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Report of work

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Chapter 1

Introduction

In our past work, "On the Design of Effective Modular Reconfigurable Grippers: an Iterative Approach" (submitted to the IEEE/RSJ International Conference on Intelligent Robots and Systems - "IROS 2011"), we investigated the possibility of developing a modular robotic gripper that allows for easy adaptation to different requirements and situations. In other words, we defined the guidelines for creating a device capable of adapting its structure and functionality to the characteristics of an object or a set of objects to be grasped. An algorithm capable of determining efficient modular gripper configurations to get a stable grasp of given objects was developed. It consists of an iterative procedure that consents to design the structure of the gripper. Starting from a simple configuration, the target is to reach a prefixed grasp quality using the minimum number of modules. During the design procedure, the grasp capability of the device is improved adding the necessary modules and fingers and adjusting its base configuration. Basically, at each step, it is necessary to generate a new manipulator model.

During our preliminary studies we manually generated these models but our intension is to create an automated framework. For these reason, as first step, we decided to develop a model generator.

Chapter 2

Report

2.1 What we have done

A model generator of modular robotic manipulators has been developed. Each model can be visualized in "OpenRAVE"[1].

"OpenRAVE" uses XML to store all robot and scene descriptions. The XML format is flexible enough to link one XML file from another like including already created objects/robots in an environment. It is also possible to specify vrml or iv formatted files within it to import models.

In "OpenRAVE", a robot manipulator can be defined as a kinematic chain of the robot joint hierarchy along with optional gripper joint values that are not used in the inverse kinematics computation but are needed for grasping purposes (chains for heads, legs do not need the joint values). A manipulator defines a new frame of reference with respect to the end effector link; all inverse kinematics computations are computed using it. Furthermore, a manipulator can have a ¡direction¿ tag specifying an axis for approaching objects or line-of-sight.

Our model generator permits to automatically generate all the necessary XML files.

2.2 Our model

The $Y1$ module [2] has been used as base module for our models. A single body module is 80 mm long, 50mm wide and 50 mm high.

Each model consists of one or more chains of modules fixed on a base. Referring to a robotic hand, each chain can be thought as a finger and the base as a palm. We assume that all the modules have the same size and shape.

Let m be the modules total number of the gripper. Let M be the maximum number of modules per each finger. M has to be chosen as a trade-off between an upper bound function of the maximum motor torque expressed by the modules and a lower bound defined as

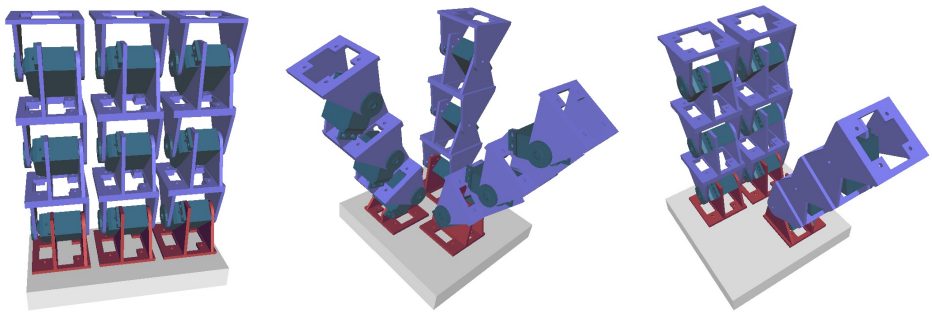
$$M_{min} = \left\lceil \frac{R}{L} \right\rceil, \tag{2.1}$$

where R represents the radius of the minimum sphere that envelops the object to grasp and L is the length of one module. M_{min} takes into account the dimension of the object to grasp.

Concerning the base of the gripper, it is our idea that it should be composed of modules itself. However, in this preliminary study we considered a prototype base plate with given positions where the modules can be fixed. We defined three kinds of *base dispositions* as shown in Fig.2.1:

- *no finger opposition base*: the fingers are placed in a way that finger opposition is not possible;
- *circular base*: the fingers are placed in a circular configuration;
- *i-opposable-thumbs base*: one or more fingers are set to be opposable to the others.

We also considered the possibility to change the distance between the slots where the fingers are placed on the base. In particular, we consider two different distances between the fingers for each base configuration.



(a) (b) (c)

Figure 2.1: Possible base dispositions for $f = 3$: *no finger opposition* (a), *circular* (b) and 1-*opposable-thumbs* (c).

