Assignment #1
Design of a Cognitive Artifact

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Ear piece with high quality audio from:
Glove → voice commands of objects nearby
App → audio based way-finding solutions
Wireless Beacons in the environment
Finger-less Glove with camera attached
App on phone that receives signals from the wireless beacons
co-robotic cane
Also connects to the wireless beacons
Beacon

10 Spatial Challenges

— 6 Challenges to Focus On —

(1) Opening Door Knobs

2 subset challenges → (1) Knowing there is a door / You are approaching a door
(2) Finding the door knob in order to open the door

Strategies → Sweep cane to understand where the cane is stopped by something like a door
Use available hand to feel around hip level for a door handle
Understand what kind of handle it is and then open the door

(2) Obstacles like Bollards for Cars / Decorative Water Fountains

2 subset challenges → (1) Knowing that there are such potential challenges
(2) Navigating away from these obstacles

Strategies → Sweep cane from right to left to feel for any changes or differences
Being aware of obstacles in familar spaces

(3) Danger in Parking Lots

Range of possible obstacles: incoming cars, cars backing up, other obstacles like speed bumps
One of the most challenging day-to-day tasks for the blind and visually impaired
↳ Even with vision, navigating parking lots can be challenging
Strategies → Sighted guide or canine-guided assistance

(4) Staircase

2 subset challenges → (1) Finding the staircase / Knowing you are approaching a staircase
(2) Getting up/down the stairs

Strategies → Lift cane down each floor level progressively until the cane tip can no longer go down
Reverse for going up stairs

(5) Staying On / Turning Directions While Walking on Sidewalk

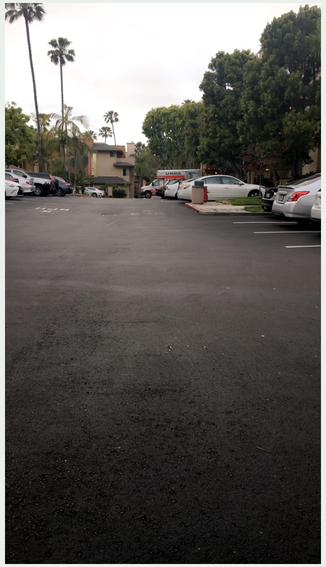
Subset of Challenges → (1) Falling off any curbs of sidewalks
(2) Stopwalks vs. Signals on streets
(3) Sudden options to go left/right on sidewalks

Strategies → Use of GPS based tools to navigate
Use sound cues to understand if there's a signal or sidewalk

(6) Crowds / People Around You

Subset of Challenges → (1) Knowing how many people are around you
(2) How to navigate with people around you
(3) Are there bikers around? People with strollers whom take up a significant amount of space? Dogs walking? Children?

Strategies → Sound cues of people around you. Barks? Kids crying?
Subtle changes in light perception



The 4 Other Challenges

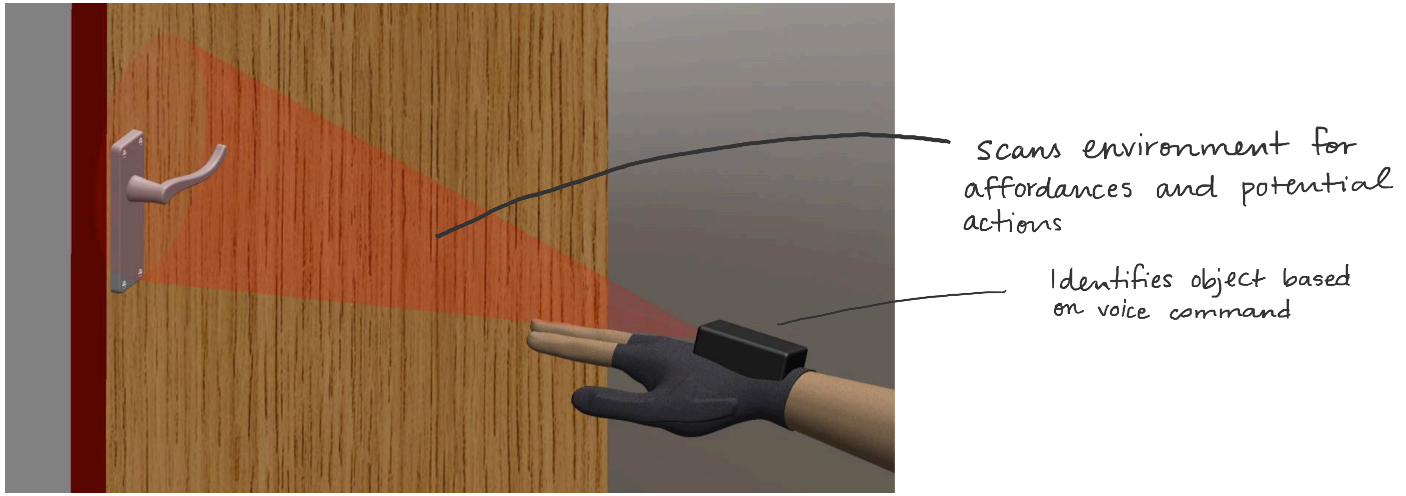
- (7) Challenges with Accommodations for Guide Dogs
  - According to The National Federation of the Blind, around 5% of blind or visually impaired individuals use a canine guide. Although it would be interesting to research the cognitive consequences of guide dogs and the resulting impact on body schema, the complexity of the spatial challenges associated with guide dogs could be the focus of an entire assignment.
- (8) Locking Door with Keys and (9) Locating Elevator Buttons
  - These challenges demonstrate the same overarching underlying spatial challenge as opening a door knob: locating small objects and understanding its affordances.
- (10) Drop to the Curb
  - This challenge is not unique and was used as an example in the instructions for the assignment. Additionally, this challenge also falls under the overarching spatial challenge of avoiding obstacles.

