Usability Study of a Virtual Reality application which allows people to watch movies together in a VR environment

By

Archana Ramesh

Project submitted in partial fulfillment of the requirements for the degree of Master of Science in Human Computer Interaction

Rochester Institute of Technology

B. Thomas Golisano College of Computing and Information Sciences

Department of Information Sciences and Technologies

Dec 6, 2018

Rochester Institute of Technology

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of
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Project Approval Form

Student Name: Archana Ramesh

Project Title: Usability Study of a Virtual Reality application which allows

people to watch movies together in a VR environment

Project Committee

Name	Signature	Date
Ronald P. Vullo		

Chair

Kristen S. Shinohara		

Committee Member

James R. Habermas		

Committee Member

ABSTRACT

The capstone project focuses on evaluating a virtual reality application designed for the purpose of watching movies together virtually, by performing a comparative usability study with the video call / screen share approach using TeamViewer software. A usability study was performed for each of the applications, and its results were analyzed to determine the overall advantages, drawbacks, and required feature improvements. The data collected from this analysis will be used to correct issues in the user experience of the virtual reality application, to add any additional features or modify existing features, and redesign the virtual reality application.

Content

1. INTRODUCTION

Before the last few of decades of the 20th century, the means of communication were limited to letters and telephones [5]; but since the dot-com boom, a lot of other means like instant messaging, video calling, social networks, etc. have helped in bridging the distances between people living in different cities / countries. Though, technology has greatly helped people to be in touch, the activities where being physically together is important was greatly missed by people [1].

Watching movies online on the various movie streaming services has become very popular in recent years [12]. A lot of people prefer to watch movies together rather than watching alone. The existence of a reliable medium for watching movies together online with your friends / family from different physical locations has become necessary.

An existing approach for people living apart to watch movies together is to use applications like TeamViewer and Skype which allows video calling and sharing of screens. In this approach, one user can play the movie on his screen and share his screen with other user, while a video call is set up at the same time between both the users. This enables users to watch the movie together via the shared screen; and to look at other people's facial expressions, convey their comments, or listen to other people's comments via video call. Though this approach might seem to achieve the task at hand, it might still make the users feel distanced from each other as it may not be the same as sitting in the same room with everyone and watching the movie.

This capstone project focused on investigating the usability aspects of watching movies using the virtual reality approach over a common video call / screen share (TeamViewer) approach.
Virtual reality is used to display and interact with objects in a virtual environment using systems like virtual reality headsets [6]. With the advancement in technology, virtual reality is being used widely in various fields. Initially, virtual reality found its applications predominantly in the gaming field; but now it is also used widely in the fields of health care, education, engineering, telecommunications, simulation, sports, military, entertainment, constructions, etc. [9]

This capstone project focused on performing a usability study on the virtual reality interface developed by another graduate student of Dr. Ronald P. Vullo using his Molly server-side framework and Mozilla's A-frame JavaScript framework [8]. The goal of this project was to blend the fields of telecommunication and entertainment with virtual reality to enable users to watch movies together in a virtual environment.

Each user was represented by an avatar, which helped other users recognize him / her in the virtual environment. The most interesting aspect of this application, which the capstone project focused on, was how the people of different age groups use the VR headset, navigate in the virtual environment and watch movies together.

This capstone project involved evaluating the virtual reality application, for watching movies together in a virtual environment, based on usability aspects by performing a comparative usability study to compare it with the video call / screen share (TeamViewer) approach discussed above. Usability studies were

performed by observing people using both the virtual reality application as well as the video call / screen share approach, and the results including the strengths and flaws of both the studies were analyzed. Finally, based on the input gathered from the participants, suggestions were made for improving the user experience, adding additional features / modifying existing features, and redesigning aspects of the virtual reality application.

2. RELATED WORK

Virtual reality has existed for nearly two decades, and it has been widely studied and predominantly used in the world of gaming and entertainment. Dorta et al. [3] talked of the use of virtual reality for watching movies, where a qualitative analysis along with questionnaires were used to perform the study. The paper concluded that though virtual reality provided a very good and immersive experience for watching movies, there is a shortcoming in the shared experiences people have while watching movies and in the expression of storytelling.

Monahan et al. [11] presented the research and development of the web-based application for collaborative e-learning which used virtual reality, multimedia and communication to engage students to learn in a virtual environment. An initial evaluation of the developed virtual reality application was conducted by performing 3 sessions of usability studies with 3 students and 1 tutor per session. The overall results were positive, with 100% participants being fully engaged in the experience and feeling that the online lecture in the virtual reality environment was really effective.

