

ROBOTICS

ASSIGNMENT 5

BY

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1 Assignment 5

1.1 Task 1

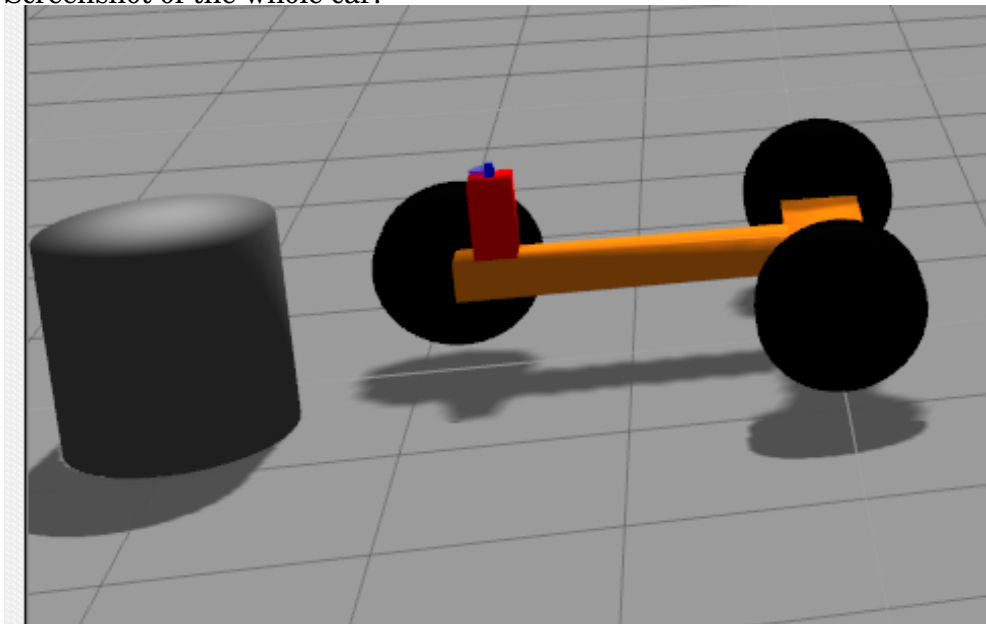
We already switched from jade to indigo for the last assignment, as can be seen in the attached picture from last week.

```
ERROR: cannot launch node of type [controller_manager/spawner]: controller_manager
ROS path [0]=/opt/ros/indigo/share
ROS path [1]=/home/doufu/workspaces/robotics/Robotik/ros/src
ROS path [2]=/home/doufu/workspaces/robotics/Robotik/ros/src
ROS path [3]=/opt/ros/indigo/share
ROS path [4]=/opt/ros/indigo/stacks
Gazebo multi-robot simulator, version 2.2.3
Copyright (C) 2012-2014 Open Source Robotics Foundation.
Released under the Apache 2 license.
http://gazebo.in.org

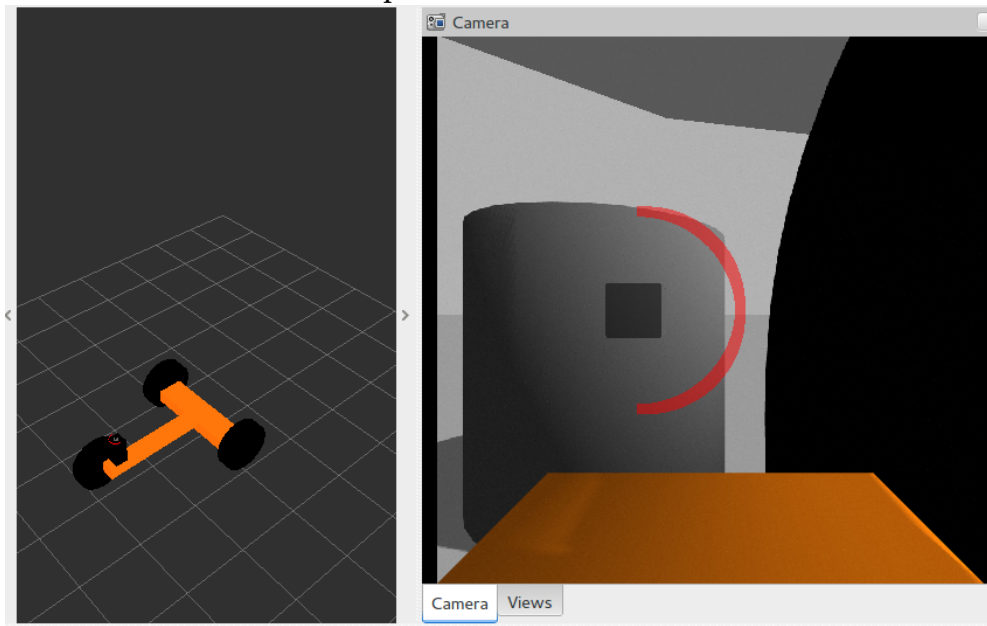
Msg: Waiting for master
Msg: Connected to gazebo master @ http://127.0.0.1:11345
Msg: Publicized address: 192.168.0.103
[ INFO] [1447703713.034499344]: Finished loading Gazebo ROS API Plugin.
[ INFO] [1447703713.049424603]: waitForService: Service [/gazebo/set_physics_properties] has not been advertised, waiting...
Msg: Waiting for master
Msg: Connected to gazebo master @ http://127.0.0.1:11345
Msg: Publicized address: 192.168.0.103
spawn_model script started
[INFO] [WallTime: 1447703713.414476] [0.000000] Loading model xml from ros parameter
[INFO] [WallTime: 1447703713.426803] [0.000000] Waiting for service /gazebo/spawn_urdf_model
[INFO] [WallTime: 1447703713.436958] [0.000000] Calling service /gazebo/spawn_urdf_model
[ INFO] [1447703713.956413577, 0.001000000]: Camera Plugin (robotNamespace = single_rrbot), Info: Using the 'robotNamespace' param: 'single_rrbot'
[INFO] [WallTime: 1447703713.967615] [0.001000] Spawn status: SpawnModel: Successfully spawned model
[ INFO] [1447703714.084895889, 0.001000000]: Camera Plugin (ns = single_rrbot) <tf_prefix>, set to "single_rrbot"
[ INFO] [1447703714.095392794, 0.001000000]: Laser Plugin (robotNamespace = single_rrbot), Info: Using the 'robotNamespace' param: 'single_rrbot'
[ INFO] [1447703714.095776597, 0.001000000]: Starting GazeboRosLaser Plugin (ns = single_rrbot)!
Error [Plugin.hh:156] Failed to load plugin librrbot_hw_sim_plugin.so: librrbot_hw_sim_plugin.so: cannot open shared object file: No such file or directory
```

