ECE 1778H

MuseGO

An Inclusive AR Museum Navigation App for Visitors of All Abilities

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Introduction

Identifying the Problem

Museums are an excellent place for experiential learning and family time for children who may have special needs. According to the 2017 Canadian Survey on Disability, more than 1 in 10 youth in Canada have one or more disabilities[1]. The 2018 Report of the National Autism Spectrum Disorder (ASD) Surveillance System[2] reveals a continuous increase in the number of children diagnosed with ASD. These children have challenges when processing sensory input. The challenge varies uniquely at a personal level. However, it can be broadly described as sensory defensive (avoiding external sensory input and having a low threshold for response to stimuli) or sensory seeking (having a high threshold for response to stimuli) behaviours[3]. These behaviours become obstacles with a child's ability to benefit from museum visits.

Environmental modifications are one way of supporting this population. However, museums cannot always alter their environment and programs to provide optimal support. Also, it is not feasible for the museum environment to be changed to meet the needs of those who respond negatively to environmental elements that others find engaging.[4] Past research on the effectiveness of sensory museum guides (like the Learning Tool[5] offered by the Ontario Science Centre (OSC)) demonstrates that such resources indeed help both sensory defensive and sensory seeking visitors prepare for and participate in museum experiences. Despite its proven effectiveness, the expectation for families to be familiar with this multi-page document to plan their visit is not very engaging nor encouraging. Furthermore, wayfinding in large-scale multi-floored cultural institutions can be intimidating, confusing or even overwhelming on its own to visitors of all abilities.

[1] Statistics Canada, "Canadian Survey on Disability, 2017," Canadian Survey on Disability, 2017, November 28, 2018, https://www150.statcan.gc.ca/n1/daily-quotidien/181128/dq181128a-eng.htm.
[2] Public Health Agency of Canada, "Infographic: Autism Spectrum Disorder among Children and Youth in Canada 2018," Government of Canada, March 29, 2018, https://www.canada.ca/en/public-health/services/publications/diseases-conditions/infographic-autism-spectrum-disorder-children-youth-canada-2018.html.
[3] Tina S. Fletcher, Amanda B. Blake, and Kathleen E. Shelffo, "Can Sensory Gallery Guides for Children with Sensory Processing Challenges Improve Their Museum Experience?" *Journal of Museum Education* 43, no. 1 (2018): 66-67.
[4] Ibid., 67.
[5] See Ontario Science Centre, *My Visit to the Ontario Science Centre*, PDF, Toronto: Ontario Science Centre, March 28, 2018. https://www.ontariosciencecentre.ca/Uploads/WhatsOn/documents/My_visit_to_the_Ontario_Science_Centre.pdf

Challenge Statement

How might we empower visitors with sensory processing needs to prepare and engage in cultural experiences by reducing confusion and the feeling of overwhelm in a museum?

The Goal of MuseGO

Past visitor research revealed that visitor experience and satisfaction ratings are often directly affected by the ability to navigate successfully around the space[6]. The goal of the app is to improve wayfinding to meet the unique needs of the museum visitors while reducing stress, exhaustion, and feeling of missed opportunity. In particular, using augmented reality (AR) technology, MuseGO offers self-guided tours that are inclusive and accessible. Based on the study that combining both sensory avoiding and seeking gallery guides into one can have a positive impact on a child's museum experience[7], MuseGO offers indoor navigation tool that encompasses sensory friendly gallery guide.

Grounded on existing Learning Tool[8] offered by the OSC, the app is a digital tool that reduces barriers and produces inclusive museum experience in becoming AODA compliant. It aims to meet the criteria of a successful sensory gallery guide by providing structure for a museum visit, facilitate active looking and discussion, and showcase interesting gallery spaces through providing a variety of sensory-rich objects[9]. Addressing accessibility, not only improves the quality of experience for individuals with accessibility needs, but for all.

Statement of Functionality

Assumptions

- The user has a personal smartphone that supports AR technology.
- User interaction with the app begins when they arrive at the institution.
- The institution offers public wifi that is accessible throughout the building.
- The start image is made available at the cultural institution participating in the app. The start image must be fixed in place, printed or projected through digital screens.

[6] Karen Hughes and Creative Director at True North, "Museum and Gallery Wayfinding: Tips for Signage, Maps and Apps," The Guardian, August 25, 2015, https://www.theguardian.com/culture-professionals-network/2015/aug/25/museum-gallery-wayfinding-tips-signage-maps-apps.
[7] Tina S. Fletcher, Amanda B. Blake, and Kathleen E. Shelffo, "Can Sensory Gallery Guides."
[8] See Ontario Science Centre, *My Visit to the Ontario Science Centre*.
[9] Tina S. Fletcher, Amanda B. Blake, and Kathleen E. Shelffo, "Can Sensory Gallery Guides," 69.