Glove Sensor

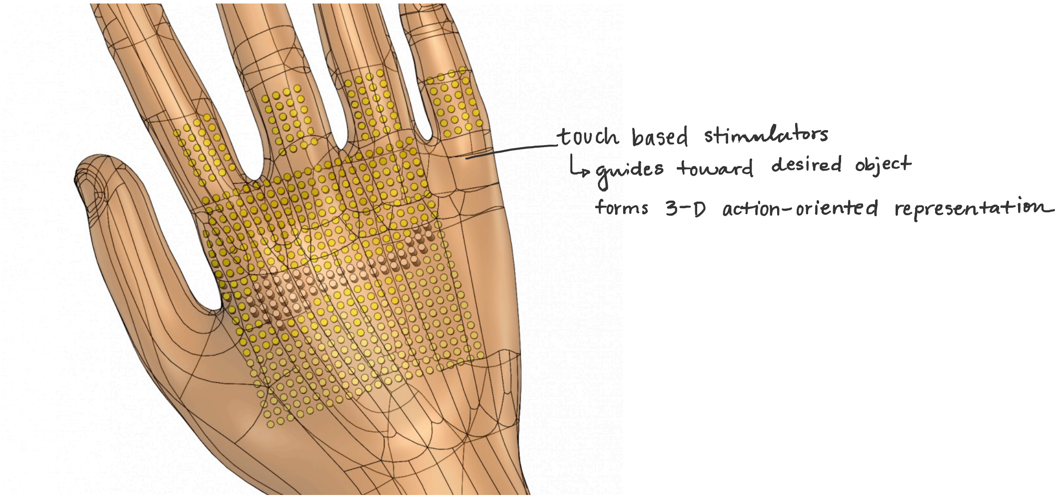
Where: Finger-less glove on hand

How It Works:

- Camera attached to glove detects small objects around user
- Users can give voice commands, that are processed with speech recognition, for objects such as “door handle”, “elevator button”, “mug”, “backpack”, etc…
- Gloves are embedded with cylindrical pins which help guide user’s hand to the object using tactile prompts/sensations (Ye)
- Cylindrical pins send a mechanical or electrical touch stimulus to develop a 3-D model of the object’s shape in the palm of user (Ye)
- Communication through ear piece to provide audio-based feedback for actions related to location of objects



Ye, C., & Shen, Y. (n.d.). Wearable Robotic Object Manipulation Aid for the Visually Impaired [Fingerless glove with a camera to detect small objects]. Retrieved from https://ualr.edu/cxye/nri.htm



