AR Gallery Wall Planner

Link to demo: https://vimeo.com/manage/videos/665669231

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Abstract

Augmented reality (AR), which enables users to see virtual 3D objects in the real world, has been effectively used in applications such as IKEA place in order to showcase furniture (Alves, 2020). In this study, we aim to evaluate how well AR works together with haptics for gallery wall planning. An AR application was built in Unity that allowed users to showcase virtual posters in a physical room. We compared it to a photo editing application which is a more simplistic way of using technology for planning room decoration that also uses haptic input. A user test with seven participants was conducted, where they evaluated the two applications in terms of usability, ease of use and user experience. From this, it was found that AR does seem to have potential to be a viable tool for gallery wall planning.

1. Introduction

Augmented reality is a technology that enables users to see virtual 3D objects in the real world by using screens and cameras to integrate them into the view of the user (Nayyar, 2018). Since the creation of the first AR in 1962, many developments within AR have been made and AR has been used and researched in areas such as architecture, maintenance, entertainment and education (Cipresso, 2018). Studies show that the use of AR in different applications can increase the user experience and provide new real value to the users (Alves, 2020) (Romano, 2021).

An application that uses AR effectively is IKEA place (Alves, 2020). In this application, consumers use touch to interact with virtual furniture objects when shopping online, enabling the customer to see how the product would look in their home before buying it. Alves (2020) found that consumers reported more confidence and convenience of purchase using this application.

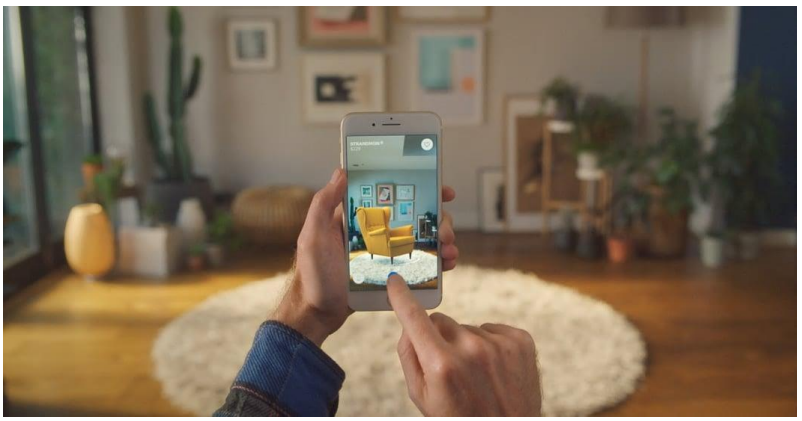

Figure 1: The IKEA Place application.

As can be concluded, AR together with haptic input in the form of touch gestures has a place in the retail industry, where proof has been found of AR increasing the value for the consumers. In this study, we want to explore further applications similar to IKEA place, namely, the planning of gallery walls. In this application, the consumers would use AR technology to decorate walls in their home with artworks, using virtual posters. This could provide great value as the technology can help the consumers perceive how the posters would look in their home before making their purchase.

To evaluate whether an application that uses AR and haptics is useful for gallery wall planning, we will compare the AR application to a photo editing application that uses still images to plan the gallery wall. The research question is phrased as follows:

Is AR together with touch input in a mobile application a viable tool for gallery wall planning?

As mentioned, previous studies have shown that AR can increase user experience and participants have expressed a preference of the AR technology (Alves, 2020) compared to traditional methods of shopping online. Therefore, our hypothesis is that the use of AR will be able to provide more value to the consumers compared to using a photo editing application, as it is a more immersive technology that can make the gallery wall look more realistic which lets the user get a better grasp on how the gallery wall will look like in real life.2. Background

In this section a brief overview of AR is described in section 2.1, a brief overview of touch input in section 2.2 and finally HCI research concerning AR together with touch is presented in section 2.3.