Normand et al. [7] talked about creating virtual avatars and using them for virtual acting rehearsals in an immersive environment. The system discussed in this paper combined a virtual reality system with body tracking. It discussed a experiment where one of the actors and the director were in London in separate rooms and the second actor was in Barcelona. The actor in Barcelona put on a headset with a wide field of view along with a body suit used for real time display and motion capture, whereas the London based actor put on VR headset on his head and a body suit for body motion tracking. Each of these actors were in the shared virtual environment space, where each one could see the other's avatar. It was concluded in this paper that the most important aspects of the experiment were the body tracking mechanisms and displaying them in body motion real time.

Chen et al. [2] talked about building an interactive virtual reality experience reminiscing the historic east Taiwan railway system. Once the system was built, 70 participants were chosen to engage with the virtual reality system to test the user satisfaction level, which was recorded on a video. The participants answered a questionnaire to assess the virtual reality system, and the results derived from this questionnaire showed that the virtual reality system resulted in a higher user satisfaction level as compared to the traditional systems used to appreciate the historic Taiwan railways.

Yoon et al. [10] studied the use of virtual reality using IR LED based head tracker and gloves, versus the use of traditional systems using mouse, keyboard and monitor for the FPS (First participant shooting) games. The results computed from the usability test performed for this study showed that the use of virtual reality interfaces for First Person Shooter games show a more immersive experience to the users compared to the traditional interfaces.

3. METHODOLOGY

The study was conducted with groups of 2 participants per study session. The participants were asked to use both TeamViewer and the virtual reality application to watch a short movie clip with the participant sitting in the other room. The participants were then interviewed about their experience with both the applications and the answers along with general feedback were noted down.

3.1 Participants

26 participants, aged between 15 to 80 years, were recruited for the usability studies being performed. These participants remained the same for both TeamViewer and virtual reality study (within-subjects study). The participants were selected in the age range of 15 to 80 years as people of different age groups might want to watch movies with their friends / family staying far away and the interaction experience with the virtual interface of participants belonging to different age groups might differ. To recruit the participants, emails and text messages were sent out with all the information; and the interested candidates were asked to fill out a screener questionnaire containing questions related to their age, familiarity and amount of usage of virtual reality systems, whether they suffer from motion sickness, etc. Based on the results of the screen questionnaires, participants were recruited such that people belonging to each age group were uniformly distributed and the people having motion sickness were filtered out. All the participants were asked to sign an informed consent form before the study was conducted.

3.2 Environment

The environment consisted of two rooms, such that voices from one room couldn't be heard in the other room. Each room had one laptop, one android phone, and 1 VR headset. Each laptop had TeamViewer installed in it, and each android phone had Firefox browser installed in it. A link to a 3 minutes long video clip on YouTube was bookmarked on the browser of each laptop for the participants to watch on TeamViewer. Another 3 minutes video clip was preset in the virtual reality application. The link to the web-based virtual reality application was bookmarked in the Firefox browser on the android phone. The android phone was placed in the VR headset as it served as the headset's screen.

3.3 Study Tasks

The tasks involved in the study were designed such that the participants could efficiently explore most of the features for both the approaches. Counter-balancing of tasks was performed in order to mitigate the issue of transfer of learning. Once tasks were formulated, a pilot test was conducted to validate the tasks and based on the results of the pilot tests, the tasks were fine tuned.

Each of the two participants were seated in different physical rooms to perform the tasks. Each room had a moderator who moderated the tasks and provided instructions / help whenever needed. The final interview for all participants was performed by one of the moderators (author of this report).
The tasks were divided based on the two approaches being used in the study:
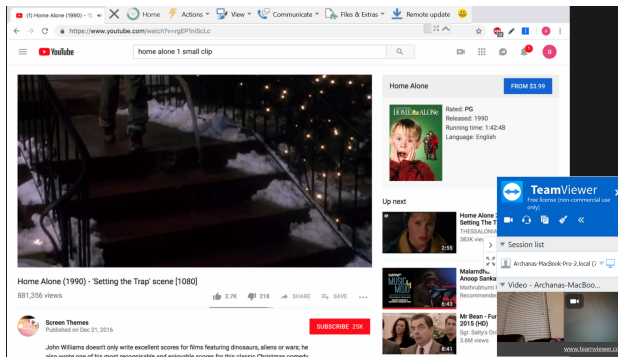- TeamViewer tasks
- Virtual reality tasks
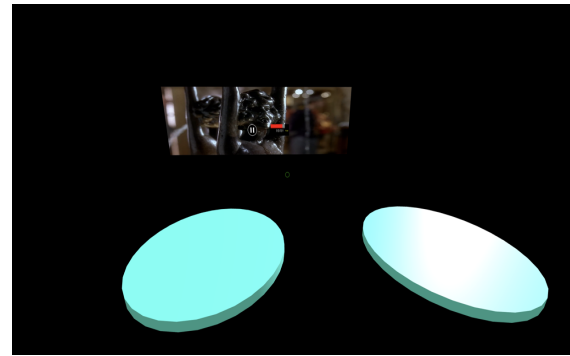
Fig. 1. TeamViewer interface

