

URDF AND YOU

ROSCON 2012

DAVID LU!!

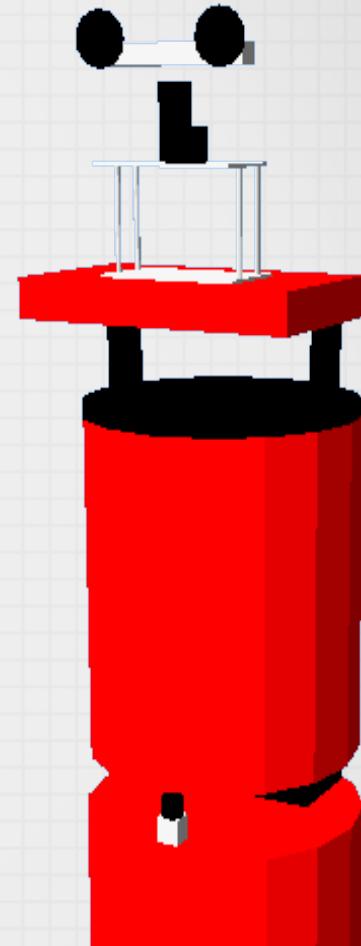
**PH.D. STUDENT
WASHINGTON UNIVERSITY
IN ST. LOUIS**

MAY 19, 2012

UNIFIED ROBOT DESCRIPTION FORMAT



```
<?xml version="1.0" ?>
<robot name="lewis">
  <link name="base">
    <inertial>
      <mass value="1"/>
      <inertia ixx="100" ixy="0" izz="100" />
      <origin />
    </inertial>
    <visual>
      <origin xyz="0 0 .15"/>
      <geometry>
        <cylinder length="0.3" radius="0.15"/>
      </geometry>
      <material name="lewisred">
        <color rgba="1 0 0 1"/>
      </material>
    </visual>
    <collision>
      <origin xyz="0 0 .15"/>
      <geometry>
        <cylinder length="0.3" radius="0.15"/>
      </geometry>
    </collision>
  </link>
  <link name="body">
    <inertial>
      <mass value="1" />
```



<http://www.ros.org/wiki/urdf>

OUTLINE

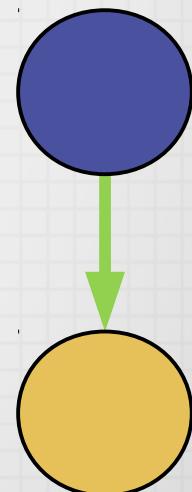
XML SPECIFICATION

TOOLS

LIMITATIONS

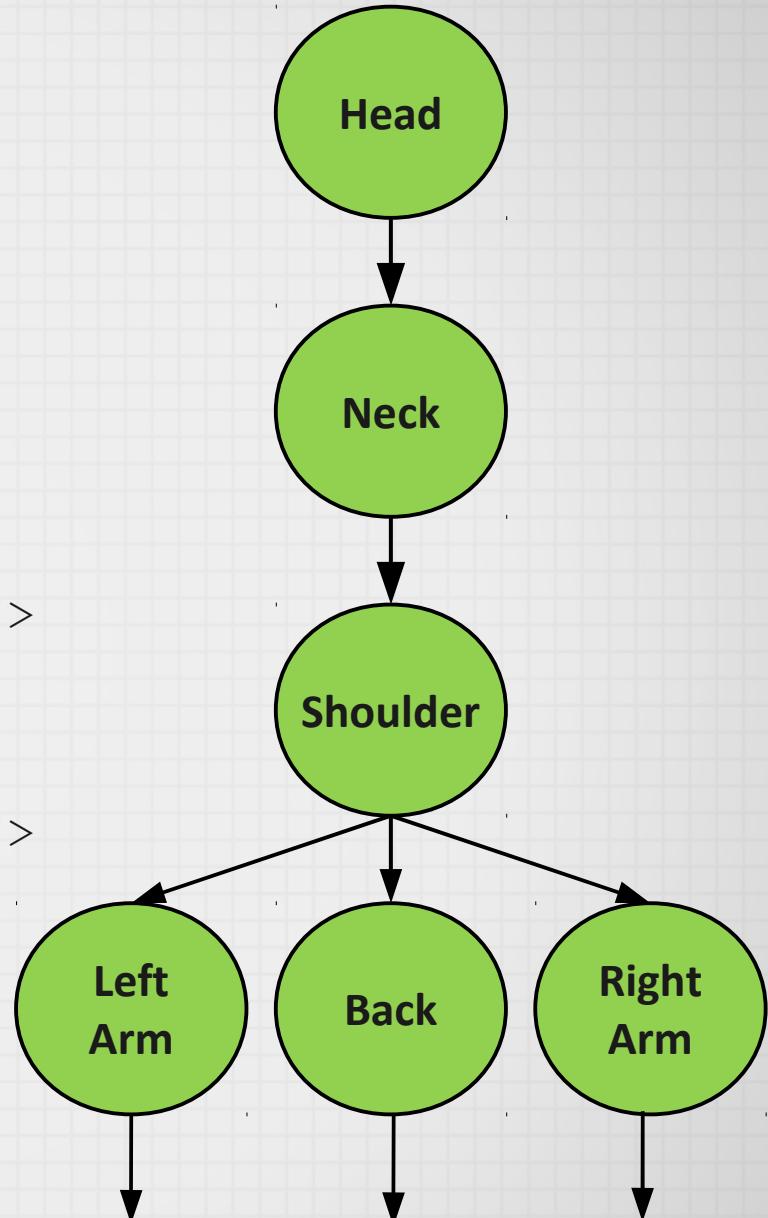
LINKS AND JOINTS

```
<?xml version="1.0"?>
<robot name="linksandjoints">
    <link name="tothepast" />
    <link name="hogthrob" />
    <joint name="expenditure" type="fixed">
        <parent link="tothepast"/>
        <child link="hogthrob"/>
    </joint>
</robot>
```



TOPOLOGY

```
<?xml version="1.0"?>
<robot name="dembones">
  <link name="head" />
  <link name="neck" />
  <link name="shoulder" />
  <link name="left_arm" />
  <link name="right_arm" />
  <link name="back" />
  <joint name="joint1" type="fixed">
    <parent link="head"/>
    <child link="neck"/>
  </joint>
  <joint name="joint2" type="fixed">
    <parent link="neck"/>
    <child link="shoulder"/>
  </joint>
  ...
</robot>
```



EXAMPLE: TOPOLOGY OF LEWIS



```
<robot name="lewis1">
  <link name="base" />
  <link name="body" />
  <link name="ptu_base" />
  <link name="ptu_piece" />
  <link name="eyes" />
  <joint name="base_to_body" type="fixed">
    <parent link="base"/>
    <child link="body"/>
  </joint>
  <joint name="body_to_base" type="fixed">
    <parent link="body"/>
    <child link="ptu_base"/>
  </joint>
  <joint name="base_to_piece" type="fixed">
    <parent link="ptu_base"/>
    <child link="ptu_piece"/>
  </joint>
  <joint name="piece_to_eyes" type="fixed">
    <parent link="ptu_piece"/>
    <child link="eyes"/>
  </joint>
</robot>
```

COORDINATE FRAMES AND TF

Parent Frame

Child Frame

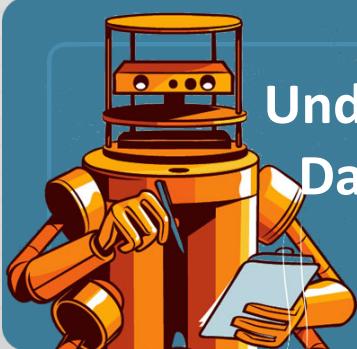
Translation

xyz (meters)

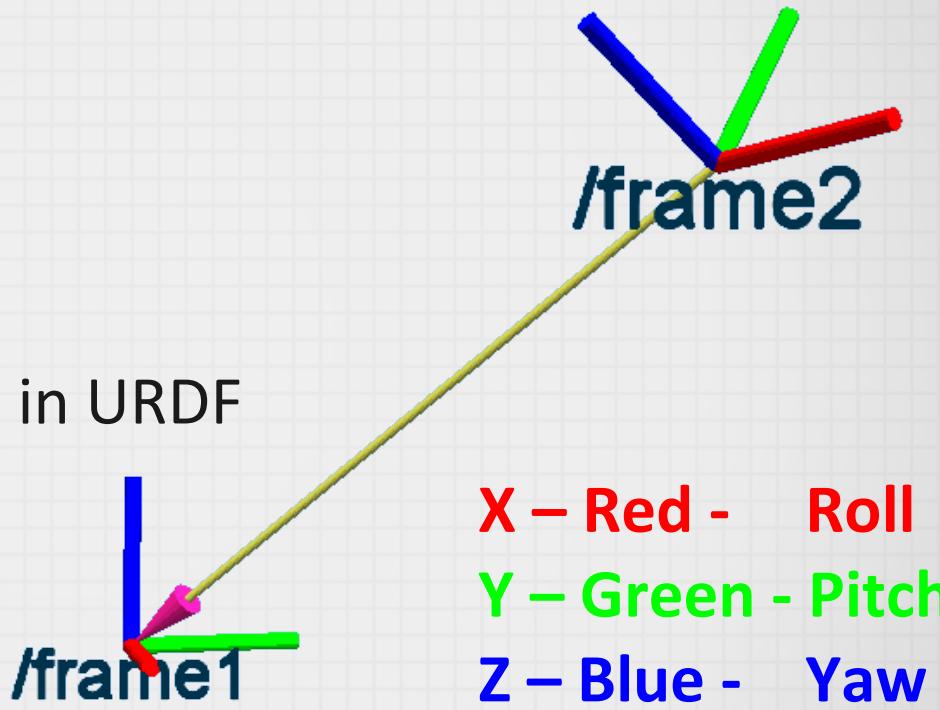
Rotation

Quaternion in TF

Roll Pitch Yaw (radians) in URDF

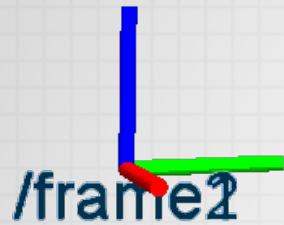


Understanding tf
Day 2: 11:00am
Tully Foote

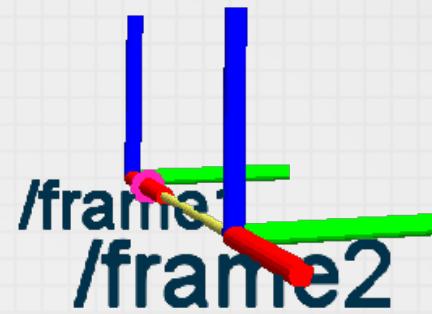


<http://www.ros.org/wiki/tf>

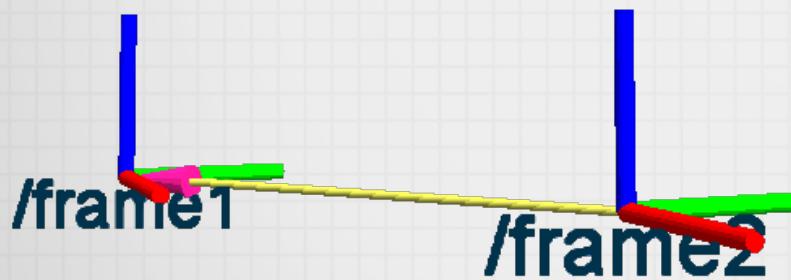
GEOMETRY OF JOINTS



```
<origin/>  
<origin xyz="0 0 0"  
       rpy="0 0 0"/>
```



```
<origin xyz=".5 0 0" />
```



