Reconfiguration algorithm for adaptive furniture

Master Thesis of Manuel Stöckli

Supervisors:
Stéphane Bonardi\textsuperscript{1}, R. Möckel\textsuperscript{1}, A. J. Ijspeert\textsuperscript{1} C.Salzmann\textsuperscript{2}

\textsuperscript{1} Biorobotics Laboratory, EPFL, Lausanne, Switzerland
\textsuperscript{2} Section of Mechanical Engineering, EPFL, Lausanne, Switzerland

The Roombots project

This project aims at designing and controlling modular robots, called Roombots, to be used as building blocks for furniture able to move, self-assemble, self-reconfigure, and self-repair [2]. Modular robots are made of multiple simple robotic units that can attach and detach depending on the task to be solved. Modular robots offer a high versatility and robustness against failure, as well as the possibility of self-reconfiguration.

We envision a group of Roombots that autonomously connect to each other to form different types of furniture depending on user requirements. This furniture will change shape over time (e.g. a stool becoming a chair, a set of chairs becoming a sofa) as well as move using actuated joints to different locations depending on the user’s needs.

References


Web: http://blogs.epfl.ch/mp/edit/page-81014.html

RBR planner

The RBR planner is based on a simplified Markov Decision Process and a method presented by Robert Fitch [3]. The set of states actually describes a set of possible surfaces or connectors where the meta-module can connect to. These surfaces are directly linked to the reward function, called reward map. The set of actions is represented by the inverse kinematics solver which allows to check if the possible surface can be reached from the current position or not. In the current algorithm this set is not explicit but has to be recalculated if necessary. The transition set is implemented as a light collision detection, where surfaces outside the reachable space of the meta-module are filtered. In the same way a surface which lies “inside” a meta-module cannot be reached.

The algorithm starts with a pre-defined initial position, a goal and a user defined grid of possible connectors. Since the reward map is considered to be constant, it will be calculated once by a leader using the grid and the goal surface(s). This map is then shared between all the meta-modules. Once every robot has received its set of instructions, it is free to move towards the goal until it reaches a goal surface. At every step the meta-module attempts to reach the surface with the highest reward value within its reachable space. If the meta-module collides with another module, the ground or with itself, the move to this surface fails and the next best contact surface is tried. The simulation ends as soon as all the meta-modules reach their assigned goal.

The new algorithm was tested in various 2D and 3D environments with a number of one to four meta-modules. The results showed that the efficiency can still be improved while the success rate is optimal and no dead-lock situations were encountered. An explanation of the low efficiency is the high number of collisions of the meta-module with the environment and with itself. The collisions lead to failed moves which in turn renders the solution non-optimal. Nevertheless the results illustrated that the algorithm can handle complex environments with obstacles or narrow passageways.

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