Autonomous Quadcopter with Human Tracking and Gesture Recognition

Functional Description and Complete System Block Diagram

Students:
Jacob Hindle, Daniel Garber, and Bradley Lan

Project Advisor:
Dr. Joseph A. Driscoll

Date:
October 22, 2013

Introduction

A “quadcopter” is a type of aircraft similar to a helicopter, but has four powered propellers which provide lift. By varying the speed of each propeller, the aircraft can be made to alter its orientation and direction of motion.

The goal of this project is to create a quadcopter that can autonomously track and follow a particular human as well as respond to gesture-based commands. The human tracking will rely on sensor data such as video images and GPS coordinates. In addition, the quadcopter will have a wifi connection, allowing live video feeds and data to be streamed over the internet. Autonomous flight will include auto-stabilization, obstacle avoidance, and a low battery landing protocol. As an added safety measure, there will be a radio control-based manual override.

Earlier senior projects used the quadcopter platform XAircraft X650CF. However, no successful autonomous flight resulted, therefore, the current project will be a new endeavour. Using the existing platform, a carbon fiber frame with four motors and speed controllers connected to an input/output module, we will design, interface, write software, and run diagnostics for sensors on the quadcopter.

Autonomous control will include the following:

- Manual override capability
- Self-stabilization during flight
- GPS data processing for tracking a human with a GPS beacon
- Vision-based tracking for indoor settings (where GPS is less reliable)
- Gesture recognition from a tracked human, allowing intuitive control
- Wifi data connection allowing video and data to stream to a website

Motivation

The use of quadcopters has expanded rapidly in recent years. Applications range from hobbyist quadcopters to military drones. For our project, a quadcopter provides an inexpensive way to safely follow a specific person, record video, and respond to gesture-based commands.

Such a device can be used for hands-free communication or observation with video and audio streaming. Applications could range from watching your child walk to school remotely to following a soldier into battle to see when they may need medical attention.

Block Diagram and Functional Descriptions

Aircraft

The starting point for the project will be the commercially-available XAircraft X650CF quadcopter [1,2], as shown in Figure 1. This aircraft has a strong and lightweight carbon fiber frame, four Xaircraft X650 p3001 brushless DC motors, and four Xaircraft X650 E3007 10A electronic speed controllers (ESCs). The X650CF also comes with an integrated inertial measurement unit (IMU) and a stabilization system that can be used to stabilize the aircraft during flight.

Figure 1: XAircraft X650 Carbon Fiber Edition.

