Attitude and position control of a quadcopter in a networked distributed system

Group 733 - Alejandro Alonso García, Amalie V. Petersen, Andrea Victoria Tram Løvemærke, Niels Skov Vestergaard, Noelia Villarmarzo Arruñada

Department of Electronic Systems - Automation and Control

Email: [aalons16] [apet13] [alavem13] [nveste12] [nvilla16] @student.aau.dk

AALBORG UNIVERSITY DENMARK

Introduction

Quadcopters constitute a control challenge due to their inherent instability and coupled behavior. However, the interest for them has increased due to the multiple possibilities they offer. A linear control solution capable of stabilizing the quadcopter and controlling its position is presented by combining state space and classical control approaches. The presented results include the attitude control performance and simulations showing the behavior of the translational controllers.

System

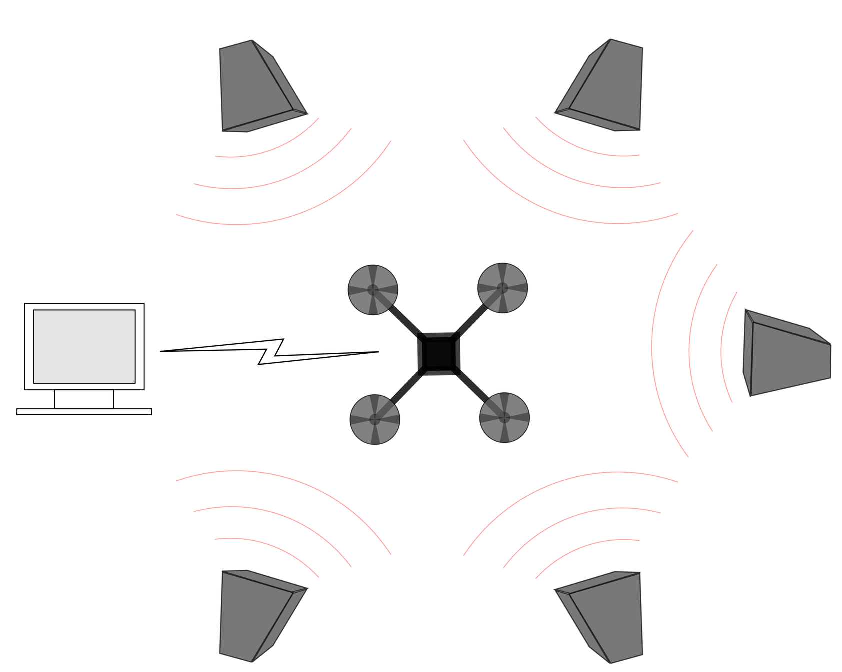

Fig. 1 : The distributed system is composed by a motion tracking system connected to a computer, the quadcopter and a radio link communication between them. The network is simulated using TrueTime during the design process to ensure stability.

