Vision-impaired Users on Online Social Network

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ABSTRACT

In this paper we present the first large scale study of how visionally impaired people use online social networks, particularly Facebook. We identify a sample of 50K visionally impaired users, and study their activities, content, and friendship networks on Facebook. We find that vision-impaired actively engage with the major activities on Facebook as the general population do, but receive more comments and likes on their content from other users. When analyzing the content produced by vision-impaired users, we also find that they openly share their experience and issues related to vision disability, and show distinctive patterns in language and technology usage as a group. We also show that vision-impaired users have relatively smaller and denser social networks, but the gap in these structural properties has been decreased through time. Our findings have implications for improving the utility and usability of online social networks for vision-impaired users, and can shed light on the design of more accessible sociotechnical systems.

Author Keywords

Vision-impaired users; vision disability; social media; social networking sites; Facebook;

ACM Classification Keywords

H.5.m. Human Factors: Measurement

INTRODUCTION

Vision-impaired people have formed a large part of the world population. Recent statistics [16, 7] show that there are 285 million visually impaired people worldwide and 6.6 million in the US. However, the presence of vision-impaired users on the Internet has been largely overlooked, partly due to the delayed devolopment of web accessibility technologies, and partly due to the lack of systematic methods to identify and reach out to this particular population. Among the small number of existing work on blind users on the Internet, most of them focused on the usability and accessibility of onine services, reporting results collected through survey and in-person interviews. As a result, how visually impaired users interact with the Internet at a large scale still remains a puzzle to us.

This paper is the first attempt to answer this question empirically with big data. Motivated by previous research highlighting the value of online social networks to people with disabilities [3, 4, 8], we are especially interested at how vision-impaired users engage with social networking sites, particularly, Facebook.

In this paper, we present insights about the use of Facebook by vision-impaired users in several perspectives, including the activities they engage with, the content they produce, and the structural characteristics of their friendship networks. Our study is motivated by the following research questions:

1. What do vision-impaired users do on Facebook? Are their behavior patterns distinctive from other users?

2. When vision-impaired users engage with social networking sites, what kind of content do they produce, share, like, and how does the network interact with them? Are people aware of this particular population online? Do they receive more social support in a large, general-purposed social network like Facebook?

3. How do vision-impaired users' social network look like? Previous research suggested that blind users have smaller social networks, to what extent this is true for vision-impaired users on Facebook?

RELATED WORK

[15] demonstrates the popularity of mobile technology, especially smart phonts, among blind population, showing that mobile apps are more accessible than desktop apps.

[9, 1] present recent research efforts on blind photography.

[2] discusses the usefulness of social network as a resource for blind users.

DATA

Equipped with free screen reader software and the a variety of assistive applications[1], the Apple iPhone has become one of the most popular devices among blind users [1]. Also, with a great design emphasis on accessibility from the beginning, Facebook's mobile interface has known for being more accessible and usable for blind users[15]. We therefore only focus our study on users who access Facebook on their iPhones, through Apple's default screen reader service (VoiceOver).

[1]For example, TapTapSee (**`http://www.taptapseeapp.com/`**), VizWiz [9].

CHI'14, April 26–May 1, 2014, Toronto, Canada.

DOI string from ACM form confirmation

Rank	VoiceOver sample	iOS sample
1	US (32.5%)	US (35.5%)
2	UK (7.2%)	UK (7.3%)
3	France (4.9%)	Japan (4.9%)
4	Gemany (4.3%)	Canada (3.8%)
5	Italy (4.1%)	Germany (3.6%)

Table 1: Top 5 self-reported countries for users in VoiceOver sample and iOS sample, with their percentages in each sample.

To do so, we detect a user with vision disability if he or she accesses Facebook in VoiceOver mode for at least 3 days a month[2].

