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DENMARK

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



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Introduction

The quadcopter constitutes 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

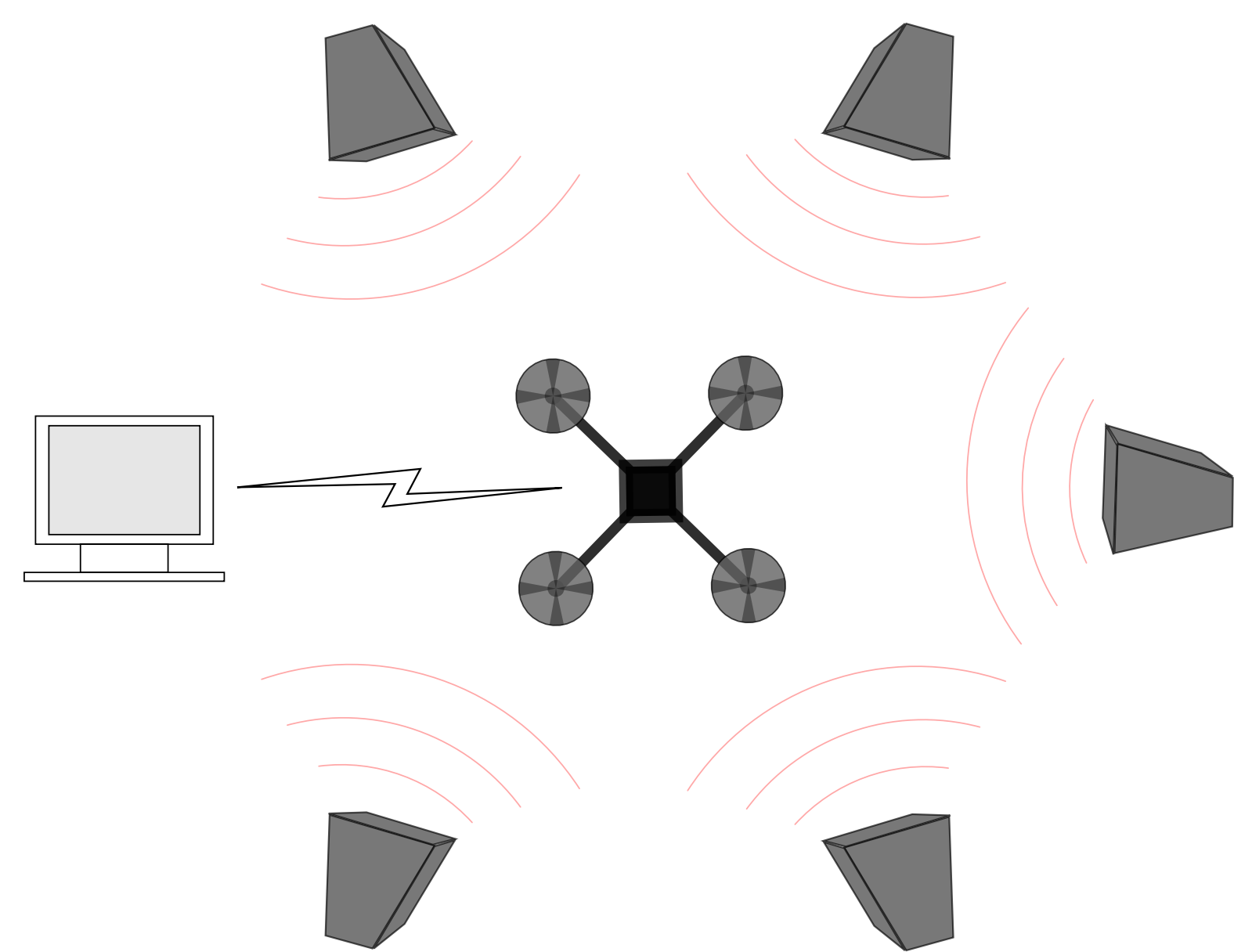


Figure: The distributed system using motion tracking and radio link communication.

