AR-based application concept design for navigation at the mall

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This thesis will provide an idea by designing an app that will help the users to navigate the mall or to know the offers or discounts of the mall. This can be made easier with the help of AR (Augmented Reality). UX and usability are taken into account while doing this thesis. An agile methodology is used where the round iterations work. There are a few questions that need to be answered at the end of the thesis.

There is an introduction to the topic at the beginning of the thesis which is then followed by some questions then user interviews, analyzing those interviews, and then prototyping which leads to the testing of the prototype and then the final product.

The work on this thesis is maintained in such a way that it can be completed in the first week of June 2022. The research on this topic can help to make navigation easier in such a way that the user saves their time and energy rather than going to the shops or using the navigation stands for searching. The process of the thesis went in a way that in the introduction part the author introduced the topic and the location for which the thesis is performed is named “Mall of Tripla”. After the introduction part, the goal of the thesis is to plan questions whose answers are to be found at the end of the thesis. Also, this part showed the research method used for this thesis. Then the author made the related research for the topics used in the thesis. The topics were AR, UCD, Usability, and User Interface Design. To proceed, a brief knowledge of these topics is required. Then the design of the concept was made. The concept design includes the profile of the user, user studies, analyzing data or user studies, and then user evaluation. Implementation is the next step after concept design. Which was followed by a low fidelity prototype and a high fidelity prototype. The high-fidelity prototype included testing of users. After testing improvement was done in high fidelity based on user feedback/results. The final step is discussion and then conclusion.

Although there is a need for more improvement in this design. If this improvement can be done then this design will prove to be very beneficial in the future as AR technology is emerging.

Keywords
AR, UX, UCD, UI, Iterative Design, Usability, User Interface design.

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1 Introduction

The study of this topic is performed by combining research and product methods by the author. The author intends to complete the degree by completing this final project (Thesis).

The app is used as a short form of “Application”. The software program is the same thing. For any hardware platform, an app may refer to a program. Apps are used to describe programs for mobile devices such as smartphones, and tablets.

In 2008, “Apple” launched “App Store” from that time the term “app” became popular (Sharpened Productions, 2012). As time passed the term app became extremely popular and now people use this term a lot. There are various kinds of apps used by people for several reasons. For Examples, social networking apps like Instagram, WhatsApp, Facebook, Health apps, Clothing apps, Gaming apps, and many more. According to key mobile app statistics, the apple app store has 1.96 million apps and the google play store has 2.87 million apps available for download (App development platform).

Everyone nowadays is busy and they always find an alternative from which they can save time and energy. Therefore, the author decided on this topic that can help people to save time as this app will guide them in the right direction instead of wandering here and there. This app can help people to navigate in a big mall by giving them directions using AR, and also providing them the notifications about sales/discount offers going around them.

Usually, when people go to unfamiliar places, they forget the path from which they came then this app will help them. Also, in the case they need to find any shop or restroom then this app is the best thing that can help them instantly rather than wandering around. This was all about navigation and how this app can provide directions using AR. Now taking the case of sales/discount offers then this app provides the sales which are going around within a few meters distance. Also, a user can see manually by typing the name of the shop or by searching the shop floor-wise, and then the discount will appear as per the selection.

The place considered in this thesis is the Mall of Tripla, located in Pasila, Helsinki (Finland) as a case study is to design and develop the concept. The total land area occupied by this mall is 85,394 square meters. This is the 4th largest shopping mall in Finland. It also has 50,000 square meters of office space. In the coming few years there will also be a hotel owned by HOK-Elanto. Here is the look of Mall of Tripla’s website https://malloftripla.fi/en/.

The main idea was to create a human-scale, light and open, having a green environment that settles and forms a rhythm (Info, 2022). They have considered a dynamic plant design that has different species. The constructed area is planted more than 35%. There is a place named Fredikanterassi that consists of commercial terraces, a public space, a playground, and also a free space to organize events. This information will help the author to design a green atmosphere in the app and as many events are going on in that place so navigation can help to go to that place.

At the moment the directions are provided in the mall using the info desks or the big screens add few places in the mall. It is sometimes difficult for a person to find or search for a place. So, to make it easier this idea of an app can be extremely helpful as it can navigate the user using augmented reality.

The design of this app is made keeping in mind the user experience and usability perspective. There are different phases to go through while making this app. The agile methodology is to be used in this. Where first is the requirement phase, then is the designing phase then is the testing phase, modifying phase, and then the next iteration if needed. This iteration plays an important in UX. As these multiple rapid prototyping cycles or iterative designs approach focuses on the design process and helps in encountering the problems. UCD which means User-Centered Design. By this method, the need and expectations of the user are found. But the main aspect to be covered is AR and how it can provide a better experience. What is AR? AR means augmented reality. It is a technology, which enabled the possibility of seeing digital media overlaid on the physical world. In case to look for navigation and discounts using this app, the phone camera or location tool is used. By using a phone camera, the location of the person can be detected.

2 Research questions and methods

For researching any topic, the researcher needs to fulfill some pre-requisites that help the researcher to create the path and specific goals for that Research topic. These things then act as a scale in order to calculate the outcome. This research contains the questions whose answers are needed to find at the end of this thesis. This thesis has two research questions.

2.1 Questions:

What is the optimal AR solution for Tripla?

How does the user perceive our solution as a user guide**?**

These are the two primary questions on which the research will be conducted. these questions will help to find the scope, challenges, and preferences for the design.

2.2 Methods:

The Systematic approach which helps in gathering and evaluating data in the research process is called the research method. With the help of research methods, reliable answers to the research questions can be found. There are different types of methods like qualitative data gathering, quantitative data gathering, and mixed data gathering those can be used to reach the goal. For these methods, the interviews and surveys are conducted based on which the evaluation is made. Here is the research method used for this thesis:

Qualitative data gathering method

This method consists of implementing both kinds of questionnaires that are open-ended and closed-ended questions (Tiffin University, 2021). In this method, the participant answered some questions which were premade, and some made during the conversation. The answers from the participants included digits, words, or sentences that were highly effective when the data was collected. This data gathering method gives a broader understanding of the participants which seemed like an advantage. The shopkeepers are also considered in this interview So as to get an idea about the sales, customers, or themselves as a user. The first part of the questions or just for the shopkeepers and the second part is for shopkeepers and the customers.

Here is the list of questions that were asked of the interviewees (shopkeepers and customers).

(Shopkeeper)
What does a typical day look like?
Do you have sales /discounts for your customers?
How do frequently you have a sale in your shop?
How do you inform your customers about the sale in your shop?
Besides your work do you shop from any other shop/visit in this mall?

(Customer + Shopkeeper)
How do frequently you visit/shop in the mall?
Do you have an idea about the location of the shops? If yes, then Is it easy to navigate?
If No, then What do you do to find the place?
Do you use info screens/info desks?
How frequently do you take help from info screen/info desks?
How do easily you get the info?
Do you think that an app that helps you to navigate the mall can be beneficial?
How do get to know sale offers in the mall?
Do you wish to use an app that can show you the discounts/sales going on in the mall?
If No, then Why?
If yes, then what are your expectations?
Any final suggestions?

The goal of this research can be acquired by analyzing the data from this research by knowing the current involvement of the user in the mall. This can help to find user engagement by sharing their experience of visiting the shops or finding the location. This method can help to find the problems they are facing regarding navigation or finding sales/discounts. This can only be done by proper analysis that could be made from these interviews leads to user experience evaluation. Based on user experience evaluation the design can be improved and developed for a better user experience.

To formulate the design a proper understanding of tools and the concept is needed. which can be done by reviewing the literature about a few related concepts such as UX, UI, UCD, AR, etc.

