Paper ID: 33392
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SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Mobile Satellite Communications and Navigation Technology (2)

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RELATIVE POSITION AND ATTITUDE DETERMINATION FOR MICRO/NANO-SATELLITES AND DRONES USING SIGNAL DIRECTION BASED ON ANTENNA ARRAYS

Abstract

In recent years, multi-vehicle formation flying has received an increasing attention because of the rapid development and potential applications of the unmanned air vehicles (UAVs) and micro/nano-satellites. To maintain a desired topology for cooperative vehicles, the high-precision relative position and attitude measurement is crucial as they are the fundamental information for consensus control and collision avoidance. However, the traditional relative navigation systems that are comprised by a lot of sensors have usually large volume and high cost. Considering the miniaturization of UAVs and micro/nano-satellites and their highly integrated functional modules, new microscale, cost-effective relative position and attitude measurement method is required.

In this paper, a novel approach is proposed, called Relative position and attitude Determination using the Signal Direction Detection (RDSDD). The approach utilizes the existing communication systems and antenna arrays on flying vehicles. We consider the scenario of multi-vehicle formation where two chief vehicles have known their relative position and attitude and the those of the other deputy vehicles needed to be determined. In RDSDD, The deputy vehicles broadcast probing signals which can be received by the two chief vehicles. The signals are transmitted and received using planar antenna arrays. Thus the angle-of-arrival (AoA) and angle-of-departure (AoD) of the line-of-sight (LOS) signal propagation path from a deputy to a chief vehicle can be estimated using the array signal processing. Then based on the measured AoAs and AoDs of the LOS paths from a deputy to the two chief vehicles, the rotation matrix and equations can be established. Following the TRIAD algorithm, the attitudes of the deputy vehicle relative to the two chief vehicles can be determined. Furthermore, its relative position is estimated by the LOS path directions. The method of RDSDD is theoretically proved and also validated by the simulation results in this paper. The signal transceiver architecture for inter-vehicle communications and the RDSDD method is also presented for its implementation in a real vehicle.

The RDSDD method makes full use of the existing on-board communication systems, without the need of the sensor components. Thus it can save space, weight, and cost for a flying vehicle significantly. In particular, it is well-suited for micro/nano-satellites and UAVs with miniature sizes in formation flying.