Réunion du Groupe de Travail UAV inter-GDR MACS – Robotique

10 Novembre 2011
ENSAM, Boulevard de l'Hôpital, Paris 13
Salle C4

Programme de la journée :

9h30-10h-15 :	Online Inertial map and trajectory estimation. Carlos SILVESTRE, ISR-Lisboa-Portugal
10h15-11h :	Modélisation de la locomotion en robotique bio-inspirée Fréderic BOYER, Mines-Nantes
11h15-12h :	Stabilisation bornée d'attitude avec et sans reconstruction Nicolas MARCHAND, GIPSA-lab-Grenoble
12h – 14h :	Pause déjeuner
14h - 14h35 :	A novel 1-gram insect-based device measuring visual motion along 5 optical directions Fréderic ROUBIEU, ISM-CNRS, Marseille
14h35 – 15h10 :	Nonlinear Control of PVTOL Vehicles subjected to Drag and Lift Forces Daniele PUCCI, INRIA-Sophia-Antipolis
15h10 – 15h45 :	Commande non linéaire pour la poursuite de trajectoires d'un système hybride projectile – drone miniature Adrien DROUOT, CRAN-Nancy
15h45 – 16h20 :	Towards the Integration of Manipulation Capabilities to a Quadrotor MAV Juan-Antonio ESCARENO, HEUDIASYC-Compiègne
16h20 – 16h40 :	Discussions/Conclusions

Résumé

9h30-10h-15 : Online Inertial map and trajectory estimation.
Carlos SILVESTRE, ISR-Lisboa-Portugal

In this talk I will present the online inertial map and trajectory estimation as well as the experimental validation for a sensor-based globally asymptotically stable (GAS) filter for simultaneous localization and mapping (SLAM), with application to uninhabited aerial vehicles (UAVs). The SLAM problem is formulated in a sensor-based framework, without any type of vehicle or inertial frame pose information in the state of the filter. The inertial transformation problem is firstly formulated as the optimal problem of finding the transformation between two different time instants, for which the matching between the two sets of landmarks is known. Resorting to a closed form solution to this problem, the absolute transformation, relative to an inertial frame set in the mission scenario, is obtained by combining the sequence of transformations since the algorithm was first initialized. An alternative approach is also discussed, which augments the filter state to track the inertial frame as an unobservable landmark. The complete performance and consistency of the proposed SLAM filter, as well as the online inertial map and trajectory estimation, are successfully validated experimentally in a structured real world environment using an instrumented quadrotor.

10h15-11h : Modélisation de la locomotion en robotique bio-inspirée
Fréderic BOYER, Mines-Nantes

Les animaux fascinent par leur capacité à se déplacer dans des milieux difficiles tout en maintenant des performances élevées en termes d'agilité et d'efficacité. Ceci explique pourquoi les roboticiens s'intéressent aujourd'hui à une nouvelle génération de robots bio-inspirés des serpents, poissons et autres papillons sphinx. Afin de progresser dans cette voie, il est essentiel de comprendre quels sont les mécanismes que les animaux ont découverts au cours de leur évolution pour résoudre les problèmes durs auxquels les concepteurs et contrôleurs de robots doivent faire face. Pour aider ces recherches, la production d'outils génériques dédiés à la modélisation, l'analyse et le contrôle de la locomotion s'avère être un atout précieux. L'exposé présenté a deux objectifs. En premier lieu, il aborde la question qualitative de la classification des modèles de la locomotion par des outils de mécanique géométrique. En second lieu, il présente des algorithmes généraux et efficaces adaptés à l'étude de la locomotion. Ces idées seront illustrées sur des cas particuliers empruntés à la nage, la reptation et le vol battant.

11h15-12h : Stabilisation bornée d'attitude avec et sans reconstruction
Nicolas MARCHAND, GIPSA-lab-Grenoble

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Le contrôle de l'assiette est à la base de la quasi-totalité des approches de stabilisation des engins volants. Dans cet exposé, nous présenterons une approche basée sur les fonctions de saturation permettant la stabilisation semi-globale (dans le sens où il existe deux points d'équilibre dont un seul est stable). Cette commande peut prendre comme paramètres les vitesses angulaires et quaternions mais aussi, dans une logique plus réaliste, directement les mesures capteurs, c'est à dire gyromètres-accéléromètres-magnétomètres ou autres. Une conceptualisation des capteurs est proposée et à partir d'hypothèses simples, la stabilisation peut être garantie, avec ou sans mesure de la vitesse angulaire. L'intérêt de ces lois de commande réside dans leur extrême simplicité et leur faible coût d'implantation.

14h - 14h45 : A novel 1-gram insect-based device measuring visual motion along 5 optical directions
Fréderic ROUBIEU, ISM-CNRS, Marseille

Autopilots for micro aerial vehicles (MAVs) with a maximum permissible avionic payload of only a,few grams need lightweight, low-power sensors to be able to navigate safely when flying through unknown environments. To meet these demanding specifications, we developed a simple functional model for an Elementary Motion Detector (EMD) circuit based on the common housefly's visual system. During the last two decades, several insect-based visual motion sensors have been designed and implemented on various robots, and considerable improvements have been made in terms of their mass, size and power consumption. The new lightweight visual motion sensor presented here generates 5 simultaneous neighboring measurements of the 1-D angular speed of a natural scène within a measurement range of more than one decade [25°/s; 350°/s]. Using a new sensory fusion method consisting in computing the median value of the 5 local motion measurements, we ended up with a more robust, more accurate and more frequently refreshed measurement of the 1-D angular speed.
In this study, the dynamic characteristics of a new 1-gram bio-inspired visual motion sensor were tested indoors on a natural coloured scene under natural light conditions. The results obtained hère show that our new tiny visual motion sensor including five local motion units can generate 5 simultaneous measurements of the angular speed detected within their individual FOVs. In addition, the motion sensor yields a median value, which was found to be 1.7-fold more accurate (Standard Deviation Error, Stderror= 11°/s) and 4-fold more frequently refreshed (67Hz) than a single local motion unit. This visual motion sensor constitutes a good trade-off between the need for reliable motion sensors and the need for multiple small-sized electronic components. This visual motion sensor can be implemented on terrestrial and aerial vehicles and used in natural environments for obstacle avoidance, take off, landing and speed control purposes.