And then when the design will be complete the observation method can be used. The observation method is used to observe the performance of the developed design which will

utilize usability tests to provide necessary knowledge about the developed design and then finally will satisfy the goal of the research.

3 Related Research:

The proper understanding of the fundamental concepts related to the thesis can be gained after reading books, browsing the Internet, or taking notes. It is especially important to focus on the concept that is used in this research process.

3.1 Augmented Reality (AR):

Augmented reality is often translated as supplemented or augmented reality, which means the addition of virtual information to the real environment in real-time. It differs from virtual reality mainly because augmented reality sees virtual things on top of real reality. Virtual reality, on the other hand, immerses the user in a completely virtual world, and then the user is unable to sense the real reality. However, the term augmented reality is establishing at extremely high speed. There are two types of AR. The two types are marker Based AR and Marker-Less AR (The Franklin Institute, 2022). The augmented reality nowadays can be seen on smart devices. AR is used in education to entertainment to business. Some of the real-world examples in different fields are (William, 2021):

- Medical augmented reality examples

(Medical training, Nursing assistants, medical diagnosis)

As Figure 1 shows “Proximie” named company that offers AR surgery tools, by which doctors can perform their tasks digitally, it also has a review and comment option for the user.

“Accuvein” is used for assisting the nurses to scan a person’s arm in order to identify their veins.

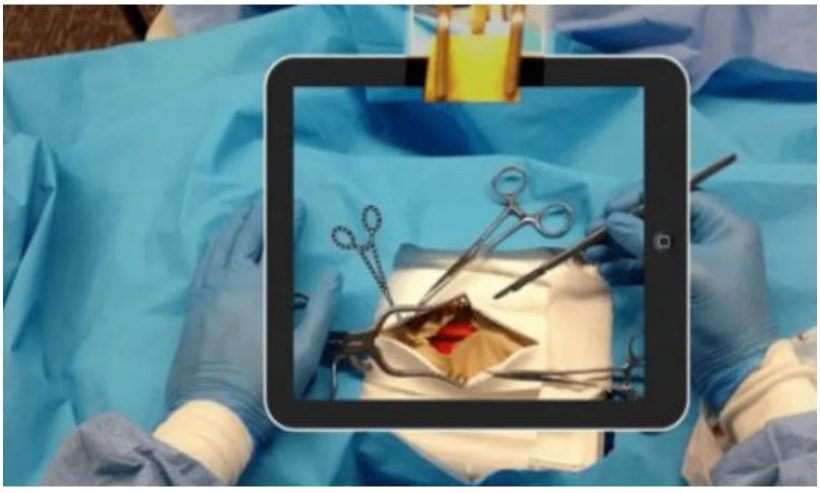

Figure 1: AR used for medical training.

- Educational augmented reality examples

(Language translations, Interactive books, STEM Kids toys/games)

"Google Translate" is used for detecting languages and then translating them to the understandable language of the user.

Figure 2 shows "I-Mechanic" app helps to view car diagnostic and maintenance information digitally. It also helps to provide suggestions for potential fixes and point out problems in the vehicle.

"Holo Popups" is a company that is creating interactive augmented reality books for kids. Where kids can see the characters come to life while reading.

STEM Kids toys. Where STEM stands for Science, Technology, Engineering, and Mathematics. "Merge Cube" toys are made keeping the concept of augmented reality in mind.

Figure 2: AR used in car repair.

- Business augmented reality examples

(Logistics, warehouse navigation, visualizing analytics, retail information, business marketing, military simulation, real estate)

Figure 3 shows how AR is used in warehouses for navigation and other information about products.

Figure 3: AR used in providing Warehouse information.

Figure 4 shows how AR is used in Real estate. It is used for getting the AR view of the house.

Figure 4: Use of AR in Real Estate.

- Travel augmented reality examples

(Travel guides, live navigation)

Figure 5 shows" eTips" is an AR app. With the help of this app, tourists can easily detect the location and information about the place by scanning their surroundings like nearby restaurants, hotels, directions, transportation, history, etc. The author used the idea of scanning from this example. In this research, the scanning code is made for knowing the location of the user. The code can be found in some places in the mall from where the scanning can be done. After this, the user knows about his location and can search for the place to go.

Figure 5: Use of AR as a travel guide.

- Entertainment augmented reality examples

(Phone gaming, board games, face filters, virtual pet)

” Pokémon Go” game is based on AR.

“Instagram, and Snapchat” apps are used for face filters. These apps also use it are for reading the face shape and the position of your eyes nose and mouth.

“Melbits POD” is a good example of a virtual pet based on AR.

- Personal augmented reality examples

(clothes shopping, interior design, food and beverages, sporting events, art, swimming goggles, promoting exercises)

“IKEA” and “Wayfair” are apps based on AR. Which helps in designing the interior.

3.2 User-Centered Design (UCD):

To make users connected to the design, the user-centered design focuses on user’s behavior preferences, likes, or dislikes. According to Norman during the design process, the focus find should be on the needs, priorities, capacities, and the behavior of the user (Norman, The design of everyday things, 2013). For the designers to design according to user needs these aspects are very helpful and essential. Anything that is made according to user needs that helps the user to do their task effectively is a symbol of a good design. Nowadays many smart devices have different functionalities that help the user to complete their tasks effectively. The UCD process is iterative because in each phase designer

has to focus on the user's needs. There is the involvement of users throughout the process when testing or doing different kinds of research and design techniques, in order to create a highly usable product.

In the user-centered design process, there is a use of different kinds of investigative and generative methods and tools like surveys, interviews, or brainstorming to understand add develop what the user needs. In each iteration, there are mainly 4 steps. (Interaction Design Foundation, 2022) Those are:

- understand the context of the use
- specify user requirement
- design solutions
- evaluation against requirements

Every step is dependent on one another in a way that if one step remains unclear then it may lead to the next step's failure.

In figure 7 from (Interaction Design Foundation, 2022), we can see how these steps are dependent on each other. And how these steps are carried out in different iterations till user needs are met.

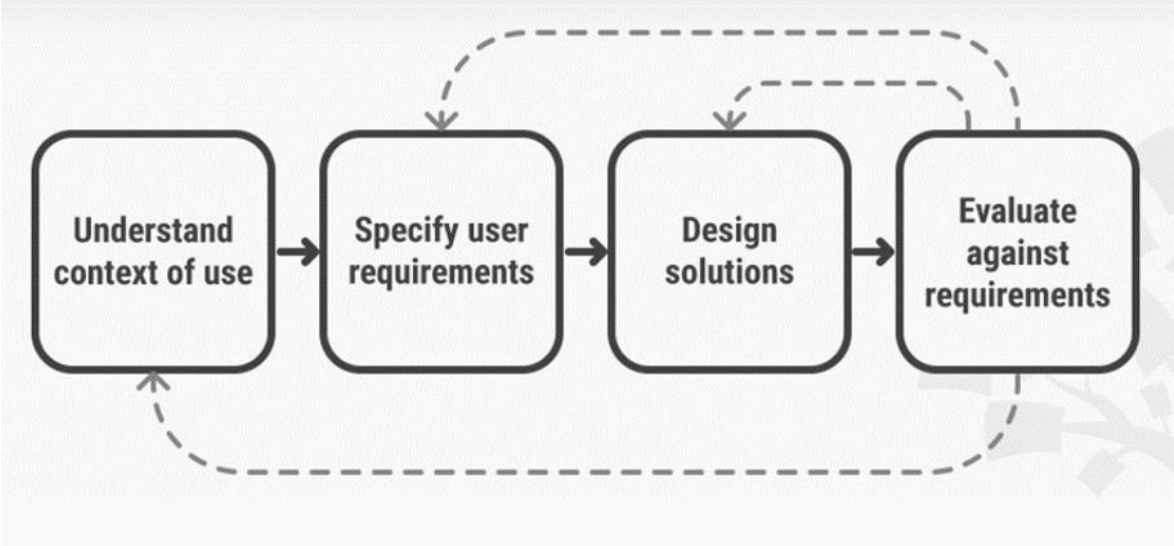

Figure 7: Explains the iterations.