2.1 A brief history of AR and its applications

The first augmented reality system was created by Ivan Sutherland in 1968 (Arth, 2015). Arth (2015) explains that the AR system was connected to a stationary computer and used a head-mounted display that was optically see-through, rendering very simple wireframe

drawings in real time as it was limited in computer power. However, it was not until years later in 1992 that the term “augmented reality” was coined by Tom Caudell and David Mizell, which referred to overlaying computer generated graphical objects on top of the real world. Caudell and Mizell argued that AR had an advantage over VR in the sense that less processing power was needed as less graphical objects had to be rendered. Five years later, the first mobile augmented reality system was presented in 1997, which used a backpack holding a computer along with a hand-held computer with a touchpad. Since then, the use of Augmented Reality (AR) has been rising mainly due to the increased processing power of devices, e.g. smartphones (Faliu, 2019). In fact, AR has even been regarded as one of the most world-changing technologies of this century because of its potential use in different fields, including entertainment, interactive digital media, healthcare, military, industry (Nayyar, 2018), customer engagement, brand recall, purchase impulsiveness and purchase confidence (Brengman, 2019).

One area where AR has been shown to provide significant value is the retail sector, where companies such as IKEA and Amazon, take advantage of AR to enhance the consumer experience (Romano, 2021). IKEA’s application of AR technology is called IKEA Place (Alves, 2020). In this application, consumers use AR technology when shopping online to place different products, mainly furniture, in a room. Alves (2020) made a study on the consumer's experience with the AR application and found that consumers reported more confidence and convenience of purchase using this application. Additionally, consumers reported a preference of this technology to make online purchases over other existing channels.

2.2 A brief overview of touch screens as input and its applications

The first touch screen technology went public in 1971 and was used in research and industrial settings (Hoye, 2010). The authors explain how with this new technology, users were able to manipulate digital environments by only the touch of a finger or another input device such as a pen. This new technology gave operators an alternative method of how they interact with different devices and it laid the groundwork for many new implementations.

Hoye (2010) explains that there are three main methods of touch screen technology: resistive, infrared and capacitive touch screens. In simple terms, resistive touch screens work by the display being bent slightly by the applied pressure from the touch. Infrared touch works by sending light and whenever it is blocked the operating system analyzes the data and recognizes where the user touched. Finally, capacitive touch screens work by measuring the change in capacitance when a user touches the display.

As far as applications of touch screens go, resistive touch screens are often used in toys, office electronics and ATMs (Nam, 2021). Nam (2021) explains that this is due to the fact that they have poor optical quality, require relatively high touch force and can only register one single touch at a time. Infrared touch screens are commonly used in the military because of their durable surfaces and ability to be handled in hostile environments (Hoye, 2010).

Finally, capacitance touch screens have been widely used in most consumer electronics such as smartphones and notebook PC's, because they can support multi-touch functions along with a high durability and good optical clarity (Nam, 2021). Because of these advantages, AR applications utilize touch as input in smartphones.

2.3 AR, touch screens and HCI

In smartphones, touch is the most common way to interact with AR (Fiorino, 2019). Research has found several interesting benefits of this multimodal interaction, which may explain why this particular multimodality is so prominent in AR. Firstly, smartphones do not usually come equipped with gesture tracking technology, which makes touch the natural choice of interaction (Fiorino, 2019). Secondly, Fiorino (2019) explains that touch has been shown to be effective to translate, resize and rotate graphical objects in AR. Finally, touch has been shown to positively affect feelings of perceived ownership of a product, which pertains to the feeling that a person 'owns' an object. This may lead to more favorable product attitudes and higher purchase intentions (Brengman, 2019).

AR in smartphones does however have limitations that may affect the usability of the HCI. For instance, ARCore, a common SDK for AR applications, utilizes oriented points to place virtual objects on angled surfaces. It works by measuring the angle between a point and the nearby points that can for instance be points with different color or contrast. This means that when a surface lacks a clear texture the detection may not work as intended. Also, this method performs better at horizontal than vertical planes. Additionally, several studies have found that users perceive AR systems to be more difficult to use compared to the physical or desktop-based alternatives (Radu, 2012). Furthermore, Radu (2012) explains that students have been shown to need higher attentional demands from AR systems, which resulted in the student ignoring vital parts of the experience. To conclude, although the interactions with AR systems have been shown to have many positive effects, AR may also have negative effects on the users. With this background, we want to explore whether the advantages that AR can bring in the context of gallery wall planning are sufficient for users to consider it a viable tool.

