Tutorial for OpenRave installation & ikfast library on Ubuntu

Ray

2020/08/24

Install openrave references

- Ubuntu16.04:

https://scaron.info/teaching/installing-openrave-on-ubuntu-16.04.html

- Ubuntu14.04:

https://scaron.info/teaching/installing-openrave-on-ubuntu-14.04.html

- openrave-installation (easy step)

https://github.com/crigroup/openrave-installation

Dependencies

First, make sure the following programs are installed on your system:

```
sudo apt-get install cmake g++ git ipython minizip python-dev python-h5py python-numpy python-scipy python-sympy qt4-dev-tools
```

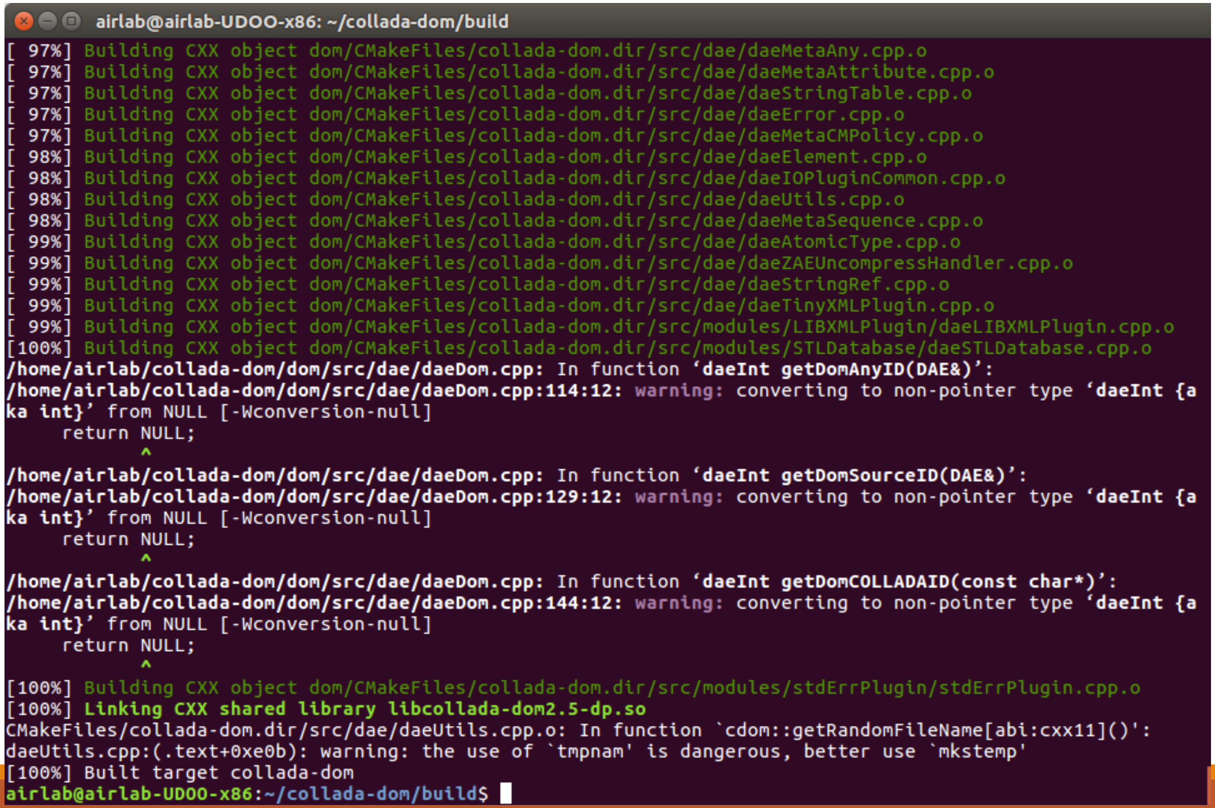
Next, you will need to install the following libraries from the official Ubuntu repository:

```
sudo apt-get install libassimp-dev libavcodec-dev libavformat-dev libavformat-dev libboost-all-dev libboost-date-time-dev libbullet-dev libfaac-dev libglew-dev libgsm1-dev liblapack-dev liblog4cxx-dev libmpfr-dev libode-dev libogg-dev libpcrecpp0v5 libpcre3-dev libqhull-dev libqt4-dev libsoqt-dev-common libsoqt4-dev libswscale-dev libswscale-dev libvorbis-dev libx264-dev libxml2-dev libxvidcore-dev
```

Dependencies

- The next dependency is collada-dom, which you can clone from Github and build from source as well:

```
git clone https://github.com/rdiankov/collada-dom.git
cd collada-dom && mkdir build && cd build
cmake ..
make -j4
sudo make install
```

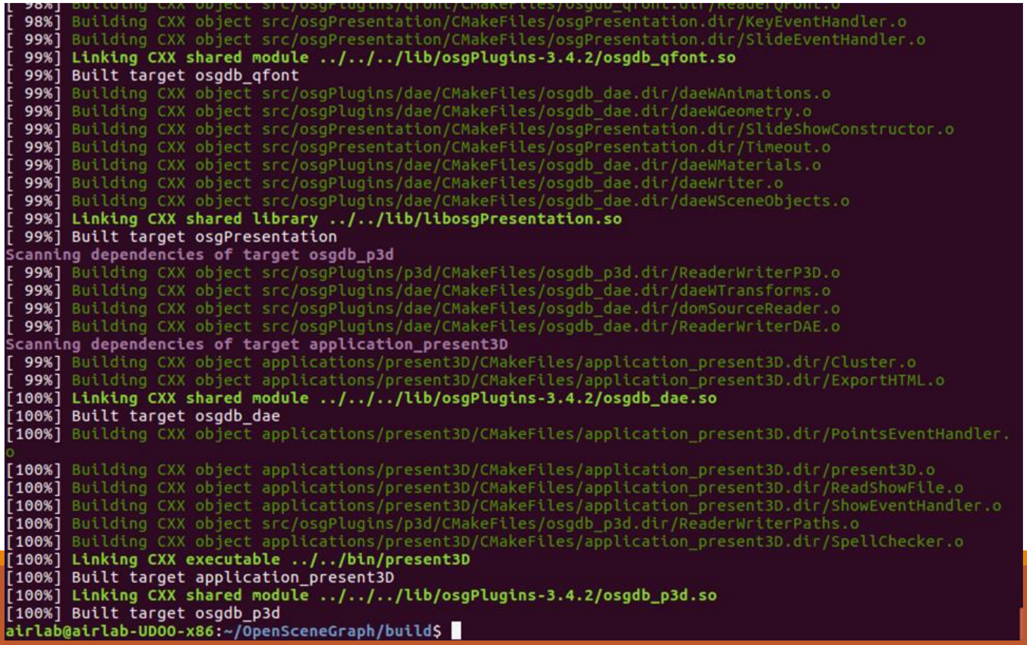


```
[ 97%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeMetaAny.cpp.o
[ 97%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeMetaAttribute.cpp.o
[ 97%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeStringTable.cpp.o
[ 97%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeError.cpp.o
[ 97%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeMetaCMPolicy.cpp.o
[ 98%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeElement.cpp.o
[ 98%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeIOPluginCommon.cpp.o
[ 98%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeUtils.cpp.o
[ 98%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeMetaSequence.cpp.o
[ 99%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeAtomicType.cpp.o
[ 99%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeZAEUncompressHandler.cpp.o
[ 99%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeStringRef.cpp.o
[ 99%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/dae/daeTinyXMLPlugin.cpp.o
[ 99%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/modules/LIBXMLPlugin/daeLIBXMLPlugin.cpp.o
[100%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/modules/STLDatabase/daeSTLDatabase.cpp.o
/home/airlab/collada-dom/dom/src/dae/daeDom.cpp: In function ‘daeInt getDomAnyID(DAE&)’:
/home/airlab/collada-dom/dom/src/dae/daeDom.cpp:114:12: warning: converting to non-pointer type ‘daeInt {a
ka int}’ from NULL [-Wconversion-null]
     return NULL;
            ^
/home/airlab/collada-dom/dom/src/dae/daeDom.cpp: In function ‘daeInt getDomSourceID(DAE&)’:
/home/airlab/collada-dom/dom/src/dae/daeDom.cpp:129:12: warning: converting to non-pointer type ‘daeInt {a
ka int}’ from NULL [-Wconversion-null]
     return NULL;
            ^
/home/airlab/collada-dom/dom/src/dae/daeDom.cpp: In function ‘daeInt getDomCOLLADAID(const char*)’:
/home/airlab/collada-dom/dom/src/dae/daeDom.cpp:144:12: warning: converting to non-pointer type ‘daeInt {a
ka int}’ from NULL [-Wconversion-null]
     return NULL;
            ^
[100%] Building CXX object dom/CMakeFiles/collada-dom.dir/src/modules/stdErrPlugin/stdErrPlugin.cpp.o
[100%] Linking CXX shared library libcollada-dom2.5-dp.so
CMakeFiles/collada-dom.dir/src/dae/daeUtils.cpp.o: In function `cdom::getRandomFileName[abi:cxx11]()':
daeUtils.cpp:(.text+0xe0b): warning: the use of `tmpnam' is dangerous, better use `mkstemp'
[100%] Built target collada-dom
airlab@airlab-UDOO-x86:~/collada-dom/build$ 
```

OpenSceneGraph

- The following dependency is OpenSceneGraph. The version provided on the Ubuntu repository is 3.2, but OpenRAVE requires 3.4, so we are going to build it from source:

```
sudo apt-get install libcairo2-dev libjasper-dev libpoppler-glib-dev libsdl2-dev libtiff5-dev libxrandr-dev

git clone --branch OpenSceneGraph-3.4 https://github.com/openscenegraph/OpenSceneGraph.git

cd OpenSceneGraph && mkdir build && cd build

cmake .. -DDESIRED_QT_VERSION=4

make -j4

sudo make install
```

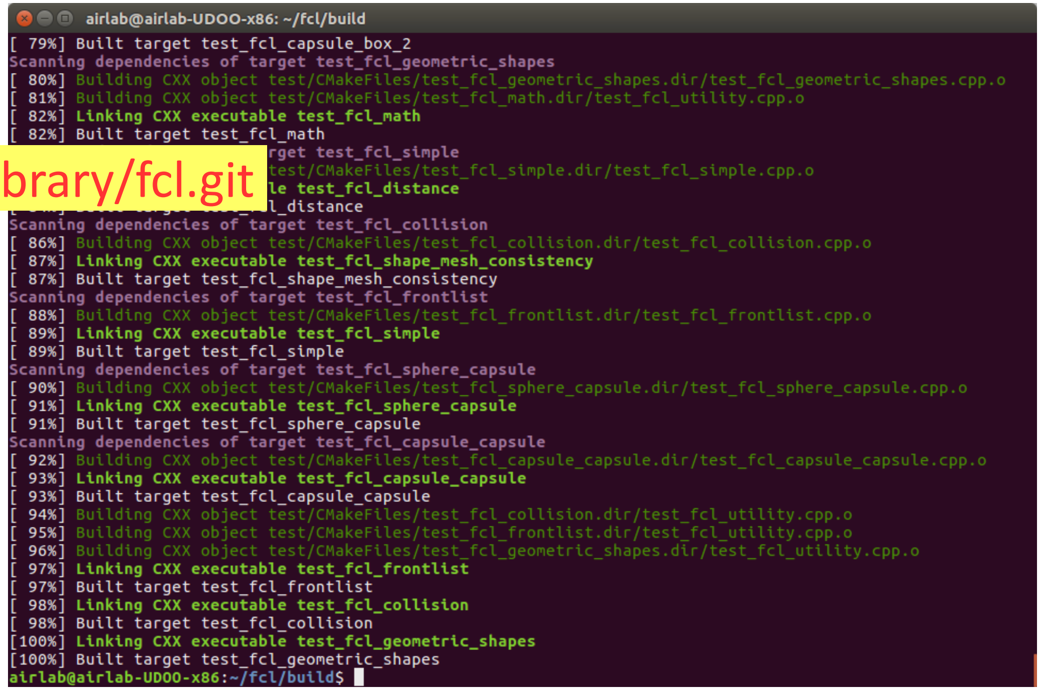


```
[ 98%] Building CXX object src/osgPlugins/qfont/CMakeFiles/osgdb_qfont.dir/ReaderQFont.o
[ 98%] Building CXX object src/osgPresentation/CMakeFiles/osgPresentation.dir/KeyEventHandler.o
[ 99%] Building CXX object src/osgPresentation/CMakeFiles/osgPresentation.dir/SlideEventHandler.o
[ 99%] Linking CXX shared module ../../../lib/osgPlugins-3.4.2/osgdb_qfont.so
[ 99%] Built target osgdb_qfont
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/daeWAnimations.o
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/daeWGeometry.o
[ 99%] Building CXX object src/osgPresentation/CMakeFiles/osgPresentation.dir/SlideShowConstructor.o
[ 99%] Building CXX object src/osgPresentation/CMakeFiles/osgPresentation.dir/Timeout.o
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/daeWMaterials.o
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/daeWriter.o
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/daeWSceneObjects.o
[ 99%] Linking CXX shared library ../../lib/libosgPresentation.so
[ 99%] Built target osgPresentation
Scanning dependencies of target osgdb_p3d
[ 99%] Building CXX object src/osgPlugins/p3d/CMakeFiles/osgdb_p3d.dir/ReaderWriterP3D.o
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/daeWTransforms.o
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/domSourceReader.o
[ 99%] Building CXX object src/osgPlugins/dae/CMakeFiles/osgdb_dae.dir/ReaderWriterDAE.o
Scanning dependencies of target application_present3D
[ 99%] Building CXX object applications/present3D/CMakeFiles/application_present3D.dir/Cluster.o
[ 99%] Building CXX object applications/present3D/CMakeFiles/application_present3D.dir/ExportHTML.o
[100%] Linking CXX shared module ../../../lib/osgPlugins-3.4.2/osgdb_dae.so
[100%] Built target osgdb_dae
[100%] Building CXX object applications/present3D/CMakeFiles/application_present3D.dir/PointsEventHandler.
o
[100%] Building CXX object applications/present3D/CMakeFiles/application_present3D.dir/present3D.o
[100%] Building CXX object applications/present3D/CMakeFiles/application_present3D.dir/ReadShowFile.o
[100%] Building CXX object applications/present3D/CMakeFiles/application_present3D.dir/ShowEventHandler.o
[100%] Building CXX object src/osgPlugins/p3d/CMakeFiles/osgdb_p3d.dir/ReaderWriterPaths.o
[100%] Building CXX object applications/present3D/CMakeFiles/application_present3D.dir/SpellChecker.o
[100%] Linking CXX executable ../../bin/present3D
[100%] Built target application_present3D
[100%] Linking CXX shared module ../../../lib/osgPlugins-3.4.2/osgdb_p3d.so
[100%] Built target osgdb_p3d
airlab@airlab-UDOO-x86:~/OpenSceneGraph/build$
```