User Authentication Management

User authentication management will identify two user types: Professional (Fig 1. Screen 2.1) and Public (Fig 1. Screen 2.2). The Professional has access to the full functionality of the app including both creating and following self-guided tours. The input method for creating AR tour requires constant interaction with the app for every step taken, from the beginning to the end. Therefore, the Public is only able to follow the pre-existing tour in order to prevent the general public visitors from being distracted if they were to take part in content creation.

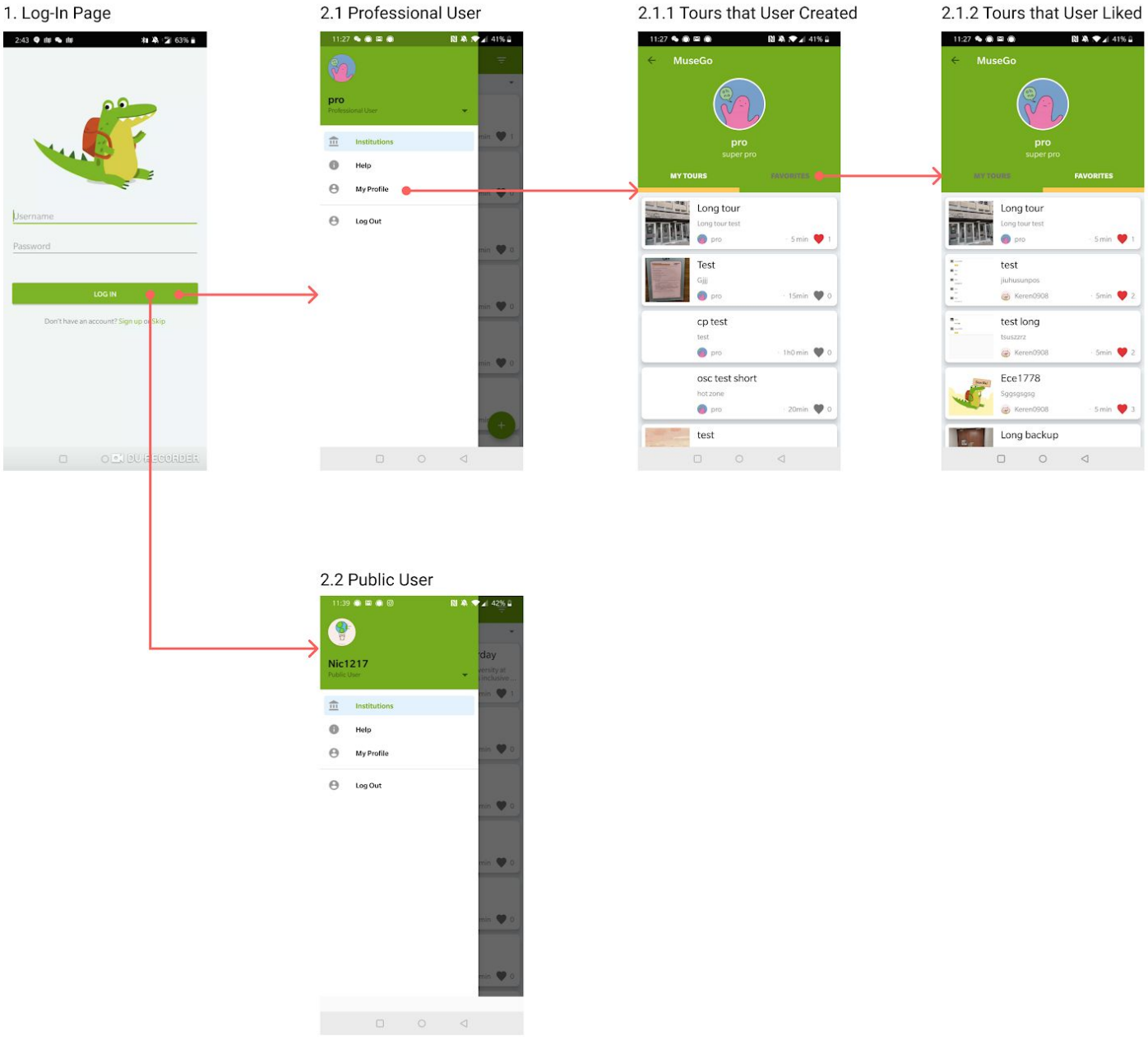


Figure 1. User Profile

Creating the Self-guided Museum Tours

Figure 2. Icon Legend

As a cross-institutional museum navigation app, users begin their interaction by selecting the institution that they are visiting (Fig 3. Screen 3).