2.3 How it works

Our model generator permits to automatically generate all the necessary XML files simply specifing the following parameters:

- DOFs;
- base disposition;
- distance between fingers;
- fingers configuration.

The fingers configuration can be specified as $x_1, x_2, ..., x_F$, where $x_i \in \mathbb{N}$ represents the number of modules for the i-th finger and F is the number of fingers.

Once the model is generated, an instance of "OpenRAVE" is launched and the model is visualized.

In the following some examples and screenshots are shown.

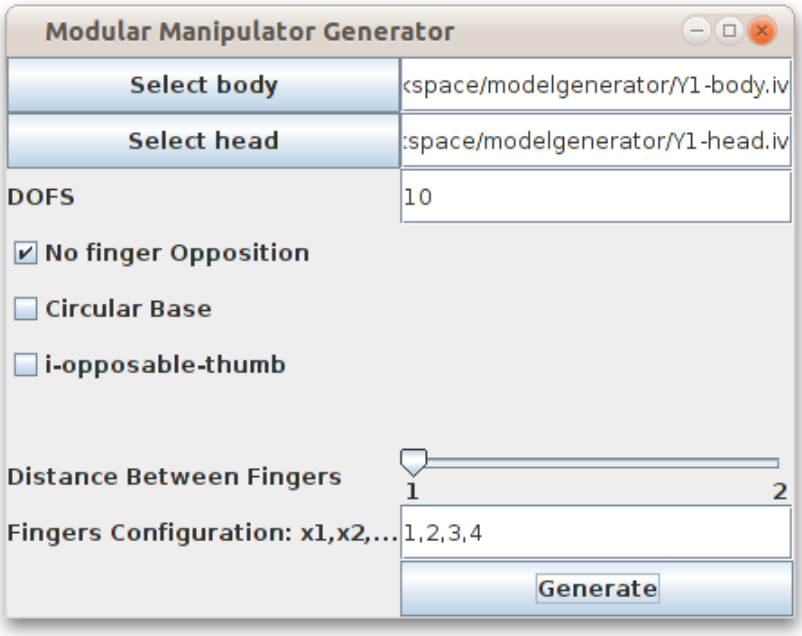


Figure 2.2: Screenshot: UI.

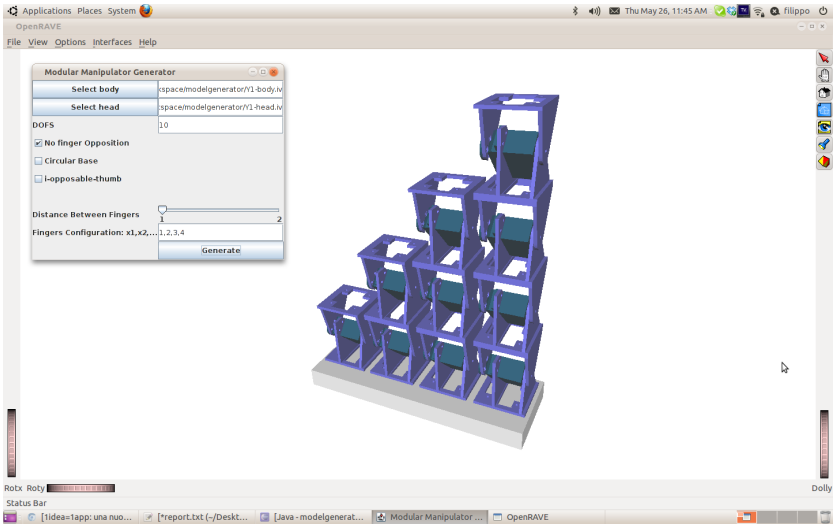


Figure 2.3: Screenshot: manipulator model with 10 DOFs, *no finger opposition base*, distance between fingers equal to 1, fingers configuration given by 1,2,3,4.