Flexible Collision Library

- In new versions OpenRAVE defaults also require you to install the Flexible Collision Library:

```
sudo apt-get install libccd-dev
git clone https://github.com/flexible-collision-library/fcl.git
cd fcl
git checkout 0.5.0  # use FCL 0.5.0
mkdir build && cd build
cmake ..
make -j4
sudo make install
```



```
airlab@airlab-UDOO-x86: ~/fcl/build
[ 79%] Built target test_fcl_capsule_box_2
Scanning dependencies of target test_fcl_geometric_shapes
[ 80%] Building CXX object test/CMakeFiles/test_fcl_geometric_shapes.dir/test_fcl_geometric_shapes.cpp.o
[ 81%] Building CXX object test/CMakeFiles/test_fcl_math.dir/test_fcl_utility.cpp.o
[ 82%] Linking CXX executable test_fcl_math
[ 82%] Built target test_fcl_math
                            rget test_fcl_simple
                           test/CMakeFiles/test_fcl_simple.dir/test_fcl_simple.cpp.o
                            le test_fcl_distance
                          l_distance
Scanning dependencies of target test_fcl_collision
[ 86%] Building CXX object test/CMakeFiles/test_fcl_collision.dir/test_fcl_collision.cpp.o
[ 87%] Linking CXX executable test_fcl_shape_mesh_consistency
[ 87%] Built target test_fcl_shape_mesh_consistency
Scanning dependencies of target test_fcl_frontlist
[ 88%] Building CXX object test/CMakeFiles/test_fcl_frontlist.dir/test_fcl_frontlist.cpp.o
[ 89%] Linking CXX executable test_fcl_simple
[ 89%] Built target test_fcl_simple
Scanning dependencies of target test_fcl_sphere_capsule
[ 90%] Building CXX object test/CMakeFiles/test_fcl_sphere_capsule.dir/test_fcl_sphere_capsule.cpp.o
[ 91%] Linking CXX executable test_fcl_sphere_capsule
[ 91%] Built target test_fcl_sphere_capsule
Scanning dependencies of target test_fcl_capsule_capsule
[ 92%] Building CXX object test/CMakeFiles/test_fcl_capsule_capsule.dir/test_fcl_capsule_capsule.cpp.o
[ 93%] Linking CXX executable test_fcl_capsule_capsule
[ 93%] Built target test_fcl_capsule_capsule
[ 94%] Building CXX object test/CMakeFiles/test_fcl_collision.dir/test_fcl_utility.cpp.o
[ 95%] Building CXX object test/CMakeFiles/test_fcl_frontlist.dir/test_fcl_utility.cpp.o
[ 96%] Building CXX object test/CMakeFiles/test_fcl_geometric_shapes.dir/test_fcl_utility.cpp.o
[ 97%] Linking CXX executable test_fcl_frontlist
[ 97%] Built target test_fcl_frontlist
[ 98%] Linking CXX executable test_fcl_collision
[ 98%] Built target test_fcl_collision
[100%] Linking CXX executable test_fcl_geometric_shapes
[100%] Built target test_fcl_geometric_shapes
airlab@airlab-UDOO-x86:~/fcl/build$ 
```

- Due to this bug, I also needed to add the following symlink to get FCL to compile:

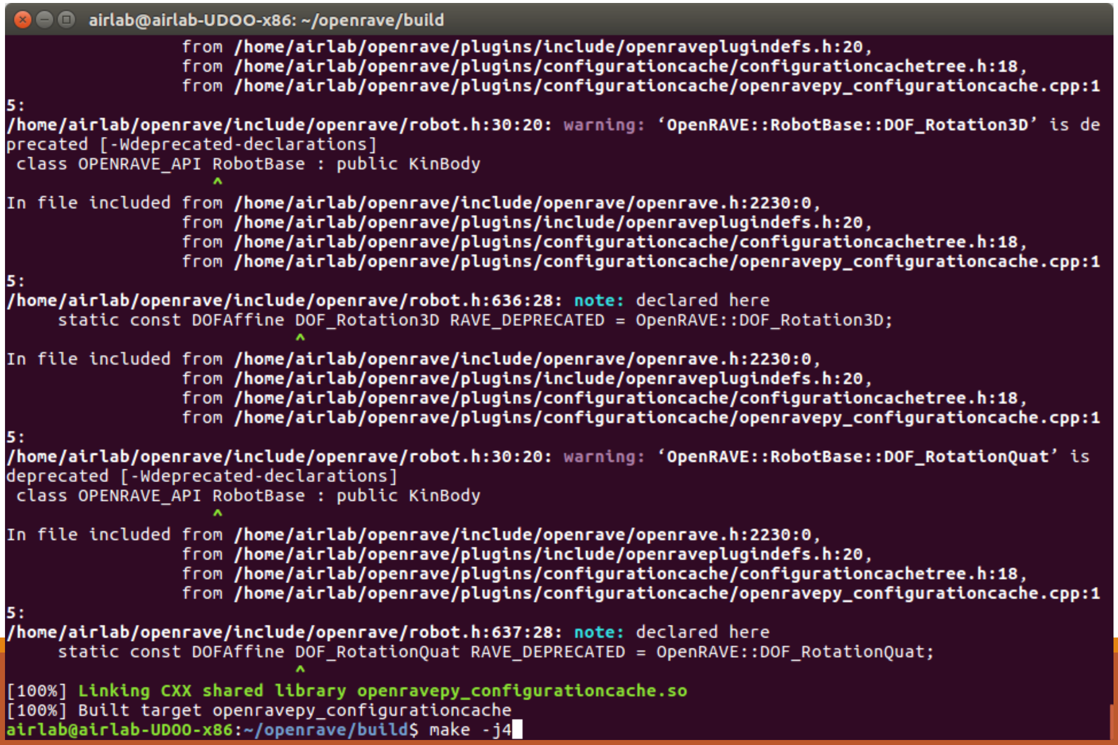
```
sudo ln -sf /usr/include/eigen3/Eigen /usr/include/Eigen
```

Alternatively, you can disable the FCL plugin by running ccmake . from your OpenRAVE build directory. Scroll down to OPENRAVE_PLUGIN_FCLRAVE and switch it to OFF.

Building OpenRAVE

- Once all this software is installed, clone the latest_stable branch of OpenRAVE from GitHub:

```
git clone --branch latest_stable https://github.com/rdiankov/openrave.git
# only run this if you don't need the latest version of OpenRAVE:
git checkout 9c79ea260e1c009b0a6f7c03ec34f59629ccbe2c
fatal: Not a git repository (or any of the parent directories): .git
cd openrave && mkdir build && cd build
cmake .. -DOSG_DIR=/usr/local/lib64/
make -j4
sudo make install
```



airlab@airlab-UDOO-x86: ~/openrave/build

```
                 from /home/airlab/openrave/plugins/include/openraveplugindefs.h:20,
                 from /home/airlab/openrave/plugins/configurationcache/configurationcachetree.h:18,
                 from /home/airlab/openrave/plugins/configurationcache/openravepy_configurationcache.cpp:1
5:
/home/airlab/openrave/include/openrave/robot.h:30:20: warning: ‘OpenRAVE::RobotBase::DOF_Rotation3D’ is de
precated [-Wdeprecated-declarations]
 class OPENRAVE_API RobotBase : public KinBody
                    ^
In file included from /home/airlab/openrave/include/openrave/openrave.h:2230:0,
                 from /home/airlab/openrave/plugins/include/openraveplugindefs.h:20,
                 from /home/airlab/openrave/plugins/configurationcache/configurationcachetree.h:18,
                 from /home/airlab/openrave/plugins/configurationcache/openravepy_configurationcache.cpp:1
5:
/home/airlab/openrave/include/openrave/robot.h:636:28: note: declared here
     static const DOFAffine DOF_Rotation3D RAVE_DEPRECATED = OpenRAVE::DOF_Rotation3D;
                            ^
In file included from /home/airlab/openrave/include/openrave/openrave.h:2230:0,
                 from /home/airlab/openrave/plugins/include/openraveplugindefs.h:20,
                 from /home/airlab/openrave/plugins/configurationcache/configurationcachetree.h:18,
                 from /home/airlab/openrave/plugins/configurationcache/openravepy_configurationcache.cpp:1
5:
/home/airlab/openrave/include/openrave/robot.h:30:20: warning: ‘OpenRAVE::RobotBase::DOF_RotationQuat’ is
deprecated [-Wdeprecated-declarations]
 class OPENRAVE_API RobotBase : public KinBody
                    ^
In file included from /home/airlab/openrave/include/openrave/openrave.h:2230:0,
                 from /home/airlab/openrave/plugins/include/openraveplugindefs.h:20,
                 from /home/airlab/openrave/plugins/configurationcache/configurationcachetree.h:18,
                 from /home/airlab/openrave/plugins/configurationcache/openravepy_configurationcache.cpp:1
5:
/home/airlab/openrave/include/openrave/robot.h:637:28: note: declared here
     static const DOFAffine DOF_RotationQuat RAVE_DEPRECATED = OpenRAVE::DOF_RotationQuat;
                            ^
[100%] Linking CXX shared library openravepy_configurationcache.so
[100%] Built target openravepy_configurationcache
airlab@airlab-UDOO-x86:~/openrave/build$ make -j4
```

Adding OpenRAVE to your path

- Finally, you will need to add OpenRAVE to your Python path:

```
export LD  LIBRARY  PATH=$LD  LIBRARY_PATH:$(openrave-config --python-dir)/openravepy/_openravepy_
```

```
export PYTHONPATH=$PYTHONPATH:$(openrave-config --python-dir)
```

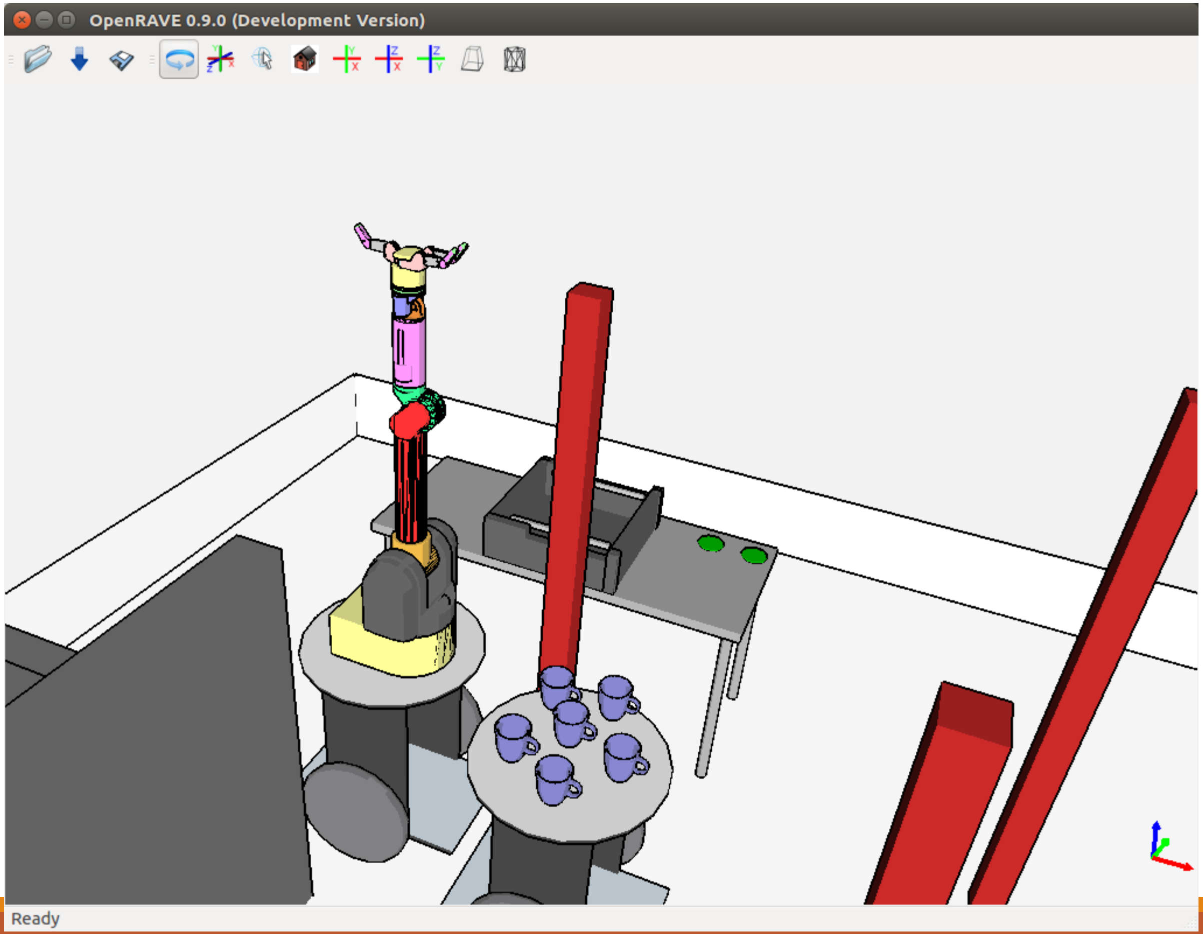
Write these two lines in your .bashrc or .zshrc to save this configuration between sessions.