We first find all Facebook users who has accessed Facebook from their iPhone in the period between June 15, 2013 and July 15, 2013. Among them, we draw a random sample 50K visionally impaired users as the **visionally impaired group**, and a random sample of 160K users who were active for at least 3 days in this period as the control group. In the rest of this paper, we will refer to the first group as *VoiceOver sample*, and the second group as *iOS sample*.

DEMOGRAPHICS

Although our study is limited to the popualation of iPhone users, given the large number of users we sampled, our sample consists of a rather diverse group of vision-impaired users in their demographics. In this section, we will present the country, age, and gender distribution of sampled vision-impaired users, and compare the with the control group of random sampled iPhone users. All the demographics dimensions we study are based on the self-reported data in user profile pages.

Country We first look at how our sampled users are geographically distributed. Table 1 shows the top 5 countries for each group, as reported in user's profile. First thing we notice is that both populations are highly concentrated in developed countries, especially, the United States (with around one thirds of users both samples). This is perhaps determined by the price and marketing strategy of iPhone as a higher-end, lifestyle-marking phone. Meanwhile, it is interesting to notice that the iPhone and VoiceOver seem to be more popular among vision-imparied users in European and American countries than Asian countries – Japan has the 3rd most iPhone users in the general iOS sample, but only ranks at the 14th in the VoiceOver sample. Overall, although our sample of vision-imparied users are highly skewed towards people from developed western countries, it achieves a much more significant level of geographical diversity compared to previous studies, with users from 183 different countries.

Age Not surprisingly, both samples are skewed towards young adults, with over 50% of the people in their 20s and 30s, slightly less than one quarter of the people in their teens, and around one quarter above 40 years old. There are only a few people in our sample who do not fill in their ages, and we also filter out people who self-reported as being over 90 years old. The average age for the VoiceOver sample is 30.14 years old, and for iOS sample is 30.43 years old. We do not see significant difference in terms of age distribution between the vision-impaired user group and the control group.

Gender Both genders are well represented in two samples. However, there are slightly more males (51.8%) than females (47.6%) in the VoiceOver sample (51.8%), but more females (51.9%) than males in the iOS sample (47.1%).

Note that although the vision-impaired users in our sample are much more diverse than previous studies in this field [15, 1, 2], it is not a fair representation of the global vision-impaired population. By constraining our study to iPhone users on Facebook, we over sample users from well-devoloped western countries, who are also younger and with relatively high income. Reaching out to vision-impaired population who are under-privileged and un-equipped with techologies and understanding their needs is definitely an important issue, but it is out of the scope of this paper due to data and technical limitations.

FACEBOOK ACTIVITY

As an online social network services, Facebook is most commonly used to share personal content (e.g., status updates, photos) and interact with content shared by friends (e.g., comments, likes). We thus focus on the four most representative activities - status updates, photo sharing, comments, and likes - and study how vision-impaired users engage with these four types of activities on Facebook. We try to understand:

- What do vision-impaired users do on Facebook? Do they generate as much content as other users?
- How do other users of the social network interact with the vision-impaired? Are they aware of the presence of vision-impaired users online? Do they engage with this population, or reject them?

To answer these two questions, we collect all the status updates, photo uploads, comments and likes by all the users in the VoiceOver sample and the iOS sample, from August 4, 2013 to August 25, 2013 (in total 3 weeks), as well as all the feedback (comment and likes) received by these content within one week since they were originated. Then we compare the volumn of content creation and feedback received across two groups.

In Figure 1, we break down user activity into three categories: content produce, feedback send, and feedback receive, and show the average value of each metric over each user group, with error bars indicating the 95% confidence interval for the mean (assuming normal distribution). For example, in Figure 1a, we count the total number of status updates and photo uploads in three weeks for each user, and plot the average value for users in iOS sample and VoiceOver sample. We can make two interesting observations from this plot: first, vision-impaired users post much more status updates than the control group; second, although vision-impaired users do upload fewer photos than users from the control group, the gap

[2] We filter out people who turned on VoiceOver once or twice, in case they enter VoiceOver mode accidentally.

is surprisingly small - vison-impaired users are producing and sharing a significant amount of photos on Facebook.