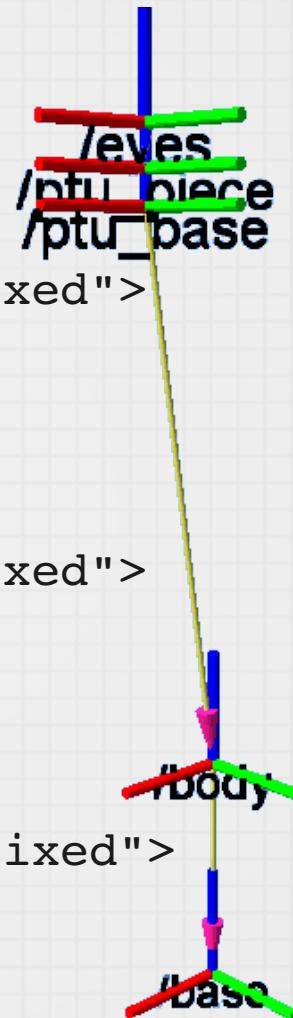
```
<origin xyz=".5 .4 0" />
```



```
<origin xyz=".5 .4 0"  
       rpy="0 0 1.51"/>
```

EXAMPLE: LEWIS' GEOMETRY

```
<robot name="lewis2">  
  ...  
  <link name="ptu_piece" />  
  <link name="eyes" />  
  <joint name="base_to_body" type="fixed">  
    <parent link="base"/>  
    <child link="body"/>  
    <origin xyz="0 0 .4"/>  
  </joint>  
  <joint name="body_to_base" type="fixed">  
    <parent link="body"/>  
    <child link="ptu_base"/>  
    <origin xyz=".14 - .007 .925"/>  
  </joint>  
  <joint name="base_to_piece" type="fixed">  
    <parent link="ptu_base"/>  
    <child link="ptu_piece"/>  
    <origin xyz="0 0 .055"/>  
  ...
```



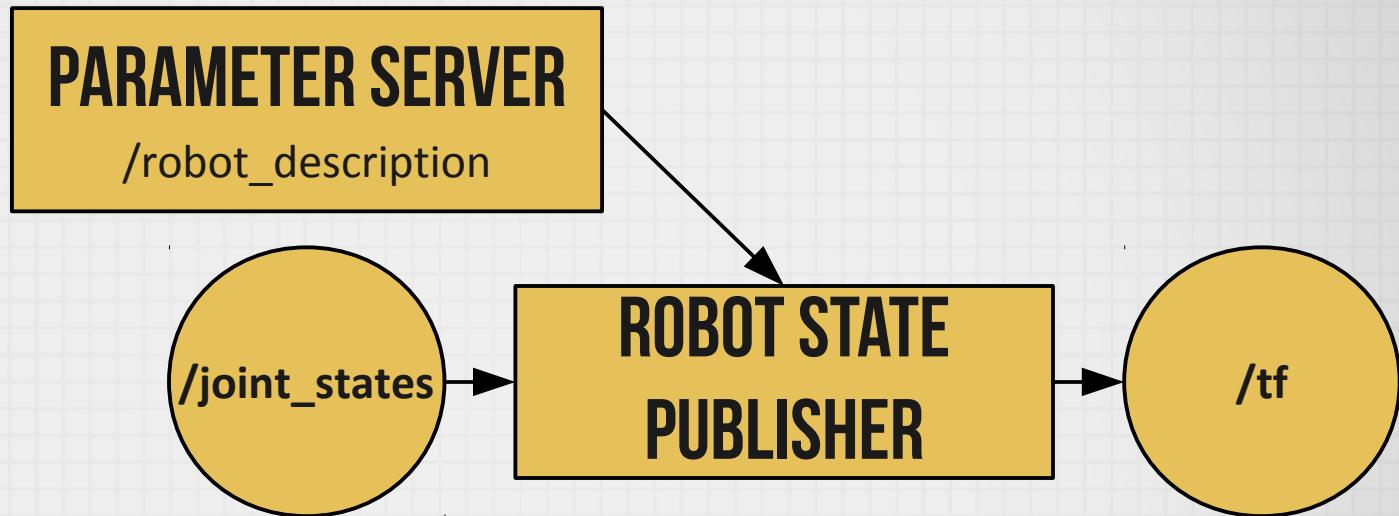
PUBLISHING TF: ROBOT_DESCRIPTION PARAMATER

PARAMETER SERVER

/robot_description

```
<param name="robot_description"  
       textfile="$(find roscon_urdf)/urdf/04-lewis.urdf"  
/>
```

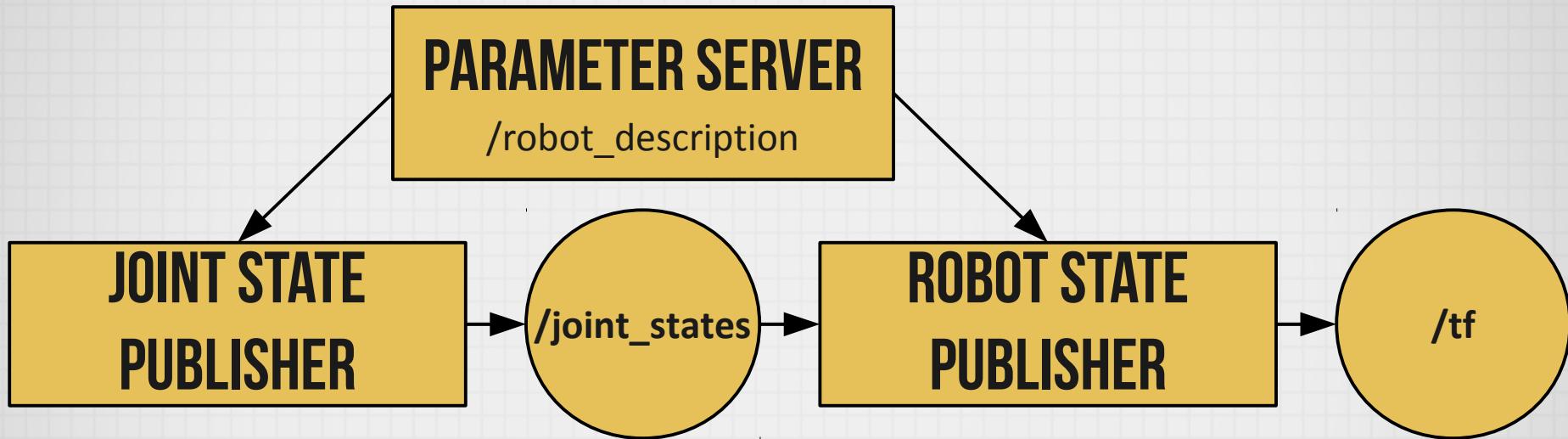
PUBLISHING TF: ROBOT STATE PUBLISHER



```
<node name="robot_state_publisher"  
      pkg="robot_state_publisher"  
      type="state_publisher" />
```

http://www.ros.org/wiki/robot_state_publisher

PUBLISHING TF: JOINT STATE PUBLISHER



```
<node name="joint_state_publisher"  
      pkg="joint_state_publisher"  
      type="joint_state_publisher" />
```

http://www.ros.org/wiki/joint_state_publisher

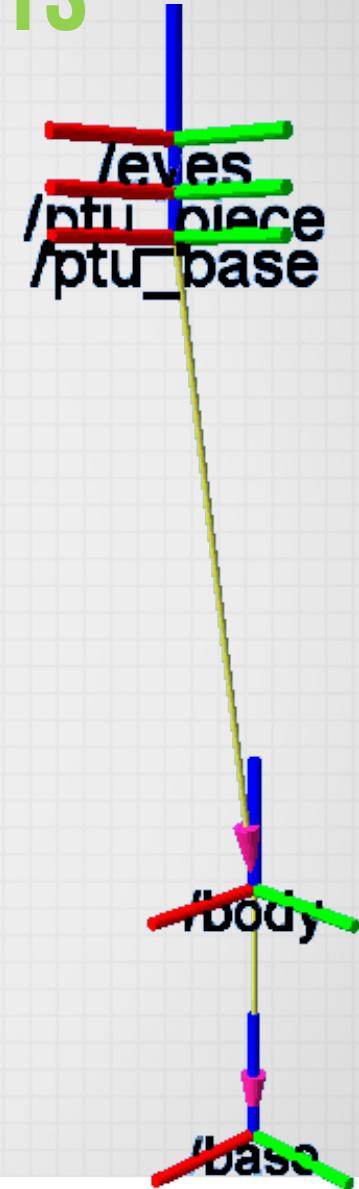
FLEXIBLE JOINTS: JOINT TYPE



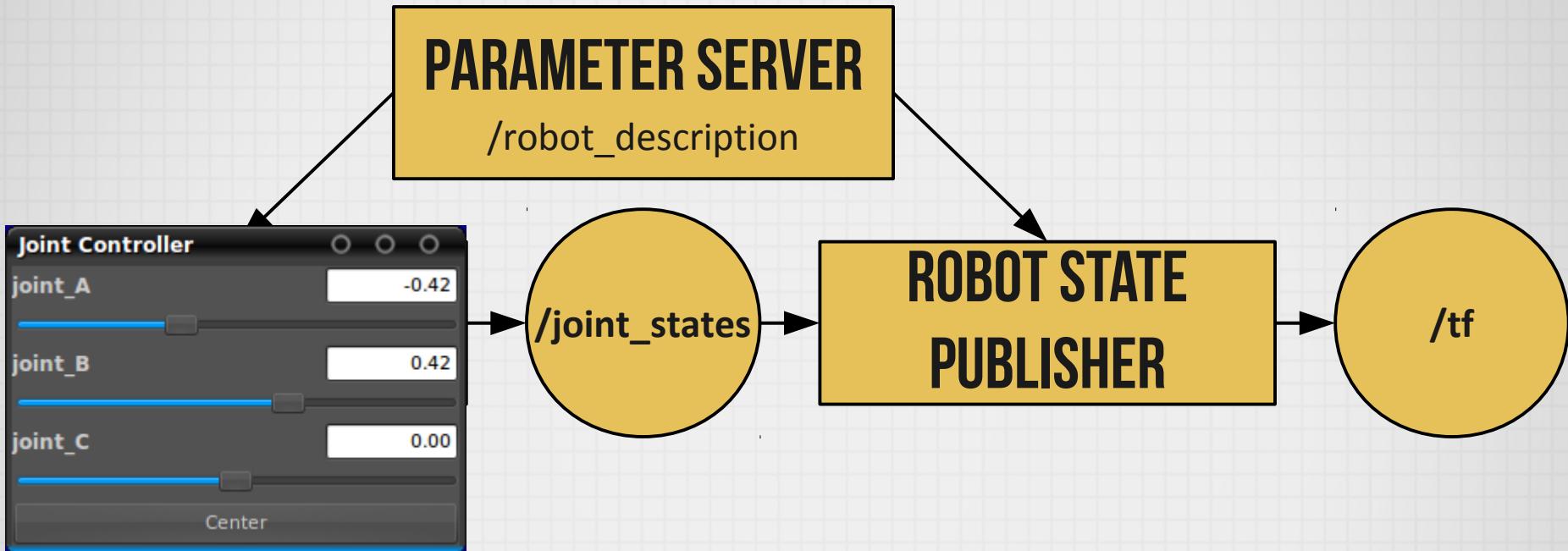
(Planar - 2D)
(Floating - 6D)