3. Method

To examine the research question a mobile application for planning gallery walls using AR technology was designed and developed. The application was built to have similar features to already existing photo editing applications such as the ability to add multiple posters onto the wall, move them around, rotate them and scale them. The AR application was also designed to have the same haptic input as existing applications. To evaluate whether the application was a viable tool for gallery wall planning a user test was conducted where participants got to use both the AR application and a photo editing application and compare how well they both worked for the task.

3.1 The application

3.1.1 Functionality and interactions

The application was designed with limited features in order to make it easier to focus the examination on the experience of using the AR and haptic technology and to minimize distractions from things such as usability issues. The visual interface of the application mainly consisted of the AR but also had a navigation bar at the bottom where the user could pick between three different posters to use for their gallery wall (See figure 2). When the user selected a poster a preview appeared in the middle of the screen showing the user where the poster would be placed. In order to see what the posters would look like in their home the user could then touch the screen for the poster to be placed out on the wall in the application. The user could select as many posters as they wanted to put up on the wall. There was also functionality to delete posters if the users wanted to change any poster.

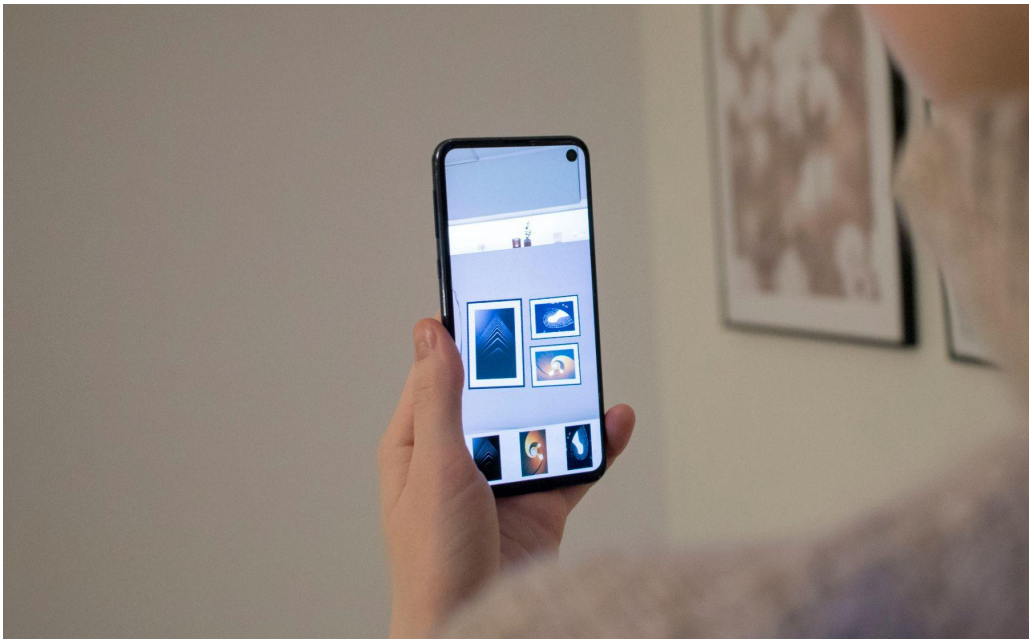

Figure 2: The AR application in use

The application used haptic input in the form of different touch gestures to let the user arrange the posters placed on the wall in the wanted way. The user could select the poster they wanted to edit by tapping on it and then do a dragging motion (one finger) to move the poster, pinching motion (two fingers) to scale it and twisting motion (two fingers) to rotate it (See figure 3). These are gestures that are used in most photo editing applications to transform photos.

Figure 3: Touch gestures to interact with the AR posters, moving gesture (left) and rotation gesture (right).

3.1.2 Technology

The AR application was built using the game engine Unity together with the AR Foundation plug-in. AR Foundation makes it possible to work with augmented reality platforms in Unity. Google's platform ARCore was used for motion tracking, environmental understanding and light estimation. The application was run on a Samsung Galaxy S10+. Custom functions using ray tracing were built for the translation, scaling and rotation of posters in the application.

