ScoutCane: A Novel Cooperative Drone-Cane System Enabling Infrastructure-Free Navigation for the Visually Impaired via Viewpoint-Invariant Semantic Graph Encoding

Xia, Kevin (School: Walt Whitman High School)

Globally, 43 million blind and 295 million visually impaired individuals lack independent indoor mobility. Existing aids are either reactive (white canes), expensive (guide dogs), or ineffective indoors (GPS). Existing indoor solutions require prior setup, including barcode landmarks, beacons, or pre-mapped LiDAR scanning. No current technology can independently guide a user to a destination in an unfamiliar building without prior infrastructure. This project proposes ScoutCane, the first assistive navigation system enabling infrastructure-free, zero-shot indoor navigation for the visually impaired. Users specify destinations via natural language, such as "I need to find a restroom," and a drone autonomously scouts the environment while a motorized smart cane guides the user along the scouted path. ScoutCane introduces viewpoint-invariant semantic graph encoding: the system extracts spatial landmark relationships and encodes them into 10,000-bit hyperdimensional vectors (1.25 KB) via attention-weighted bundling for robust cross-view matching. To ensure user safety, an Evidential Deep Learning (EDL) layer dynamically quantifies navigational uncertainty to prevent confident failures. This high-level planner then directs a low-level reinforcement learning agent for real-time physical obstacle avoidance. In preliminary real-world evaluation across 5 novel indoor environments, ScoutCane successfully guided the user to the target destination in 37 of 40 trials. Compared to unassisted white cane exploration, ScoutCane averaged 3× faster navigation and an 85% reduction in obstacle collisions. ScoutCane demonstrates that encoding spatial relationships enables robust, infrastructure-free assistive navigation and introduces a new representation paradigm for cross-view perception.

Awards Won:
Third Award of $1,200