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Low Vision Goes Hi-Tech

Low vision means that even with glasses, contact lenses, medicine, or surgery, people find everyday tasks difficult to do. It can affect many aspects of life, from walking in crowded places to reading or preparing a meal. The tools needed to stay engaged in everyday activities vary based on the degree and type of vision loss. For example, glaucoma causes loss of peripheral vision, which can make walking or driving difficult. By contrast, age-related macular degeneration affects central vision, creating difficulty with tasks such as reading.

The world of digital logic and miniaturised computing has led to a revolution in low vision aids. Many people are already using tablets and e-readers to access reading materials in large fonts and others are taking advantage of the opportunity to download audio-books from their local libraries. But those technologies are only the beginning.

This issue of Primary Eyecare takes a look at a few of the new technologies funded by the US National Eye Institute that aim to lessen the impact of low vision and blindness.

Co-robotic cane

Navigating indoors can be especially challenging for people with low vision or blindness. While existing GPS-based assistive devices can guide someone to a general location such as a building, GPS isn't much help in finding specific rooms. This has prompted Cang Ye, Ph.D., of the University of Arkansas at Little Rock to develop a co-robotic cane that provides feedback on a user's surrounding environment.

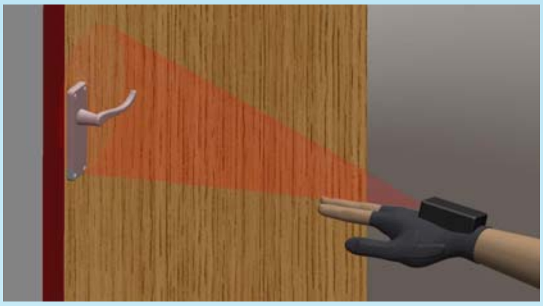
The co-robotic cane features a computerized 3-D camera to "see" on behalf of the user and a motorized roller tip that can propel the cane toward a desired location. This allows the user to follow the cane's direction. As the user moves along, he or she can speak into a microphone and a speech recognition system interprets verbal commands and guides the user via a wireless earpiece. The cane's credit card-sized computer is currently configured to store and use pre-loaded floor plans but Ye envisions being able to download floor plans via Wi-Fi upon entering a building. The computer analyses 3-D information in real time and alerts the user of hallways and stairs. The cane gauges a person's location in the building by comparing the current image captured by the camera with the previous image. As the user moves through the building the cane determines the user's location by comparing the progressively changing views relative to the starting point.

Robotic glove finds door handles, small objects

In the process of developing the co-robotic cane, Ye realized that closed doorways pose yet another challenge for people with low vision Finding the door knob or handle

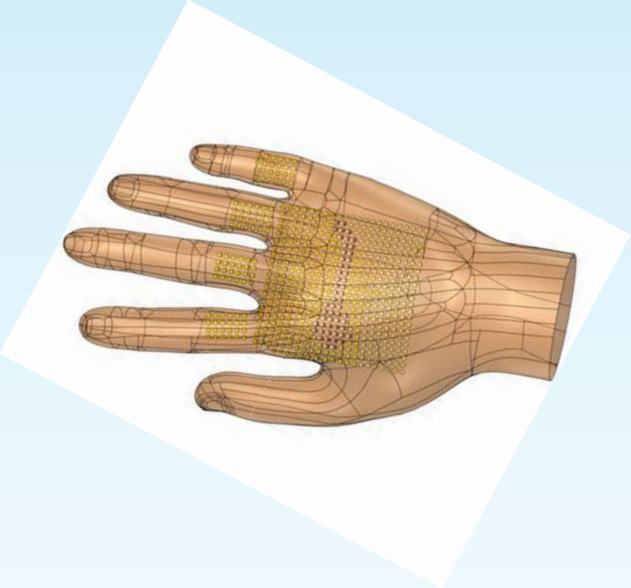
Navigation, orientation, and mobility can all be made easier!

and getting the door open can be a real challenge. To help someone with low vision locate and grasp small objects more quickly, Ye designed a fingerless glove device.