Install finished

Running a first example

- You can check that your installation works by running one of the default examples:

```
openrave.py --example graspplanning
```



Create ikfast library

- Reference:

http://docs.ros.org/kinetic/api/moveit_tutorials/html/doc/ikfast_tutorial.html

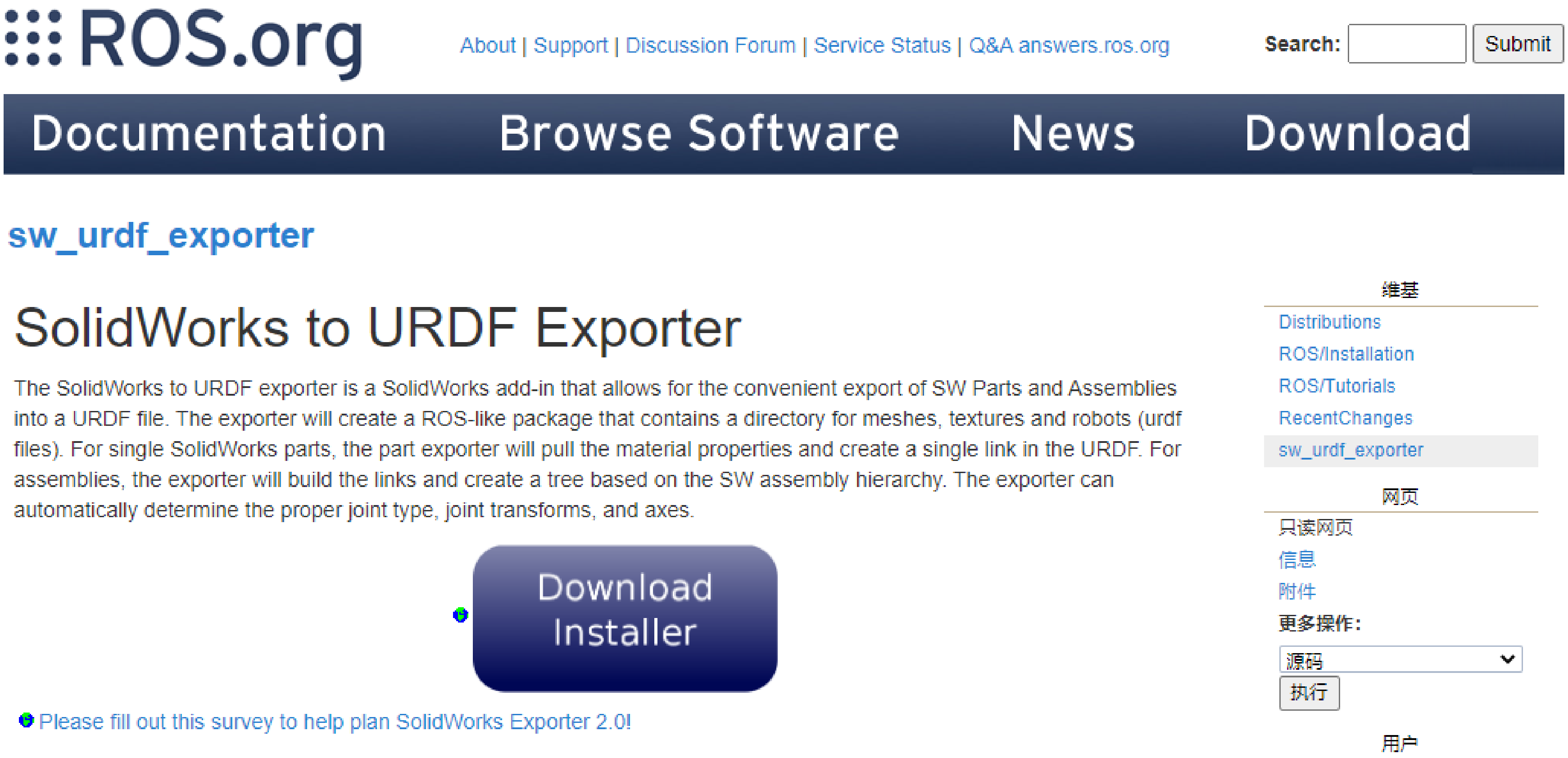
http://sdk.rethinkrobotics.com/wiki/Custom_IKFast_for_your_Baxter

- First: create or get robot URDF model file.

Create URDF form SW

- Install URDF Exporter on SolidWorks

http://wiki.ros.org/sw_urdf_exporter
https://blog.usejournal.com/control-any-robotic-arm-with-ros-b10a3115306c



ROS.org
About | Support | Discussion Forum | Service Status | Q&A answers.ros.org
Search:
Submit
Documentation
Browse Software
News
Download

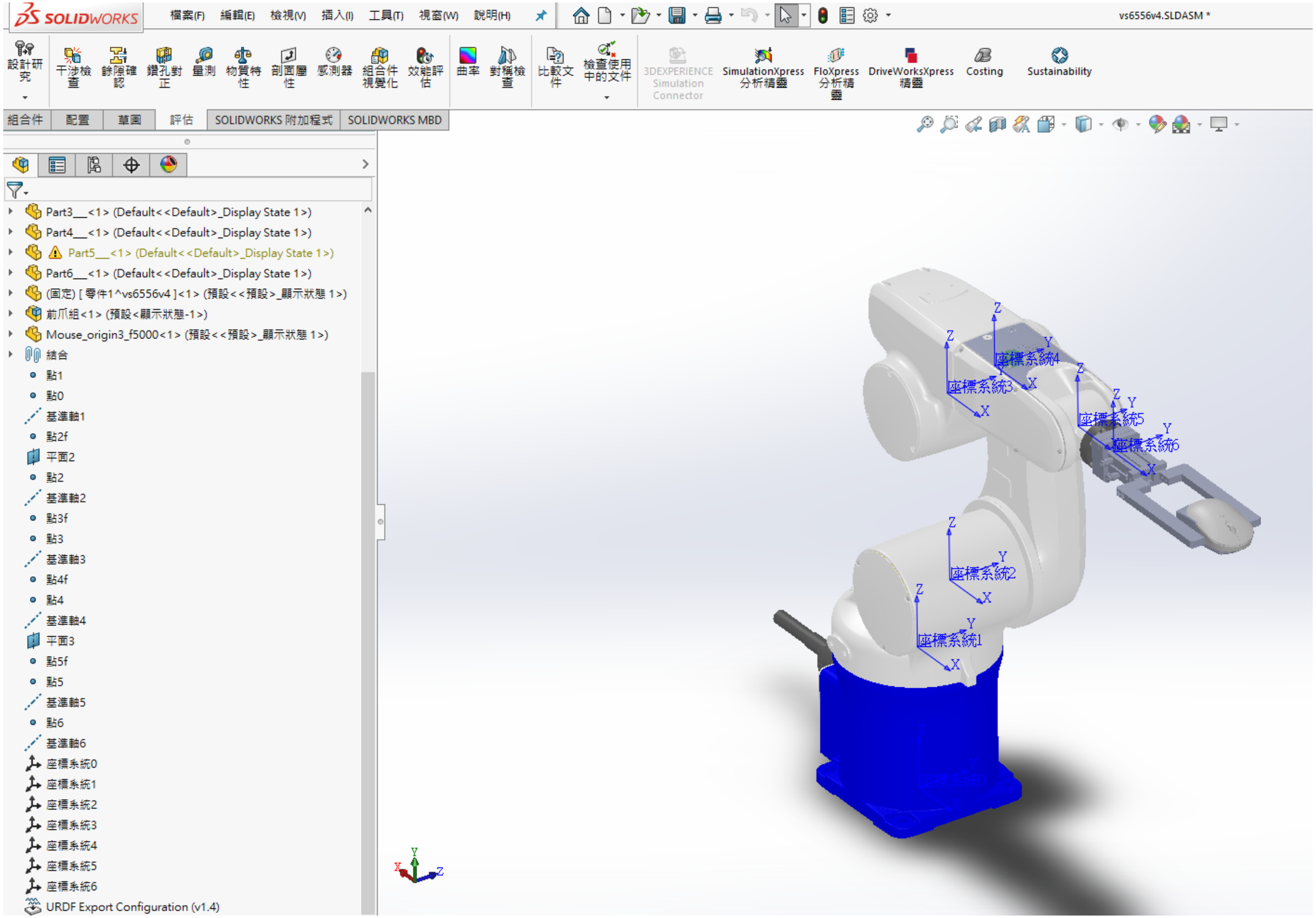
sw_urdf_exporter

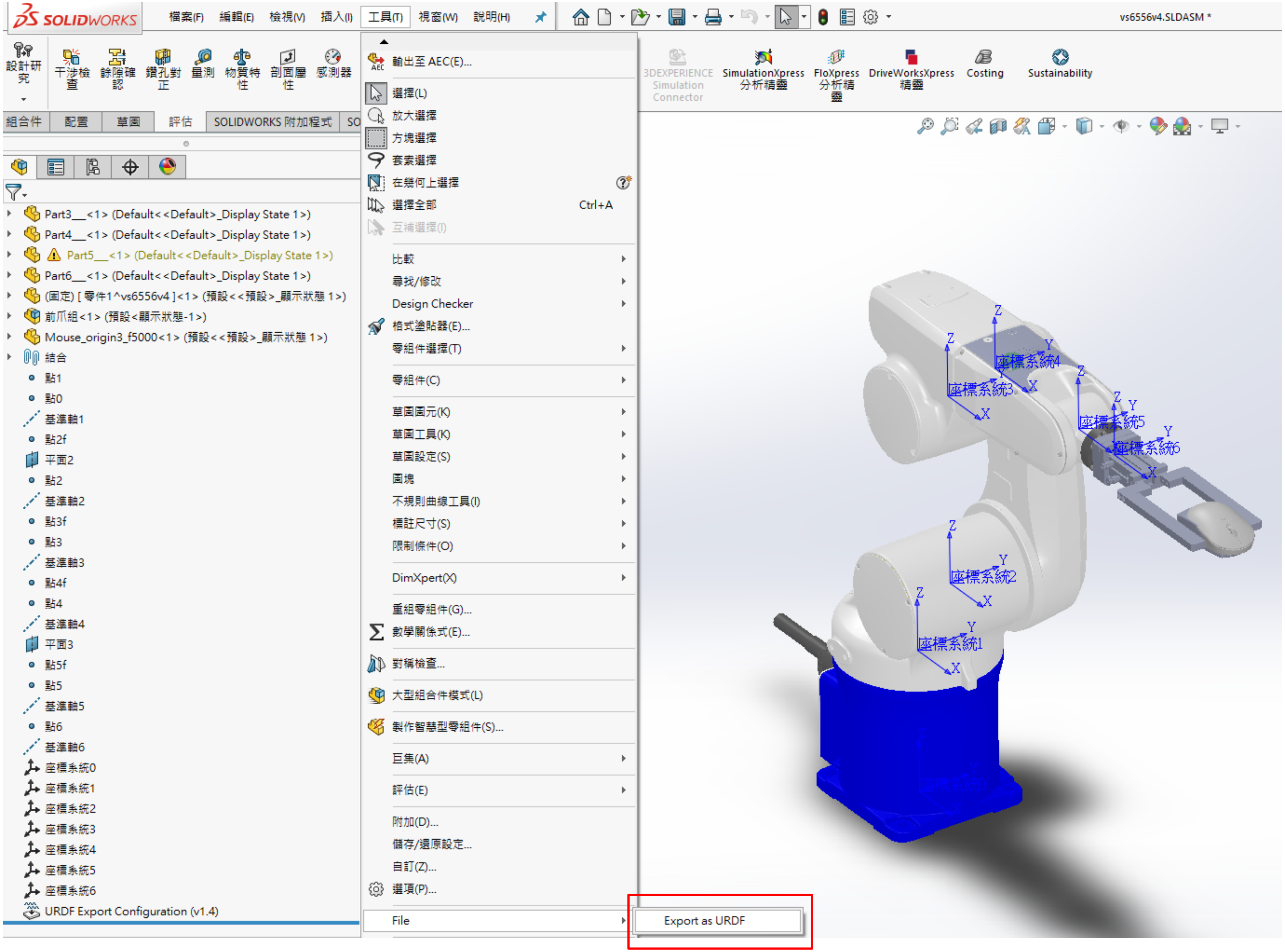
SolidWorks to URDF Exporter

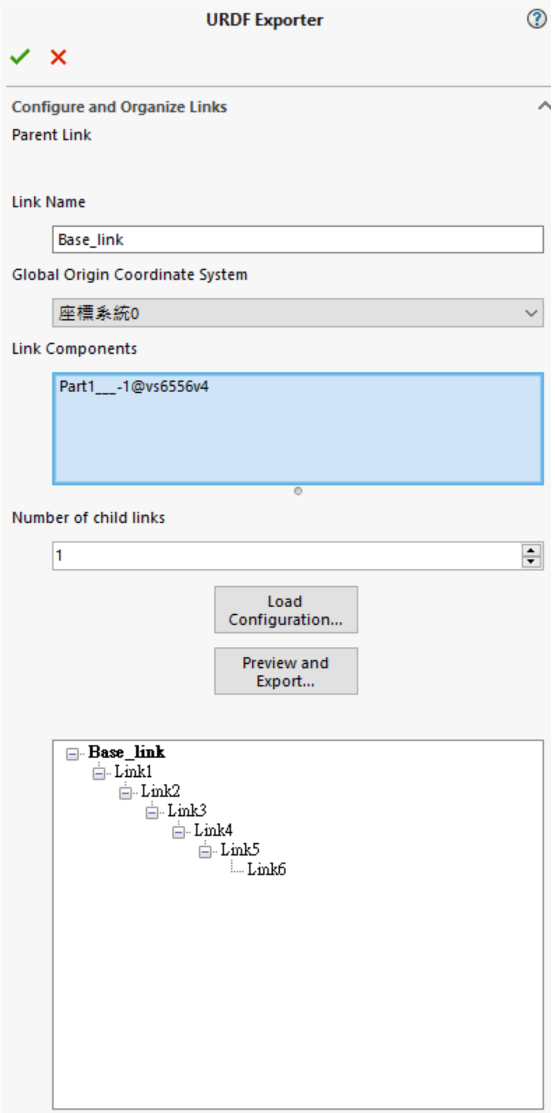
The SolidWorks to URDF exporter is a SolidWorks add-in that allows for the convenient export of SW Parts and Assemblies into a URDF file. The exporter will create a ROS-like package that contains a directory for meshes, textures and robots (urdf files). For single SolidWorks parts, the part exporter will pull the material properties and create a single link in the URDF. For assemblies, the exporter will build the links and create a tree based on the SW assembly hierarchy. The exporter can automatically determine the proper joint type, joint transforms, and axes.

