Autonomous Quadcopter with Human Tracking and Gesture Recognition

Project Proposal

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Project 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

Project Description

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 balance the aircraft during flight.

Figure 1: XAircraft X650 Carbon Fiber Edition.

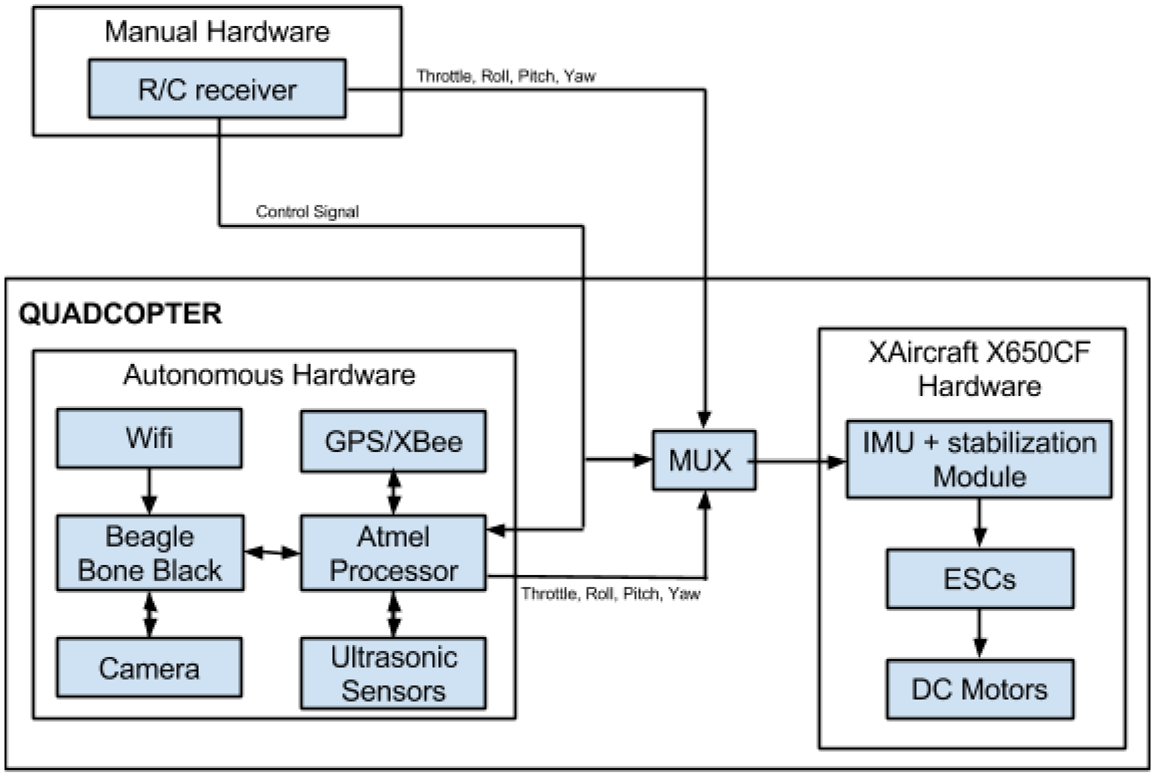


Figure 2: Block Diagram of Quadcopter System

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 a secure digital card until the data can be uploaded 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.

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. GPS will allow the quadcopter to place itself near the target, but the camera will allow for better tracking. 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.

Functional Requirements

Manual override

- There shall be a manual override, in the form of a standard R/C system, to switch from autonomous control to manual R/C control. The Turnigy Power System 9X 2.4G 9 Channel controller will be the initial platform and will be upgraded as needed.

Wifi connectivity

- A WiFi connection shall be established for the purpose of live video streaming or sending other data to a website (assuming constant connection on Bradley's campus.)
- If WiFi is not available data shall be stored on a SD card until WiFi is available

GPS

- GPS data shall be retrieved at a minimum rate of 1 Hz

- GPS data (latitude, longitude, altitude, etc.) for the quadcopter shall be gathered from a GPS unit on the quadcopter
- GPS data (latitude, longitude, altitude, etc.) for the human shall be gathered, from a GPS unit held by the human, and transmitted to the quadcopter via RF link
- GPS latitude and longitude coordinates received by the quadcopter shall be used to set waypoints for human tracking