Inspired by this result, we not only look at the total number of comments and likes sent or received by sampled users, but also, in particular, the number of comments and likes that are associated with photos. As shown in Figure 1b and Figure **??**, comparing to sighted users, vison-impaired users:

- give significantly more likes in general, including more likes of photos posted by others;
- receive more likes and comments on their status updates;

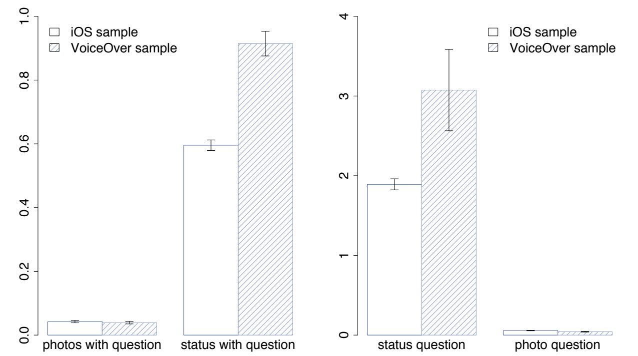
Overall, VoiceOver users are highly active at generating content and giving feedback to others' content on Facebook. There is no siginificant evidence that their ability to engage with the service is confined or limited as comparing to other users. Moreover, the vision-impaired users in our sample on average receive more feedback on their status updates (and presumably more attention) from other users on Facebook.

In terms of photo-related activities, VoiceOver users do upload slightly fewer photos, but they comment on as many photos as the iOS sample users, and like even more photos. However, different from the status updates, the photos uploaded by VoiceOver users do not receive more comments or likes from others comparing to the photos uploaded by users in iOS sample.

Since some previous studies suggest that crowdingsourcing, or friendsourcing vision-related questions on social networks can be a great resource for blind users [2, 1], we also examine the question-asking activity of vision impaired users on Facebook by looking for question marks in status updates and photo captions, a heuristic method that have been commonly used in prior studies [11, 12]. Figure 2a shows the total number of questions asked in status updates and photo captions over three weeks, averaged per capita for each sample group[3]. Overall, we find that the question-asking behavior is rather rare in both populations, especially, asking question about photos is very uncommon. This result is consistent with previous findings that blind users are very reluctant to ask vision questions to their social networks due to the very high social cost perceived [2]. However, when the vision-impaired users do ask questions in the social media, they receive significantly more response than the general population do (see Figure 2b).

Maybe instead of the raw count, using the ratio of questions in all status updates and in all photos (aggregated over each sample). For example, over all status updates posted by VoiceOver users, 17% of them containing question mark, but for iOS sample, 18.2% containing question marks. And for photos, only 0.4% of the photos uploaded by VoiceOver users contain question mark, and the number is exactly the same for iOS sample.

[3]Here we show the raw number of questions instead of the proportion of them in status updates, because many users did not post any status updates in the entire period thus it is not clear what the proportion means in those cases. When only considering users non-zero status updates, the median ratio of status updates with question is 0 for both groups.



(a) Question ask

(b) Question response

Figure 2: Social Q&A and response received on Facebook: (a) total number of questions asked in status updates and photo captions; (b) total number of people who response to questions asked by sampled users.