3.2 Evaluation

To evaluate how well AR works together with haptics for gallery wall planning it was compared to a photo editing application, which is a more traditional way of using technology for planning room decoration that also uses haptic input. To represent this we used the Android application *Photo on Photo*[1]. This application was chosen since it had very limited features which was desirable since the goal was to use it to evaluate the experience of doing gallery wall planning in 2D. It also had a similar interface and way of interacting to the AR application. Except for the visual input, the only difference between the two applications was the way of selecting which posters to use. The AR application had the posters in the navigation bar whereas in the photo editing application the user had to click on "add photo" and go into a folder on the smartphone's photo gallery where the three posters could be selected. The users were however asked to look past this difference. The photo editing application also had slightly more tools for photo editing but the user's were only asked to use those that also where available in the AR application i.e. translation, scaling and rotation to make the comparison as fair as possible.

We recruited seven participants to do the user test. The participants were first asked about their previous experiences of planning and putting up posters or paintings and were thereafter introduced to the two different applications to be tested. The same device was used on all tests and they all took place in the same room which had a plain wall and the participants got to try out both applications to style this wall. They were asked to explore the applications as much as they wanted (See examples in figure 4). Afterwards an interview was held where the

[1] https://play.google.com/store/apps/details?id=com.doionline.photoonphoto&hl=en&gl=US

participants had to rate both applications separately on a 5-point scale in regards to the following questions:

1. *How well did the application work for the purpose of gallery wall planning?*
   (1: "Not well at all" to 5: "Very well")
2. *How did it feel to use the application?*
   (1: "Very hard" to 5: "Very easy")
3. *In a whole, how would you rate your experience of using the application?*
   (1: "Very unsatisfied" to 5: "Very satisfied")

The participants were then asked to motivative their rating and were also asked a few additional questions about whether there was anything that they felt was missing from the applications and whether they thought they would use either of them when planning gallery walls in their own homes.

The participants were three men and four women and were all students between the ages of 21-28. All of them had previous experience of putting up posters and planning what it would look like in their homes but only one of them had used an online planning tool before.

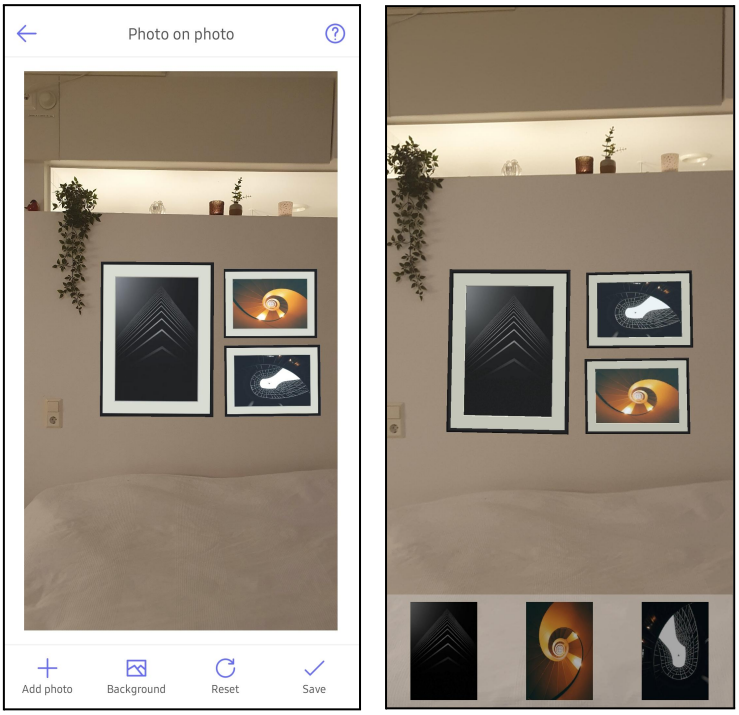

Figure 4: Examples of poster-layouts that the participants would create in the user test (Photo on Photo to the left, AR application to the right)

4. Results

This section presents the results from the interviews and quantitative analysis of the user tests in a summarized manner. This includes the participants' earlier habits of organizing posters, how the applications compared against each other in certain aspects, what was liked and

disliked about each application, as well as potential improvements to the applications that were brought up.

4.1 Participant's current habits of organizing posters

The vast majority of our participants (6 out of 7) had previously not used any programs or applications to plan the layout for their room. The one participant that had done so expressed some frustration about the application that was previously used. In that application, the participant had to manually create a mockup room from scratch, which implied everything from choosing color of the walls to importing posters and associated frames. This took time and resulted in a simulation of the room that was not entirely accurate compared to the reality.