Gesture recognition

- Using image processing, a camera shall recognize three different gestures given by the user for the following tasks:
    - Increase distance, by 1 meter unless the quadcopter is 10 meters away from the user, between the user and the quadcopter
    - Decrease distance, by 1 meter unless the quadcopter is 5 meters away from the user, between the user and the quadcopter
    - Land safely on the ground
- The gestures for these maneuvers shall be the right turn, left turn, and stop signals used by bicycle riders
- A camera image shall be processed by the beaglebone black at a minimum rate of 1 Hz
- Gesture recognition shall be done using OpenCV

Flight Specifications

- The aircraft shall maintain a minimum height of 3 meters from the ground unless landing
- The aircraft shall maintain a minimum distance of 5 meters from the user
- The aircraft shall carry no more than 850 grams
- The aircraft shall fly no faster than 2 meters per second in autonomous mode unless needed to avoid an obstacle

Object Avoidance

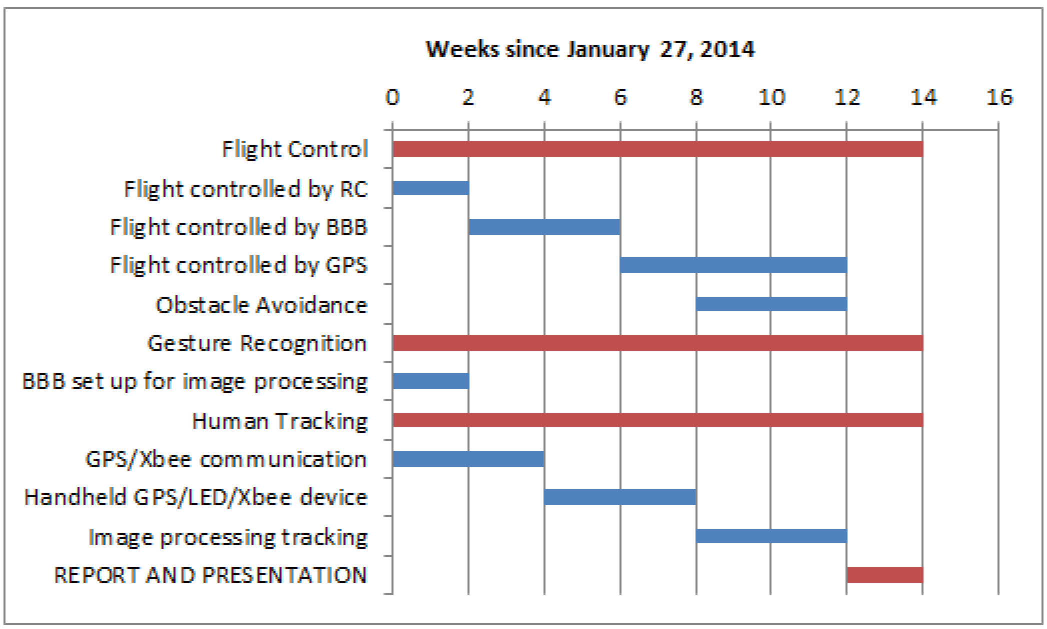
- Using ultrasonic sensors and image processing from the camera, the quadcopter shall avoid trees, buildings, people, and all other obstacles
- The ultrasonic sensors shall relay distance reading at a rate of 1 Hz at minimum
- Images from the camera shall be used to avoid obstacles using an optical flow algorithm

Other Requirements

- A BeagleBone Black (BBB) or a similar Linux-based single-board computer (SBC) shall be used
- Programs running on the BBB shall be written in C/C++ and Python
- An ATmega328P shall be used for sensor interfacing if deemed necessary by timing requirements or pin shortages on the BBB.
- Programs for the ATmega328P shall be written in C

Schedule

Task	Start	Duration
Flight Control	**0**	**14**
Flight controlled by RC	0	2
Flight controlled by BBB	2	4
Flight controlled by GPS	**6**	**6**
Obstacle Avoidance	**8**	**4**
Gesture Recognition	0	14
BBB set up for image processing	0	2
Human Tracking	**0**	**14**
GPS/Xbee communication	0	4
Handheld GPS/LED/Xbee device	4	4
Image processing tracking	8	4
REPORT AND PRESENTATION	**12**	**2**



Equipment List

<u>What we have:</u>

XAircraft Quadcopter
GPS
10 DOF IMU
Ultrasonic Sensors
R/C Controller

<u>What we need:</u>

BeagleBone Black Single-board Computer
XAircraft GPS
New Flight Controller
Camera
XBee

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>.