ME Seminar

Artificial Echolocation: Neural models for object perception from wave scattering

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ABSTRACT

Waves carry information through space and time, and extracting meaning from them lies at the heart of perception in both natural and engineered systems. This talk addresses how to extract meaningful information from waves, through the lens of biological echolocation. Many animals, including bats and dolphins, navigate complex environments using ultrasound, precisely extracting spatial details from echoes through specialized physiology and neural processing. This remarkable sensing strategy has long inspired artificial sonar systems, yet despite significant advances, engineered solutions still fall short of the perceptual acuity seen in biology. I will present an artificial echolocation framework that uses convolutional neural networks (CNNs) to interpret ultrasound echoes for object recognition. The approach features a scalable, modular architecture of parallel CNNs, each trained for a specific object shape and augmented with physics-informed synthetic data. This design enables the system to learn new objects by simply adding CNNs, without retraining existing networks. Importantly, models trained entirely on synthetic data can accurately classify measured echoes, alleviating the need for extensive data acquisition. I will also discuss a correlation between network predictions and acoustic echo features, offering insights into how the model "hears," rather than treating it as a black box. This research presents a new paradigm for machine-based sensing that mirrors the efficiency and adaptability of biological echolocation. It opens pathways for advanced sonar technologies in imaging, non-destructive evaluation, material characterization, and autonomous navigation, bridging the gap between engineered and biological perception.

ABOUT THE SPEAKER

Dr. Ganesh Patil is a Postdoctoral Research Fellow in the Department of Mechanical Engineering at the University of Michigan Ann Arbor, and a 2025 Postdoctoral Affiliate with the Michigan Institute for Data and AI in Society (MIDAS). He earned his Ph.D. and M.S. in Mechanical Engineering from the University of Illinois Urbana-Champaign, and his B.Tech and Licentiate Diploma from VJTI, Mumbai. Dr. Patil's research focuses on mechanical wave propagation, with the aim of developing advanced materials and methods for more reliable, efficient, and safer engineering systems. His work has earned several honors, including the 2024 USNC/TAM 5MT PhD Thesis in Mechanics Competition Award from the National Academies of Sciences, Engineering, and Medicine; Best Paper Awards from the Acoustical Society of America in 2020 and 2022; and multiple teaching accolades, such as the Mavis Future Faculty Fellowship, MechSE Teaching Fellowship, and the Smith TAM Teaching Assistant Award. He is also a recipient of the 2012 Lord Reay and Dadabhoy Naoroji Gold Medals from VJTI, and brings three years of industrial research experience in vibration and durability from his time at Bajaj Auto Ltd., Pune.

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