The EMeRGE modular robot, an open platform for quick testing of evolved robot morphologies

Rodrigo Moreno
Universidad Nacional de Colombia
Bogota, Colombia
rmorenoga@unal.edu.co

Ceyue Liu
China University of Mining & Technology
Beijing, China
liuceyue@gmail.com

Andres Faina
IT University of Copenhagen
Copenhagen, Denmark
anfv@itu.dk

Henry Hernandez
Universidad Nacional de Colombia
Bogota, Colombia
heahernandezma@unal.edu.co

Jonatan Gomez
Universidad Nacional de Colombia
Bogota, Colombia
jgomezpe@unal.edu.co

ABSTRACT

This work presents the hardware design and implementation of the EMeRGE open modular robot platform. EMeRGE (Easy Modular Embodied Robot Generation) modules are designed to be cheap and easy to build and their hardware is open for anyone to use and modify. Four magnetic connectors enable the quick assembly of different complex robot morphologies like the ones generated by evolutionary robotics experiments. Non-human agents, like robotic manipulators, can also take advantage of the magnetic connectors to assemble and disassemble morphologies.

CCS CONCEPTS

•**Computer systems organization → Robotic control;** *Robotic components; Evolutionary robotics;* Embedded systems;

KEYWORDS

Modular Robots, Morphology, Quick assembly, Magnetic connectors, Open hardware, Transferability

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1 INTRODUCTION

When automatically designing the morphology and control of robots using evolutionary algorithms, solutions are usually tested in simulation but few are transferred to real robots. In contrast to transferring only controllers, evolving and testing morphologies in reality involves a lot of effort and resources. The introduction of rapid prototyping technologies such as 3d printing has helped reduce the costs associated with building and testing different robot morphologies in reality but it can still take a lot of time to print every part of a robot and assemble sensors and actuators into it [1, 6]. Evolutionary robotics experiments can take advantage of modular robot systems to quickly test individuals in real life. The advantage is that simulated morphologies can be very quickly assembled using real modules, that can be reused, thus increasing the rate at which experiments can be made. In [3] an evolutionary system is developed in which the goal is to evolve robots that can be assembled using modules. However, in this and other existing platforms building the modules themselves can still be a complex and expensive process and several are usually needed to build robots that can move to perform different tasks. Automatic connectors that come embedded in some prototypes are also difficult to build and increase the weight and energy consumption of the module. Even in the case of using manual connectors like in [3] moving parts and screws increase the time to complete an assembly. A new modular robot platform, the EMeRGE (Easy Modular embodied Robot Generation) module is described in this work. EMeRGE modules are designed to be easily built using relatively cheap, commercially available components and their hardware design files are open for anyone to use and modify (see footnotes 1 and 2). Modules are easy to assemble to other modules, using magnetic connectors, so that different morphologies can be tested quickly in reality. Magnetic connectors are present in four faces of the module and infrared sensors which allow the EMeRGE platform to build more complex morphologies with more capabilities than similar open modular robot platforms [5]. The magnetic connector can also enable non-human agents, like robotic manipulators, to assemble and disassemble morphologies. The idea of using a robotic arm is also explored in [2] but with the use of glue to attach different modules making the disassembly process more difficult in turn.

2 THE EMERGE MODULAR ROBOT PLATFORM

The hardware of the EMeRGE module is designed for evolutionary and locomotion learning experiments. It allows for the quick assembly of different morphologies that can contain basic sensors. Different mechanical variations can be designed into the system so heterogeneous sets of modules can be used[1]. The module fits inside

[1]The mechanical design can be found here: goo.gl/08LC79

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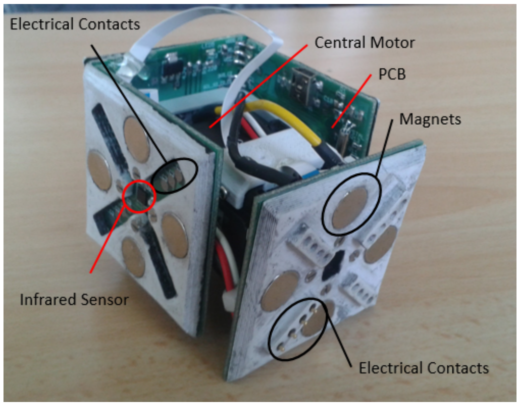

Figure 1: The EMeRGE robotic module

a 81x61x62mm parallelogram, and the module itself resembles a small cube with a central hinge. The central hinge is comprised of a Dynamixel AX-12A servo motor with a pair of brackets screwed to the motor axle and to its bottom. Also screwed to the brackets are two layers that act as faces for the cube, the first layer from the outside is a 3D printed plastic part that houses neodymium magnets and the second layer is a PCB in charge of routing communications and power to the other faces and the motor. The mating magnetic faces maintain mechanical and electrical connection. Only four faces of the cube possess connector faces being one of them male, the other two are purposefully left empty to let the central hinge move. Two joined faces can sustain up to 1.3 N.m of torque before complete disconnection. The motor has a maximum torque of 2.5 N.m.

There are currently two implementations of the electronics [2], one that enables the control of the robots with as less components as possible and another that lets the robot do on board processing and sense the environment. The first routes signals directly from the Dynamixel AX-12A motor to the connector faces. The Dynamixel motor uses a multidrop half duplex serial communication scheme that can be daisy chained. Only three signals are needed: power, ground and data. Three of the PCBs are soldered to each other (see figure 1) to provide mechanical stiffness and communication among them, the remaining PCB and the motor are connected by wires. Modules are powered by an external source which is routed to all modules through the connector faces. Modules must be connected to an external computer through a half duplex serial converter in order to be controlled. The second implementation of the electronics introduces an on board microprocessor, an 32 bit ARM®Cortex®-M PSoC®chip from Cypress. The microprocessor is capable of reading sensors, control the motor, and communicate with other modules. The chip can be programmed with different digital or analogue modules thus saving space in the PCB layout, i.e. a CAN controller can be programmed into the chip. A VCNL4010 infrared proximity sensor is also included at the center of each connector face (see figure 1) and a CAN bus for communicating with other modules is implemented, although different communication protocols can be used.

[2]The electronics designs can be found here: goo.gl/EJNggy

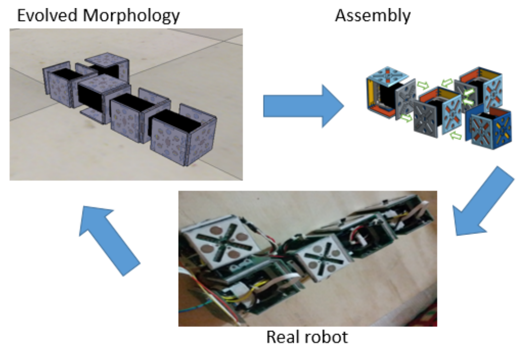

Figure 2: Building of simulated morphology in roughly 25s.

3 FROM SIMULATION TO REALITY

The EMeRGE module can be integrated into robot morphology evolution systems like in [7], in which modular morphologies are generated in simulation using different approaches. Figure 2 shows and example of how morphologies generated in simulation can be implemented as real robots in seconds. By taking advantage of the fast connection feature and other physical properties of the module, a robotic manipulator can be used to automate not only the assembly but also the disassembly process of morphologies obtained in evolutionary systems. This is an insight that we are currently exploring which can be advantageous for systems trying to bridge simulation and reality like [4]. More EMeRGE morphologies can be seen here: http://vimeo.com/rodrm/emerge-modular-robot

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