Demo Abstract: BlimpProbe: An Aerial Surveillance Platform

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ABSTRACT
This paper proposes a blimp-based vehicular sensing system, called BlimpProbe, which travels above ground to perform environmental monitoring. We describe an application in atmosphere science that is suitable for this blimp-based sensing system.

Categories and Subject Descriptors
C.3 [Special-Purpose and Application-Based Systems]: Real-time and Embedded Systems.

General Terms
Design, Experimentation.

Keywords
Unmanned aerial vehicles, mobile sensors, environmental monitoring

1. INTRODUCTION
Recently, we have seen the development of a variety of vehicular-based mobile sensing systems that travel on the ground [3], in the air [2][3], or in the water [1] while performing environmental sensing. This paper proposes an aerial vehicular sensing system, called BlimpProbe, which travels above ground to monitor the environment. Blimps have interesting properties that give them unique advantages over other aerial vehicles based on micro-airplanes and helicopters: (1) Blimps incur a lower cost than micro-airplanes and helicopters. (2) Blimps can hover above a target area for an extensive time with little or no energy expenditure, enabling long-term aerial surveillance. (3) Blimps can carry a heavier equipment load, including additional battery packs, sensors and actuators, than micro-airplanes and helicopters.

Given its advantages, BlimpProbe provides an aerial surveillance platform to enable atmospheric science applications that demand long-term and wide-area environment sensing. For example, one possible application is to find optimal placements of wind turbines which maximize the amount of renewable energy generation. Since wind and weather patterns are dynamic and often change across seasons, finding these optimal placements require long-term data collection and development of an accurate three-dimensional wind model over a wide geographical area. Another application is in detecting and tracking of air pollution. Depending on wind and weather patterns, air pollutants can travel and disperse over a wide geographical area.

IPSN'12, April 16–20, 2012, Beijing, China.
ACM 978-1-4503-1227-1/12/04.

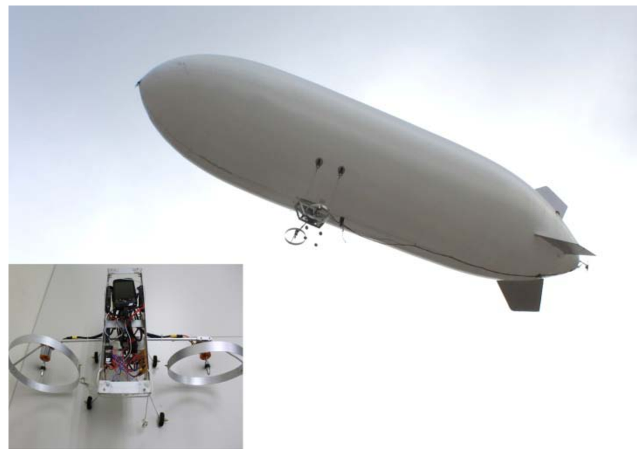

Figure 1. BlimpProbe Prototype

2. SYSTEM OVERVIEW
Figure 1 shows our BlimpProbe prototype. When inflated with helium, the blimp is 4.5 meters long and 1.1 meters in diameter. Its net lift is 2.3 kilograms. The tail of the blimp has three fins. A turbofan motor, placed at the tail of the blimp, adjusts the blimp's heading direction. Additionally, two turbofan motors are mounted on two sides of the blimp's gondola. Each turbofan can change its orientation and vary its speed, enabling the blimp to propel forward, hover, ascend and descend.

