

Software Development for Industrial Robots

OpenRAVE

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Overview

- 1 Introduction to OpenRAVE
- 2 Installation
- 3 Getting starting with OpenRave
- 4 OpenRAVE - Programming
- 5 Simple Examples



Introduction to OpenRAVE

History

- environment for testing, developing, deploying motion planning algorithms in real-world robotics applications
- founded by Rosen Diankov at Quality of Life Technology Center in Carnegie Mellon University Robotics Institute in 2006

Rosen Diankov – Developer of
OpenRAVE [OpenRave]

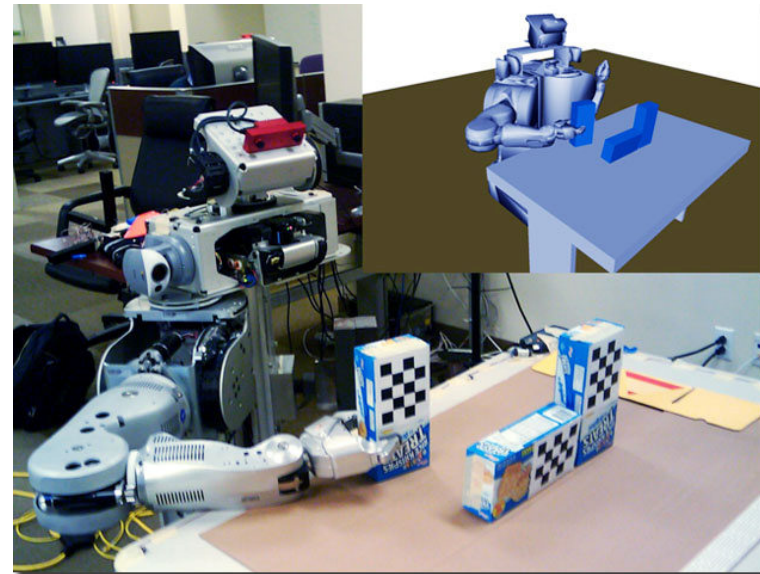


Introduction to OpenRAVE

Characteristics

- simulation, analysis of kinematic and geometric information related to motion planning
- easily integrated into existing robotics systems because of OpenRAVE's stand-alone nature
- plugin architecture easily write custom controllers or extend functionality
- important target application: industrial robotics automation

Application of OpenRAVE [OpenRave]



Installation

Linux (Ubuntu)

Shell-Commands for installation

- `sudo add-apt-repository ppa:openrave/release`
- `sudo apt-get update`
- `sudo apt-get install openrave`

Setting Environment Variable

- `export PYTHONPATH=$PYTHONPATH:'openrave-config --python-dir'`

Installation

Windows

Download link

- http://openrave.org/docs/latest_stable/install/#install

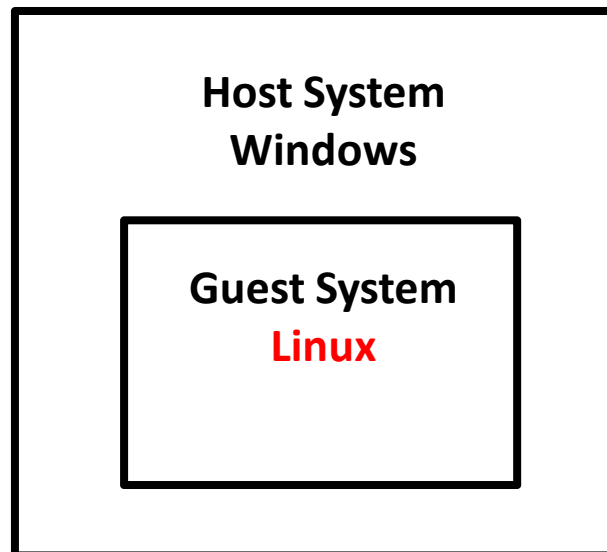
Required libs

- Boost 1.44
- Qt 4.7.1
- Python 2.6
- Python NumPy 1.6.0
- Python SymPy 0.7.1
- Python SetupTools 0.6c11 Library
- boost_xx_44.dll
- ...
- **Suggestion:** use a virtual linux machine

