Chapter 5
Visualization and Setup Evaluation

One field of application for the capability map is the visualization and inspection of the robot arm workspace. In this chapter, the workspace is visualized for several robot arms and discussed with respect to potential tasks. Furthermore, the capability map is used to objectively evaluate the quality of a setup for human robot interaction.

5.1 Robot Arm Workspace Visualization

When no task specification is given, the capability map can be used to identify categories of tasks that the robot is suitable for. Given a task description, the suitability of the robot can be determined. The visualization of the capability map can be used for workspace and failure analysis. It can be determined which regions the robot can reach in a versatile manner.

5.1.1 Visualization for Industrial Robots

Kuka KR16

The Kuka KR16 \cite{59} is an industrial robot. It is designed to have a big workspace and to be able to accomplish manufacturing tasks in its whole workspace. The KR16 is a general purpose robot and its capability map reflects this. In Figure 5.1, the capability map for the 6 DOF Kuka KR16 industrial robot is shown. The color encodes the reachability index $D$. The index $D$ is high (blue region) throughout the whole workspace. The TCP frame is shown as a coordinate system at the flange of the robot. The last axis of the robot performs a rotation about the $z$-axis of this TCP. Because of the link limits of $\pm 350^\circ$ for this axis, the indices $D$ and $D_o$ are identical throughout the workspace. In Figure 5.1, it can be seen that the dexterous workspace volume for the chosen TCP is empty. The maximum length of the KR16 is 2.5 times that of the DLR LWR. Due to memory limitations, the sphere diameter for the capability map of this robot arm is $l_c = 0.1 \, \text{m}$.
Fig. 5.1 Capability map is visualized for the Kuka KR16, a general purpose industrial robot. The color encodes the reachability index $D$. The reachability index is high (blue region) throughout the whole workspace. The coordinate system at the flange of the robot shows the pose of the TCP frame. The x-axis is shown by the red arrow, the y-axis by the green arrow and the z-axis by the blue arrow.

Schunk PowerCube Arm

The capability map for the Schunk 6 DOF PowerCube light weight robot arm [98] is significantly different. The workspace is smaller than that of the DLR LWR due to the shorter arm length (0.9 m) and the arm’s capabilities in its workspace are much more restricted. In Figure 5.2, the capability map is shown. The color encodes the reachability index $D_o$. The arm can be attached to a mobile base as shown in Figure 5.3. To indicate the workspace to the front of the robot, the first rotation axis of the robot arm is shown by a white arrow. The map for the Kuka KR16 has a mean reachability index $D_o$ of 52.8, while the map for the PowerCube robot arm has only $D_o = 19.5$. Also the maximum value of this index differs significantly. The KR16 robot has many regions (dark blue, $D_o = [78 – 87]$) that it can reach in a nearly dexterous manner, i.e. from all possible directions. In contrast the PowerCube arm, has a reachability index of 52 at maximum. As seen in Figure 5.2 the best reachable region for the Schunk arm is at shoulder height. If the arm should serve as the arm of a humanoid robot and accomplish human-like manipulation tasks this is clearly undesirable. The human often manipulates with the arm bend at 90°. Therefore, the best reachable region for a manipulator intended for human-like manipulation