Enactive Framework of Individual In the Absence of Vision System

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COGS 100 - Cyborgs Now and in the Future

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February 07, 2024

Interactive Navigation Strategies for Blind People Using Cybernetic Artifact

Introduced by Francisco Varela, Evan Thompson, and Eleanor Rosch, enactivism in Cognitive Science refers to "the manner in which a subject of perception creatively matches its actions to the requirements of its situation" (2017). This derives a tight connection between the environment and the action of a body, which interactively affects cognition. To examine this enactive framework, we are interested in studying the absence of a human vision system and the alternative navigation strategy an entity can take.

Having a vision impairment or even blindness is now a global issue that at least 1 billion people encounter (WHO, *Eye care, vision impairment and blindness*). These people often require extra assistance in their independent movement, and these aids can be a white cane, a sentient assistant device, or a guide dog. As the white cane is an easily and commonly used tool, it allows users to scan their environment to have a sense of their surroundings. This tool served as an extension to the user to sense the environment as an embodied method. Our research, therefore, is to analyze the navigation challenge of the situated interaction and strategies for blind people to complete a specific navigation task.

Navigation task

In our scenario, a UCSD student with a visual impairment primarily relies on his white cane for mobility. He is now tasked with navigating from the restaurant Fanfan to Geisel Library. This journey presents multiple challenges for the blind student. The first difficulty he will encounter is the crowded sidewalk, especially around noon, when people are moving between classes, and pedestrians move in various directions. Additionally, he must cross a lane designated for bicycles and scooters, which lacks a traffic light. Pedestrians often find themselves needing to avoid bicycles and scooters in this area. Finally, the route from Fanfan to Geisel also includes walking down a long flight of stairs, which creates additional difficulty and is dangerous for a blind person. (For details of the route see Diagram 1.1)

Navigation Challenges and Strategies

First Challenge — Crowds

In this navigation test, the first challenge the blind student faces is walking across Muir College Drive, a crowded sidewalk where people are moving in multiple directions. Unlike walking in a quiet, controlled space, crowds create a constantly changing situation that includes lots of obstacles and risks. The blind student must depend on tactile feedback from the cane to detect immediate obstacles, such as unpredictably moving people, uneven ground, or unexpected barriers. Furthermore, the ambient noise in crowded areas can significantly decrease the student's ability to use auditory cues for orientation and risk detection. (see Diagram 1.2)

Solution 1

To overcome the challenge of navigating through a crowd, the blind student using a white cane can employ specific interactive strategies that align with the enactive framework. One strategy is that the student can improve the cane technique to a more protective mode, using shorter, more frequent sweeps to detect immediate obstacles. This involves an increased tactile sensitivity to interpret subtle changes in cane feedback, allowing for quick reactions to dynamic obstacles. The grip and the way the hand holds the cane may also adjust to maintain balance during sudden movements. (see Diagram 2.1)

Second Challenge — Bicycles and Scooters

Aside from physical obstacles like crowds in usual class time, scooters and bicycles inside UCSD's campus are popular commuting tools for students which can potentially be a more dynamic disruption and even a threat for the student. A lane horizontally across our designated path (see Diagram 1.3), always has scooters or bikes shuttling between. Embedding this situation to the student, who does not possess a well-functioning vision system, it turns out that the student lacks the synchronized perception of moving obstacles.

Solution 2

Because of the rapid dynamic change in surroundings compared to the much slower interaction between the student and moving objects, a potential strategy will aim to increase this connection. Breaking down the steps into microstructures, the student, at the intersection of the path and the scooter lane, can first sense the increasing noise of scooters and bikes coming across. Then, based on this sensation-action loop, the student can knock the ground with the tip of the white cane. This is the process of interacting with the environment to signal others. A crucial step here is to raise the white cane gradually from the ground and horizontally carried with the student. This is also a signal to the environment as a sign of passing through. Once the student hears the lowering noise of the scooters or bikes, the student can take the action to put the tip of the white cane down to the ground as usual. (Process details shown in Diagram 2.2) Therefore, a complete cycle of enactive framework can be done by those actions and signaling sensations. However, a better solution will be figured out using our designed cyborg artifact in a later section.

Third Challenge — Stairs

In Diagram 1.4, we identify the third challenge on the path from Fanfan to Geisel Library: a flight of downward staircase that takes part in the last portion of the route. Individuals with typical vision utilize their visual system to effortlessly discern the distance between each step, adjusting their stride accordingly to manage the variations in depth and height. This ability allows them to walk on the stairs with confidence and security. In contrast, visually impaired individuals, like the blind student, who rely solely on a white cane face a considerable obstacle here, this staircase becomes a dangerous barrier. The cane can detect the presence of steps and the edge of each stair, but it does not provide information about the depth of each step or the overall length of the staircase. This lack of depth perception can make the descent particularly unsafe, as it increases the likelihood of missteps that can lead to falls and injuries.

