California Polytechnic State University
Art and Design Department
ART 388: Interaction Design II Winter 2017
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Self-Driving Wheelchair

A wheelchair that drives itself to the user.

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Introduction

Abstract

This is a self-driving wheelchair that can drive itself to the user. It targets anyone with a disability that requires a wheelchair and is often moving back and forth from their chair to a separate activity. Essentially the wheelchair would locate the user through GPS and drive to them when they need it. It uses similar technology as self-driving cars. It will use Laser Illuminating Detection and Ranging (LIDAR) which allows it to see potential hazards. It will have an electric engine that can be turned on, initiated, or canceled by the user regardless of their location. The purpose of this self-driving wheelchair is that there are little to no automatic transportation devices that support situations in an uneven and rough terrain. It is a well deserved need for paraplegic surfers.

Schedule

Week 2: Jan 16 - Jan 20
Begin research
Define main functionality

Week 3: Jan 23 - Jan 27
Report research
Create personas and goals

Week 4: Jan 30 - Feb 3
Define necessary use cases
Determine exact functionalities
List all user flow steps
Begin preliminary mockups and wireframes

Week 5: Feb 6 - Feb 10
Finalize interactive wireframes
Usability tests on wireframes and review findings

Week 6: Feb 13 - Feb 17
Make needed changes from usability test results
Review flowcharts and wireframes

Week 7: Feb 20 - Feb 24
Visual Design
High-definition static mock-ups

Week 8: Feb 27 - Mar 3
Continue working on high definition static mock-ups
High-definition interactive mock-ups

Week 9: Mar 6 - 10
Begin building final product

Week 10: Mar 13 - 17
Finalize final product
Present final product on Mar 15

Week 11: Mar 20 - 24
Final report due

Audience

Anyone with a disiblity that requires a wheelchair and is often moving back and forth from their chair to a separate activity.

Technical requirements

If the user plans to use it for water purposes, they need a waterproof smart phone or smart watch.

The self-driving wheelchair is reliant on the technical advancement of combining radar, laser light, GPS, and computer vision to create a control system that can correctly identify obstacles and relevant signage.

The map needs to be extremely updated and detailed so the user and software are completely in sync on the destination the user picks.

Possible constraints

The technology to produce the wheelchair may be too expensive for the average user to purchase.

Research

Preliminary research design

What is the hardest thing you've struggled with while being in a wheelchair?
Did you have any struggles doing your daily activities while in the chair?
What do you like most about your chair?
What is your ideal chair?
How would you rank the features of your chair on what is most important/used?
What is a time waster when using the wheelchair?
When are there times where you are separated from your chair?
How do you get back to it?.

Findings from the research

Siena Beacham. 11 weeks in a wheelchair. Surfer.
Most frustrating was being on the sand, she wanted to crawl to the water but she was already too weak. She couldn't get to do the things she loved so watching me(Marion) surf was torturous. She couldn't even get to the kitchen for a glass of water easily because she had to roll carefully of the bed/couch to then crawl to the crutch and lift herself onto the chair. Then bringing it around was impossible because her hands were busy rolling the chair. She had to become ultimately dependent on the people around her and trust that everyone would bring her the things she needed and be cautious of the bumps and so on. Waiting for help took up most of her time. She said, "In a weird way, it was nice to take things at a slower pace. I couldn't ever rush through everything which was refreshing. Although, I started to develop a little bit of a depression. Mind over matter has to step in and you have to find the part of your life that is worth celebrating and focus on that."

Bridget McWaid. 2 months in a wheelchair. Biker.
Being at wheelchair level was difficult. When dining out, people had to bring her food. Also, she often couldn't use here chair in congested public areas so she would hobble back and forth to her chair. If she wasn't with her friend or company, no one would really ask her if she needed help. Except professors were extra nice but that didn't actually help me. My chair made me take 5x longer to get anywhere. Her ideal chair would be automatic with compartments and a pull out table.

Louise Bruton. 23 years on crutches. 6 years in a wheelchair.
Louise still has difficulty knowing what she needed in a wheelchair. She's on her third wheelchair now and still finds it hard to know what adjustments she needs to find a perfect wheelchair. First-time wheelchair users aren't taught what options they have with the device. Her main struggle with her wheelchair is it not feeling sturdy while she is active and the struggle of its maintenance. She would like to have a smoother ride by having larger front wheels. She really likes having a light chair so she can lift it. She would also like to have a wheelchair that is a little bit taller. She is separated from her wheelchair when she goes on airplanes. Her wheelchair does not fit in the aisles so she has to be placed in a slimmer chair and her wheelchair is packed away with the rest of the luggage. She says it feels a bit degrading having to be dependent on the airline and their staff. One time they airplane even lost her wheelchair and that was very scary.