Figure 2 shows the system architecture of the BlimpProbe. Almost all electric devices are housed in the blimp's gondola, which contains the following components. (1) The primary component is an Android-based smart phone. The phone comes with various built-in sensors, including a GPS receiver to obtain the blimp's location, a digital compass to sense the blimp's heading, an accelerometer to detect the blimp's movement, and a camera to capture ground images. (2) An IOIO board is used to connect the smart phone to an

Arduino board as well as to the motors. The smart phone runs the blimp's navigation program. The navigation program changes the headings and speed of the blimp by generating PWM (Pulse Width Modulation) signals to control the motor. (3) The Arduino Pro mini board connects to three off-phone weather sensors: temperature, humidity, and barometric pressure, as well as a three-axis gyroscope sensor. (4) When the blimp travels within the radio range of 3/3.G cell towers, the smart phone acts as a gateway to transmit any collected sensor data to the PC on the ground. The PC then displays (real-time) sensor readings on its screen and stores them in a database.

3. CHALLENGES

We have identified the following research challenges for BlimpProbe.

- *Energy*. For efficient use of energy in aerial sensing, planning the blimp's flight route to optimize sensing coverage is an important issue. In particular, when multiple blimps are deployed in an area for collaborative environmental sensing, further optimization is possible by planning their flight routes collaboratively.
- *Communication*. In aerial sensor networks, flight information is exchanged among BlimpProbes in real time in order to compute optimal flight route planning. Additionally, sensor data is sent to the sink (i.e., the PC on the ground) through mobile phones' radios. Power consumption, reliability and connectivity are foremost consideration in wireless communication.
- *Sensor noises*. Sensors all have noises. For example, the GPS sensor has positional error. These noisy sensor data would have to be processed and filtered.

4. DEMO SCRIPT

In this demonstration, we will exhibit our BlimpProbe prototype and demonstrate its operation. Conference attendants will be able to see the maneuverability of the BlimpProbe and to watch BlimpProbe's real-time sensor data collection on the PC's screen.

5. REFERENCES

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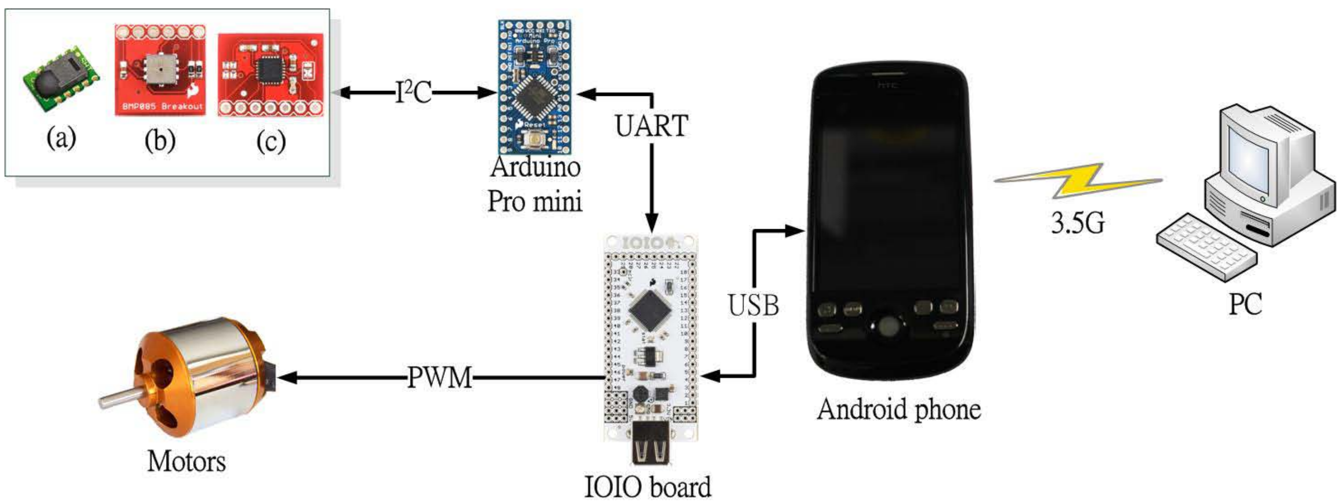

Figure 2. System overview. (a) temperature and humidity sensor - SHT11. (b) barometric pressure sensor - BMP085. (c) three-axis gyroscope - ITG-3200.