User-centered design theory is providing solutions to many different fields like industrial design, interactive design, architecture, distance education, ergonomics, etc. And one of them is the integration of UCD theory in nursing teaching. Following the design method of user-centered design theory, the nursing study is integrated with teaching characteristics of nursing majors like concern and humanity, intuition, and foreseeability, scientificity and

standardization, correction, completeness, and progress. Figure 8, shows these aspects (Li Pan, 2020):

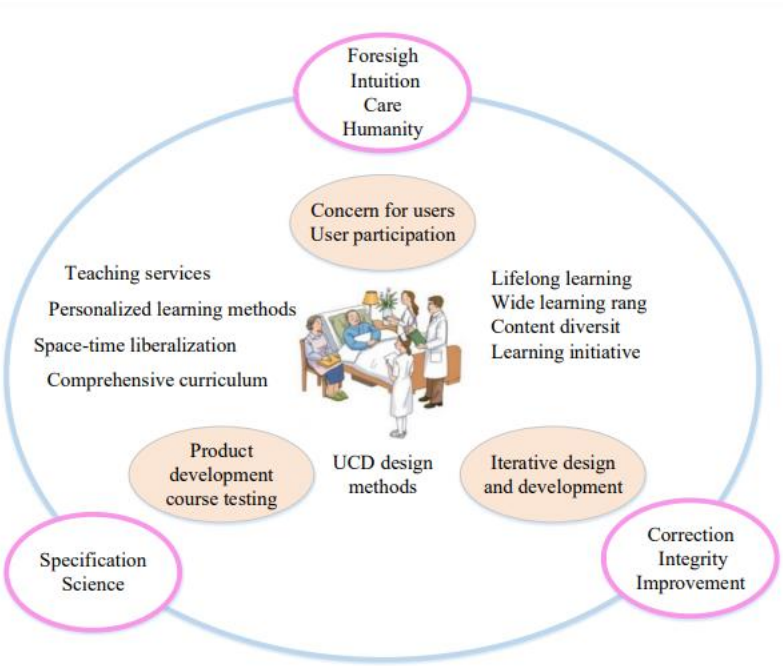

Figure 8: Integration of Nursing study

3.3 User interface design

Strong evidence and theories are needed to design a new system. This evidence and theories are the results of hard work done by experienced designers and researchers. There are guidelines of dos and don'ts based on this research and evidence. Though these guidelines may vary from one design to another still some design principles are more fundamental and applicable to a wide range of designs. By following these guidelines not only beautiful designs are created but the usability also increases. When the design does not focus on task identification then it becomes useless.

Fundamental rules of design. There are many principles of design but according to Donald Norman there are six basic design principles, and these principles are visibility, feedback, affordance, mapping, constraints, and consistency (Grimley, 2019).

There are different things on which designs are based. Here are a few design types:

- Emotions and Experience Design
- User-Centric Design
- Interaction Design
- Visual Design

Humans are emotional by nature. Emotions have an impact on our actions. Hot and sunny days may boost energy whereas cold and dark might have might be depressing. When broadly categorizing emotion and experience design it is divided into 3 categories i.e., Visceral level, behavioral level, and reflective level (Rusli, 2017).

3.4 Usability and User Experience Evaluation

Many products have and do not have usability in them. Sometimes people confuse between the working or functioning of a product. If the product is working as per its design, function, and user needs then it is considered good usability. But if it is not working let us put the needs/demands of the user then it is considered as bad usability. Due to bad usability users can face many problems. According to Nielsen, bad usability means no customers/users. The same is in the case of user experience. If the design of the product fails to accomplish the user's tasks, then it is considered a bad design and therefore leads to a bad user experience. So, Usability and UX evaluation are the important parts of designing.

3.4.1 **Usability**

Usability is known as a quality attribute that helps to assess the easiness of the user interfaces. "Usability" refers to "Ease of use." To check the ease of use five components that are to be kept in mind (Nielsen, Usability 101: Introduction to Usability, 2012):

- Learnability: How easily the user understands the tasks.
- Efficiency: After visiting once, how quickly can the user perform the task.
- Memorability: How easy it is for the user to use the app after a long time.
- Errors: How many times do user fails in their tasks, and how easy is the error recovery?
- Satisfaction: How happy the user is after using the app?

One more key aspect of the quality attribute is utility. The function of Utility is to check whether the solution provided to the user is made according to his needs or not?
When both the aspects "usability" and "utility" is considered then it makes the product "useful".

3.4.2 User Experience

The experiences of the user to deal with a system at different stages is called user experience. According to the Interaction design foundation, UX is the basis of UCD (user center design). Different steps in the designing process can be iterative like researching,

wireframing, prototyping, etc. In all these steps the decision/advice of the user is needed. User experience evaluation can be done with proper research, where the user's goal and obstacles are made clear in order to continue with the process. So, user research in this case is a very essential part. User research can be done by engaging the user with the product. User engagement can be emotional, cognitive, or behavioral. By doing so useful and useless aspects can be seen or noticed. User engagement analysis is a way to analyze the extent to which a user is engaged. To understand more about user experience, Peter Morville made a UX honeycomb structure. With the help of that structure, there are a few questions that need the answer from the user. If the user answers the questions correctly Then the experience of the user can be charged based on his answers. (DeRome, 2015). The honeycomb structure is made of different components like useful, usable, desirable, valuable, findable, accessible, and credible. The questions related to these terms can be asked as:

- Can you use it?
- Can you find it?
- Does it serve a need that you have?
- Do you want to use it?
- Do you find it valuable?
- Do you trust it?
- Is it accessible to you?

3.5 AR applications in the mall

Augmented reality is one amongst the different XR technologies. AR act as a bridge between the real and the virtual world. Augmented reality support for a location-based service. The smartphone can be used to experience augmented reality. The introduction of augmented reality was made in the 1950s by Morton by Heilig. He was a writer in the film industry. He came up with the idea for the big screen. According to his idea, the viewer should be able to feel the event with their senses. In 1962 he created a prototype which he named sensorama (Jaakko, 2013). By that time there came the improved versions of AR. Nowadays IKEA Place is a good example of augmented reality. It is a mobile application made with the concept of AR. This application lets the user choose the furniture or home appliances in their home environment through the lenses of their mobile devices. Augmented reality is different from virtual reality in the sense that it co-exists in both the real and virtual world. Whereas virtual reality can be seen with the help of VR devices. Also, this technology isolates the user from the real world.

There are different ways for different AR technologies to work. The common things used in AR technology are simultaneous localization, computer vision, mapping, machine learning, and artificial intelligence technologies that help in superimposing the virtual world on the real world. The working of all these technologies is so for creating the outside environment, the camera is used. To understand the real world and find the targets, computer vision with machine learning is used. And then digital information like images is placed on the top of the real-world (SMLease Design, 2022).

4 Concept design

As technology is evolving day by day to make things simple AR can be used. With the help of AR, app users can easily find locations in no time. This research will help to understand the expectations and preferences of the user. the user study was done by interviewing the users via Zoom or Microsoft Teams apps. to figure out the design features this knowledge will be really helpful. There were different steps included in this research process that included questions that were taken as the basis for data extraction. User imagination/suggestions also helped in the design process.