Solution 3

Enhancing the design of the white cane to include a broader base could indeed offer a more stable and tactilely informative tool for navigating stairs. By widening the contact area at the cane's tip, the blind student gains increased tactile feedback from the ground, allowing for better spatial and textural resolution with each tap or sweep. This modification would enable the cane to cover more surface area per movement, providing a more detailed map of the environment and increasing the stability when the cane encounters the edge of a step. The broader base could be designed with materials that enhance grip, reducing the chance of slippage and increasing confidence when ascending or descending stairs. Of course, it is essential that the student receives training to become familiar with the new design and its capabilities. (For details of the design see Diagram 2.3)

Cyborg Artifact

After the analysis of three principle challenges and possible interactive strategies, we can now proceed to the next step to incorporate technology-based aid into this navigation task. For the strains of solving our second challenge - dynamic obstacles, it can be done better by a design of cyborg artifact. A cyborg artifact is a tool designed by an artificial cybernetic system. For the principle of simplicity in using this artifact, our initiative is to improve the prototype - white cane - by adding necessary sensor sets to it. According to "Tools for the body (schema)", an external artifact that acts as an extension of the body schema will extensively render more sensational information to the student.

We can see that our newly developed “white cane” is now equipped with several distance sensors, a light warning, and vibrational devices (Diagram 2.4). Five distance sensors at the middle of the white cane are set evenly apart and each can detect a sector of 36° with a detection radius. Those distance sensors only transmit signals independently when an object is found less than the radius. Each distance sensor is connected to a vibrational device that is finger-scaled so that signals from different sensors will transform into vibrational signals sensed by the student’s fingers. Therefore, the student can perceive a raw surrounding structure in 5 directions in front of him/her. Every time a tap on the ground will enable a signaling process. If no vibrational signals are sent to the vibrational devices, then a light warning at the tip will flash to indicate the potential movement of the student to others because no object is detected in the five directions.

Cyborgs Now and In the Future

Our study on navigation strategies of visually impaired individuals, transitioning from the use of a traditional white cane to a sophisticated cybernetic artifact, offers profound insights into human adaptability and perception. By applying enactivism, it emphasizes the close relationship between an individual's activities and the environment. We identified three specific navigation challenges and developed corresponding strategies to address the problems. The creative improvements made to the white cane by incorporating sensor technologies represent a breakthrough and demonstrate the enormous potential of technology to enhance human skills. As we look to the future, we predict a new era of human-technology interdependence to make our lives better!

Diagrams

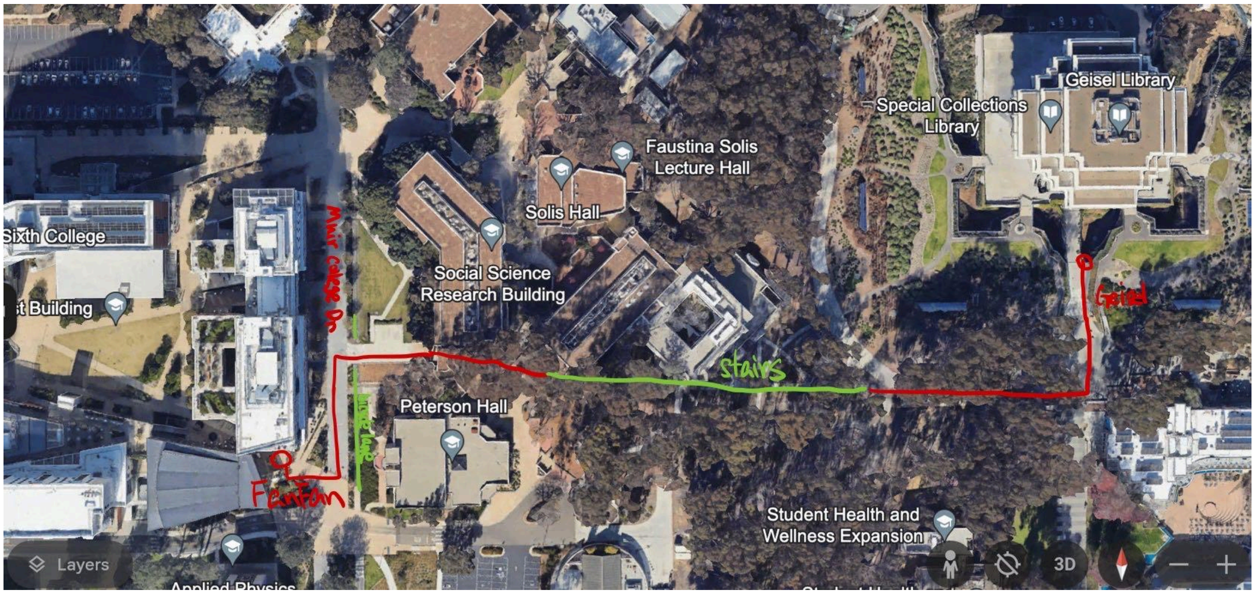

Diagram 1.1 The route from FanFan to Geisel total about 0.4 mi. Including the label of challenges.