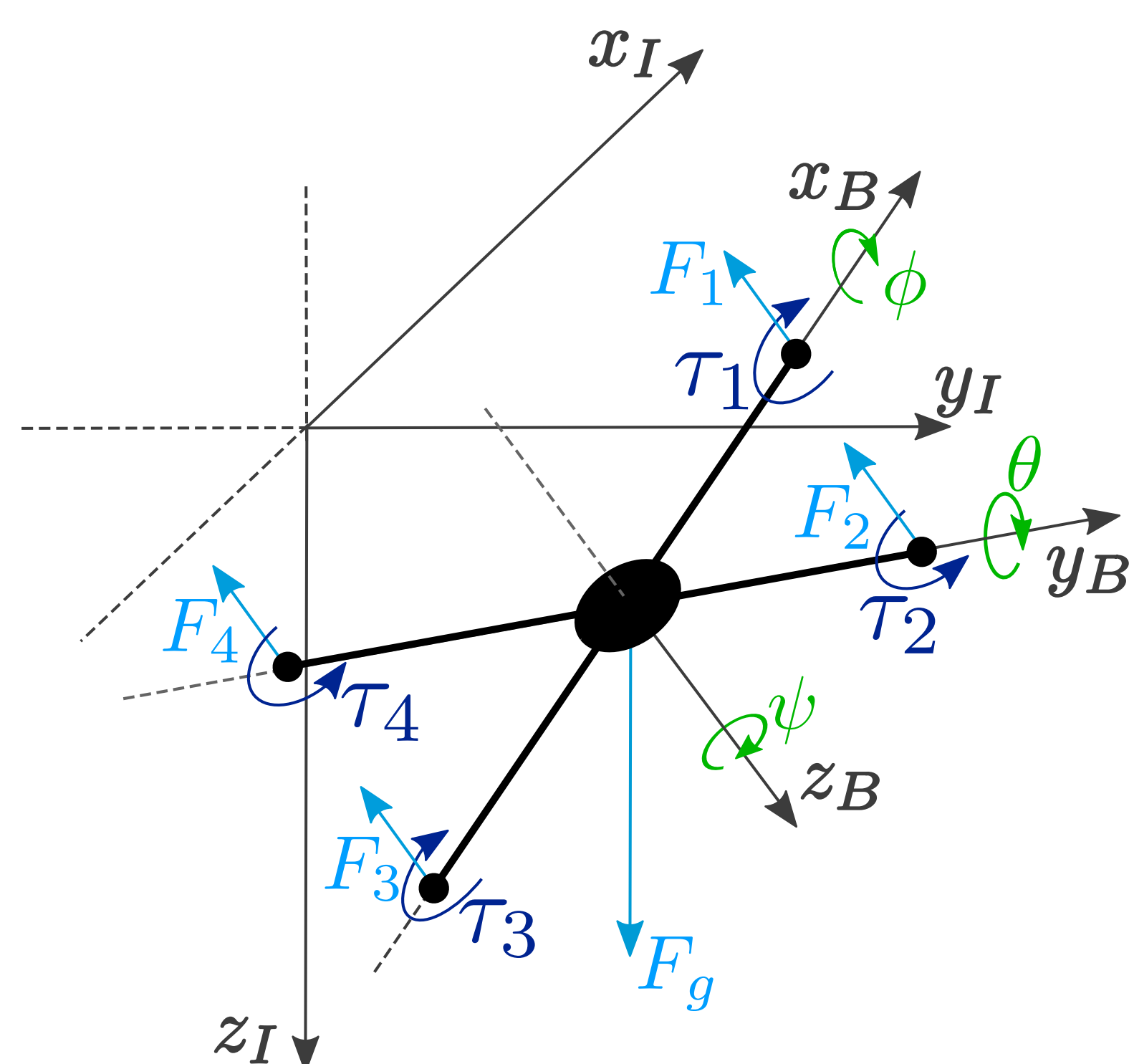


Figure: Free body diagram of the quadcopter along with the inertial and body coordinate systems.