4.1 User profile

The user profile is made to get the basic details of the user. In table 1, the data collected from the user is user's age, gender, nationality, role when the user visits the mall(can be either visitor, or the shopkeeper), smartphone(devices used by the users), AR apps(shows if user have any experience of using any AR app?), then is the specific reason for visiting the mall(can be shopping, eating, etc.) this was optional for the user, then was the user's family status that gave details about the marriage, kids, single, etc.

Table 1: User profile table.

User	1	2	3	4	5	6	7
Age	40	26	31	35	39	28	41
Gender	Male	Male	Female	Female	Male	Female	Female
National-ity	Finland	Nepal	Bangla-desh	Russian	Estonia	Indian	Indian
Role	Visitor	Visitor	Visitor	Worker	Visitor	Worker	Visitor
Smartph one	iPhone	iPhone	android	iPhone	android	android	iPhone
AR apps	Snapchat, Instagram	Insta-gram	Snap-chat, Insta-gram	Insta-gram	Snap-chat, Insta-gram	Nothing	Snap-chat, Insta-gram
Reason for com-ing to the mall	Shopping	Eating	With kids	Work	Shop-ping	Work	Trans-portation
Family Status	Married	Single	Married, have kids	Married	Single	Single	Married, have kids

The main thing the starting is to make the interviewee comfortable before starting the interview. All the details of the interview were provided to the interviewee. The interview was taken on teams/ Zoom. Few interviewees agreed to record the interview, but few denied it due to their reasons. Interviews were analyzed by task matrix. Interview transcripts are attached at the end in the appendix.

4.2 User Studies:

After interviewing the user, a user scenario was made and tested with a few users. User scenario allows the designer to understand user needs, it helps to make the objectives clearer, it is made concise, and it focus lays on the experience, this fosters empathy with users. This scenario is task focused. The scenario is made to tailor the experience so that the design should meet the user needs and motivations (Costa, 2020). Before writing the scenario the knowledge about the user was collected, the goals and tasks were written, the problems and possibilities were reviewed so that the path must be made clear.

User Scenario

Tia is a mother of two kids. She is 38 years old. She is also working Part time. She frequently visits the mall to buy clothes, groceries, accessories. Mall of Tripla is the closest mall for her to buy everything at one place. She enters the mall from different doors. Every time she enters the mall, she gets confused with the shops and the directions. Also, as the mall is so big, she sometimes cannot visit all the shops to find the things at affordable prices. She is sad and disappointed as she does not have enough time to wander in the mall and search for a place or a thing she needs. Fortunately, now she started using the app AR. She is very happy with the app. Whenever she visits the mall now, she uses the navigation option to find a place where she wants to go without wasting time. Also, when she chooses the second option for sales/discount, from her app she gets information that weather there is any discount going on in that shop or not. She sometimes chooses sales/discount nearby option, which shows the sales going on around when she is passing by the shops. This saves her time and money.

In this user scenario, the user needs to imagine and follow the scenario. The aim of this scenario is to get user an idea. This idea will give the user the sight to use the app and the function that will be available in the app.

4.3 Data analysis:

The data analysis was done based on interviews using the task matrix in table 2. Different users have different behaviors which helped to know about their views and behavior. From the feedback of the user, it is told that they liked the concept and were eager to see/use this kind of app. It was difficult for the users to imagine the concept without a prototype and less/no knowledge of AR. Few users questioned how to use the camera. Then the answer to their question was added to the improved version of the scenario. Few users also asked about the language used in the app. The information is valuable as it provides valuable insights, features, and aspects of the AR design. There were eleven questions in the task metrics for which the answers were Yes, No, sometimes/maybe.

Table 2: Task matrix

No	Questions	User1	User2	User3	User4	User5	User6	User7
1	Frequent Visitor	Yes	Yes	yes	yes	yes	yes	yes
2	User Friendly	Yes	Yes	yes	yes	yes	yes	yes
3	Information at one platform (location, Sale)	Yes	Yes	yes	yes	yes	yes	yes
4	Location search	Yes	No	yes	yes	No	No	yes
5	Good graphic / design	Yes	Yes	yes	yes	yes	yes	yes
6	Using info desks or screens	Sometime	sometime	yes	No	yes	sometime	No
7	UX rules to be used	Maybe	Yes	yes	yes	Maybe	yes	yes
8	Do you like to use the AR app	Maybe	Maybe	yes	yes	yes	yes	yes
9	Do you find the places/discounts easily	Yes	No	yes	yes	no	yes	sometime
10	User reviews/recommendation	Yes	Yes	maybe	maybe	yes	maybe	yes
11	It is important that the app updates current information?	Yes	Yes	yes	yes	yes	yes	yes

4.4 User's evaluation

After reviewing the task matrix and scenario feedback, the user evaluation was made. the evaluation was so that there was a need to add a few lines in the scenario in order to make it clearer. So here is the improved version of the scenario. based on the results of the interviews the users were waiting for the prototype and were really willing to use the AR app.

After getting the user feedback from the first scenario the modified version of the scenario is made. Although the scenario was made to focus on the task but after the feedback from the user, there felt the need to focus on the function also. For making a perfect scenario, different takes can be made. But for this research the scenario is made twice. From the modified version of scenario, few outcomes those helped were to know about the user, the thing that made the user to make this kind of research, the task or goal, the completion path, points that creates stress to the user. Here is the improved version of the scenario:

User Scenario

Tia is a mother of two kids. She is 38 years old. She is also working Part time. She frequently visits the mall to buy clothes, groceries, accessories. Mall of Tripla is the closest mall for her to buy everything at one place. She enters the mall from different doors. Every time she enters the mall, she gets confused with the shops and the directions. Also, as the mall is so big, she sometimes cannot visit all the shops to find the things at affordable prices. She is sad and disappointed as she does not have enough time to wander in the mall and search for a place or a thing she needs. Fortunately, now she started using the app AR. She is very happy with the app. Whenever she visits the mall now, she chooses the navigation option and then scan code on nearby shop entrance door to find her current location. Then Type the shop name where she wants to go. Also, when she chooses the second option for sales/discount, from her app she gets information that whether there is any discount going on in that shop or not. She sometimes chooses sales/discount nearby option, which shows the sales going on around when she is passing by the shops. This saves her time and money.

After the improved version of the scenario, the persona is made. From Figure 9 “persona” will help to understand the type of user for this app.