Jamie. Has Muscular Dystrophy.
Jamie's largest struggle being in a wheelchair is transportation. Daily tasks like getting dressed can be difficult and trying to move from chair or bed or vice versa. He thinks says an ideal chair wouldn't require any maintenance and would have cup holders. The only time he is separated from is chair is if he is in bed or just in his room and using his computer chair instead. His computer chair rolls as well.

Christiaan "Otter" Bailey. 11 years on a wheelchair. Professional Paraplegic Surfer.
Christiaan shared with us that a lot of his struggles compile around his actual body struggles. Although, he says that outside of urban areas or really outside of the US, there is less accommodation for wheelchair users. For him the overall perception for wheelchair users has come a long way, especially athletes. They used to have a hard time getting sponsors which would make it harder for them to be able to afford to continue their sports. In regards to being separated from his chair, he says hi chair is effectively his legs so they are not parted often. When they are, it is when surfing or on a plane really. When he is surfing he does the same as the original inspiration for this project, George, and scoots/drags his lower body up the beach and onto the sidewalk up to his parked wheelchair. His sole opinion on the chair that would save him from his daily beach scoots was that it would be too expensive and hard to depend on not breaking down because of the salt water..

Personas

Hailey Matthews. 19 years old.
Hailey grew up in Long Beach playing all kinds of sports. She is naturally athletic and excelled at basketball and surfing. She loves to travel. When she was 14 years old, she was celebrating the end of the school year and went cliff jumping with her friends and accidentally landed too close to a rock. She became paralyzed from the waist down. She was still very passionate about being active and continued to pursue basketball and surfing by joining paraplegic clubs. When playing basketball she can easily transport from chair to chair, but when surfing she scoots up the sand to the sidewalk where her chair waits for her. Hailey just started college and has become frustrated with how difficult it can be to get around without help from others. Starting at a new school, she finds it difficult to ask others for help and would not like to be dependent on others. In congested areas, such as the dining commons, she has to put her wheelchair in a different location from where she's sitting and crawl to her seat.

"I do not like to burden others by being dependent on them."

–Hailey Matthews

Goals

Wants to be more independent.

Wants to be able to transport herself/take care of herself in all circumstances.

Competitive analysis

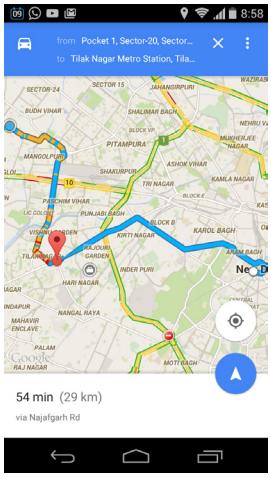
Competitive products

In the market, there are electric wheelchairs that allows the user to control the movement of the wheelchair by a joystick. We'd like to create an interface that can be used while sitting on the wheelchair and while apart from it to control its path. The interface screen will be the same on the wheelchair and on the app in order to maintain consistency and provide comfortability. The app interface can have a similar interface to self-driving cars. Transparency of the wheelchair path is crucial for users to develop trust between the technology and the algorithms the vehicle uses to make its decision (which can be largely invisible).

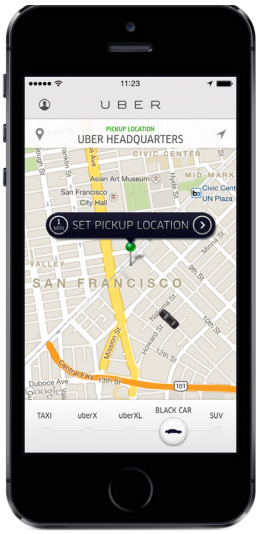
Volvo released an easy-to-use interface to oversee when drivers switch between having control versus letting the car drive. When the car enters a route what autonomous driving is available, the car sends a message that Auto Pilot is ready. Lights begin flashing on the steering-wheel as well to further signify the user. Unlike Volvo, the self-driving wheelchair will always have auto pilot available.

OSU Personal Robotics Group is developing a small package that can be mounted on a powered wheelchair to give it self-driving capabilities. Users would attach the package to their wheelchairs, plug it into the batteries and the chair control electronics. Instead of it being self-driving, the user will build maps of their areas to help the robot navigate these spaces autonomously. There will be multiple input devices for the wheelchair to know where to go by using an on-screen map, eye-gazing in the world, and voice commands.

