Grade your Hand Toolbox

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I. INTRODUCTION

The toolbox allows to calculate the degree of anthropomorphism of artificial hands. The result will be a percentage value which indicates to what extend the hand is similar to the human hand. In our case we contrast the artificial hand to 31 human grasp types [1],[2] which define the capabilities of the human hand. The following sections will explain how a new artificial hand can be evaluated according to the measure.

The basic idea is to sample all possible fingertip configurations (positions and orientations of the five fingers) of an artificial hand. That dataset is then contrasted against the human by projection to a low dimensional space. In that space the comparison can be visualized and measured. A larger coverage indicates that the hand is closer to the human hand. In our case the human hand serves as the golden standard, being the most versatile end-effector we know of.

Some remarks:

- For more details on the system we refer you to [3].
- The software is distributed under GPL3.

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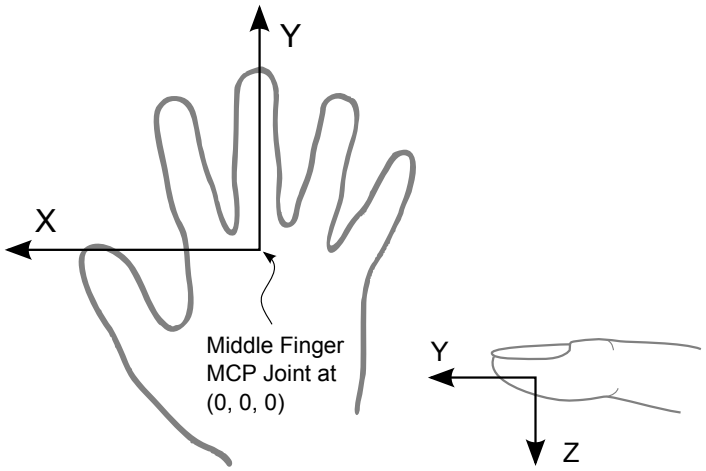

(a) Coordinate system definition of the hand coordinate system. The origin is located at the MCP joint of the middle finger.

(b) Coordinate system definition at the fingertip. The origin should be located in the middle of the fingertip.

Fig. 1. Coordinate system definitions

- If you have results on your own hand, let us know and we'll add the results to the web page!
- The toolbox can be found at http://grasp.xief.net.
- The GP-LVM model was obtained with the FGPLVM toolbox of Neil Lawrence, which can be found at http://www.cs.man.ac.uk/~neill/fgplvm/.

II. Setting up the System

Tested Matlab versions are R2012a.

The only toolbox needed is the robotics toolbox of P. Corke [4] Release 9. The toolbox can be downloaded at http://petercorke.com/Robotics_Toolbox.html.

III. Workflow

The script gradeHand.m shows how to get the results for the SensorHand Model. For other hands the hand model file has to be adapted or the fingertip poses can be calculated in another program. More on that can be found in Section IV. When using a hand model in our Matlab environment the workflow is the following.

1) Create a hand model (sensorhandmodel.m)
2) Calculate the fingertip poses via forward kinematics (robotfkine.m)
3) Scale the fingertip data (scaleData.m)
4) Project the data to 2D (data2latent.m)
5) Calculate the coverage (handMetricBox.m)
6) Visualize the results in the 2D space (plotProjection.m)

A. Coordinate Systems

Figure 1 shows the definition of the coordinate systems. It is important to be in accordance with that definition as otherwise the projection will not work properly as the fingertip coordinates would be different. The origin of the hand coordinate system (Figure 1(a)) is set at the MCP joint of the middle finger. That guarantees that the points will be well aligned with the human dataset. For the fingertip coordinate system (Figure 1(b)) the origin is in the middle of the distal segment, located underneath the fingertip.

Other important definitions:

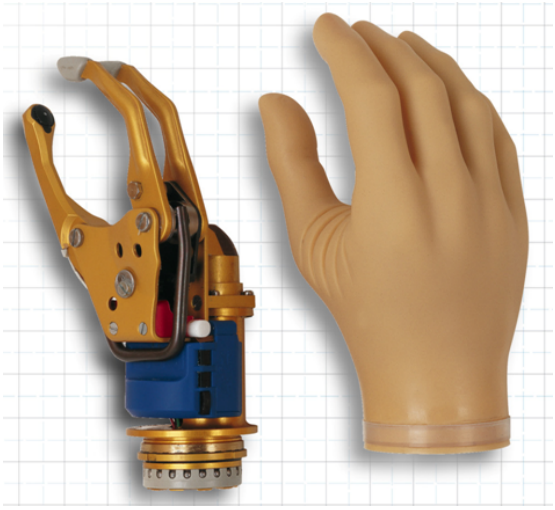

Fig. 2. The Otto Bock SensorHand, the left picture shows the hand without the covering glove. The right picture presents the glove that is put over the hand for protection of the hand and for cosmetic reasons. That results in a 5-digit design.

- All rotations are parameterized in rotation matrices. That means that one 3D rotation is defined with a set of 9 variables.
- All lengths are in cm.
- The handlength of the human hand is measured from the tip of the longest finger to the wrist crease baseline, similar to [5].

