

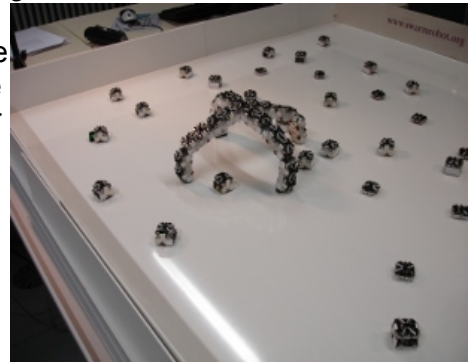
Internship - Robot Metamorphosis

Almende B.V.

Introduction

Situated in Rotterdam, Almende B.V. (2000) is a research company, which performs research in a diverse range of disciplines, building on principles of *self-organization*. This ranges from networks of people, represented by software agents, enabling self-organization on a communication level; to networks of entities, on-the-fly planning within logistics acknowledging the fact of a dynamic environment, incidents, and hence, the infeasibility of static planning; to networks of sensor nodes - enabling anonymous (compared to cameras) monitoring of expected or suspected movement patterns in a health-care institute or airport; to networks of robot modules, the subject of this internship. Daughter companies of Almende apply the research in commercial products.

Almende participates in the European FP7 project, Replicator. Within this project a so-called *Replicator organism* is created. Such an organism contains a multitude of concatenated cube-sized 9x9x9 cm robots. Those cube-sized robots, or cells, allow the organism to take different forms and append the organism with sensory and motor capabilities. The control architecture needed for such a Replicator - which is able to morph, adjusting to its environment: take the form of a snake to go through a hole in the wall, reform to a spider to climb over obstacles - has an enormous amount of degrees of freedom, is very adaptive to its environment, needs to combine sensory information from many and heterogeneous sensors, has to express this information in a useful format for assembly, locomotion and self-reconfiguration and has to compress and distribute its capabilities on a limited, embedded distributed robotic platform. One of the roles of Almende within this project is so-called *morphodynamic control*, in other words, controlling this very *metamorphosis*. Within Replicator other partners develop robot hardware and electronics such as the Universität Stuttgart, Universität Graz, Universität Karlsruhe and Scuola Superiore Sant'Anna. Sensors are built by the Sheffield Hallam University, Fraunhofer Gesellschaft, Institut Mikroelektronických Aplikací, Ubisense and Ceske Vysoke Ucení Technické v Praze.



Within the Replicator project Almende implements morphodynamic control by so-called *gene regulatory networks* ("scholar google" on Bongard) in a virtual 3D space. The existence of a controller that preserves body characteristics, makes it possible that evolution does not need to *rediscover* the mapping. For example, input neurons in an artificial neural network in a 3D space can represent sensor positions on the external body (Roggen, Federici). Metamorphosis can be implemented by *post-development* use of a gene regulatory network (Quick, Nehaniv in "Evolving Embodied Genetic Regulatory Network-Driven Control Systems"). The robot organisms driven by this metamorphosis process are simulated in the Delta3D game engine and hooked up by ethernet to boards with a Blackfin dual core processor running C/C++ programs in a lightweight Linux version.

Function description

The internship will consist of developing one or more scenarios for metamorphosis using a gene regulatory network in a post-development stage. It will include at least one *comparison* with other techniques to implement (bodily) metamorphosis. Such as there are reaction-diffusion models, graph grammars (Klavins), or other approaches (Rubenstein). The scenario(s) should allow at least one reciprocal transition from for example robot spider to snake. Preferably this transition would be initiated after a certain observation in the *environment*. A lizard may lose its tail on an encounter

with a predator; likewise, a Replicator organism might undergo a transition towards a snake on the discovery of a hole in a wall. The scenario(s) will be implemented in the Delta3D HIL (Hardware-In-the-Loop) simulator.

Function requirements

A student in the master Artificial Intelligence, Knowledge Engineering, Robotics, Neuroscience, Cognitive Psychology, Synthetic Biology, Electrical Engineering, with deep interest for (neuro)evolution. This is a vast and multidisciplinary topic, hence, *affinity* with topics like embodiment, robotics, is considered very important, because in-depth knowledge about all following "pros" will take a lifetime, and cannot be a prerequisite. The company has international employees and lots of international partners, hence, fluent English is essential. It is *not* required to speak Dutch.

Pros: knowledge about:

- Artificial neural networks;
- Morpholaxis, embryogenetics;
- Programming on embedded devices, C/C++.

For further information, see <http://replicator.almende.com> and <http://www.replicators.eu>.

Contact:

MSc./Ir A.C. van Rossum

Researcher

Almende B.V.

Westerstraat 50

3016 DJ Rotterdam

The Netherlands

Email: [anne @ almende . com](mailto:anne@almende.com)

Phone: +31 (0)10 85 119 25

Website: <http://www.almende.com/>