When creating a new tour, the Professional is provided with a step by step how-to instructions (Fig. 3, Screen 5). The content creation officially begins by the scanning of the start image (Fig. 3, Screen 6.1). As the user walks around the space, the user may place an arrow or an icon to provide information on environmental factors (Fig. 3, Screen 6.2). The decision on which sensory-related information and icons to be incorporated in MuseGO was based on the Learning Tool[10]. Some icons have been re-designed and colours were applied to improve its comprehensiveness. A help page (Fig. 2) is available at all times. The user concludes the creation of the tour by placing the end object, accessed by clicking the “end” button (Fig. 3, Screen 6.5).

The user must input the following information to finish and share the tour with the public (Fig. 3, Screen 6.7):

- Tour title
- Floor
- Description
- Anticipated length of the tour
- Tags
- Photos

Additionally, the following information is automatically populated.

- User name
- Date
- Tags related to accessibility

[10] See Ontario Science Centre, *My Visit to the Ontario Science Centre*.

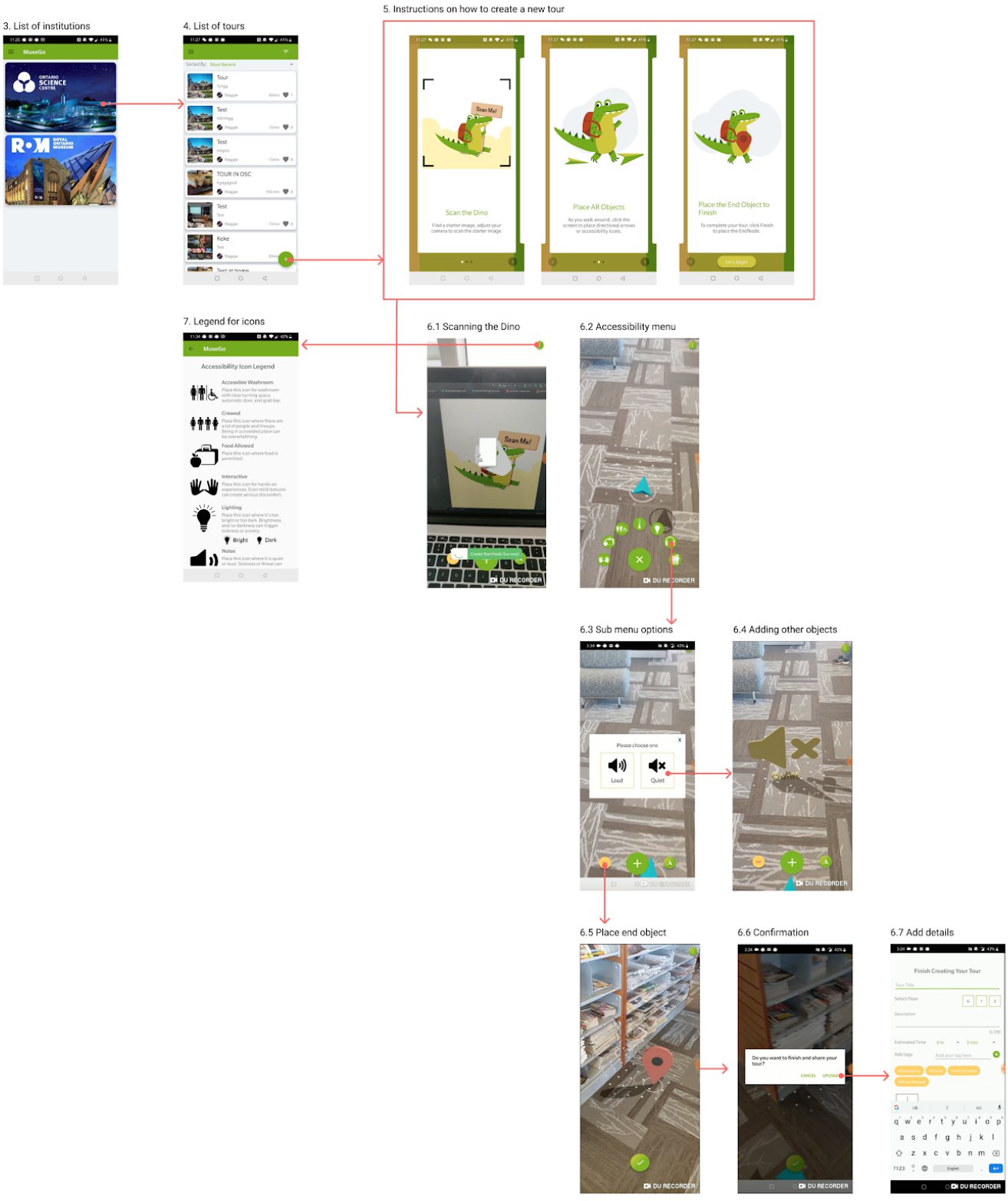


Figure 3. Creating Tours

Using MuseGO for Self-Guided Museum Tours

Maximizing the findability and searchability of all existing tours allow visitors to select the tour that meets their personal needs and wants. The sorting (Fig. 4, Screen 4.1) and filtering (Fig. 4, Screen 4.2) features are crucial in this process.