B. Scaling

The function scaleData.m scales the positional variables to a standard range and translates the positions so that they are aligned with the human MCP joint. [1]

IV. Generation of Fingertip Dataset of the Artificial Hand

In order to measure the coverage of a hand a set of fingertip postures is needed. They can be obtained in two different ways. The first one is to translate the kinematic data of the hand into our Matlab environment. A sample hand file is provided and one would have to adapt the DH parameters, the base and fingertip matrices in order to change the model.

A. In our Matlab Environment

We provide you with the model of the Otto Bock SensorHand. The hand has one coupled DoF which is opening and closing the hand. Therefore it is easy to calculate the corresponding joint angles. That is just a number of equally spaced samples. For more complex hands the space of hand configurations has to be sampled either random or in a systematic way.

The model is stored in the sensorhandmodel.m file. It returns the data of the robotic hand (5 manipulators of type robot) the joint values, the labels (lbls) and the handlength.

If you want to create a hand in our environment we recommend using the sensorhandmodel.m as start and adapt the function so that it fits your hand. You will have to define the DH parameters of the 5 fingers, the parameters of the finger base and an rotation at the fingertips. To visualize the hand you created the function visualizeHand.m can be used.

[1]The functions which visualize the 3D positions of the fingertips transform the human fingertip the other direction so that the MCP joint is located at (0,0,0). However, the data which was used for training the projection does not have the MCP joint at (0,0,0).

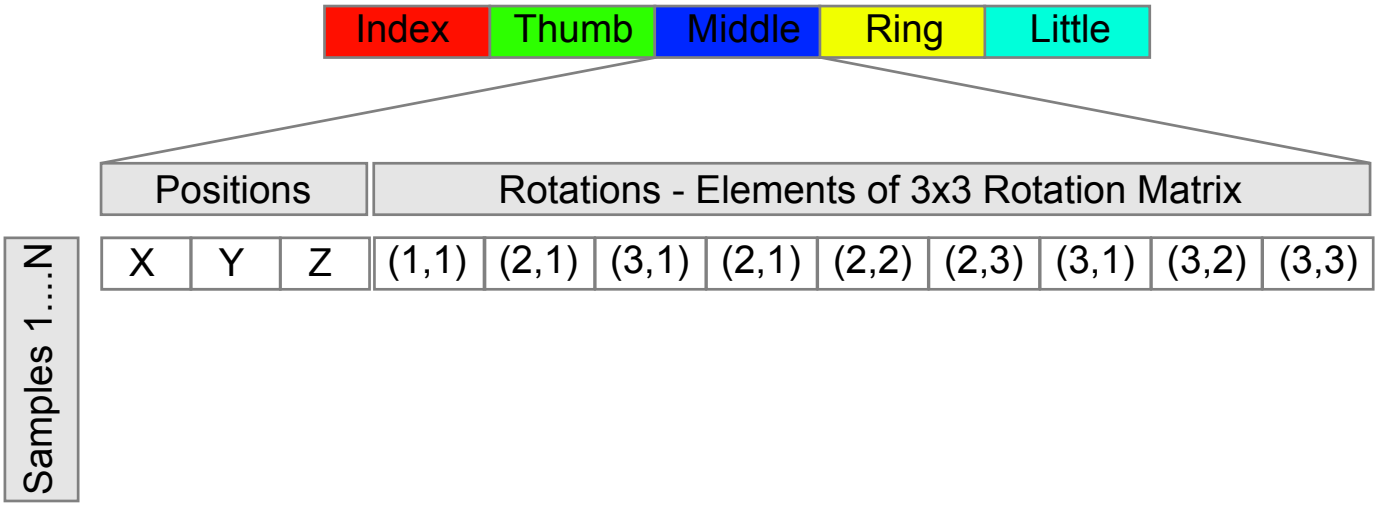

Fig. 3. Format of the matrix which stores the fingertip postures. The color code is in accordance to the colors of the visualization functions.

B. In an External Environment

It is also possible to use your own software or environment to calculate the fingertip postures. Make sure that the rotations are stored in rotation matrices and the format of the datamatrix is in accordance to Figure 3. In the file gradeHand.m the matrix with the fingertip postures correspond to the variable datamat. Additionally a labels variable (lbls) and the handlength has to be defined. The first function relevant in that case is scaleData.m, which is responsible for the scaling of the positions.

V. Revision History

A. Release 1

- Initial Release

B. Release 2, Aug. 28, 2012

- Some bugs fixed
- Included dist2.m in the distribution

C. Release 2.1, Dez. 18, 2012

- Adapted code to work with the Robotics Toolbox Release 9.
- Changed the sampling of the joint angles in sensorhandmodel.m

References

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[3] T. Feix, J. Romero, C.-H. Ek, H.-B. Schmiedmayer, and D. Kragic, "A metric for comparing the anthropomorphic motion capability of artificial hands," *Robotics, IEEE Transactions on*, to appear.

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