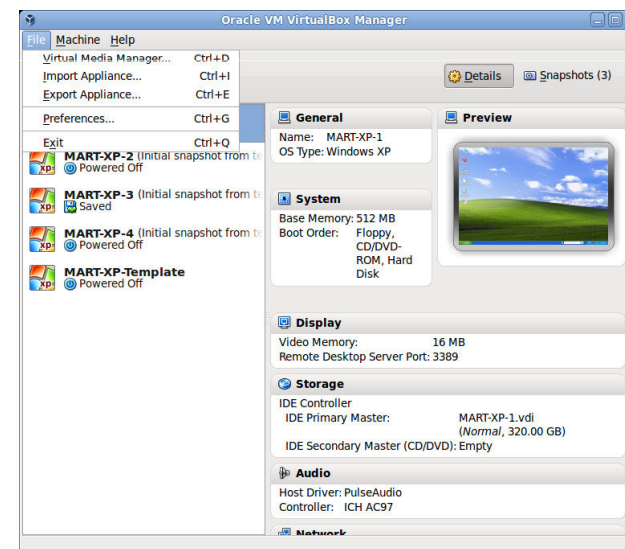
Installation Virtual Machine

Download link

- <https://www.virtualbox.org/wiki/Downloads>
- Embedding given virtual machine
- File->Appliance import



Principle of a virtual machine



GUI of VirtualBox

Getting started with OpenRAVE

Documentation

2 main components

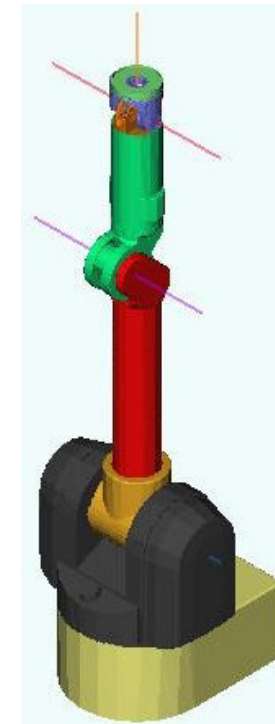
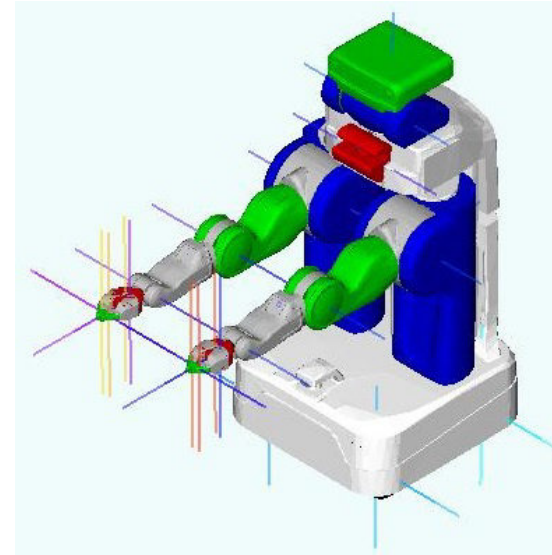
- openravepy_int
- openravepy_ext

3 major subcomponents

- databases Package
- examples Package
- interfaces Package

Quick Links

- Python API
- Core C++ API
- Developers Guide



Robots from OpenRAVE Database
[OpenRave]

