Can Quadrotors Succeed as an Educational Platform?

Zachary Dodds

Harvey Mudd College 301 Platt Blvd. Claremont, CA 91711
dodds@cs.hmc.edu

Abstract

The flexibility and controllability of quadrotor helicopters have made them a recent focus of interest among robotics and AI research groups. At the same time, their popularity has led to a wide range of commercially available platforms, some at prices accessible for undergraduate educational use. This project evaluates the ARDrone quadrotor helicopter as a basis for use in undergraduate classes such as robotics, computer vision, or embodied AI. We have encountered both successes and frustrations in using the ARDrone to date. Looking forward, the quadrotor's capabilities do seem a promising basis for future curricular offerings.

Motivation

Hands-on undergraduate AI/robotics classes try to balance two conflicting objectives when choosing robot hardware. On one hand, robots with cameras, range sensing, and access to plenty of computer power allow students to investigate the field's most important algorithms and computational ideas. On the other hand, cost constraints and the ability to personalize smaller platforms make them attractive options. In addition, from both the instructor's and the students' point of view, the ease and flexibility of the software interface is an important factor in choosing a robot.

This project has investigated a relatively new platform, the ARDrone quadrotor helicopter[1], as a possible basis for AI/robotics courses and projects. There are more capable (and expensive) quadrotor platforms[2] that have been the choice of AI research groups (Gillula et al. 2011, Mellinger et al. 2010, Erdinc, Ostrowski, and Taylor, 2005). At the same time, research into *accessible* quadrotor platforms has helped broaden their audience (Burkamshaw 2010). This submission expands that work by exploring – and enhancing -- the educational readiness of these platforms.

At only $350, the ARDrone is inexpensive enough to consider for educational use at a variety of different kinds of institutions. That drone and its basic capabilities are summarized in Figure 1.

Figure 1. (**top**) the ARDrone beside an iRobot Create (**bottom**) a snapshot from the drone's outward and downward video feeds.

Experiences

Hardware

To our delight, we have found the ARDrone to be a very robust platform. In our initial flights using the freely provided iPhone controller we found that it held up very well despite repeated crashes into the walls inside and outside our lab. Gentle contact does not cause a problem at all; more dramatic impacts trigger the helicopter's on-board emergency shut-down routine, quickly dropping the

[1] http://ardrone.parrot.com/parrot-ar-drone/usa/
[2] http://www.asctec.de/

robot to the ground. Both the forward-facing and the downward-facing cameras have performed reliably. Similarly, the ultrasonic sensor that estimates height above the groundplane works exactly as well as any small-robot sonar does: sufficient for hovering, though not precise.

Software

The software has been less forgiving than the hardware in our experience. We have successfully used both the provided C++ software development kit (SDK) and a custom-built Java interface, adapted from contributions by the ARDrone's user community. Although there are user reports of successful installations of the SDK on operating systems other than Ubuntu, our efforts to that end (on both Mac OS X and Windows) have not yet been successful. In our exhibition at AAAI we hope to shed more insight – and success – in using those operating systems. Under Linux, however, the ARDrone SDK works as advertised. As of this submission, students in our AI topics in vision and robotics elective have successfully processed video from both cameras, as shown in Figure 1.

To offer an interface using an OS and language with which high-school students are more likely to be comfortable, we have been developing a pure-Java library that communicates with the drone via its ASCII protocol directly. Starting from contributions by the ARDrone's user community, we have integrated access to the control and the forward-camera video stream. Because the interface is Java, a high-school junior has been able to use it to demonstrate mixed-modality robot coordination. The system controls both a Create and an ARDrone (Figure 2):

1. When the Create realizes that it cannot proceed to the goal above the wall, it signals the drone to take off and hover over the scene.
2. As the drone hovers, its video feed is processed to determine whether exploration to the right or to the left is more promising.
3. The system signals the preferred direction, extracted from the overhead view, to the ground-based robot, which then proceeds to the goal.

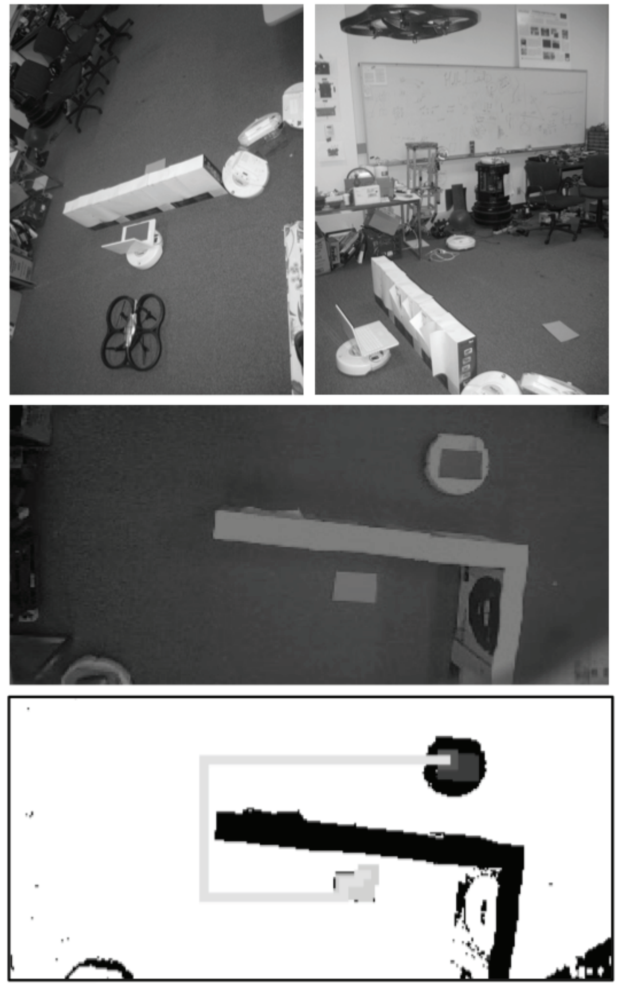

Figure 2. Critical moments from a drone-enabled navigation task: (**top left**) the initial configuration of drone, Create, and obstacle (**top right**) the drone hovering over the scene (**middle**) an image from the drone's downward-facing camera (**bottom**) the computed shortest path for the Create, available because of the addition of overhead sensing on the quadrotor helicopter.

Perspective

Because we have been developing the Java API along with this student's project, each effort has pushed the other forward. We feel that this task's ambition and feasibility shows that the ARDrone holds considerable educational promise. The project itself succeeded, too, taking first place in Los Angeles's science fair in April 2010. In August we will report on strides we have taken to make quadrotor helicopters as capable and as accessible a resource as possible for AI educators.

References

Gillula, J., Hoffmann, G. M., Huang, H., Vitus, M. P. and Tomlin, C. J. 2011. Applications of Hybrid Reachability Analysis to Robotic Aerial Vehicles. *The International Journal of Robotics Research* 30(3) 335-354.

Mellinger, D., Shomin, M., Michael, N., and Kumar, V. 2010. Cooperative Grasping and Transport using Multiple Quadrotors. Proceedings, *10th annual Symposium on Distributed Autonomous Robotic Systems*, Lausanne, Switzerland, Nov 2010.

Erdinc, A., Ostrowski, J. P., and Taylor, C. J. 2005. Control of a Quadrotor Helicopter Using Dual Camera Visual Feedback. *The International Journal of Robotics Research* 24(5) 329-341.

Burkamshaw, L. K. 2010. Towards a Low-cost Quadrotor Research Platform. Master's Thesis, Naval Postgraduate School, March 2010.