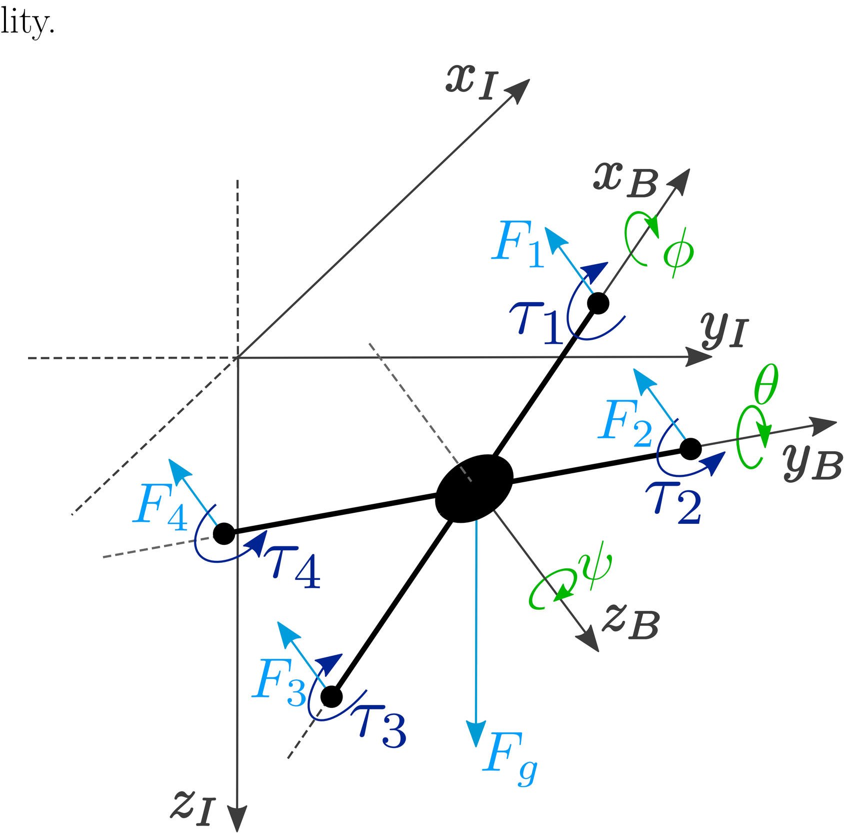

Fig. 2 : Free body diagram of the quadcopter along with the inertial and body frames used for modeling.

Control Solution

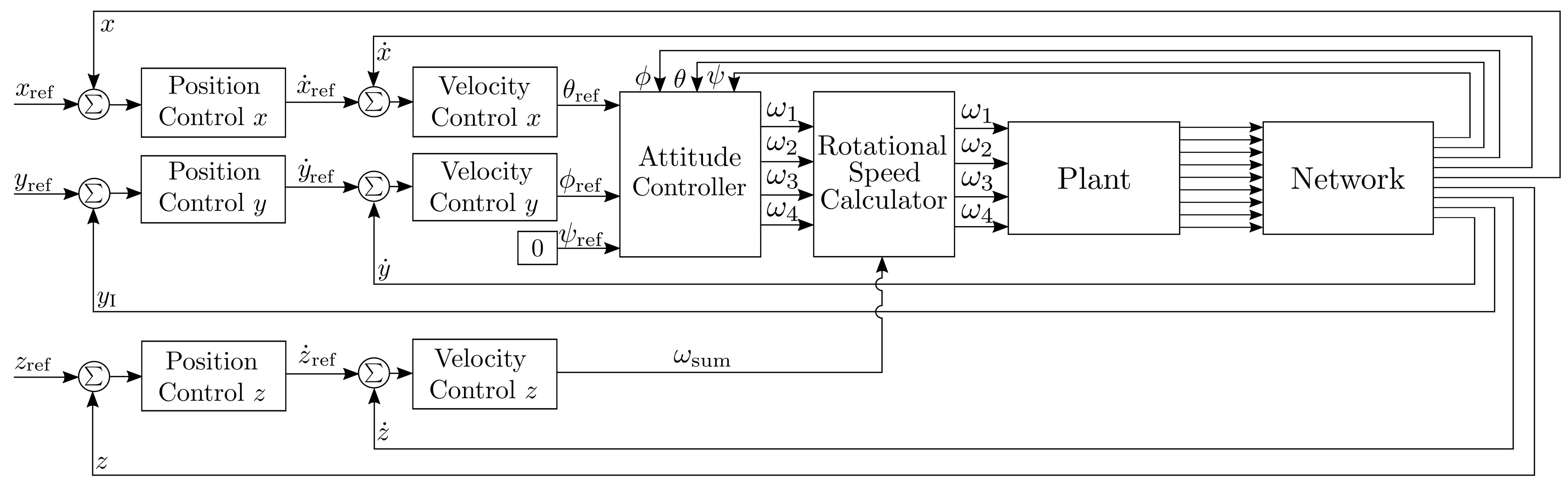

Fig. 3 : Diagram of the control solution.

Attitude controller

- State feedback with integral control using LQR is designed for tracking references and handling disturbances.
- A reduced order observer is used to estimate the angular velocities.

Translational controllers

- PI controllers are used to control the velocities in order to handle input disturbances.
- The outer loops are P controllers used to control the positions.
- The bandwidths of the cascaded controllers are taken into account to reduce the effect of the dynamics of the inner loops in the outer loops.

