Le 7 décembre 2022
GT-UAV, Véhicules Aériens

LS2N (Centrale Nantes)

Le GT UAV du GDR Robotique propose, en collaboration avec le GDR MACS (outils MACS appliqués aux drones aériens), une journée de séminaire le 7 décembre 2022 au LS2N à Nantes. Elle aura lieu dans l'amphi S qui se situe dans le bâtiment S.
Cette journée sera composée de onze présentations scientifiques (15mn de présentation puis 5 minutes de questions) ainsi qu'une visite de l'arène de vol du LS2N avec une séance de démonstrations.
Le programme prévisionnel de la journée sera le suivant (voir page suivante pour le programme détaillé):

9h25 : introduction rapide de la journée par les animateurs du GT-UAV

9h30 : Target aerial search and recognition: a cooperative navigation strategy between air and ground vehicles,
Mathilde THEUNISSEN, LS2N

9h50 : Decentralized control and estimation of a flying parallel robot interacting with the environment,
Shiyu LIU, LS2N

10h10 : Gathering spatially and temporally spreading data with aerial robots,
Hai-Nguyen NGUYEN, LAAS

10h30 : Controller and Trajectory Optimization for a Quadrotor UAV with Parametric Uncertainty,
Ali SROUR, IRISA/INRIA Rennes, RAINBOW

10h50 à 11h00 : pause

11h00 : Open Libraries and Interface for Vehicles Experimentation,
Antonio MARINO, IRISA/INRIA Rennes, RAINBOW

11h20 : Decentralized Connectivity Maintenance for Quadrotor UAVs with Limited Field of View,
Maxime BERNARD, IRISA/INRIA Rennes, RAINBOW

11h40 : Control Approaches for a Tethered Drone In an AWE Application,
Zakeye AZAKI, GIPSA-LAB

12h00 à 14h00 : Pause repas

14h00 : Vol automatique d'un oiseau mécanique à ailes battantes guidé par un champ de vecteur,
Abdoullah NDOYE, ISM

14h20 : Event-Based Sliding-Mode Control for VTOL Rotorcrafts Multi-Agent Systems,
Jonatan ALVAREZ, IPSA

14h40 : Exploration et cartographie basé flux optique par drone hexarotor,
Xavier DAINI, ISM

15h00 : Active Cooperative Localization of Multi-Drone Systems using Distributed Optimization,
Nicola De CARLI, IRISA/INRIA Rennes, RAINBOW

15h20 : visite de l'arène de vol et démonstrations.

17h00 : fin de la journée

Programme détaillé

Mathilde THEUNISSEN

Title: Target aerial search and recognition: a cooperative navigation strategy between air and ground vehicles

Abstract: I will present a cooperative navigation architecture to make an aerial vehicle manages a group of independent ground vehicles performing a target search and recognition mission. Firstly, to detect targets, the aerial drone tracks a trajectory that is conceived to cover all the surface to scan. Meanwhile, using the camera below the drone, a vision algorithm, developed to consider aerial images characteristics, searches for targets, and estimates their position. After the aerial drone has covered the entire area and found the targets, the navigation strategy assigns to each ground vehicle the closest target for ground monitoring. Each ground vehicle autonomously navigates to the nearest target avoiding obstacles, while the aerial drone follows the mission using the dynamic center of mass of the ground vehicles. Finally, experiments and testing results that validate the cooperative navigation architecture will be presented.

Shiyu LIU

Title: Decentralized control and estimation of a flying parallel robot interacting with the environment

Abstract: Aerial manipulation is an emerging domain where multirotor Unmanned Aerial Vehicles (UAVs) are equipped with onboard end-effectors for grasping, transporting and manipulating objects. To enhance the payload capacity and achieve full manipulability in 3-dimensional space, a flying parallel robot (FPR) was previously proposed in which a number of UAVs are used to collectively support a passive parallel architecture. In this talk, we will address the estimation and control methods applied to the FPR considering the interaction with the environment. A momentum-based observer is firstly established to estimate the external wrench acting on the robot, which is completed by an impedance-based controller with wrench tracking capability to allow the robot interacting with the environment. The decentralized strategies based on onboard and intrinsic measurements of UAVs are proposed, allowing each UAV to perform its own control based on its own measurements and information shared within all the UAVs. Experiments show the effectiveness of the proposed methods in regulating the robot configuration, achieving precise positioning tasks through teleoperation and performing contact-based interactions with an object in the environment.