Getting started with OpenRAVE

Execution

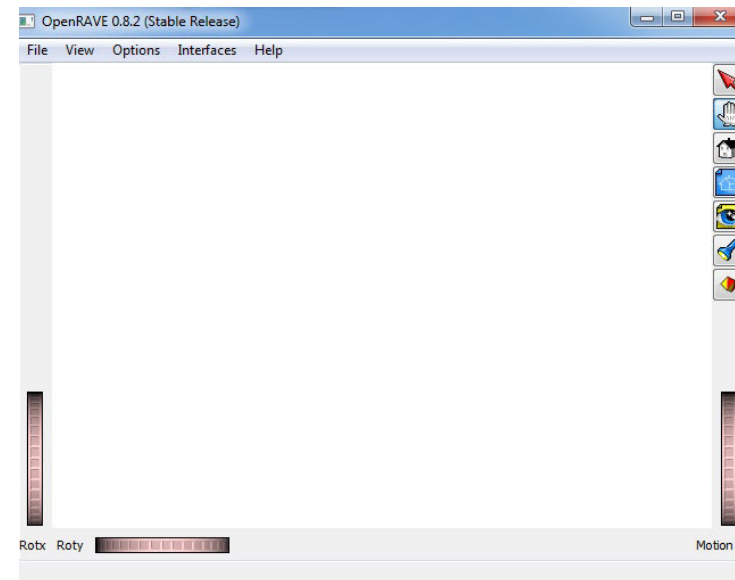
IDLE

- Open python file (openrave.py)
- Execute with F5

Windows Command Prompt (cmd)

- Change directory to ...
- Execute openrave.py

OpenRAVE GUI [OpenRave]



OpenRAVE

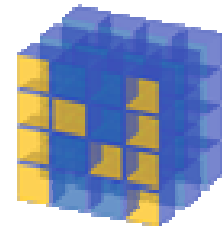
Programming – Basics

OpenRAVE

- http://openrave.org/docs/latest_stable/getting_started/#getting-started

Python, NumPy and SciPy

- <http://www.python.org/>
- <http://www.numpy.org/>
 - Efficient data structures for numerical work
 - Matrix / vector manipulation (for our purpose)
- <http://www.scipy.org/>
 - Additional routines for scientific work
 - Integrals, differential equations, optimization



OpenRAVE

Programming – Code examples

NumPy

```
import numpy as np

#initialization vector
v1 = np.array([0,1,2,3,4])
V2 = np.arange(5)
#initialization matrix
A1 = np.mat([[1,2,3], [4,5,6]])
A2 = np.mat('[1 2 3; 4 5 6]')
A3 = np.array([[1,2,3], [4,5,6]])

#multiplication
V1 * v2
A1 * A2.T
A1.T
A1.I
```

OpenRAVE

Programming – Code examples

OpenRAVE

```
import openravepy as rave
import numpy as np

env = rave.Environment()
env.SetViewer('qtcoin')
env.Load('data/lab1.env.xml')

# your robot code ...
robot = env.GetRobots()[0]      # first robot
rodies = env.GetBodies()        # list of all bodies

robot[bodies].Set[Get]Transform[DOF, DOFValues,...]()
# for more information lookup the example on the website
```