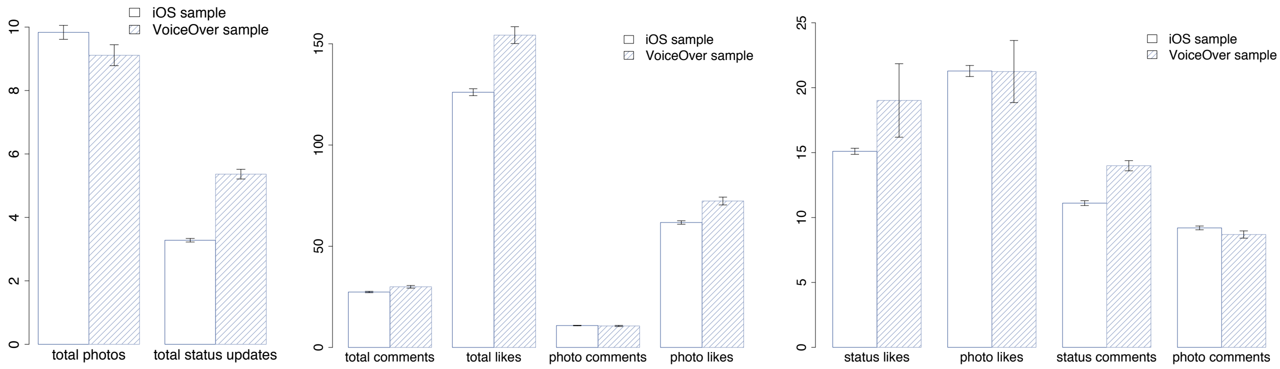
CONTENT ANALYSIS

Knowing that vision-impaired users actively produce and share content on Facebook, and receive more feedback for their content, we would like to take a closer look at the content generated by vision-impaired users, looking for the key differences between the content shared by the vision-impaired and the general population. What do vision-impaired users talk about in their status updates? What kind of photos do they upload? Do they talk about their disabilities, or that is a "taboo" topic for them? Why do other users on Facebook prefer to engage with the content from vision-impaired users?

To answer these questions, we take all the textual content in status updates and photo captions by sampled users with locale is 'en-US' (US English), and apply the trend detection algorithm as described in [10]. Using the colletion of text by users in the iOS sample as a baseline, we find the most representative words used by VoiceOver users with both the absolute change metric and the probability change metric. Although the probability change metric has been most recommended and widely applied in the industry [6], we include the results based on absoluate change metric because it favors words with higher frequencies, thus can offer a better sense about the prevelance of those selected words.

As previous section has shown that people response differently to the status updates and to the photos by VoiceOver users on Facebook (see Figure 1c), to better understand the differece in the nature of these two types of content, we separate the text from status updates with the text photo captions and run the trending term detection algorithm independently on each corpus.

At a high level, we find that vision-impaired users do openly talk about issues related to vision disability and accessibility. Also, we are able to identify several technologies and applications besides VoiceOver (e.g., TapTapSee, tunein, peachtree audio) that are especially popular among the vision-impaired users. This finding can help us not only improve the interga-



(a) Content produce

(b) Feedback send

(c) Feedback receive

Figure 1: Per user activity over three weeks, averaged across user samples

tion of social media and these apps for a more accessible and smoother experience, but also better identify and recognize vision-impaired users on the site.

In the rest of this section, we will present more detailed analysis on status updates and photos.

Status Updates

Our method for identifying the most representative is a direct application of the two-point trends detection algorithm as described in [10]: using the status updates of iOS sample users as text from the first time period and the status updates of VoiceOver sample users as text from the second time period, we want to find the words with the most significance "rising" patterns from the first time period to the second time period. To measure the signficance of the change, we use normalized absolute change and probability change metrics defined as below:

Let n_0 and n_1 denote the total number of token in the text from the first and second time periods respectively, and $f_0(w)$ and $f_1(w)$ denote the frequency of the word w in the first and second time periods respectively, we define the **normalized absolute change** for word w as $f_1(w)(n_0/n_1) - f_0(w)$, and the **probability change** as $\binom{n_1}{f_1(w)} p_0(w)^{f_1(w)}(1-p_0(w))^{(n_1-f_1(w))}$ (here $p_0(w) = f_0(w)/n_0$, $p_1(w) = f_1(w)/n_1$).

