Acoustic Source Localization using a Microphone Array

Design and Implementation of a Drone Tracking System

Students

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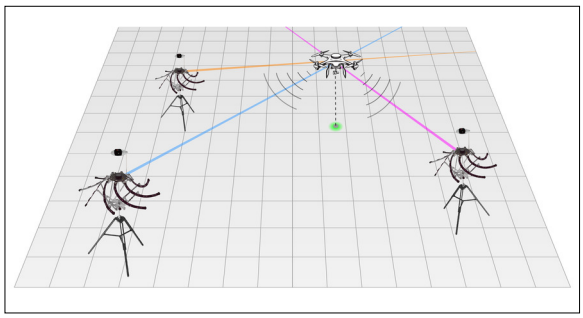
Introduction: In recent years, the rising popularity of drones has led to increased concerns about privacy, espionage, and military misuse. As a result, the development of effective drone localization systems has become crucial. Existing technologies primarily rely on visual, thermal, or radar detection, each with its limitations, especially in low visibility conditions. Humans, however, have a natural ability to locate objects, such as drones, by their audible noise. This observation has inspired the aim of this project, which is to achieve acoustic localization of objects, particularly drones, using sound detection.

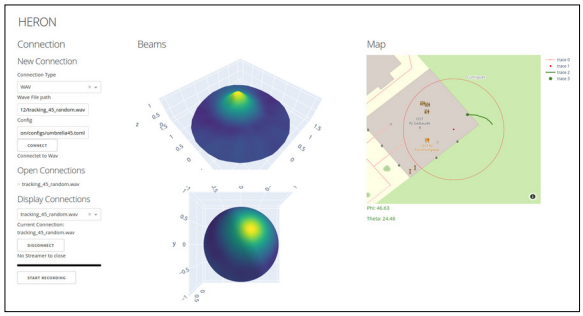
Approach: The project's approach involves using an array of multiple microphones in conjunction with beamforming algorithms to determine the direction of a sound source. However, identifying the sound's direction alone is insufficient to pinpoint an object's exact location. Therefore, multiple arrays, placed at different locations, are combined to estimate the target's position. The primary focus of this project was the development of a microphone array optimized to analyze the direction of a sound source. Through a custom-built simulation environment and validation measurements, an optimal array geometry was identified. It compromises 32 MEMS microphones in a unique cone-shaped, three-dimensional arrangement based on eight adjustable arms. A specialized hardware setup was developed for real-time audio processing and data transmission over a LAN network to a centralized computer running advanced beamforming algorithms. A peak finder and Kalman tracker were implemented for detecting and tracking sound sources. The developed application provides an interactive web interface visualizing directional sound power heatmaps and a map view of each object's location.

Result: The array geometry and beamforming algorithms enabled correct localization of drones at distances exceeding 70 meters. This achievement met the project's requirements and demonstrated the system's potential in applications beyond drone detection, thanks to its flexible setup.

Areal Visualizations of Multiple Microphone Arrays
Own presentment



Web-Interface with Live Drone-Tracker
Own presentment



Final Microphone Array Implementation
Own presentment

Advisor
Hannes Badertscher

Subject Area
Electrical Engineering