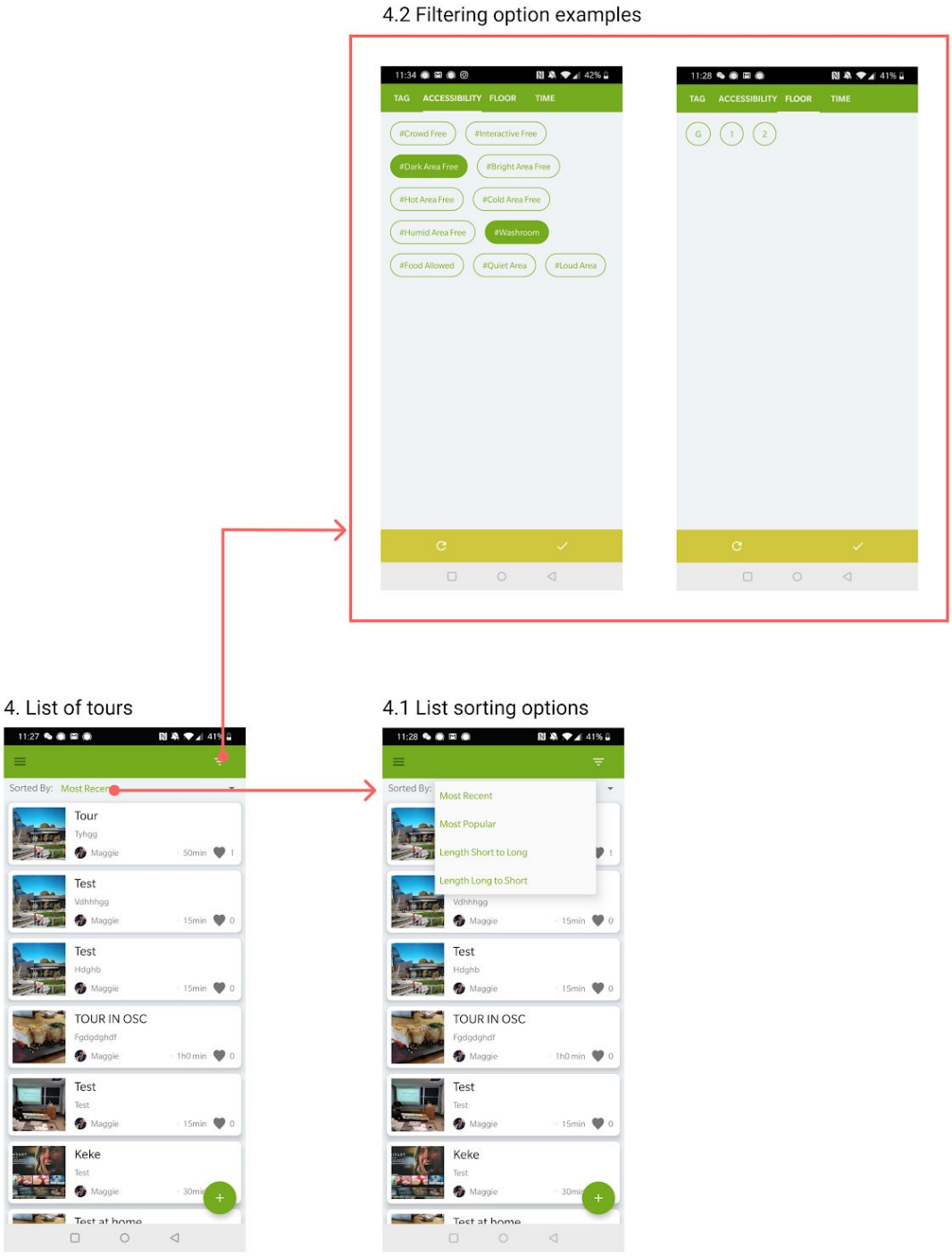


Figure 4. Sorting & Filtering

The environmental condition related tags used for filtering are binary (hot vs. hot area free) to address both sensory defensive and seeking behaviours. At the same time, the visitor may choose any tour and simply decide to not engage with certain areas or activities based on their observation of what is coming up. MuseGO does not attempt to make the decision for the user. Instead, it empowers effective decision making and preparedness for users to plan accordingly.