To reduce the noise in our data, we filter out the terms that appear less than 10 times in the VoiceOver sample, and less than 30 times in the iOS sample (since iOS sample has 3 times more people than the VoiceOver sample). We also normalize the language use across users by only counting each word at most once per user, which effectively reduce the algorithm's bias towards words used by users who post long, repetitive status updates (e.g., pet's names). The top 10 words selected by these two metrics from all status updates by the VoiceOver user sample are shown in table 2 (all text are converted to lowercase).

Abs. change	**Prob. change**
blind	blind
braille	braille
guide	sighted
accessible	blindness
sighted	goalball
cane	voiceover
audio	paratransit
blindness	inaccessible
impaired	accessible
visually	impairment

Table 2: Top 10 most representative words in the status updates of VoiceOver users.

It is striking to see that all top 10 words by both metrics are all related to vision disability: comparing to other iPhone users, VoiceOver users on Facebook openly share their experience with vision impairement and voice their concern on accessibility issues in both the physical world and the Internet. The highly characteristic content generated by vision-impaired users distinguishes them from other social media users, making it possible to automatically detect users with vision disability by their language use. Meanwhile, the uniqueness in the status updates of vision-impaired users can also be associated with, or contribute to the higher volume of feedback from other users, as being perceived as more interesting/meaningful/important.

Photo Sharing

Knowing that vision-impaired users also post a significant amount of photos on average, we want to assess the content of these photos, and understand whether vision-impaired users upload photos that are as characteristic as their status updates. And if yes, why do vision-impaired users' photos not receive as much feedback from others as their status updates do?

We apply the same method as presented above, this time with the collection of text from photo caption. In Table 3, we show

Abs. change	Prob. change
tunein	peachtree
radio	tun.in/se8qe
listening	hatchi
peachtree	facebook.com/hatchiapp
tun.in/se8qe	#dailyquote
hatchi	taptapsee
facebook.com/hatchiapp	solara
#dailyquote	itunes.com/apps/esperlabsllc/solara
taptapsee	navy/gold
bit.ly/11j2rfj	tunein

Table 3: Top 10 most representative words in the photo captions by VoiceOver users.

the top 10 most representative words that describe VoiceOver users' photo uploads.

At a first glance, the buzzwords picked from photo captions do not appear to be as relevant to vision disability as the words from status updates are. We see some words related to listening to radio (e.g. "listening", "radio'), which makes sense since vision-impaired users do listen to radio programs much more than sighted users. Following this clue, we realize that most of the words shown in Table 3 are related to *specific activities or applications vision-impaired users engage with* online or with their mobile phones. For example, *tunein* is probably from the product named "TuneIn Radio", one of the largest mobile applications for online radio (including radio stations and podcasts) [13]. And *peachtree* [4] is a popular radio station on TuneIn Radio. Photo captions containing "peachtree" are mostly like this: "I am listening to Eagles - Hotel California by Eagles on Peachtree Radio FM with TuneIn Radio `http://tun.in/se8QE`". In the end, we would like to highlight a very popular photography application for iPhone users with vision impairement - *TapTapSee*[5]. As described in the top customer review in iTunes AppStore[6]: "It is a camera [app] that when a picture is taken will give back a verbal description of what is seen. I use it to detect colors in order to cord Nate [sic] my wardrobe. It is one of the most helpful apps that I have on my iPhone." Hundreds of VoiceOver users in our sample have taken photos with this application and uploaded these photos to Facebook with captions like "I discovered this was a 'Woman Wearing Black Fur Hat' with TapTapSee" and "I discovered this was a 'Golden Wonder Cheese & Onion Chips' with TapTapSee".

The top keywords from photo captions suggest that many of the photos uploaded by vision-impaired users are automatically imported and narrated by other apps instead of the users themselves. As a result, these photos can potentially be viewed by others as less authentic or even spammy, thus attract less feedback than the status updates do. Meanwhile, with the popularity of photo Q&A systems such as TapTapSee and VizWiz [9], more and more blind users can get satisfactory answers to vision question without paying the high social cost of asking their friends in social networks[2].