When the participants were asked how they usually proceed to plan their gallery wall, most answered that they had done it by trial and error. One participant had tried to hold posters up against the wall and estimate the position by eye measure before hanging them up. Two others had hung them up on the wall, then stepped back to evaluate the result. If needed, they had done some adjustments. Only one participant mentioned that he usually hangs up posters with the help of another person, which simplifies the process. The rest of the participants expressed some difficulties with doing this task on their own.

4.2 Quantitative comparison

The results from the quantitative rating of the applications are presented below. For each quantitative question, the average and median was calculated.

	Photo editing application	AR application	Photo editing application	AR application	Photo editing application	AR application
Question	1	1	2	2	3	3
Average	3,57	3,86	3,86	3,86	3,57	4,29
Median	4	4	4	4	4	5

Table 1: Results from quantitative survey questions

4.3 Qualitative comparison

4.3.1 Usefulness

The AR application provided a better experience according to most participants due to the immersiveness of placing virtual objects in the real world. Four participants mentioned that the AR application was better for the purpose as it enabled them to see the wall from different angles and distances, which helped them in deciding where to place posters and see how they would look together with other furniture in the room. Two participants also thought that the AR application felt more real and therefore more useful compared to the photo editing application. A few also mentioned that the AR application would be better to plan their gallery wall layout as they can easily try the posters on different walls by just looking around.

All the participants were positive regarding if they would ever use any of the tested applications for future gallery wall planning. However, they gave mixed answers regarding which of the applications they would use and in which scenarios. Three participants expressed that the photo editing app could be more comfortable to use as they would not have to move around the room to plan their wall but could instead do it from their sofa. Despite this, two of them still preferred the AR application over the photo editing application because of the immersive aspect. The last one of the three would prefer AR when planning together with friends or similar. Furthermore, two participants raised that it would be easier to share pictures of planned gallery walls with friends and ask for opinions when using the photo editing application.

4.3.2 Controls and usability

The ease of use of the applications was rated similarly according to the quantitative result. However, the qualitative result had mixed motivations on the ease of use. Five participants thought that the AR application had a more intuitive way of selecting and placing a poster, since they could just select it in the menu and touch once to place it. Something that further weakened the usability of the AR application was the occasional instability and inaccuracy of it. Five of the participants thought that the AR application was shaky and also had worse touch feedback, which made the posters harder to control sometimes. This made it hard for the participants to arrange the posters in the way they wanted. This was especially annoying according to one participant, who valued accuracy highly and mainly based his higher preference of the photo editing application on this aspect.

4.4 Potential features

Apart from improvements of the AR technology, the participants mentioned several new features that could be applied to the AR application to make it more reliable and useful. The most requested function was some kind of alignment tool, or a grid, that would help the user to position posters beside each other and make sure they are placed in a straight manner. Continuing on the aspect of accuracy, some users wanted to see the distances between posters, as well as the size of the posters themselves. Other features that were requested were the ability to save a created gallery wall with specific positions and artwork in order to showcase them at a later occasion, and the ability to lock a poster into place so the user cannot accidentally move or scale it.

5. Discussion

In this section we will evaluate the insights gathered from the interviews in order to draw conclusions about the AR applications viability as a tool for gallery wall planning. Furthermore, we will raise some of the error sources and issues of our interface and how it was tested with users. Finally, we will discuss the potential developments of the interaction

with the AR application and how the insights from this study can be implemented in future applications for interior design.

5.1 AR for gallery wall planning

The quantitative evaluation showed that the AR application was generally rated higher in satisfaction of use and fulfillment of purpose, while scoring the same as the photo editing application on ease of use. This implies that using AR technology for gallery wall planning overall seems more satisfactory than photo editing applications. However, this score is only a mere comparison to the photo application in numbers, and does not directly answer the question about whether AR indeed is a viable tool for gallery wall planning.

