Autonomous Navigation for Small Flying Vehicles

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Introduction

The development of small size autonomous flying vehicles represents one of the current frontiers of research in mobile robotics. In this context, the level of autonomy depends on the navigation capabilities of a flying robot. Navigation systems for ground robots are becoming a consolidated technology. However, these approaches cannot be directly applied to small flying vehicles due to their limited payload. This prevents the use of bulky and accurate sensors which mare common on ground robots.

Figure 1. The blimp used in our experiments.

We describe a cheap and lightweight navigation system consisting in a low resolution web-cam and a single sonar sensor. Our system has been validated on a small autonomous blimp (see Figure 1) by means of several experiments.

Autonomous Blimp

The blimp used in our experiments is depicted in Figure 1. It is based on a commercial 1.8m blimp envelope and in detail described in [1]. The blimp is steered by three motors. The gondola includes an Intel XScale PXA270 based system-on-a-chip with 600 Mhz and 128 MB RAM running Linux.
For our experiments we used a downward-facing USB camera and a sonar sensor at the bottom of the gondola. The total weight of the gondola and hardware is about 200 grams.

Navigation System

Our navigation system runs on a modular distributed architecture. The different modules communicate via network, and can be run on separate machines. The on-board system only acts as a network bridge between the on-board sensors and actuators and a remote controlling PC which does the main computation.
Main components for a navigation system are the position estimation and efficient controllers. For pose estimation we developed an effective network-based SLAM algorithm that relies on visual information [2,3].

Figure 2. The environment (left) and one of the resulting maps (right) from the blimp experiments.

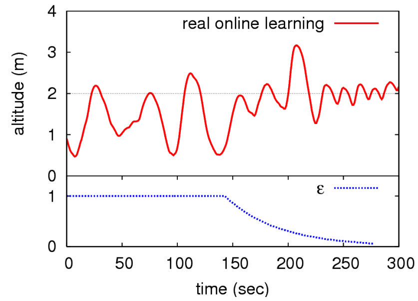

Figure 3. Altitude of the blimp while it learns to stabilize at 2 m**.**

Experiment 1 - Accuracy of the learned maps

To test the accuracy of the learned maps of the visual SLAM system we used markings with known distances on the floor as a ground truth. The blimp was placed in the environment visible in Figure 2 (left) and manually steered in loops over the markings on the floor. The visual map of one of these loops can be seen in Figure 2 (right). The average error of the distances in these maps was under 5%.

Experiment 2 – Altitude control

For the controller we seek to learn the best policy from scratch for the current conditions while the blimp is in operation. For this task, we use the Monte Carlo learning approach using Gaussian processes to reinforcement learning as proposed in [1]. Figure 2 shows the altitude of the blimp, while it learns to control the altitude online.

Experiment 3 – Autonomous flight

In another experiment the blimp moved completely autonomously. The data from the visual SLAM system was used to stabilize the position of the blimp at a given position. I.e., the blimp was placed in an unknown environment and followed a program to always return to it's starting position, when moved away by outer forces. During 20 minutes the blimp was manually pushed away several times and always returned to its starting position, within the physical possibilities of the vehicle.

References

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