To summarize our content analysis, we find that vision-impaired users openly talkabout their experiences and issues with vision disability and web accessibility. Their stories and concerns are well received and responsed by other users of the social network. Our trend detection algorithm is able to identify the most characteristic words and applications used by the vision-impaired users, showing great potential on better profiling scheme for this specific population.

NETWORK STRUCTURE

In previous sections, we found that vision-impaired users are actively engaging with their social networks, talking about their conditions and concerns openly, and receiving more feedback from other users. But how much of these observations can be explained by the structural properties of vision-impaired users' social networks? For example, as previous study showed that users with more diverse and sparser friendship network perform more self-censoring on Facebook [5], can the openness we observe in vision-imparied users be a result of their social networks being denser than the average? On the other hand, the reason that vision-impaired users receive more comments and likes may simply be that they have more friends (thus a bigger audience) than an average user.

To answer these question, we will study in-depth the structural properties of the social networks around vision-impaired users, focusing on the network size, density, and the interconnectivy among vision-impaired users.

Network Size

Previous work has suggested that blind users have smaller social networks than average [2]. In our data, the median friend count is 208 for users in the VoiceOver sample, and 242 for the iOS sample. The mean value for VoiceOver sample is 339.9, and for iOS sample is 367.5. Although all these numbers are much higher than reported [2], a student t-test comparing the mean of friend count across these two samples gives $p < 2.2e-16$, supporting that the average network size is greater in the general iOS sample than in the VoiceOver sample.

Also, as the VoiceOver sample may contain users with different levels of vision impairement, we also extract the set of users who mentioned "TapTapSee" in their status updates or photos, and use them as a confident representation of blind (or near-blind) users. We denote this set of users as the *TapTapSee sample*. We then take the median and mean friend count for users in the TapTapSee sample, and they are 161 and 222.4 respectively. These numbers are even lower than what we get in the VoiceOver sample, although still higher than the average [14].

It seems that vision-impaired users do on average have smaller social networks, as comparing to other users. However, since it takes much longer time to accumulate friends than to generate content, and newer users will in general have less friends than older users, we want to further test to

[4] `http://tunein.com/radio/Peachtree-Radio-FM-s198932/`
[5] `http://www.taptapseeapp.com/`
[6] `https://itunes.apple.com/us/app/taptapsee-blind-visually-impaired/id567635020?mt=8`

what extend the difference in friend count between these two groups can be explained by the difference in the length of time people have spent on Facebook? As the devolopment of web accessibility progressed so rapidly in the past few years, it can be only until recently that vision-impaired users are able to use SNS as easily as other users [15]. In fact, when comparing the "Facebook age" (number of days since a user joined Facebook) across these two samples, we find that VoiceOver users are in general newer to Facebook than the average iOS users: the median Facebook age for VoiceOver sample is 38 months whereas for iOS sample is 46 months (t-test on sample mean gives a p-value less than $2.2e-16$). To illustrate how friend count changes with Facebook age, we plot the median friend count for users who joined Facebook in the same month (see Figure 3). Our result shows that the gap in the network size of these two populations has been descreasing over time. Especially, when we control on Facebook age, new Facebook users (i.e., people who joined in the past 2 to 3 years) seem to have similar network size across two groups.

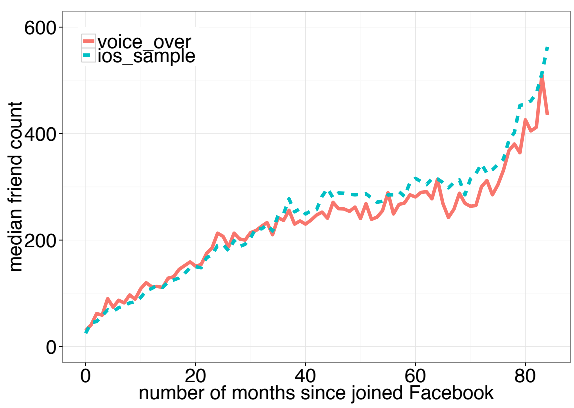


Figure 3: Network size as function of Facebook age.