Users are prompted with a step by step instruction (Fig. 5, Screen 9) on how to guide themselves through the AR tour. Upon image recognition, the user begins navigating the space (Fig. 5, Screen 10).

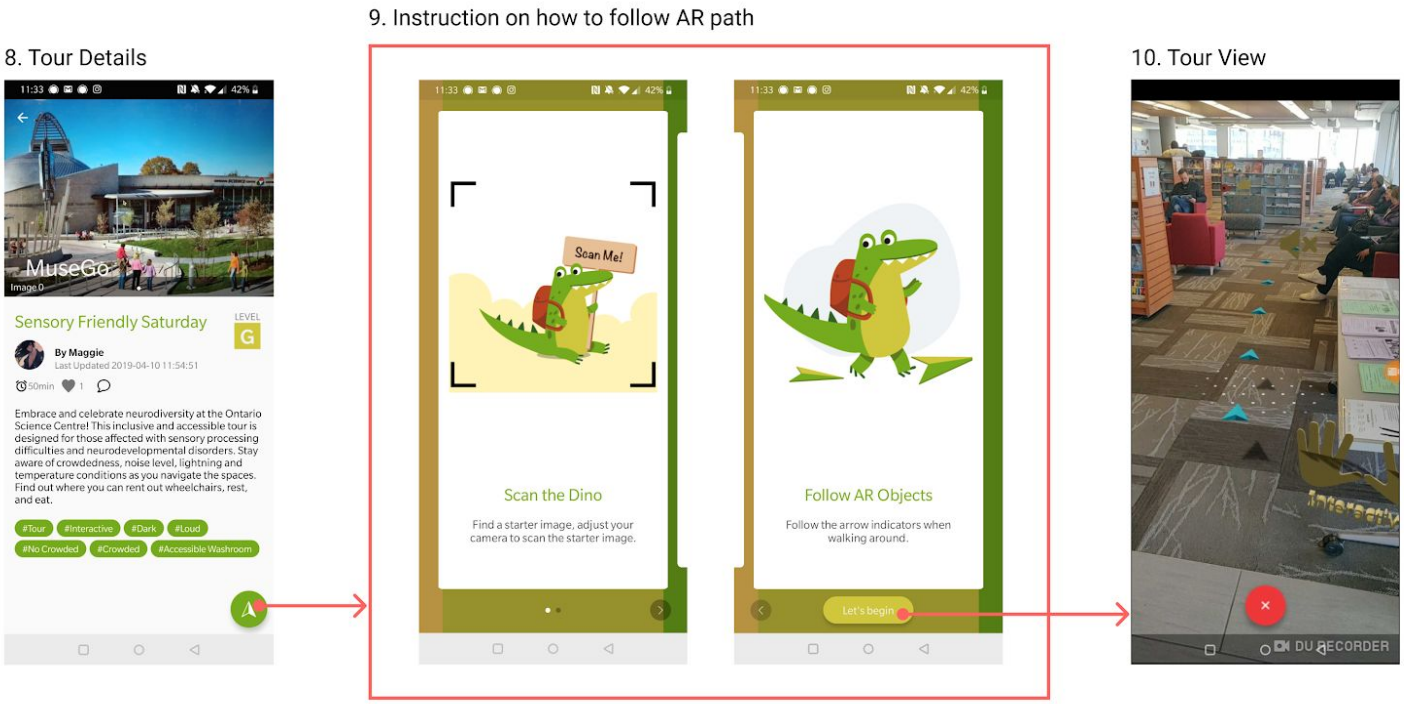


Figure 5. Following Tours

Community Building

Users can like or leave comments (Fig. 6, Screen 11.1) on the tours. This community engagement feature addresses Providing Accessible Customer Service Feedback requirement by ensuring that customers with disabilities can communicate with organizations about how well they are meeting customers' needs.[11] Using the app, museums can receive and respond to feedback from visitors.

[11] Greg Thomson, "Providing Accessible Customer Service Feedback," Accessibility for Ontarians with Disabilities Act (AODA), March 05, 2019, https://www.aoda.ca/providing-accessible-customer-service-feedback/.