Visual language references

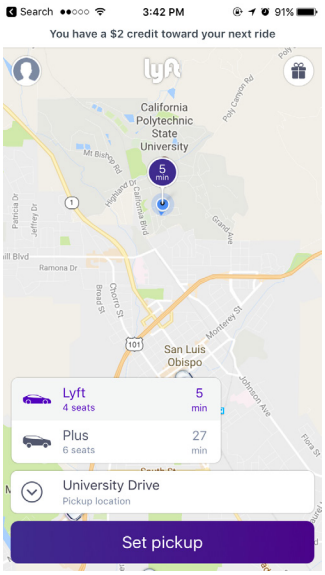


Google Maps
Google maps uses floating buttons and a bottom slider to include more functions on their application. They also have an exceptionally detailed and reliable map.



Uber
Uber does a great job of showing the user where drivers are at and highlighting the path they will take to get to and from you.

Volvo
This image is a display of one of the first user interfaces for a self-driving car. It's simple and clean. It also allows the user to see the path from a slightly higher point of view.

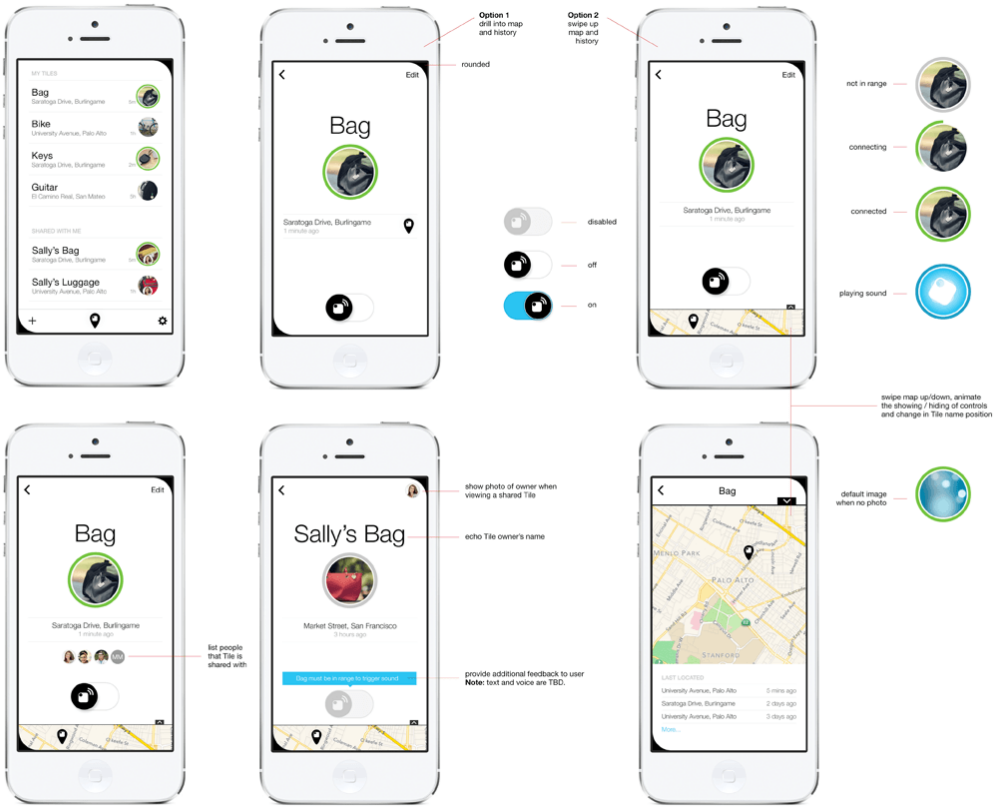


Lyft

Lyft has many similarities to Uber in their interface design. Both have a set pickup location at the bottom of the screen. The map takes up majority of the screen in order to provide the user optimal view of their surroundings.

Tile (below)

Tile provides a menu to select different items to track. We used that as a reference to list our different wheelchairs and locations.