EXAMPLE: LEWIS WITH FLEXIBLE JOINTS

```
<joint name="base_to_body" type="continuous">
  ...
  <axis xyz="0 0 1"/>
</joint>
<joint name="body_to_base" type="fixed">
  ...
</joint>
<joint name="base_to_piece" type="revolute">
  ...
  <limit upper="3.14" lower="-3.14"
        velocity="1.0" effort="1.0"/>
  <axis xyz="0 0 1"/>
</joint>
<joint name="piece_to_eyes" type="revolute">
  ...
  <limit upper=".54" lower="-.82"
        velocity="1.0" effort="1.0"/>
  <axis xyz="0 -1 0"/>
</joint>
```

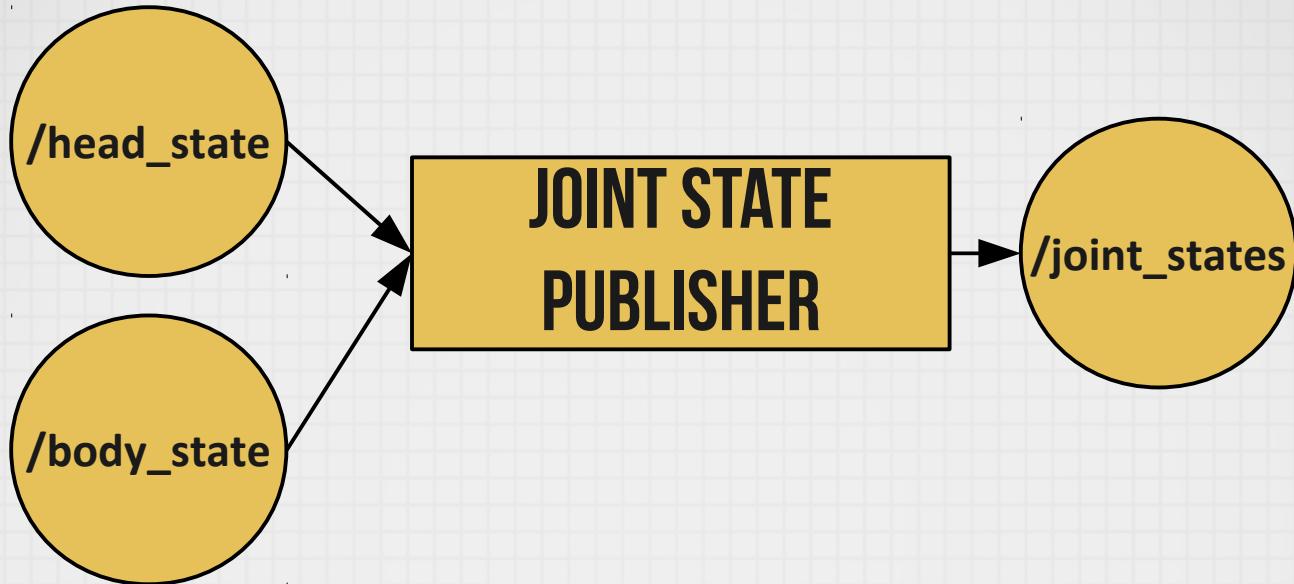


JOINT STATE PUBLISHER WITH GUI



```
<node name="joint_state_publisher"
      pkg="joint_state_publisher"
      type="joint_state_publisher">
  <param name="use_gui" value="True"/>
</node>
```

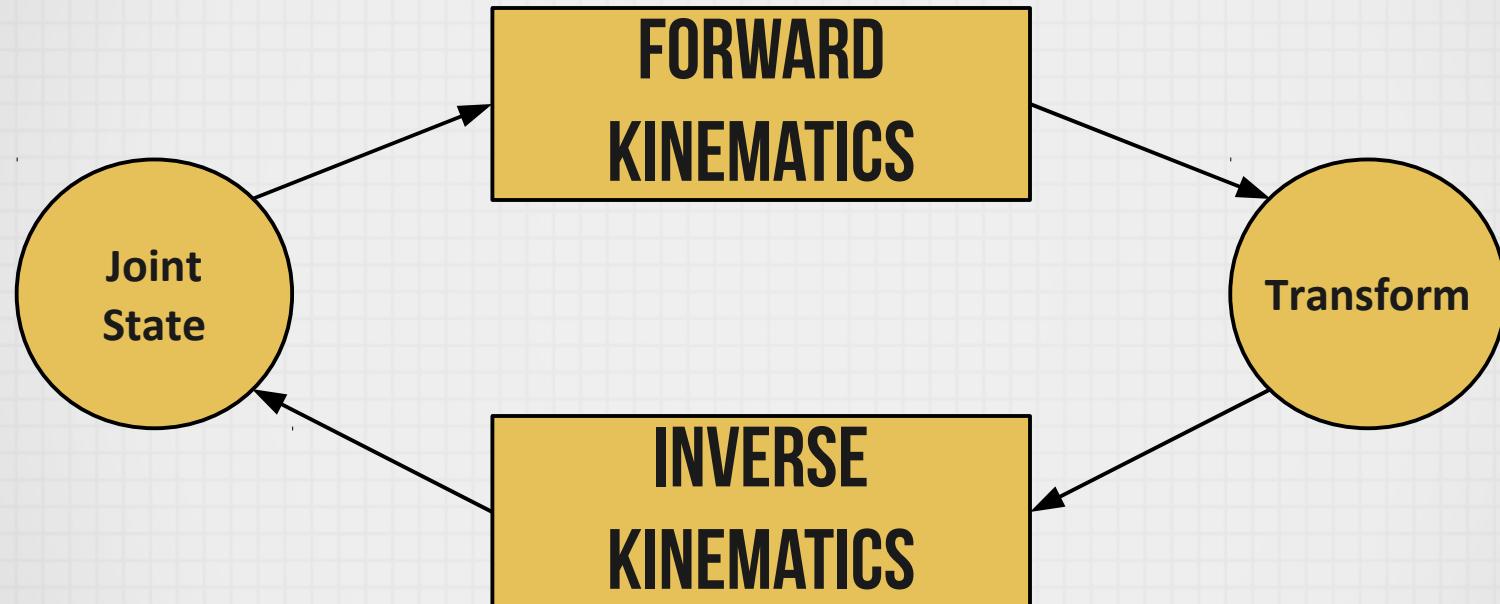
JOINT STATE PUBLISHER WITH SOURCES



```
<node name="joint_state_publisher"  
      type="joint_state_publisher"  
      pkg="joint_state_publisher">  
  <rosparam param="source_list">  
    [head_state, body_state]  
  </rosparam>  
</node>
```

KINEMATICS WITH KDL

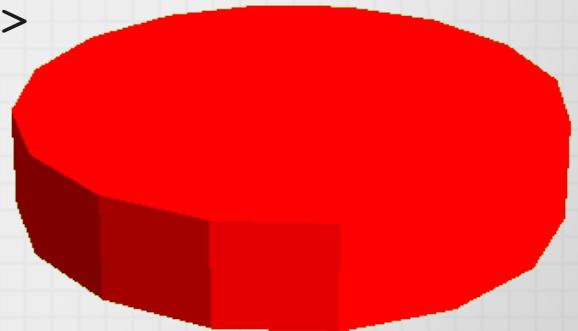
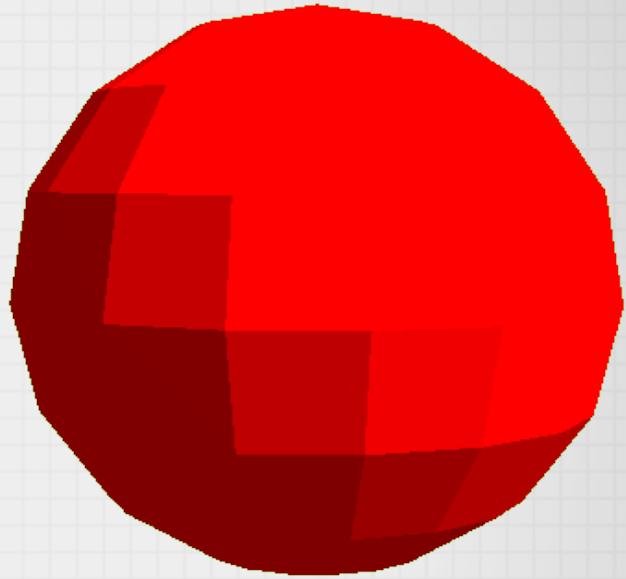
Kinematics and Dynamics Library



http://www.ros.org/wiki/arm_navigation

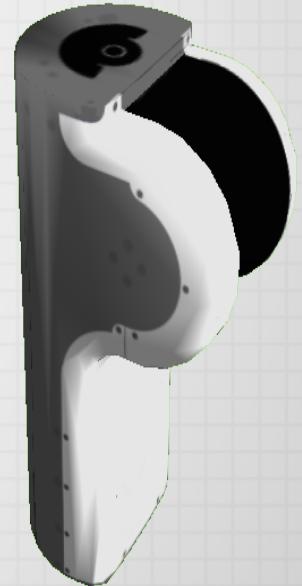
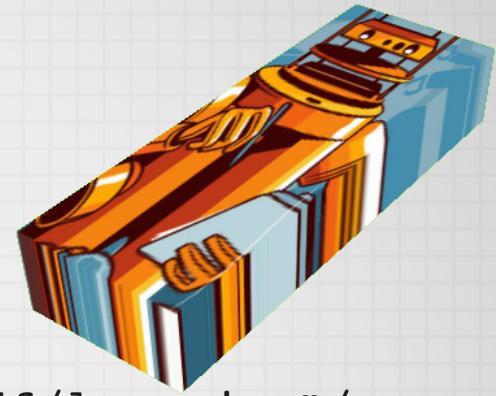
VISUALIZATION: GEOMETRY AND MATERIAL

```
<link name="sphere">
  <visual>
    <geometry>
      <sphere radius=".5" />
    </geometry>
    <material name="red">
      <color rgba="1 0 0 1" />
    </material>
  </visual>
</link>
<link name="cylinder">
  <visual>
    <geometry>
      <cylinder radius=".5" length=".2" />
    </geometry>
    <material name="red" />
  </visual>
</link>
```

