

## Comparison of Direction of Arrival Estimation Method for Drone Based on Phased Microphone Array

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**Abstract :** Drones were first developed for military use and were used in World War 1. But recently drones have been used in a variety of fields. Several companies actively utilize drone technology to strengthen their services, and in agriculture, drones are used for crop monitoring and sowing. Other people use drones for hobby activities such as photography. However, as the range of use of drones expands rapidly, problems caused by drones such as improperly flying, privacy and terrorism are also increasing. As the need for monitoring and tracking of drones increases, researches are progressing accordingly. The drone detection system estimates the position of the drone using the physical phenomena that occur when the drones fly. The drone detection system measures being developed utilize many approaches, such as radar, infrared camera, and acoustic detection systems. Among the various drone detection system, the acoustic detection system is advantageous in that the microphone array system is small, inexpensive, and easy to operate than other systems. In this paper, the acoustic signal is acquired by using minimum microphone when drone is flying, and direction of drone is estimated. When estimating the Direction of Arrival(DOA), there is a method of calculating the DOA based on the Time Difference of Arrival(TDOA) and a method of calculating the DOA based on the beamforming. The TDOA technique requires less number of microphones than the beamforming technique, but is weak in noisy environments and can only estimate the DOA of a single source. The beamforming technique requires more microphones than the TDOA technique. However, it is strong against the noisy environment and it is possible to simultaneously estimate the DOA of several drones. When estimating the DOA using acoustic signals emitted from the drone, it is impossible to measure the position of the drone, and only the direction can be estimated. To overcome this problem, in this work we show how to estimate the position of drones by arranging multiple microphone arrays. The microphone array used in the experiments was four tetrahedral microphones. We simulated the performance of each DOA algorithm and demonstrated the simulation results through experiments.

**Keywords :** acoustic sensing, direction of arrival, drone detection, microphone array

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