1.2 Task 2

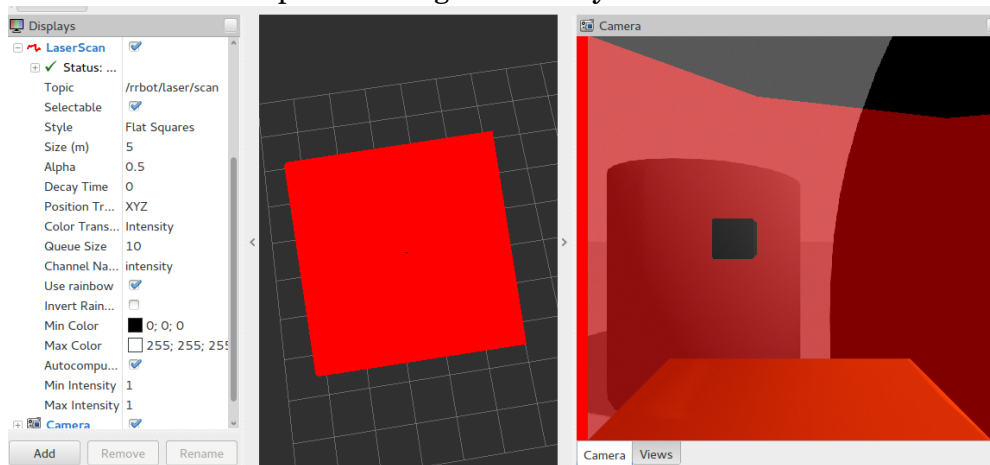
Screenshot of the whole car:



Screenshot of the camera-picture:



Screenshot of the point cloud generated by the laser-scanner:



1.3 Task 3

$$\begin{aligned}\alpha_1 &= 0 \\ d_1 &= L_1 \\ \Theta_1 &= 180 \pm \epsilon_{\Theta_1} \\ a_1 &= 0\end{aligned}$$

$$\begin{aligned}\alpha_2 &= 90 \pm \epsilon_{\alpha_2} \\ d_2 &= 0 \\ \Theta_2 &= 45 \pm \epsilon_{\Theta_2} \\ a_2 &= 0\end{aligned}$$

$$\begin{aligned}\alpha_3 &= 0 \\ d_3 &= 0 \\ \Theta_3 &= 45 \pm \epsilon_{\Theta_3} \\ a_3 &= L_2\end{aligned}$$

$$\begin{aligned}\alpha_4 &= 90 \pm \epsilon_{\alpha_4} \\ d_4 &= d_4 \\ \Theta_4 &= 0 \pm \epsilon_{\Theta_4} \\ a_4 &= 0\end{aligned}$$

$$\begin{aligned}\Theta_1 &= 180 \pm \epsilon_{\Theta_1} \\ \Theta_2 &= 45 \pm \epsilon_{\Theta_2} \\ \Theta_3 &= 45 \pm \epsilon_{\Theta_3}\end{aligned}$$