Results

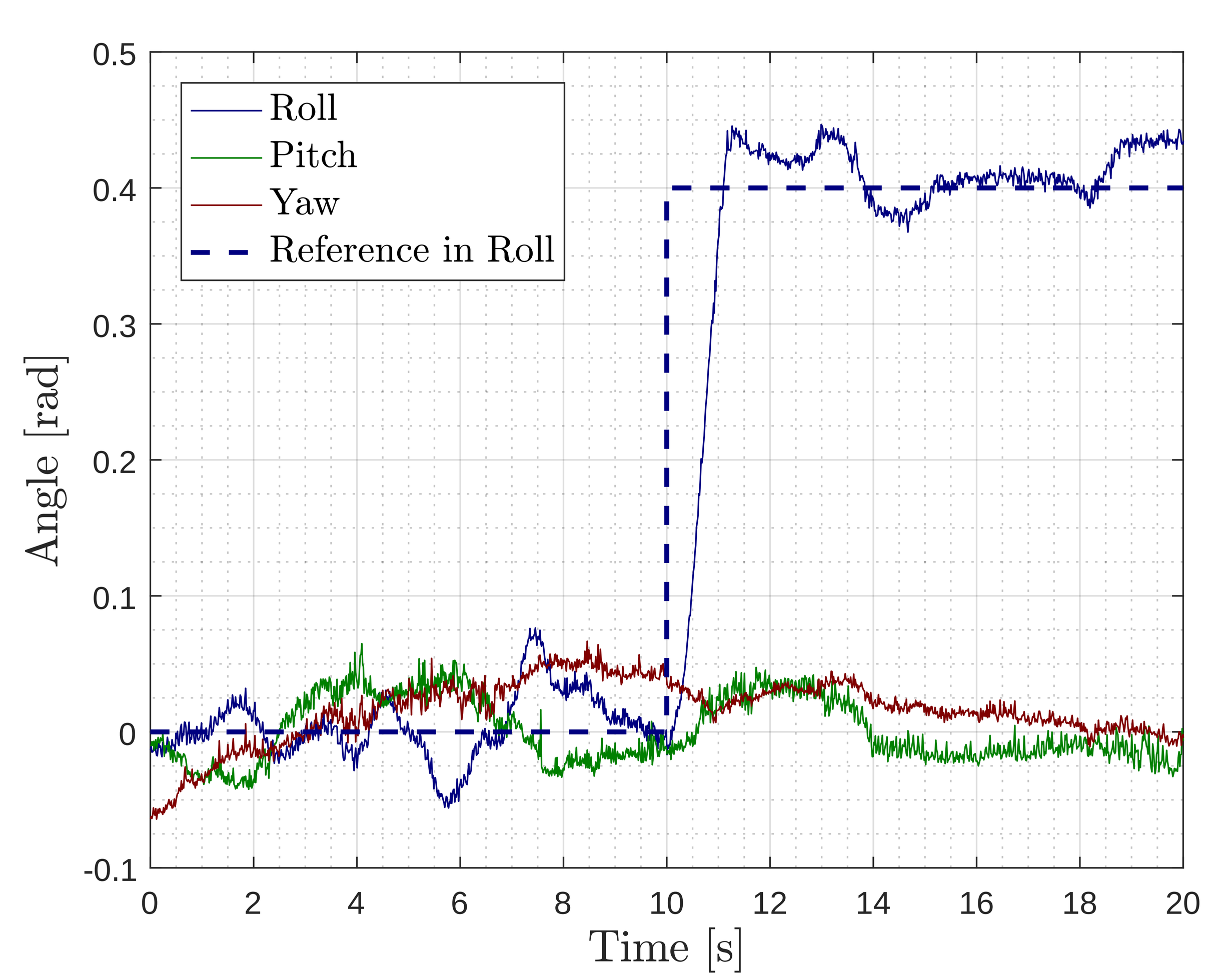

Fig. 4 : Attitude control on the quadcopter. The first part of the figure shows how the angles are stabilized, then, a reference in roll of 0.4 rad is given to the controller while the other angles remain at zero.

