Low-Cost Tactile Interfaces for Non-Visual Exploration of Planetary Datasets

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Interaction with planetary exploration efforts need not be confined to visual media, and inclusive public engagement efforts can benefit from the adoption of non-visual methods for interacting with planetary science data. These technologies can enhance interactions with planetary exploration efforts for individuals with visual impairments or blindness.

Methods for generating tactile public engagement and education products

MORE CURATED EXPERIENCE

MORE USER AGENCY

3D printed materials
- Pro: Excellent quality, reproducible models of planetary datasets (e.g., topography)
- Con: Relatively long lead time (30 minutes to many hours), limiting the responsiveness to new inquiry.

Thermal expansion machines
- Pro: Rapid (~few seconds) creation of bump-map images on low-cost swell paper substrate.
- Con: Expansion is binary, resulting in a lower-fidelity tactile reproduction than a 3D printed surface.

Tactile displays / interfaces
- Pro: Instantaneous interaction with multi-dimensional data, provides great user agency and responsiveness to new inquiry.
- Con: Very high cost/complexity; few resources for development in public engagement / educational space.

Project ESPRESSO *Accessible Exploration Initiative* and *Tactile Telescope System*

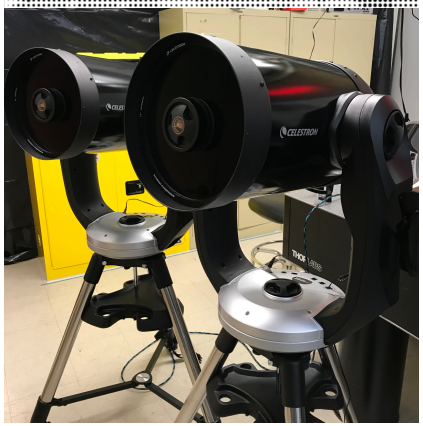
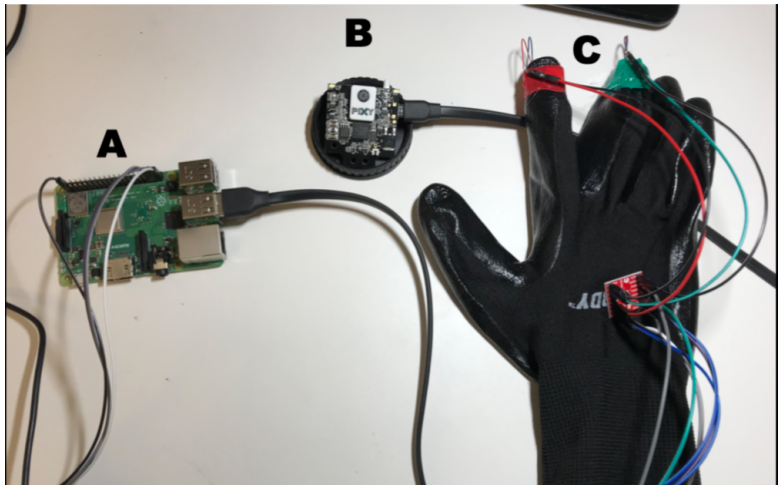
The Project ESPRESSO SSERVI node's new Accessible Exploration Initiative is devoting effort to identifying promising technologies for improving accessibility of planetary exploration data and field experiences.

The Tactile Telescope System includes two C11 telescopes outfitted for real time planetary and deep-sky imaging, and is designed to feed a portable projector as well as a thermal expansion machine. This system provides means for groups of people to simultaneously interact with real-time visual imagery of the sky and inon-visually in near-real time with the persistent thermal expansion prints.

To improve responsiveness of the Tactile Telescope System, we have also developed a **Low-Cost Haptic Interface Glove.** The low-cost (~$150 USD) system consists of a glove with uniquely colored fingertip pads with embedded vibration motors, a fingertip-tracking camera, and a control computer. We use a low-cost (~$60) Pixy2 camera that performs on-board color-based object, fed to a Raspberry Pi 3 B+ single-board computer (~$30). When the glove is held above the camera, the (x,y) location of each fingertip is mapped onto an (x,y) location in the dataset to be explored (in preliminary efforts, these were monochromatic lunar images collected by the C11s). The amplitude of the vibration driven in each fingertip is set by the data value at this location (e.g., the image level). In early testing, glove users can easily distinguish the lunar phase by sensing the periphery of visible illumination and discern a degree of terrain texture.

Ongoing refinement of the design includes more stable finger tracking and multiple actuators per finger for finer detail delivery, as well as software adjustments to improve recognition of detail in a variety of planetary datasets (including topography, imagery, and numerical models).

Top panel: Lunar LOLA topography data filtered for printing on a thermal expansion machine.

Center panel: Project ESPRESSO Tactile Telescope System's twin C11s. One outfitted for planetary imaging, the other for wide-field deep sky imaging; both use single-shot color sensors.

Bottom panel: Protype ultra-low cost haptic glove. A: Raspberry Pi controller. B: Fingertip-tracking camera. C: Glove, with uniquely-colored fingertips for tracking and with embedded haptic feedback motors. Images from C11 telescopes processed by RPi in real time for glove interaction.