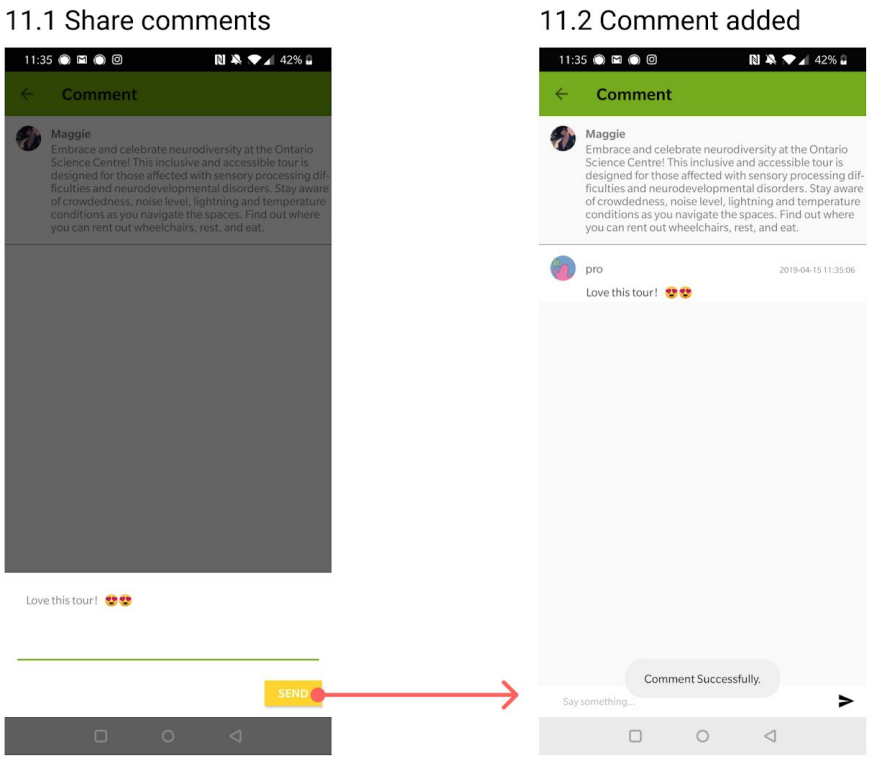


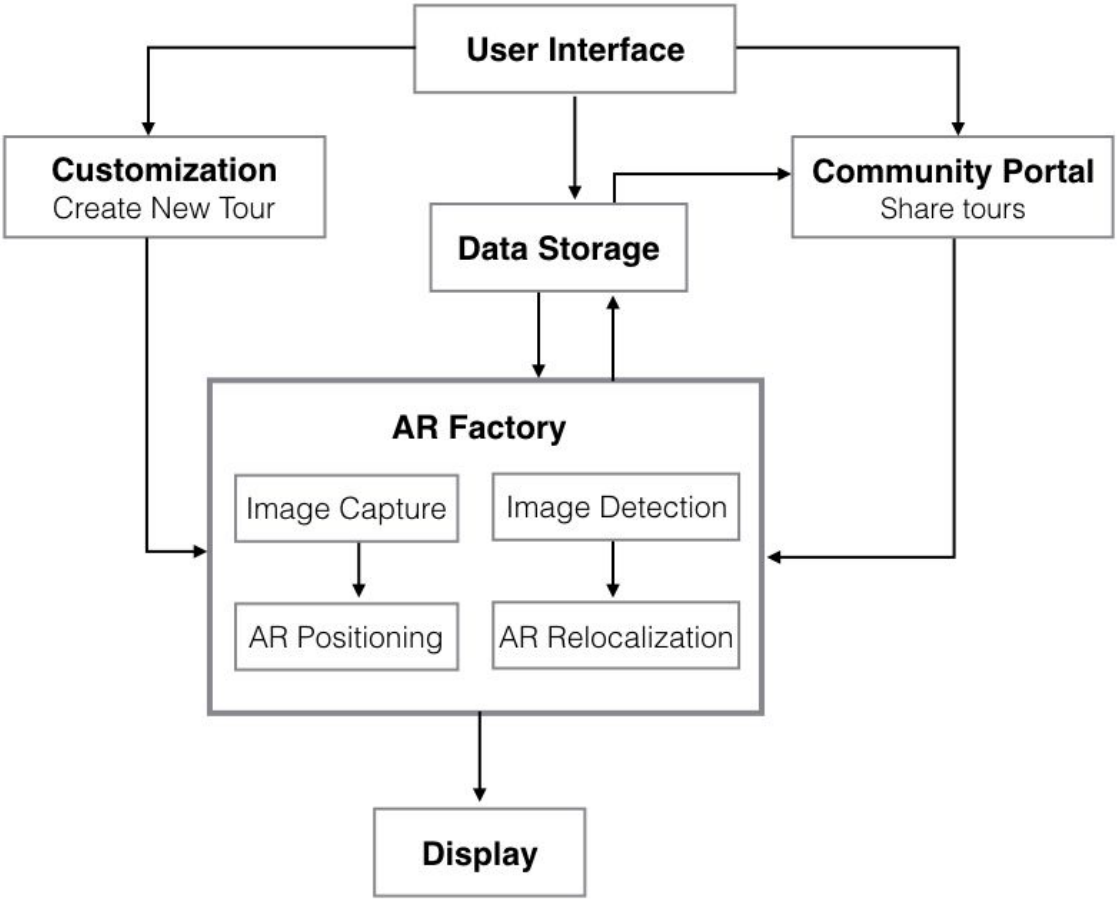
Figure 6. Comment

Current Limitations

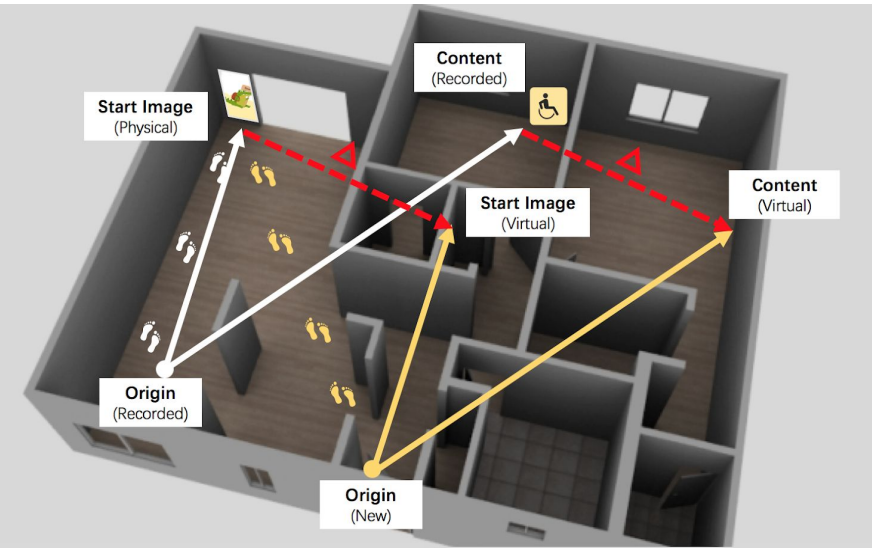
- Due to the technical limitation of ARcore, the act of scanning the start image needs practice and learning for an accurate result.
- Once the users place the AR object, they cannot delete or change its position. This significantly limits flexibility when creating.
- During the onsite testing at the OSC, ARcore became less reliable when there was a dramatic lighting change or due to physical properties of some floors that failed to detect the plane. Additionally, there are wifi dead zones due to the historical architectural design of cultural institutions. Under this condition, the paths of the tour must be shorter, divided into smaller zones such as by exhibition spaces. Such short tours become less meaningful as a navigation tool but remain meaningful in communicating environmental factors.

Structure of the Software

Block Diagram



Blocks	Descriptions
Authentication	Professional users are registered through an invite code. Otherwise, users register as public. The two 'roles' are saved in 'user' database in Firebase.
Customization	The creation of a AR tour begins when the user places the AR anchor on the start image through scanning using the smartphone's camera. Then, ARCore tracking can tell the physical location that begins the AR session and allows objects to be placed. User inputs more information about the tour such as title, description, tags, along with automatically generated sensory-related tags. This information is stored in Firebase.

Community Portal	The user can select a tour from the list. The path can be ranked by 1) the number of likes; 2) timestamp; 3) length