Please fill out this survey to help plan SolidWorks Exporter 2.0!

- Create reference points, axis, coordinates each joint




SOLIDWORKS
檔案(F)
編輯(E)
檢視(V)
插入(I)
工具(T)
視窗(W)
說明(H)
vs6556v4.SLDASM *
設計研究
干涉檢查
餘隙確認
鑽孔對正
量測
物質特性
剖面屬性
感測器
3DEXPERIENCE Simulation Connector
SimulationXpress 分析精靈
FloXpress 分析精靈
DriveWorksXpress 精靈
Costing
Sustainability
組合件
配置
草圖
評估
SOLIDWORKS 附加程式
Part3__<1> (Default<<Default>_Display State 1>)
Part4__<1> (Default<<Default>_Display State 1>)
Part5__<1> (Default<<Default>_Display State 1>)
Part6__<1> (Default<<Default>_Display State 1>)
(固定) [零件1^vs6556v4]<1> (預設<<預設>_顯示狀態 1>)
前爪組<1> (預設<顯示狀態-1>)
Mouse_origin3_f5000<1> (預設<<預設>_顯示狀態 1>)
結合
點1
點0
基準軸1
點2f
平面2
點2
基準軸2
點3f
點3
基準軸3
點4f
點4
基準軸4
平面3
點5f
點5
基準軸5
點6
基準軸6
座標系統0
座標系統1
座標系統2
座標系統3
座標系統4
座標系統5
座標系統6
URDF Export Configuration (v1.4)
輸出至 AEC(E)...
選擇(L)
放大選擇
方塊選擇
套索選擇
在幾何上選擇
選擇全部 Ctrl+A
互補選擇(I)
比較
尋找/修改
Design Checker
格式塗貼器(E)...
零組件選擇(T)
零組件(C)
草圖圖元(K)
草圖工具(K)
草圖設定(S)
圖塊
不規則曲線工具(I)
標註尺寸(S)
限制條件(O)
DimXpert(X)
重組零組件(G)...
數學關係式(E)...
對稱檢查...
大型組合件模式(L)
製作智慧型零組件(S)...
巨集(A)
評估(E)
附加(D)...
儲存/還原設定...
自訂(Z)...
選項(P)...
File
Export as URDF
座標系統1
座標系統2
座標系統3
座標系統4
座標系統5
座標系統6
X
Y
Z



URDF Exporter

Configure and Organize Links

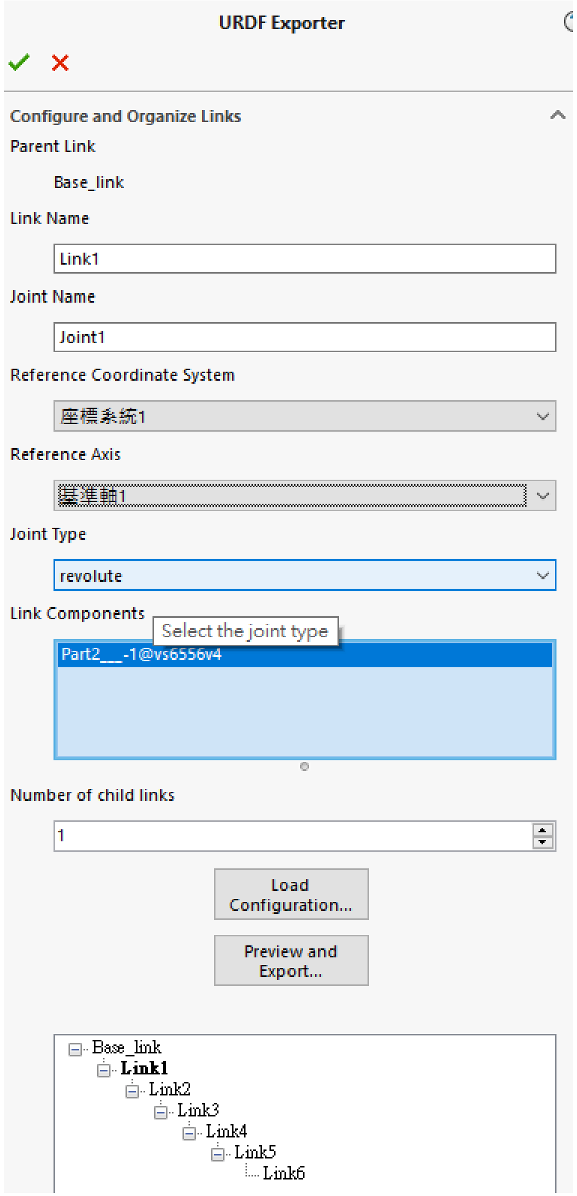
Parent Link

Link Name: Base_link

Global Origin Coordinate System: 座標系統0

Link Components: Part1___-1@vs6556v4

Number of child links: 1



URDF Exporter

Configure and Organize Links

Parent Link: Base_link

Link Name: Link1

Joint Name: Joint1

Reference Coordinate System: 座標系統1

Reference Axis: 基準軸1

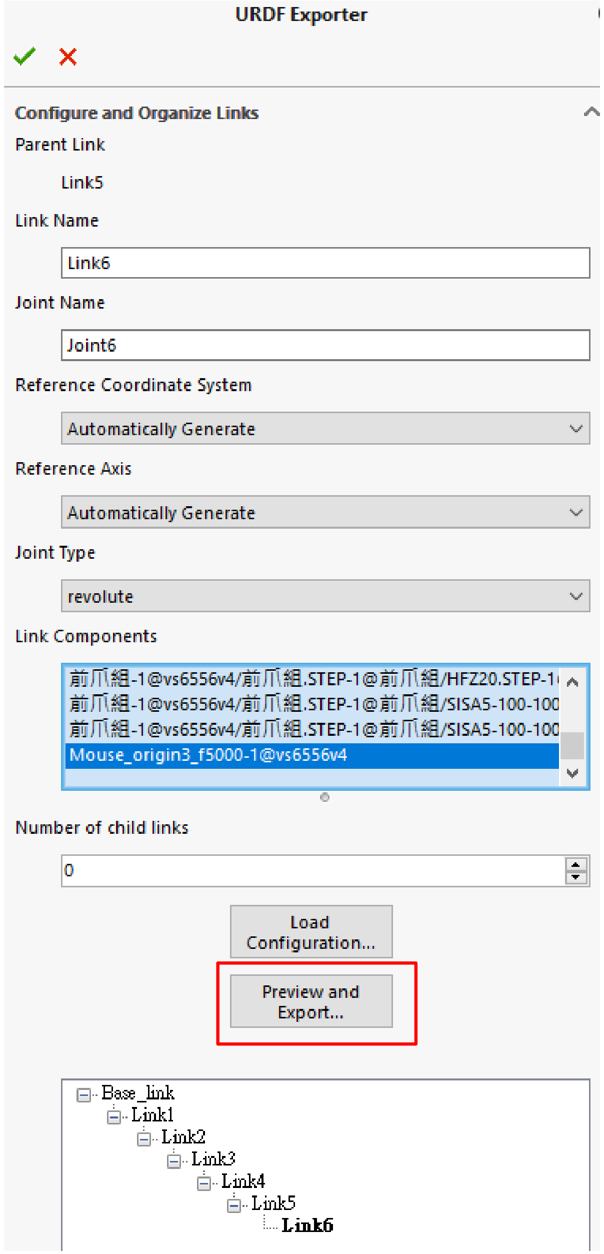
Joint Type: revolute

Link Components: Part2___-1@vs6556v4

Select the joint type

Number of child links: 1

......



URDF Exporter

Configure and Organize Links

Parent Link: Link5

Link Name: Link6

Joint Name: Joint6

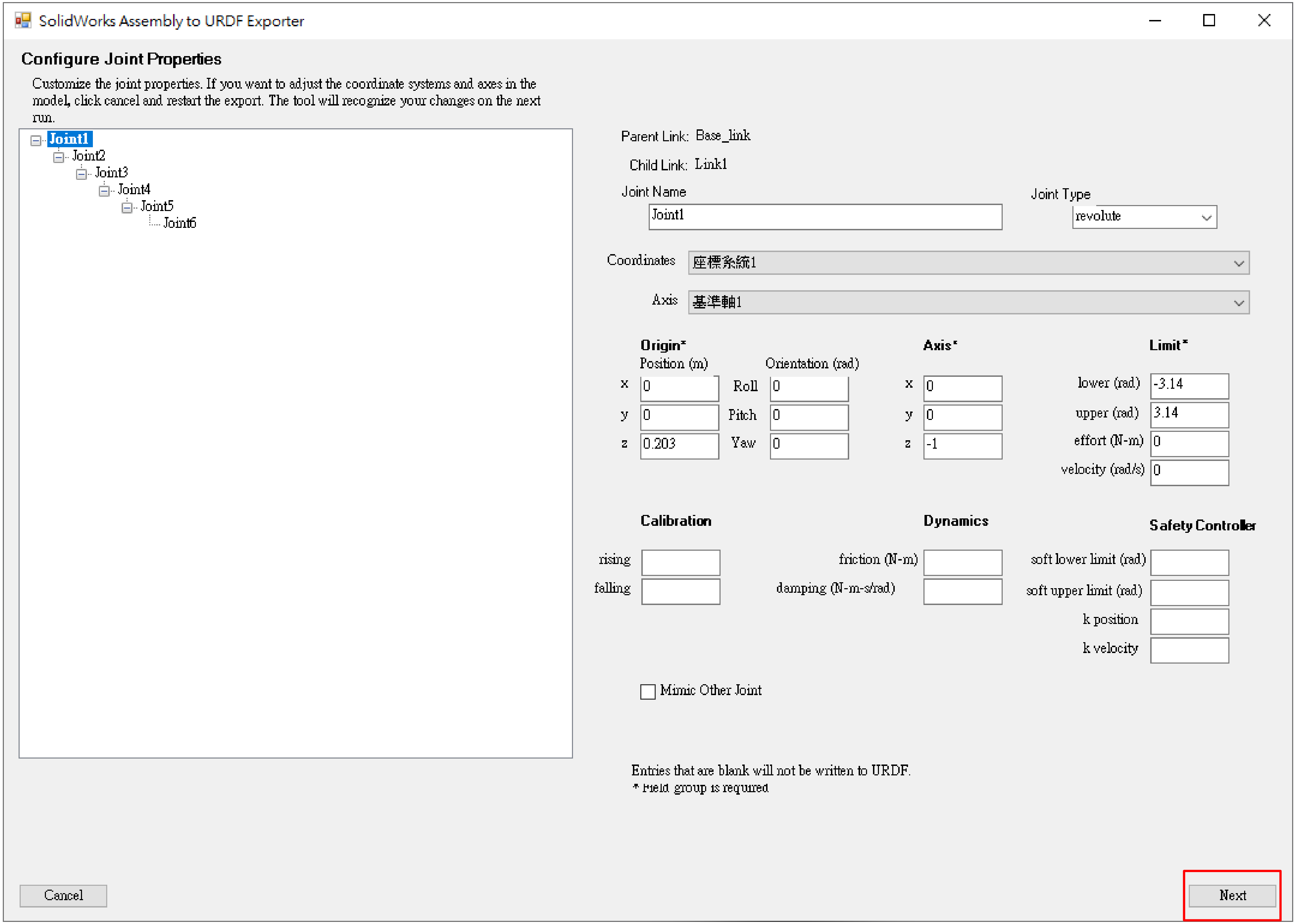
Reference Coordinate System: Automatically Generate

Reference Axis: Automatically Generate

Joint Type: revolute

Link Components:
前爪組-1@vs6556v4/前爪組.STEP-1@前爪組/HFZ20.STEP-1
前爪組-1@vs6556v4/前爪組.STEP-1@前爪組/SISA5-100-100
前爪組-1@vs6556v4/前爪組.STEP-1@前爪組/SISA5-100-100
Mouse_origin3_f5000-1@vs6556v4

Number of child links: 0



SolidWorks Assembly to URDF Exporter

Configure Joint Properties

Customize the joint properties. If you want to adjust the coordinate systems and axes in the model, click cancel and restart the export. The tool will recognize your changes on the next run.