Fig. 2. Virtual reality application interface

3.3.1 TeamViewer Tasks

For the TeamViewer tasks, the participants were briefed at the beginning of the session about the tasks to perform and were encouraged to have a general conversation with each other as the movie progressed. The participants were asked to disconnect the connection and exit the applications when the movie ends.

The participant sharing their screen was referred to as *host* and the participant viewing the shared screen was referred to as *friend* in the TeamViewer tasks. The following were the tasks the participants were asked to perform on the TeamViewer interface:

1. Open the TeamViewer interface.
2. **Host**: Share the ID and password for the TeamViewer connection with the *friend* via the moderator. Accept screen share / control request from the friend.
   Friend: Send a request to the *host* TeamViewer client to share / control the *host's* screen using the ID and password received from the moderator.
3. Turn on the microphone and video in the TeamViewer interface.
4. The *friend* can now view the *host's* screen and the *host* should play the movie clip using the bookmarked YouTube video.
5. Converse with each other while watching the movie clip.
6. Pause and resume the movie clip.
7. End the session on TeamViewer after the movie clip has finished playing.

Follow up questions were asked regarding their experience as a whole while watching the movie together, difficulties in performing tasks, etc.

3.3.2 Virtual Reality Application Tasks

For virtual reality tasks, each participant was asked to visit the link to the web-based virtual reality application on the Firefox browser of the provided android phone. The phone was then placed into the VR headset and the participants were asked to wear the headset. The participants were briefed at the beginning of the session about the tasks to perform and were encouraged to have a general conversation with each other, as the movie progressed, just like they would when they were actually watching a movie with a

friend. Both the participants were asked to remove the VR headset and exit the application by closing the Firefox browser on phone, once the movie ended. The older adults and the people not familiar with virtual reality systems were given a short demo on the usage of the VR headsets and were given time to get acquainted with the system.

The following were the tasks the participants were asked to perform on the virtual reality application:
1. Connect using the link to the virtual reality environment.
2. Explore the virtual environment using head movements.
3. Navigate to different viewpoints located in the virtual environment by focusing the cursor on different viewpoints.
4. Start the movie clip displayed on the virtual screen by focusing the cursor on the pause / play button on the virtual screen.
5. Watch the movie together and converse during the movie.
6. Navigate to different viewpoints to watch the clip from different angles.
7. Exit the virtual environment once the movie has finished playing.

3.4 Data Collection

The participants were observed as they used both the TeamViewer and the virtual reality application.
The participants were encouraged to express their views / concerns as they performed all the tasks. Observations were noted down, and the participants were only given additional instructions / help if they asked for it, which helped in observing which features were difficult for them to figure out by themselves. There was no time limit set for any given task, the participants were allowed to take their own time to experience both the approaches. The reactions and comments given by participants were also noted down for all the follow up questions.

After the tasks were performed by the participants, interviews were conducted based on their experience of performing the given tasks. The data collected from the interviews was qualitative. Performing an entire usability test session including 2 participants took approximately 30 to 40 minutes. The questions asked during the interviews were as follows:

3.4.1 TeamViewer Questions

1. How did you find the overall communication channel to be, in terms of talking to your friend while watching the movie? Was it clear?
2. What did you think of the overall experience of watching movies with your friend using TeamViewer?
3. Did you find it easy to set up the video call, share your screen, setup audio communication, and start watching the movie?
4. Did you feel the virtual presence of the other participant while watching the movie or could there be anything that could be done better to make you feel so?
5. Would you be open to watching a two to three hour long movies using TeamViewer?
6. Were both the participants able to start, stop and pause the videos, and was the communication channel clear at all times devoid of lag.

