Thermodynamics modelling of power production in living systems: a biomimetic model of optimisation constrained by resource management

— LIED —
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To know more about it, see

– Herbert *et al.* Thermodynamics of Animal Locomotion. *Phys. Rev. Letters* (2020):

– Goupil *et al.* Thermodynamics of metabolic energy conversion under muscle loadtext, *New J. Phys.*, (2019)

Figure 1: Two morphotypes of the same species, *Astyanax mexicanus*. Left is the slow, blind and depigmented cave morphotype, right is the fast surface morphotype. From our description, both locomotion type can be recoverd by simply varying the number of standard muscle fibers N.

Power production mechanism, eg dedicated to locomotion, is a general and vital process based in the animal world on the degradation of ATP molecules during the Krebs cycle. However, this common process, far from freezing the modalities of use and power production of living systems, adapts to the specific environmental constraints encountered by each population. More specifically, we are interested, in a biomimetic approach, in the **adaptive optimisation of energy conversion systems according to the constraints imposed on access to resources.**

To this end, we developed a theoretical and experimental approach, deriving the well-known Onsager formalism of **non-equilibrium thermodynamics** to living systems and relying on the description of **biological mechanisms of metabolism**, and in particular oxygen consumption. This allows us to reconstruct the energy flows through the organism and to characterise it quantitatively using generic parameters allowing inter-individual comparison.

Master Internship In previous work, we have shown that it is possible to describe the different gaits of an organism (walk, trot and gallop in the case of the horse) with a single degree of freedom, the number of standard muscle fibers involved in locomotion. The development of the model for different organisms is the focus of the internship, along two axes. The first is the use of data from the literature, which we propose to exploit in relation to recent theoretical developments. This involves extracting the data of interest after identifying them in the literature. The second is based on experiments carried out in the laboratory on two sub-populations of *A. mexicanus*. A small pirana with two highly differentiated morphotypes. These are adapted to their environment, very poor in one case, very rich in nutrients in the other. The cave morphotype has evolved into a non-pathological form of type 2 diabetes.

A taste for programming languages, especially Python, is required.