Diagram 1.2 Taken outside of Fanfan. The weather conditions were bad but there was still quiet some people walking on Muir College Dr from different directions. (Challenge 1)

Diagram 1.3 The bicycle lane right next to FanFan (Challenge 2)

Diagram 1.4 The long doward staircases. (Challenge 3)

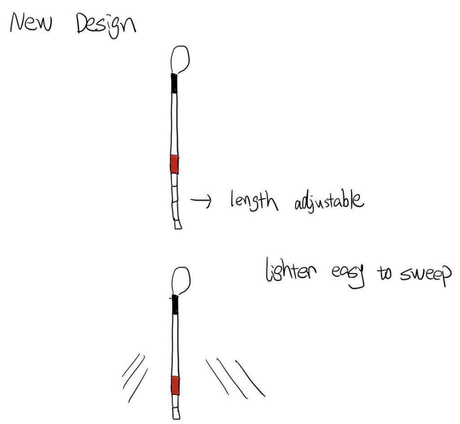

Diagram 2.1 New design shortens white cane (Solution 1)

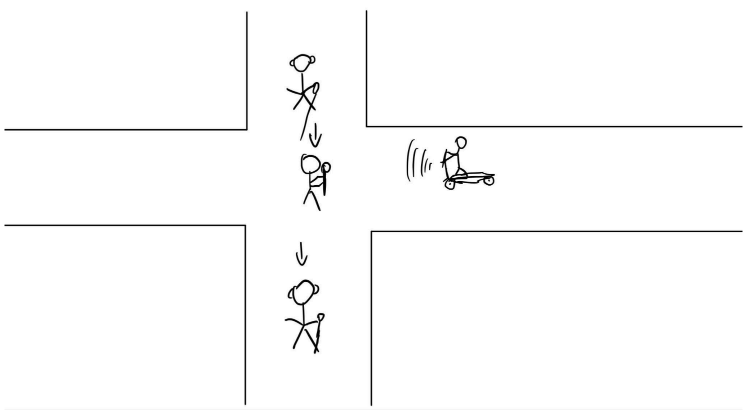

Diagram 2.2 The illustration of interactive strategy (Solution 2)

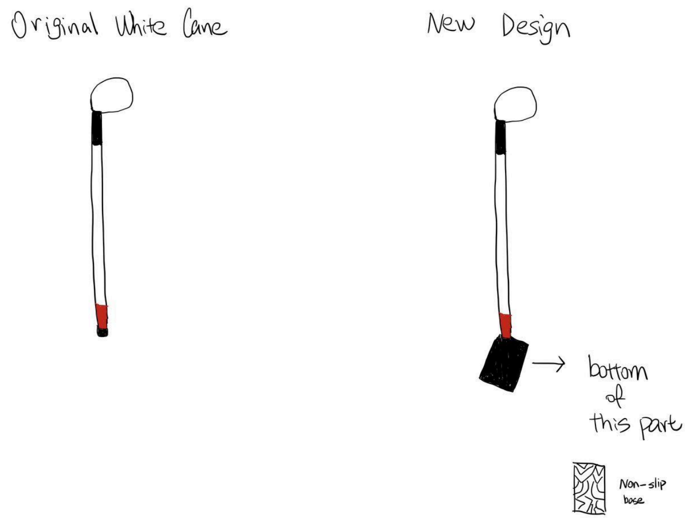

Diagram 2.3 The new design of the white cane has a broader base that teaches the surface of the ground. (Solution 3)

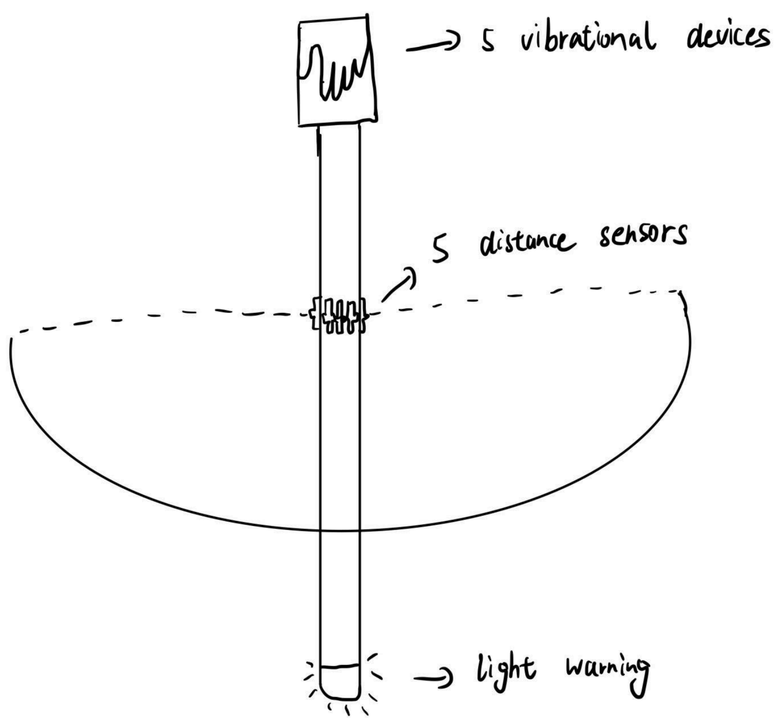

Diagram 2.4 - Cyborg Artifact Design

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