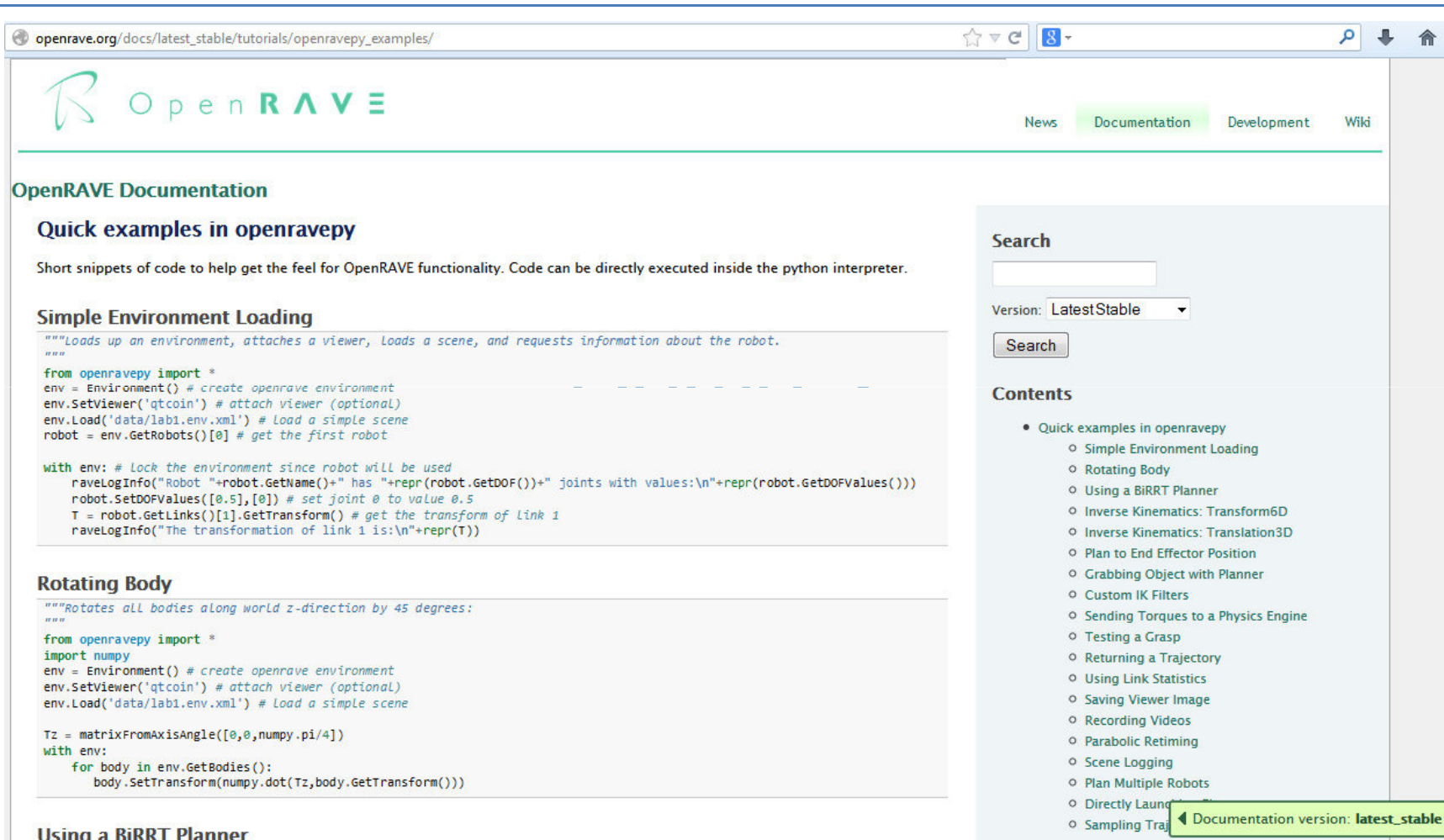
OpenRAVE

Programming – Short demonstration

Demo 1

OpenRAVE

Programming – Short demonstration



The screenshot shows the OpenRAVE website with the URL `openrave.org/docs/latest_stable/tutorials/openravepy_examples/`. The page features a navigation bar with links for News, Documentation, Development, and Wik. The main content area is titled "OpenRAVE Documentation" and includes a section for "Quick examples in openravepy". Below this, there are two code examples: "Simple Environment Loading" and "Rotating Body". The "Simple Environment Loading" example shows how to create an environment, load a scene, and get information about the robot. The "Rotating Body" example shows how to rotate all bodies along the world z-direction by 45 degrees. On the right side, there is a search bar and a "Contents" section listing various topics. A green box at the bottom right of the page indicates the documentation version is "latest_stable".

openrave.org/docs/latest_stable/tutorials/openravepy_examples/

OpenRAVE

News Documentation Development Wik

OpenRAVE Documentation

Quick examples in openravepy

Short snippets of code to help get the feel for OpenRAVE functionality. Code can be directly executed inside the python interpreter.

Simple Environment Loading

```
"""Loads up an environment, attaches a viewer, loads a scene, and requests information about the robot.
"""
from openravepy import *
env = Environment() # create openrave environment
env.SetViewer('qtcoin') # attach viewer (optional)
env.Load('data/lab1.env.xml') # load a simple scene
robot = env.GetRobots()[0] # get the first robot

with env: # Lock the environment since robot will be used
    ravelogInfo("Robot "+robot.GetName()+" has "+repr(robot.GetDOF())+" joints with values:\n"+repr(robot.GetDOFValues()))
    robot.SetDOFValues([0.5],[0]) # set joint 0 to value 0.5
    T = robot.GetLinks()[1].GetTransform() # get the transform of link 1
    ravelogInfo("The transformation of link 1 is:\n"+repr(T))
```

Rotating Body

```
"""Rotates all bodies along world z-direction by 45 degrees:
"""
from openravepy import *
import numpy
env = Environment() # create openrave environment
env.SetViewer('qtcoin') # attach viewer (optional)
env.Load('data/lab1.env.xml') # load a simple scene

Tz = matrixFromAxisAngle([0,0,numpy.pi/4])
with env:
    for body in env.GetBodies():
        body.SetTransform(numpy.dot(Tz,body.GetTransform()))
```

