

Indoor Aerial Robot Competition: Challenges in Search and Rescue Applications

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Abstract

Tasks like bomb-detection, search-and-rescue, and reconnaissance in near-Earth environments are time, cost and labor intensive. Aerial robots could assist in such missions and offset the demand in resources and personnel. However, flying in environments rich with obstacles presents many more challenges which have yet to be identified. For example, telephone wire is one obstacle that is known to be hard to detect in mid-flight. This paper describes how a blimp can be used in an aerial robot competition to identify other key challenges when flying in these cluttered environments.

Introduction

Homeland security and search-and-rescue missions often require large, diverse task forces. Ground-based robots have shown much potential in offsetting this demand in resources and personnel (Blitch 2002) (Murphy & et al 2000). However, flying has certain advantages over crawling. For example, gathering intelligence around a mountain or in a cave could be done quickly and efficiently with an aerial robot. Also, oftentimes different perspectives (e.g. "bird's-eye" view or a view through a higher-story window) can be more effective. As a result, heightened interest has evolved in small unmanned aerial vehicles (UAVs) that can fly in and around buildings, at low altitudes over rugged terrain, and under forest canopies. Conventional UAV navigational methods rely heavily on global positioning systems (GPS) and inertial measurement units (IMUs) for navigational waypoints and localization, respectively. However, GPS signals are faint when line-of-sight to the satellites is occluded. Furthermore, UAVs capable of maneuvering in *near-Earth* environments must be small and capable of flying at extremely slow speeds (Green, Oh, & Barrows 2004). Therefore, the payload capacity is significantly reduced and carrying bulky sensors, like IMUs, is not feasible. The net effect is that small lightweight (i.e. less than 100 grams) alternative approaches are required for the development of sensor suites for aerial vehicles flying in near-Earth environments.

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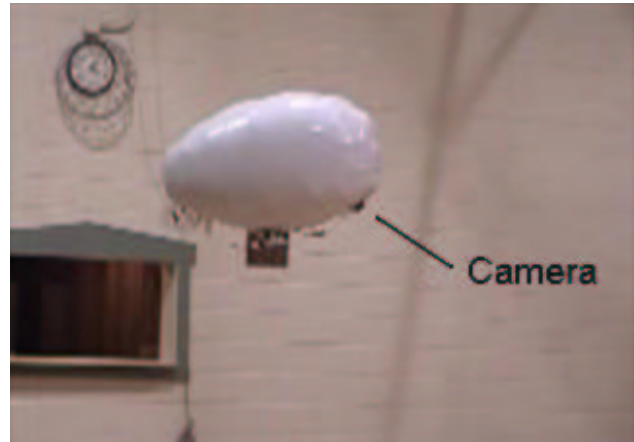


Figure 1: A 30 *inch* diameter blimp carrying a 14 *gram* mini wireless camera can provide surveillance images of urban structures.

Small commercial UAVs, capable of flying in near-Earth environments, are currently being developed by Honeywell, BAE Systems and Piasecki Aircraft. However, they are not yet available as research platforms. Nonetheless, sensor suites enabling autonomous navigation can be developed in parallel. A blimp is a simple and safe test bed suitable for sensor suite evaluation (see Figure 1). A 30 *inch* diameter blimp can fit through standard doorways and carry a payload of 60 *grams*. This is enough to carry a miniature wireless camera, or stereo pair, as well as ranging sensors (IR, SONAR, laser, etc.). With payloads under a 100 *grams*, optimizing the number and types of onboard sensors is critical. Optimization requires the identification of environmental obstacles and challenges. Towards this, Drexel University conceived and hosted an aerial robot search-and-rescue competition on May 1st, 2005. To the authors best knowledge, this indoor flying robot contest is the first of its kind in North America. The competition was structured to highlight the challenges and employment potential for UAVs in search-and-rescue missions.

