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

School of Information and Communication Technology - Department of Control and Automation
Email: [aalons16] [apet13] [alavem13] [nveste12] [nvilla16] @student.aau.dk

AALBORG UNIVERSITY DENMARK

AALBORG UNIVERSITY DENMARK

Introduction

Quadcopters constitute a control challenge due to its unstable nature 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 control its position is presented by combining state space controllers and classical control. The presented results include the attitude control performance and a 3D simulation graph showing a trajectory followed by the quadcopter.

System

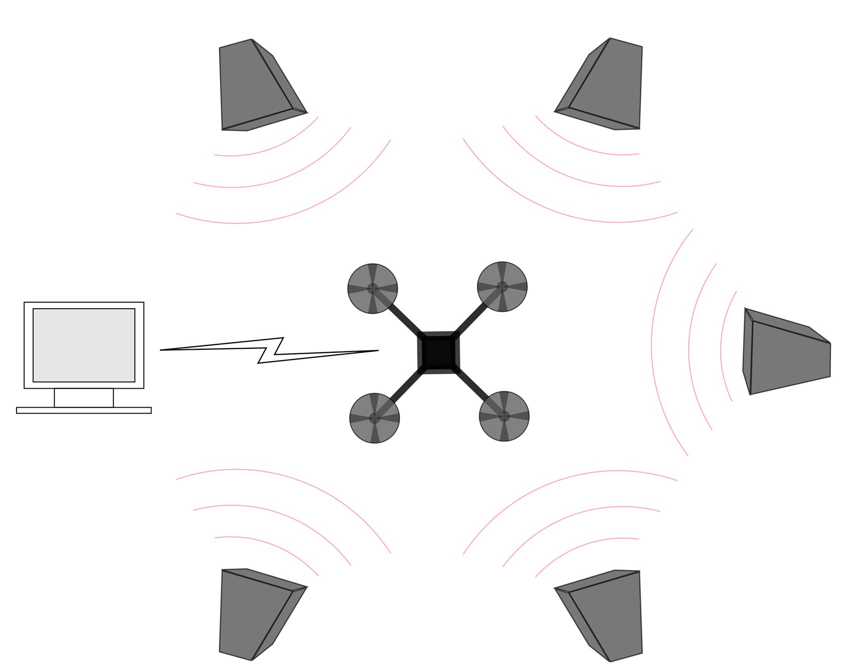

Fig. 1: The distributed system is composed by a motion tracking system connected to a computer, the quadcopter and a radio link communication between them. The network is simulated using TrueTime during the design process to ensure stability of the controllers.