Hai-Nguyen NGUYEN

Title: Gathering spatially and temporally spreading data with aerial robots

Abstract: Aerial robots have been used effectively for data acquisition applications. Without the struggles of walking or crawling over complex terrains, flying robots can collect data from far-reaching locations in a timely manner. In many applications, such as gathering data for ecological studies or in infrastructure monitoring, it is of great importance to have datasets that reflect the long-term changes in the environment. Because of the poor endurance of the hovering robots, collecting both spatially and temporally spreading data

presents a significant challenge. In this presentation, we propose approaches that enable aerial robots to efficiently collect temporally spreading data at the spatial resolution needed. Both approaches will be presented from design and control perspectives. The first approach is directly placing sensors into the environment with the robot, complementing the fine spatial resolution offered by the vision-based perception system onboard the robot with the temporally dense data gathered from the fixed-to-the-environment sensors. The second approach consists of utilizing the robot itself as a remote-sensing instrument by exploiting the ability to perch onto the environment of the robot to overcome its poor endurance. The proposed approaches illustrate the benefits of utilizing physical interactions in flying robots, demonstrated in placing sensors onto vertical/inclined surfaces and perching to irregular-shaped structures.

Ali SROUR

Title: Controller and Trajectory Optimization for a Quadrotor UAV with Parametric Uncertainty

Abstract: We exploit the recent notion of closed-loop state sensitivity to critically compare three typical controllers for a quadrotor UAV with the goal of evaluating the impact of controller choice, gain tuning and shape of the reference trajectory in minimizing the sensitivity of the closed-loop system against uncertainties in the model parameters. To this end, we propose a novel optimization problem that takes into account both the shape of the reference trajectory and the controller gains. We then run a large statistical campaign for comparing the performance of the three controllers which provides some interesting insight for the goal of increasing closed-loop robustness against parametric uncertainties.

Antonio MARINO

Title: Open Libraries and Interface for Vehicles Experimentation

Abstract: We present OLIVE, a platform to experiment with single robots and a heterogeneous team of robots, composed of different mobile platforms with different hardware. The current state of multi robots platforms lacks do not adapt to heterogeneous robots and provides only simple distributed control routines for a robot team. Recent works like ChoiRbot offers a toolset to execute complex distributed multi-robot tasks with Robot Operating System 2 (ROS2) to work with distributed control architecture. However, they miss a complete architecture that allows an easy deployment of distributed control solutions in multiple environments: simulation, indoor with and without motion capture, and outdoor. OLIVE aims to provide the necessary infrastructure to experiment in a complete transparent way for the users thanks to ROS2 and Unity3D simulation environment. We leveraged on the different expertise of the Rainbow team members to interface with different hardware like px4 drones and genom3-based robots and integrate with robust software packages in robotics like ViSP (visual servoing platform). We will show working examples controlling multiple aerial vehicles and satellites.

Maxime BERNARD

Title: Decentralized Connectivity Maintenance for Quadrotor UAVs with Limited Field of View

Abstract: We present a decentralized connectivity-maintenance algorithm for controlling a group of quadrotor UAVs with limited field of view (FOV) and not sharing a common reference frame for collectively expressing measurements and commands. This is in contrast to the vast majority of previous works on this topic which, instead, make the (simplifying) assumptions of omnidirectional sensing and presence of a common shared frame. For achieving this goal, we design a gradient-based connectivity-maintenance controller that can take into account the presence of a limited FOV by controlling the robots yaw angle. We also propose a novel (to our knowledge) decentralized estimator of the relative orientation among neighboring robots, which is instrumental for correctly implementing the connectivity-maintenance action. We validate the approach in realistic simulations using ROS 2 and Unity that show the effectiveness of our approach.

Zakeye AZAKI

Title: Control Approaches for a Tethered Drone In an AWE Application

Abstract: The purpose of Airborne Wind Energy (AWE) systems is to harvest high-altitude wind energy and convert it into electrical energy. In this work we focus on the on-ground production system whereby the device follows a predetermined trajectory and produces aerodynamic lift and drag forces transmitted via a tether to the on-ground station for conversion into electricity. We address the problem of controlling the drone based AWE system generating electrical power on ground to follow a prescribed geometric path in the take-off and landing phases. We consider two different control strategies: the Feedback linearization technique with PID control denoted as (FL+PID). The second control strategy is the Sliding Mode control with Feed-forward of the external aerodynamic disturbances denoted as (SMC+FF).