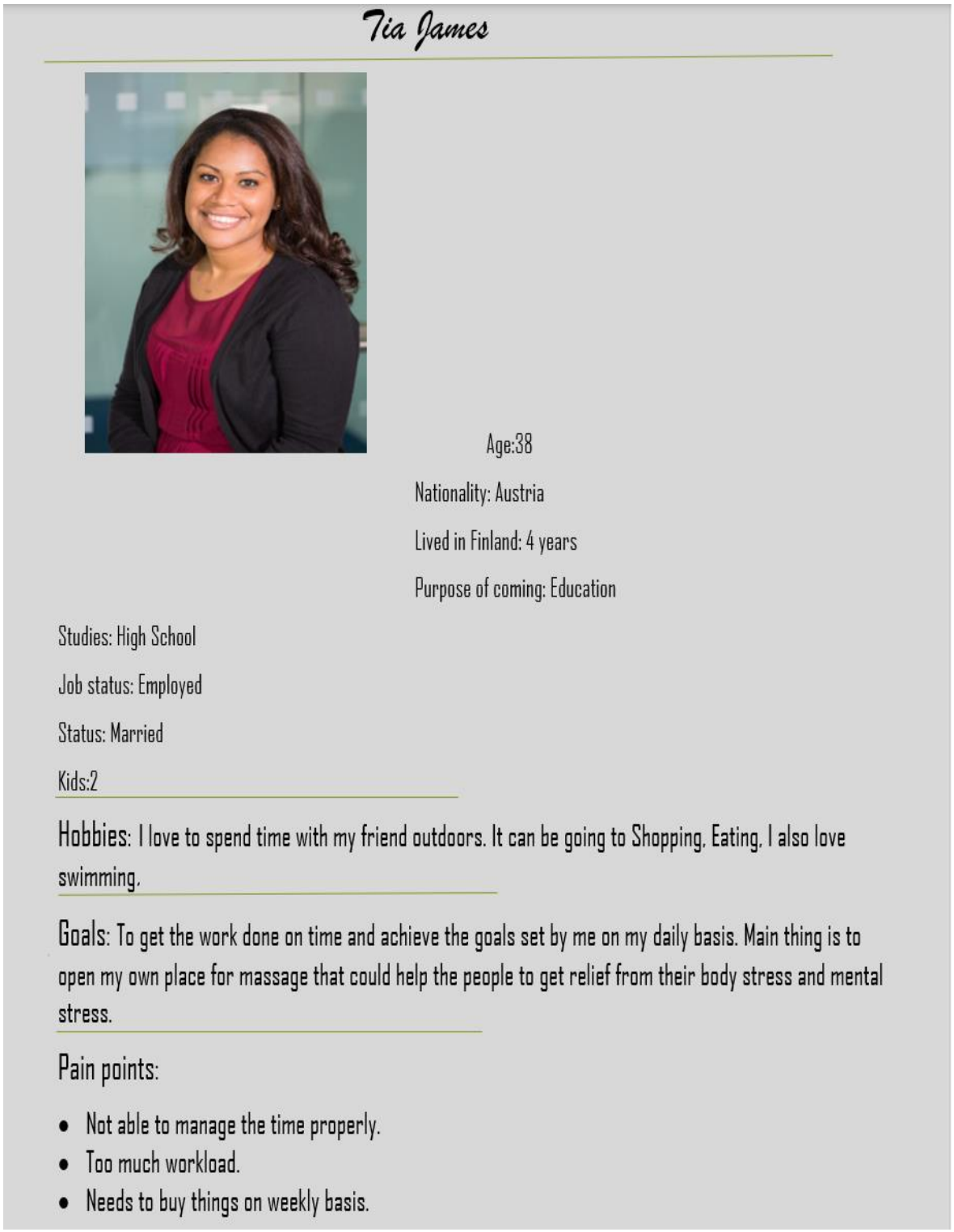

Figure 9: Persona made for this research.

5 Implementation

User interviews gave answers to many questions and helped to proceed further with the research and design. For the interview, the invitation was sent to the 15 users but only seven of them were able to make up for the interview. The user profile is mentioned above about the users who were interviewed. There were three males and four females who attended the interview.

Interview results:
In table 3, the interviews results were mostly positive. Few of the users were confused as they have not used or do not have enough knowledge about AR technologies.
Here is the result table:

Table 3: Interview result feedback.

	Feedback (Happy=5, Not happy=1)	***Improvement/ Expectation***
User 1	5	
User 2	5	Waiting for the prototype
User 3	4	
User 4	4	
User 5	4	
User 6	3	
User 7	5	Waiting for the prototype

After getting the Persona and the modified version of the scenario the next step is the implementation of the design. The implementation of the design is done by making the low-fidelity prototype at first and then the high-fidelity prototype. The lo-fi will give the path on which the design should be made and then in high-fidelity the process will be followed.

The low fidelity will be drawn by creating a user journey map. This user journey map will show the process in the form of boxes and that process will provide the low-fidelity prototype. Miro will be used for drawing the user journey map. Low fidelity prototype will be drawn on the paper.

In hi-fi prototype the selection of colors, shape, text, font pictures are to be made and then this hi-fi will be tested with users. The users will follow the test cases. Based on those test cases the users will provide the feedback and the duration for each test case will be noted. The test cases duration and feedback will be provided in the appendix part. The clear picture of the design can be seen after the high-fidelity prototype. As decided from

the starting the high-fidelity prototype will be made using Figma. When the design is made the usability will be tested using usability Heuristics.

6 Prototyping and product concept

Lo-Fi prototype:

After getting the results from the users. Also gathering knowledge from the related research many concepts were made clear. The UCD and UI principles are needed to be followed in this prototyping process. As a result, from the user scenario, the user journey map is made which is remarkably similar to the wireframing. From figure 10, in this user journey map, the touchpoints are mentioned. This journey map starts with the downloading of the application leading to guide the functions in the app.

Before the Low-Fidelity prototype, here is the user journey map:

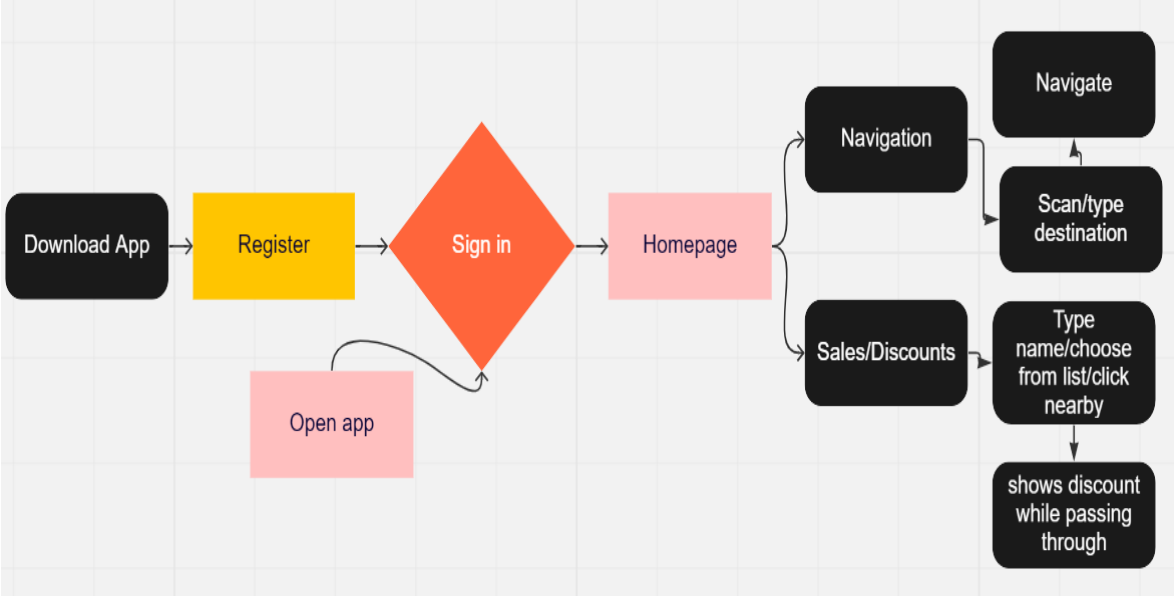

Figure 10: User Journey from Miro

In the user journey map, for the new user, the first step is to download the app and then get registered. In the registration process, a few details of the user are needed i.e., name, email, and password. After this step, the user needs to sign in then the user is directed to the homepage. There are two options on the home page one is navigation and another one is sales or discounts. Based on user requirements then the user chooses the option and then goes further with the process. If the user chooses the navigation option, then the user can type the location manually or can scan the code from the nearby entrance door of any shop. By doing so the app will locate the user and will ask for the destination. The user can type an alphabet/word to select the destination. Then the app will guide the user using In AR mode. In case of sales or discounts, user locations are needed which can be

done by manually entering or by scanning the code. Once the location is detected the app will start showing the sales or discounts of the nearby shop.

