 Continuous Use of the Twitter Bot

In the group discussion experiment described in this chapter, we were able to prompt participants to discuss and provide new information. Nevertheless, it is thought that because the participants were not yet accustomed to the bot, they did not check the bot tweets and the tweets did not tie in to their discussion. Therefore, we continuously operated the bot in an online group discussion and investigated the reactions of the participants. This chapter presents an overview of the experiment and characteristic results.

6.1 Overview of the Experiment

Out of the participants who took part in the group meeting described in Chap. 5, five participants discussed their individual graduation research, using Twitter.

In this experiment, the frequency of bot tweets was determined by the total number of characters of user tweets made thus far. In particular, useless information such as hash tags or URLs was removed from the participants' tweets, and the remaining data stored as text. When the number of characters of the text, which was converted to UTF-8, surpassed 2000, a keyword was extracted. The reason for using number of characters, rather than amount of time, to set keyword extraction frequency was that the discussion was not separated into sessions or fixed time slots. Also, the reason it was essential to convert the text to UTF-8 was that the Yahoo! JAPAN text analysis API requires search queries to be in UTF-8 format.

6.2 Results of the Experiment

In this meeting, the twitter bot tweeted eleven times, and six tweets were reacted (liked and retweeted) to by users. Besides there were many interactions between users, 28 tweets were replies in all 103 tweets.

Table 6 shows one of the characteristic timelines. At this time, participants were discussing a study conducted by "user04" on linking onomatopoeia and actions.

From this timeline, the keyword "onomatopoeia" was extracted and the bot was able to provide three webpages. One of these, an article from Gigazine, was closely related to the current discussion, so "user01" and "user05" reacted to it. In response to the reactions, "user04" explained to other participants the difference between the contents of the article and his own study.

6.3 Considerations

In this experiment, there were many exchanges of opinions between participants, and many remarks about the bot tweets, in contrast to the study meeting experiment detailed in Chap. 5. One reason for this difference may be that the second experiment centered on discussion in a small group. Additionally, it is thought

Table 6. Timeline when we continue to use Twitter bot (translated from Japanese)

Username	Tweet
user04	The thing that pains me. It's onomatopoeia
user01	Onomatopoeia
user02	What were the results of the onomatopoeia experiment in the end?
user05	I can't resist pronouncing "onomatopoeia"
user04	Onomatopoeia is tormenting me
user01	"Onomatopoeia" isn't on Wikipedia, but "Giseigo" is
user04	Changes were seen in the onomatopoeia of the same motions depending on environment
user04	The next thing is how to link it to the attributes of characters
user05	In line-of-sight measurement, the only thing I understood was that there's a difference in the length of time between when people are suffering and when they're not
user02	@user04 So did you finally calm down after all?
bot	There has also been such a study before! "Instruction on'expression' of the child care and education content (expressive body movements)..." ci.nii.ac.jp/naid/400188785···
bot	There is such a news article! "Online dictionary that automatically collected examples of onomatopoeia..." gigazine.net/news/20080229···
bot	There is this is kind of summary article! "Twitter bots that you can't understand (Cuisine and Ingredients)" matome.naver.jp/odai/214089614···
user05	Ah, had it already been researched...?
user01	There is a dictionary of onomatopoeia!
user04	This only publishes examples, but my study analyzes actual movement data to determine whether you can really pronounce the sounds. Probably

that participants had become more accustomed to group discussion online than before, and had come to understand what kind of tweets the bot makes. Furthermore, this discussion was not separated into time slots, allowing participants to take the time to read the webpages provided by the bot. From these results, it is expected that if participants are accustomed to meetings of this format and are afforded time to read the webpages, promotion of understanding and the further development of discussion can be achieved.

Participants expressed the opinion that there was not time to read all the webpages provided by the bot. For them, three webpages per keyword are too many. Therefore, it is necessary to reduce the number of webpages presented at one time, or consider ways to allow participants to understand the content in a shorter period of time.

7 Conclusion

This study was carried out to develop a Twitter bot which provides related articles to participants in meetings in order to facilitate livelier discussion and promote understanding. The method used involved obtaining tweets during meetings and extracting a characteristic keyword. Using this keyword, the bot searched in several websites and selected one best webpage from each website by using the tf-idf and cosine similarity estimation method. Finally, the Twitter bot tweeted the titles and URLs of the webpages.

The bot was operated in various study meetings, to investigate whether it was able to provide appropriate webpages and affect online discussion. The results of the operating experiments reveal that there were a little effects in online meetings in which the participants did not know each other, and that participants used Twitter as a means to take notes rather than to discuss. On the other hand, our system was able to provide informations which the users prefer and the participants discussed actively and made new realizations as a result of the bot tweets.

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