14h45 – 15h30 : Nonlinear Control of PVTOL Vehicles subjected to Drag and Lift Forces
Daniele PUCCI, INRIA-Sophia-Antipolis

Feedback control of aerial vehicles in order to achieve some degree of autonomy remains an active research domain after decades of studies on the subject. The complexity of aerodynamic effects and the diversity of flying vehicles partly account for this continued interest. Lately, the emergence of small vehicles for robotic applications (helicopters, quad-rotors, etc) has also renewed the interest of the control community for these systems. In this talk we aim improving and extending existing feedback control techniques by taking into account aerodynamic effects in the control design.
Most of aerial vehicles belong either to the class of fixed-wing vehicles, or to that of rotary-wing vehicles. The first class is mainly composed of airplanes. In this case, weight is compensated for by lift forces acting essentially on the wings, and propulsion is used to counteract drag forces associated with large air velocities. The second class contains several types of systems, like helicopters, ducted fans, quad-rotors, etc. In this case, lift forces are usually not preponderant and the thrust force, produced by one or several propellers, has also to compensate for the vehicle's weight. These vehicles are usually referred to as Vertical Take-Off and Landing vehicles (VTOLs) because they can perform stationary flight (hovering). On the other hand, energy consumption is high due to small lift-to- drag ratios. By contrast, airplanes cannot (usually) perform stationary flight, but they are much more efficient energetically than VTOLs in cruising mode. Control design techniques for airplanes and VTOLs have developed along different directions and suffer from specific limitations. Feedback control of airplanes explicitly takes into account lift forces via linearized models at low angles of attack. Based on these models, stabilization is usually achieved through linear control techniques. As a consequence, the obtained stability is local and difficult to quantify. Linear techniques are used for VTOLs too, but several nonlinear feedback methods have also been proposed in the last decade to obtain (semi) global stability. These methods, however, are based on oversimplified aerodynamic models that neglect aerodynamic forces. In fact, even drag effects are but seldom taken into account. Therefore, thèse methods are not relevant to the control of airplanes or any other aerial vehicle subjected to significant lift forces. Another drawback of the independent development of control methods for airplanes and VTOLs is the lack of tools for flying vehicles that belong to both classes. These are usually referred to as convertible as they can both perform stationary flight and benefit from lift properties at high airspeed via optimized aerodynamic profiles. This versatility explains the growing interest in the design and control of such systems in recent years. The control literature on this topic, however, is scarce. This can be explained by the difficulty to operate transitions between stationary flight and cruising modes, in relation to strong variations of drag and lift forces during these transitions.
In view of these observations, we believe that there is a strong potential benefit in bringing control techniques for airplanes and VTOLs closer. A major difficulty for the control of winged systems is the dependence of aerodynamic forces upon the so called angle of attack. Under some assumptions, we show that part of these forces can be compensated for via a change of thrust control input so that the dynamics of the transformed system does not depend on the angle of attack. The control design is then much simplified, and can be addressed with techniques recently proposed in the literature. In particular, semi-global stability and robustness to unmodelled dynamics can be achieved. However, the model allowing for the so-called spherical-transformation does not take into account the stall phenomena of aerodynamic forces. We show that these phenomena perturb the structural properties of the system's dynamics and affects the existence, multiplicity and continuity of equilibrium points.

15h30 – 16h15 : Commande non linéaire pour la poursuite de trajectoires d'un système hybride projectile – drone miniature
Adrien DROUOT, CRAN-Nancy

Dans le cadre de la protection du citoyen et des infrastructures vitales et des réseaux, un concept innovant de drone miniature est proposé. Il s'agit de lancer à partir d'un tube portable dédié, un projectile subsonique qui se transforme en drone miniature (MAV) une fois arrivé au-dessus du site à observer. Un tel système hybride, appelé GLMAV pour Gun Launched Micro Air Vehicle, est dédié à toutes formes de surveillance et de contrôle de personnes et d'infrastructures par la voie aérienne puisqu'il sera doté d'un système de vision embarqué avec transmission des images en temps réel.
L'état d'avancement des travaux relatifs à la commande concernant la poursuite de trajectoires longitudinale, latérale, verticale et d'orientation du GLMAV sera présenté. Il sera notamment mis l'accent sur des commandes de type backstepping ainsi qu'une commande en cascade. Des résultats de simulation ainsi les perspectives seront également évoquées.

16h15 – 17 h : Towards the Integration of Manipulation Capabilities to a Quadrotor MAV
Juan-Antonio ESCARENO, HEUDIASYC-Compiègne

Recently, the applications range of Miniature Aerial Vehicles (MAVs) has increased significantly thanks to the enhanced navigation/maneuvering capabilities. However, the role of the unmanned vehicle remains as a passive agent in the mission context, restricted to surveillance/monitoring tasks. Thus, in order to enlarge the operational scope of MAVs, the vehicle must integrate new operational capabilities such as the interaction with the surrounding environment. To this end, we are addressing a concept that combines the 3D-mobility within cluttered environments of miniature flying robots with the advantages of teleoperated manipulator, obtaining a vehicle with a hybrid operational profile that is capable of load grasping/transporting as well as object manipulation.