2.1.2 | URDF: Limitations and XACRO

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Limitations of URDF

1. Robot descriptions cannot be changed

2. Only tree structures

3. No `<sensor></sensor>`

4. Low reusability of URDFs

Limitation 1 – immutability

- Result of typical control flow

- Robot description read only once from parameter server

- No standardized way to notify consumers of changes

- Risk of *desynchronization* of nodes

Limitation 2 – no cycles

- Joints have only a single parent and child

- Only acyclic, directed graphs (or: trees) can be modeled

- Real-world impact: dual-arm manipulation, parallel grippers, etc

Limitation 3 – no sensor element

- Sensor meta-data cannot be incorporated into URDF directly

- Alternatives exist, but data is distributed

- Diminishes value of URDF as *central* robot description

Limitation 4 – reusability

- Only a single `<robot>` tag in a URDF
- No support for import of remote files
- Composite scenes have to be merged manually
- No way to compose multiple URDFs

Solution: XACRO (XML Macros)

- Programmatic URDF generation
- Templates
- Parameters

XACRO: example

```
arm_macro.xacro

<xacro:macro name="arm" params="parent arm_name">
  <link name="${arm_name}_link_1" />
  <joint name="${arm_name}_joint_1" type="..">
    <parent link="${parent}" />
    <child link="${arm_name}_link_1" />
  </joint>
</xacro:macro>
```

XACRO: example (2)

```
robot.xacro

[..]
  <link name="torso" />
[..]
  <xacro:arm parent="torso" arm_name="left" />
  <xacro:arm parent="torso" arm_name="right" />
[..]
```

XACRO: Composability?

- Import macros from other files

- Parameterize templates

- Composite robots & scenes easier:
    - Import macro from file
    - Invoke macro

XACRO: Conversion

- Disadvantage: XACRO not directly compatible with URDF

- Transformation needed

- Command:

```
$ rosrun xacro xacro /path/to/robot.xacro > robot.urdf
```

- Also checks for a valid XACRO file

End of part 2 - recap

- Limitations of URDF:
  - Immutability
  - Only tree structures
  - No tags for sensors
  - Low reusability (composability)

- XACRO:
  - Programmatic URDF generation
  - Macros, parameters, includes