Predicting the future: Predictive control for astronomical adaptive optics

Kooten M.A.M. van

Predicting the Future

Predictive Control for Astronomical Adaptive Optics

Maaike A. M. van Kooten

Front cover design was made from simulated phase screen of full atmospheric turbulence and a residual phase screen using predictive control. I enjoy watercolor painting as a hobby and used a watercolor effect to create the final cover design.

Predicting the Future

Predictive Control for Astronomical Adaptive Optics

Proefschrift

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van de Rector Magnificus prof. mr. C.J.J.M. Stolker;
volgens besluit van het College voor Promoties,
te verdedigen op 4 november 2020
klokke 16:15 uur

door

Maaike Anna Maria van Kooten

geboren te Richmond, Canada
in 1992

Promotiecommissie:

Promotor: Prof.dr.ir. N. Doelman
Copromotor: Dr.ir. M. Kenworthy

Overige leden:

Prof.dr. H. Rottgering	Leiden Universiteit
Prof.dr. C. Keller	Leiden Universiteit
Prof.dr. B. R. Brandl	Leiden Universiteit
Dr.ir. G. Witvoet	Technische Universiteit Eindhoven
Dr. S. Kendrew	European Space Agency

Keywords: adaptive optics, control, prediction, turbulence

ISBN 978-94-6361-467-2

An electronic copy of this thesis can be found at https://openaccess.leidenuniv.nl

To my husband for his limitless support and dedication.

"It's a dangerous business, going out your door. You step onto the road, and if you don't keep your feet, there's no knowing where you might be swept off to".

J.R.R. Tolkien,
The Fellowship of the Ring

Acknowledgements

> "For the Quest is achieved, and now all is over. I am glad you are here with me. Here at the end of all things"
>
> J.R.R. Tolkien, *The Return of the King*

At the end of a PhD I can now proudly declare that I am an independent researcher ready to head out into academia and make contributions to my field. Yet, I am most definitely not a self-standing researcher, but rely on my peers, colleagues, friends, and family to not only support me but to inspire me. Without the people around me, my work would not only be impossible, but also not as much fun.

Without my peers and colleagues—David, Steven, Emiel, Sebastiaan, Kelsey, Alex and so many more—this dissertation would not have been possible. I am thankful for all the support, knowledge, conversation, and laughter you have supplied. I have enjoyed our coffee times, group meetings, conference trips, and daily office life. I have learned so much from you all.

My supervisors, Niek and Matt, have both guided me in my research as well as my future career. Thank you for giving me the opportunity to work with you. Thank you for treating me as an equal while at the same time gently guiding me to successfully completing my PhD. I look forward to our future collaborations.

To my friends, thank you for constantly inspiring and supporting me. Doing life together, sharing our successes and failures, laughing together, and learning from each other. Thank you all for welcoming me into your lives and becoming a great support system in the Netherlands.

To my family, thank you for putting up with a stressed-out bachelor student that often put her school work ahead of her family. To my younger sister Emma, thanks for putting up with me. Mom and Dad, thank you for always believing in and encouraging me to go for it. Mom, thank you for trying to teach me work-life balance! Dad, you are an inspiration. Now I can truly appreciate all the hard work you put in as a professor growing up and be in awe of your publication record.

Last but definitely not the least, thank you to my husband who has been my most constant support and advisor. Jon thank you for all the in depth discussion and debates. I am so grateful I can discuss and share my work with you. We are here together at the end of our PhDs. "I am glad you are here with me. Here at the end of all things, [Jon]"

Contents