The qualitative evaluation seems more promising in answering the research question, and gave valuable insights as to *why* the users liked the AR technology for planning a gallery wall over the photo editing application. The main aspect that was appreciated with the AR application was the ability to look at the gallery wall from different distances and angles as it helped the participants to make decisions about the gallery planning more easily. Furthermore, the AR application was good at giving the participants a general idea of how they could plan their gallery wall in a quick but still very immersive fashion. However, as the AR application requires users to actively move around and point their phone in certain directions, it does have some disadvantages in terms of ease of use. Some users thought about gallery planning as something that they wanted to do while sitting comfortably on their sofa. This implies that the AR application may be more viable in terms of usability for some users or scenarios, while less viable in others. The few objections towards using the AR application was mainly that it wasn't accurate enough while placing posters, or that the AR technology itself was too unstable. These issues are something that is indeed relevant to the question of using AR as a tool, but one can assume that they will become better as the technology develops.

5.2 Areas of application

Based on the results from the user tests, AR shows potential to be used as a tool for gallery wall planning. Some adjustments of the application can be done to improve the user experience, however it seems to be useful in the specific area. The users that pointed out the need for aligning tools still saw potential of the application to the whole. However, in areas of application that require more detailed adjustments, AR as it works today may not be the most appropriate tool. Since the AR experience itself does not work entirely faultlessly, involving such parameters would perhaps complicate the development and result in a worse user experience. One example of an area of application that is not as dependent on details is interior design, where AR could potentially work as a tool. Interior design as it works today, when done in 3D, is usually done by creating a mockup room or a simulation that is not the physical room. Here, AR could work as a tool for interior designers to show how the design would work in the physical room.

5.3 Methodological critique

5.3.1 Using AR on vertical surfaces

As mentioned in the background section, AR does not work quite as well with recognizing vertical planes as horizontal ones. Our application had some slight issues with wall detection that likely depended on this. All posters were not deployed perfectly straight against the wall, since the wall was white and plain without any textures. We were aware of the problem with vertical detection and tried solving this by adding real world objects in front of the wall in order to get some reference points and imitate a real room. This helped, but more reference points could have been added. Alternatively, another wall with more texture could have been chosen.

Additionally, in the last user test in particular, the deployment of the posters had big issues. The participant failed to get them straightly attached to the wall. This test was performed at the end of the day when light conditions were changed, which could potentially have complicated vertical plane recognition even more. If we would have added more reference points to the wall or chosen another one with texture, the light conditions would potentially not have affected the results as much. However, this also shows that the AR does not perform as well in some environments.

5.3.2 Earlier experience of photo editing applications

On one hand, earlier experience of photo editing apps should have perhaps been a requirement to participate in the test. Only one participant had previously used a photo editing application to plan their gallery wall, indicating that this method is perhaps not something people generally use to plan their gallery wall to begin with. On the other hand, if the participants had earlier experience of photo editing apps it could have influenced the results. Earlier experience could for example have an effect on ease of use of an application, since they are familiar with the functions.

5.4 Future work

There were some great ideas of improvements and features brought up by the participants that could be very relevant in order to further increase the viability of the application. First and foremost, many participants mentioned that they would like some kind of align or grid feature. Many also mentioned distance and sizing metrics would be valuable tools to have while organizing posters in the application, with one participant saying that these types of features were crucial for him to use the application. Hence, precision of poster layout overall seems to be a shared factor that could make the application more usable in general. However, in order to provide an accuracy of this level the AR technology would probably need to be developed further in order for the features to run smoothly.

Another feature that was mentioned frequently was the ability to save gallery walls in order to view them at a later occasion. This could potentially help users to share ideas with others, or give the user some time to think about their idea. Furthermore, this would be a way for

interior designers, as mentioned previously, to share ideas of gallery walls to clients. The feature would however be rather hard to implement as it would require the application to recognize the room as it potentially changes in design.

6. Conclusion

As in the case with the furniture placement with the IKEA Place application, AR and touch seems to be a rather viable tool for gallery wall planning as well. Despite using vertical planes instead of horizontal, the application we created in this project was able to showcase posters well enough to be appreciated by our test participants. Most participants preferred using AR over standard photo editing in order to plan their gallery wall because of its immersive aspect, allowing them to more easily test and decide what looks good in their room. Regardless, further developments of the AR technology would benefit the application as it would provide a more stable user experience, as well as allow for precision making with features such as alignment or measurement.

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