Mapping and exploration systems using a quadcopter

1 Problem domain

The goal of this project is to add increased autonomical functionality to a quadcopter. Due to the large degree of interest in drones (of which a quadcopter is a variety) it is a rapidly expanding field of study. Drone applications range from military use, anti poaching assistance, recreational use, as well as research. Due to their relatively low cost and small size, drones provide a platform that is easily accessible and highly useful as a research tool. Quadcopters currently rely on user input for all of their instructions on where to move to next. This project will add a level of autonomy to a quadcopter so that it can move about a room on its own accord as well as map a topographical view of the objects below it.

2 Objectives of research

This research aims to work on three main areas:

1. To get a quadcopter to move to precise locations when given pseudo commands from a user.
2. Perform route planning as well as executing searching algorithms that will allow for an area to be explored and mapped.
3. To allow for situational awareness so that barriers to movement can be detected and avoided.

This research will follow on from Oliver Boyers[5] work in 2013 with quadcopters and tracking objects and expand it so that a quadcopter is able to perform autonomous movements about a room.

3 Background of quadcopters

The Parrot AR Drone 2.0 has become one of the top quadcopters available on the market [3]. It is a mid-range drone costing R2 999.99 [2] and is available without requiring a license or prior expertise. The current version of the Parrot AR Drone has a forward and downward facing camera as well as an ultrasound ground sensor. There are three gyroscopic sensors on-board the drone that allow for directional movement sensing. All the data that the drone captures is processed by the Linux 2.6.32 real time operating system and fed back to the control device via WiFi [6].

The Parrot AR Drone has a Software Development Kit (SDK) that allows the user to send instructions to the Drone via the PCs WiFi adaptor. The SDK comes prepackaged with a collection of libraries that add functionality to the Drone without the user having to get into the mechanics of connecting to the Drone. [8]

A second SDK, that can be used to interface with robots, is the EZ Builder software. EZ Builder is an intuitive programming environment supporting C#, C++ and VB [4]. EZ Builder aims to make interfacing with robots and their peripheral devices, such as cameras, more streamlined. Using the OpenCV library in C# EZ Builder allows for the drone's outputs from cameras to be processed and the updated commands sent back to the drone.

4 Approach

This project will evolve through several steps so that the development of an autonomous drone builds on the previous steps in an iterative manner. The evolutionary steps that will be followed are:

1. The drone must move in all directions (up, down, right, left, forward and backward) following instructions laid out by the programmer.

2. The drone must move a certain distance in any direction. This will allow for a high level of control (move forward 2m, move up 1m, etc.).

3. Perform search patterns (such as grid searches) and choose the best route from point A to point B. This will require both route optimization as well as remembering an old path that has already been taken.

4. Allow for collision detection so that the quadcopter can fly from point A to point B, interpreting obstacles in the way and working out a new route around the obstacles. This will require the drone to be able to identify objects in its way using image processing techniques such as optical flow and object recognition [7].

5. By utilising the on-board sonar and cameras, build up a relief map of the area below the quadcopter. This will be added onto the search patterns. Multiple snapshots of the ground will be stitched together to form a single map.

After the above functionality has been added, the quadcopter will be able to move from point A to point B, perform a search of a room, map its surroundings, as well as move between rooms.

5 Requirements

The Parrot AR Drone does not allow for its on-board software to be changed. For this reason all processing on data retrieved from the drone's sensors will be processed on a controlling computer. The hardware required will therefore have to support the vaious software tools that will be used to process the data that is received from the drone.

5.1 Hardware

- Computer capable of running Windows 7 or higher
- WiFi dongle
- Parrot AR Drone 2.0

5.2 Software

- Windows 8.1
- Linux distribution (Ubuntu)
- AR Drone SDK
- EZ Builder
- OpenCV
- Visual studios with C#

6 Project Progression Time line

Date	Action
28 February 2014	Formal project proposal.
3 March 2014	Summary of AR Drone history, AR Drone SDK and EZ Robot.
20 March 2014	Read and summarise papers on similar topics.
25 March 2014	First draft literature review and plan of action.
30 March 2014	Final literature review and plan of action.
5 April 2014	Obtain and install all the required software and ensure that it is working correctly.
15 April 2014	Complete program to allow the user to control the AR Drone through a computer interface (Phase 1).
30 April 2014	Complete program to allow the user to control the AR Drone's specific movement (Phase 2).
5 May 2014	Test accuracy of the droness manouverability.
20 May 2014	Complete search grid program so the drone can perform flight patterns (Phase 3).
30 June 2014	Complete program to instruct the drone to perform collision detection (Phase 4).
30 July 2014	Beta test version of the relief mapping software for the drone (Phase 5).
10 August 2014	Test accuracy of mapping software in controlled environment.
20 August 2014	Integrate all software to map unknown rooms with obstacles.
30 August 2014	Complete testing on the drone' s ability to map an unknown environment.
15 September 2014	Complete short paper.
30 September 2014	First draft of project write up.
15 October 2014	Second draft of project write up.
30 October 2014	Final project write up submitted.
7 November 2014	Release project website.

References

[1] C. Bills, J. Chen, and A. Saxena. Autonomous mav flight in indoor environments using single image perspective cues. In *Robotics and Automation (ICRA), 2011 IEEE International Conference on*, pages 5776–5783, May 2011.

[2] Incredible Connection. Parrot ar drone 2.0. Online, February 2014.

[3] CRAIGI. 10 best quadcopters for 2013 holiday gift giving and 2014 use! Online, October 2013.

[4] EZ-Robot Inc. Ez robot. Online.

[5] Boyers OH. Ar drone: A conceptual view of target recognition and tracking. Bachelor of science (honours), Rhodes University, October 2013.

[6] PArrot SA. Technical specifications. Online, February 2014.

[7] Milan Sonka, Vaclav Hlavac, Roger Boyle, et al. *Image processing, analysis, and machine vision*, volume 3. Thomson Toronto, 2008.

[8] Pierre Eline Stephane Piskorski, Nicolas Brulez. *A.R.Drone Developer Guide*. Parrot, sdk 1.7 edition, May 2011.