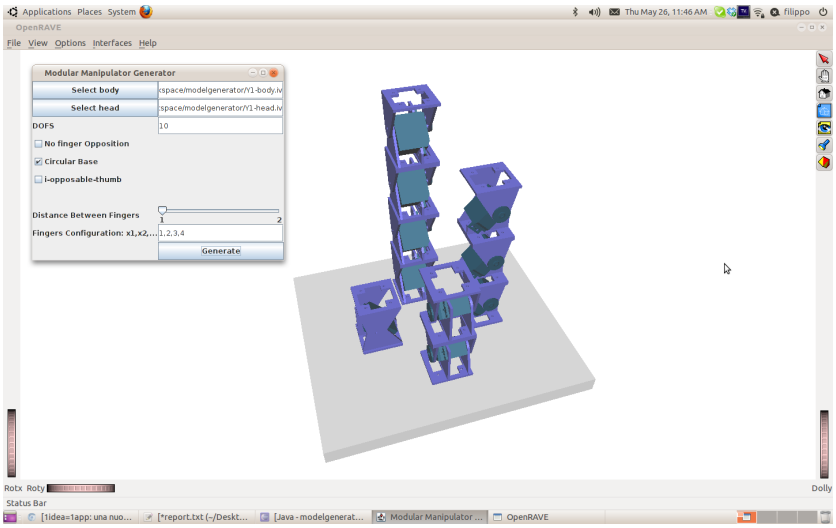


Figure 2.4: Screenshot: manipulator model with 10 DOFs, *circular base*, distance between fingers equal to 1, fingers configuration given by 1,2,3,4.

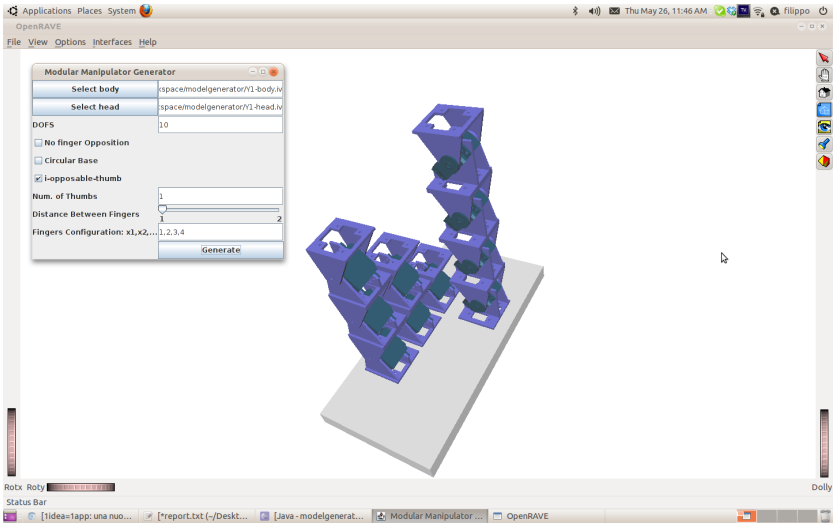


Figure 2.5: Screenshot: manipulator model with 10 DOFs, *1-opposable-thumbs base*, distance between fingers equal to 1, fingers configuration given by 1,2,3,4.

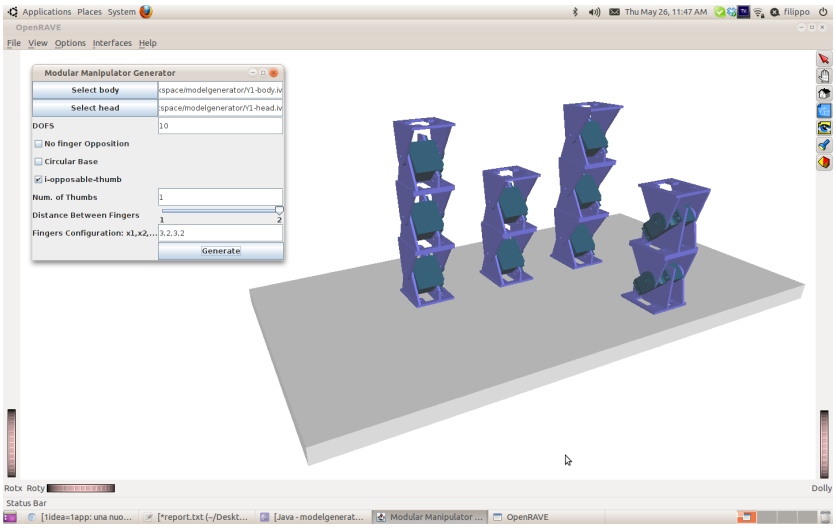


Figure 2.6: Screenshot: manipulator model with 10 DOFs, *1-opposable-thumbs base*, distance between fingers equal to 2, fingers configuration given by 3,2,3,2.

Bibliography

[1] Rosen Diankov. *Automated Construction of Robotic Manipulation Programs*. PhD thesis, Carnegie Mellon University, Robotics Institute, August 2010.

[2] J. Gonzalez-Gomez, H. Zhang, E. Boemo, and J. Zhang. Locomotion capabilities of a modular robot with eight pitch-yaw-connecting modules. In *Proceeding of CLAWAR*, pages 12–14. Citeseer, 2006.