Ye's fingerless glove uses a camera to detect small objects such as door handles. On the back surface is a camera and a speech recognition system, enabling the user to give the glove voice commands such as "door handle," "mug," "bowl," or "bottle of water." The glove guides the user's hand via tactile prompts to the desired object. Guiding the person's hand left or right is easily achieved using an actuator on the thumb's surface takes care of that in a very intuitive and natural way, however prompting a user to move his or her hand forward and backward, and getting a feel for how to grasp an object, is more challenging.

Ye's colleague Yantao Shen, Ph.D., University of Nevada, Reno, developed a novel hybrid tactile system that comprises an array of cylindrical pins that send either a mechanical or electrical stimulus. The electric stimulus excites the nerves on the skin of the hand to simulate a sense of touch. The pins (shown in yellow) pulse in a pattern indicating that the hand should move backward or forward. A larger system on the palm (shown in purple) creates a 3-D representation of the object's shape. For example, if your hand is approaching the handle of a mug, you would sense the handle's shape in your palm so that you could adjust the position of your hand accordingly. As your hand moves toward the mug handle, any slight shifts in angle are noted by the camera and the tactile sensation on your palm reflects such changes.



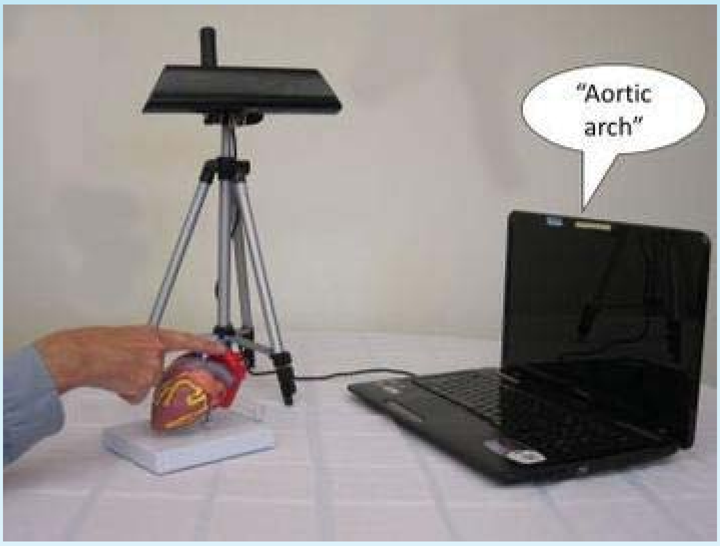
Smartphone pedestrian-crossing app

Street crossings can be especially dangerous for people with low vision. James Coughlan, Ph.D., and his colleagues at the Smith-Kettlewell Eye Research Institute have developed a smartphone app that gives auditory prompts to help users identify the safest crossing location and stay within the marked pedestrian-crossing.

The app harnesses three technologies and triangulates them. GPS is used to pinpoint the intersection where a user is standing. Computer vision is then used to scan the area for crossings and cross now lights. That information is integrated with a geographic information system (GIS) database containing a crowdsourced, detailed inventory about an intersection's quirks, such as the presence of road construction or uneven pavement. The three technologies compensate for each other's weaknesses. For example, while computer vision may lack the depth perception needed to detect a median in the centre of the road, such local knowledge would be included in the GIS template. And while GPS can adequately localize the user to an intersection, it cannot identify on which corner a user is standing. Computer vision determines the corner, as well as where the user is in relation to the crossing, the status of the traffic lights, and the presence of vehicles.

CamIO system helps explore objects in a natural way

Imagine a system that enables visually impaired biology students to explore a 3-D anatomical model of a heart by touching an area and hearing “aortic arch” in response. The same system could also be used to get an auditory readout of the display on a device such as a glucose monitor. The prototype system, designed with a low-cost camera connected to a laptop computer, can make physical objects – from 2-D maps to digital displays on microwaves – fully accessible to users with low vision or blindness.