Control Solution

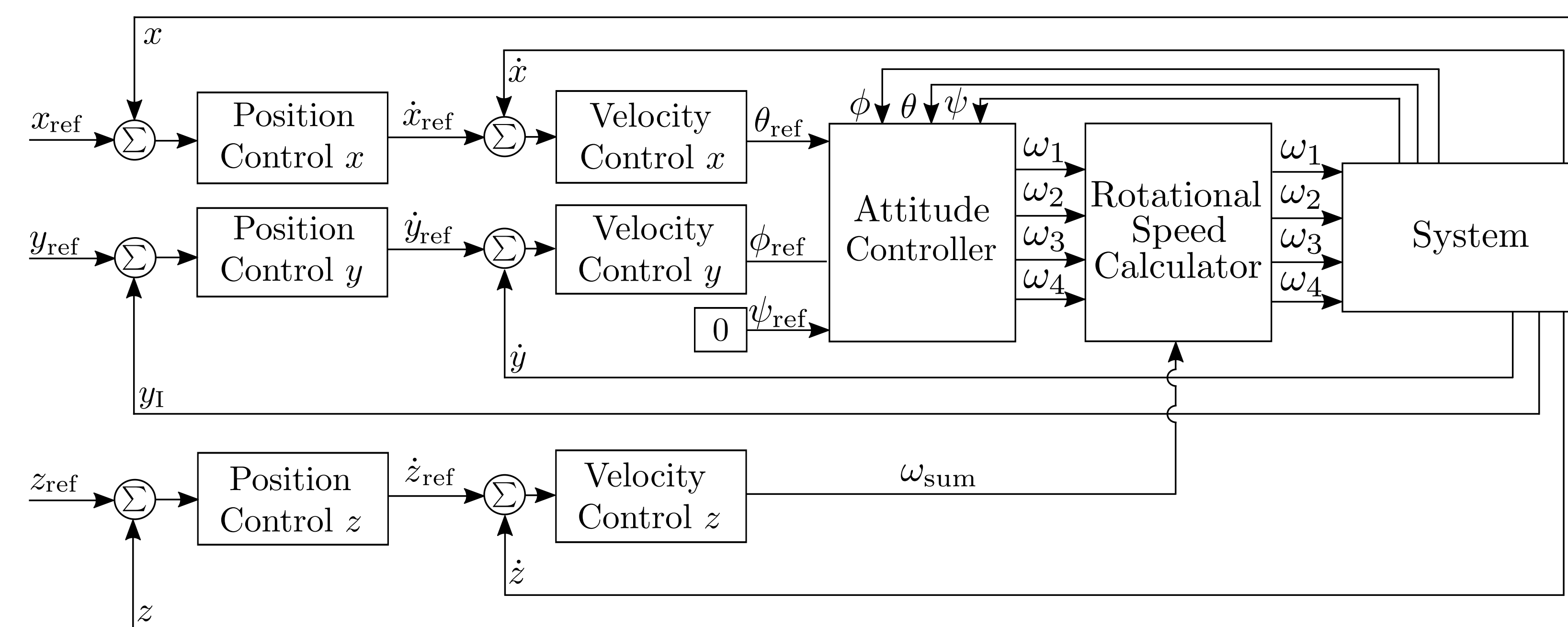


Figure: Figure caption

Attitude controller

- State feedback with integral controller 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
- The outer loops are P controllers used to control the translational position.
- The bandwidth of the cascaded controllers is taken into account to reduce the effect of the dynamics of the inner loop in the outer loop.