3.4.2 Virtual Reality Application Questions

1. How did you find the overall communication channel to be, in terms of talking to your friend while watching the movie? Was it clear? Please rate on a scale of 1 to 10
2. Did you prefer any of the viewpoints over the other? And why?
3. What did you think of the overall experience of watching movies with friends in the VR environment.
4. Did you find it easy to move around in the VR environment?
5. How does it feel to use VR headsets to watch movies together over watching it using TeamViewer?
6. Did you feel the virtual presence of the other participant while watching the movie or could there be anything that could be done better to make you feel so?
7. Would you be open to watching a two to three hour long movies in the VR environment?
8. Were you able to figure out ways to start, stop and pause the videos?

3.5 Data Analysis

The entire study lasted for around 30 - 45 minutes each, after which the raw data collected from the interviews was tabulated in an excel worksheet. The raw data consisted of 26 entries in the form of feedback / comments to all the questions asked during the interviews and some observations made by the moderator. To analyze this purely qualitative data, the responses for both sets of tasks were coded in order to extract common patterns from the raw data.

Inductive coding of the raw data was performed by assigning codewords to each of the user input noted for each of the question for each participant. A set of codewords and their counts were maintained, and new code words were added to the set based on the responses discovered during the analysis. Each of the user inputs was assigned code words and two other excel worksheets were maintained to keep track of the code words and the count of those code words for each type of task (TeamViewer and virtual reality application).

To avoid multiple counts of a code word for the same participant, a master list of code words for each type of task was maintained per participant, which contained only unique code words and the counts of the code words were incremented using this list. This ensured that if a participant had the code *COMMUNICATION_GOOD* assigned to more than one response, only total of one occurrence of that code was counted for that participant.

Coding the data and counting the occurrences of the code words resulted in two lists (one for each type of tasks) of code words along with their unique counts. These code words along with their counts were then grouped into categories based on their similarity to determine the common patterns from the collected data. This is called axial coding. For e.g. the code words *EXPERIENCE_NOT_GOOD, EXPERIENCE_NOT_SATISFACTORY, EXPERIENCE_TERRIBLE* were all grouped together under *EXPERIENCE_NEGATIVE*. The final count for each group was determined by making sure that the count represented unique participants. For e.g. a participant having codewords *COMMUNICATION_CLEAR* as well as *COMMUNICATION_GOOD* was counted as 1 occurrence for the group *COMMUNICATION_POSITIVE*. While evaluating each group, the unique count for a group as well as the counts of the code words within the group were taken into consideration.

Hybrid groups were also created, especially for analyzing the responses related to communication, which gave insights like how many participants had only positive experience (no complaints at all) with communication, how many experienced good communication but complained about lag, how many had only negative experience, etc.

These results were then analyzed and the findings in the following section were discovered.

4. FINDINGS

The findings of the study showed that the virtual reality application was not the top choice of the participants; but the responses given by the participants indicated that with some improvements to the application, it had a potential to be better than TeamViewer for watching movies online.

4.1 TeamViewer Findings

In terms of communication, 6 out of the 26 participants had a very bad experience with communication being either laggy or unclear. On the other hand, 8 participants didn't have any problems with communication at all. 6 participants had an overall good communication with only a little lag. A couple of participants also suggested that communication is dependent on the speed of the internet connection.
As for the movie audio, 8 participants experienced lag, echo and disturbance in the movie audio. One of the participants wasn't able to hear the movie audio at all. A couple of participants also complained of having trouble understanding audio from the communication (other participant) and the movie at the same time.

A few participants felt that TeamViewer isn't made for this purpose, and there will be other better ways available for the purpose of watching movie together virtually. This was because they felt TeamViewer was primarily intended to be used for collaborating on work assignments and not for entertainment purposes. On the other hand, a couple of participants felt that using TeamViewer for this purpose was convenient for watching movie with friends over long distance.

Setting up TeamViewer was easy for 22 of the participants, whereas rest of them needed help and felt the need to be technologically savvy to use TeamViewer. All but one participant found it easy to pause, resume, and stop the movie on TeamViewer.

About 11 participants felt that the other participant was virtually present with them while watching the movie clip, while 6 other participants only felt a little virtual presence. 6 participants felt that the virtual presence would be felt more if the other participant's webcam window size could be expanded. Webcam video quality was found to be unclear and laggy as reported by 9 participants. Lag was experienced in the movie by 7 participants, which also led to the participants feeling little to no virtual presence.

