Modelling of Modular Robots via Component Systems with Dynamic Reconfigurations
Master 2 Internship

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1 Context and goals

The main goal of this project is to apply component-based models and techniques to modular robots.

1.1 Modular robots

There are several types of networked modular robots where every entity (i.e., module robot) is able to compute and communicate with its neighbors (by using sensors and actuators). We consider modular robots capable of moving on the soil by sliding along the faces of their neighbours (as in Visible Sim [1]).

1.2 Component-based systems

We consider systems with reconfigurable components, i.e. the systems whose architectures can evolve dynamically according to their specific needs, critical properties, available resources, etc. We have developed an implementation allowing to guide and to control dynamic reconfigurations of component-based systems by using adaptation policies for Fractal [BCL+06] or FraSCAti citeseinturier2011component components. Other component-based approaches have been developed, and we are more specifically interested in BIP, DR-BIP et Java-BIP. BIP [2] is a framework for component-based design of correct-by-construction software and embedded systems, where components are modelled as finite state machines.

1.3 Project goals

The internship aims at simulating modular robots by using the BIP framework, where every robot would be a component. Afterwards, we intend to apply adaptation policies to obtained BIP models. In our approach, these policies are composed of adaptation rules whith guards - invariance constraints, and with safety or liveness properties.

1.4 Required skills

Good analytical skills are necessary, as well as a good understanding of finite state automata and labelled transition systems. The development will require C++ and/or Java. The successful internship could lead to writing a research article.

2 In more detail

2.1 On the architecture

By using BIP or its extensions, notably DR-BIP or Java-BIP, it will be necessary to create a *robot* component representing a module of a modular robot. A simulation of modular robots could correspond to

1. `https://projects.femto-st.fr/projet-visiblesim/en`
2. `https://www-verimag.imag.fr/New-BIP-tools.html?lang=en`

compound components containing several basic components, all instantiated from the *robot* component. Every *robot* has to communicate with its neighbours and respect the motion rules, which will be applied to it.

To this end, some *design patterns* [ABB+16] of the BIP model BIP could be used.

The trainee is expected to submit an architecture proposal (*provided* /*required* interfaces, methods, etc.) to begin encoding.

A comparison of BIP, its variants and extensions, notably DR-BIP and Java-BIP, will be necessary to choose the most promising approach wrt. the feasibility of dynamic reconfigurations guided by properties, and the need for scale up.

2.2 On the simulation

Once the architecture of the *robot* component is defined together with the compound components, their implementation could be done. The simulation is expected to be performed by using the rules and algorithms used in Visible Sim.

2.3 On the adaptation

This part of the project consists in establishing whether the results could be improved by using adaptation policies.

Références

[ABB+16] P. Attie, E. Baranov, S. Bliudze, M. Jaber, and J. Sifakis. A general framework for architecture composability. *Formal Aspects of Computing*, 18(2) :207–231, April 2016. Open access.

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[SMR+11] L. Seinturier, P. Merle, R. Rouvoy, D. Romero, V. Schiavoni, and J.B. Stefani. A component-based middleware platform for reconfigurable service-oriented architectures. *Software : Practice and Experience*, 42(5) :559–583, 2011.