Journée GT - UAV

Programme détaillé (abstracts inclus)

Le GT UAV aura lieu le vendredi 12 octobre au laboratoire Heudiasyc à Compiègne.

Un buffet sera offert par l'Heudiasyc et le GDR. Merci de vous inscrire auprès de Pedro Castillo: pedro.castillo@hds.utc.fr

Pedro Castillo et Franck Ruffier (Coordinateurs du GT UAV)

9h10: Accueil des participants

9h20: **Didier Thelliol** (CRAN, Nancy) : Fault-tolerant Control Methods Design: Application to UAVs Testbed

10h10: **André Preumont** (UBL, Bruxelles) : COLIBRI: A Robotic Hummingbird

11h00: Pause Café

11h10: **Julien Erskine** (LS2N, Nantes): Analysis, Configuration Design and Control of an Aerial Cable-Towed System

11h50: **Hussein Hamadi** (Heudiasyc, Compiègne): Wind tolerant controller and robust INS/GPS sensor fusion architecture for multirotor UAV

12h30: Buffet

14h00: **José Alfredo Guerrero** (TSCF Team at Irstea, Aubière): Forced Bipartite Consensus for Multi-Agent Systems.

14h40: **Juan Antonio Escareno** (XLIM UMR 7252, Limoges) : Time-Delayed Multi-Agent System Dynamics and Coordination Control for Transport Operations

15h20: **Hernan Abaunza** (Heudiasyc, Compiègne) : A Dual Quaternion Chattering-Free Sliding-Mode Controller for a Quadrotor Aerial Manipulator

16h00: **Visite Labo / Demos**

16h30: Discussion - fin réunion

Didier THEILLIOL and Jean-Christophe PONSART
CRAN UMR 7039, CNRS - Université de Lorraine

Title: **Fault-tolerant Control Methods Design: Application to UAVs Testbed**

Abstract: Faults or failures such as defects in components, instruments, controllers and/or control loop can cause undesired reactions and consequences such as damages to technical parts of the plant, to human life or to the environment. Traditionally, the objective of Fault Tolerant Control System (FTCS) is to maintain its current performance close to the desired one and preserve its stability conditions despite of component and/or instrument faults; in some circumstances a reduced performance may have to be accepted as a trade-off leading to a sub-optimal outcome. Design of control systems to achieve fault-tolerance for closed-loop control of safety-critical systems has been an active area of investigation for many years. It becomes more and more clear that there are certain trades-offs between achievable normal performance and fault-tolerance capability. However, despite of the many efforts in control community, most of the contributions did not consider or take into account the reliability of components, algorithms or soft computing structures to guarantee such performance and to reduce the gap between nominal and faulty case. This talk aims at presenting new and innovative research results on how to design Fault Tolerant Control Systems with particular attention to consider failure/ fault (or also model degradation) and combine reliability analysis in the design procedure and/or real-time control synthesis. Current and future research is presented in order to solve the above challenging research problems devoted to safety-critical systems such as unmanned aerial vehicle (UAV) or first work on fleet.

Biography: Didier Theilliol received the Ph.D. degree in Control Engineering from University of Lorraine (France) in 1993. Since September 2004, he is a full Professor in Research Centre for Automatic Control of Nancy (CRAN - www.cran.univ-lorraine.fr) at University of Lorraine where he co-ordinates and leads national, European and International R & D projects in steel industries, wastewater treatment plant and aerospace domains. Didier Theilliol is the co-head of the Control, Identification, Diagnosis department of the Research Center for Automatic Control of Nancy. It gathers around 80 people among which 39 researchers and professors. His current research interests include intelligent and classical model-based fault diagnosis method synthesis and active fault-tolerant control system design for linear time invariant, linear parameter varying, multi-linear systems and also reliability analysis. He has published over 200 journal/conference papers. He is currently an Associate Editor of ISA Transactions Journal, Unmanned Systems journal and International Journal of Applied Mathematics & Computer Science. Didier Theilliol was Associate Editor of IEEE Transactions on Reliability (2013-2016).