AR Factory	When creating, it records the position of origin point related to that start image. Then, it records all other AR object locations related to the origin point. When viewing the tour, the user scans the start image which allows the app to calculate offset from the recorded origin to the new origin. Then apply this offset to all other AR pieces and place them into the physical world correctly. 

Reflection

Android or iOS? We came across rich resources and SDK in iOS platform. Using available SDK in the iOS platform has the potential to create a better AR solution. For example, Placenote can scan the world maps as a canvas to precisely position 3D content indoors and outdoors.

What are some other best practices for navigation strategies? We challenged ourselves to work in the AR space and it has been a truly exciting and rewarding experience. However, we acknowledge that there are other none-AR navigation solutions that are less risky and more accessible to the public.

How can I translate a hard document to a mobile app experience? We learned to be flexible with the digitization process. It required several iterations and testings to recognize and fill the gaps in our apps such as the addition of the help button and concise labelling of icons.

How can we clearly communicate a complex concept in a presentation? Avoiding jargons, clearly explaining that museums are beyond artworks hanging on the walls, transparently talking about pivoting from the initial concept to our new approaches, and not relying on the assumption on audience's prior knowledge are some ways that we could improve communication in our presentations.

Next Steps

Implement an intuitive input method when creating a tour. This will allow community driven contents where anyone can easily create new contents without being distracted from the planned museum visit while also creating a tour path for other fellow visitors.

