DRIVING MORPHOGENESIS TOWARDS TARGET PATTERNS

LABORATORY : Institut Lumière Matière
IN COOPERATION WITH : iLM

LEVEL : M1 / M2
TEAM(S) : MMCI

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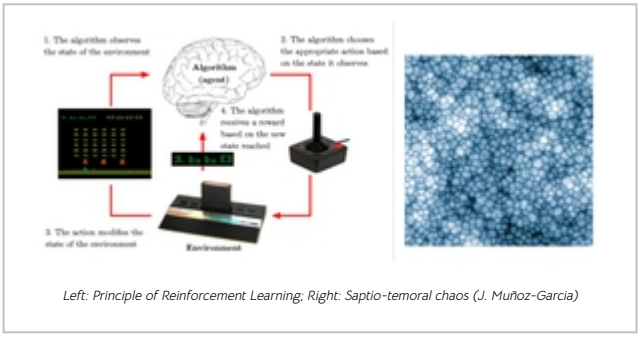
KEYWORD(S) : Machine Learning / Control theory / Non-equilibrium Physics

SCIENTIFIC CONTEXT :



Left: Principle of Reinforcement Learning; Right: Saptio-temoral chaos (J. Muñoz-Garcia)

Instabilities in non-equilibrium and nonlinear systems give rise to a wide variety of patterns, ranging from simple periodic structures to complex spatio-temporal chaos. These structures can be used to design specific patterns, such as periodic networks of dots, or stripes. Such an approach has been very successful in the past decades because it allowed one to form complex self-assembled nanostructures at solid surfaces (under electric fields or during the growth of thin films), or in soft-matter systems (such as di-block copolymers, or membrane wrinkles) without having to sculpt directly the surfaces by means of some lithographic techniques. Instead, the patterns emerge spontaneously if the system experiences some specific physical conditions.

However, in this approach, the design of a pre-defined pattern can only be obtained by a trial-and-error process, where one has to change the physical ingredients in various ways, and see what emerges. Recent advances of control theory and Machine Learning methods now open possibilities for a novel approach, in which one could directly find a strategy to reach a given arbitrary morphology.

MISSIONS :

In this internship, we will explore startegies for driving instabilities towards pre-defined patterns by means of an external time-dependent driving force. We will work with model equations that describe non-equilibrium systems (such as, e.g., the Kuramoto-Sivashinsky equation, see Figure). Our ultimate theoretical goal is to understand in which sense universality can emerge in control strategies. The analysis will be a priori based on Machine-Learning approaches such as Reinforcement Learning (see Figure) during the internship. However, depending on the student, analytical approaches based on control theory can also be developed.

OUTLOOKS :

Thesis possibility after internship: YES

BIBLIOGRAPHY :

Keywords: Machine Learning, Control theory, Non-equilibrium Physics, Nonlinear Dynamics

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