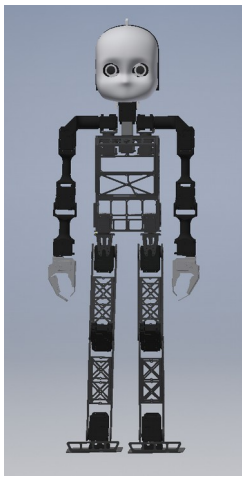
How To - Convert from CAD AutoDesk Inventor to a URDF step by step

(current version: `nimbro_cad/URDF/2015_11_03_NICU`)

[additional hints: 1 , 2]



1. Autodesk Inventor:

- Open CAD Model:
  - **`nimbro_cad/NICU_Assembly_CAD/complete.iam`**

    (if there are problems with paths/references, first open the CAD project: nimbro_cad/NICU_Assembly_CAD/Nicu.ipj)

    If possible, check if:
  - at least one assembly should be grounded within one group/assembly
  - check axis of coordinate frames – should be consistent for each assembly!

    (see general coordinate frames hints)
  - !! check that no assembly is flexible in highest possible level

    (if there is an assembly flexible, the export will not work)
  - all important links need to be shown as individual assemblies in the final CAD assembly

    (include components at the highest possible level)
  - there exists relationships (=joints)
  - measurement units should be meters, but currently I scale the units within the export of URDF

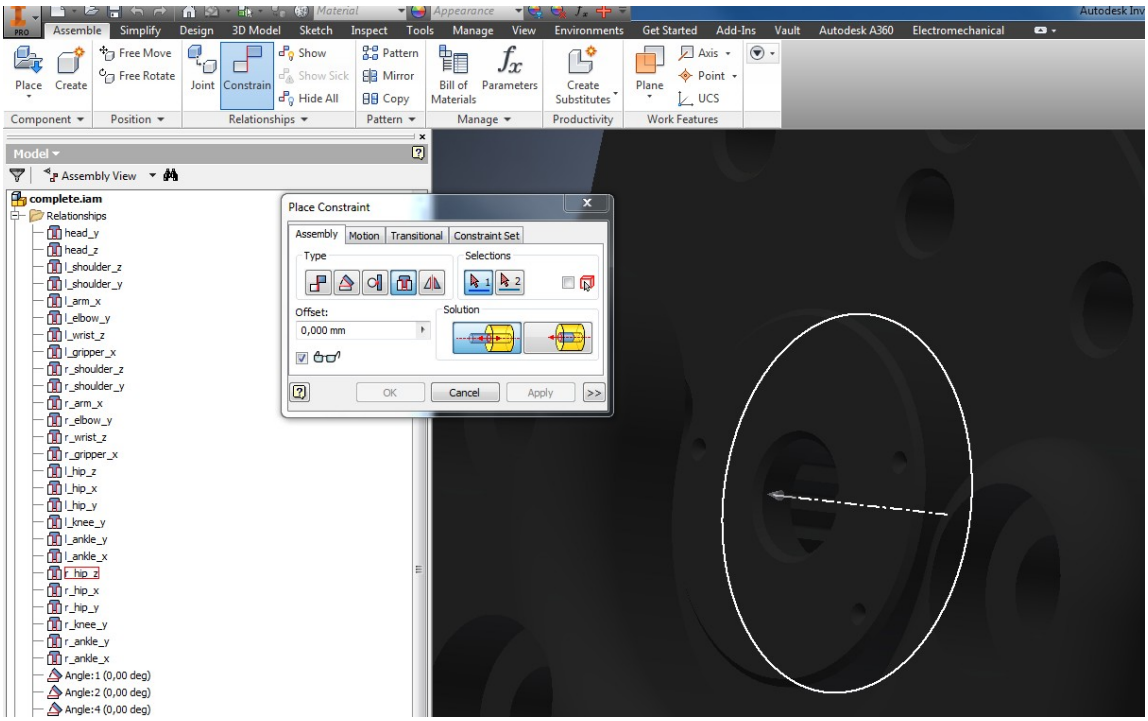
    (see later in the YAML file)
  - materials/colors are defined

- General Coordinate Frames Hints:
  - RVIZ and CAD convention :
    - red - x
    - green – y
    - blue -z
    - RIGHT HANDED
  - Each CAD assembly should be centered & coordinate frame needs to be set, so that:
    - X-axis points forward
    - Z-axis points up
    - Y-axis points right