- Joint1
  - Joint2
    - Joint3
      - Joint4
        - Joint5
          - Joint6

Parent Link: Base_link

Child Link: Link1

Joint Name: Joint1

Joint Type: revolute

Coordinates: 座標系統1

Axis: 基準軸1

Origin*

Position (m)		Orientation (rad)	
x	0	Roll	0
y	0	Pitch	0
z	0.203	Yaw	0

Axis*

x	0
y	0
z	-1

Limit*

lower (rad)	-3.14
upper (rad)	3.14
effort (N-m)	0
velocity (rad/s)	0

Calibration

rising

falling

Dynamics

friction (N-m)

damping (N-m-s/rad)

Safety Controller

soft lower limit (rad)

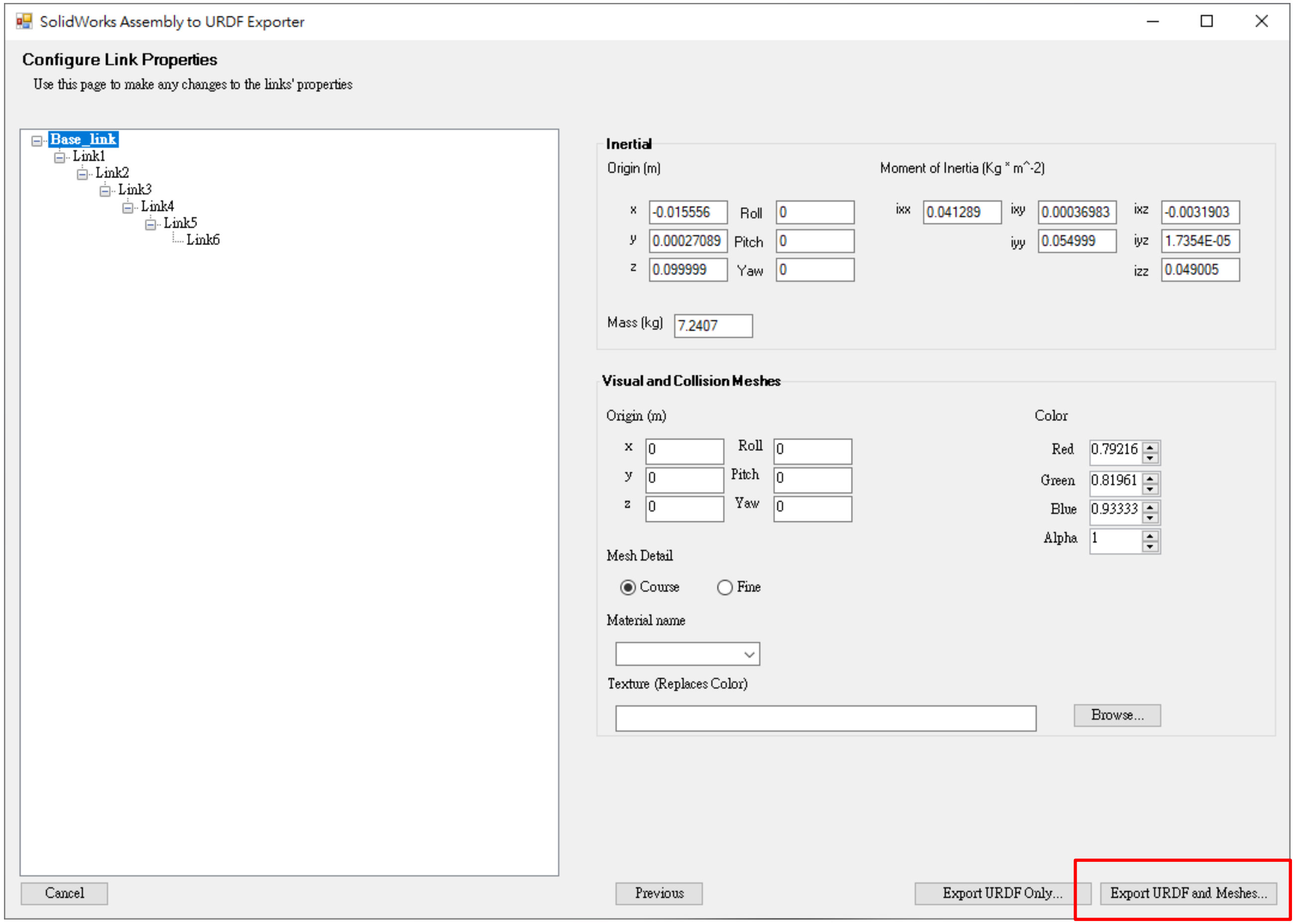
soft upper limit (rad)

k position

k velocity

□ Mimic Other Joint

Entries that are blank will not be written to URDF.
* Field group is required



SolidWorks Assembly to URDF Exporter

Configure Link Properties

Use this page to make any changes to the links' properties

- Base_link
  - Link1
    - Link2
      - Link3
        - Link4
          - Link5
            - Link6

Inertial

Origin (m)

x	-0.015556	Roll	0
y	0.00027089	Pitch	0
z	0.099999	Yaw	0

Moment of Inertia (Kg * m^-2)

ixx	0.041289	ixy	0.00036983	ixz	-0.0031903
		iyy	0.054999	iyz	1.7354E-05
				izz	0.049005

Mass (kg) 7.2407

Visual and Collision Meshes

Origin (m)

x	0	Roll	0
y	0	Pitch	0
z	0	Yaw	0

Color

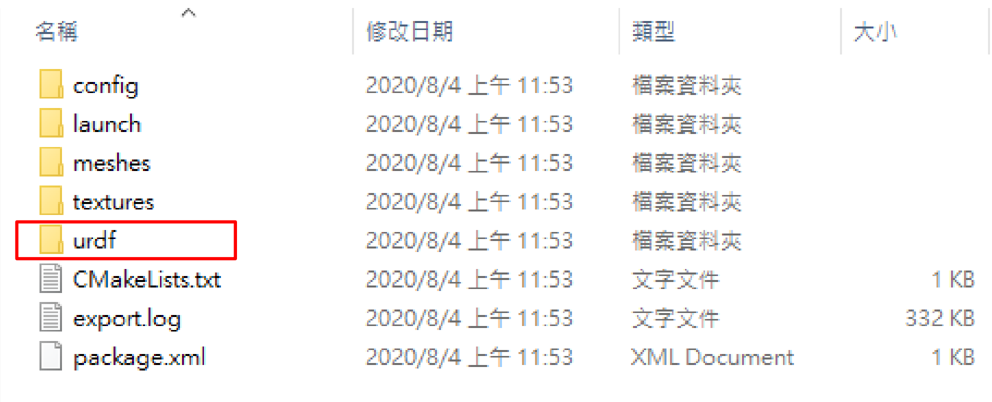
Red	0.79216
Green	0.81961
Blue	0.93333
Alpha	1

Mesh Detail

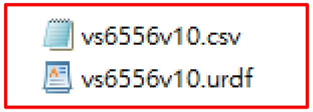
● Course ○ Fine

Material name

Texture (Replaces Color)



名稱	修改日期	類型	大小
config	2020/8/4 上午 11:53	檔案資料夾	
launch	2020/8/4 上午 11:53	檔案資料夾	
meshes	2020/8/4 上午 11:53	檔案資料夾	
textures	2020/8/4 上午 11:53	檔案資料夾	
urdf	2020/8/4 上午 11:53	檔案資料夾	
CMakeLists.txt	2020/8/4 上午 11:53	文字文件	1 KB
export.log	2020/8/4 上午 11:53	文字文件	332 KB
package.xml	2020/8/4 上午 11:53	XML Document	1 KB



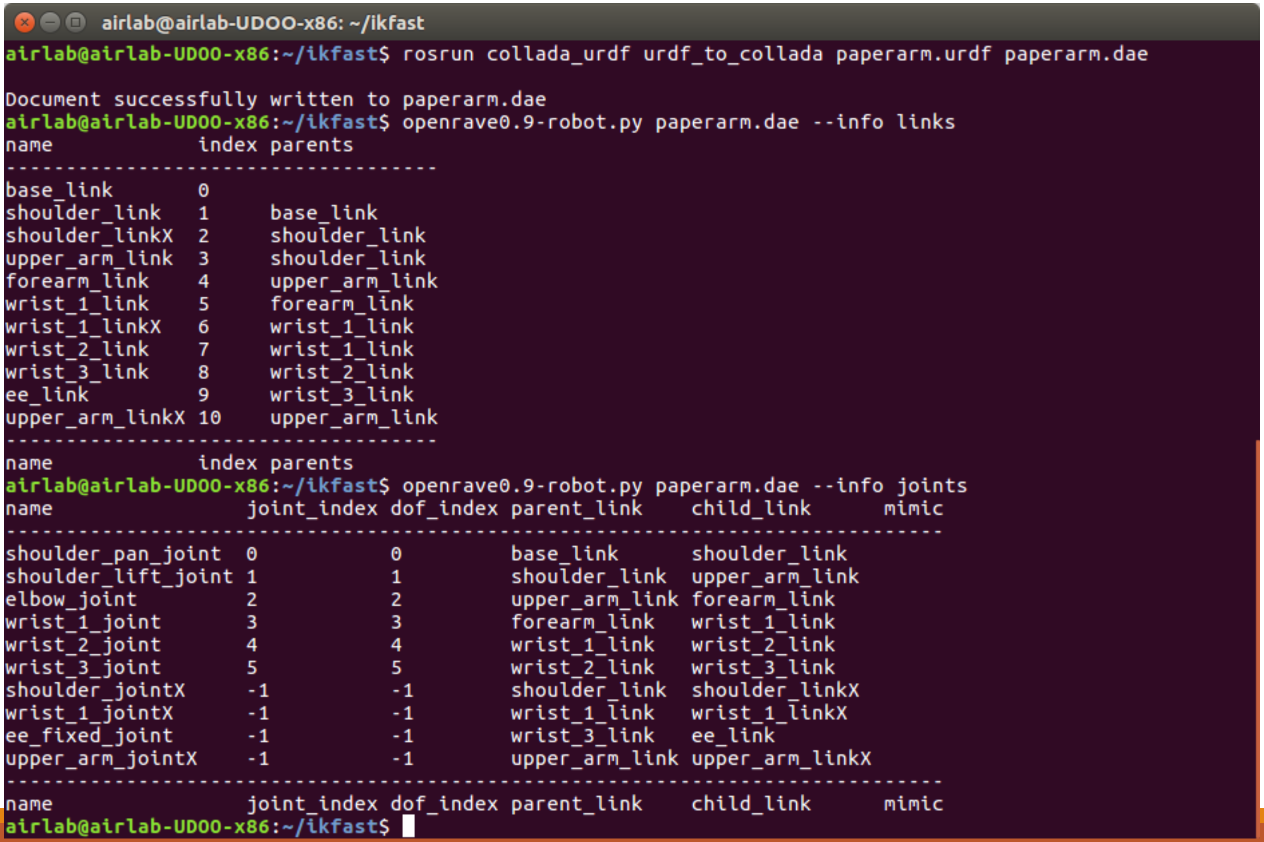
vs6556v10.csv
vs6556v10.urdf

Create DAEs for Robot

rosrun collada_urdf urdf_to_collada paperarm.urdf paperarm.dae

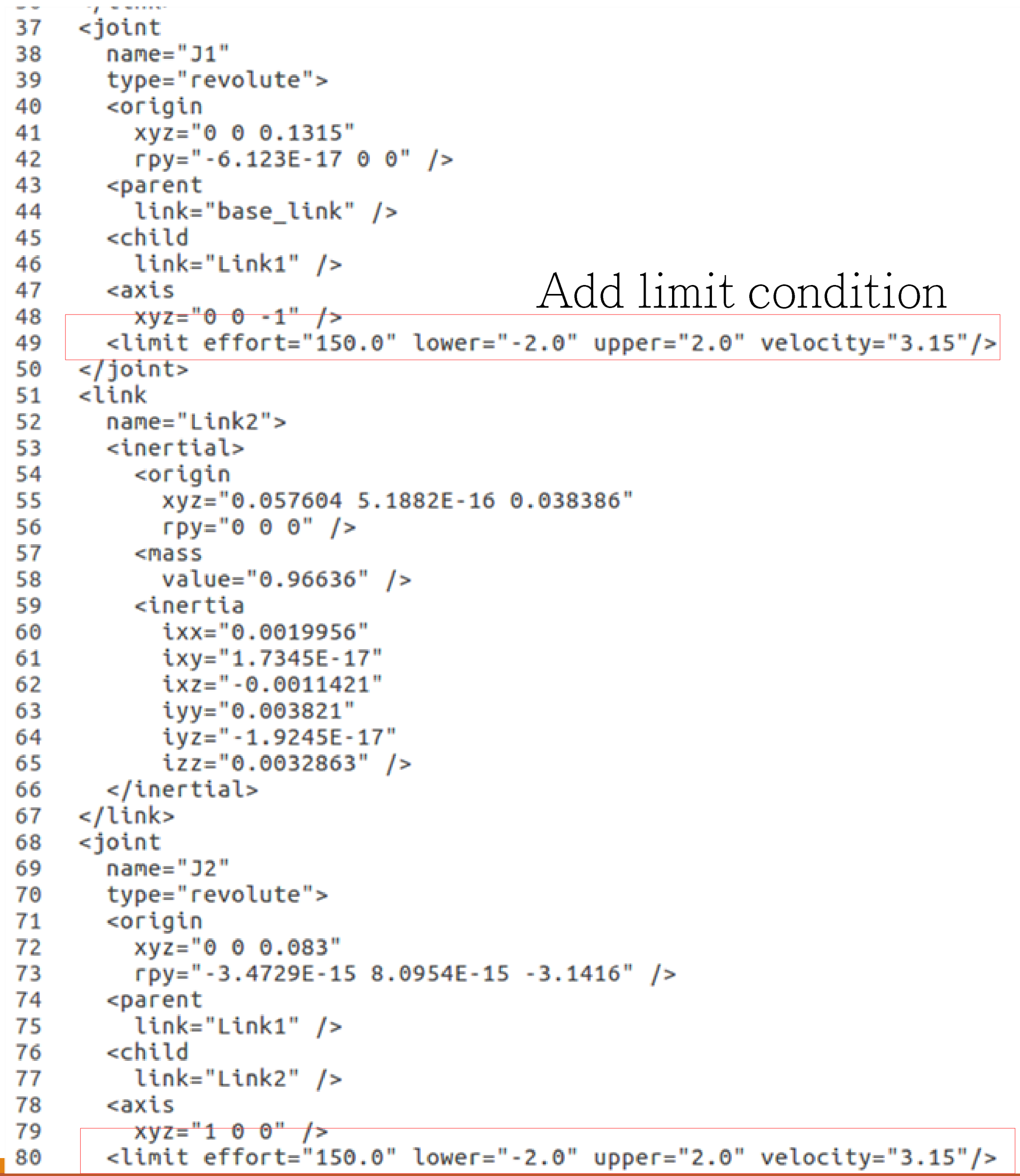
openrave0.9-robot.py paperarm.dae --info links

