EXTENDING THE SENSOR EDGE
SMART DRONE POSITIONING SYSTEM

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Project Overview

The purpose of this project is to design and implement an on-drone distributed positioning system, taking into consideration computational and power constraints. It will require the design and implementation of a distributed calculation mechanism to allow drones in a pack to determine their position (and that of their neighbours). Positioning is based on the drone sensor data and data sniffed from the sensors of other drones in the pack, supplemented by additional sensor data.

Background

There have been a few implementations of systems that rely on the positioning information of drones. Ars Electronica Futurelab used quadrocopters for formation flying based on GPS. The AR.Drone research and development team created an autonomous demo with a localisation system based on a "magic carpet". Finally, a group from GRASP Labs from the University of Pennsylvania used nano quadrocopters to develop a 3-dimensional positioning system using motion cameras.

TABLE OF LOCALISATION TECHNIQUES

SYSTEM	COVERAGE	ACCURACY
GPS	Worldwide (Outdoor)	10m
RFID	Several rooms	2m
Ultrasound	Single room	2cm
Audible sound	Single room	<10cm
Radio-based	Several rooms	3m
Ultra-wideband	Several rooms	<1m

ACCURACY DEPENDS ON LOCALISATION TECHNIQUE IMPLEMENTATION

There are numerous technologies that can be used for localisation each with their advantages and disadvantages. A common technique is to use a GPS-like algorithm with static infrastructure to estimate a position.

Hardware Overview

EMBEDDED COMPUTER SPECIFICATIONS
ARM Cortex-A8 1 GHz CPU
DDR2 256MB RAM @ 1 Gbit
Linux kernel

System Design

Step 1: Select drones that will be beacons in the pack.
Step 2: Initialise positioning tables for each drone.
Step 3: Beacon drones acquire their positions and broadcast their table to passive drone(s).
Step 4: Passive drone(s) acquire their positions in the pack and broadcast their table to the pack.
Step 5: Each drone makes comparisons between their table and tables being broadcast by other drones, their table is updated (if necessary).
Step 6: Each drone acquires their position periodically, beacon drone positions from flight control and passive drone(s) based on beacon drone positions. Drone's broadcast their table when position in the pack is calculated.

Position Acquisition

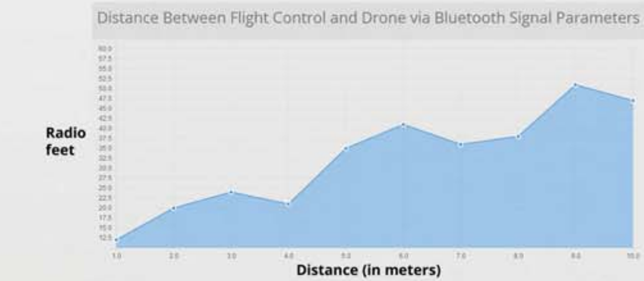
Step 1: Store drones orientation and altitude data in table.
Step 2: Calculate distance relative to flight control (using tables from beacon drones, if possible).
Step 3: Determine position using trilateration/multilateration.
Step 4: Calculate angle relative to flight control.

TABLE OF POSITIONING DATA

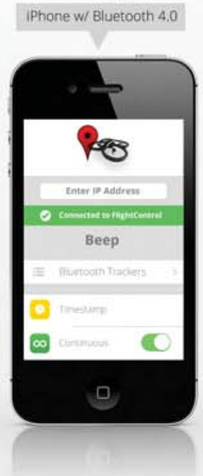
ESSID	POSITION	ANGLE	ORIENTATION	ALTITUDE	BEACON
ardrone2_358	(240, 145)	101°	NW	1.012	true
ardrone2_321	(120, 50)	76°	N	0.734	true
ardrone2_643	(195, 100)	66°	SE	0.986	false

PROPOSED STRUCTURE FOR POSITIONING TABLE

Experiment Results



Prototype

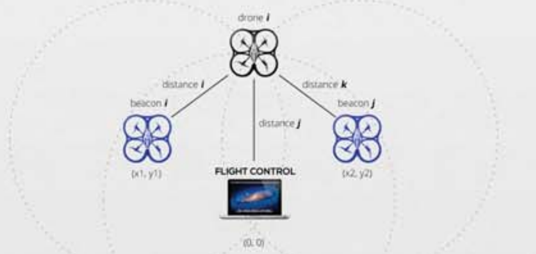


The prototype for the smart drone positioning system includes three drones, two *beacons* and one *passive* drone. The *beacon* drones are equipped with an iPhone and a Bluetooth tracker. The *passive* drone is equipped with just a Bluetooth tracker.

FlightControl controls the drones and communicates with beacon drones via the iPhone application. In addition, *FlightControl* is running an audio detector that calculates the distance to beacon drones and gathers data from the Bluetooth trackers and performs trilateration with collected data to estimate a position.

Multiple Drone Control

All drones are controlled from flight control via a router. Each drone's IP address is reconfigured to connect to the router, so that flight control is able to control all drones at the same time.



PROPOSED PROTOTYPE IN ACTION, 2-DIMENSIONS LIFTED INTO 3-DIMENSIONS USING ULTRASONIC SENSOR

Conclusion

The AR.Drone 2.0 with the addition of supplementary sensors were used in a pack to create a positioning system. Experiments included using WiFi, packet-based and recieved signal strength (RSSI). Using Bluetooth, RSSI and signal parameters and also audible sound. Using radio based technologies means the issues with radio-waves such as multipath, interference and their unpredictability remain. Future technologies such as Ultra-wideband could in theory make these issues less preeminent.

Futhermore, the audible sound solution would need to be refined to include noise filters to make the detector more robust in the real world.