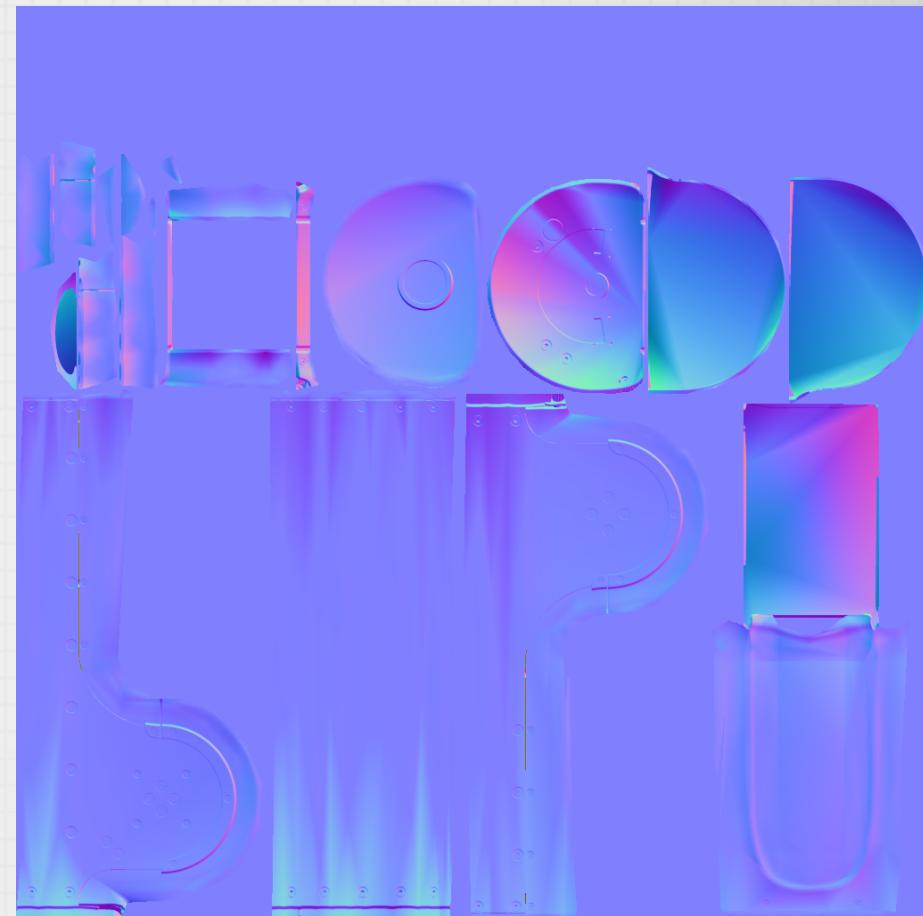
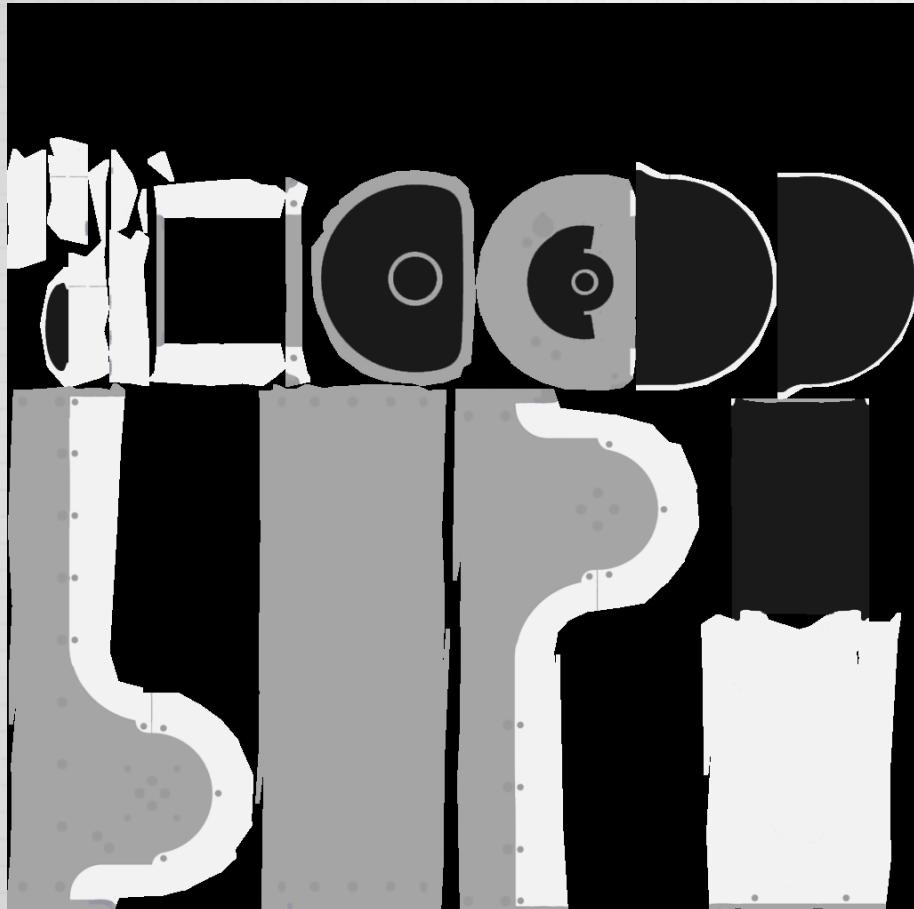


VISUALIZATION: GEOMETRY AND MATERIAL

```
<link name="box">
  <visual>
    <geometry>
      <box size="1.5 .5 .25"/>
    </geometry>
    <material name="pattern">
      <texture filename="package://roscon_urdf/logo.jpg"/>
    </material>
  </visual>
</link>
<link name="mesh">
  <visual>
    <geometry>
      <mesh filename=
        "package://roscon_urdf/shoulder_pan.dae" />
    </geometry>
  </visual>
</link>
```



VISUALIZATION: COLLADA DATA



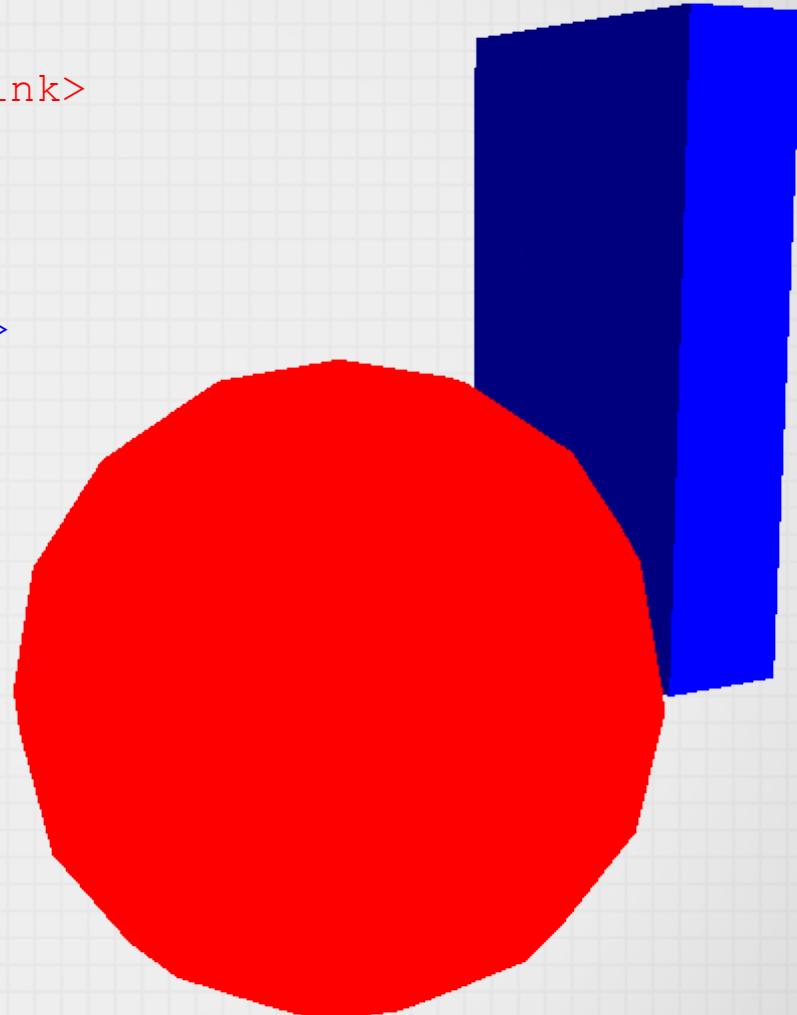
VISUALIZATION: VISUAL ORIGIN

```
<robot name="origins">
  <link name="base_link">...</link>

  <link name="leg">
    <visual>
      <geometry>
        <box size="0.6 .2 1.0"/>
      </geometry>
      <origin xyz="? ? ?"/>
    </visual>
  </link>

  <joint name="base_to_leg"
        type="continuous">
    <parent link="base_link"/>
    <child link="leg"/>
    <origin xyz="? ? ?"/>
    <axis xyz="0 1 0"/>
  </joint>

</robot>
```



VISUALIZATION: VISUAL ORIGIN

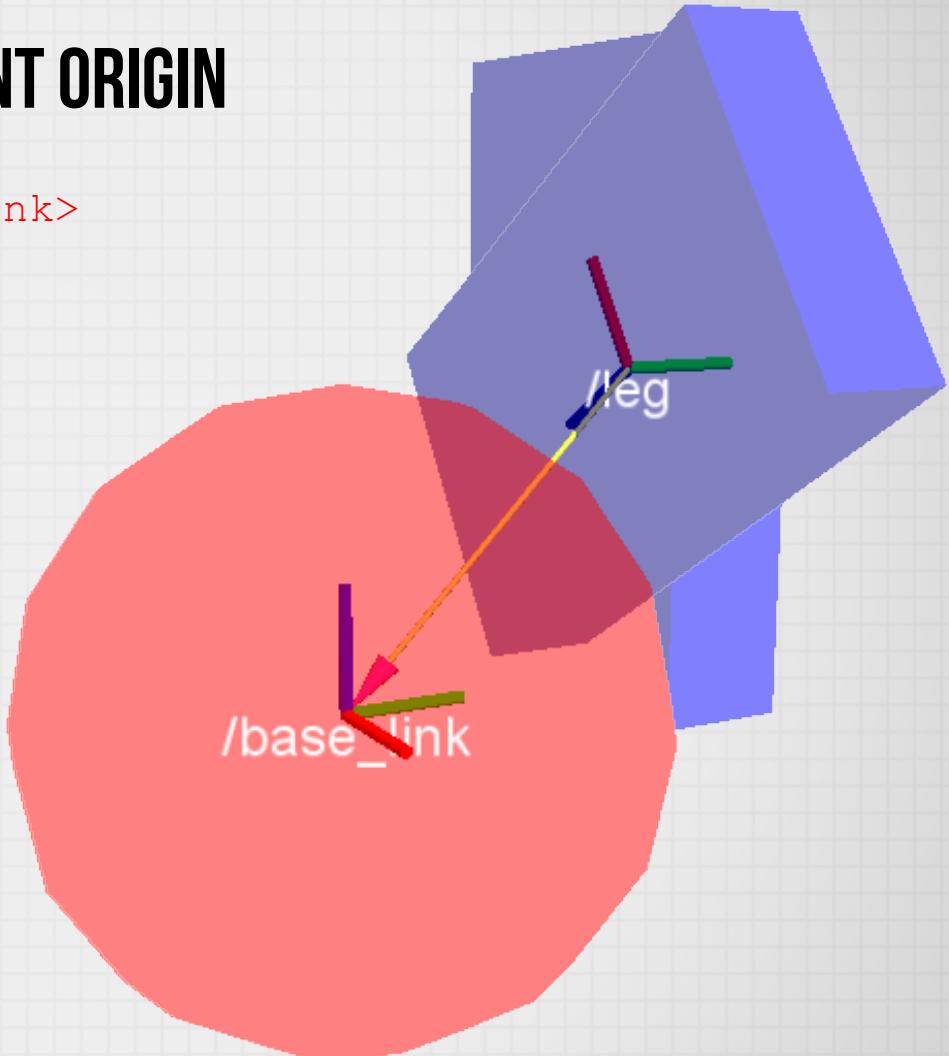
JUST THE JOINT ORIGIN

```
<robot name="origins">
  <link name="base_link">...</link>

  <link name="leg">
    <visual>
      <geometry>...</geometry>
    </visual>
  </link>

  <joint name="base_to_leg"
        type="continuous">
    <parent link="base_link"/>
    <child link="leg"/>
    <origin xyz="0 .5 .5"/>
    <axis xyz="0 1 0"/>
  </joint>

</robot>
```



