Local Positioning System for Quadcopters

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Motivation

Unmanned aerial vehicles (UAVs), especially Quadcopters, are used for an increasing number of applications and environments.

Applications for localization systems:
- Guided learning
- Autopilot systems
- etc.

Motivation

Problem Statement

Given a bounded 3-dimensional space $V$, the position $M$ of a UAV should be determined within a certain precision.

Implementation

transmitter (loudspeaker) placed on the UAV which sends ultrasonic signals

Time Difference of Arrival (TDOA)

- Ultrasonic burst signal transmitted at $t_0$
- Received at $t_1 = t_0 + d_1 / v$ by receiver 1
- Difference $t_2 - t_1$ can be measured by the system (similar for $r_2, r_3, ...$)
- Position of the mobile object inferred by values $t_1$ and known position of receivers

Solved Difficulties

 Burst Detector

For TDOA calculation time measurements are crucial:
- Burst signal must be detected reliably and precisely.

TDOA Calculation: Particle Filter

Exact solution of the TDOA problem is not practical:
- Overdetermined system: Large number of receivers.
- Noisy values: Measurement errors influence accuracy of the determined position.
- Outliers: Some of the receivers might not detect the burst signal properly.

Solution: using a particle filter for TDOA calculation.

Results

Static position tests

Transmitter placed on a tripod within space $V$.
- Dimensions of $V$: $x_{max} = 10m$, $y_{max} = 3m$, $z_{max} = 2m$
- Standard deviation: $a_{x0} = 1.5$ to $4.9cm$,
- $a_{y0} = 5.8$ to $13.4cm$

Mobile object tests

Transmitter placed on a model railway waggon on a oval shaped track.
- Speed: $v_{max} = 0.2m/s$ to $0.75m/s$
- Standard deviation: $a_{x0} = 6.0$ to $7.3cm$

Autopilot for quadcopter

Demonstration of the implemented system to be used in an autopilot setup for a quadcopter:
- Dimensions of $V$: $x_{max} = 15m$, $y_{max} = 3m$, $z_{max} = 3m$
- Follow a path consisting of pre-defined waypoints.
- Video: UAV performs several repetitions of an 8-figure.

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