Using a coloured-based tracking algorithm to avoid collisions with the Crazyflie Nano Quadcopter

Duco de Vries
Jeroen Rijnbout
Romy Visser

University of Amsterdam

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Supervisors: Toto van Inge, Elise Koster, Tim van Rossum,
Leo Dorst, Michael Cabot, Robrecht Jurriaans.

Abstract

A small quadcopter was tracked with a webcam by sticking yellow-coloured paper under the frame of the quadcopter. Tracking could be used to auto-stabilize the quadcopter on a certain position and avoid collisions in an environment where collisions could occur.

I. Introduction

Autonomous robots are used more and more often in various fields, such as search and rescue, but also in other sectors, such as the filming industry. Small flying robots can be very useful as they can be controlled by humans or made semi-autonomous or even fully autonomous. A flying robot that is tracked by a camera from the ground can be programmed in such way that it can stabilize and hover above one specific position. This can be useful when filming movies from positions which cannot be reached by a normal cameraman and which can be reached by helicopters. They can also be used in the weather forecasting industry in which they can be used to collect data from the sky or the ground by hanging in the air on a specific position or by flying around. The self-stabilizing prevents shaky movie images or corrupted data, because the robot was moved by the wind or because the controller of the robot is too sensitive to keep the robot in perfect place.

Flying robots are a lot cheaper than helicopters or heavy equipment to film in difficult places. This helps the people to do their job easier and also takes away a certain safety risk, since there are no longer people needed in difficult, high and dangerous positions or people in helicopters. On top of that, small flying robots are very manoeuvrable and lightweight, this makes them perfect for agile movements and filming indoors and can therefore make filming from an altitude or angle a lot easier.

There already has been done a lot of work in the field of tracking objects with cameras and there has also been quite some experiments done with autonomous flying robots. However, there have not been much experiments done with autonomous flying robots that are small and really lightweight. A lot of code used for tracking objects is already available on platforms such as OpenCV.

In this experiment a nano quadcopter, the Crazyflie, is used. The Crazyflie is quite small, so detecting him and tracking him is more difficult than it has been with bigger moving objects. If the computer is able to track it, this would mean that small objects too can be recognised instead of only large objects, such as the normal sized quadcopters. Usually only large objects are used in scientific research when used in tracking, so this is a twist to the usual research. The Crazyflie is also very new, it is not used yet very often, and so it is already of interest for scientific research to see what the Crazyflie can do and what it can be used for. If the Crazyflie has the same capabilities as a large quadcopter and had agility, the agility of the Crazyflie could increase the functionality of quadcopters.

The research question is whether a flying robot could hover autonomously in a predefined space by tracking the robot with a colour-based tracking algorithm. To get to this result there are a couple of subproblems that need to be satisfied in order to get the solution for the problem. The subproblems consist of flying the robot to a specific location, tracking the robot with a camera and making it stabilize itself.

It is possible to detect and track a flying robot based on its colour in comparison to the colours of the environment in which the robot is flying. The tracking can be done with a colour-based algorithm and the robot could be programmed in such way that it is able to stabilize itself while hovering in the same position.

To be able to track a small flying robot the Crazyflie Nano Quadcopter is used. A small adaption had to be made to make it visible for a camera, which in this case is a webcam, to make the robot stand out from its background. The Crazyflie is controlled with a Playstation 3 controller.

The prediction is that it will be possible to fly the robot to the wanted destination with the controller and that the webcam is capable of tracking the right object, which is the robot. The trickiest part will be to program the robot in such way that is stabilizes itself when hovering in one position.

II. Material and methods

Figure 1: The CrazyFlie Nano Quadcopter

The aim of this research was to get the Crazyflie Nano Quadcopter 10DOF to autonomously stabilize on a center point in a captured frame. The first step in realizing this was to recognize and track the Crazyflie using a webcam. The Crazyflie is a small (nano) quadcopter with no distinctive colors or features that would make it easy to recognize. Yellow paper was placed on the bottom of the Crazyflie so it would be recognizable by the webcam, which tracks objects through colours. The OpenCV object tracking software [openCV contributors, 2013] allowed for making adjustments in HSV (Hue, Saturation, Value) values to isolate the yellow color of the paper. Tracking was tested using a green background to ensure good contrast with the bottom of the Crazyflie.