From figure 11, the low fidelity prototype is made on paper. Low fidelity prototype is particularly important to get a basic idea of what the app looked likes. In the low fidelity prototype the buttons, background, font, etc. are temporary. As the prototype was on paper so it was not tested.

Here are a few pictures of low fidelity prototype:

Figure 11: Few pictures of a Low-Fidelity prototype

Hi-fi prototype

Using the idea of low fidelity, high fidelity was developed. In this high fidelity, the use of AR can be seen. The emphasis on the color choices, details, and interactivity was given in this high fidelity. The UI principles and UCD methods played an especially important role in creating high fidelity. User research helped in detailing user needs, expectations, and pain points.

Colors are very much related to human emotions which is why color psychology was kept in mind before choosing the colors in the app. The background color chosen in the high fidelity is blue because it brings the feeling of freedom (Edwards, 2013). In the visual part, the icons designed were quite similar to the icons used nowadays. It was done because the user must feel comfortable while using the app. Grouping is done for similar items. The difference in color or opacity helps the user to differentiate between their choices.

From Figure 12, The view of the color used as background color:

The color of the font is white:

The Text used is Roboto. The author choose this text as it suited well to the design according to her.

The shape of the buttons and blanks is Rectangular.

Figure 12: Hi-fi prototype that shows the regularity, color, shape, and icons.

The central part, i.e., the Navigation part is designed carefully. As this part consists of an AR view, So the differentiation is made between the real and the virtual components. The design was in such a way that the user was able to see its visibility in the real world, along with the necessary information from the virtual world (in Figure 13).

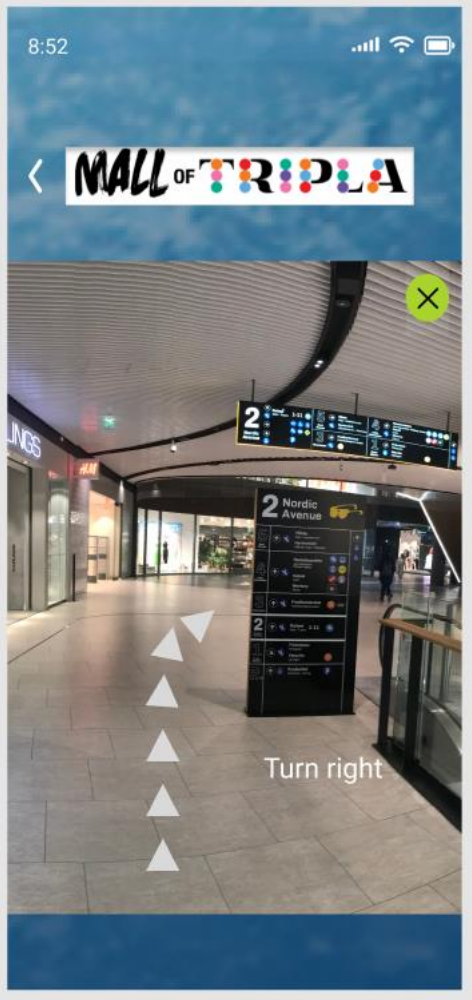

Figure 13: AR view of Hi-fi prototype.

From table 4, The high-fidelity prototype was tested with the users. The evaluation of the high-fidelity prototype was done using Jakob Nielsen's 10 Usability Heuristics (Nielsen, Articles, 2020). These heuristics were extremely helpful in testing. As these shows how is visibility status of the app, is there a match between the app and the real world, whether do user have control and freedom to use the app, have the design followed the standards and consistency, what about error prevention, etc.

Table 4: Hi-fi prototype testing.

	Heuristics	Pass	Medium	Fail
1.	Visibility of system status	X		
2.	Match between system and real world		X	
3.	User control and freedom	X		
4.	Consistency and standards	X		
5.	Error prevention		X	
6.	Recognition rather than recall	X		
7.	Flexibility and efficiency of use	X		
8.	Aesthetic and minimalist design	X		
9.	Help users recognize, diagnose, and recover from errors	X		
10.	Help and documentation		X	

The research was used for preparing the concept of 3D navigation design where AR takes place. The results of the interviews were utilized for taking user needs and expectations into account. Figma was used to develop the Hi-fi prototype. The was made in such a way that it should cover the design aspects to make the design simple. Gestalt principles of design were taken into account to maintain similarity, continuation, closure, proximity, figure/ground, symmetry, and order in the design (Williams, 2021). Also, the other aspects were taken into account to maintain user control, consistency, flexibility, recognition, etc. This design is a concept for AR technology.

From table 4, the evaluation was done by looking at the actions. From table 5,6,7 the steps were followed by the user as provided. Based on these steps the heuristics were analyzed. This is test case 1, which showed the navigation.

Table 5: Actions performed by the user for test case 1(Navigation).

Steps	**Actions**	**Response**	**Pass/ Fail**	**Suggestions**
1	Press email button	Email typed		
2	Press password button	Password typed		
3	Press login button	Logged in		
4	Press navigation button	Permission page, press yes		
5	Code scanning page (code automatically gets	Shows the user location page		

	scanned when the camera is focused on code)			
6	Click on “where to” blank	Sinsay appears		
7	Press Search button	Navigation starts		

Table 6: Actions performed for test case 2(Shows the sales/discounts without navigation).

Steps	**Actions**	**Responses**	**Pass/Fail**	**Suggestions**
1	Press email button	Email typed		
2	Press password button	Password typed		
3	Press login button	Logged in		
4	Press sales/discounts button	Page opens		
5	Move from up to down	Sales will appear		
6	Press Floorwise	Floorwise view will appear		
7	Hovering on the shops names	Discounts will appear		

Table 7: Actions performed for test case 3(Signing in into the app).

Steps	Actions	Responses	Pass/Fail	Suggestions
1	On login screen1, press sign up	Register screen appears		
2	Press name	Name written		
3	Press email	Email typed		
4	Press password	Password typed		
5	Press retype password	Password retyped		
6	Press sign up	Signed in,login screen 1 appears		

There were 3 test cases for this app design that were followed by the user. The time spent on these use cases was also observed. The test cases were first to find the location,

second to find sales/discounts, third is to signup. The time spent by the user is shown in the table in the appendix.

Thus, after testing and evaluating a high-fidelity prototype. The answers to both the research questions were found. The optimal AR solution for Mall of Tripla is an AR app. Creating the concept design of this AR app was my goal for this thesis. By observing and analyzing table 2,3,4 in this thesis, it can be seen from the interviews the result was positive. Users liked the design. User-Centered Design was the basis of this AR app. The users perceived the AR solution as a user guide. As app guided the path to the user. The design of the prototype was in such a way that the app tracks the user's location. This was done with the help of a camera. User needs to focus the camera on the scanning code and automatically app detects the location of the user. The destination place is then typed by the user. After clicking on the search button, the app guides the user in AR mode. User needs to follow the instructions and direction of the arrows. While navigating the app also indicates the sales going on around him within a 5m distance. Therefore, users found this solution quite easy and helpful for navigation purposes.

7 Discussion

The goal of the research was to answer the given questions as mentioned in point 3 of this thesis.

- What is the optimal AR solution for Tripla?
- How do users perceive AR solutions as a user guide?

