

**Research Unit:** Rennes

**Domain:** STIC pour les sciences de la vie et de l'environnement

**Theme:** Observation et modélisation pour les sciences de l'environnement

**INRIA Research Project:** FLUMINANCE Project

**Title of the subject:**

Design of reduced models for fluid flow control by visual servoing.

**Context:**

Fluid flow control is a recent and active research domain. By flow control one means acting on the flow (for example, like techniques based on blowing and suction) to move its current state to a desired one or, more simply, to stay in a desired state whatever external conditions may arise. A significant part of the work carried out so far in that field has been dedicated to the control of the transition from laminarity to turbulence. Delaying, accelerating or modifying this transition is of great economical interest for industrial applications. For instance, it has been shown that for an aircraft, a drag reduction can be obtained while enhancing the lift, leading consequently to limit fuel consumption.

Most part of the works concerns open-loop, manipulated or forced flow control. In the Fluminance team we focus on closed-loop control by visual servoing. That means that the control law relies on visual features extracted from image sequences.

**Description of the candidate activity:**

Controlling a flow is a complex problem for several reasons. An important one is the dimension of the state vector that describes the current state of the flow (typically  $10^7$ ). That is why a huge amount of works focuses on reduced order models able to describe the complexity of the system. However, these works have not been designed for the case of a closed-loop control flow.

We propose in this subject to design a new class of reduced order model where the control signal is explicitly taken into account. Therefore, from this new model the control law will be easily derived. First, we will consider the case of a linearized system for which techniques to reduce its dimension exist. However, even in that simpler case the stability of the real (non linear) system is not guaranteed when the control law has been designed from the reduced model. We plan to design a reduced model according to the literature of automatic control and next to adapt it in the context of fluid flow control. The idea is to design the reduced model according to a particular objective for which it will be used (the minimization of the drag or the kinetic energy for example). We will validate this approach in the case of the control of the Poiseuille flow in an unstable regime.

Next, we will extend this approach to the non-linear case. Of course, it seems to be very difficult to directly deal with the Navier-Stokes equations that describe the flow. We will rather focus on the Burgers equations (the one-dimensional Navier-Stokes equations).

**Applicant profil:**

The candidate must hold a PhD related to the use of reduced order models in automatic control or fluid flow control. An excellent practice in matlab or C/C++ is also required.

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