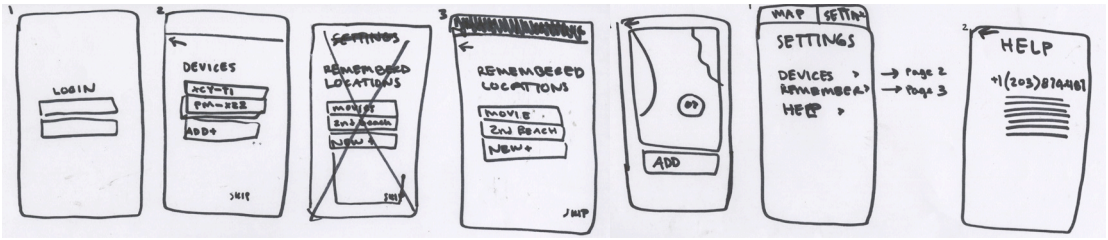


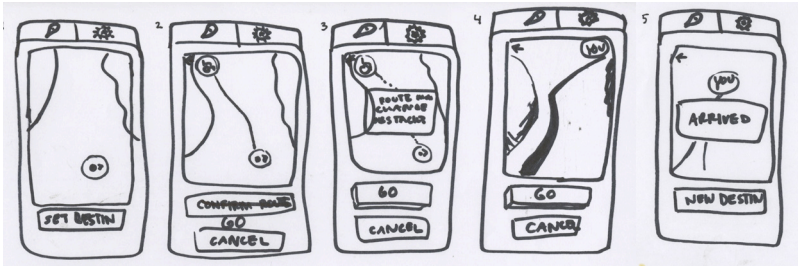
User interaction design

Scenario

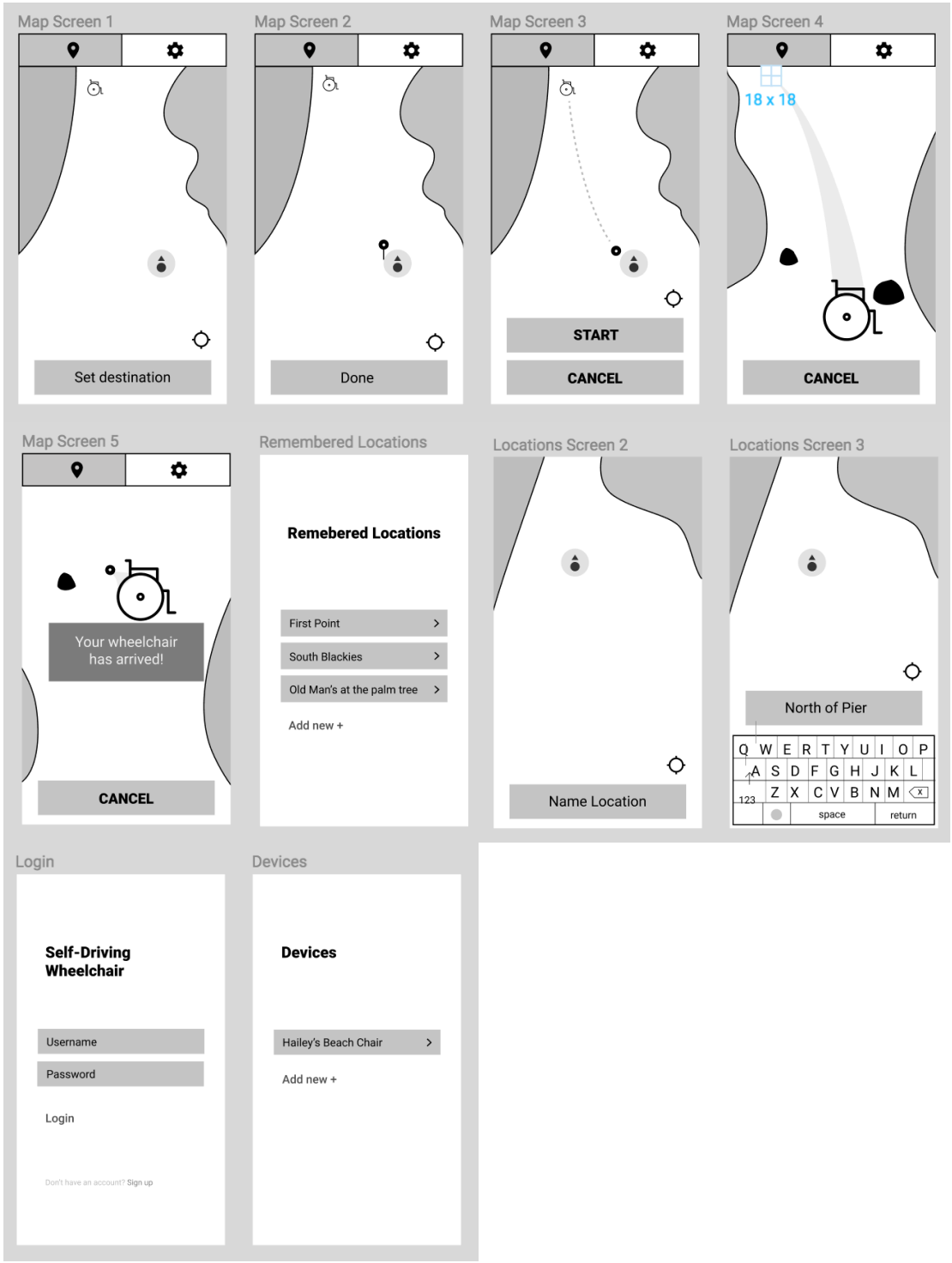
Hailey is going surfing at the beach and parks her wheelchair next to the jetty. The current was strong that day and by the time she was done with her surf session she was 100 meters away from her wheelchair. She takes out her (waterproof) smart phone and opens up the Self-Driving Wheelchair App. She is automatically logged into her account and selects her pickup location for the chair to drive itself to. She presses it to go and her chair starts driving. However, she suddenly has more energy and decides to catch a few more waves before she heads home. She cancels the chair's route for now. Fifteen minutes later, she is very tired and has called it a day. She couldn't imagine scooting up the beach to get to her chair. She opens up the app once again and resets her pickup location and the self-driving wheelchair makes its way towards her. On the app, she can see what path the self-driving wheelchair is taking to get to her. Once the wheelchair arrives to her destination, it stops and she gets onto it. She places her surfboard on her lap and sets the next location to her car. After a tireless day of surfing, Hailey is glad she doesn't have to exert any extra energy having to get to and from her wheelchair.