Annahme: Der Ursprung von Koordinatensystem 4 ist um d_4 vom Ursprung des Koordinatensystems 3 in der Tiefe (d) verschoben.

$$\begin{aligned}T_3^2(\alpha_2, a_2, \Theta_3, d_3) &= \begin{pmatrix} \cos(\Theta_i) & -\sin(\Theta_i) & 0 & a_{i-1} \\ \sin(\Theta_i) \cdot \cos(\alpha_{i-1}) & \cos(\Theta_i) \cdot \cos(\alpha_{i-1}) & -\sin(\alpha_{i-1}) & -\sin(\alpha_{i-1}) \cdot d_i \\ \sin(\Theta_i) \cdot \cos(\alpha_{i-1}) & \cos(\Theta_i) \cdot \sin(\alpha_{i-1}) & \cos(\alpha_{i-1}) & \cos(\alpha_{i-1}) \cdot d_i \\ 0 & 0 & 0 & 1 \end{pmatrix} \\ T_3^2(\alpha_2, a_2, 45, d_3) &= \begin{pmatrix} \cos(45) & -\sin(45) & 0 & 0 \\ \sin(45) \cdot \cos(45) & \cos(45) \cdot \cos(45) & -\sin(45) & -\sin(90) \cdot 0 \\ \sin(45) \cdot \cos(90) & \cos(45) \cdot \sin(90) & \cos(90) & \cos(90) \cdot 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \\ T_3^2(\alpha_2, a_2, 45, d_3) &= \begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{\sqrt{2}} & 0 \\ 0 & \frac{1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\end{aligned}$$

1.4 Task 4

1.4.1 a)

$$\begin{aligned}
 {}^0_3A(q_1, q_2, q_3) &= {}^0_1A(q_1) \cdot {}^1_2A(q_2) \cdot {}^2_3A(q_3) \\
 {}^0_3A &= \begin{pmatrix} \cos(\Theta_1) & -\sin(\Theta_1) & 0 & 0 \\ \sin(\Theta_1) & \cos(\Theta_1) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_2 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{pmatrix} \\
 {}^0_3A &= \begin{pmatrix} \cos(\Theta_1) & -\sin(\Theta_1) & 0 & 0 \\ \sin(\Theta_1) & \cos(\Theta_1) & 0 & 0 \\ 0 & 0 & 1 & d_2 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{pmatrix} \\
 {}^0_3A &= \begin{pmatrix} \cos(\Theta_1) & -\sin(\Theta_1) & 0 & 0 \\ \sin(\Theta_1) & \cos(\Theta_1) & 0 & 0 \\ 0 & 0 & 1 & d_2 + d_3 \\ 0 & 0 & 0 & 1 \end{pmatrix}
 \end{aligned}$$

Beschreibung der Koordinaten des Zielsystems:

$$\begin{aligned}
 f : \mathbb{R}^3 &\longrightarrow \mathbb{R}^3 \\
 f &= B \\
 B &= \begin{pmatrix} \cos(\Theta_1) & -\sin(\Theta_1) & 0 \\ \sin(\Theta_1) & \cos(\Theta_1) & 0 \\ 0 & 0 & d_2 + d_3 \end{pmatrix} \\
 x &= \cos(\Theta_1) - \sin(\Theta_1) \\
 y &= \sin(\Theta_1) + \cos(\Theta_1) \\
 z &= d_2 + d_3
 \end{aligned}$$

1.4.2 b)

$$\frac{x}{d\Theta_1} = -\sin(\Theta_1) - \cos(\Theta_1)$$

$$\frac{x}{dd_2} = 0$$

$$\frac{x}{dd_3} = 0$$

$$\frac{y}{d\Theta_1} = -\sin(\Theta_1) + \cos(\Theta_1)$$

$$\frac{y}{dd_2} = 0$$

$$\frac{y}{dd_3} = 0$$

$$\frac{z}{d\Theta_1} = 0$$

$$\frac{z}{dd_2} = 1$$

$$\frac{z}{dd_3} = 1$$

1.4.3 c)

$$J(q) = \begin{pmatrix} -\sin(q_1) - \cos(q_1) & -\sin(q_1) + \cos(q_1) & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{pmatrix}$$