Overall, only 3 participants had a bad experience watching movie on TeamViewer, while 7 participants had a good experience and 8 participants felt the experience was ok. Although most people had a more than ok experience, 16 participants stated that they weren't willing to watch a 2-3 hour long movie on TeamViewer

online. A few participants from the rest stated that they would only watch a 2-3 hour long movie if the experience was devoid of lag.

3 participants said they preferred watching movies alone and don't like to chat during the movie; whereas one participant found it creepy as it felt like the other participant in the webcam window is constantly staring.

One of the key observations as seen in the feedback of a couple of participants as well as the moderators was that the participant who plays the movie on their local screen and shares their screen doesn't experience any lag; but the other participant experiences a lot of lag.

Some other concerns raised by the participants included security issue (as the screen sharer gives control to the other participant of their system), difficulty in focusing on the movie, and the TeamViewer tab being fixed on the top of the screen.

4.2 Virtual Reality Application Findings

All but one participant experienced problems with communication, out of which 14 participants weren't able to communicate at all, 3 participants could hear but couldn't get their voice through to the other participant, and rest experienced lag, echo and disturbance in the communication.

In terms of viewpoints, 10 participants preferred the center viewpoint and 9 participants preferred the front viewpoint near the screen. Only 2 people preferred the viewpoints on the left or right sides, while 3 people liked all the viewpoints. A couple of participants stated that viewpoints were really useful, and 3 other participants suggested that the viewpoints can be designed better by placing them closer to each other and adding more viewpoints. A few participants also complained that if they were on the same viewpoint as the other participant, they were not able to see the other participant's avatar; and as a suggestion to fix this issue a participant advised that only one avatar should be allowed on a viewpoint at a time.

Moving from one viewpoint to another was easy for 19 participants, but 2 participants out of the rest couldn't figure out how to move around even with instructions. The rest found it difficult initially and needed instructions to figure out how to move around.

A few participants found it difficult to find the movie screen and also felt the screen to be small and far away. A couple of participants said that the quality of video was bad. About 12 participants noticed a lot of lag in the application. Headache and dizziness were experienced by 8 participants, which was caused by lag for 5 participants.

Pausing and playing the movie was easy for 11 participants, while the rest felt it was difficult because the pause / resume button was small and it was difficult focusing the cursor on it due to lag. Around 4 participants found it disturbing to have the red progress bar and the pause / play button always being displayed on the screen. Some of the participants said that cursor could improve as it was difficult to find it and focus using it.

16 participants reported overall experience to be in need of a lot of improvements, while a few from the rest felt the experience was immersive. 9 participants said that the virtual reality application made them feel like they were watching a movie in a real theatre.

As for the virtual presence of the other participant being felt, around 21 participants stated that they could not feel the other participant being virtually present with them. About 8 participants were not happy with the avatar of the other participant, stating that a real human avatar is needed instead of a box and annotations can be added to identify the avatar. One of the participants stated that they would like to see the other avatar sitting next to them like in a real movie theatre, rather than the avatar moving around and blocking the view of the screen as reported by 4 other participants. 12 participants stated that the avatar for the other participant either disappeared after a while or was not visible during the entire movie clip. One participant said that seeing the avatar of the other participant was not necessary, and just their voice would have been enough to feel their virtual presence.

When asked about watching a 2-3 hour long movie using the virtual reality application, 16 participants were not willing to doing it; while 6 of the rest were up for it and the rest 4 participants were unsure.

Most of the participants were comfortable wearing the VR headsets, but 8 participants found the headsets to be uncomfortable because they felt the headsets were heavy and might slip off the head while moving. 4 of the participants reported that a lot of head movement is required to find the screen and one of the participants stated that the head had to be moved very slowly in order to have a smooth experience. A couple of participants also reported that the virtual reality application was too sensitive to their movements at times.

As for the improvements, a couple of participants suggested that using browser as a platform for the application was not a good idea and that an android or iOS application would be more powerful providing a lag-free experience. Around 3 participants stated that the usability of the application needed improvements; and most of the participant believed that getting rid of the lag in the application would make it a seamless experience.

When asked to compare the experience of the virtual reality application with TeamViewer, 14 participants reported that TeamViewer was a better choice for the purpose of watching movie together virtually; while the rest said that the virtual reality application devoid of lag and with smooth improved experience would be the best choice. 4 of the participants really loved the virtual reality concept for watching movies virtually and looked forward to watching movies virtually with their friends.