Using a BiRRT Planner

Search

Version: LatestStable

Search

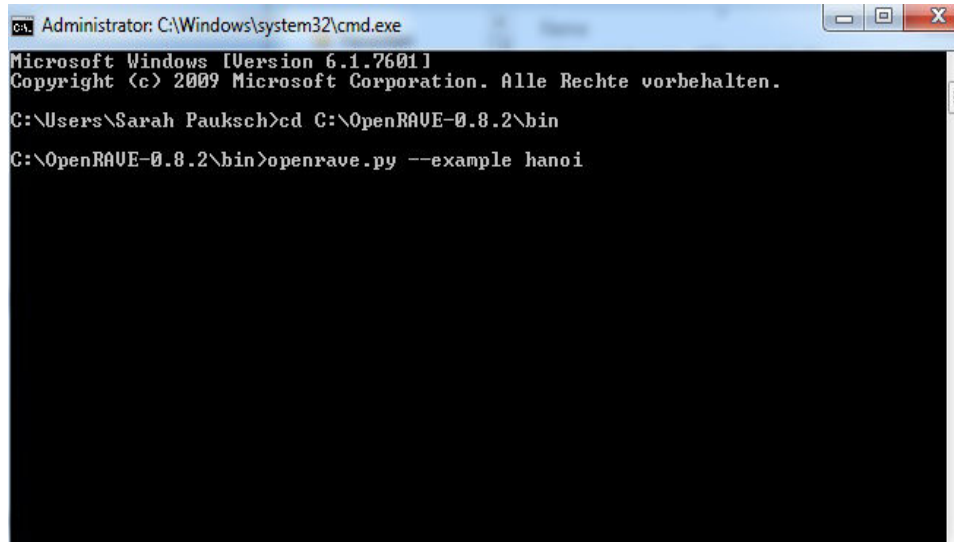
Contents

- Quick examples in openravepy
 - Simple Environment Loading
 - Rotating Body
 - Using a BiRRT Planner
 - Inverse Kinematics: Transform6D
 - Inverse Kinematics: Translation3D
 - Plan to End Effector Position
 - Grabbing Object with Planner
 - Custom IK Filters
 - Sending Torques to a Physics Engine
 - Testing a Grasp
 - Returning a Trajectory
 - Using Link Statistics
 - Saving Viewer Image
 - Recording Videos
 - Parabolic Retiming
 - Scene Logging
 - Plan Multiple Robots
 - Directly Launching
 - Sampling Trajectories

Documentation version: latest_stable

Screenshot openrave.org

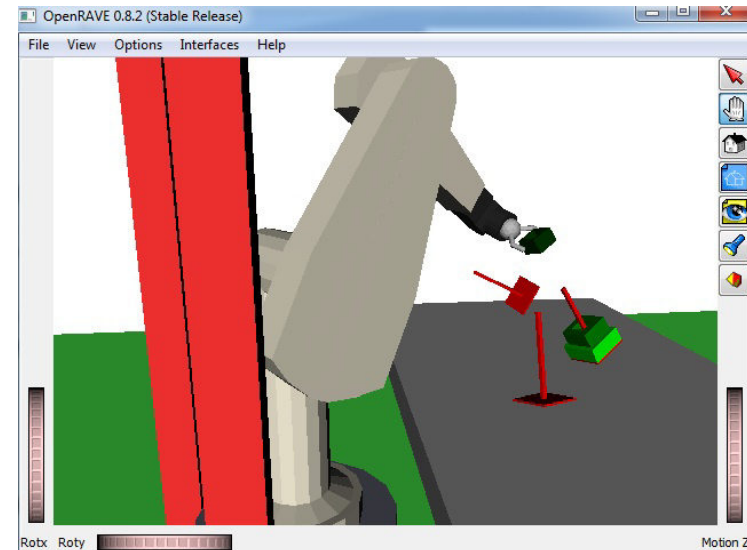
Simple Example



```
Administrator: C:\Windows\system32\cmd.exe
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. Alle Rechte vorbehalten.

C:\Users\Sarah Pauksch>cd C:\OpenRAVE-0.8.2\bin
C:\OpenRAVE-0.8.2\bin>openrave.py --example hanoi
```