The CamIO (short for camera input-output) also under development by Coughlan, provides real-time audio feedback as the user explores an object in a natural way, turning it around and touching it.

CamIO was conceived by Joshua Miele, Ph.D, a blind scientist at Smith-Kettlewell who develops and evaluates novel sound/touch interfaces to help people with vision loss. Coughlan plans to develop a smartphone app version of CamIO. In the meantime, software for the laptop version will be available for free download. To watch a demonstration of the CamIO system, visit http://bit.ly/2CamIO.

High-powered prisms, periscopes for severe tunnel vision

People with retinitis pigmentosa and glaucoma can lose most of their peripheral vision, making it challenging to walk in crowded places like airports or malls. People with severe peripheral field vision loss can have a residual central island of vision that’s as little as 1 to 2 percent of their full visual field. Eli Peli, O.D., of Schepens Eye Research Institute, Boston, has developed lenses constructed of many adjacent one-millimetre wide prisms that expand the visual field while preserving central vision. Peli designed a high-powered prism, called a multiplexing prism that expands one’s field of view by about 30 degrees.

Peli considers that an improvement, but not good enough, so he and his colleagues mathematically modelled people walking in crowded places and found that the risk of collision is highest when other pedestrians are approaching from a 45-degree angle.

To reach that degree of peripheral vision, he and his colleagues are employing a periscope-like concept, using non-parallel mirrors to provide a view that would otherwise be out of sight. The prototype developed by Peli and colleagues now achieves a 45-degree visual field. Their next step is to work with optical labs to manufacture a cosmetically acceptable device that can be mounted into a pair of glasses. The aim is to develop magnetic clip-ons for spectacles that could be easily mounted and removed.

The Implantable Miniature Telescope

The IMT is approved for implantation in phakic patients 65 years or older with a visual acuity between 6/48 and 6/240 as a result of bilateral central scotomas associated with end-stage AMD. Patients must also have findings of disciform scar or GA, cataract, and show, in preoperative testing, an improvement of at least five letters with the aid of an external telescope. The IMT consists of wide-angle micro-optics that work in concert with the cornea to project a high resolution 2.7× magnified image kover approximately 55° of the central and peripheral retina. The optical system is designed to allow patients to recognize images using natural eye movements that were previously difficult or impossible to discern. The telescope, optimized for intermediate vision, is implanted unilaterally and used for central vision, while the contralateral eye maintains peripheral vision for orientation and ambulation. Standard spectacles provide distance and near correction.

A four-step program, CentraSight, has been developed: diagnosis of end-stage AMD associated with bilateral central scotomas and evaluation to ascertain whether or not the telescope prosthesis will benefit the patient; selection of the eye targeted for implantation and evaluation of patient expectations; provided the patient benefits from telescope magnification, the patient is seen by a cornea-trained cataract surgeon to make sure the eye is anatomically appropriate for the surgery, and if so the telescope is implanted; post-surgery low vision rehabilitation is provided for 3-4 months to educate patients on how to use their new visual status.

The surgery is more challenging than standard cataract surgery primarily due to the size of the implant. After crystalline lens removal, the limbal wound is enlarged to approximately 12 mm; a 7 mm or larger capsulorhexis is recommended to allow easy placement in the capsular bag. The anterior chamber and capsule are filled with a cohesive ophthalmic viscosurgical device (OVD) while the endothelium and device are coated with a dispersive OVD. The corneal lip is gently elevated andthe telescope is passed into the capsular bag while avoiding endothelial cell layer touch. Seven to eight interrupted sutures are used toclose the corneal incision, and a peripheral iridectomy is performed. A sub-Tenon's steroid injection, betamethasone 6 mg or methylprednisolone 100 mg, is given along with a topical antibiotic. Postoperative sub-Tenon's steroid injections were given during the initial clinical trials; currently most surgeons have found adequate inflammation control with topical administration alone. A topical nonsteroidal anti-inflammatory drug, topical steroids, and mydriatics are prescribed. An extended anti-inflammatory drug regimen is recommended.