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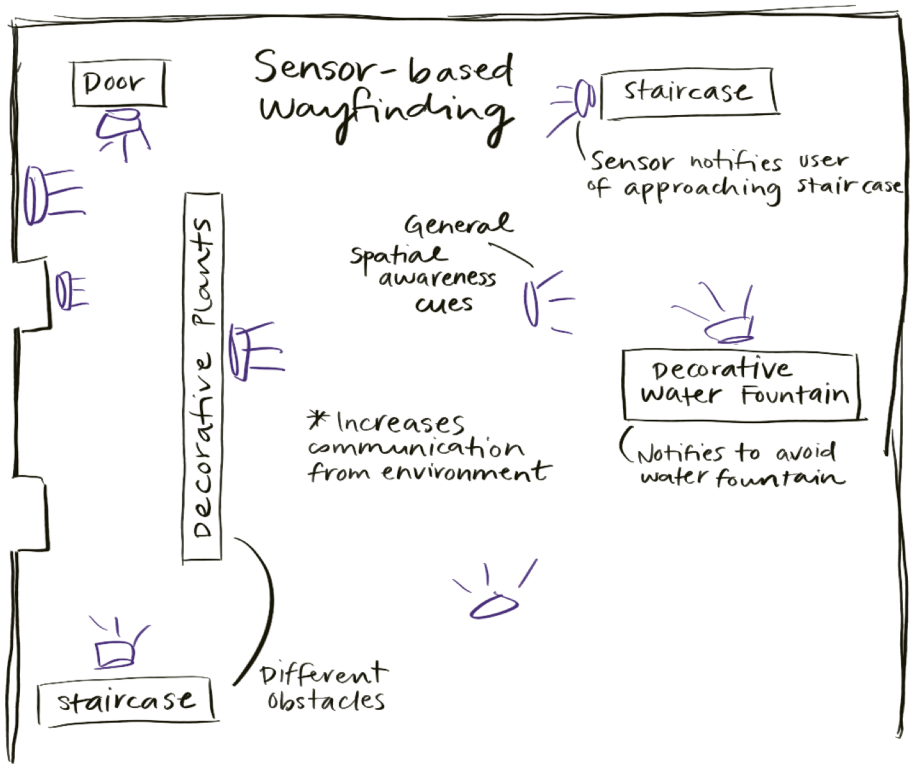
Wireless Beacon Sensor

Where: In the environment. Both indoor (doors, walls, elevators) and outdoor (staircases, water fountains, sidewalks)

Purpose: Method of wayfinding that does not rely on vision.

How It Works:

- Uses Bluetooth to send out location-based signals to app on cellphone
- Each beacon builds a spatial model with a set of spatial information and key location markers or obstacles (How 2018)
- Beacon routinely scans environment to update its spatial model



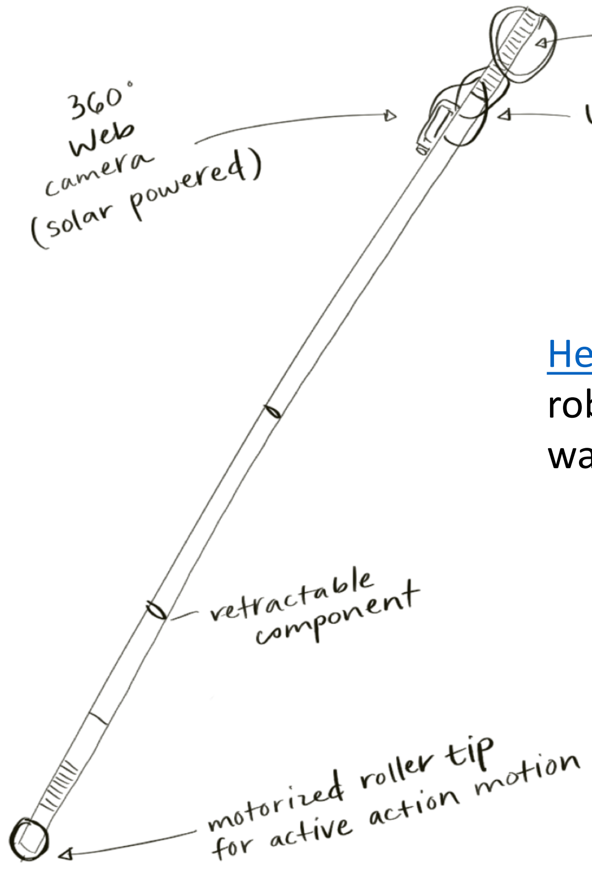
Robotic Cane

Where: Tool for use by user's hands

Purpose: "See" on behalf of the user and build predictive models to help navigate users through crowds and other spatial obstacles.

How It Works:

- Intended to be used as a traditional cane with additional features
- Assesses a person's current location and predicts potential future movements using computer vision techniques and comparing changing views from camera (Ye 2016)
- Camera near the top of cane and motorized roller tip to propel users towards a certain direction



Here is a video of the use of robotic cane technology for wayfinding

Wayfinding App

Where: Phone of user

Purpose: Communicate with beacon sensors in the environment .

