PhD defense

by

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Defense title:

"Power Line Perception on Aerial Robots for Autonomous Cable Landing and Recharging"

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POPULAR SCIENTIFIC ABSTRACT

Nicolaj Haarhøj Malle

Power Line Perception on Aerial Robots for Autonomous Cable Landing and Recharging

This Ph.D. study investigates the hardware and software required for multirotor aerial robots, also known as drones, to autonomously navigate near high-voltage overhead power lines and land on them for recharging. The aim is to develop an aerial robot with the ability to perceive individual power line cables in its surroundings and use this perception system to guide the robot safely to a target cable on which it can land and recharge its batteries. Augmenting aerial robots with the ability to self-recharge from the worldwide energy transmission grid has the potential to significantly increase the number of viable use cases for aerial robots. One use-case, which is being explored in the Drones4Safety project, is the use of autonomous, self-recharging aerial robots to continuously inspect and monitor critical infrastructure such as railways, bridges, and power lines. With no need for humans to pilot them or change their batteries, such aerial robots would be able to significantly increase the frequency and simplicity of inspections. This would help ensure safe operation of the infrastructure as well as timely maintenance.

In order to autonomously navigate environments near power lines and perform complex tasks such as landing on the cables for recharging, the aerial robot must be able to perceive its surroundings. To determine which sensor technologies would be best suited for such power line perception systems, we survey and subsequently evaluate suitable devices on the market. The results of the evaluation show that the capabilities of frequency-modulated continuous wave mmWave radar match the requirements for lightweight and robust power line detection from an aerial robot. Such devices are small, cheap, and solid-state and are able to detect power line cables at distances beyond 30 meters. With this sensor, we develop a lightweight power line perception system and integrate it onto an aerial robot using PX4 for onboard flight control and ROS2 as the robotics middleware. This prototype system demonstrates reliable pose estimation of individual overhead power lines based on which we show autonomous power line aware flight maneuvers in an outdoor power line test facility. To allow the aerial robot to search for and identify suitable landing locations, we develop functionality to autonomously follow and reconstruct grid infrastructure. The functionality of this system is successfully tested with multiple types of structures, including distribution power lines and light rail transit infrastructure. Finally, we build one last aerial robot prototype based on the outcomes from the previous systems with which we demonstrate the maneuvers required to recharge from DC power lines, specifically performing a double power line landing to connect high and low voltage through a charging circuit. Ongoing and future research efforts are dedicated to refining the self-recharging concept to bring the technology to the broadest possible array of robots.