Towards Vision-Based Autonomous Cross-Country Soaring for UAVs

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devant le jury composé de :

M. Yann LE GORREC	Professeur des Universités ENS2M	Examinateur
Mme Isabelle FANTONI	Directeur de recherche Heudiasyc UTC	Rapporteur
M. Robert LUCKNER	Professeur Université Technique de Berlin	Rapporteur
Mme Caroline PONZONI CARVALHO CHANEL	Ingénieur-Chercheur ISAE	Examinateur
M. Carsten DÖLL	Ingénieur de Recherche ONERA	Co-directeur de thèse
Mme Yoko WATANABE	Ingénieur de Recherche ONERA	Co-directeur de thèse

Abstract

Small fixed-wing Unmanned Aerial Vehicles (UAVs) provide utility to research, military, and industrial sectors at comparably reasonable cost, but still suffer from both limited operational ranges and payload capacities. Thermal soaring flight for UAVs offers a significant potential to reduce the energy consumption. However, without remote sensing of updrafts, a glider UAV can only benefit from an updraft when encountering it by chance. In this thesis, a new framework for autonomous cross-country soaring is elaborated, enabling a glider UAV to visually localize sub-cumulus thermal updrafts and to efficiently harvest energy from them.
Relying on the Unscented Kalman Filter, a monocular vision-based method is established, for remotely estimating sub-cumulus updraft parameters. Its capability of providing convergent and consistent state estimates has been assessed by Monte Carlo Simulations. Model uncertainties, image processing noise, and poor observer trajectories can degrade the estimated updraft parameters. Therefore, a second focus of this thesis is the design of a robust probabilistic path planner for map-based autonomous cross-country soaring. The proposed path planner balances between the flight time and the outlanding risk by taking into account the estimation uncertainties in the decision making process. It is shown that the computational load of the suggested path planner is implementable on a low-cost computer platform. The suggested updraft estimation and path planning algorithms are jointly assessed in a 6 Degrees Of Freedom flight simulator, highlighting significant performance improvements with respect to state of the art approaches in autonomous cross-country soaring.

Keywords : Unmanned Aerial Vehicle, vision-based autonomous cross-country soaring, sub-cumulus updraft, estimation, Unscented Kalman Filter, robust and probabilistic path planner