Sketches





Wireframes


Map Screen 1
Set destination
Map Screen 2
Done
Map Screen 3
START
CANCEL
Map Screen 4
18 x 18
CANCEL
Map Screen 5
Your wheelchair has arrived!
CANCEL
Remembered Locations
Remebered Locations
First Point
South Blackies
Old Man's at the palm tree
Add new +
Locations Screen 2
Name Location
Locations Screen 3
North of Pier
Login
Self-Driving Wheelchair
Username
Password
Login
Don't have an account? Sign up
Devices
Devices
Hailey's Beach Chair
Add new +

Usability analysis

Usability analysis tests

Set their current location and get picked up there.

Bookmark a new remembered location and get picked up there.

Check the status of the wheelchair before going off alone.

Usability analysis results

Users were able to successfully get picked up.

Because the prototype didn't have a moveable map, it was sometimes difficult for the user to interact with the interface.

Users would try to click on the screen to drop a pin or to bookmark a new remembered location. However, they were supposed to go through settings. We want to provide an option to create a remembered location through the map.

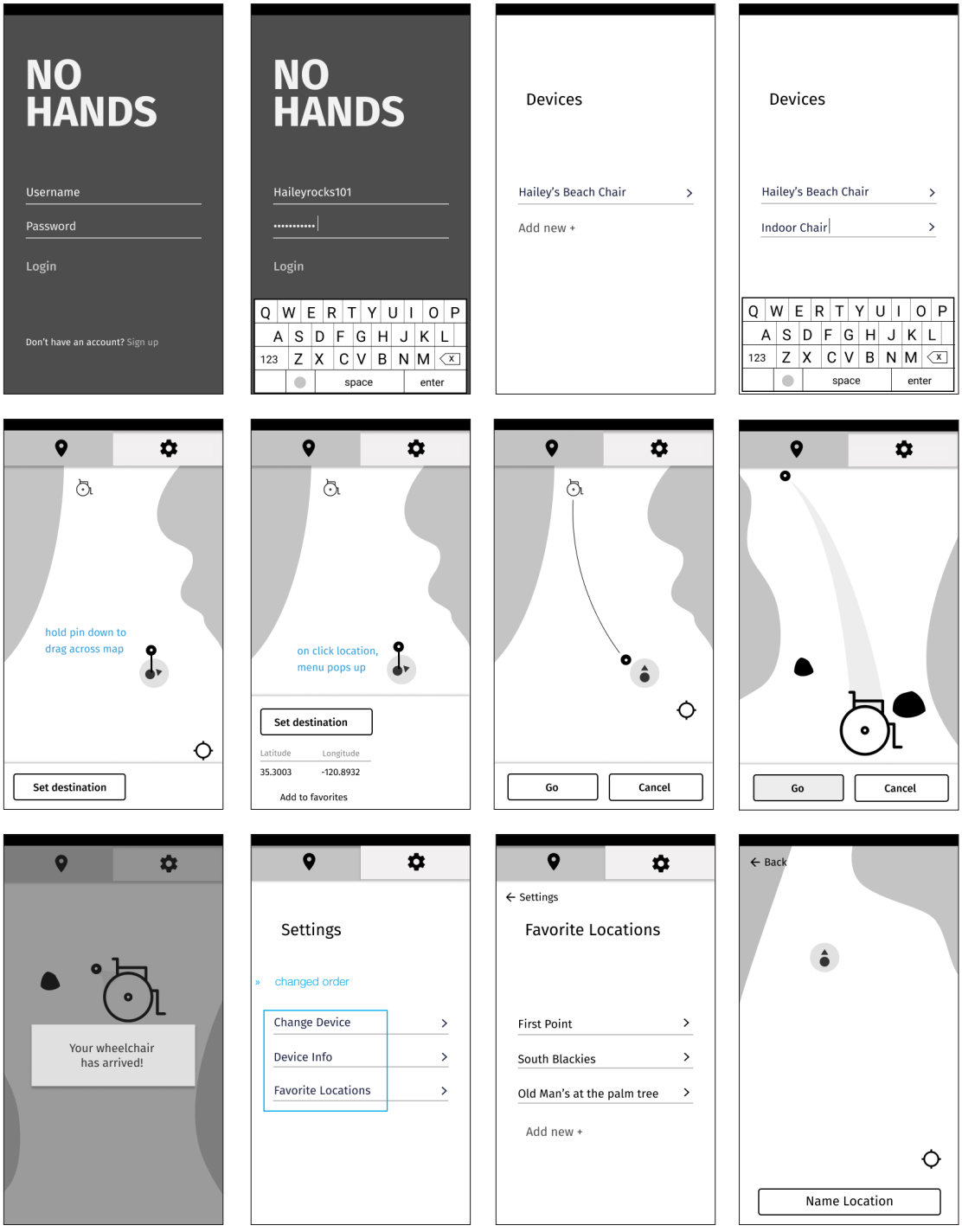
Users often clicked devices when looking for device battery level instead of device info.