openrave0.9-robot.py paperarm.dae --info joints



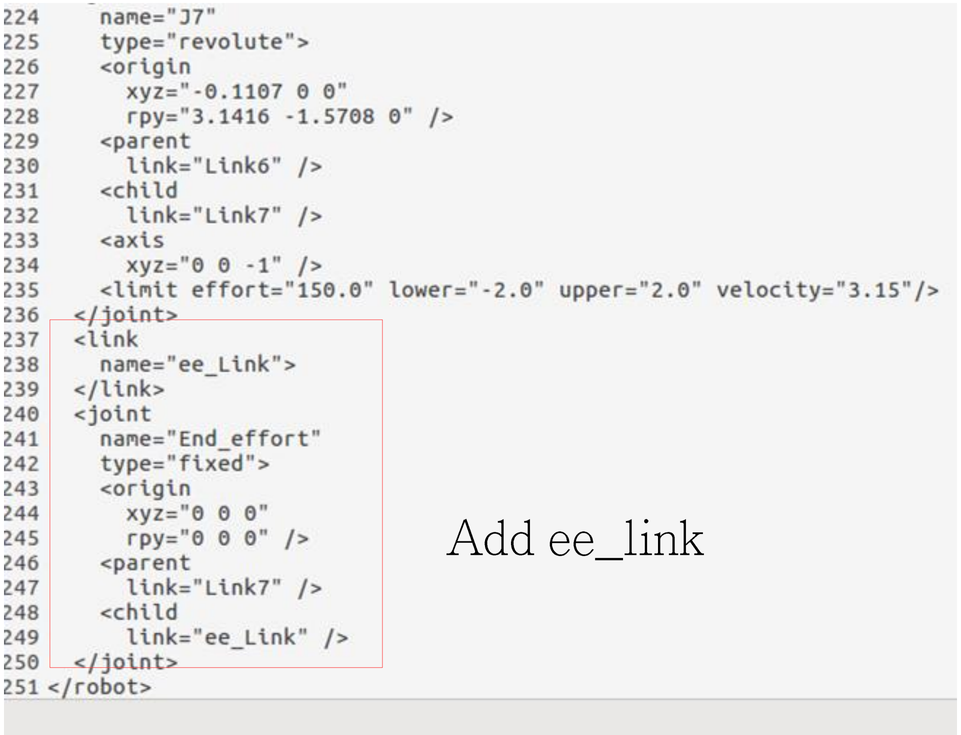
```
airlab@airlab-UDOO-x86:~/ikfast$ rosrun collada_urdf urdf_to_collada paperarm.urdf paperarm.dae

Document successfully written to paperarm.dae
airlab@airlab-UDOO-x86:~/ikfast$ openrave0.9-robot.py paperarm.dae --info links
name            index parents
------------------------------------
base_link       0
shoulder_link   1     base_link
shoulder_linkX  2     shoulder_link
upper_arm_link  3     shoulder_link
forearm_link    4     upper_arm_link
wrist_1_link    5     forearm_link
wrist_1_linkX   6     wrist_1_link
wrist_2_link    7     wrist_1_link
wrist_3_link    8     wrist_2_link
ee_link         9     wrist_3_link
upper_arm_linkX 10    upper_arm_link
------------------------------------
name            index parents
airlab@airlab-UDOO-x86:~/ikfast$ openrave0.9-robot.py paperarm.dae --info joints
name                joint_index dof_index parent_link    child_link      mimic
------------------------------------------------------------------------------
shoulder_pan_joint  0           0         base_link      shoulder_link
shoulder_lift_joint 1           1         shoulder_link  upper_arm_link
elbow_joint         2           2         upper_arm_link forearm_link
wrist_1_joint       3           3         forearm_link   wrist_1_link
wrist_2_joint       4           4         wrist_1_link   wrist_2_link
wrist_3_joint       5           5         wrist_2_link   wrist_3_link
shoulder_jointX     -1          -1        shoulder_link  shoulder_linkX
wrist_1_jointX      -1          -1        wrist_1_link   wrist_1_linkX
ee_fixed_joint      -1          -1        wrist_3_link   ee_link
upper_arm_jointX    -1          -1        upper_arm_link upper_arm_linkX
------------------------------------------------------------------------------
name                joint_index dof_index parent_link    child_link      mimic
airlab@airlab-UDOO-x86:~/ikfast$
```

URDF for 7 axis robot



Add limit condition

```
  <joint
    name="J1"
    type="revolute">
    <origin
      xyz="0 0 0.1315"
      rpy="-6.123E-17 0 0" />
    <parent
      link="base_link" />
    <child
      link="Link1" />
    <axis
      xyz="0 0 -1" />
    <limit effort="150.0" lower="-2.0" upper="2.0" velocity="3.15"/>
  </joint>
  <link
    name="Link2">
    <inertial>
      <origin
        xyz="0.057604 5.1882E-16 0.038386"
        rpy="0 0 0" />
      <mass
        value="0.96636" />
      <inertia
        ixx="0.0019956"
        ixy="1.7345E-17"
        ixz="-0.0011421"
        iyy="0.003821"
        iyz="-1.9245E-17"
        izz="0.0032863" />
    </inertial>
  </link>
  <joint
    name="J2"
    type="revolute">
    <origin
      xyz="0 0 0.083"
      rpy="-3.4729E-15 8.0954E-15 -3.1416" />
    <parent
      link="Link1" />
    <child
      link="Link2" />
    <axis
      xyz="1 0 0" />
    <limit effort="150.0" lower="-2.0" upper="2.0" velocity="3.15"/>
```



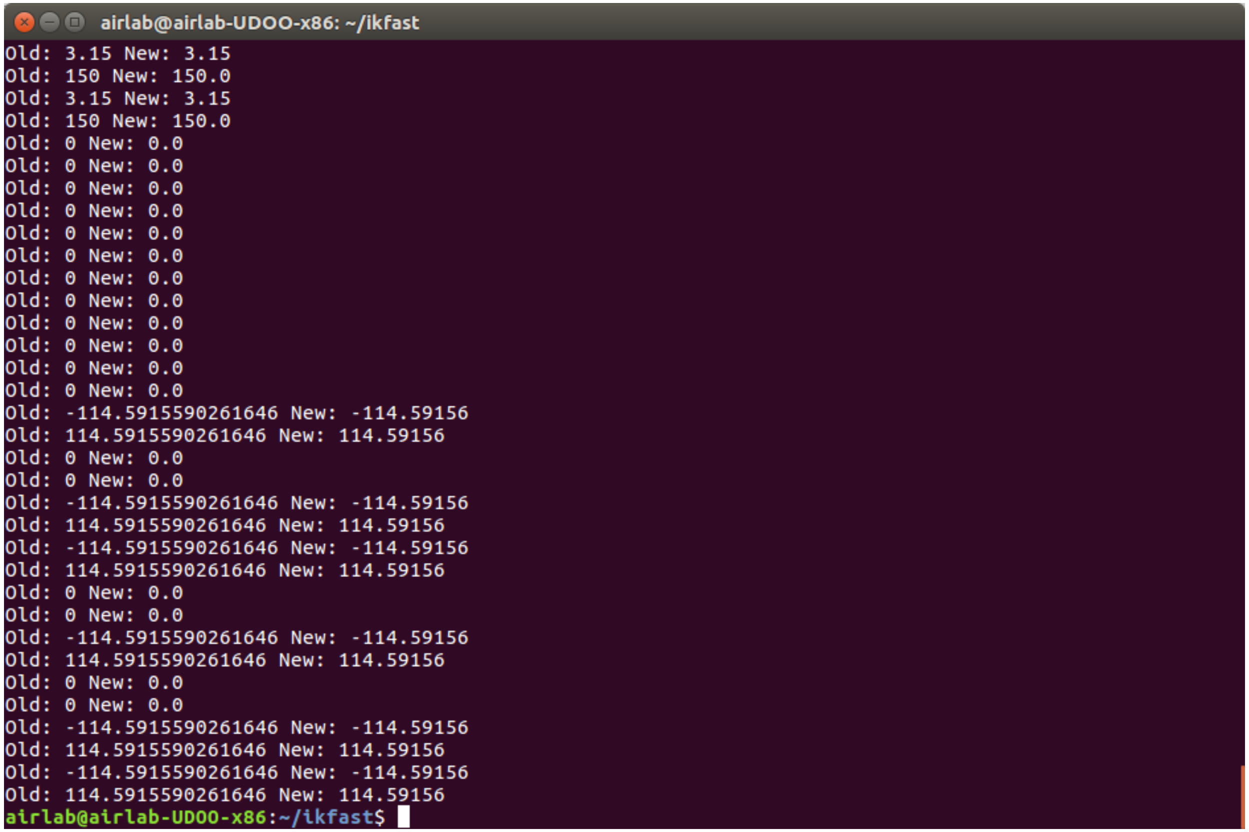
Add ee_link

```
    name="J7"
    type="revolute">
    <origin
      xyz="-0.1107 0 0"
      rpy="3.1416 -1.5708 0" />
    <parent
      link="Link6" />
    <child
      link="Link7" />
    <axis
      xyz="0 0 -1" />
    <limit effort="150.0" lower="-2.0" upper="2.0" velocity="3.15"/>
  </joint>
  <link
    name="ee_Link">
  </link>
  <joint
    name="End_effort"
    type="fixed">
    <origin
      xyz="0 0 0"
      rpy="0 0 0" />
    <parent
      link="Link7" />
    <child
      link="ee_Link" />
  </joint>
</robot>
```

Rounding DAEs for Robot

sudo apt-get install ros-kinetic-moveit-kinematics

rosrun moveit_kinematics round_collada_numbers.py paperarm.dae paperarm.round.dae 5



```
Old: 3.15 New: 3.15
Old: 150 New: 150.0
Old: 3.15 New: 3.15
Old: 150 New: 150.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: -114.5915590261646 New: -114.59156
Old: 114.5915590261646 New: 114.59156
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: -114.5915590261646 New: -114.59156
Old: 114.5915590261646 New: 114.59156
Old: -114.5915590261646 New: -114.59156
Old: 114.5915590261646 New: 114.59156
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: -114.5915590261646 New: -114.59156
Old: 114.5915590261646 New: 114.59156
Old: 0 New: 0.0
Old: 0 New: 0.0
Old: -114.5915590261646 New: -114.59156
Old: 114.5915590261646 New: 114.59156
Old: -114.5915590261646 New: -114.59156
Old: 114.5915590261646 New: 114.59156
airlab@airlab-UDOO-x86:~/ikfast$
```