VISUALIZATION: VISUAL ORIGIN

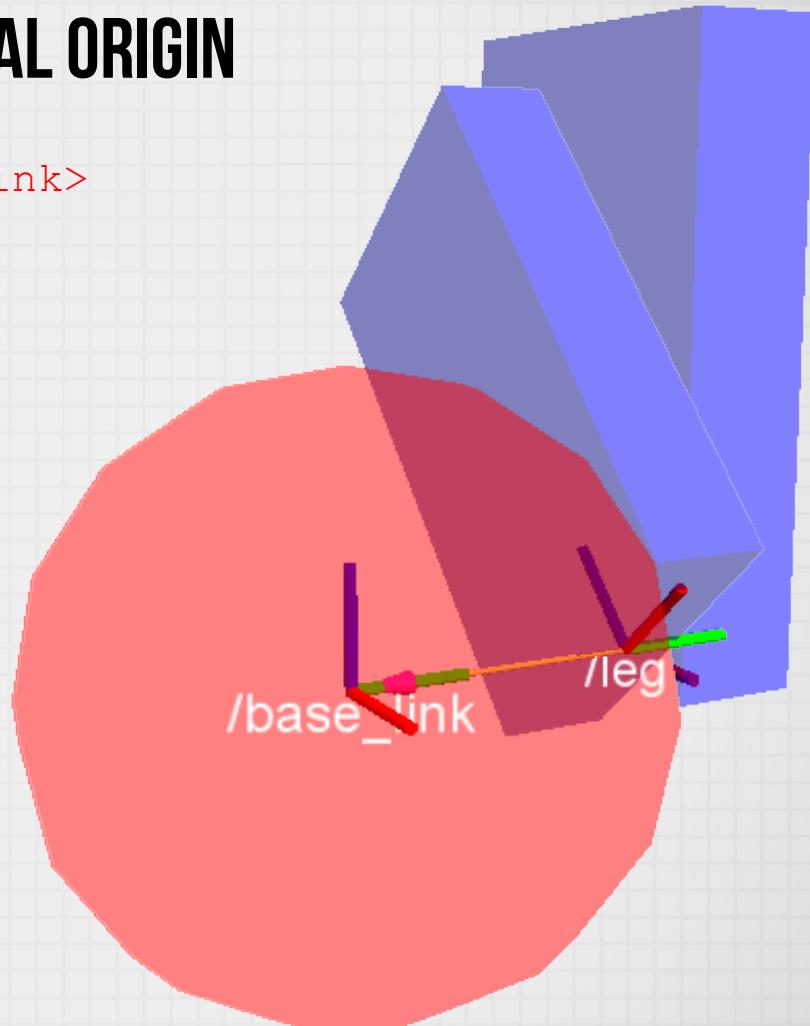
JOINT ORIGIN + VISUAL ORIGIN

```
<robot name="origins">
  <link name="base_link">...</link>

  <link name="leg">
    <visual>
      <geometry>...</geometry>
    </visual>
    <origin xyz="0 0 .5"/>
  </link>

  <joint name="base_to_leg"
        type="continuous">
    <parent link="base_link"/>
    <child link="leg"/>
    <origin xyz="0 .5 0"/>
    <axis xyz="0 1 0"/>
  </joint>

</robot>
```



VISUALIZATION: VISUAL ORIGIN

JUST VISUAL ORIGIN

```
<robot name="origins">
  <link name="base_link">...</link>

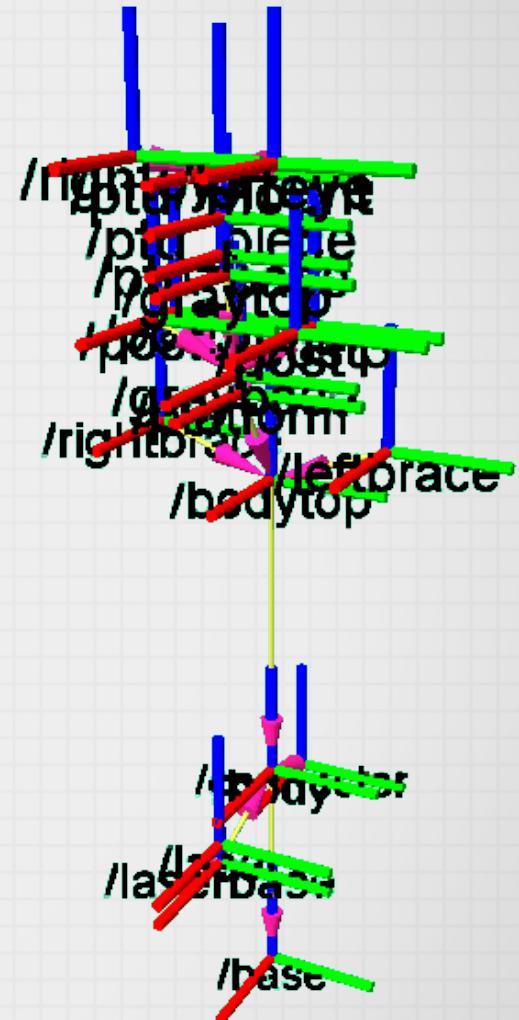
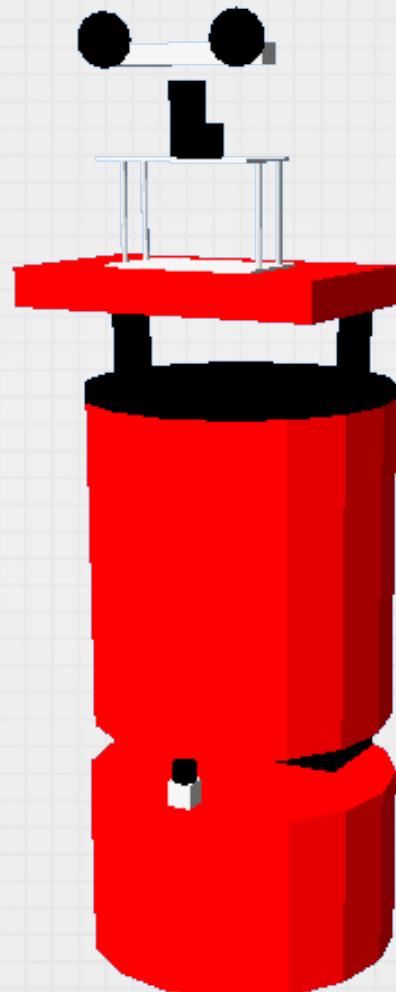
  <link name="leg">
    <visual>
      <geometry>...</geometry>
    </visual>
    <origin xyz="0 .5 .5"/>
  </link>

  <joint name="base_to_leg"
        type="continuous">
    <parent link="base_link"/>
    <child link="leg"/>
    <axis xyz="0 1 0"/>
  </joint>

</robot>
```

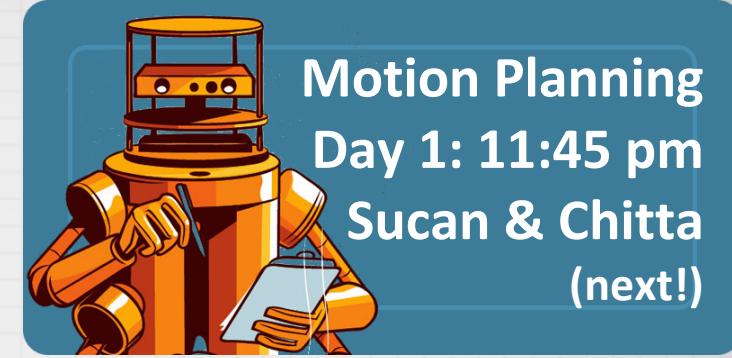


EXAMPLE: LEWIS' VISUAL

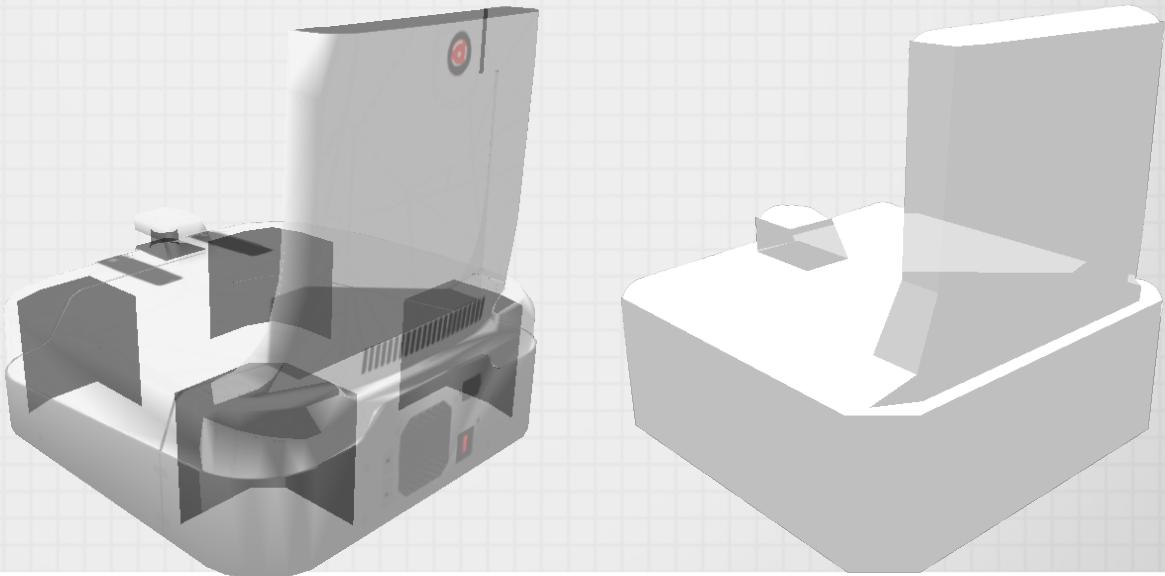


COLLISIONS: GEOMETRY

```
<link name="base_link">
  <visual>
    <geometry>
      <mesh filename=
        "package://pr2_description/meshes/base_v0/base.dae"/>
    </geometry>
  </visual>
  <collision>
    <geometry>
      <mesh filename=
        "package://pr2_description/meshes/base_v0/base_L.stl"/>
    </geometry>
  </collision>
</link>
```



Motion Planning
Day 1: 11:45 pm
Sucan & Chitta
(next!)