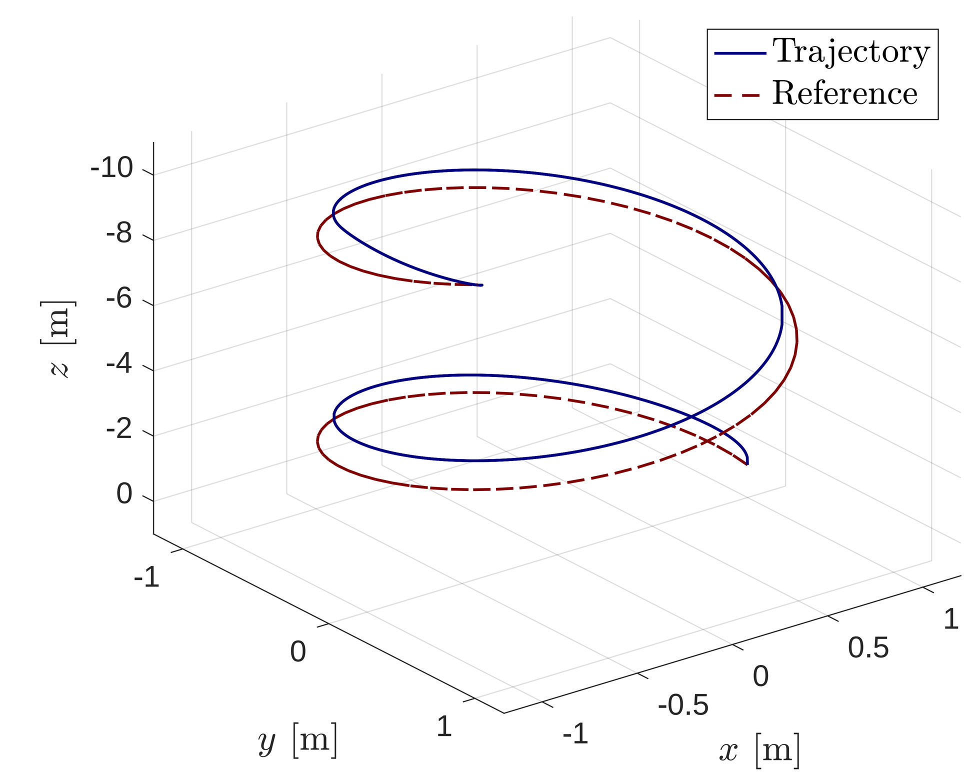

Fig. 5 : The translational controllers tracking a helical trajectory. The network is included in all simulations.

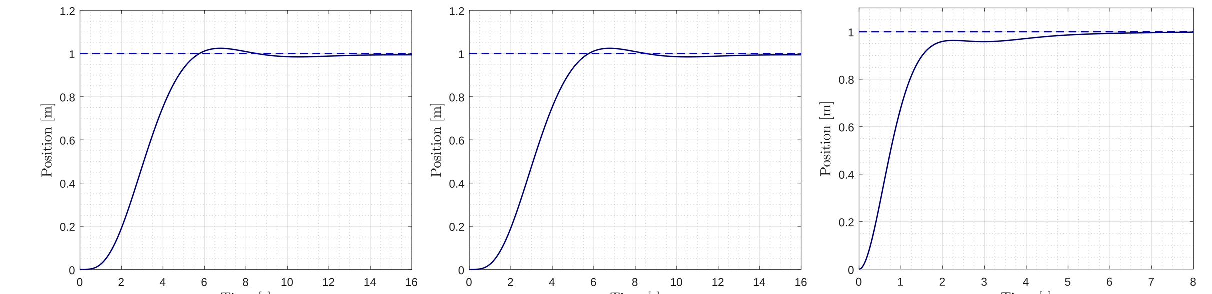

Fig. 6 : Step responses of the translational position controllers in simulation.

Discussion

The network delay and sampling rate affect the controllers' performance, however, they still achieve the given references in simulation. Experimental results could not be presented for the translational controllers, as it has not been possible to implement the translational controllers with success in due time. The design is however deemed reasonable, as simulations show that the design should work in reality. The attitude controller is implemented and achieves the given references successfully.

Conclusion

A model has been obtained by first principle modelling. A linear control system was designed to stabilize the quadcopter and control its position. The attitude controller has been designed as state space, and the translational control system is designed as classical control. Network effects are included in the control design. The results reveals that the attitude and the simulated translational quadcopter behavior have been successfully controlled.

References

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