3 years thesis grant in Computer Science

Self-organizing cellular systems for sequential active perception on a mobile robot

Institutions : The Ph.D student will join the IMS[1] team of Supélec and the UMI 2958 CNRS/Georgia Tech lab[2]. The team brings together UMI members from Supélec and Georgia Tech and this research program will contribute to the collaborations between the two institutions.

Location : The IMS Team is located at the Metz Campus of Supélec[3]

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The main motivation of the study is to tackle the difficult problem of automatically understanding a rich and natural environment using mostly visual sensors. The availability of two outdoor robots in our lab (see. figure 1) adds a challenging framework to this study, but the research direction has to be focused in such an opened scientific field.

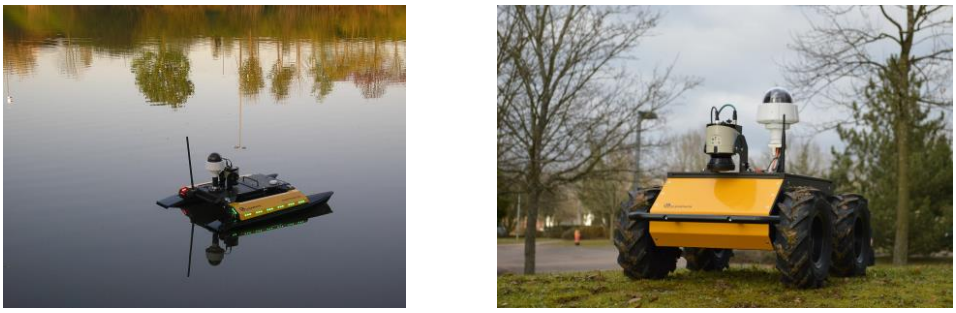

Figure 1: The Kingfisher robot on lake Symphonie and the Husky robot of the Metz Campus. Both robots are available as experimental platforms for this thesis.

This research projects takes inspiration from the human brain as a fruitful hint towards the design of a computational architecture able to understand natural scenes. More precisely, in the case of visual understanding, many works in biology and psychology stressed that vision is rather a sequential palpation of details than a global computation of the whole surrounding scene. This palpation is driven by neural structures, based on highly coupled populations of elementary computing units, i.e. the neurons, whose dynamics leads to a global, robust and harmonious signal processing resulting in a given animal behaviour. Such properties are, on the one hand, the result of evolution which brought the anatomical structure of our brains to maturity. They are also due, on the other hand, to the massive self-organization processes inside the brain, at the timescale of an individual's

[1] Information, Multi-modality and signal, see `http://ims.metz.supelec.fr`.
[2] `http://www.umi2958.eu`
[3] `http://www.supelec.fr/metz`
[4] `http://www.metz.supelec.fr/metz/personnel/frezza`
[5] `http://www.robotics.gatech.edu/team/faculty/pradalier`
[6] `http://www.metz.supelec.fr/metz/personnel/fix_jer`

life, in order to adapt to the world contingencies. Considering primates (among other species able of cognition), evolution clearly resulted in generic structures able to learn behavioral skills, rather than predefined wiring of dedicated neural systems.

This thesis will start with the following questions:

- Why is sequential palpation suitable for understanding a visual scene?
- Is processing based on a population of cellular units particularly suitable for this process?
- How can we endow artificial neural systems with self-organizing properties in order to avoid an a priori task-dependent design? Is it simpler?
- Can this approach to computing contribute to overcome the problems encountered by robotic systems in natural environment?
- Will we be able to control the complex dynamics emerging from such systems?

This thesis will address these questions by designing self-organizing cellular systems for mobile robots, in the continuity of our team's previous work.

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