
Filtering Shared Social Data in AR

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Abstract

We describe a method and a prototype implementation for filtering shared social data (e.g., 360 video) in a wearable Augmented Reality (e.g., HoloLens) application. The data filtering is based on user-viewer relationships. For example, when sharing a 360 video, if the user has an intimate relationship with the viewer, then full fidelity (i.e. the 360 video) of the user's environment is visible. But if the two are strangers then only a snapshot image is shared. By varying the fidelity of the shared content, the viewer is able to focus more on the data shared by their close relations and differentiate this from other content. Also, the approach enables the sharing-user to have more control over the fidelity of the content shared with their contacts for privacy.

Author Keywords

Augmented Reality; Virtual avatars; Sharing Social Experiences; 360 panoramas; live video stream

ACM Classification Keywords

H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities

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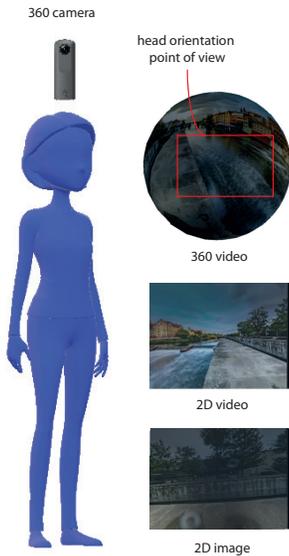


Figure 1: Sharing point of view with different fidelity of its representation.

Introduction

Social Augmented Reality (AR) applications such as Wikitude¹ and World Around Me², place virtual cues over live video of the real world, showing content produced by the user's social network. However, with people having hundreds or thousands of contacts in social networks, this AR view can quickly become cluttered. Our previous work explored how users can differentiate between AR representations of social contacts in AR using different levels of proximity and fidelity [5]. The current work explores how the type and amount of shared data from a social contact can vary based on a social AR continuum [4].

Viewing the highest fidelity of the shared content, for example, live streaming 360 videos and audio from a remote contact, might seem to be the most desirable option. However, when having many friends (social contacts), all of them sharing high fidelity data content might be an overwhelming experience. The user may not be able to distinguish between social contacts, and may not be able to enjoy their content. Also for the user sharing the content, revealing full fidelity to everyone could be concerning in terms of privacy, hence there is a need to control and filter the fidelity of shared content based on social relationship.

In this work, we are trying to answer the question, what would be the best way to share rich data (such as 360 videos) within a large social network? The hypothesis is that filtering data based on the user-viewer relationship or proximity will increase the feeling of being together or interconnectedness.

Related Work

Proximity-based interactions in AR/VR has been studied before as social bubbles [7] where projection and mobile phones are used to connect two people remotely. They described a four layers of gradual engagement model based on physical distance between remote collaborators in synchronous situations. This work was limited to synchronous situation and mainly for collaboration purposes.

Virtual avatars have been studied in social applications such as social networks and multi-users environments such as in Second Life [3] and other VR games. Virtual avatars have been used to share social experiences such as in Facebook Spaces[2] where users can meet in VR, take selfies and teleport to a 360 video. However, representing social contact in VR/AR can be overwhelming [5]. It will be more overwhelming to represent the data content that social avatars are trying to share.

Building on previous work in proximity-based relationship [7], we focus on the shared contents of social avatars in asynchronous situation. Unlike previous work in social avatars, we study representing social contacts in large-scale network. We aim to reduce clutter that maybe caused by displaying the social avatars and their shared content. We address the question of how we can use social relationship between avatars and the viewer as a way to filter and enhance viewing the shared-content experience.

Sharing Social Data

From the perspective of the person who is sharing the data (sharer) with their social contacts (Figure 1), the data is collected in its highest fidelity (e.g. a full spherical 360 view) which will be shared with those viewers with the closest social relationships (most intimate). For less intimate friends a 2D video will be shared, extracted from the 360

¹<https://www.wikitude.com/>

²<https://worldaroundmeapp.com/>



Figure 2: Social contact sharing in different relationships with the viewer. (Left to right: intimate, friend, stranger). The shared data content (top of avatar) is filtered out (360 video, 2D video, 2D image) based on social relationship.

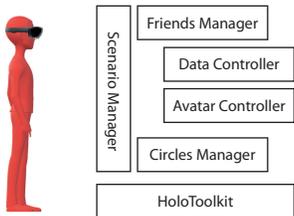


Figure 3: System components.

video based on the sharer's view direction over time. For strangers, the sharer can select which snapshot image from the 2D video sequence to display for strangers relationship. The basic metaphor is that the closer the relationship that the user has to the viewer, the richer data that they can share from their point of view (360 videos, 2D videos, images).

A use-case scenario for filtering by sharer is where the sharer is going on a hike and wanting to share the experience of being in an interesting place such as a river. The sharer takes a 360 video of the surrounding environment and shares the data with his/her followers. The sharer then gets to see how the followers are able to see the shared data based on their social relationship to him/her.

