# Encoding Object Outlines through 3-D Sound for Object Shape Recognition

Yi Yang, PhD, Penn State Abington, USA
Jacob Benfield, PhD, Penn State Abington, USA
Dmytro Suprun, Penn State Abington, USA
Viet Hung Tran, Penn State Abington, USA

## Abstract

Mammals such as bats and dolphins, including humans, have developed natural sensory-substitution capability such as echolocation. Previous studies have shown that humans with impaired vision are able to achieve a high degree of independence and self-reliance once they learn echolocation [1]. Further studies using MRI and PET reveal that echolocation activates both cortical auditory and visual area of the human brain, where the latter is not known for auditory processing [1][2][3]. However, studies has demonstrated that dolphins are capable of detecting the objects' globe appearance and features through echolocation [4] [5], and bats are able to detect object shape by echolocation [6]. There is no clear indication that human ecolocators can achieve object shape recognition similar to dolphins and bats. Previously, we have presented a proof of concept study on the LIDAR Assist Spatial Sensing (LASS) system that is inspired by echolocation [7]. The system intends to provide people with impaired vision of their surrounding spatial information through stereo sound at varying pitch. The study has demonstrated that blindfolded individuals equipped with the LASS system are able to quantitatively identify surrounding obstacles, differentiate their relative distance, and distinguish the angular location of multiple objects with minimal training. In this paper, we further explore the potential of representing the shape of objects through stereo sound, to enable the visually impaired users obtain shape information through the LASS system.

## Image

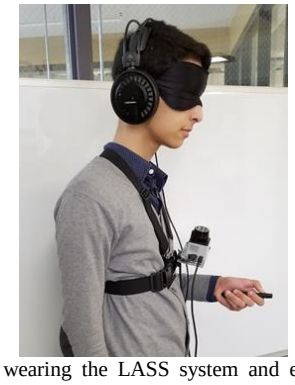


Fig. 1. Participants wearing the LASS system and equipped with a laser pointer.

## Recent Publications (minimum 5)

[1] L. Thaler, S. R. Arnott, and M. A. Goodale, "Neural correlates of natural human echolocation in early and late blind echolocation experts," PLoS One, vol. 6, no. 5, 2011.

[2] V. L. Flanagin, S. Schörnich, M. Schranner, N. Hummel, L. Wallmeier, M. Wahlberg, T. Stephan, and L. Wiegrebe, "Human Exploration of Enclosed Spaces through Echolocation," J. Neurosci., vol. 37, no. 6, pp. 1614–1627, 2017.

[3] P. Arno, A. G. De Volder, A. Vanlierde, M.-C. Wanet-Defalque, E. Streel, A. Robert, S. Sanabria-Bohórquez, and C. Veraart, "Occipital Activation by Pattern Recognition in the Early Blind Using Auditory Substitution for Vision," Neuroimage, vol. 13, no. 4, pp. 632–645, 2001.

[4] H. E. Harley, E. A. Putman, and H. L. Roltblat, "Bottlenose dolphins perceive objet features through echolocation," Nature, vol. 424, pp. 667–669, 2003.

[5] A. A. Pack, L. M. Herman, M. Hoffmann-Kuhnt, and B. K. Branstetter, "The object behind the echo: Dolphins (Tursiops truncatus) perceive object shape globally through echolocation," Behav. Processes, vol. 58, no. 1–2, pp. 1–26, 2002.

[6] C. M. DeLong, R. Bragg, and J. A. Simmons, "Evidence for spatial representation of object shape by echolocating bats ( Eptesicus fuscus )," J. Acoust. Soc. Am., vol. 123, no. 6, pp. 4582–4598, 2008.

[7] C. Ton, A. Omar, V. Szedenko, V. Tran, A. Aftab, F. Perla, M. J. Bernstein and Y. Yang, "LIDAR Assist Spatial Sensing for the Visually Impaired and Performance Analysis" Accepted by *Transactions on Neural Systems & Rehabilitation Engineering (TNSRE), 2018.*

## Biography

Yi Yang received his Ph.D in Electrical Engineering in 2013 at the Johns Hopkins University. Since 2015, he has been an Assistant Professor in the Department of Science and Engineering at Penn State Abington. His current research focuses on LIDAR Assist Spatial Sensing and analyzing the system performance for improvements; applying optical coherence tomography in the field of art conservation; advancing virtual laboratory in the field of optics and photonics.

Email: yzy1@psu.edu