Abdoullah NDOYE

Titre: Vol automatique d'un oiseau mécanique à ailes battantes guidé par un champ de vecteur

Résumé : Dans cette présentation, le contrôle automatique d'un oiseau mécanique à aile battante de 10 grammes appelé le Metafly est effectué dans le but de suivre une trajectoire déterminée en utilisant le cap. Pour cela, la référence pour le contrôle du cap est fournie par un champ de vecteurs calculé en fonction de la trajectoire souhaitée. Le robot est doté d'un mécanisme directionnel qui permet de tourner en augmentant la tension d'une aile tout en relâchant l'aile opposée. La dynamique de l'oiseau étant très non-linéaire, une série d'essais en vol libre a été réalisé afin d'identifier un modèle simple entre la commande de direction et le cap, valable uniquement dans un certain domaine de vol. L'identification du système nous a permis d'ajuster le contrôleur de cap. Une boucle interne sur le roulis est ajoutée afin d'éviter le décrochage. Les résultats expérimentaux montrent que notre stratégie basée sur les champs de vecteurs nous permet de suivre des trajectoires circulaires et des trajectoires en forme de huit.

Jonatan ALVAREZ

Title: Event-Based Sliding-Mode Control for VTOL Rotorcrafts Multi-Agent Systems

Abstract: The work investigates the consensus control of a Multi-Agent System (MAS) composed by Vertical Takeoff and Landing (VTOL) rotorcrafts subject to aerodynamic disturbances. Initially, the attitude's VTOLs model based on quaternion formalism is detailed to subsequently derive the corresponding control law. Likewise, the MAS translational dynamics is extended to entail the airframe's aerodynamics. In order to achieve the consensus objective, a robust adaptive event-triggered sliding-mode control (SMC) is synthesized considering a leader-follower scheme guaranteeing Lyapunov's closed-loop stability and avoiding the Zeno behavior. Results from an extensive simulation stage witness the effectiveness of the proposed control scheme.

Xavier DAINI

Titre : Exploration et cartographie basé flux optique par drone hexarotor

Résumé : Dans le cadre de nos recherches sur la robotique aérienne d'inspiration biologique, nous avons développé un pilote automatique basé sur le flux optique pour explorer et cartographier de façon indépendante et concomitante une zone inconnue. En simulation, un hexarotor complètement actionné est équipé de 2 caméras à large champ visuel orientées de part et d'autre, à droite et à gauche du drone. Le contrôleur (inspiré de Serres Ruffier 2015) permet d'explorer l'environnement en régulant le flux optique issu de la paroi la plus proche et utilise des critères également basés flux optique pour tourner. Pour cartographier, le drone utilise le fait que la norme du flux optique lors d'une translation suit une loi proche d'une gaussienne pour une surface plane. En utilisant la position angulaire du maximum de cette loi gaussienne, le drone en estime l'angle entre la rétine de la caméra et la surface plane. La distance du drone à cette surface peut être également déduite du flux optique. Les simulations produites par notre système logiciel (Gazebo, ROS, Python, Matlab) montrent que le drone peut cartographier, par exemple, un octogone : il raffine son estimation d'angle lorsqu'il revient sur une surface déjà observée (après un tour). Cette redondance d'informations permet au drone de reconstruire plus précisément l'environnement, en accumulant les zones reconnues à chaque tour. D'autres simulations montrent que le système est performant dans des environnements plus complexes géométriquement. Il est ainsi possible d'explorer et cartographier dans un environnement plus complexe fait de virages en L, en épingle à cheveu et de surface plus irrégulière.

Nicola De Carli

Titre : Active Cooperative Localization of Multi-Drone Systems using Distributed Optimization

Abstract : Cooperative localization (CL) in a common frame from relative sensing is a classical topic in the multi-robot community. Typical sensors for quadrotor groups provide measurements of the relative distance (e.g. using ultra-wideband sensors) and/or the relative bearing (e.g. using cameras) among neighbors. The ability to localize a group of drones measuring only partial information about their relative position (e.g. only one

among distances or bearings), under the only constraint of the sensing graph being connected (not necessarily rigid), strongly depends on the trajectories followed by the drones. In order to provide the state estimator with a well-conditioned estimation problem, we generate trajectories which aim at maximizing the information collected by the drones along the future horizon. This is achieved by relying on a common measure of the of the local observability of nonlinear systems which is the so-called Observability Gramian and by solving a decentralized optimal control problem cooperatively relying on modern distributed optimization algorithms, which are recently being introduced in the multi-robot community. The case study we consider is the cooperative localization for a group of quadrotor UAVs able to measure relative bearings when in visibility and within a certain range.