Viewing Shared Social Data

The user viewing the shared data (viewer) uses a wearable AR interface to see content from their social network superimposed over the real world based on proxemics.

A use-case scenario of filtering by viewer is where the viewer is interested in seeing what their social contacts (followers) are up to and the places they have been to. The viewer can look around through the AR display to see the social contacts placed around him/her in 3 circles ordered by relationship. On top of each social contact, the viewer can see the content they're sharing which is filtered based on the social relationship between the social contact and the viewer.

Based on our earlier work [4], the people who are socially closer will appear in the AR view visually closer and have a more realistic representation. The content shared by each social contact will appear above their avatar (see Figure 2), and to view the contents closer, the user can select it (e.g. using the HoloLens air-tap gesture) to bring the content

closer or move inside the 360 video sphere. The user can then tap again to bring back the content to its original place to see other social contacts.

In addition to this basic operation, here we propose the viewers seeing the shared content in different fidelity (360 videos, 2D videos or images) based on the social relationship (intimate, friend or stranger). While the sharer could restrict the fidelity of the shared content based on the social relationship as mentioned earlier, the viewer could also filter the content based on his or her preference. In order to avoid getting mentally overloaded by viewing a lot of content in high fidelity, the viewer should be able to choose the preferred fidelity for the shared content from each social contact. This could be achieved either explicitly choosing a fidelity for each social contact, or implicitly by moving closer to or further from the avatar representing the contact.

Prototype

To explore using a social AR continuum metaphor for sharing data between social contacts, we built a prototype on a HoloLens. The prototype software is built using Unity 3D game engine and it allows users to view their social contacts on a wearable AR headset. Figure 3 shows the structure of the prototype system.

The prototype places social contacts around the user (viewer) in 3 concentric circles which are controlled by *Circles Manager*. The social contacts have different visual fidelity and proximity based on their initial relationship to the viewer rendered using *Avatar Controller*. The avatars were randomly pre-generated without any resemblance to actual contacts. We used MakeHuman³ to generate the 3D avatars. The viewer (HoloLens user) can turn his or her head to face different social contacts and then use gestures (air taps) to in-

³<http://www.makehuman.org/>

Table 1: Questionnaires for Social Presence including the following dimensions: CoPresence (CoP), Attentional Allocation (Atn), Perceived Message Understanding (MsgU). *=negative

CoP	
Q1	I noticed the other social contacts.
Q2	The other social contacts' presence was obvious to me.
Q3	The other social contacts caught my attention.
Atn	
Q1*	I was easily distracted from the other social contacts when other things were going on.
Q2	I remained focused on the other social contacts throughout our interaction.
Q3	The other social contacts did not receive my full attention.
MsgU	
Q1	The social contacts shared data (360, video, photo) were clear to me.
Q2	It was easy to understand the social contacts shared data (360, video, photo).
Q3*	Understanding the social contacts' shared data (360, video, photo) was difficult.

interact with the contact (viewing their data or changing their position which represents social relationship). The interactions with HoloLens are enabled using the open source library *HoloToolkit*⁴. The shared data content by social contacts are controlled by *Data Controller* which determines which fidelity need to be displayed based on the social relationship between the avatar and the viewer. The top-level *Scenario Manager* defines the implementation needed for different conditions in the user study including interaction with avatars, shared data and the concentric circles.

Pilot User Study

We conducted a pilot user study to test the system usability and its effect on social presence comparing the following conditions:

- C1-Baseline: Shows the shared 360 video from all social contacts.
- C2-Tap to change: Filter the fidelity of the shared 360 video based on the relationship between viewer and the social contact. The user can tap on any social contact to cycle through the different relationships.
- C3-Walk to change: Filter the fidelity of the shared 360 video based on physical distance between the viewer and the social contact.

The task was to ask participants to wear the headset and observe 12 social contacts (mocked up, not reflecting the participant's real social contacts) placed around the user at equal angles away from each others to complete a circle (360°) around the viewer, and at different distances to the viewer (centre) based on the social relationship. Each social contact had shared content floating above their head.

⁴<https://github.com/Microsoft/MixedRealityToolkit-Unity>

Depending on the type of the social relationship that the social contact had with the viewer, the shared content was filtered.

The participant could view the data content by performing the air-tap gesture on the content. Once tapped, the content moved closer to the viewer. For instance, if the viewer tapped on the sphere of a 360 video then the sphere immerses the user to experiences it, while for a 2D video, it gets closer to the user so they can see it in full screen.

We asked participants to answer 5-point Likert-scale questions shown in Table 1 which are based on prior work [1]. We also asked participants to rate their experience on the Subjective Mental Effort Questionnaire (SMEQ) [6].

Results

We ran a pilot user study with 8 participants (4 female) aged 26-35 (SD=3.03). All participants used social networking platforms on regular basis, and most of them were familiar with AR/VR displays.

After filling in a demographic questionnaire, we asked the participants to experience the three conditions in a random order, then they filled in a social presence questionnaire and SMEQ about the condition they just tried. After finished all three conditions, we asked them to fill-in a post-experiment questionnaire where we asked about the overall experience and if they have any suggestions to improve.

