

Siddharth Bharthulwar

An Eye in the Fog: Development of a Novel Navigational and Visual Guidance System for Aircraft Operations in Low Visibility Conditions

Low visibility weather conditions at airports obscure crucial visual features that pilots must identify to safely land, leading to hundreds of annual aviation accidents. Instrument Landing System (ILS), the existing radio-signal-based system for navigation in low visibility, presents significant safety and cost limitations. These disadvantages can be eliminated with a system that uses remote sensing data and 3D synthetic vision. Machine learning algorithms parse preexisting LiDAR point cloud data to preemptively localize and segment relevant structural features in an aircraft's predicted field of view (FOV). Structural data are aggregated to reconstruct a pilot's environment in 3D, which is augmented in live time to synthetically replicate a pilot's FOV to visually guide the pilot in live time. The validity of the resulting system was determined through both algorithmic and simulated real-world testing. Algorithmic metrics indicate that the system mapped an aircraft's environment with 97.3% spatial accuracy (ROC AUC = 0.91 ± 0.04 , F1 = 0.980, IoU = 0.973). Real world testing conditions were simulated with cockpit inertial data from real flights and showed that the system was able to accurately identify pertinent terrain data and intelligently guide the aircraft down a glide slope in real time. These results suggest that an implementation of the developed guidance system with existing avionics hardware is a feasible replacement for current navigation systems. The developed navigational aid is applicable for nearly all aircraft and geographical regions due to the widespread and low-cost nature of the remote sensing data and spatial mapping algorithms used.