The **French-German Research Institute of Saint-Louis (ISL)** situated in the border triangle of Germany, France and Switzerland is an internationally renowned research institute belonging to a global industrial and economic network.
The spectrum of our core activities comprises a variety of topics: aerodynamics, energetic and advanced materials, lasers and electromagnetic technologies, protection, security and situational awareness. Our activities are related to both basic and applied research.

ISL is offering a **PhD Position**

Research field: Flight techniques for projectiles

High maneuverability guided projectiles flight control design with reduced actuator requirements

Motivation

Standard ballistic artillery ammunition (both fin & spin stabilized) used in current theaters of operation suffer from a relatively large on-target dispersion due to various factors (wind shears, uncertain launch conditions, etc.). A solution to the problem is to integrate guidance & control capabilities to these systems to increase their range and accuracy for stationary and also for moving targets. However, due to various practical design reasons the controllability potential of guided projectiles is reduced with respect to for example tactical missiles. For this reason it is imperative to squeeze out all the control performance possible under the low cost constraints of these systems which most importantly includes only a limited number of on-board actuators.

State of the art

ISL has an established know-how and a proven research record in the design of implementable high performance algorithms for both fin and spin stabilized guided projectiles. These algorithms have been already implemented in high fidelity virtual reality simulators, hardware in the loop wind tunnel prototypes and will be tested in free flight in the years to come in the context of the long range guided projectiles roadmap (DFGP and LRGP projects). There is still though a lack of internal know how on flight control design using a limited amount of on-board actuators which implies the use of the so called Bank-To-Turn (BTT) or Bank-While-Turn (BWT) configurations. In addition, existing flight control algorithms based on linearization gain scheduling may not guarantee stability and performance under some flight conditions (high angles of attack, low speeds, etc.).

To this end, more systematic design methods such as LPV or adaptive control approaches need to be investigated.

Research Proposal

The first problem to be tackled is the flight dynamics modeling of a fin-stabilized guided projectile with a reduced number of actuators. This includes a full 6DoF nonlinear simulator using the latest advances of the GNC group in the field. A linearized model will then be obtained in the form of a Linear Parameter Varying (LPV) model throughout the whole flight envelope of the system (i.e. aerodynamic angles, altitude Mach, etc.) in view of the control design. This LPV model needs to capture well enough the dynamics of the projectile and to integrate all possible sources of system aerodynamic or mechanical uncertainty for robustness analysis purposes. Finally implementation constraints such as computation and sensor delays will be integrated already from this phase.

The second problem to be tackled is the understanding of the structure of a Bank-To-Turn (BTT) or a Bank-While-Turn (BWT) autopilot as opposed to the currently used Skid-To-Turn (STT) architecture which demands for a higher number of control fins and hence actuators.

The third problem to be tackled is the design of the autopilot itself both for the roll and lateral dynamics of the guided projectile.

An LPV autopilot offers many advantages over previously used techniques such as guaranteed bounds on the performance and robustness over the whole flight envelope. Current methods in LPV control design struggle with problems of scalability and to overcome this, a new approach separating control synthesis into an observer/state feedback problem is proposed which generates an easily implementable controller. Additionally, the proposed approach is based on a set of pure integrators that allow the integration of anti-wind up methods permitting the designer to cope with actuator saturation problems.

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