Research visit report - Mobilita 200

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From October 8 to December 8 I was visiting the Robotics and Interactions laboratory led by Antonio Franchi of the Laboratory for Analysis and Architecture of Systems (LAAS) in Toulouse, France. The goals of my stay were as follows. First, to model the output of my innovative mutual localization system for unmanned aerial vehicles (UAVs) called UVDAR that I have developed in my previous cooperation with the target institution. This model is intended to be used with a high-level onboard tracking system. Second, to develop a theoretical basis for formation flying with and formation reconstruction thereof, based on mutual relative pose measurements interpreted through the output of the developed output model. Third, to publish the results of this research, as well as to further cooperate on developing a publication of earlier joint research in an impacted journal.

The institution provided me with their advanced knowledge on measurement modeling, that allowed me to design a suitably accurate, yet computationally light and practically applicable model of the UVDAR measurement. This model is based on the Unscented transform (UT) that accounts well for the highly non-linear transformation from the object space into the image space, that takes place with this sensor. This filter, in our case, is used in the reverse direction compared to what would typically be the case in a standard Unscented Kalman filter. On the second front, I leveraged the highly specialized knowledge of de-centralized formation flight algorithms that the institution has accumulated over extensive previous research into the subject. I have extended their rigidity-based control into the measurement space of the UVDAR, comprised uniquely of the relative position combined with relative yaw, to exploit to the full extent the strengths of the system, as well as the fact that a relative pose formation, as opposed to a bearing-based or distance-based formation, is always rigid, as long as it represents a connected graph of mutual measurements. This yielded a formation that can theoretically be controlled by moving freely a single UAV within it. Based on the results of simulating this formation flight control scheme, I have additionally endeavored to improve the robustness of the control to measurement errors of a real sensor such as the UVDAR, since the previous research on such control schemes almost exclusively considered a non-realistic perfect measurements. To do this, I have used the output model mentioned above, and assigned to the control action derived from the measurements weights, such that the formation converges to the desired shape smoothly and without oscillations, which was so far validated in sumulation. This research is currently being prepared for publication.

Additionally, close and on-the-spot cooperation with Antonio Franchi, who is my co-author, made it possible for us to prepare and submit a journal paper documenting my previous research and experiments, that has been recently accepted to the prestigious IEEE Robotics and Automation Letters (RA-L) journal, with additional option to present it in the International Conference on Robotics and Automation (ICRA) later this year.