Biography: Jean-Christophe Ponsart is a full professor in the Research Centre for Automatic Control of Nancy (CRAN) at University of Lorraine (Nancy, France). He received the Ph.D. degree in 1996 from University of Savoie (Annecy, France) in Control Engineering (nonlinear control of magnetic suspensions and its digital implementation aspects). In 1997, he participated in the design and implementation of real-time controllers with digital signal processor architecture for an industrial company. He received his Habilitation Diriger des Recherches in 2011 from the University of Lorraine in Model-based Fault Tolerant Control and Application to a Winding Machine. His current research interests include sensor and actuator model-based fault diagnosis (FDI) method synthesis and active fault-tolerant control (FTC) system design for LTI, LPV, nonlinear systems. He has published over 100 journal/conference papers and is co-author of a book untitled Fault-tolerant Control Systems: Design and Practical Applications.

A. Preumont, A. Roshanbin
Université Libre de Bruxelles (ULB), Brussels, Belgium

Title: **COLIBRI: A Robotic Hummingbird**

Abstract: This talk will describe the results of a 7 years project aiming at designing, constructing and testing a hovering flapping twin-wing robot of the size of a hummingbird (Figure 1). The paper describes the main steps of the study and the main features of the vehicle: wing aerodynamics, flapping wing mechanism, control mechanism, flight dynamics, stability analysis, power consumption, flight simulation and flight testing. The wings consist of stiffened membranes attached to two orthogonal bars (the leading edge bar and the control bar); they have a single degree of freedom (flapping) and the wing camber is obtained passively. Aeroelastic coupling of the wing dynamics/aerodynamics is used for lift enhancement. The pitch roll and yaw control moments are obtained by wing twist modulation which consists of moving the control bars in order to modify the camber distribution along the span, leading to a reorganization of the air flow and produce the appropriate control moments: a dissymmetry between left and right will produce a roll moment, and a dissymmetry between front and back half-strokes will produce a pitch moment.

Biography: Andr Preumont received his MSc in Aeronautics from the university of Liege (Belgium) in 1973 and his PhD in Applied Sciences in 1981. He spent 10 years in the nuclear industry before moving in academia. He has been a professor of Mechanical Engineering and Robotics at the Universit Libre de Bruxelles (ULB) since 1987, full professor and director of the Active Structures Laboratory from 1991 to 2016, then Emeritus. His research interests are in the field of SMART structures and precision engineering, with a particular attention to space systems. He is the author of 7 books. He is a member of the Belgian Royal Academy and of the French Acadmie de lAir et de lEspace (AAE). He was the recipient of the Alexander von Humboldt Research Award in 2011 (Darmstadt, Germany). He was a visiting professor at Virginia Tech (USA), UT Compigne and INSA Lyon (France), and Politecnico di Milano (Italy). He is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA).

José Alfredo Guerrero
TSCF Team at Irstea, Aubière

Title: **Forced Bipartite Consensus for Multi-Agent Systems**

Abstract:
This work addresses the problem of forced bipartite consensus on multi-agent systems (MAS) with application to quadrotor coordination. Opposite to standard consensus algorithms, the purpose of bipartite consensus is to divide the MAS into two groups or clusters. Resulting groups or clusters converge to the exact same solution with opposite sign, i.e. agents in the same group find a consensus or agreement while clusters, between them, get to a disagreed consensus. We extend the concept of multi-agent bipartite consensus to the case of forced bipartite consensus on leader-based multi-agent systems. Since tracking of a desired reference is based on the center of mass of the entire group, we analyze the controllability and observability properties from input and output of the leader. Quadrotor platoon switching behavior between coordination and danger avoidance shows a potential application of the proposed control approach. Results have been validated in simulation.