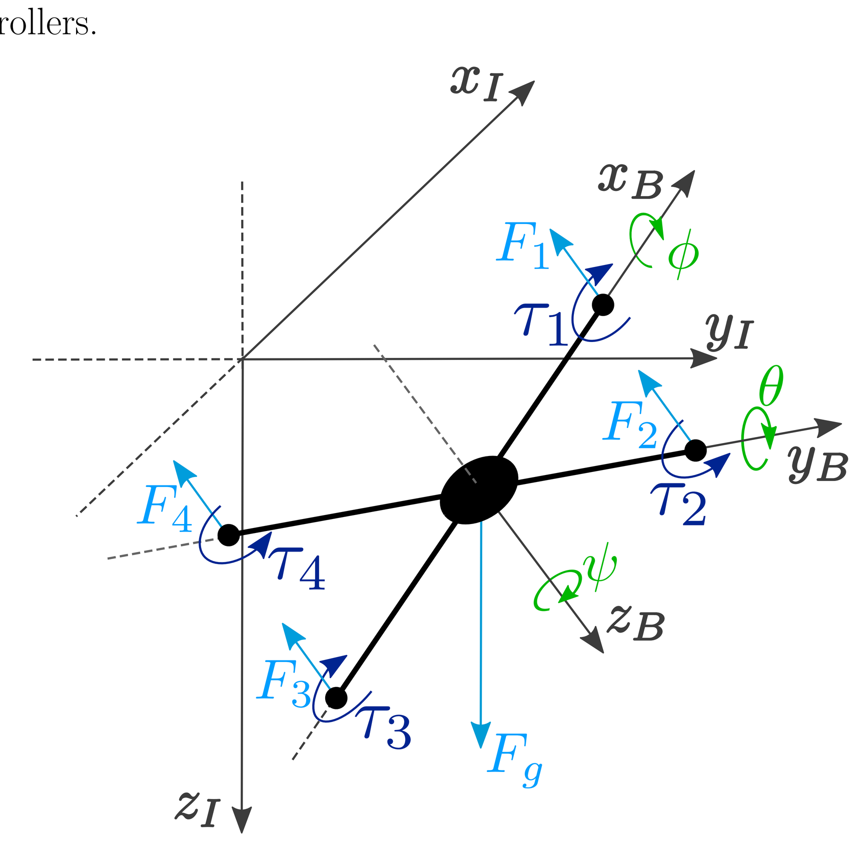

Fig. 2: Free body diagram of the quadcopter along with the inertial and body coordinate frames used for modeling.

Control Solution

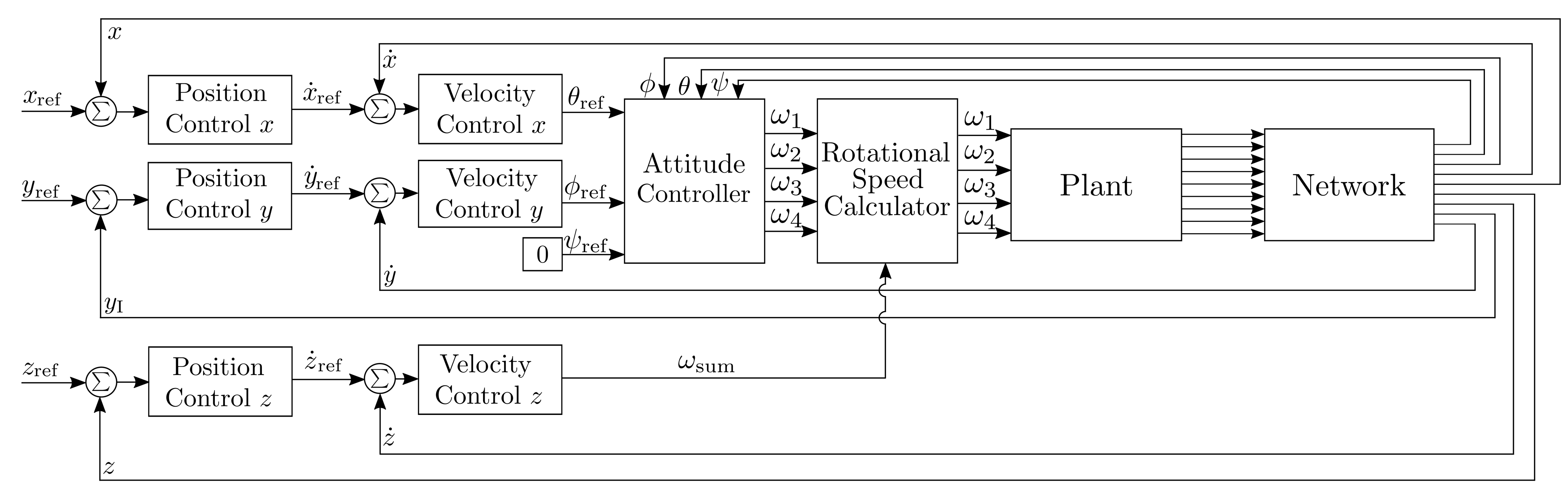

Fig. 3: Diagram of the control solution.

Attitude controller

- State feedback with integral control designed with LQR is used 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 translational velocities in order to handle input disturbances.
- The outer loops are P controllers used to control the translational positions.
- The bandwidth of the cascaded controllers are taken into account to reduce the effect of the dynamics of the inner loop in the outer loop.