Prior studies found that the use of virtual reality for watching movies was not a good choice because the social presence was not felt as the users had to make an effort to communicate in order to keep the contact during the movie. This study found that the major reasons why virtual presence was not felt using the virtual reality application were the poor or no communication channel, lot of lag in the application making it difficult to focus and causing dizziness / headache, difficulty pausing / playing the movie, square shaped avatar instead of a human-like avatar, discomfort caused by VR headsets, etc. If these issues are fixed, then the virtual reality application seems to have great potential and would be a great way to watch movies online together.

4.3 Common patterns:

- Using TeamViewer, most of the participants were able to communicate without any issues. On the other hand, using virtual reality application, almost all the participants faced issues while communicating with the other participants. For more than half the number of participants using the virtual reality application, the communication channel wasn't established at all (they were not able to hear each other, though they were speaking into the microphone); while in case of a few other participants only one-way communication was established. A lot of lag, echo and disturbance was also experienced on both the platforms by the participants who were able to communicate with the other participant. The overall quality of communication on both the platforms also seemed to be dependent a lot on the internet connection speed.

- Some of the participants experienced lag, echo and disturbance in the movie audio and video on TeamViewer. The lag in movie and audio was mainly observed on only one participant's side TeamViewer client, which was displaying the screen shared by the other participant. Understanding the other participant speaking and the movie audio at the same time was also difficult for some participants on TeamViewer. The virtual reality application seemed to be performing really well in terms of the quality of the movie audio and video as only a couple of participants complained about it.

- Using TeamViewer for watching movies together online was thought to be convenient, especially if the friends live in different cities. Some people opposed this thought by claiming that TeamViewer was not designed for this purpose and there might be other better ways available for the purpose of watching movies together online. On the other hand, even though participants faced a lot of issues with the virtual reality application, they still seemed fascinated by the whole concept and looked forward to using an improved version of the application in the near future.

- Setting up TeamViewer to watch movies was easy for most of the participants. The only participants who felt it was difficult and needed help were middle aged and older participants, who also self identified as not being very tech savvy. Using the virtual reality application was found to be very easy by almost all the participants as there was hardly any setup required.

- Almost all the participants were able to pause, resume, and stop the movie on TeamViewer. On the contrary, more than half the number of participants didn't find it easy to pause / resume the movie in the virtual reality application as the pause / resume button on the screen was too small to be easily focused on with the cursor because of lag.

- Majority of the participants felt that the other participant was virtually present with them while watching the movie on TeamViewer. On the virtual reality application's side, most of the participants did not feel the other participant being virtually present with them. The absence of communication was a major reason, and the inability to see a real participant or a human-like avatar in the virtual environment instead of cube shaped avatars was another common reason for most of the participants to feel isolated. Also, almost half the number of participants reported that the avatar

for the other participant kept disappearing or was not visible from the beginning. Participants also expressed the need for annotations for the avatars to help identifying the other participant, as a few participants had no idea that the cube shape is another participant's avatar until they were informed. Additionally, if there are more than 2 friends watching a movie in the virtual environment, it will be a necessity for the users to identify the other avatars. Also, A very few participants prefered to watch movies alone and generally didn't like to speak during movies, and thus did not care much about the virtual presence.

● The webcam video quality was reported to be poor by a lot of participants. The size of the webcam window was also found to be small and option to expand it would make the experience better as per some participants. Also, the other participant looking at the screen seemed as if the participant is constantly staring at the webcam (which is usually positioned right above the screen) which was perceived as a creepy experience by a participant.

● Most of the participants preferred watching the movie from the center or the front viewpoints closer to the screen in the virtual reality application. Viewpoints were found to be useful but, a need for viewpoints being closer to each other and more number of viewpoints was expressed by a few participants. Moving from one endpoint to another was easy for most of the participants, and only a few participants needed help figuring it out. The need for restricting only one avatar per viewpoint was expressed as the other avatar would become invisible if both the participants landed on the same viewpoint. Also, participants had to often switch viewpoints to unblock the view of the movie screen which was being blocked by other participant's avatar.

● Participants found it difficult at times to find the movie screen in the virtual reality environment at times. Also, the lag and virtual motion being too sensitive to the actual head movement resulted in headache and dizziness in a few participants.