Present AR content in a precise location. Overlaying the AR markers with the museum's indoor map can communicate further information in a preview to potential visitors even before starting the AR tour.

Adhere to AODA mobile app compliance. Ensure that mobile can be accessed by smartphones' built-in assistive technologies.[12]

Test at other institutions. Ensure that the app remains functional at various cultural institutions under the conditions that they have public wifi. Identify some barriers that may arise such a wifi dead zones.

[12] See Greg Thomson, "Mobile Apps for People with Disabilities," Accessibility for Ontarians with Disabilities Act (AODA), June 14, 2018, https://www.aoda.ca/mobile-apps-for-people-with-disabilities/.

Member Contributions

Christina Park, Specialist

Liaison with the OSC. I was in contact with museum professionals to conduct market research. I established a working relationship with the OSC where I shared the project progress, gathered resources on sensory friendly programs and coordinated on-site testing. I conducted the user testing on site to evaluate its functionality.

Concept, Content, and UI Design. I researched mobile apps in the museum sector to study current trends and AR applications. I learned UI practices for AR. I translated collected information and research to a mobile app experience digitizing the content and developing information architecture. I designed the workflow, UI mock-ups, and graphical elements. I 3D modelled the AR objects.

Project Management. I took meeting notes for internal and external meetings. I ensured timely completion of deliverables in the agile development process and maintained to do list. I took the lead in completing the deliverables including proposals, reports, and pitch deck.

Keren He, Programmer

Technical Research. I researched about AR and how it can be implemented.

Development. I created the skeleton of the android project. I implemented the AR ‘follow path’ feature including detecting the target image, retrieving the pose of AR objects and implementing the AR relocalization algorithm to place the objects in the right position. For community portal part, I implemented the museum list page, tour list page for each institution, sorting and filtering, thumb up function and comment function for each path. I contributed to refining the UI.

Yifan Zhang, Programmer

Technical Research. I researched on AR and found the feasible algorithm to store the AR tour and reproduce the AR tour correctly in reality.

Development. I implemented the different AR objects involved in the AR museum tours and set up the structure to store all information about the tour in Firebase. Also, I implemented the tour detail and instruction pages for both creating and showing the tour. I finished the user authentication part with login, sign up and user authority management. I also improved the UI based on the mock-ups.

Specialist Essay

Traditionally speaking, museums are housed in historical buildings which are expanding and adapting over the years to meet the curatorial and service needs of the cultural institution. Consequently, wayfinding is a pressing issue. Continuous efforts are being made to improve visitor experience through improved signage, front-of-house staff, and downloadable maps and guides. MuseGO is a tool for visitors that uses the newest technologies to improve the visitor experience in the physical space, making a positive impact on museum visitors to instill confidence when navigating the internal space. In addition to its navigation features, the app uniquely addresses the needs of those visitors experiencing challenges with processing sensory input.

In recent years, cultural institutions have been actively moving towards interactive exhibits involving technological interventions. This shift is transforming the museum experience from a purely visual experience of viewing collections of static artifacts to interactive experiences that address auditory and kinesthetic learning styles. It is easy to imagine children getting excited in these new immersive sensory-rich experiences while forgetting about those with special needs who may be restricted from getting the full experience out of them due to physical and mental conditions. The OSC is indeed one of the most appropriate use cases of the app due to its diverse experiential components. As such, the features of MuseGO become impactful as cultural institutions begin to offer experiences that involve various senses.

The OSC has been working in collaboration with the Geneva Centre for Autism to develop contents for the Learning Tool and offer programs adjusted for monthly Sensory-Friendly Saturdays.[13] However, such collaboration with experts and community groups are not always feasible to all cultural institutions due to limited resources such as time and cost. This poses challenges for some cultural institutions from being onboard to offer sensory museum guides despite acknowledgement of its effectiveness. MuseGO's broad application allows cultural institutions across Canada and around the world to offer structured museum guides that accommodate various needs.

The app aims to demonstrate that designing for equity and accessibility helps everyone, not just those who are disabled. While accessibility is a core objective, inclusive design serves many people by enabling people with diverse characteristics to use the app in a variety of different environments and circumstances. Our solution for one user group can benefit a much broader audience. The app removes barriers to communication and interaction that many people face in the physical world. Through MuseGO, it has become easier for cultural institutions can open its doors to visitors of all abilities, empowering visitors to actively prepare for and participate in the museum experience.

[13] "Ontario Science Centre Celebrates Neurodiversity with Sensory-friendly Saturdays," Ontario Science Centre, March 28, 2018, https://www.ontariosciencecentre.ca/media/details/468/.

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All team members, Christina Park, Keren He, and Yifan Zhang , share our permission to publicly post the following on the course website:

- Video of the final presentation;
- Final report; and
- Source code

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