Juan Antonio Escareno
XLIM UMR 7252, Limoges

Title: **Time-Delayed Multi-Agent System Dynamics and Coordination Control for Transport Operations**

Abstract:
This talk addresses an strategy regarding the consensus of a multi-agent system (MAS) in order to perform transport operations in presence of time-delay in the state vector and the communication links. The retarded multi-agent system (RMAS) consists of a set of three omnidirectional agents evolving within the XY 2D space. It is assumed a delayed feedback and communication. This causes stability issues for consensus purposes. The present scheme deals with a accurate attitude and transnational consensus by means control law designed based on the actual time-delay. A simulation stage is conducted to validate the effectiveness of the proposed control scheme during time-delay and time-delay-free transportation operations

Biography:
He received the Ph.D. degree in automatic control from HEUDIASYC Laboratory, University of Technology of Compiegne (UTC), France in 2008. He has held a post-doctoral fellowship position at International Joint Unit of CNRS, 3175 LAFMIA hosted by CINVESTAV, from 2008 to 2010. He was a CNRS project researcher at University of Technology of Compiegne, from 2010 to 2012. In March 2012, he was a visiting researcher at the French Nuclear Energy Commission (CEA), at Fontenay-aux-Roses, France. From July 2012 to October 2013, he was postdoctoral researcher at the Department of Control and Micro-Mechatronics Systems (AS2M) at FEMTO-ST (Franche-Comt Electronics Mechanics Thermal et Optical) UMR CNRS 6174, Besanon, France. From 2014 to 2018, he has held an associate professor position at Institut Polytechnique de Sciences Avances at Ivry-sur-Seine. He si currently associate professor at the ENSIL-ENSCI (Limoges University) with research affiliation to the UMR CNRS 7252 XLIM research institute, with the mechatronics group (ReMIX).

Julien Erskine
PhD Student at LS2N, Nantes

Title: **Analysis, Configuration Design and Control of an Aerial Cable-Towed System**

Abstract: Aerial manipulation of objects by multiple UAVs through cables is investigated from a parallel robotics perspective. An adaptation of established wrench analysis techniques for cable-driven parallel robots is shown, allowing a determination of the comprehensive wrench set of a general multi-cable load suspended from quadrotors. An control strategy for a 3-quadrotor translational system is presented, making use of an outer control loop structure based on a computed torque controller. The prototype and initial results are presented, demonstrating the effectiveness of the controller. The wrench analysis method is validated by experimentally demonstrating the limits of the controllable configurations of the system.

Hernan Abaunza
PhD student at Heudiasyc, Compiègne

Title: **A Dual Quaternion Chattering-Free Sliding-Mode Controller for a Quadrotor Aerial Manipulator**

Abstract:
Modeling and control of aerial robotic manipulators is a challenging task due to the inherent complexity of the multiple rotations and translations involved on their components. Dual quaternions are an alternative to the classical Euler approach for describing kinematic and dynamical models in a simpler manner. This talk presents a chattering-free sliding mode controller for a quadrotor aerial manipulator model based on dual quaternions. Adaptations of the classical sliding mode approach are proposed to accustom this technique to the 3D rotations and translations inherent of dual quaternions.

Hussein Hamadi
PhD student at Heudiasyc, Compiègne

Title: **Wind tolerant controller and robust INS/GPS sensor fusion architecture for multirotor UAV**

Abstract:
Control design for multi rotors UAV is an important challenge for engineers and scientists, due to the fact that the standard configurations are under-actuated, highly nonlinear, and unstable systems. In this presentation, a wind force compensation strategy is proposed for a quadrotor. This strategy relies on a second order sliding mode controller based on the super twisting algorithm (STA) with an observer. The Second-order sliding mode technique ensures robustness to external disturbances and time varying, parametric and nonlinear uncertainties. Also, we present a fault tolerance architecture for data fusion mechanisms that tolerates hardware faults in the sensors and software faults in the data fusion.