From the questionnaire results (Figure 4) we can see that C2 was rated (3.6) better in term of social presence compared to C1 (3.3) in average. C3 (3.5) was relatively close compared to C2. The SMEQ results show that all three conditions were rated low in mental effort, while both C2 (M=16.875) and C3 (M=16.875) were rated lower than C1 (M=21).

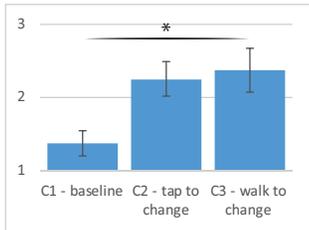


Figure 5: Conditions ranking results. Reverse rating scale: 3=most favorable, 1=least preferred. Whiskers=standard error. * = statistically significant difference (Friedman test: $\chi^2(2) = 7, p = .05$).

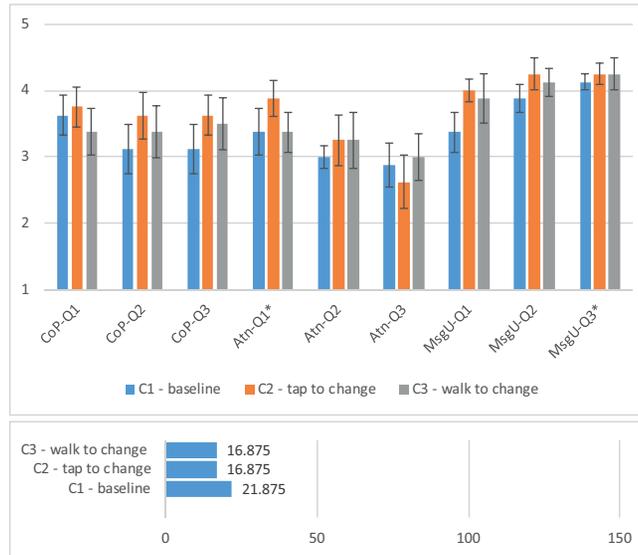


Figure 4: Results of social presence (top) and SMEQ (bottom). *=reversed rating scale. Whiskers=standard error

As part of post-questionnaire, we asked participants to rate the three conditions (1=least preferred, 3=most preferred). The ranking results (see Figure 5) show that C1 was least preferred (1.3) while C2 (2.25) and C3 (2.375) are close. There was statistically significant difference in ranking conditions $\chi^2(2) = 7, p = 0.05$. Post hoc analysis with Wilcoxon signed-rank tests was conducted. There was a statistically significant difference between C1-baseline and C3-Walk to change. ($Z = -2.081, p = 0.037$).

Discussion

From a semi-structured interview after the experiment, most users found that the condition "C3-walk to change" was more fun and natural way to view shared data from social

contacts. "I feel it's more real and fun to view the 360 video by walking toward the avatar". Also, other people found that the walking condition is more suitable for an outdoor or open area to avoid running into obstacles while walking. For the condition "C2-tap to change" was found more convenient to tap on the social contact to change the relationship rather than requiring more physical effort in walking. The base condition C1 was the least favourite for participants as it was overwhelming with showing all 360 videos all around.

On the downside, participants mentioned some weakness for condition "C2-tap to change" as that in the chance of clutter by being able to bring all social contacts to a small area of the intimate circle. While the condition "C3-walk to change" didn't have that issue, it was highlighted that by walking you can accidentally change the relationship with other social contacts that the user is not focusing on. For example, the avatars behind or on either side of the user are affected by the user movement even though if they were not the intention of the user to get closer to and away from. Viewing 360 videos through an optical see-through display was considered not as ideal as the 360 video appears to be semi-transparent on top of the real environment.

Overall the participants expressed their interest in using such system to manage and view their social contacts and shared content in AR, and that it's useful and easy to use.

Limitations and future work

This prototype used asynchronous sharing where social contacts are not online at the same time sharing live data. The shared content is previously prepared and the 360 video is previously processed to extract a 2D video and a 2D image. However, the method we applied for filtering could be applied to synchronous sharing as well. In the future, we will add live video streaming from the social con-

tacts and live scaling down the contents based on social relationships. The concept does apply to synchronous sharing where social contacts are online at the same time. In the future, we will extend this prototype for synchronous sharing experience. We can expand the implementation to include spatial audio as fidelity to filter based on social relationship. Additionally, we will conduct a full quantitative and qualitative user study to measure the effect of filtering content type on social presence and user experience.

Conclusion

We presented a mechanism of presenting shared data content through filtering the content type based on social relationships between the user and the social contacts.

We implemented a HoloLens prototype applying the proposed method in an asynchronous collaboration scenario and conducted a pilot user study using the prototype. The study compared three conditions: viewing 360 without filtering, filtering based on the social relationship, and filtering based on distance.

Initial results showed a trend of participants favouring having an option to filter data over no-filter. We reported on participants' qualitative feedback that provides insight for future directions.

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