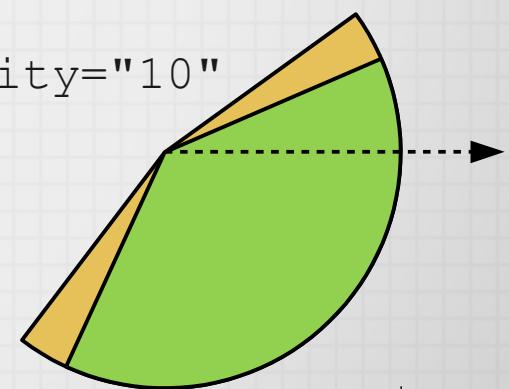


[http://www.ros.org/wiki/
collision_environment](http://www.ros.org/wiki/collision_environment)

SIMULATION: INERTIA AND JOINT PROPERTIES

```
<link name="r_shoulder_pan_link">
  <inertial>
    <mass value="25.799322"/>
    <origin xyz="-.001 .024 -.098"/>
    <inertia ixx=".866" ixy="-.061" ixz="-.121"
              iyy=".874" iyz="-.059" izz=".274"/>
  </inertial>
  ...
</link>
<joint name="r_shoulder_pan_joint" type="revolute">
  ...
  <limit effort="30" velocity="2.088"
        lower="-2.28" upper=".71" />
  <safety_controller k_position="100" k_velocity="10"
        soft_lower_limit="-2.14"
        soft_upper_limit="0.56"/>
  <dynamics damping="10.0"/>
  <calibration rising="-.785"/>
</joint>
```

$$\mathbf{I} = \begin{bmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{bmatrix}$$



SIMULATION: GAZEBO

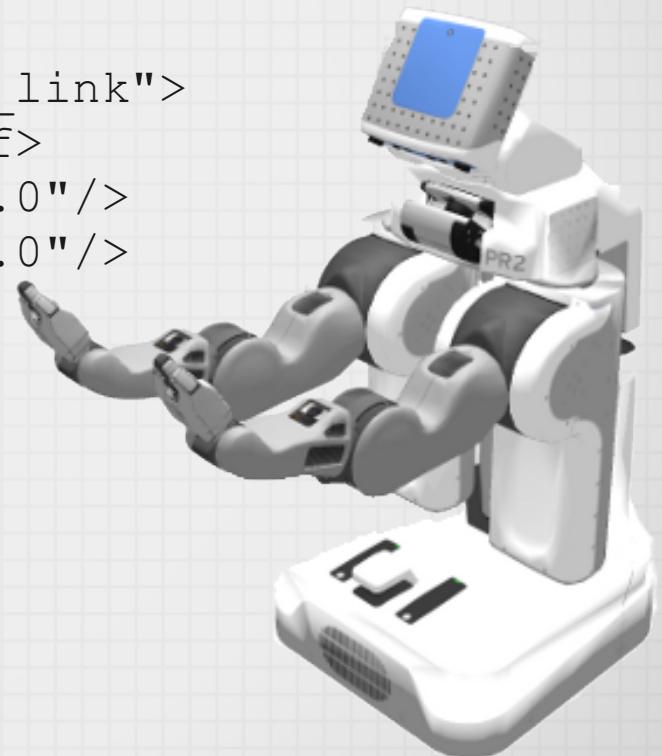
```
<transmission name="r_shoulder_pan_trans"
    type="pr2_mechanism_model/SimpleTransmission">
<joint name="r_shoulder_pan_joint"/>
<actuator name="r_shoulder_pan_motor"/>
<mechanicalReduction>63.1552452977</mechanicalReduction>
</transmission>
```

```
<gazebo reference="r_gripper_r_finger_link">
<turnGravityOff>true</turnGravityOff>
<mu1 value="500.0"/><mu2 value="500.0"/>
<kp value="1000000.0"/><kd value="1.0"/>
</gazebo>
```



Gazebo
Day 1: 2:45 pm
Hsu & Koenig

<http://www.ros.org/wiki/gazebo>



TOOLS: APIs AND BASIC UTILITIES

C++

urdf_parser
urdf_interface

PYTHON

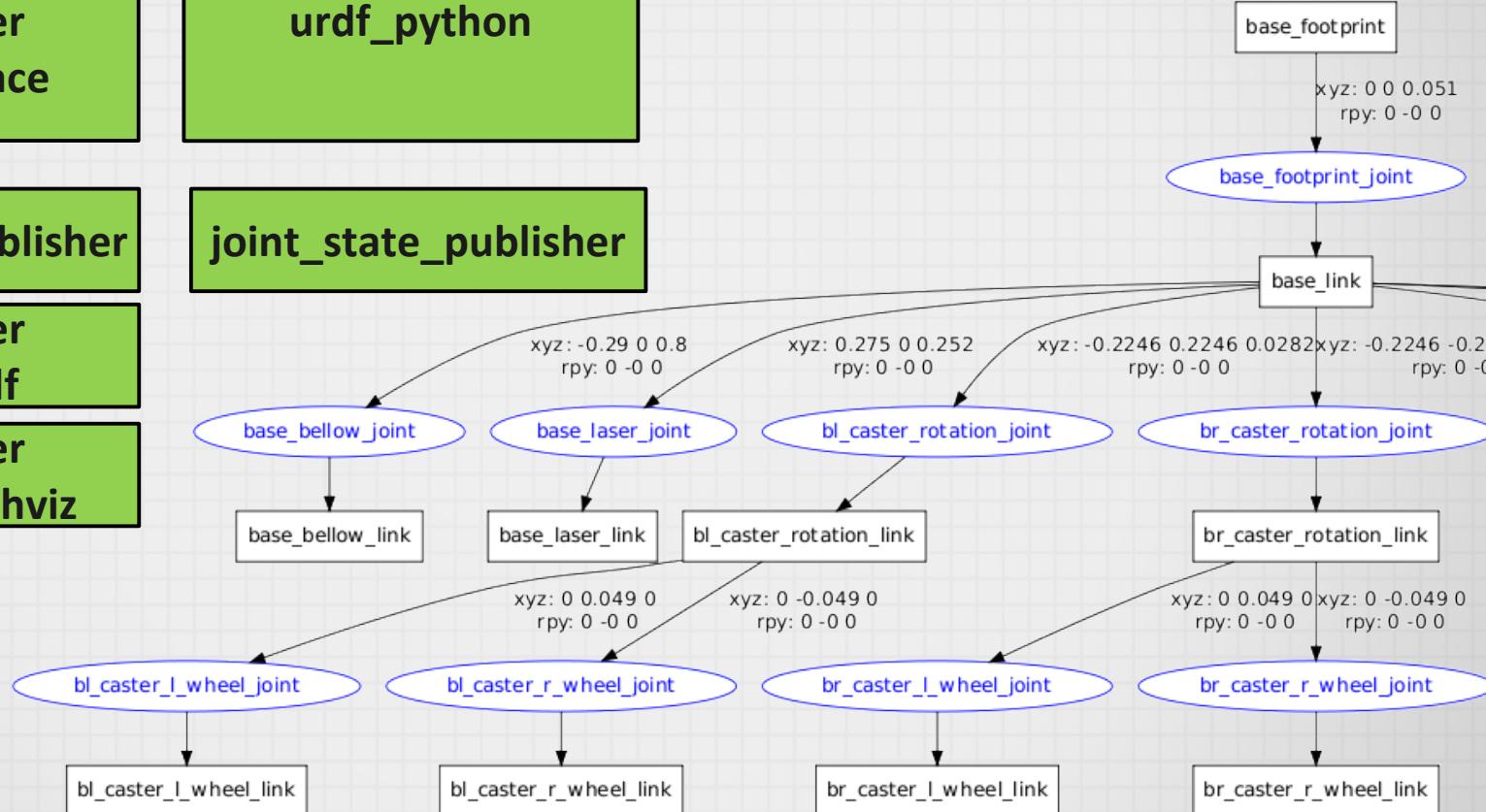
urdf_python

robot_state_publisher

joint_state_publisher

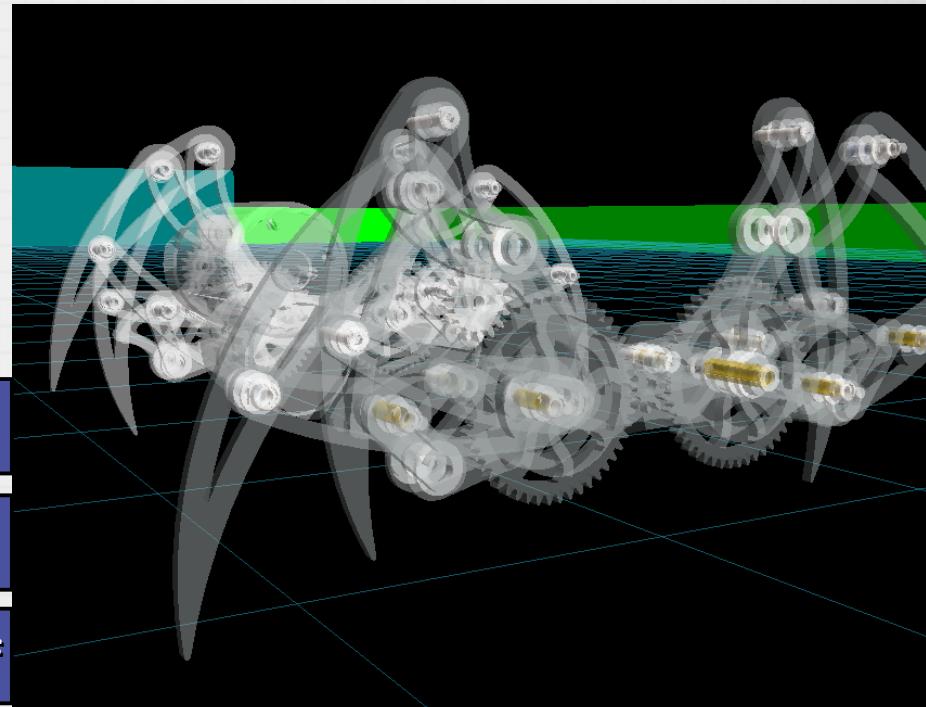
urdf_parser
check_urdf

urdf_parser
urdf_to_graphviz



TOOLS: CONVERSION

COLLADA (COLLAborative Design Activity)
Ivcon (3ds, ase, byu, obj, stl, stlb and more)
simmechanics_to_urdf (CAD programs)