Network Density

Another hypothesis we want to test is that vision-impaired users have more homogenous, thus denser social networks. Previously research showed that blind users on Facebook have their social networks comprised primary of friends, family and colleagus (in total over 95% of all Facebook friends) [2]. As a result, we expect to see the friends of a vision-impaired user are more likely to also be friend with each other, forming a more intimate, tightly connected social network. To measure the connectedness of a user's social network, we define the ego graph clustering coefficient of a user u_i as:

$$C_i = \frac{\text{number of edges between } u_i\text{'s friends}}{n_i \times (n_i - 1)/2} \quad (1)$$

Here n_i is the number of friends u_i has.

The greater C_i is, the denser user u_i's social network is. C_i is 0 when none of u_i's friends connects to each other, and is 1 when u_i's friends form in a fully connected clique. Figure 4 shows the empirical CDF curves for the values of ego graph clustering coefficient in different samples. At a high level, the result is consistent with our hypothesis: although very similar, VoiceOver users do have overall slightly smaller ego graph clustering coefficient than the general iOS sample. However, the result is reversed when comparing the iOS sample with the TapTapSee sample: TapTapSee users seem to have denser social networks than the control group.

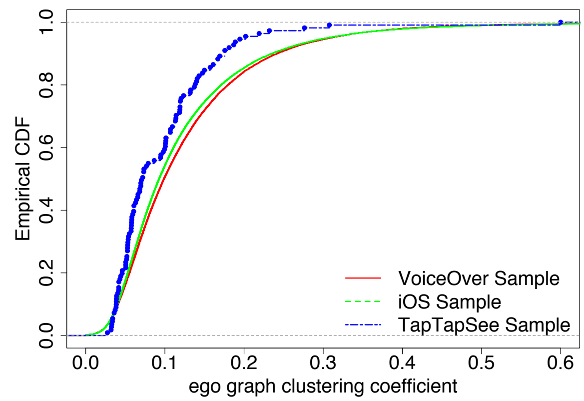


Figure 4: Distribution of ego graph clustering coefficient

We can also quantify the homogeneity of a user's social network by the number of distinct social communities among his/her friends. We use the algorithm as presented in [14] to detect and identify communities in each user's ego network, and show the distribution of community count across users in three samples in Figure 5. As Figure [?] shows, the level of diversity in personal social networks is almost identical for users from VoiceOver sample and users from iOS sample, with about half of the sample having only one community, and almost 90% of the sample having up to 3 communities. Meanwhile, users from the TapTapSee sample do seem to have more communities, but only when the total count of communities is small (up to 3). Overall, our result confirms that most vision-impaired users have closed connected social networks with a few communities (presumably formed by friends, family and colleagues), but so do other users of Facebook.

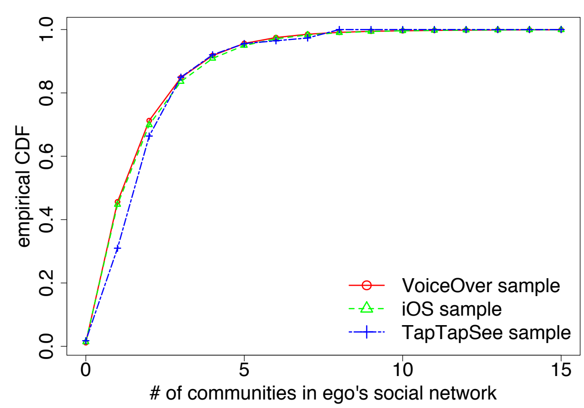


Figure 5: Distribution of number of communities in a user's social network

Interconnectivity among Visually Impaired Users

The last question we want to ask about the network structure of vision-impaired users is about the interconnectivity among them: are vision-impaired users more likely to be friend with other vision-impaired users? A hypothesis based on the classic homophily theory would say “yes”, however, given the relative lower number of friends vision impaired users have, they are statistically less likely to have friends with a specific trait than people from the general iOS sample.

