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Thesis title An Acoustic Indoor Localization System for Unmanned Robots with Temperature Compensation and Co-channel Interference Tolerance
(温度補償および同一チャネル干渉耐性を備えた無人ロボットのための屋内音響測位システム)

Field robotics have been advancing rapidly in recent years, driving their use and application into new and more demanding environments. One such environment that has received less attention to date is indoor operations, such as those in greenhouses. There is a niche for developing an indoor localization system for controlling multiple unmanned ground vehicles (UGV) and unmanned aerial vehicles (UAV). Therefore, a spread spectrum sound-based local positioning system (SSSLPS) was developed. Since sound velocity is affected by temperature, the SSSLPS needs to be tolerant of temperature variations within the greenhouse. A novel temperature compensation algorithm was developed using estimated sound velocity that was hypothesized would provide a more accurate sound velocity estimate than that of conventional methods that rely on temperature sensors. To confirm this, experiments were conducted in a 3 m x 9 m ridged greenhouse. The proposed algorithm had an improved accuracy of 14 mm compared to a conventional sensor-based method (30 mm) and had temperature variation tolerance of up to 11 °C difference within the greenhouse. Apart from temperature tolerance, the signals' co-channel interference issue is also needed to be tackled. Concerning this interference problem, time division multiple access (TDMA) and frequency division multiple access (FDMA) were evaluated for their anti-interference capability. For static results, the FDMA method suffered complex effects, including overlapping of signals and high frequency sound damping, whilst TDMA had an issue with time delay for signal transmission. The signal-to-noise ratio (SNR) of the FDMA did not perform as well as the TDMA method did, with an average SNR of 9.57 dB and 31.6 mm positioning accuracy compared to that of 28 dB, and 12.2 mm for the TDMA method in an 8.3 m × 22 m greenhouse. During dynamic movement of an UGV, both access methods had a range error of less than 100 mm for a moving velocity of 300 mm/s. To further extend the SSSLPS for navigation on a UAV, the problems of UAV noise and unstable movement in the air of the UAV need to be addressed. A novel Doppler compensation algorithm was proposed. Compared to the previous compensation method using an extracted carrier wave, the proposed algorithm for estimating the frequency shifts reduced the failure detection rate from 27.9% to 9.8%. The proposed algorithm has a better performance at detection rate as the proposed algorithm covers all the possible frequency shifts, also improved the error of using the proposed algorithm was 74.5 mm while using the previous method was 88.2 mm. The research has developed SSSLPS with the temperature and signal crosstalk tolerance and has allowed the positioning system to be used on a UAV using a new Doppler shift algorithm.