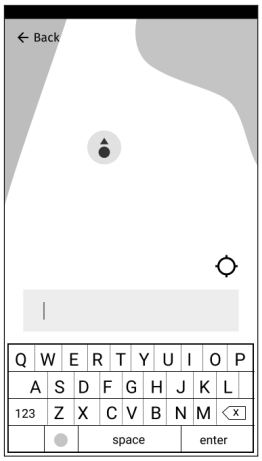
Settings names were unclear. We changed "Devices" to "Change Devices".

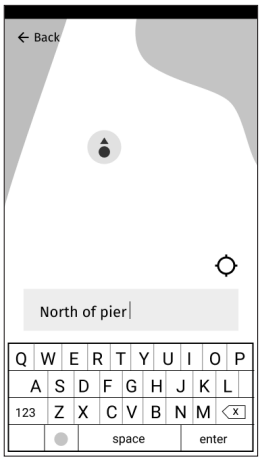
Users naturally clicked on a remembered location upon startup instead of skipping ahead to their location on the map. Get rid of remembered locations upon startup because it is not necessary.

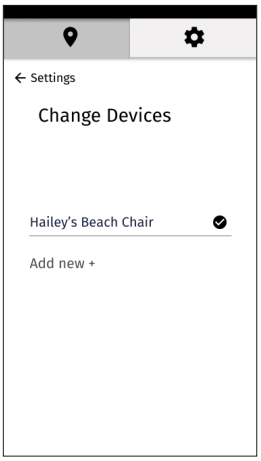
The name remembered locations is not as familiar as favorites. We changed the name to "Favorite Locations".

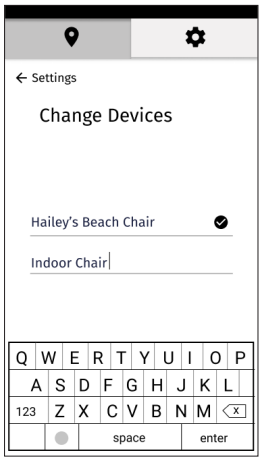
Changes from the results of usability analysis

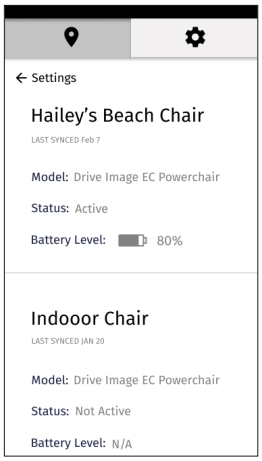



Back
Q W E R T Y U I O P
A S D F G H J K L
123 Z X C V B N M
space
enter


Back
North of pier
Q W E R T Y U I O P
A S D F G H J K L
123 Z X C V B N M
space
enter