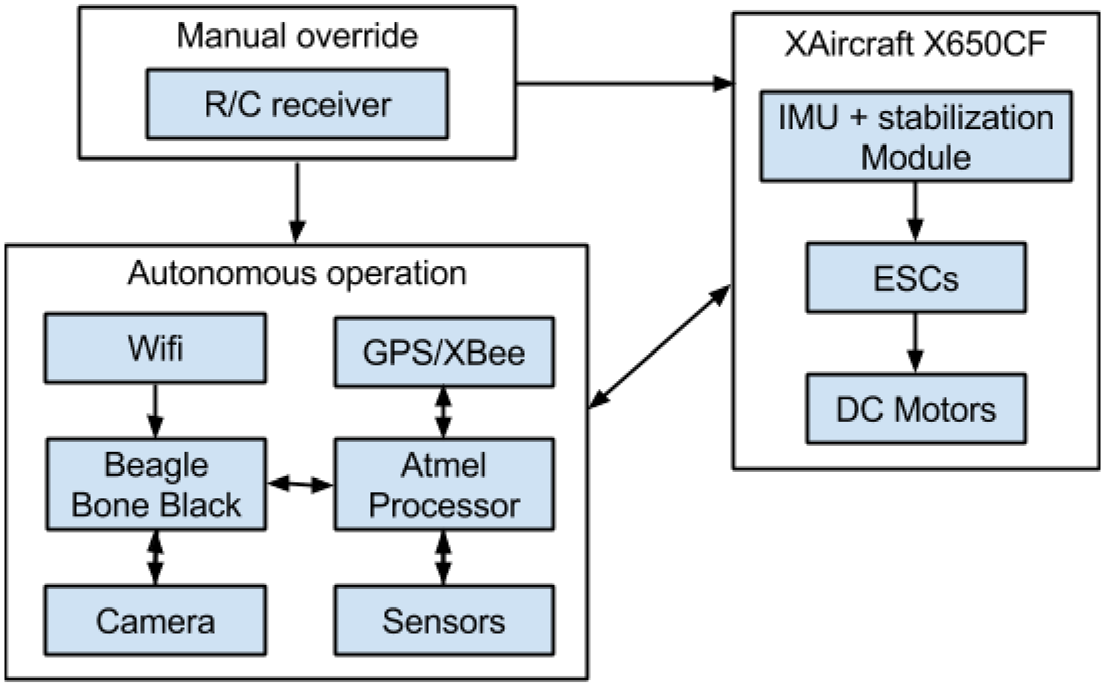

Figure 2: Block Diagram of Quadcopter System

Controllers

The control tasks will be divided between two microcontrollers: a BeagleBone Black (or equivalent) single board computer (SBC), and an Atmel-based (or equivalent) single board microcontroller (SBμC). The SBC will process images and perform computation for autonomous flight control. The SBμC will interface with the sensors and actuators, serving as a connection between the SBC and the quadcopter.

Manual override

For safety reasons, a human operator may take control of the quadcopter at any time. A switch from the radio controller (R/C) will cause the autonomous control system to immediately stop sending motion commands and relinquish all flight controls to the R/C.

Wifi connectivity

A wifi adapter will be used with the SBC. Constant wifi connectivity is expected as the quadcopter flies at low altitudes on Bradley's campus. This connection will allow the SBC to stream video and other data to a remote location. If wifi is not available all data will be stored on an secure digital card until the data can be upload to the web via wifi.

GPS
The human target will be tracked and followed using GPS information. The human will have a GPS beacon in his/her possession for this purpose. It will continually get its GPS location and use radio communication modules, such as XBee radio frequency modules (or equivalent), to transfer the data to the quadcopter. Both the beacon and the aircraft will have the radio modules, allowing for data transfer, and GPS receivers, allowing each to determine current location. The quadcopter's autonomous control system will use this information to update navigational commands to continue following the target at a safe distance. if GPS information is not available image processing will be used to follow the target.

Camera
Video and other data will be used to avoid obstacles in flight while following a human. The video feed will also be used to assist in tracking the target, especially indoors where the GPS signal will likely be weak. Additionally, the video feed can be streamed via wifi to a website. Computer vision techniques such as optical flow, pattern recognition, and others will be used to process the video data for these uses [3].

Gesture recognition
The tracked human will be able to use arm/hand gestures to trigger actions in the quadcopter. Such actions may include the start/stop of video recording, landing, adjust, following distance, and others. This adds a safety element to the system, allowing the nearby human to influence the quadcopter's behavior. This could be valuable if, for example, the human sees an impending collision that the quadcopter has not noticed. Gestures will be detected using image processing techniques.

Other sensors
Other sensors can be interfaced as needed during the project. These could include sensors not critical to flight but deemed useful in other applications, such as temperature or other environmental sensors.

Summary
This project will produce a unique flying robotic platform that follows a particular human at a safe distance. It will avoid obstacles and respond to the human's gesture-based commands. Video and other forms of data can be sent to a website via an onboard wifi connection. For safety, manual control (via a radio control transmitter) can be enabled at any time.

References

[1] "Home-XAircraft." *Home-XAircraft*. N.p., n.d. Web. 26 Sept. 2013.

<http://xaircraft.com/en/portal.php>.

[2] "X650." *XAircraft Wiki*. N.p., 27 Oct. 2011. Web. 26 Sept. 2013. <http://wiki.xaircraft.com/en-us/X650>.

[3] Karim, Achour, and Kahlouche Souhila. "Optical Flow based robot obstacle avoidance." *Advanced Robotic Systems International*. n. page. Web. 26 Sep. 2013. <http://cdn.intechopen.com/pdfs/4206/InTech-Optical_flow_based_robot_obstacle_avoidance.pdf>.