CMD with python command

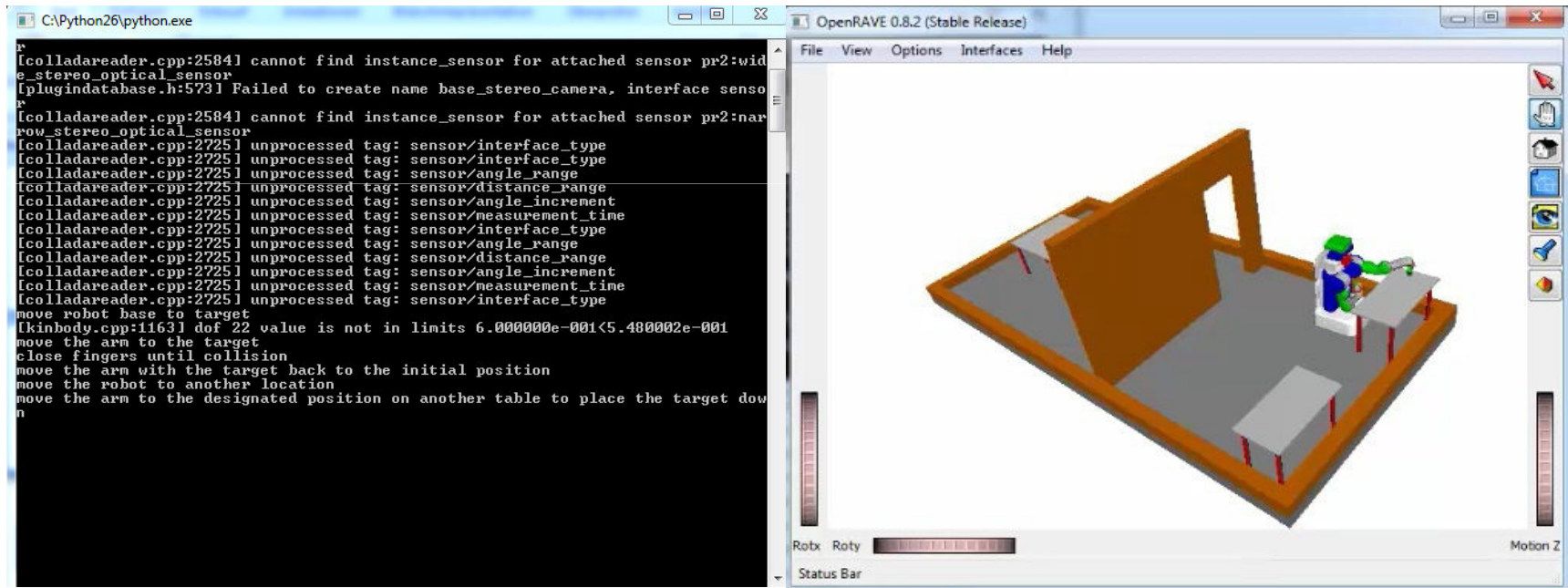


OpenRAVE 0.8.2 with example „Hanoi“

- Open example with CMD command or click on .py in examplefile
→ console and OpenRave will be open and present the process

Simple Example

- Look in examplecode
 - Right click to .py → “Edit with IDLE”



OpenRAVE 0.8.2 with example „simplemanipulation“

Literature

- [OpenRave]
 - <http://www.openrave.org>
 - http://openrave.org/docs/latest_stable/getting_started/#getting-started
 - <http://www.programmingvision.com>
- [Python]
 - www.python.org
 - <http://www.numpy.org/>
 - <http://www.scipy.org/>
- [Tools]
 - <https://www.virtualbox.org/wiki/Downloads>

Important files in Linux and Windows

Linux

- Examples:
 - /usr/lib/pythonX.X/dist-packages/openravepy/_openrave_0_8/
- Data:
 - /usr/share/openrave-0.8/

Windows

- Examples:
 - C:\OpenRAVE-0.8.2\Lib\site-packages\openravepy_openravepy_examples
- Data:
 - C:\OpenRAVE-0.8.2\share\openrave-0.8