Several annual robot competitions exist such as *US FIRST* or *RoboCUP*. However, the majority of these competitions are based around ground robots. The few competitions that

exist for aerial robots do not focus on the challenges of autonomous flight in near-Earth environments. For example, the Association for Unmanned Vehicle Systems International (AUUVSI) hosts an annual aerial robot competition in a large outdoor field where teams can utilize strong GPS signals for navigating their robots. Navigation systems which rely on GPS, however, will not function inside urban structures or other enclosed environments where GPS is not available. This competition will serve as one of the first in identifying near-Earth challenges for miniature unmanned aircraft.

This paper illustrates how a blimp can be used as a test bed for such an aerial robot competition. A blimp's platform characteristics and dynamics is discussed. Sensors, particularly optic flow (Green, Oh, & Barrows 2004) (Harrison & Koch 1999) and computer vision (Hamel, Mahony, & Chriette 2002) (Zhang & Ostrowski 1999) are demonstrated. The competition rules and tasks to be exercised such as collision avoidance, gust stabilization and controllability are described. The paper also summarizes the results of the 2005 Competition.

Aerial Robot Competition

An aerial robot competition will be hosted by Drexel University in early Spring 2005. The competition serves to demonstrate the potential for aerial robots in search-and-rescue missions as well as highlight some of the key challenges. Students from local Philadelphia colleges and universities can provide integral feedback to the field by identifying such challenges and coming up with viable solutions and suggestions on how to adapt to dynamic environmental conditions.

Competition Rules and Guidelines

Each team, consisting of 4 undergraduate students and 1 faculty advisor, will be provided with a low-cost aerial robot kit (less than 500 USD). The kit will include all necessary avionics and sensors needed (e.g. blimp, helium, wireless camera, etc.) to achieve autonomous flight behaviors. Teams are not limited to what is in the kit as the competition seeks to inspire new and innovative ways to achieve autonomy.

A basketball gymnasium will be the home of the competition. Varying lights and fans can be used to simulate conditions found in a search-and-rescue mission. Teams will have to demonstrate autonomous collision avoidance on the right half of the course. Obstacles such as hanging lights and concrete walls, will be placed at arbitrary positions. A black line will be taped on a white floor denoting a *collision-free* path. Teams must develop a line following algorithm to successfully traverse this portion of the course. Equipping robots with additional sensors in order to confirm a collision-free path is permissible. Contestants will also have to demonstrate autonomous terrain following by avoiding an obstacle of varying height. Towards the end of the course, robots will be met with a low-speed fan to simulate wind disturbances. Wind gusts severely affect a blimp's flight stability and thus cannot be flown effectively in medium to high winds. Students may utilize the existing sensors or add new sensors

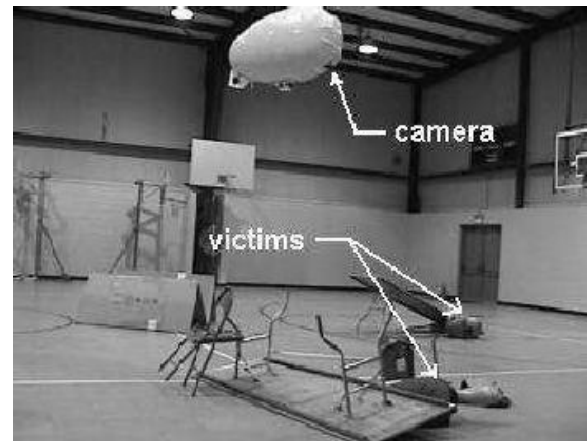


Figure 2: Search-and-rescue portion: locate victims with blimp's wireless camera.

to solve these more complex tasks. Points will be awarded based on how far through the course contestants are able to travel.

The left half of the court will be set up as a search-and-rescue mission (see Figure 2). Using a wireless camera mounted on the blimp's gondola, students will use teleoperated control to: search for immobile victims on the ground and deploy markers to pinpoint victim locations. Blimp operators cannot directly view the rescue area, but will be forced to look at video images transmitted wirelessly from the blimp's camera. During this portion of the competition, contestants will have to develop a method to replace the weight of the deployed markers so that the blimp's neutral buoyancy will not be affected. Points will be awarded based on how close the markers are to each victim.

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