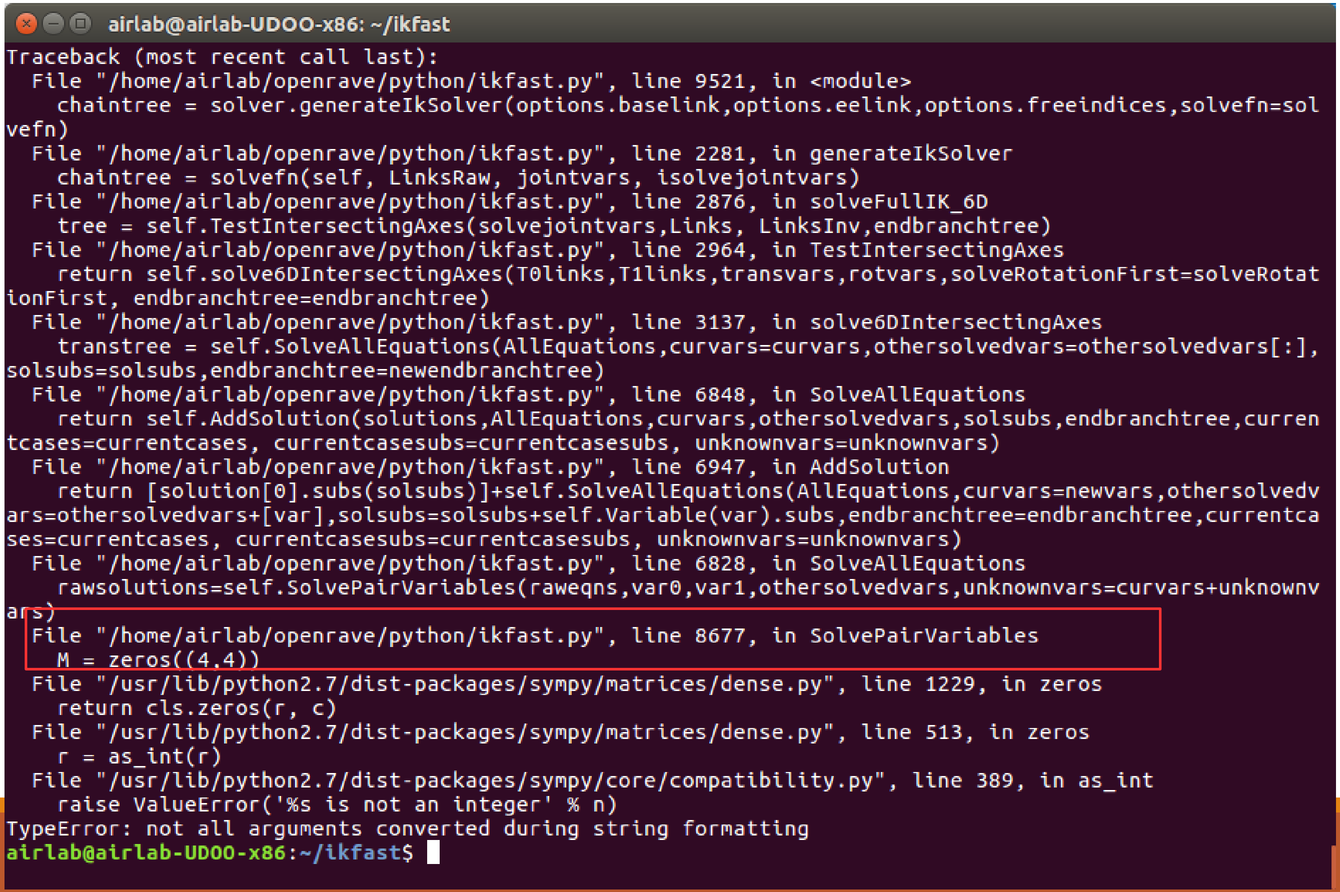
Change python spmpy version

sudo apt install python pip

sudo pip uninstall sympy

sudo pip install sympy==0.7.1

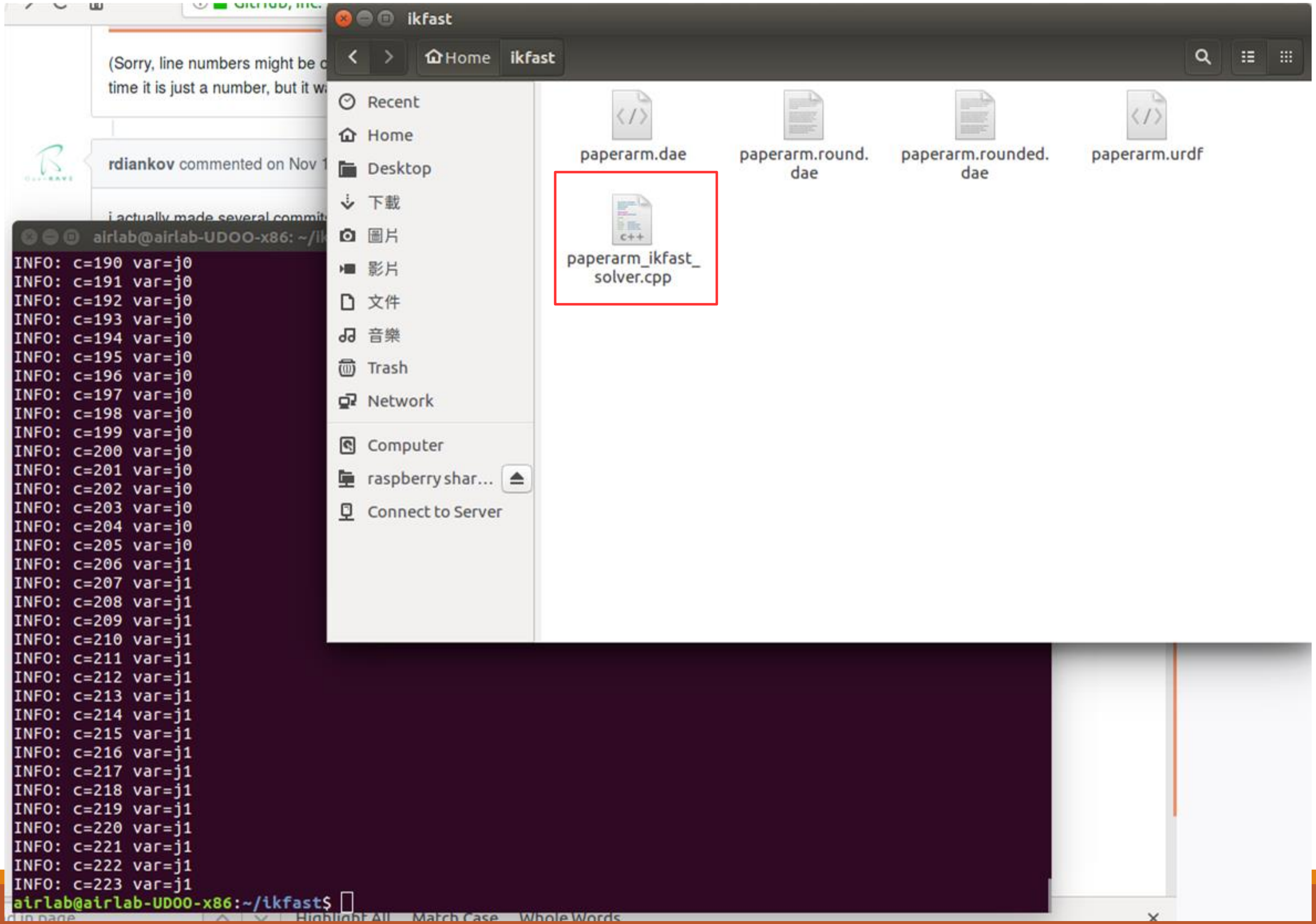
- https://github.com/rdiankov/openrave/issues/376



```
Traceback (most recent call last):
  File "/home/airlab/openrave/python/ikfast.py", line 9521, in <module>
    chaintree = solver.generateIkSolver(options.baselink,options.eelink,options.freeindices,solvefn=sol
vefn)
  File "/home/airlab/openrave/python/ikfast.py", line 2281, in generateIkSolver
    chaintree = solvefn(self, LinksRaw, jointvars, isolvejointvars)
  File "/home/airlab/openrave/python/ikfast.py", line 2876, in solveFullIK_6D
    tree = self.TestIntersectingAxes(solvejointvars,Links, LinksInv,endbranchtree)
  File "/home/airlab/openrave/python/ikfast.py", line 2964, in TestIntersectingAxes
    return self.solve6DIntersectingAxes(T0links,T1links,transvars,rotvars,solveRotationFirst=solveRotat
ionFirst, endbranchtree=endbranchtree)
  File "/home/airlab/openrave/python/ikfast.py", line 3137, in solve6DIntersectingAxes
    transtree = self.SolveAllEquations(AllEquations,curvars=curvars,othersolvedvars=othersolvedvars[:],
solsubs=solsubs,endbranchtree=newendbranchtree)
  File "/home/airlab/openrave/python/ikfast.py", line 6848, in SolveAllEquations
    return self.AddSolution(solutions,AllEquations,curvars,othersolvedvars,solsubs,endbranchtree,curren
tcases=currentcases, currentcasesubs=currentcasesubs, unknownvars=unknownvars)
  File "/home/airlab/openrave/python/ikfast.py", line 6947, in AddSolution
    return [solution[0].subs(solsubs)]+self.SolveAllEquations(AllEquations,curvars=newvars,othersolvedv
ars=othersolvedvars+[var],solsubs=solsubs+self.Variable(var).subs,endbranchtree=endbranchtree,currentca
ses=currentcases, currentcasesubs=currentcasesubs, unknownvars=unknownvars)
  File "/home/airlab/openrave/python/ikfast.py", line 6828, in SolveAllEquations
    rawsolutions=self.SolvePairVariables(raweqns,var0,var1,othersolvedvars,unknownvars=curvars+unknownv
ars)
  File "/home/airlab/openrave/python/ikfast.py", line 8677, in SolvePairVariables
    M = zeros((4,4))
  File "/usr/lib/python2.7/dist-packages/sympy/matrices/dense.py", line 1229, in zeros
    return cls.zeros(r, c)
  File "/usr/lib/python2.7/dist-packages/sympy/matrices/dense.py", line 513, in zeros
    r = as_int(r)
  File "/usr/lib/python2.7/dist-packages/sympy/core/compatibility.py", line 389, in as_int
    raise ValueError('%s is not an integer' % n)
TypeError: not all arguments converted during string formatting
airlab@airlab-UDOO-x86:~/ikfast$
```

Generate the IKFast Solver

```
python ~/openrave/python/ikfast.py --robot=paperarm.round.dae --iktype=transform6d --baselink=0 --eelink=9 --savefile=paperarm_ikfast_solver.cpp
```



(Sorry, line numbers might be c
time it is just a number, but it w

rdiankov commented on Nov 1

i actually made several commit

```
airlab@airlab-UDOO-x86: ~/ik
INFO: c=190 var=j0
INFO: c=191 var=j0
INFO: c=192 var=j0
INFO: c=193 var=j0
INFO: c=194 var=j0
INFO: c=195 var=j0
INFO: c=196 var=j0
INFO: c=197 var=j0
INFO: c=198 var=j0
INFO: c=199 var=j0
INFO: c=200 var=j0
INFO: c=201 var=j0
INFO: c=202 var=j0
INFO: c=203 var=j0
INFO: c=204 var=j0
INFO: c=205 var=j0
INFO: c=206 var=j1
INFO: c=207 var=j1
INFO: c=208 var=j1
INFO: c=209 var=j1
INFO: c=210 var=j1
INFO: c=211 var=j1
INFO: c=212 var=j1
INFO: c=213 var=j1
INFO: c=214 var=j1
INFO: c=215 var=j1
INFO: c=216 var=j1
INFO: c=217 var=j1
INFO: c=218 var=j1
INFO: c=219 var=j1
INFO: c=220 var=j1
INFO: c=221 var=j1
INFO: c=222 var=j1
INFO: c=223 var=j1
airlab@airlab-UDOO-x86:~/ikfast$ 
```

For 7 axis robot

```
python ~/openrave/python/ikfast.py --robot=A1.round.dae --iktype=transform6d --baselink=0 --eelink=8 --freeindex=2 --savefile=A1_ikfast_solver.cpp
```

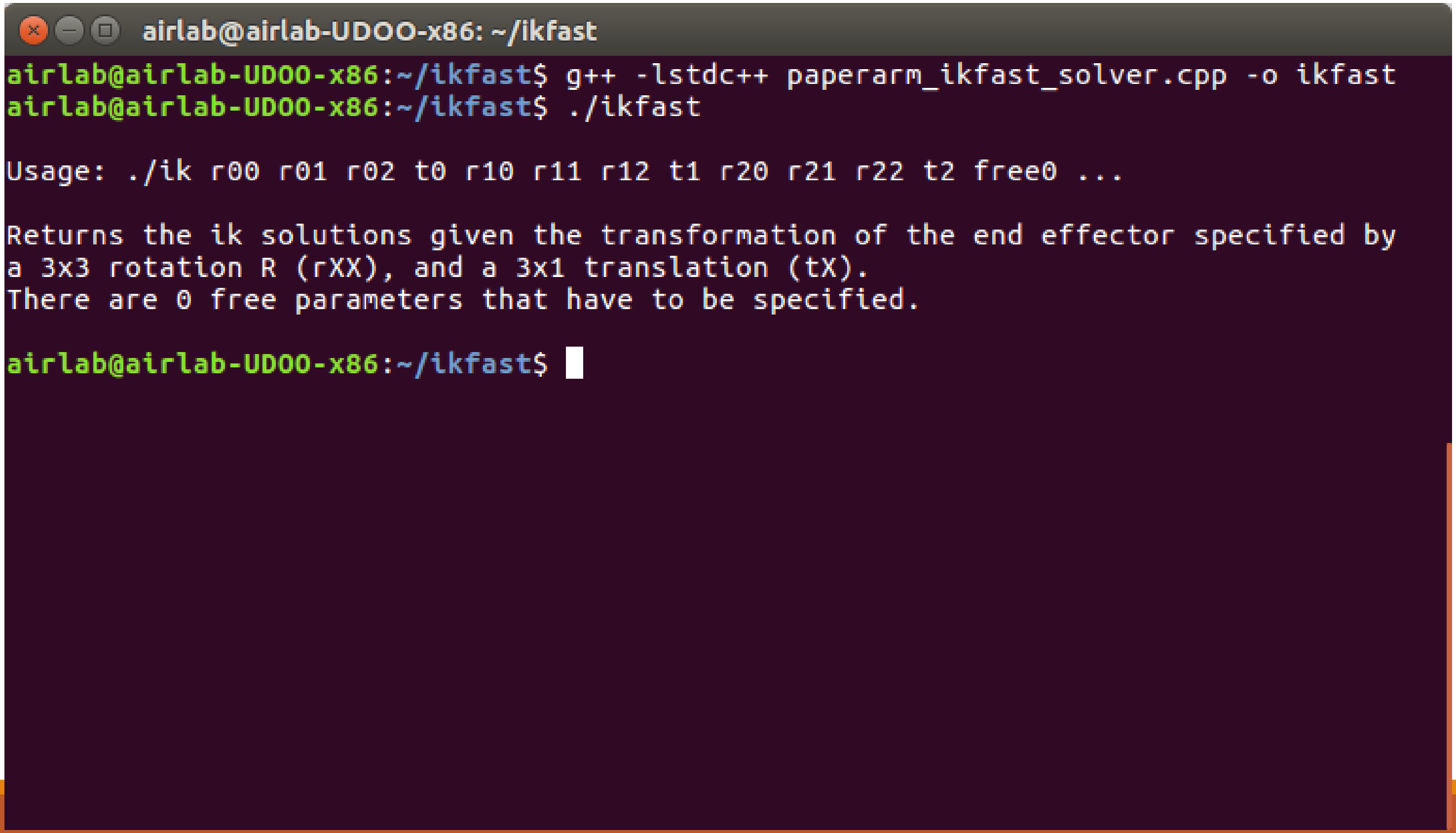
Free joint = joint 3 (norm case)

--freeindex=2

Build program by g++

- Copy ikfast.h from openrave/python/
- To compile with g++:

