

Proposal for Master Thesis
Issam Al-Bittar (2462862)

Deployment and Recovery of Beacons with a Quadrocopter

The DFKI (Deutsches Forschungsinstitut für Künstliche Intelligenz GmbH) in Bremen aims to develop a flying system that can collect a beacon from one place and release it in another place. This system could be used in many mobile robot scenarios, such as search and rescue application, where the beacon could be placed by the flying robot first, then a mobile ground robot or a rescue man with mobile navigator can use these beacons.

The flying robot should be able to perform the subtasks:

- 1- Move to a previous-defined position (the first position of the beacon).
- 2- Catch the beacon.
- 3- Move to a previous defined destination and release the beacon.

The given task should be achieved in an urban environment, so the flying robot should be able to provide large area navigation source -such as GPS- as well as local area navigation sources such as inertial navigation and visual based navigation.

Small rotorcrafts vehicles will be very suitable robots for such task due to their interesting abilities in manoeuvring, hovering, and being able to be used in urban environment. In recent years many small rotorcrafts which provide many navigation sources and powerful data fusion units were invented. This thesis tries to use one of these rotorcrafts -which is a quadrocopter aircraft- to achieve the mentioned task.

The used Quadrocopter provides GPS and IMU navigation data (the IMU contains MEMS gyros, Pressure, temperature, and Magnetic field sensors). And as a result of its high payload capacity, different extra sensors – such as different cameras- can be hold. The used Quadrocopter provides also three levels of control, which are:

1. Low level: where the user commands are direct motors voltages.
2. Middle level: where the user commands are the desired angles (roll, pitch), the desired derivative of the yaw, and the desired thrust.
3. High level: where the user commands are the desired waypoints and the maximum velocity on the path.

The Quadrocopter uses two micro processors to apply the previous levels of control. It can also hold an Atom Processor Board for higher level algorithms.

Catching the beacon requires certain accuracy in position determining. Mostly, using GPS and IMU unit will not achieve this accuracy, so other navigation source

should be added. An added fixed camera with some visual servoing techniques will be used to define the relative position of the beacon regarding to the quadrocopter position.

Visual servoing techniques use the visual information derived by image processing algorithms in the control loop. In this thesis an “eye in hand feature based servoing” will be used, this type of servoing try to recognize a previous-defined pattern attached to the beacon, and estimate the error between the pattern position and the quadrocopter position.

Many efforts were made to find control architectures and models for quadrocopters. In this thesis a suitable model and control architecture should be chosen. One possibility would be using a separated cascade architecture, where the high control levels (provided by the used quadrocopter) can be used. Other possibilities will be using the low level of control with behaviour-based control models.

The bottle neck -when using visual servoing techniques- is to have a robust controller, several issues related to robustness should be discussed such as: Keeping features in the camera’s field of view, the effect of image noise on the behaviour of the control loop, and the effect of slight changing in the model’s parameters.

To achieve the given task, the following steps have to be performed:

- Define the used pattern and the pattern recognition algorithm, which ensures some dynamic properties with robustness (some previous work in DFKI could be used).
- Define the suitable visual servoing technique (image based visual servoing or position based visual servoing) .
- Define the used control architecture and model.
- Design the controller, which means to define the control laws that generate the desired angles and thrust commands when using control level (2), or determine the value of the motors’ voltages when using level (1).
- Develop or adopt and implement the image processing algorithms in a testing environment.
- Develop and implement the controllers using Matlab.
- Implement the previous algorithms into the atom processor -the processor that must be added to the quadrocopter- using c or c++.
- Build the total path (give the commands needed to go to the first position, move to visual servoing control to catch the beacon, then go to the last position and release the beacon).

Contents

1	Introduction	4
1.1	Task	4
1.2	Problem	4
1.3	Motivation	4
2	State of art	4
3	Hardware description	4
4	Theory	5
4.1	Visual Servoing	5
4.1.1	Coordinate Frames and projective geometry	5
4.1.2	Position based servoig	5
4.1.3	Image based servoing	5
4.1.4	Eye on hand , feature based servoing	5
4.1.4.1	feature detection	5
4.1.4.2	feature traking	5
4.2	Control architecture	6
4.2.1	Mathematical description	6
4.2.2	Separated Cascade architecture	7
4.2.3	Behavior-based control models	8
5	Implementation	9
5.1	Hardware implementation	9
5.2	Software implementation	9
5.2.1	Initial implementation	9
5.2.2	Implement and test the algorithms with Matlab	10
5.2.3	Implement the last algorithm with c/c++	10
6	Testing	10
6.1	Testing setup	10
6.1.1	preparatory work	10
6.1.1.1	quadrocopter calibration	10
6.1.1.2	camera calibration	10
6.1.2	send and receive data	10
6.2	Results	10
7	Conclusion	10