1. Описание на алгоритми, апаратна или програмна част
   1. Контролер

Lot of controllers have been already developed for quadrotor system. In this chapter I am going to mention some of them and provide short summary.

* 1. ПИД

(Bouabdallah et al. 2005) have used this controller to stabilize the attitude of the quadrotor around the hover position. The controller was designed using linearized model of the quadrotor in the hover trim point. The controller was developed using the nonlinear Simulink model and it was verified on the physical system. The resulting controller was able to stabilize the physical system within three seconds.The linearity of the controller constraints its use only around the hover trim point. Strong perturbation from this positions leads to loss of control. (Hoffmann et al. 2007) have used PID control for controlling attitude, altitude and position. Results were satisfactory, but the quadrotor has not performed any aggressive maneuvers and the disturbance rejection of the control system was not very good.

* 1. LQR control

(Castillo et al. 2005) have implemented this kind of controller. During simulation the controller has performed satisfactory. When strong perturbation was introduced the controller due to its linearity was not able to stabilize the system. On the physical model, this controller was not able to stabilize the system at all. (Bouabdallah et al. 2005) have implemented LQR controller using multiple trim points. Unfortunately they have not implemented the motor dynamics into the model. This lead to worse performance than their already mentioned PID controller.

The ArduCopter already includes this kind of autopilot, but it is a PI, Proportional-Integral, controller that stabilizes the angular rates and will therefore be changed to a controller based on the model of the system, considering its limitations.

The control loop of the tricopter can be seen as one inner and one outer loop, see Figure 2.4. The inner loop is a faster one and controls the rotational rates of the tricopter. The frequency of this loop is 50Hz, which gives a hard deadline of 20 ms the loop has to compute the input signal to the system. The outer loop is a slower one and this controls translational position, translational velocity and rotational angles of the tricopter. In this thesis, only the inner loop is considered.

Unfortunately it was not possible to implement more modern controllers such as the LQ optimal regulator or controllers synthesized using the H∞ minimization. This lead to pure proportional controllers' design. It was very interesting to see that even those very simple controllers are able to stabilize and even provide robust performance when a suitable architecture is chosen. The comparison between LQ and P regulator was carried out and evaluated. The LQR provides faster and smoother response but the difference is not dramatic. Then more advanced control algorithms can be implemented as well, such as already mentioned LQR and H∞ minimization or model predictive control (MPC) algorithm as a higher level control and planning platform. This algorithm can use the already developed inner loops as a low level control interface providing optimal control therefore lowering the power consumption and improving the performance.