Results

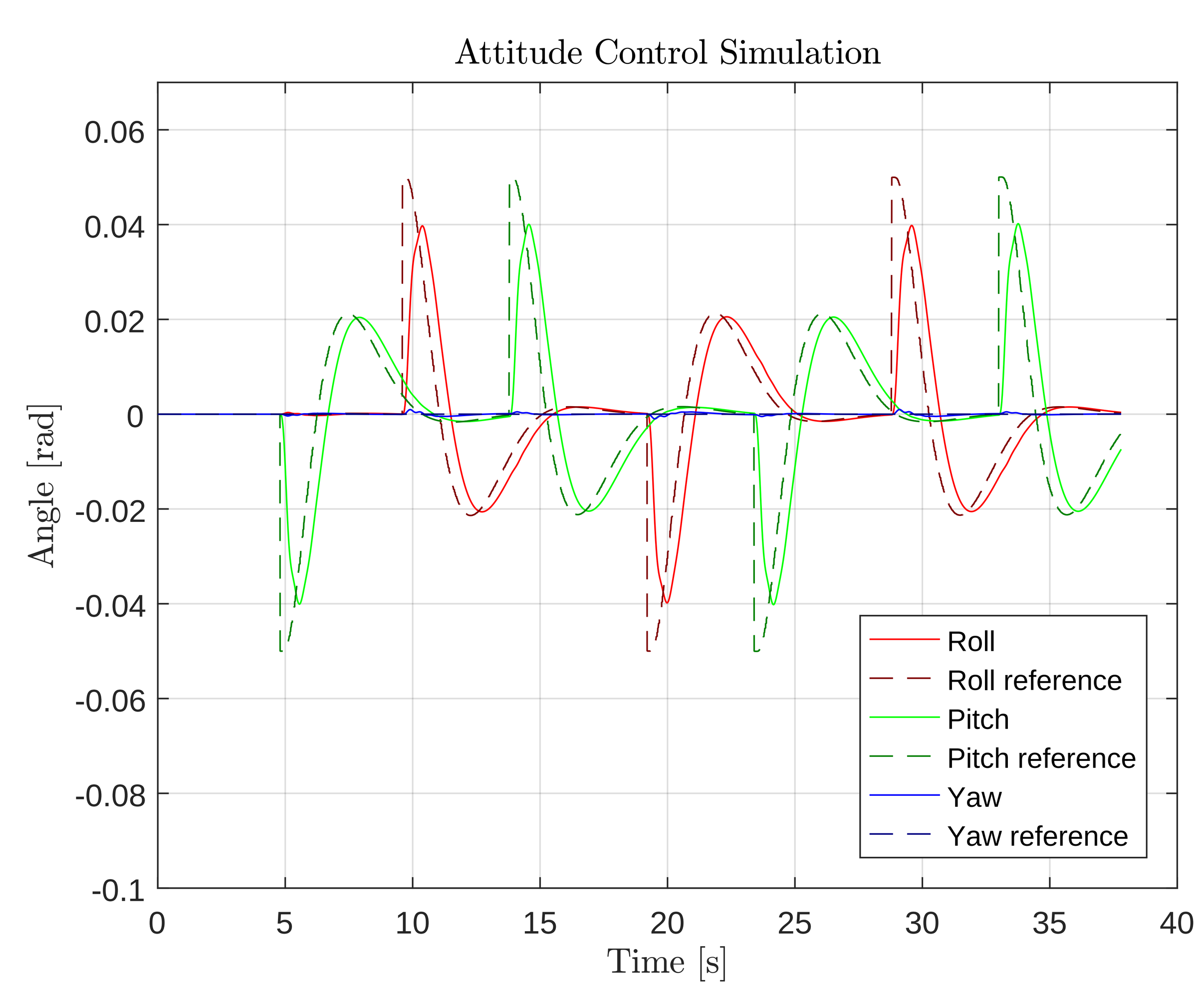

Fig. 4: Figure caption

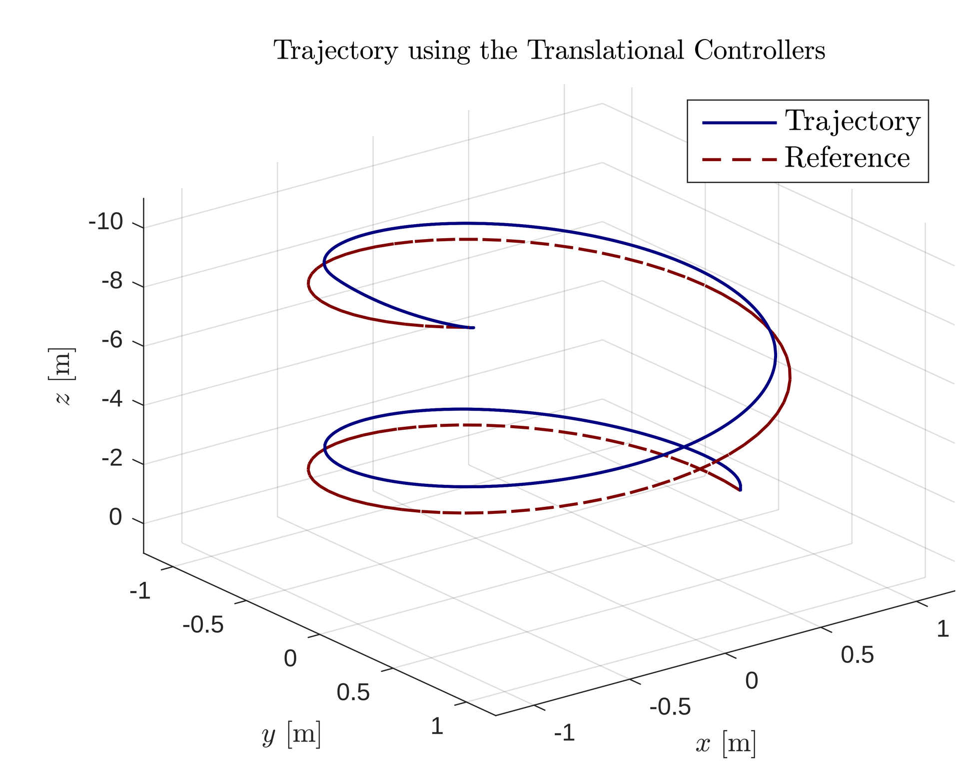

Fig. 5: The translational controllers tracking a helical trajectory. The network is included in all simulations.

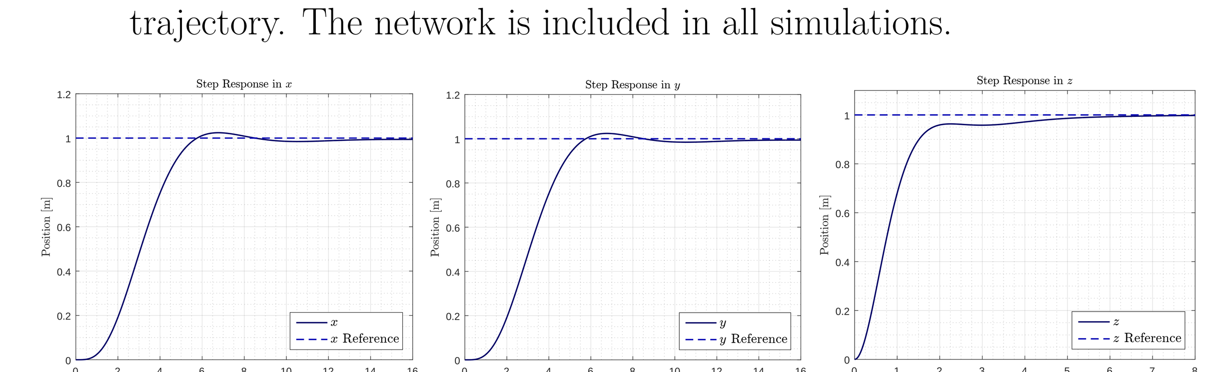

Fig. 6: Step responses of the translational position controllers in simulation.

Discussion

The results obtained in the simulations show both the attitude and position response of the quadcopter.
It is seen that the controllers achieve the desired reference even though the network delay and the sampling rate affect the performance. The main network effect is the designed bandwidth of the controllers. This occurs due to the limited frequency in which the sensor data is obtained from the motion tracking system through the wireless connection.

Conclusion

The control system has been split into an attitude and a translational controller. The former has been designed using a state space approach, including state feedback with integral control and a reduced order observer. The translational control system has been designed with a classical control approach and result in three cascade loops, including proportional and PI controllers.

References

[1] Abbas Emami-Naeini Gene F. Franklin J. David Powell. *Feedback Control of Dynamic Systems*. 7th Edition. Pearson, 2015.

[2] Dan Henriksson Anton Cervin et al. "How Does Control Timing Affect Performance? Analysis and Simulation of Timing Using Jitterbug and TrueTime". In: *IEEE Control Systems Magazine* (2003).

Acknowledgements

Henrik Shøiler, Associated Professor, Aalborg University.