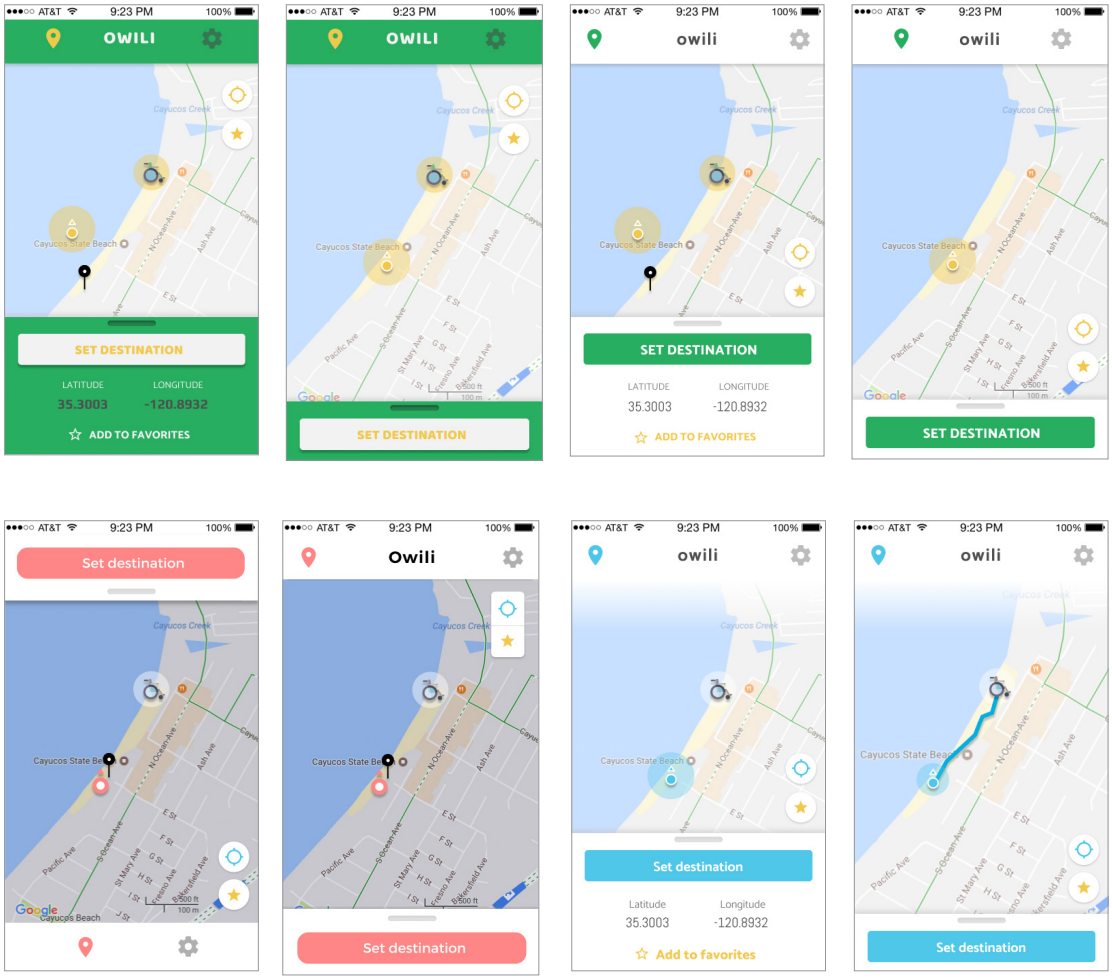

Settings
Change Devices
Hailey's Beach Chair
Add new +


Settings
Change Devices
Hailey's Beach Chair
Indoor Chair
Q W E R T Y U I O P
A S D F G H J K L
123 Z X C V B N M
space
enter


Settings
Hailey's Beach Chair
LAST SYNCED Feb 7
Model: Drive Image EC Powerchair
Status: Active
Battery Level: 80%
Indooor Chair
LAST SYNCED JAN 20
Model: Drive Image EC Powerchair
Status: Not Active
Battery Level: N/A