● Wearing the virtual reality headset was comfortable for most of the participants, but a few participants felt it was too heavy and would slip off their head during head movements.

● The movie screen in the virtual reality application was reported to be small and placed far away. Also, participants felt that having the pause / resume button and the red progress bar constantly displayed on the movie screen was disturbing.

● Most of the participants had a satisfactory to good experience with TeamViewer. On the contrary, most of the participants using virtual reality application felt the need for the overall experience to improve a lot to be considered satisfactory. A lot of participants still felt that the experience was immersive and felt like watching a movie in a real theatre.

● But, majority of the participants weren't willing to watch a 2-3 hour long movie together with their friends via TeamViewer. Lag seemed to be the major reason for participants not having a good experience and opting for not watching long movies on TeamViewer. Using virtual reality application, only a small number of participants were willing to watch a long movie, with the condition that lag and a lot of other features were improved to provide a seamless experience.

- Even though a lot of issues were reported by participants about their experience with virtual reality application, the overall preference was about the same. Most of the participants who chose virtual reality application said that the reason for that decision was the immersive experience and the potential that the application had if it was improved to provide a smooth experience.

4.4 Limitations

Some of the obstacles faced in the project were as follows:
- One of the tasks in this study was to familiarize the older adults with virtual reality. As they were not acquainted with the virtual reality technology, it was necessary to make sure that they know how to use the virtual reality application, navigate and explore the virtual environment using head movements, etc.

- Not all participants knew each other and thus, the communication between them during the movie seemed very formal and limited at times.

- During the virtual reality tasks, it was difficult to make sure that the participants were following the given instructions, as the moderators were not able to see the screen while the participants were using it. Whenever the participants couldn't figure out something, the moderators found it difficult to help the participants out as they were unaware of where the participant is looking in the virtual environment, and if the participants are able to notice the viewpoints or screen functions.

- High end phones with large RAM capacity had to be used for the study to ensure good performance in the virtual reality application, as phones with lower RAM seemed to have a lot of lag issues.

- The virtual reality application would drain the phone's battery very quickly, and thus the phones had to be charged between every session.

5. DISCUSSION

Dorta et al. [3] discussed that watching movie together and communicating during the movie are important aspects of enjoying a movie. Their study claimed that virtual reality applications using VR headsets is not a good choice for watching movies together as the participants have to make an effort to communicate in order to keep the contact with the other and hence the social presence is not felt. On the contrary though the results of this capstone study state that the virtual presence was not felt using the virtual reality application, almost half of the participants said that virtual reality was a great choice for watching movies online. Most of the participants felt that the virtual presence was not felt because of the issues in the application like lag, lack of communication channel, improper avatars, etc., and they looked forward to watching movies using a future improved version of the application. Overall, the idea of watching movies in a virtual environment was welcomed by most of the participants if the technology was improved and thus it contradicts the claim that using virtual reality headsets is not a good choice for watching movies together.

The results of the initial evaluation, of the virtual reality application for collaborative learning, conducted by Monahan et al. [11] stated that using virtual reality provided an immersive and engaging experience, and was very effective means for learning. Also, other related studies by Chen et al. [2] and Yoon et al. [10] concluded that virtual reality applications provide a much more immersive experience than the experience provided by the traditional systems in place. Similarly, the results of the study, conducted for using virtual reality application for watching movies, aligned with the above evaluation. A lot of participants either found the experience of watching movies in the virtual environment very immersive, or felt that a future improved version of the application had a great potential for creating an immersive and engaging experience.

5.1 Design Recommendations

Some of the recommendations for the virtual reality application based on the feedback from participants / as well as observing the common patterns are as follows:

1. Increase the number of viewpoints and the proximity between viewpoints and place them strategically such that no user can block some other user's view of the movie screen. Limit only one user's avatar per viewpoint. This will prevent the overlapping of avatars as well as making the virtual environment more realistic as in the real world only one person occupies a seat in a room.
2. Improve the communication channel so that participants can communicate with ease without lag and echo.
3. A tutorial inside the virtual environment on the first launch of the application to ensure the users get acquainted to all the functionalities.
4. Improve the quality of movie video.
5. Make the size of the movie screen larger so that it doesn't seem small or far away.
6. Get rid of the lag in the application, as this eventually caused dizziness in many participants.
7. Make the pause / play button slightly larger so that it is easy to focus. Getting rid of lag will also make it easy for people to focus the cursor on screen and other functions.
8. Improving the cursor design as people found it hard to find it and focus on it.
9. The progress bar and the pause / play button need not be visible on the screen constantly. They can be either triggered to be visible by some other button outside the screen / some action or they can be displayed outside the screen constantly.
10. Adding capability to customize avatars and having human-like avatars will ensure that users are able to identify the other users easily.
11. Many of the participants needed a lot of head movement to find the screen and noticed that the virtual movements were too sensitive to the head movements at times. This experience could be improved.
12. When the user starts the virtual reality application, the first view should be in the direction of the screen. This will prevent the users from trying to find the movie screen initially. Also, to ease the process of finding the screen, indicators can be displayed in the virtual environment pointing towards the direction of the screen. This recommendation is based on Nielsen's heuristics.
13. The virtual reality application could be made as an Android / iOS application rather than a web-based interface, as native applications are more powerful than web-based applications [13].

5.2 Future work

The scope of this project was to perform a Usability Study on a Virtual Reality application which allows people to watch movies together in a VR environment in order to determine the usability flaws in the application. Based on the results of the study, a lot of design recommendations were made, which can be further researched upon to make the user experience much more immersive and smoother.

One of the first aspects would be to further research into the representation of avatars. Research can be based on the aspects like the look of the avatar, what kinds of avatar are noticed better, should it represent a character or the user himself, how to make the avatar more expressive, making the avatar also lip sync while the user is talking, annotations to identify user's avatar, how to make the avatar more realistic, whether the avatars should always be standing or it could have the capability to sit during the movie, etc. More research can be done on viewpoints. Research can be conducted for finding the best and most strategic positions / layout for viewpoints that prevents users from blocking the other user's views. In addition, research can also be done on the best size and shape for the representation of the viewpoints, number of viewpoints, their proximity from each other, etc.

Improving the screen functions in the virtual environment like pause / play button, forwarding and rewind using the progress bar, etc. can also be researched on. The aspects like the size and placement of the pause / play button, if it should be visible at all times, or should it be only visible at times, what could trigger the visibility of the button, etc. can be determined by performing more research and studies. Also, research can be conducted on how to make sure that the screen functions like pause, play, fast-forward, rewind, etc. are not triggered by accident.

Once the virtual reality application is improved by fixing all the technical issues and incorporating design recommendations, it would be helpful to conduct a quantitative usability study to provide more insights on the usability of the new version of the application.

6. CONCLUSION

The study resulted in a list of findings stating the positives and negatives of each approach for watching movies together online via two video applications, TeamViewer and Virtual Reality. Overall, the participants had a much better experience with TeamViewer as compared to their experience with the virtual reality application. Even virtual presence of the other participant was felt more using TeamViewer than the virtual reality application. Prior studies found that the use of virtual reality for watching movies was not a good choice because the social presence was not felt as the users had to make an effort to communicate in order to keep the contact during the movie. This study found that the major reasons why virtual presence was not felt using the virtual reality application were the poor or no communication channel, lot of lag in the application making it difficult to focus and causing dizziness / headache, difficulty pausing / playing the movie, square shaped avatar instead of a human-like avatar, discomfort caused by VR headsets, etc. If these issues are fixed, then the virtual reality application seems to have a great potential and would be a great way to watch movies online together.

The results were more or less balanced and there was no clear winner, with TeamViewer getting 54% of the total votes. The positive aspects of TeamViewer were that the virtual presence was felt by many participants, since they could communicate with the other participant using audio and webcam video, it was easy to stop/play the movie, however the experience was not immersive and webcam screen was very small. Though virtual reality application received a lot of feedback containing complaints regarding several existing issues like audio, and video lag and the dizziness caused by the lag, communication channel not being established, hard to focus on the pause/play button, cube-shaped avatars making participants feel no virtual presence, and other avatars blocking the view of the movie screen. On the other hand, participants really liked the immersive experience of the virtual reality application which made them feel like watching the movie in an actual theatre and also it was easy for them to move around in the virtual environment using the viewpoints. Participants enjoyed exploring the virtual reality application and the idea of watching movie together online using the virtual reality application was welcomed with great enthusiasm by most of the participants. The participants who chose TeamViewer as a preference, did so because of the existing issues in the virtual reality application; and they expressed the desire to revisit an improved version of the application in the future. Participants expressed that the virtual reality application had a great potential to be the best method of watching movies virtually, and with improvements it would surely be preferred more than the TeamViewer method.

7. ACKNOWLEDGEMENT

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