After reviewing the results of the research. AR solution for Tripla is a navigation app. This app will guide the users in the mall. It was observed that during the pandemic Covid-19, People avoided going to the shopping centers but as the vaccination was done. The people again started their hobbies, shopping, eating, and enjoying. Therefore, they started visiting malls. The Mall of Tripla is so big that it is difficult for people to memorize or remember the directions or locations. So, they were wishing to use something that would help them to guide and make things easier for them, as a result, their time can also be saved with this app.

This concept came into mind when I saw people standing in the long queues before the info desks to get help with location. The observation was made on a number of people visiting their desks and screens in one hour. From that observation, it was found that around 10 visitors visit desks and screens in an hour. The number was high enough to start thinking of a solution. Then AR solution came to mind. The information about the place was gathered and analyzed. After which the author came up with a few questions those were to be asked from the interviewees. Interview dates were fixed. And the interview was done. After the interview, the answers were analyzed in the form of task metrics, also there came many suggestions from the users which proved to be helpful. Going further with the results the scenario and the persona was made. Which was the result of user feedback that was taken by sending the scenarios to the user and the user replied in a text format.

For a good design, there are few principles those were followed like usability heuristics, Gestalt principles of design, Norman's views, etc. From figure 4, To check the design the usability test was done. The results of the test were positive, and the test was successful. The user was able to go through all the steps within time. Which shows the design’s usability, user-friendliness, and intuitiveness.

The related research proved to be highly effective as it provided information that was very useful for this thesis. Studying the concept to a deep extent gave a clear picture of the processes used in the design system. User Center Design knowledge was implemented while designing this AR app. Every design should have four elements i.e., affordance,

constraint, mapping, and feedback. These four elements are applied to all designs. (Norman, The design of Everyday Things, 2002)

The author tried making this design a “Good design”. For a good design, it is particularly important to understand the users first. There are few principles of a good design. Those principles are: (Skrok, 2021)

- Good design is innovative.
- Good design makes the product useful.
- Good design is aesthetic.
- Good design makes a product understandable.
- Good design is unobtrusive (fulfill the purpose).
- Good design is honest.
- Good design is long-lasting.
- Good design is thorough down to the last detail.
- Good design is environmentally friendly.
- Good design is as little design as possible.

All the necessary steps were followed in this research process to reach the goal. From table 2,3,4, the concept of an AR proved to be successful as the results were quite satisfying. Although the 3D prototype is the next step which can be only done by using 3D apps to get a clearer picture of AR.

8 Conclusion

The study of this thesis measured the outcome and success of the usability by going through the process of user centered design. The outcome of this is the concept design of the app that can be used as AR navigation tool in future for the better experience of the user. The outcomes presented in this research are explained in theory and also on the interviews performed with the users. The success of the app can be seen from the feedback after the user testing. Analyzing the data made this research's topic of significant use. People were happy visiting the malls after the restrictions ended. AR solution proved to be successful. As users were happy with the design concept. And were really willing to use this kind of app. The AR technology is growing, and people are becoming aware of this technology. The design of this App gives them a view of AR technology. The users played important role in improving the design. This thesis follows the iterative design approach. Following this approach means that usability can be enhance by user experience.

The relevant information about the background of the work, research methods, implementation, design methods, etc. can be found from the theoretical part of the thesis. The introduction part explained the location for which the design of the app is made, it also introduces about the concepts and the idea of the app, or it explains the topic of the thesis. Then the research method part explains the aim of the thesis by giving the questions whose answers were to be found to reach till the conclusion. The question guided the path and helped in progressing. The questions were related to the main goal of the research. It also explains the type of method used for gathering the data. The answers to the two questions were found at the end of the thesis.

The theory in the related research showed how AR is advancing and made the terms clear. The terms like UCD, UX, Usability, AR, User interface design. The theoretical part provided comprehensive knowledge although it seemed short. When performing the research, it was observed that for the user, usability and user experience are very important.

As a user guide, the design was really helpful. Users liked the navigation method, the icons, and the design. They found it easy to understand and remember the icons and buttons. It helped the user to save time and energy. Different analytical methods helped in the research for finding user interests. Literature reviews proved to be highly effective as they gave brief knowledge of the topics those are used in this research. If further research and improvement in the design is made then this design will prove to be really valuable. In the future, this app needs more improvement in design in regard to AR. And that can only be done with some other 3D designing tool.

The references used in research process can be a bit old, but they were very useful and are used and are relevant to the research. The books by Nielsen and Norman are used as a reference although they are quite old but the points written in the book still exists are are valid too.

The result of this thesis which is the concept design of the AR app can be considered successful. As the design is the answer to the research questions that was to find the solution, and the how user will perceive that solution. So, after conducting different interviews research, and after following the methods/steps. The result is positive. The author was able to reach the goal. It is assumed that further research on this topic can improve and strengthen the design.

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Appendices

Appendix 1. Interviews transcript

User 1

Interview: what is your age?

User: 40

Interviewer: your gender?

User: Male

Interviewer: Where are you from?

User: Finland

Interviewer: Are you married?

User: Yes.

Interviewer: What is your role?

User: visitor

Interviewer: What phone do you use?

User: iPhone

Interviewer: Do you use AR apps?

User: Yes, Snapchat and Instagram

Interviewer: What is the reason you visit the Mall of Tripla?

User: Shopping

Interviewer: do you visit frequently the Mall of Tripla?

User: Yes, I do.

Interviewer: Do you have idea about the location of the shops? If yes, then Is it easy to navigate?

User: Yes, now I have. As I have been coming here for a long time now.

Interviewer: Do you use info screens/info desks?

User: Not now.

Interviewer: How frequently do you take help from info screen/info desks?

User: Few times. In the starting but not now.

Interviewer: How easily do you get the info?

User: I have been coming here to shop so finding info is not difficult for me

Interviewer: Do you think that an app that helps you to navigate in the mall can be beneficial?

User: Yes

Interviewer: How do get to know able sale offers in the mall?

If yes, then what are your expectations?

User: I look for the shops online.

Interviewer: Do you wish to use an app that can show you the discounts/sales going on in the mall?

User: Yes. It makes the shopping experience good.

Interviewer: If yes, then what are your expectations?

User: User-friendly app. Easy to use.

User: 2

Interview: what is your age?

User: 26

Interviewer: your gender?

User: Male

Interviewer: Where are you from?

User: Nepal

Interviewer: Are you married?

User: no, I am single

Interviewer: What is your role

User: visitor

Interviewer: What phone do you use?

User: iPhone

Interviewer: Do you use AR apps?

User: Yes, Instagram

Interviewer: What is the reason you visit the Mall of Tripla?

User: Eating

Interviewer: do you frequently visit the Mall of Tripla?

User: Yes, I do.

Interviewer: Do you have idea about the location of the shops? If yes, then Is it easy to navigate?

User: Yes, I remember the ways to the shop so for me it is easy.

Interviewer: Do you use info screens/info desks?

User: Sometimes

Interviewer: How frequently do you take help from info screen/info desks?

User: Few times. In the starting but not now.

Interviewer: How do easily you get the info?

Interviewer: Do you think that an app that helps you to navigate in the mall can be beneficial?

User: Yes

Interviewer: How do get to know able sale offers in the mall?
If yes, then what are your expectations?

User: I look for it when I come here.

Interviewer: Do you wish to use an app that can show you the discounts/sales going on in the mall?

User: Yes. It makes the shopping experience good.

User 3

Interview: What is your age?

User: 31

Interviewer: Your gender?

User: Female

Interviewer: Where are you from?

User: Bangladesh

Interviewer: Are you married?

User: yes, I am, and I do have kids

Interviewer: What is your role?