Results

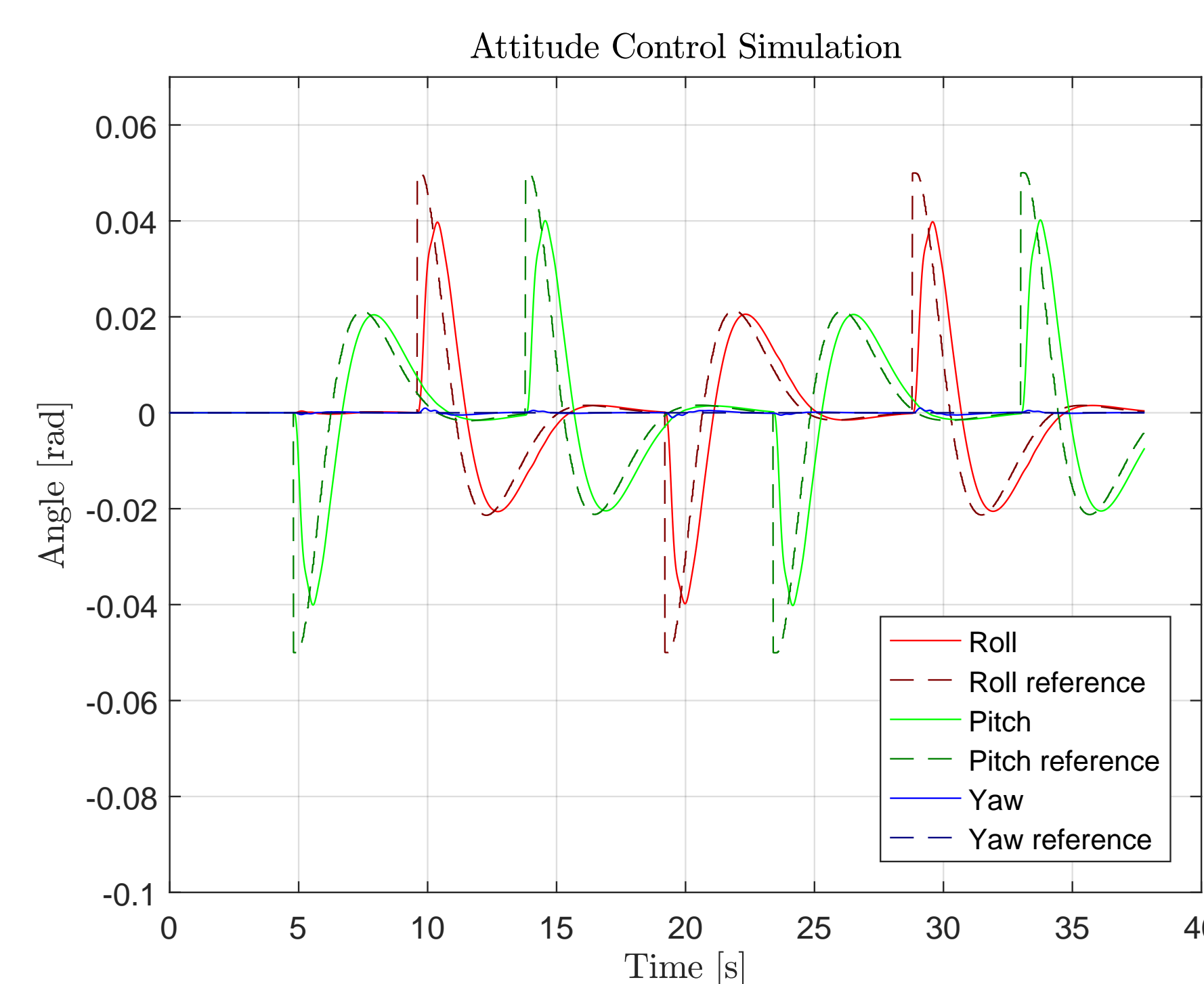


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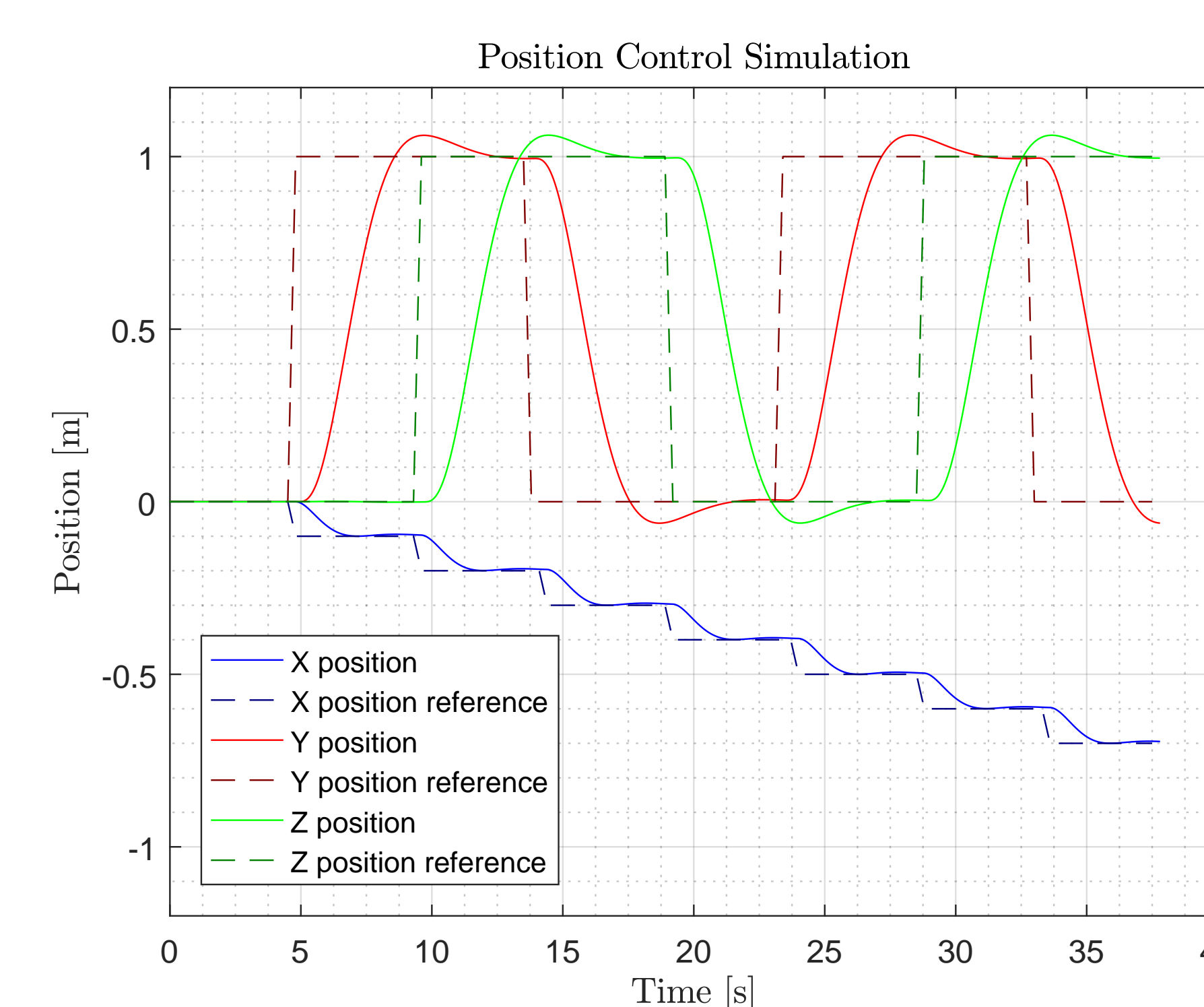


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Discussion

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.