How It Works:

- Establishes a point of communication between the glove, beacon sensor, and robotic cane
- Processes signals from the beacon sensors and communicates with user through ear piece
- Provides audio-based descriptions of nearby area and potential spatial obstacles to avoid
- Provides directions to help user navigate through area

Coping with the Identified 6 Challenges

(1) Opening the Door Knob

- Beacon sensor and camera on robotic cane notify user of door via the app and ear piece
- Glove sensor sends out touch sensations to user's palm to develop a 3-D model of door handle
- Glove sensor guides user to door handle

(2) Obstacles Like Bollards for Cars / Decorative Water Fountains

- Beacon sensors alert users about the key location features including the water fountains and bollards via the Wayfinding App and ear piece
- Motorized roller tip in the robotic canes can help users walk around such obstacles

(3) Danger in Parking Lots

- Beacon sensors can notify users of cars near-by via the ear piece and app
- Robotic cane can help users stay on the right side of and navigate the parking lot
- Robotic cane can also help propel users out of the way of cars or any other obstacles
- Beacon sensors can also notify users of speed bumps near by

(4) Staircase

- Beacon sensors and robotic cane camera will alert the user of staircases nearby
- Robotic cane can be used to better navigate the staircase
- Gloves can be used to help users find the railing of the staircase

(5) Staying On / Turning Directions While Walking on Sidewalk

- Beacon sensors allow individuals to be more aware of their surroundings
  - ↳ Directions for where to turn / how to navigate the sidewalk to reach desired destination
    Warning audio-based notification when user is too close to the sides of the side walk
  - ↳ Example: Beacon sensors at bus stop can also send alerts to earpiece about bus times
- Robotic cane and motorized roller tip can help users stay on the side walk and follow directions to destination

(6) Crowds / People Around You

- Beacon sensors provide general info about extent of crowds
- Robotic cane can use its camera and algorithms to help navigate through crowds based on previous data
  - ↳ With more use, the roller tip can better understand each user's walking patterns and reaction times
    - ↳ More tailored navigational assistance

Perception and Action

- (1) According to Gibson, affordances are the purpose of perception (Dawson 2014). The robotic glove continuously scans and identifies small objects like door handles, elevator buttons, and water bottles in order to build a model for the user based on the potential affordances. This allows individuals to be more aware of the affordances in their environment.
  - Embodied cognitive science focuses on the coupling feedback relationship between an agent and the world. The limits of an agent impact how the agent experiences the world (Dawson 2014). In this case, visual limitations change the extent to which individuals are able to interact with the world around them. With the glove, individuals are able to increase the way they interact with the world.
  - This world was not built or tailored to augment the challenges faced by those with visual impairments. This not only impacts the means in which individuals are able to offload cognitive tasks, but also impacts how the environment is acted upon by individuals with visual impairments.
- (2) According and unique to Noe's enactive approach, perception is action, a form of action. For all individuals, the world becomes perceivable as you physically move and interact with it. Enactment is a significant factor in perception. Rather than the mind building an internal representation of the world, perception is active and action-oriented (Noë 2006) .
  - With the enactive approach, there are two different types of blindness: one caused by the physical limitations of the visual system and experiential blindness. Blind and visually impaired individuals have to navigate the world differently because they are working to perceive the environment around with with both types of blindness.
  - Experiential blindness highlights the importance of understanding in navigating the visual stimulus humans receive. Even with restored vision, the new visual stimuli would still be uninformative because one needs to understand the significance of the stimuli.
  - Thus with these new sensors, individuals are not only receiving the audio feedback that is communicating what's out in the world , but also the touch-based stimulation of the glove sensors and motorized roller tip help clarify the action-based significance behind the stimuli received from the beacon sensors and cane camera. This can be related to the importance of affordances in interacting with an environment. This technology takes a affordance-focused lens to help alleviate experiential blindness.

Cognitive Consequences

- (1) Body Schema
  - Schema refers to the model for the body in your brain and the pattern of thinking about your body. And the use of tools has been proven to change the visual mental schema to have an updated version of a body map recognizing the additional affordances the tool enables (Maravita 2004).
  - This technology will naturally impact the schema because the glove sensors and improved robotic cane increase the reaching space and be a significant factor in the body-centered representation of space.
- (2) Cybernetics
  - David Thomas focused on control and communication as a fundamental component in understanding cybernetics. With this technology, blind and visually impaired individuals are better able to communicate with and have control over their environments (Thomas 1995). Individuals can give voice commands to locate objects in the environment with the use of the glove sensor. With the beacon sensors, there is greater signal communication between the environment and the individual (through audio, mechanical sensations, and speech recognition) regarding what is out there (obstacles, crowd level, general information, etc…)
  - Ultimately, the different facets of this technology allows individuals to increase the extent of communication and control mechanisms between the environment and the individual.
- (3) Embodiment
  - Due to the causal coupling between our external and internal resources, tools such as a robotic canes, glove sensors, beacon sensors in the environment become integrated into the way we go about our lives (Scott 2019). Thus, these tools will become an extensions of any user’s body.

Citations

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