# Towards an event-driven approach to the emergence of behaviors

Team BISCUIT, Loria

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## 1 Context

The BISCUIT[1] team from the Loria laboratory brings together researchers interested in new computational paradigms. Under this paradigms, calculations are adaptive, distributed and decentralized, carried out by a mass of simple calculation units that communicate mainly with their close neighbors. These properties are compatible with the use of unsupervised – but guided – self-organization principles in order to tackle difficult problems such as situated cognitive computation, autonomous robotics, adaptive allocation of computation resources, *etc.*.

The brain is a tangible evidence of the efficiency and adaptation abilities that one car reach by relying on this kind of principles. Thanks to the interaction between humans or, more generally, animals and their world, the structure of the brain, relatively homogeneous but already partially specified in the genetic code, will develop and organize itself, specializing some of its parts. This theory of emergence of cognition (McClelland, 2010) is very attractive, but its underlying mechanisms are still poorly understood. Moreover, recent progress in deep learning does not, unfortunately, advance knowledge in this direction.

With this in mind, we want to explore what we believe is an essential component, though rarely addressed, of the emergence of behaviors. The artificial agents that we consider evolve in continuous sensorimotor spaces, both temporally and spatially. Conversely, the most elementary cognitive processes are based on *instants* where decisions are made. In the continuous course of time, these instants are points where recognition emerges from perceived signals, where an action is triggered. The agent, according to this principle, is cognitive as it interacts with its environment by "pulses", by building the *events* necessary for its coupling with the outside world. To palpate a scene with your eyes, to resume the expression of Merleau-Ponty, to detect a particular object, to decide to seize it, to seize it, can be seen as the production of events where perception and action merge. The question is then to know how this concept of event is created, how the world evolves from an ever-changing continuum to a sequence of discrete events. How a cognitive relation to the world can be developed ? How do we go from a purely reactive agent to an agent that *takes a decision* ?

The BISCUIT team is committed to "*really doing something with Spatialized and Decentralized Population of computing units*" (SDP) rather than trying to model the structure of the brain with accuracy. The subject of the proposed doctoral thesis is one more step in this direction.

## 2 Goals

The main goal of this thesis is to propose tangible mechanisms to answer this difficult issue of "pulsing" the world, especially from the temporal point of view, into significant events for an artificial autonomous agent. These proposals must be in accordance with the hypothesis that guide the work of the BISCUIT team, namely the use of unconventional computing that is decentralized, distributed, and with local communications (SDP).

[1] Bio-Inspired Situated Cellular and Unconventional Information Technology, http://biscuit.loria.fr/

A first step will be devoted to the appropriation of the models and algorithms developed in the team, where continuous dynamical neural fields (DNF) (Alecu et al., 2011), self-organizing maps (SOM) (Kohonen, 2013), reinforcement learning (RL) (Sutton and Barto, 1998) all mix together while ensuring the compatibility with the capabilities of actual ”neuromorphic” processors. This period will also be an opportunity to familiarize yourself with a literature inspired by fields such as cognitive science, developmental robotics or even psychology of child development. Notions such as habituation, sensitization, intrinsic curiosity, novelty detection are some sources of inspiration (some examples of readings: (Banquet et al., 1997; Blank et al., 2005; Westermann et al., 2007; Novianto et al., 2013)).

In parallel, the problem will be explored in a concrete way through a simulation environment mixing Unity3D[2] and ROS[3]. The aim is to progressively understand and appropriate the scientific questions raised in the context of this internship topic, and experience has shown us that these problems are better understood when they are really faced.

In a second step, it will be necessary to implement, test and explore the solutions proposed during the thesis. Validation will largely be experimental because self-organization mechanisms rarely lend themselves to analytical studies. This can be done both in virtual simulated environments (as previously mentioned) and, taking advantage of hardware and software at our disposal, on real robotics platforms.

## 3 Working conditions and desired skills

The doctoral student will be welcomed at the Loria, a bi-localized laboratory in Nancy and Metz[4] in France. He or she will work on both sites, at her convenience, under the supervision of Hervé Frezza-Buet and Alain Dutech. Scientific collaboration with other team members is expected, as well as more general scientific discussions and collaborations with other members of the laboratory. The expected duration of the doctorate is three years.

Some knowledge in biology, psychology, philosophy, *etc.*, naturally imposing themselves on this type of subject, is expected, as well as a taste for creativity and multidisciplinary work. A good background in computer science and good programming skills are required. The team will provide a set of programming tools, robotics platforms and all the human support necessary to the technical aspects of the work, allowing the doctoral student to focus on scientific issues. Being comfortable with `C++`, ROS and `python` would be a plus, the code production will be done under Linux.

## References


Alecu, L., Frezza-Buet, H., and Alexandre, F. (2011). Can Self-Organisation Emerge through Dynamical Neural Fields Computations? *Connection Science*, 23(1):1–31.

Banquet, J. P., Gaussier, P., Dreher, J. C., Joulain, C., Revel, A., and Günther, W. (1997). Chapter 4 space-time, order, and hierarchy in fronto-hippocampal system: A neural basis of personality. In Matthews, G., editor, *Cognitive Science Perspectives on Personality and Emotion*, volume 124 of *Advances in Psychology*, pages 123 – 189. North-Holland.

Blank, D., Kumar, D., Meeden, L., and Marshall, J. (2005). Bringing up robot: Fundamental mechanisms for creating a self-motivated, self-organizing architecture. *Cybernetics and Systems*, 36(2):125–150.

Kohonen, T. (2013). Essentials of the self-organizing map. *Neural networks*, 37:52–65.

McClelland, J. L. (2010). Emergence in cognitive science. *Topics in Cognitive Science*, 2(4):751–770.


[2] https://unity.com/
[3] https://www.ros.org/
[4] On the CentralSupélec campus in Metz.

Novianto, R., Johnston, B., and Williams, M.-A. (2013). Habituation and sensitisation learning in asmo cognitive architecture. In Herrmann, G., Pearson, M. J., Lenz, A., Bremner, P., Spiers, A., and Leonards, U., editors, *Social Robotics*, pages 249–259, Cham. Springer International Publishing.

Sutton, R. and Barto, A. (1998). *Reinforcement Learning.* Bradford Book, MIT Press, Cambridge, MA.

Westermann, G., Mareschal, D., Johnson, M. H., Sirois, S., Spratling, M. W., and Thomas, M. S. (2007). Neuroconstructivism. *Developmental science*, 10(1):75–83.