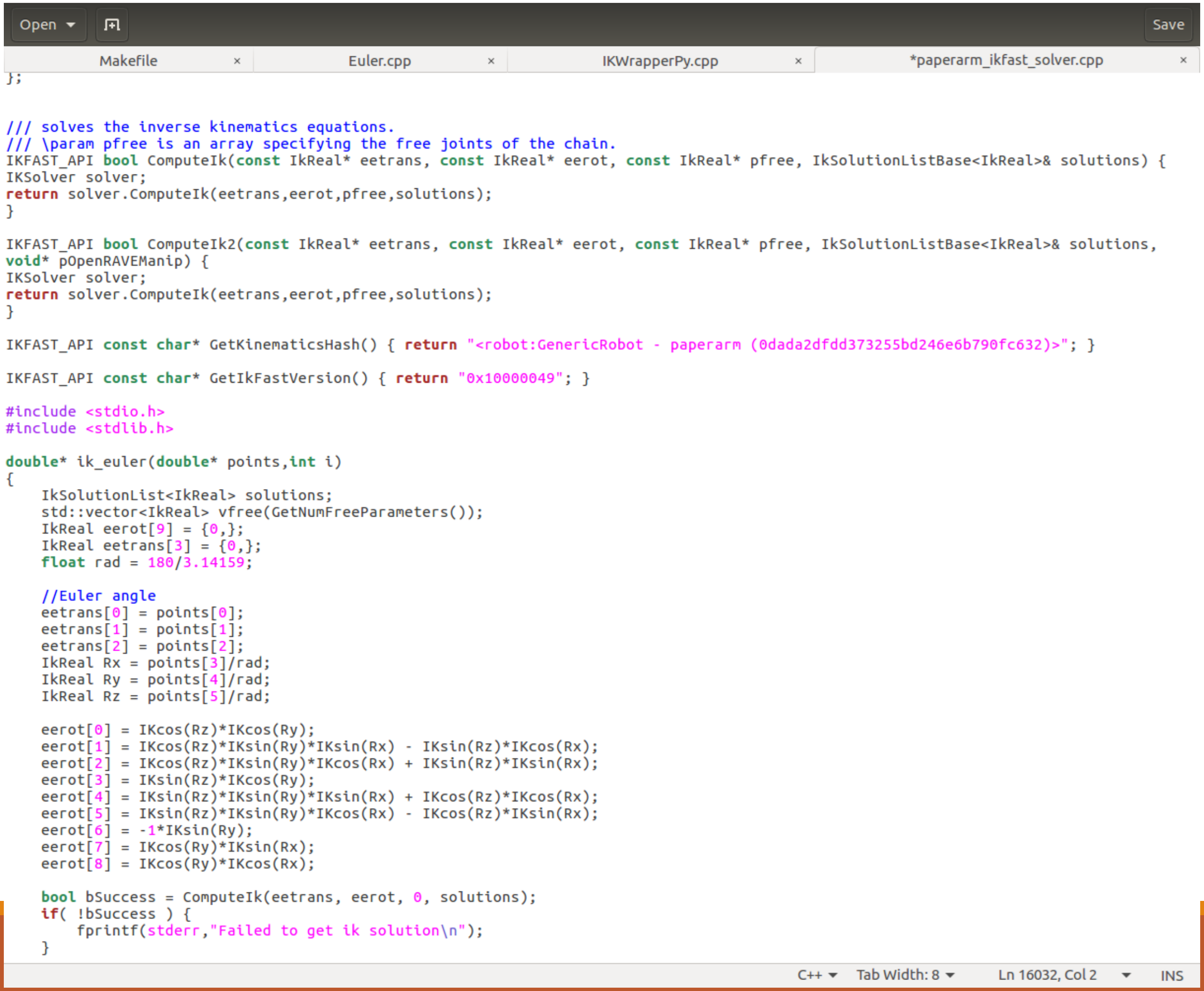
g++ -lstdc++ paperarm_ikfast_solver.cpp -o ikfast



```
airlab@airlab-UDOO-x86:~/ikfast$ g++ -lstdc++ paperarm_ikfast_solver.cpp -o ikfast
airlab@airlab-UDOO-x86:~/ikfast$ ./ikfast

Usage: ./ik r00 r01 r02 t0 r10 r11 r12 t1 r20 r21 r22 t2 free0 ...

Returns the ik solutions given the transformation of the end effector specified by
a 3x3 rotation R (rXX), and a 3x1 translation (tX).
There are 0 free parameters that have to be specified.

airlab@airlab-UDOO-x86:~/ikfast$ 
```

Edit solver.cpp

- Copy Euler.cpp replace solver.cpp main function (line:15963).
- Save as ikfast_solver.cpp



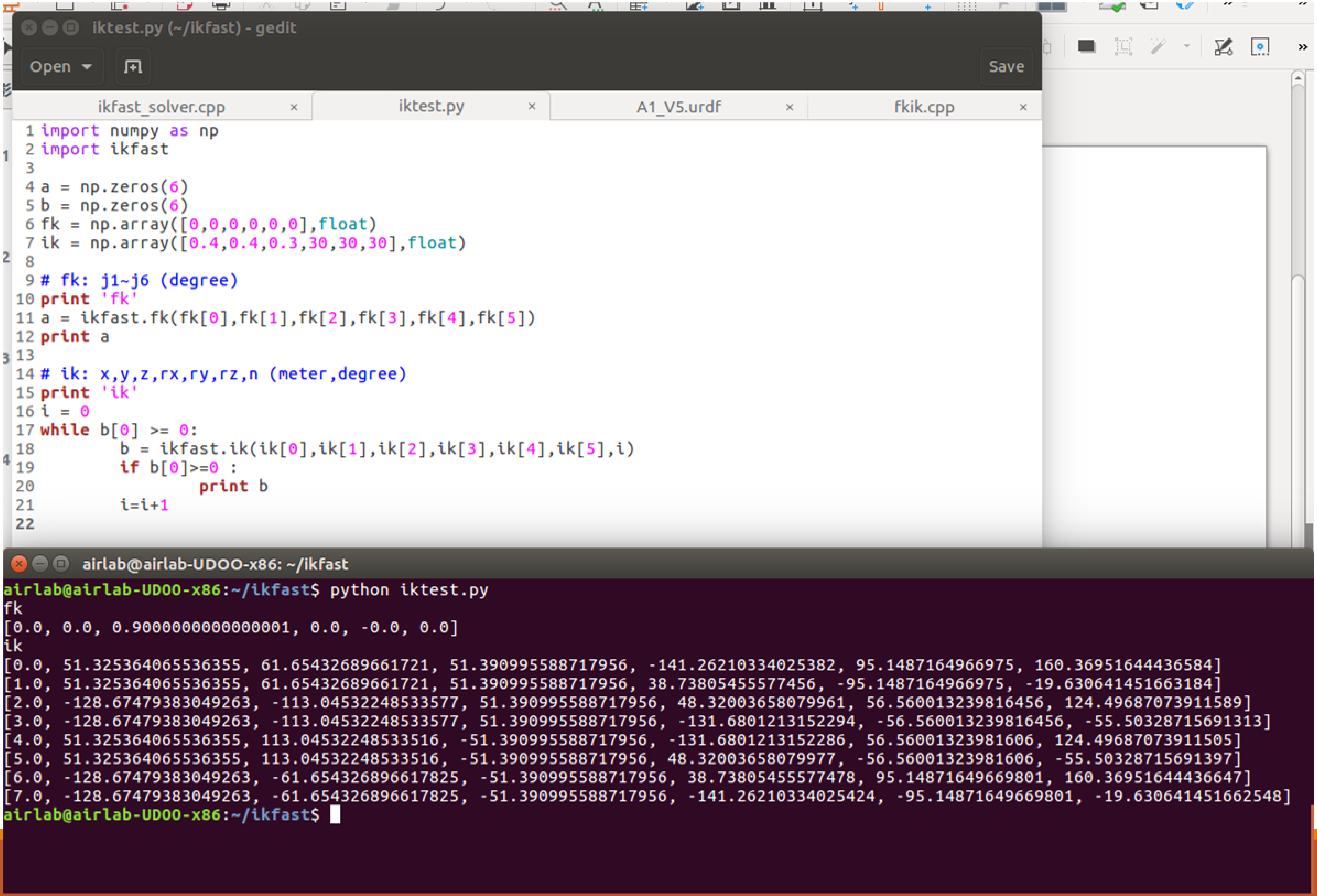
```cpp
};

/// solves the inverse kinematics equations.
/// \param pfree is an array specifying the free joints of the chain.
IKFAST_API bool ComputeIk(const IkReal* eetrans, const IkReal* eerot, const IkReal* pfree, IkSolutionListBase<IkReal>& solutions) {
IKSolver solver;
return solver.ComputeIk(eetrans,eerot,pfree,solutions);
}

IKFAST_API bool ComputeIk2(const IkReal* eetrans, const IkReal* eerot, const IkReal* pfree, IkSolutionListBase<IkReal>& solutions,
void* pOpenRAVEManip) {
IKSolver solver;
return solver.ComputeIk(eetrans,eerot,pfree,solutions);
}

IKFAST_API const char* GetKinematicsHash() { return "<robot:GenericRobot - paperarm (0dada2dfdd373255bd246e6b790fc632)>"; }

IKFAST_API const char* GetIkFastVersion() { return "0x10000049"; }

#include <stdio.h>
#include <stdlib.h>

double* ik_euler(double* points,int i)
{
    IkSolutionList<IkReal> solutions;
    std::vector<IkReal> vfree(GetNumFreeParameters());
    IkReal eerot[9] = {0,};
    IkReal eetrans[3] = {0,};
    float rad = 180/3.14159;

    //Euler angle
    eetrans[0] = points[0];
    eetrans[1] = points[1];
    eetrans[2] = points[2];
    IkReal Rx = points[3]/rad;
    IkReal Ry = points[4]/rad;
    IkReal Rz = points[5]/rad;

    eerot[0] = IKcos(Rz)*IKcos(Ry);
    eerot[1] = IKcos(Rz)*IKsin(Ry)*IKsin(Rx) - IKsin(Rz)*IKcos(Rx);
    eerot[2] = IKcos(Rz)*IKsin(Ry)*IKcos(Rx) + IKsin(Rz)*IKsin(Rx);
    eerot[3] = IKsin(Rz)*IKcos(Ry);
    eerot[4] = IKsin(Rz)*IKsin(Ry)*IKsin(Rx) + IKcos(Rz)*IKcos(Rx);
    eerot[5] = IKsin(Rz)*IKsin(Ry)*IKcos(Rx) - IKcos(Rz)*IKsin(Rx);
    eerot[6] = -1*IKsin(Ry);
    eerot[7] = IKcos(Ry)*IKsin(Rx);
    eerot[8] = IKcos(Ry)*IKcos(Rx);

    bool bSuccess = ComputeIk(eetrans, eerot, 0, solutions);
    if( !bSuccess ) {
        fprintf(stderr,"Failed to get ik solution\n");
    }
```

Create C library for python

- Copy Makefile, ikfast.h, IKWrapperPy.cpp from source
- Edit solver.cpp to Euler mode (fk_euler/ik_euler)
- Makefile:

```
iklib.so: IKWrapperPy.cpp ikfast_solver.cpp
    g++ -fpic -c -lstdc++ -llapack -I/usr/include/python2.7 -I/usr/lib/python2.7/config-arm-linux-gnueabihf IKWrapperPy.cpp ikfast_solver.cpp
    g++ -shared  IKWrapperPy.o ikfast_solver.o -o ikfast.so
clean:
    @rm IKWrapperPy.o ikfast_solver.o ikfast.so
```

Python application


iktest.py (~/ikfast) - gedit
Open
Save
ikfast_solver.cpp
iktest.py
A1_V5.urdf
fkik.cpp
airlab@airlab-UDOO-x86: ~/ikfast

```python
import numpy as np
import ikfast

a = np.zeros(6)
b = np.zeros(6)
fk = np.array([0,0,0,0,0,0],float)
ik = np.array([0.4,0.4,0.3,30,30,30],float)

# fk: j1~j6 (degree)
print 'fk'
a = ikfast.fk(fk[0],fk[1],fk[2],fk[3],fk[4],fk[5])
print a

# ik: x,y,z,rx,ry,rz,n (meter,degree)
print 'ik'
i = 0
while b[0] >= 0:
        b = ikfast.ik(ik[0],ik[1],ik[2],ik[3],ik[4],ik[5],i)
        if b[0]>=0 :
                print b
        i=i+1

```

```
airlab@airlab-UDOO-x86:~/ikfast$ python iktest.py
fk
[0.0, 0.0, 0.9000000000000001, 0.0, -0.0, 0.0]
ik
[0.0, 51.325364065536355, 61.65432689661721, 51.390995588717956, -141.26210334025382, 95.1487164966975, 160.36951644436584]
[1.0, 51.325364065536355, 61.65432689661721, 51.390995588717956, 38.73805455577456, -95.1487164966975, -19.630641451663184]
[2.0, -128.67479383049263, -113.04532248533577, 51.390995588717956, 48.32003658079961, 56.560013239816456, 124.49687073911589]
[3.0, -128.67479383049263, -113.04532248533577, 51.390995588717956, -131.6801213152294, -56.560013239816456, -55.50328715691313]
[4.0, 51.325364065536355, 113.04532248533516, -51.390995588717956, -131.6801213152286, 56.56001323981606, 124.49687073911505]
[5.0, 51.325364065536355, 113.04532248533516, -51.390995588717956, 48.32003658079977, -56.56001323981606, -55.50328715691397]
[6.0, -128.67479383049263, -61.654326896617825, -51.390995588717956, 38.73805455577478, 95.14871649669801, 160.36951644436647]
[7.0, -128.67479383049263, -61.654326896617825, -51.390995588717956, -141.26210334025424, -95.14871649669801, -19.630641451662548]
airlab@airlab-UDOO-x86:~/ikfast$ 
```