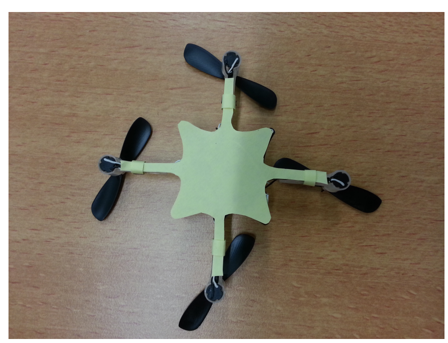

Figure 2: Yellow stickering on the downside

III. Results

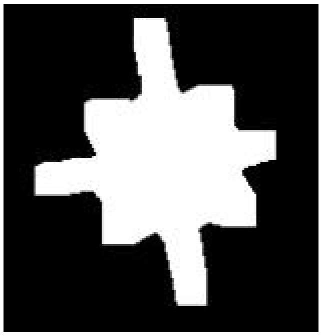

Figure 3: Thresholded image, OpenCV

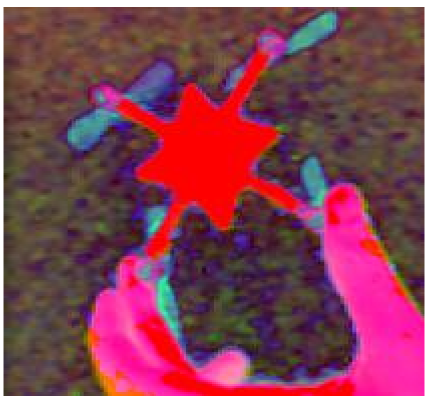

Figure 4: HSV adjusted image, OpenCV

Values used in OpenCV for the HSV image.

	INT	Default
H_MIN	0	0
H_MAX	49	256
S_MIN	0	0
S_MAX	49	256
V_MIN	158	0
V_MAX	256	256

Using the threshold image and the HSV image it was possible to consistently track the Crazyflie. Tracking results were best when the Crazyflie was tracked on a dark background due to the contrast with the tracking sticker. Because some surrounding objects may have the same color as the color used for tracking the Crazyflie additional tracking references could be implemented (e.g. the square shape of the tracking sticker). Due to time restraints it was not possible to fully implement auto-stabilizing for the Crazyflie. The next step in the process would have been to develop code that would register the distance from the Crazyflie to the desired hovering location and calculate the required adjustments needed to reach the optimum position. These adjustments could then be sent directly to the Crazyflie to adjust the hovering position.

Figure 5: Crazyflie recognized and tracked, OpenCV

IV. Conclusion

Using a coloured-based tracking algorithm to track a flying object with a camera to stabilize it in one position and to avoid collision with walls in a controlled environment is doable and succesful. Future research could focus on tweaking the tracking algorithm and the programming of the quadcopter itself [wiki.bitcraze.se contributors, 2013] so that the quadcopter can be controlled in a non-controlled environment.

It would be of interest to explore the possibilities of extending the Crazyflie with modules (for instance: a Global Positioning System or a temperature sensor) once the Crazyflie can fly on its own. These extensions could then be used to map certain variables in an environment, such ad temperature or air density.

V. Appendix

In this appendix all used hardware and software is described.

- Lenovo z580, OS Windows 7, 64-bits laptop.

- Crazyflie Nano Quadcopter 10 Degrees of Freedom manufactured by BitCraze, firmware flashed: cflie-2013.4. http://BitCraze.se/ [wiki.bitcraze.se contributors, 2013]
- CrazyRadio dongle, Windows 7 drivers.
- Crazyflie PC Client for Windows.
- Playstation 3 DualShock SixAxis Controller manufactured by Sony.
- MotionInJoy Gamepad Tool to use the PS3 controller with the Crazyflie PC Client. http://MotionInJoy.com/
- Microsoft Visual C++ 2010 Express.
- OpenCV (for computer vision) 2.4.5 for Windows. [openCV contributors, 2013]

VI. Acknowledgements

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We were the first group of students that worked with the Crazyflie so we had to figure everything out by ourselves, we would like to thank everyone in the RoboLab that tried helping us getting the Crazyflie to work.
Advice given by Robrecht Jurriaans and Sander Latour has also been a great help in choosing our research.

References

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