Our result supports our hypothesis that vision-impaired users are more likely to friend other vision-impaired users. Figure 6 shows the distribution of the number of VoiceOver sample friends in each user’s neighborhood. Here, we can see a clear distinction between the CDF curves for these two groups: while there is almost no user in the iOS sample who has more than one friend in the VoiceOver sample, there are over 20% of the users in the VoiceOver sample who have at least one friend who is also in the sample, and around 10% of the VoiceOver sample having more than 10 friends using VoiceOver as well.

Such signficant interconnectivity among vision-impaired users would potentially introduce structural clustering of them on the Facebook network, which may eventually lead to self-organized communities of vision-impaired users. This might be a factor that contributes to the charactristics of content produced and shared by vision-impaired users. The structure clustering can also be very helpful when trying to auto-detect the presence of vision-impaired users.

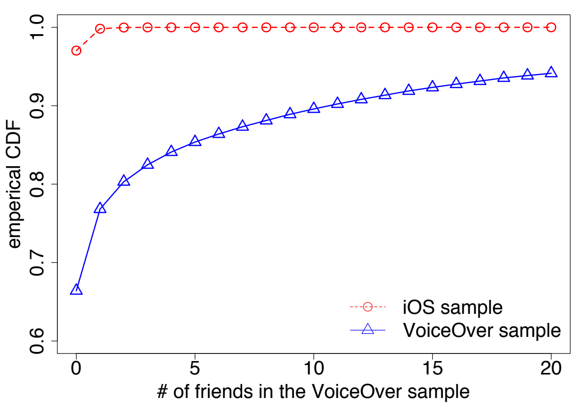


Figure 6: Distribution of the number of friends in VoiceOver sample

CONCLUSION

In this paper, we describe a few findings on how vision-impaired users engage with social media, more specifically, Facebook.

We find that, vision-impaired users engage actively with the major social activities on Facebook (status updates, comments, and likes) just like the general population, including some photo-related features (e.g., photo comments and likes). On the other hand, when vision-impaired users produce and share personal content such as status updates, they receive much more feedback (i.e., comments and likes) from others than the average. These findings suggest the utility of Facebook as a platform for vision-impaired users to openly share their experience, voice their concerns, and as a channel to receive attention and support from others.

We also study the content generated by vision-impaired users, by running trend detection algorithm on the text from their status updates and photo captions. We find highly characteristic keywords in vision-impaired users’ content: the most representative words in vision-impaired users’ status updates are all related to vision disability, while many of the photos are associated with (and perhpas auto uploaded by) popular applications vision-impaired users engage with (e.g. online radio, photography app). Our content analysis reveals distinctive features of the language and the activities of vision-impaired users online, paving the way for devoloping machine-learning models to recognize vision-impaired users beyond the population of iPhone/VoiceOver users.

In the end, we study the structural properties of vision impaired users’ social networks on Facebook, testing the hypothesis that vision-impaired users have smaller but denser social networks. We do find evidence supporting this hypothesis at a high level, however, we also notice that the difference in network structure between these two groups has been diminishing over time, demonstrating our progress towards a increasingly equal and accessible online environment. We also see the network clustering among vision-impaired users: they are much more likely to have friends who are also vision-impaired.

Nevertheless, our study has been confined to a very specific subset of vision-impaired users online and in the world. In the future, we would like to expand our study to a bigger, and more general group of vision-impaired users, and also look into other perspectives of vision-impaired users’ online presence with insights from qualitative studies.

ACKNOWLEDGMENTS

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