Visual Tracking and Control of a Quadrocopter

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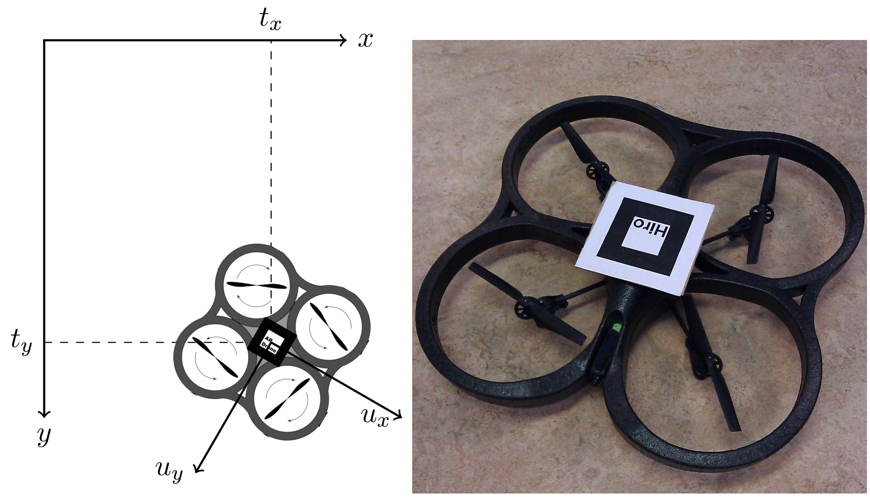

Figure 1: Left: The AR.Drone as viewed from the camera, Right: A photo of the Parrot AR.Drone equipped with a laser printed marker

A quadrocopter is a type of flying vehicle with four rotors positioned on the corners of a square, all directed upwards (see Figure 1). Since the past 5 years, they have become cheap enough for people to buy to use as toys. Still, they come in many different price ranges, from as low as 40 Euros for a small and simple model up toward 4000 Euros for an industrial grade version. Quadrocopters are often easy to control remotely by a human, mainly because a small computer chip on the quadrocopter itself takes care of stabilizing the vehicle. It has a kind of semi-autopilot which translates the directional commands a human gives it, into the motor speeds which are required to perform the maneuver. If a human were to try to control the 4 motors directly, it would be too difficult to keep it steady. The main reason a computer is better at controlling the quadrocopter, is because it has access to an array of sensors, such as accelerometers, which give the pitch and roll angle of the quadrocopter, ultrasound or air pressure sensors, which gives the altitude, and a magnetometer, which measures the yaw direction (rotation around the vertical axis). This information coupled with fast processing power (in the order of thousands calculations per second), enables it to quickly react and compensate for disturbances such as strong crosswind, while maintaining a roll and pitch angle specified by the human operator. In addition to pitch and roll, the operator can control its yaw angle, and thrust in the direction of the rotors.

In this thesis a consumer oriented quadrocopter called AR.Drone, produced by the French company Parrot[2], has been used. The goal was to investigate how a vision based feedback can improve the autonomous features of a quadrocopter. Two solutions were investigated, where the first consists of a setup with a camera mounted in the ceiling of a room.

Image analysis algorithms were used to identify the position and orientation of the quadrocopter in 3 dimensions. A black and white image was attached to the top of the quadrocopter to increase the robustness of the identification algorithm. The software library ARToolKit [1] was used to identify the black and white image representing the position and orientation of the quadrocopter. Position controllers were developed to control the most relevant degrees of freedom, namely, position in x, y and z and yaw rotation. A speed controller along a trajectory of points in x and y was also developed. Figure 2 shows the quadrocopter flying in a square shaped trajectory at constant velocity and Figure 3 shows the velocity in the x component.

The second solution took a rather different approach, it used the camera already present on the AR.Drone to identify a 6-axis industrial robot in its vicinity. A set of algorithms were developed which successfully identified different parts of the robot arm, for example the total area of the robot was interpreted as a relative reference of the distance to the robot. By the use of such algorithms, commands were generated to position the quadrocopter to point toward the industrial robot at all times, at a set distance from it, and orthogonally to the plane spanned by the robot's arms. The solution performed well and the setup was demonstrated at an open house event at the ABB department, *Strategic R&D for Oil, gas and Petrochemicals* in Oslo.

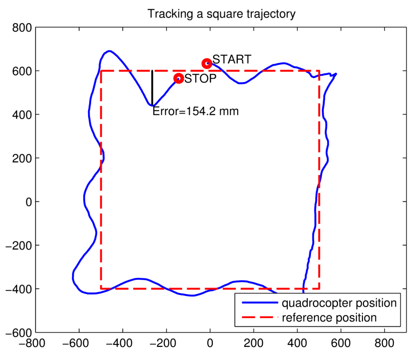

Figure 2: Position [mm] when tracking a square trajectory

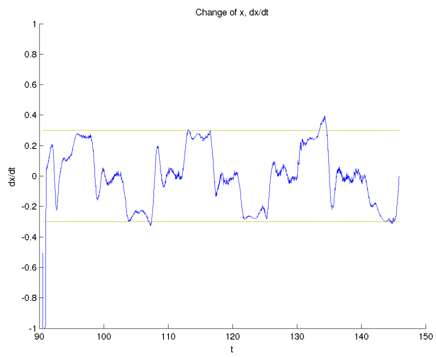

Figure 3: The measurement of $\dot{x}$ [mm/s] over time [s] when following a trajectory with the shape of a square

References

[1] ARToolKit:
`http://www.hitl.washington.edu/artoolkit/`
Date of visit: 2015-05-06

[2] Parrot:
`http://www.parrot.com/`
Date of visit: 2015-05-06