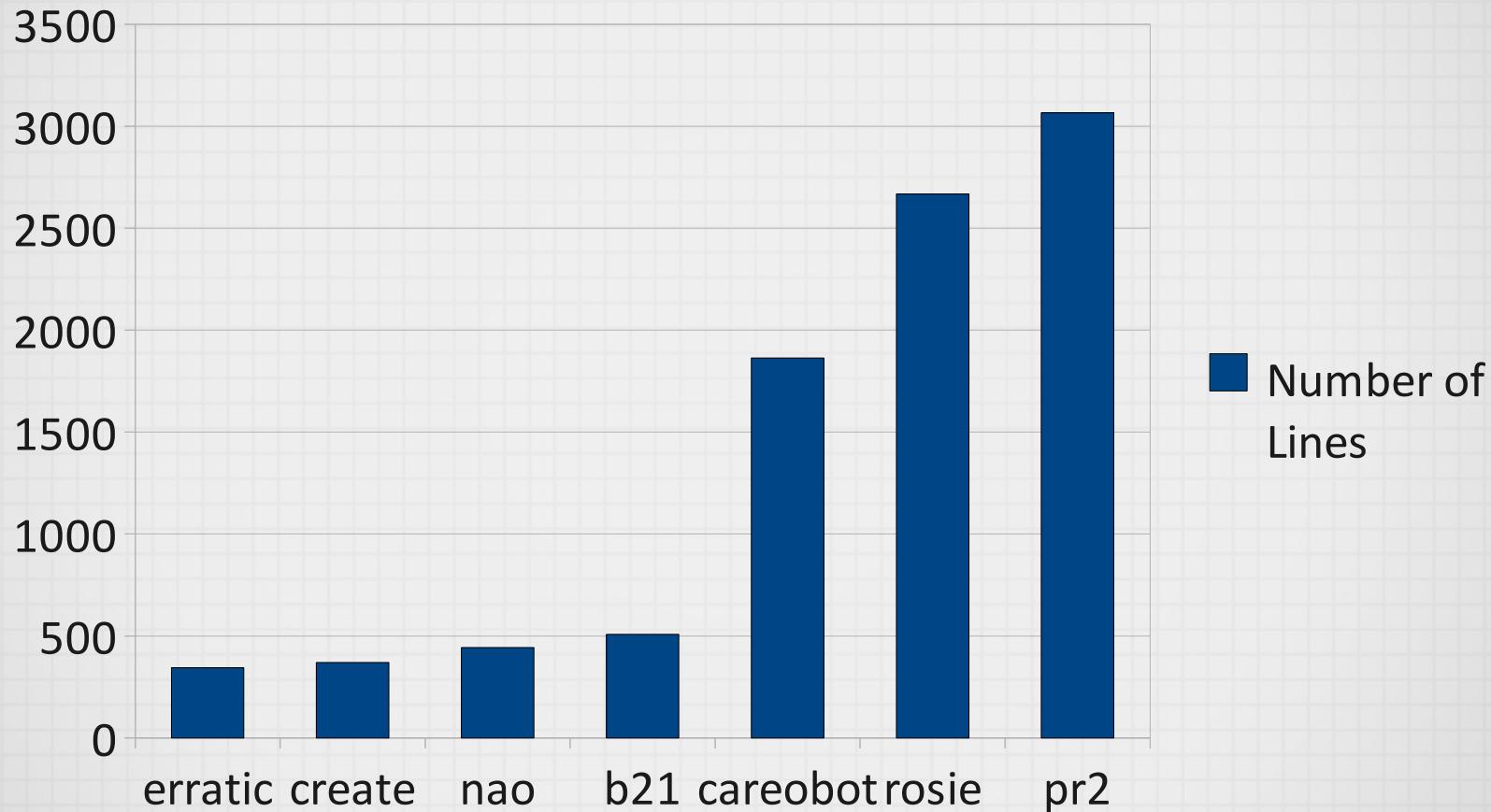
http://www.ros.org/wiki/collada_urdf

<http://www.ros.org/wiki/ivcon>

http://www.ros.org/wiki/simmechanics_to_urdf

TOOLS: XACRO

STATISTICS



<http://www.ros.org/wiki/xacro>

TOOLS: XACRO

LAUNCHING

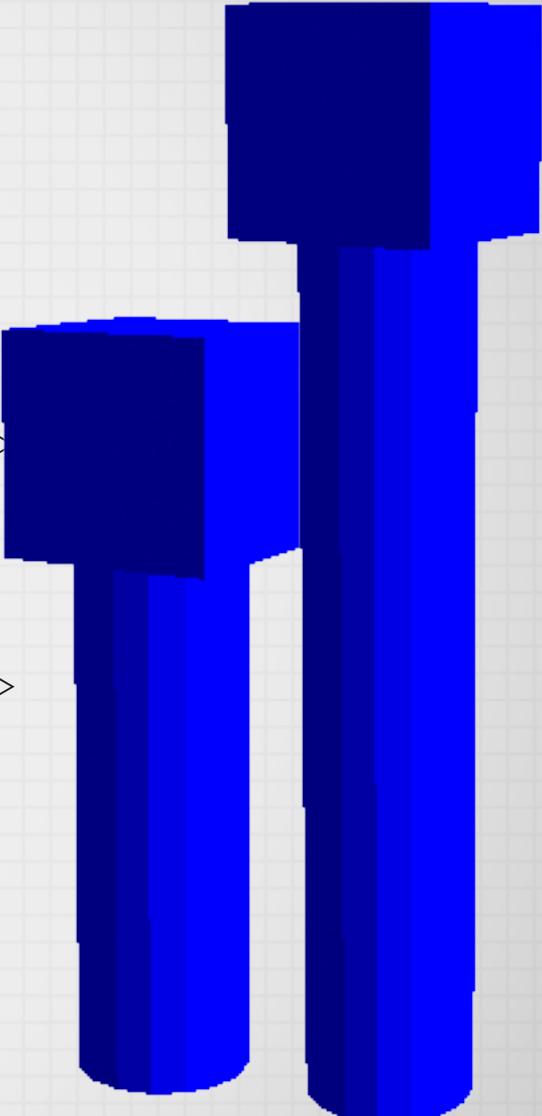
```
<param name="robot_description"
  textfile="$(find roscon_urdf)/urdf/04-lewis.urdf"
/>

<param name="robot_description"
  command="$(find xacro)/xacro.py
    $(find roscon_urdf)/urdf/11-xacro.xacro"
/>
```

TOOLS: XACRO

PROPERTIES

```
<xacro:property name="width" value=".2" />
<xacro:property name="bodylen" value=".6" />
<link name="base_link">
  <visual>
    <geometry>
      <cylinder radius="${width/2}" length="${bodylen}" />
    </geometry>
  </visual>
  <collision>
    <geometry>
      <cylinder radius="${width/2}" length="${bodylen}" />
    </geometry>
  </collision>
</link>
<joint name="base_to_arm" type="fixed">
  ...
  <origin xyz="0 ${bodylen/2} 0" />
</joint>
```

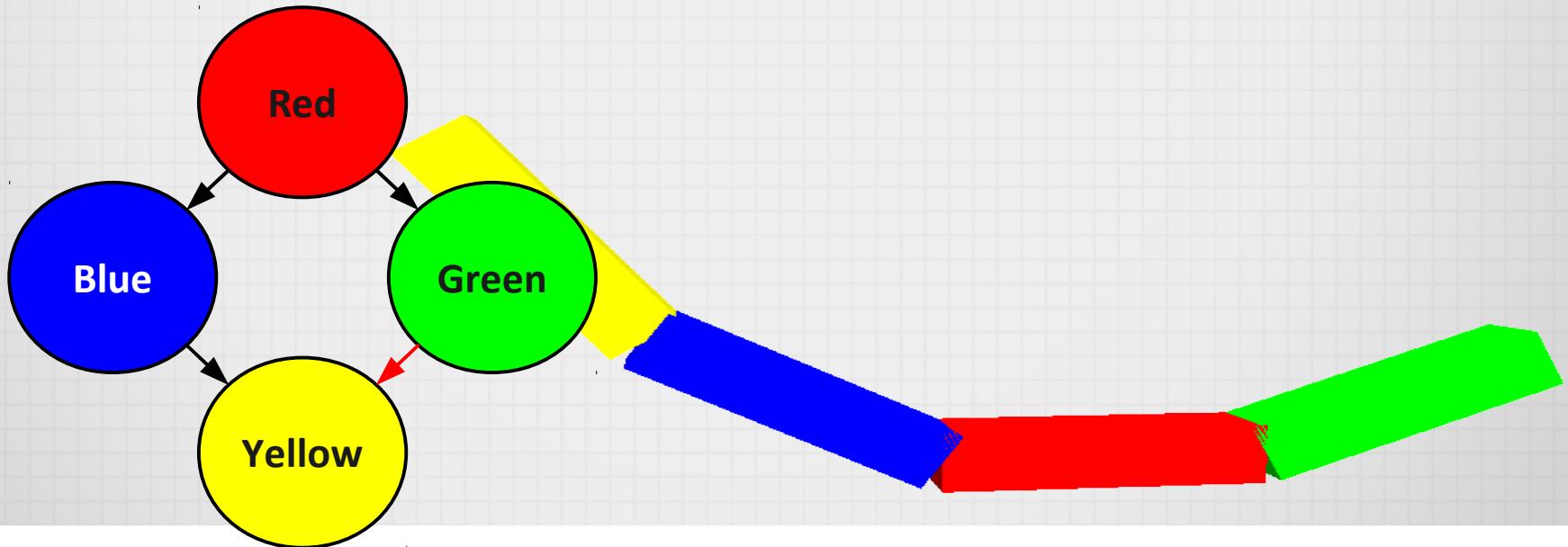
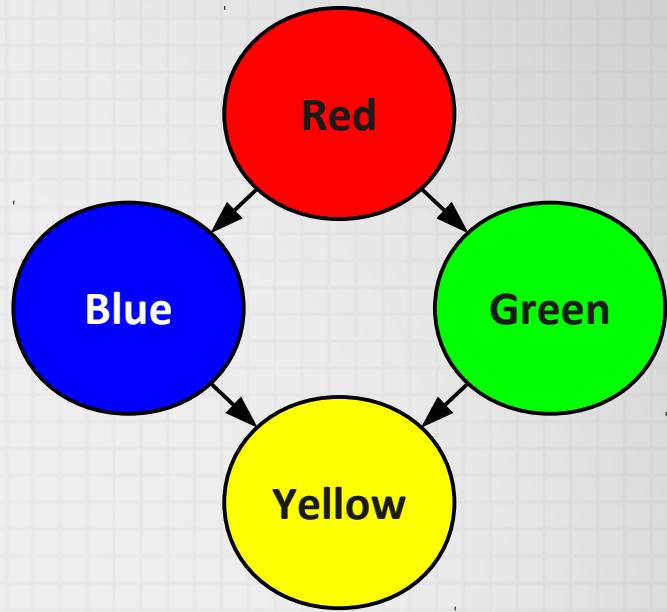
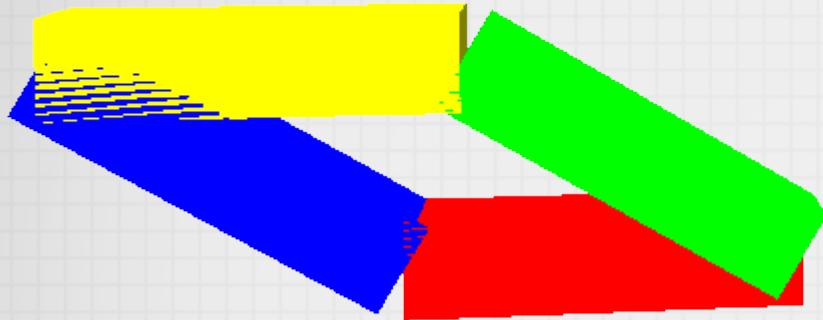


