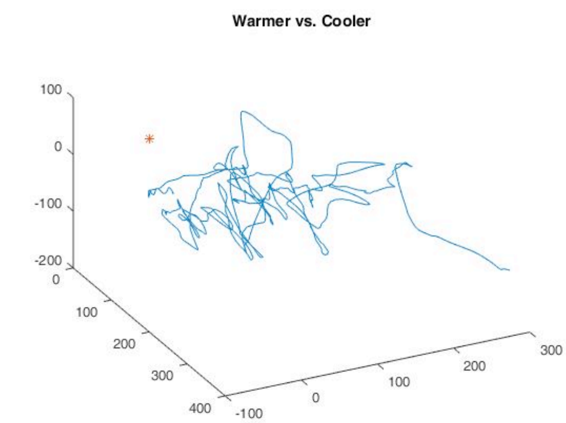
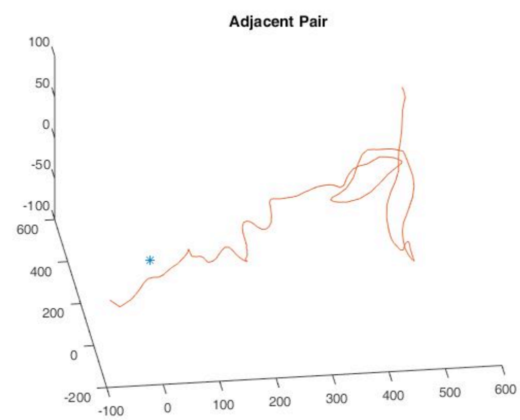
J. Canady, S. Satpute, R. L. Klatzky, G. Stetten, "Validating FingerSight with a 3D Infrared Tracking System," BMES 2018.

Introduction: Computer vision is finding a place in many applications, moving from the factory floor to self-driving cars. Its potential for helping the visually impaired holds great promise. Our laboratory has been developing FingerSight [1,2], consisting of a miniature camera and array of vibrators mounted on the finger. It relies on computer vision to recognize and locate particular targets in the camera image and gives guidance via haptic feedback through the vibrators. Controlled and rapid scanning of the visual environment is possible with the hand, providing the visually impaired user with the ability to "see" with their finger and use that information to navigate areas and find objects critical to their daily lives. To devise optimal control processes for this new human-machine system, we are developing a 3D tracking system for experiments with the FingerSight device, and report on our preliminary results here.

Materials and Methods: The current FingerSight device is composed of four cell-phone vibrators, as well as a miniature camera mounted to the proximal phalanx of the index finger. Attached to the device is an array of four infrared LED markers to be detected by an Optotrak Certus (NDI, Inc.). In the current preliminary experiment, the participant is blindfolded and attempts to reach a target using feedback from the vibrators, which are arranged around the finger at 90° increments, so as to be oriented to the dorsal, lateral, medial, volar aspects of the finger. The target, a 5 mm diameter white dot on a black background, is automatically identified in real time in the camera image using the OpenCV software library, and this information is used to activate the four vibrators through one of two activation strategies: (1) Warmer vs. Cooler, in which all vibrators are activated when the target is seen moving closer to the center of the image, and (2) Adjacent Pair, in which two adjacent vibrators are activated to indicate the proper direction of motion to better center the target in the image. 3D coordinates of each IR-LED are recorded at 10 Hz and the centroid is computed. When the participant arrives at the target, the vibrators are all activated with a long pulse to indicate that the experiment is over.





Results and Discussion: 3D plots of the path of the centroid over time are shown below for a single subject and trial. Performing the task with the Warmer vs. Cooler vibrator activation (top) strategy took 87.2 seconds to complete, while the experiment using the Adjacent Pair (bottom) strategy took 17.2 seconds. Motion with the Adjacent Pair strategy was clearly smoother and better directed, with guidance being refined as the participant approached the target (shown by '*').

Conclusions: Using the tracking system, we were able to demonstrate that one control strategy was more effective than the other for this participant. Future studies will expand to more vibrator activation strategies and will record camera orientation as well as location using full rigid body transformations. We expect to use these data to enhance how subjects use the FingerSight device in various tasks.

Acknowledgements: Funding provided by the Swanson School of Engineering and the Office of the Provost at the University of Pittsburgh, as well as the Pittsburgh Innovation Challenge (PInCh). We wish to thank Pitt EXCEL for guidance and support.

References:

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