- <u>Relationships defined on highest possible level:</u>

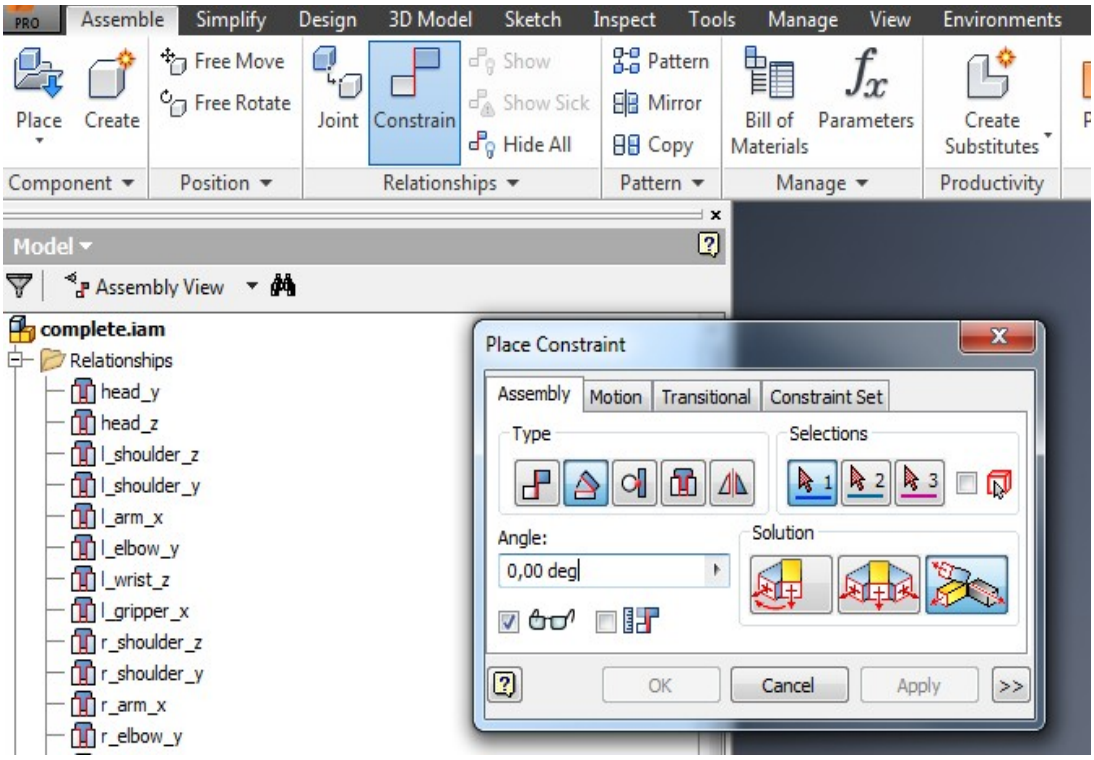
  To be able to export all joints and links of the robot correctly and as needed, I had to define relationships (joints) within CAD on the highest possible level. Also, to export the rotation axis exactly at the center of the joint, I only found following (cheated) way:
  (If you find a better – and especially more CAD suitable way – please let me know!)

  - Define only one constraint for each joint, like this (in the highest level):

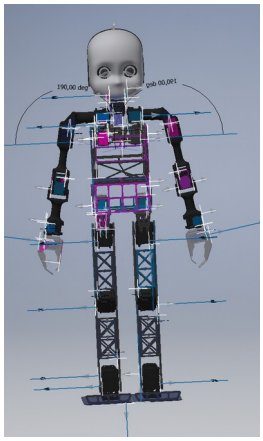


- <u>Center the coordinate frame of one assembly:</u>
  - unground grounded assembly (if its more than one, unground all)
  - enable “visibility” for all origin planes (XY, YZ, XZ)
  - define a relationship (mate) between a plane (e.g. XZ) and a plane of the object
    choose constraint XZ plane and the corresponding XZ plane on assembly that is showing AGAINST the direction of y
  - repeat this for another plane (e.g. YZ)
  - check if it is the orientation of axis you wanted (if not try different constraints)
  - if the coordinate frame is correct relative to the assembly part, follow with:
  - ground originally grounded assembly (there should always exist a grounded object)
  - delete the two constructed constraints/new relationships
  - undo “visibility” of planes
  - save ;-)