User: Visitor

Interviewer: What phone do you use?

User: Android

Interviewer: Do you use AR apps?
User: Yes, Instagram and Snapchat

Interviewer: What is the reason you visit the Mall of Tripla?

User: I come here with my kids.

Interviewer: Do you frequently visit the Mall of Tripla?

User: Yes, I do.

Interviewer: Do you have idea about the location of the shops? If yes, then Is it easy to navigate?

User: Yes, I remember the ways to the shop so for me it is easy.

Interviewer: Do you use info screens/info desks?

User: No, I remember this place now

Interviewer: How frequently do you take help from info screen/info desks?

User: Few times.

Interviewer: How do easily you get the info?

User: I look at the website

Interviewer: Do you think that an app that helps you to navigate in the mall can be beneficial?

User: Yes

Interviewer: How do get to know able sale offers in the mall?

If yes, then what are your expectations?

User: When I visit with my kids, I do check on stores for sales and discounts.

Interviewer: Do you wish to use an app that can show you the discounts/sales going on in the mall?

User: Yes. Sure.

Interviewer: If yes, then what are your expectations?

User:Eeasy to find about sales and discounts.

User 4

Interview: what is your age?

User: 41

Interviewer: your gender?

User: Female

Interviewer: Where are you from?

User: India

Interviewer: Are you married?

User: Yes.

Interviewer: What is your role

User: Visitor

Interviewer: What phone do you use?

User: iPhone

Interviewer: Do you use AR apps?

User: Instagram and Snapchat

Interviewer: What is the reason you visit the Mall of Tripla?

User: I take the train to my workplace from here

Interviewer: Do you visit frequently the Mall of Tripla?

User: Yes, daily

Interviewer: Do you have idea about the location of the shops? If yes, then Is it easy to navigate?

User: No

Interviewer: Do you use info screens/info desks?

User: Yes, often

Interviewer: How frequently do you take help from info screen/info desks?

User: mostly every time I am here for shopping.

Interviewer: How easily do you get the info?

User: It is not easy for me.

Interviewer: Do you think that an app that helps you to navigate in the mall can be beneficial?

User: Yes, for sure

Interviewer: How do get to know able sale offers in the mall?
If yes, then what are your expectations?

User: I try to look but it is not easy for me to get this information.

Interviewer: Do you wish to use an app that can show you the discounts/sales going on in the mall?

User: Yes. It makes the shopping experience good.

Interviewer: If yes, then what are your expectations?

User: User-friendly app. Easy to use.

User 5

Interview: what is your age?

User: 39

Interviewer: your gender?

User: Male

Interviewer: Where are you from?

User: Estonia

Interviewer: Are you married?

User: No

Interviewer: What is your role

User: Visitor

Interviewer: What phone do you use?

User: Android

Interviewer: Do you use AR apps?

User: Instagram and Snapchat

Interviewer: What is the reason you visit the Mall of Tripla?

User: Shopping

Interviewer: do you visit frequently the Mall of Tripla?

User: Yes, frequently

Interviewer: Do you have idea about the location of the shops? If yes, then Is it easy to navigate?

User: Yes, mostly

Interviewer: Do you use info screens/info desks?

User: Yes, sometimes

Interviewer: How frequently do you take help from info screen/info desks?

User: Not much

Interviewer: How easily do you get the info?
User: I know this mall now.

Interviewer: Do you think that an app that helps you to navigate in the mall can be beneficial?

User: Yes, I can be for someone who visits sometimes

Interviewer: How do get to know able sale offers in the mall?
If yes, then what are your expectations?

User: I come here quite often so I just keep on looking at stores

Interviewer: Do you wish to use an app that can show you the discounts/sales going on in the mall?

User: Yes. It makes the shopping experience good.

Interviewer: If yes, then what are your expectations?

User: User-friendly app. Information about sales and discounts.

User 6

Interview: what is your age?

User: 28

Interviewer: your gender?

User: Female

Interviewer: Where are you from?

User: Indian

Interviewer: Are you married?

User: No

Interviewer: What is your role

User: I work here.

Interviewer: What phone do you use?

User: Android

Interviewer: Do you use AR apps?

User: No

Interviewer: Do you have idea about the location of the shops? If yes, then Is it easy to navigate?

User: Yes, mostly

Interviewer: Do you use info screens/info desks?

User: Yes, sometimes

Interviewer: How frequently do you take help from info screen/info desks?

User: Not much

Interviewer: How easily do you get the info?

User: I know this mall now.

Interviewer: Do you think that an app that helps you to navigate in the mall can be beneficial?

User: Yes, I can be for someone who visits sometimes

Interviewer: What does a typical day look like?

User: Well, it is a normal day. Handling customers. Handling cash and other normal stuff.

Interviewer: Do you have sale /discounts for your customers?

User: yes.

Interviewer: How frequently do you have a sale in your shop?

User: Mostly seasonal

Interviewer: How do you inform your customers about the sale in your shop?

User: We put discount /offer stuff nearby and put discount/offer on the entrance door.

Interviewer: Besides your work do you shop from any other shop/visit in this mall?

User: yes, I do shop here.

Interviewer: Do you wish to use an app that can show you the discounts/sales going on in the mall?

User: Yes.

Interviewer: If yes, then what are your expectations?

User: Nice app that is easy to use.

User 7

Interview: What is your age?

User: 35

Interviewer: Your gender?

User: Female

Interviewer: Where are you from?

User: Russia

Interviewer: Are you married?

User: yes

Interviewer: What is your role

User: I work here.

Interviewer: What phone do you use?

User: iPhone

Interviewer: Do you use AR apps?

User: I use Instagram

Interviewer: Do you have idea about the location of the shops? If yes, then Is it easy to navigate?

User: Yes, mostly

Interviewer: Do you use info screens/info desks?

User: No

Interviewer: How frequently do you take help from info screen/info desks?

User: Not much

Interviewer: How easily do you get the info?

User: I know this mall now.

Interviewer: Do you think that an app that helps you to navigate in the mall can be beneficial?

User: Yes, I can be for someone who visits sometimes

Interviewer: What does a typical day look like?

User: Well, it is a normal workday. Helping customers, resolving any issues

Interviewer: Do you have sale /discounts for your customers?

User: Yes.

Interviewer: How frequently do you have a sale in your shop?

User: Once in a few months most on special days like Black Friday, Halloween, etc.

Interviewer: How do you inform your customers about the sale in your shop?

User: We put ads on paper and put discounts/offers on the entrance door.

Interviewer: Besides your work do you shop from any other shop/visit in this mall?

User: Yes, I do shop here.

Interviewer: Do you wish to use an app that can show you the discounts/sales going on in the mall?

User: Yes.

Interviewer: If yes, then what are your expectations?

User: A nice app that is easy to use.

Appendix 2. Scenario Feedback

User 1: The scenario looks good and easy to follow.
User 2: I liked the scenario. This is a good idea to design. The features are nicely framed.
User 3: The story is good. The question came to my mind after ready this story is about the language used in the app?
User 4: There is one thing that is not clear to me if we use the navigation option, then how will it function?
User 5: The scenario seems nice and well-interpreted but I can comment only after the prototype**.**

Appendix 3. Usability test results.

Users	Completed task	Time spent	Suggestion/comments
1	3/3	2:36	User-friendly design
2	3/3	3:06	Easy to use
3	3/3	2:49	The color choice was good.
4	3/3	2:45	Good design idea.
5	3/3	2:31	Hoping to use this kind of app
6	3/3	2:58	Looked Interesting
7	3/3	2:53	Liked the idea and design concept