User interface design

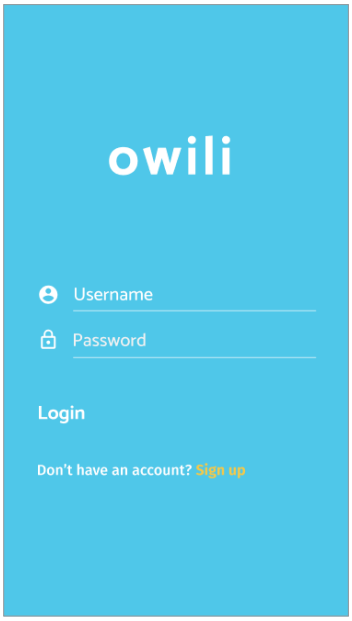
Annotated layouts



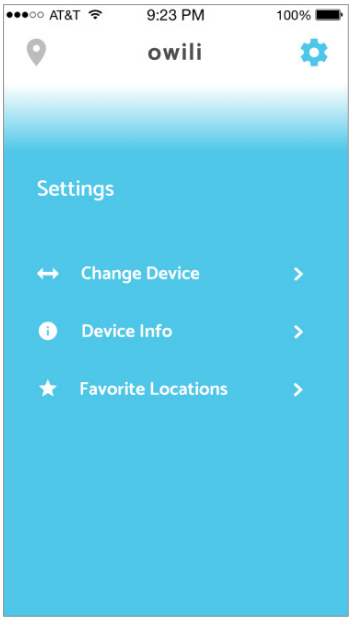
Final product

Future enhancements

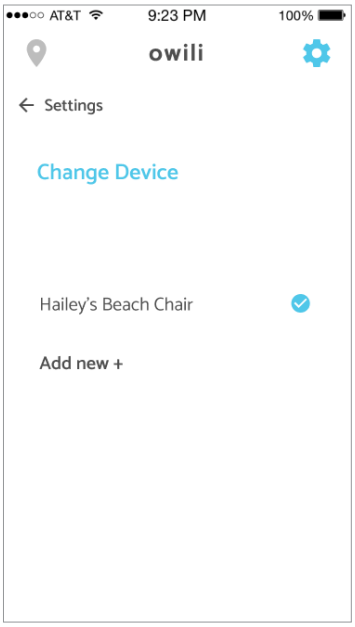
A future enhancement for this application could allow other registered users to control where the wheelchair goes. A key use case for this would be in hospitals where this is not enough staff to push patients around in or obtaining the wheelchairs. Instead, nurses can set the pickup location and destination and get confirmation about whether the patient is seated on the chair.



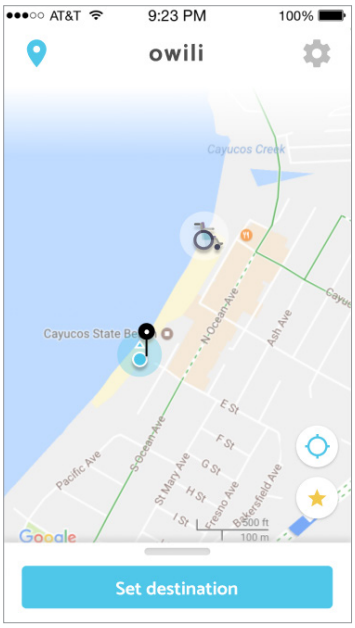
Opening login screen.



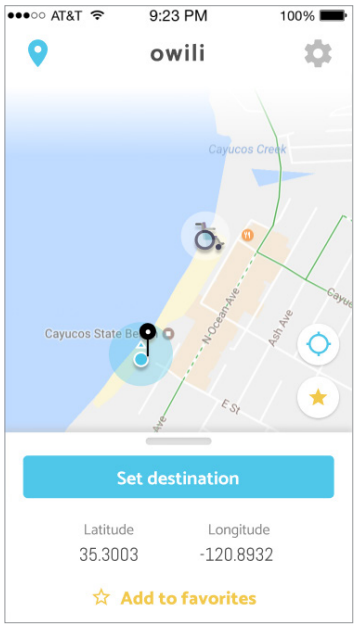
Settings Screen.



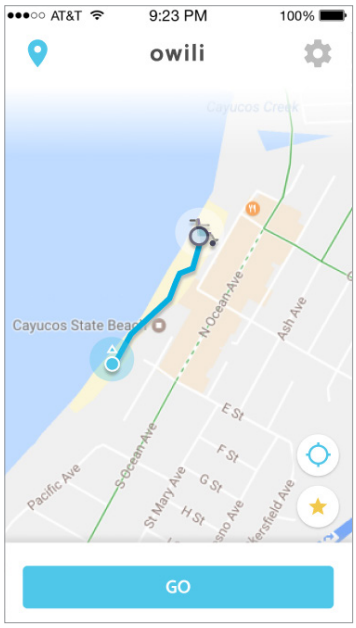
One screen deeper than the general settings page. This layout is consistent with all other specific settings screens.



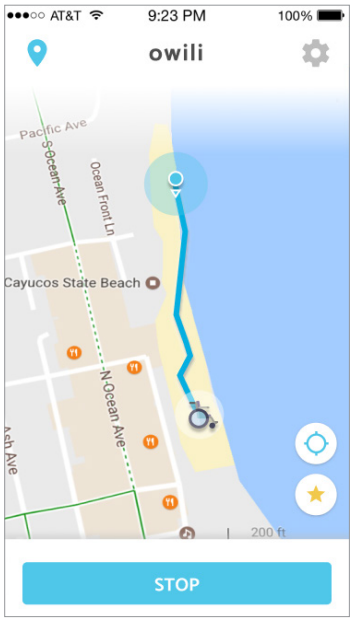
You can drag the pin wherever desired on the map.



Slide up bottom tab for information about your location.



Start the wheelchair's route.



Pause or cancel the route at any point.