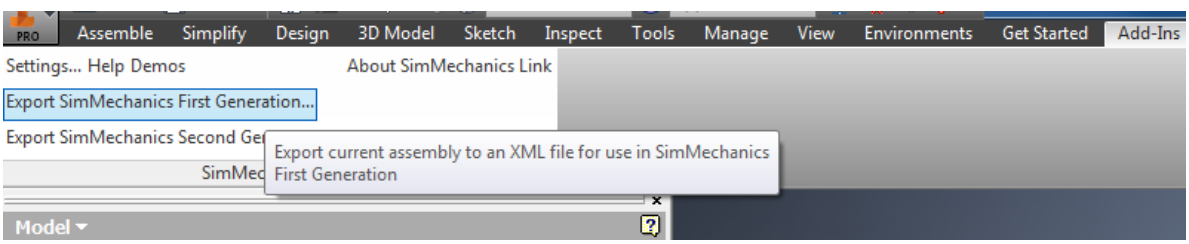
- Center the joints as good as possible in CAD:
  - define a relationship (constraint) of the type angle – with that you can define the angle between different planes



  - repeat this until all joints are in the degree that you wish
  - delete those relationships to export the CAD model

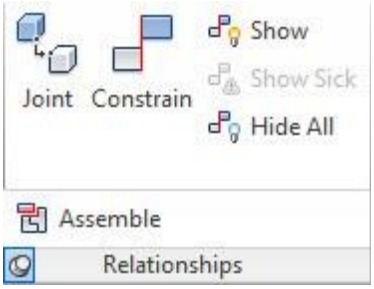


- Export from CAD with Simmechanics
  - Click: Add-Ins – Export via **First** Generation



- Possible Reasons for Problems with Export from CAD
  - Some assemblies are still flexible - this icon means flexible: 
  - There needs to be a grounded component in EACH level – icon for grounded: 
  - Some links are not assembled to each other (do not have any relationship)

    This can be set by:



2. Convert exported xml file with simmechanics - via ROS with a YAML

- .YAML file:
  - The .YAML file describes where the stl files can be found, how much those meshes need to be scaled, and describes parameters of the joints (e.g. name, axis of rotation and limits)

  - Within “cad_params.yaml” change the package path in which the STL files can be found. You will have to change `package://iris_sandbox/` to your package that contains all the meshes (! for RVIZ it needs to be a ROS package)

```
filenameformat: "package://iris_sandbox/2015_11_03_NICU/%s"
```

- Required (manual) changes of the .yaml file - if there have been changes in the CAD file

  - If the joints do not correspond to their name and everything feels wrong, it might be that due to some changes in CAD, the joint IDs have been defined differently in the exported XML file than before. Therefore, the IDs of the redefined joints in the .yaml file do not correspond to the actual joints.
  - My workaround for that:
    - Print out the Joint ID while running convert.py *(by `rosrun simmechanics_to_urdf convert.py complete.xml cad_params.yaml xml > URDF.urdf`)*

      To do so, add in the ROS package “simmechanics_to_urdf” in “convert.py” in line 200:

```
print('Joints '+str(uid))
print('Joints parent'+str(joint['parent']))
```

- Open the newly created URDF.urdf
- Sort the joints and their IDs in the order of the yaml file (to make the manual mapping easier)

  The output will be similar to this one:

  ```
  Joints head:2--neck:11
  Joints parent17
  Joints neck:1--torso:11
  Joints parent7
  ```
- Enter the new joint IDs in the cad_params.yaml file correspondingly
- Delete the URDF.urdf and rerun convert.py with the correct joint IDs

- Export to URDF via ROS with the defined .yaml file:

  `$ rosrun simmechanics_to_urdf convert.py complete.xml cad_params.yaml xml > URDF.urdf`

3. Change, Check and Work with final URDF

- Check/Change within URDF manually (alternatively change .yaml see in 2.) :
  - Check if correct package is set (should have been set in .yaml file before...)

    ```
    <mesh filename="package://iris_sandbox/2015_11_03_NICU/arm_upper_right_iam_f559c4b9.STL"/>
    ```
  - Change offsets of joints with <origin rpy= “”...>

- Check if URDF is “working”:

  ```
  $ check_urdf URDF.urdf
  ```

- Create a graph of the URDF in pdf:

  ```
  $ urdf_to_graphiz URDF.urdf
  (to look at you could do: $ evince URDF.pdf )
  ```

- **Visualize URDF in RVIZ (for example instead of importing the URDF in VREP):**

  ```
  $ roslaunch urdf_tutorial display.launch model:=URDF.urdf gui:=True
  ```

  1. Set Fixed Frame: torso:11
  2. Set TF Marker Scale smaller e.g. 0.2