2013 Summer UAV Camp at Embry-Riddle Aeronautical University--Prescott, Arizona

Joe Woong Yeol, PI

Summary

The UAV 2013 summer camp at ERAU is a new program amongst the other summer programs. The class is offered to 20 interested high school students and is led by 3 experienced ERAU students with the guidance of an ERAU professor in the robotic department. The program includes 1 week of applied experience on operating, maintaining, programming, and constructing a fully functional quadcopter. The program also introduces basic concepts of robotic sensor feedbacks, mechanical system design, history of robotics, and introduction to contemporary UAVs. The program also provides a wide range of college activities to simulate a college life environment for the high school students.

Program Data

Number of Student: 20

Number of Student Instructors: 3

Number of Program Professor: 1

Number of Quadcopters: 4

Program Duration: 5-1/2 days

Day 1

The program begins with an introduction to robotics via a series of lectures on:

- History of robotics, from development of the first robot to the present
- Mechanism of gears and other mechanical structures
- Types and classification of UAVs
- Robotic sensor and control systems and feedback loops

After the series of lectures, the students are placed into groups to construct their own robot out of LEGO© using the LEGO© mind storm kit. The objective is to design a mechanical system that moves solely using propeller driven motion. The students' design will be put to the test through competition. The design result varies significantly from a few inches to more than 5 feet in 15 seconds.

The objective of Day 1 is to familiarize the student with the theoretical as well as practical components of engineering. The lectures provide the basic information necessary for understanding how a machine functions fundamentally. The LEGO competition provides a transition to the practical aspect of engineering, allowing the students to go through stages of design, testing, and analyzing steps of the engineering process. Pairing the students in groups allows the students to get to know each other and promotes teamwork which also is an important quality for engineers.

Day 2

The students are provided with some more lectures that focus on quadcopters, the UAVs they will be working with.

- Quadcopters, history and mechanism
- Safety when handling quadcopters
- Parts and components of quadcopters

The students are divided into groups of the same number and each group is assigned a quadcopter kit. The kit includes various tools, measuring devices, and quadcopter parts. The instructors guide the students through the assembling process step by step, while explaining the main functionality of each of the components. Following the assembly of the quadcopter, each group learns the steps to calibrate the quadcopters. This includes radio, accelerometer and compass calibration. The groups are then led to the RC field to learn to fly the quadcopter. The first flight is a closely monitored manual control flight performed by every student. In order to prevent quadcopter crashes and accidents, the instructor works with each student to ensure safe and correct operation. The initial quadcopter fly is generally hovering within eyesight with a very short fly time, mostly to give the students a feel of the manual control of the quadcopter. There should be no crashes at this level.

Day 3

The students are taught autonomous control including autonomous navigation, landing, and take off commands in the ArduPilot interface. The instructors guide the students through operation of the ArduPilot interface and the location of autonomous flight were set to be at the RC field. The autonomous flight path was simple—have the quadcopter take off and land after flying across and back—we used the RC field strip. Depending on weather conditions, the calibration and programming setup, the execution of the autonomous flight by quadcopter may vary. Generally, the autonomous flight is executed with success, but termination of battery power or underestimation of battery life usually is the cause of crashes for quadcopters during autonomous flight.

After the autonomous navigation flight, the teams return to the laboratory to repair any damage likely sustained by their quadcopters. This step is crucial in allowing the students to practice problem identification, problem analysis and troubleshooting. After this experience, teams were once more lead into the field for manual control flights.

Since most students enjoy flying quadcopters, additional flight time is scheduled mostly to allow the high school students time to "play" with these quadcopters that are worth a couple hundred dollars. Having fun is one of the important factors that is incorporated into the course in hopes that this enjoyment will foster continued interest and passion for robotics, engineering and aviation.

Day 4

The last flight of the previous day may result in many damaged quadcopters that require repair, recalibration, or maintenance. The next lesson is to introduce the crash prevention concept of exoskeleton structure. The lecture covers the various commercial, research, and military designs for quadcopter protection. The lecture also includes a safety briefing on some of the more dangerous crafting tools that will be used. The final lecture of the program is on the generic engineering process to formally introduce the idea of structured design planning used by engineers. Students are given polyester foam and carbon fiber rods to work with and are expected to follow the engineering design process in creating their exoskeleton. Teams that complete the exoskeleton construction are allowed more flight time on flying the quadcopter with the new protection system.

The construction of the exoskeleton requires some time and usually takes up the entire day. Depending on the speed of the teams, there are two options. One is give the final team competition criteria right away as they work, which will be hosted on the final day, or, second, if the teams finish fairly quickly, then they are assigned more flight time with the mounted exoskeleton in place. Flying with the exoskeleton may have different effects on the quadcopter—depending on the weight and center of mass, the team may have to recalibrate the quadcopter each time for flying.

Depending on the weather and proficiency of the student, a night flight can be planned as the quadcopter can be equipped with LEDs during flight. Alternately, a camera flight can also be planned.

Day 5

This is the day to prepare for the final competition. There will be a brief introduction on the criteria of the competition and the scoring system. The final competition incorporates autonomous navigation, exoskeleton flight, as well as manual control. There will also be sensors involved. In this summer camp, an egg drop competition is hosted which requires each team to drop an egg in a deployable device control by a servo, at a specified location using autonomous navigation and requires a return to the take-off point using manual control. The preparation takes the whole day as the teams need to design and construct the egg deployment device. At this point the teams are working at their own pace with instructors assisting each team.

Day 6

Day 6 is only half a day. The morning portion includes the preparation and the competition. Weather is a factor on the performance of the quadcopter. The completion of the competition marks the end of the program. Follow up is included at the end of the program ceremony hosted by ERAU.

Summary

The ultimate goal is for high school students, without any prior experience on UAVs, to be able to understand, control, and maintain a UAV platform. The particular UAV of this program is the quadcopter, which means the student, at the end of program, will be proficient at flying, maintaining, fixing, modifying, as well as preliminary programming of the quadcopter. Besides handling UAVs, the program also aims at developing the engineering mindset through introduction of the engineering design process, problem solving and identification, and teamwork. Overall, the program aims to foster a student's interest and passion for robotics, engineering, and aviation for college-bound high school students.