TOOLS: XACRO

FULL MACRO

```
<xacro:macro name="leg" params="prefix reflect">
  <link name="${prefix}_leg">
    <visual>
      <geometry>
        <box size="${leglen} .2 .1"/>
      </geometry>
      <origin xyz="0 0 -${leglen/2}"/>
    </visual>
  </link>
  <joint name="base_to_${prefix}_leg" type="fixed">
    <parent link="base_link"/>
    <child link="${prefix}_leg"/>
    <origin xyz="${reflect*width} 0 .25" />
  </joint>
</xacro:macro>
<xacro:leg prefix="right" reflect="1" />
<xacro:leg prefix="left" reflect="-1" />
```

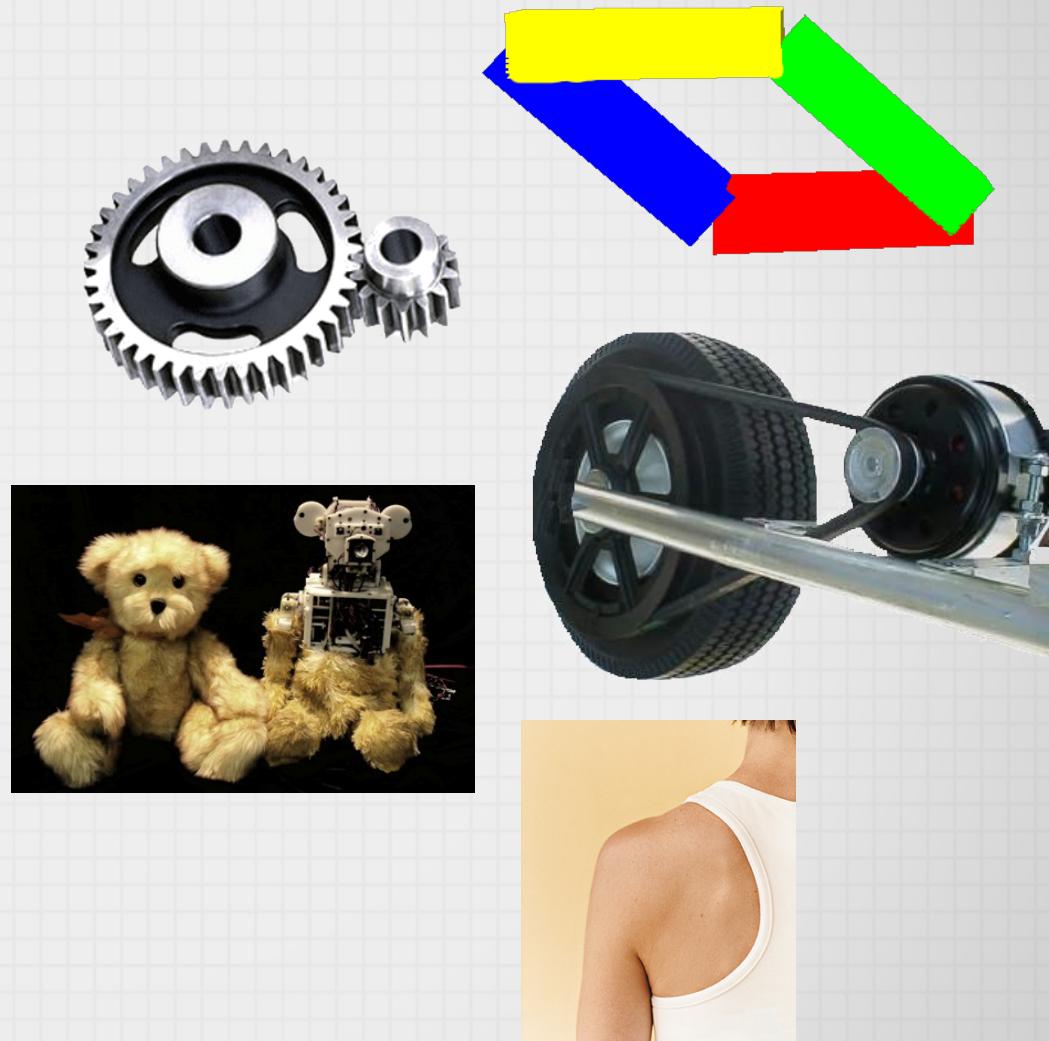
LIMITATIONS: FOUR BAR LINKAGE



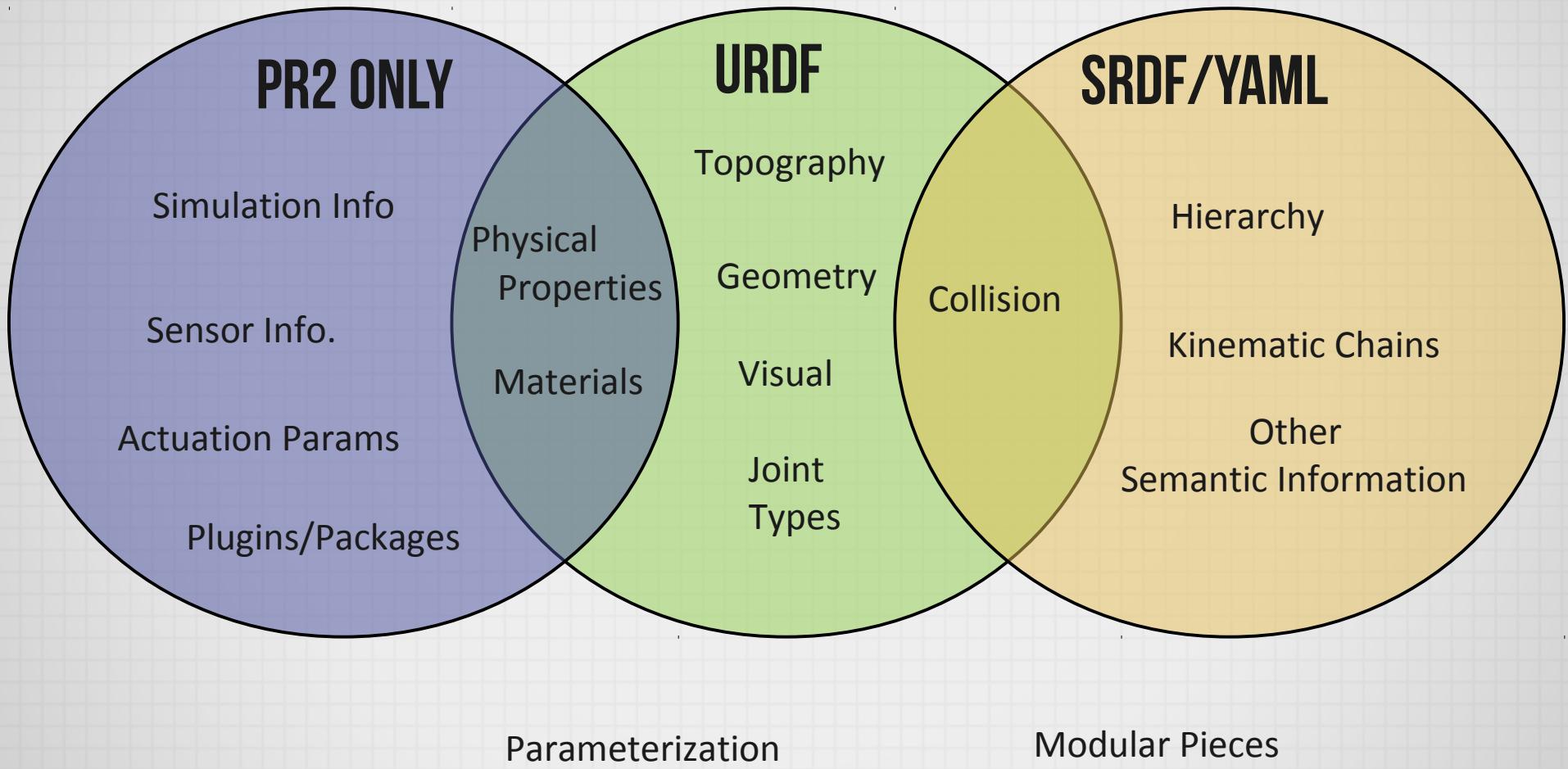
LIMITATIONS: LIMITED MODELING ABILITY

Unable to Model:

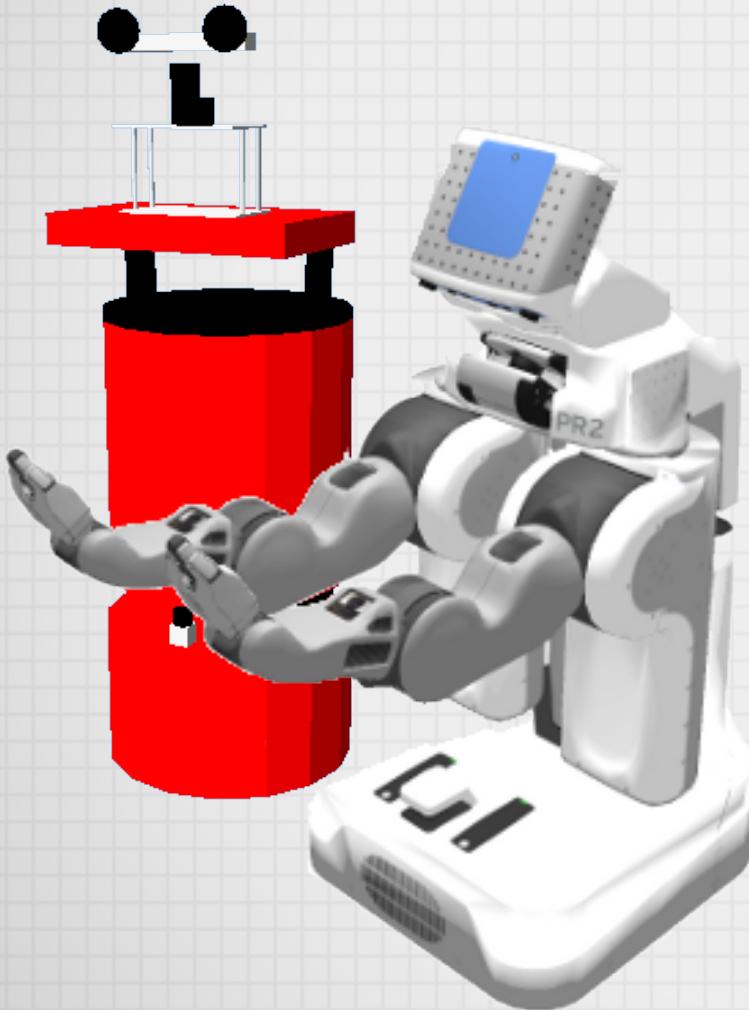
- Four Bar Linkage
- Functional Gears
- Pulleys/Ropes
- Flexible Materials
- Certain Types of Joints
- Unoptimized Complex Models



LIMITATIONS: U IS FOR UNIFIED



URDF AND YOU



NAME:

David Lu!!

WEBSITE:

cse.wustl.edu/~dvl1

EMAIL:

davidlu@wustl.edu

REPOSITORY:

tinyurl.com/roscon-urdf

TWITTER:

@probablydavid

@lewistherobot

LINKS:

| URDF | | |
|-------------|--------|-----------------|
| Topology | | Geometry |
| Launch | Visual | Other Props. |
| Tools | | Xacro |
| Limitations | | |