Institute of Mechatronic Systems
Leibniz Universität Hannover

BWH

KUKA

Tutorial

# LightWeightRobotIGT – Getting Started

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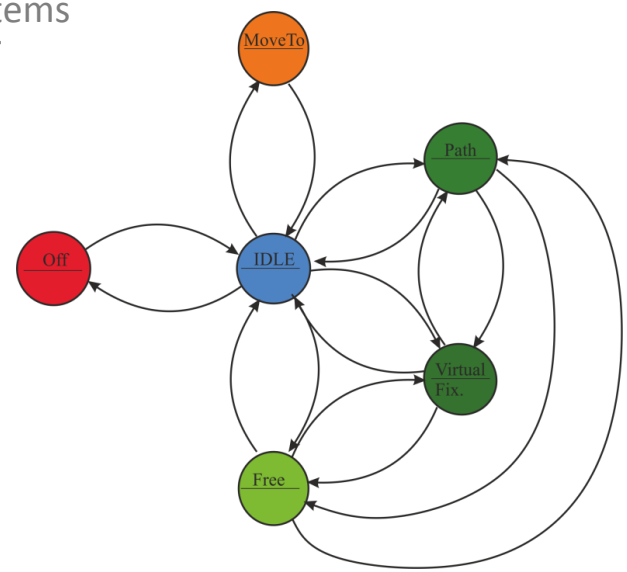
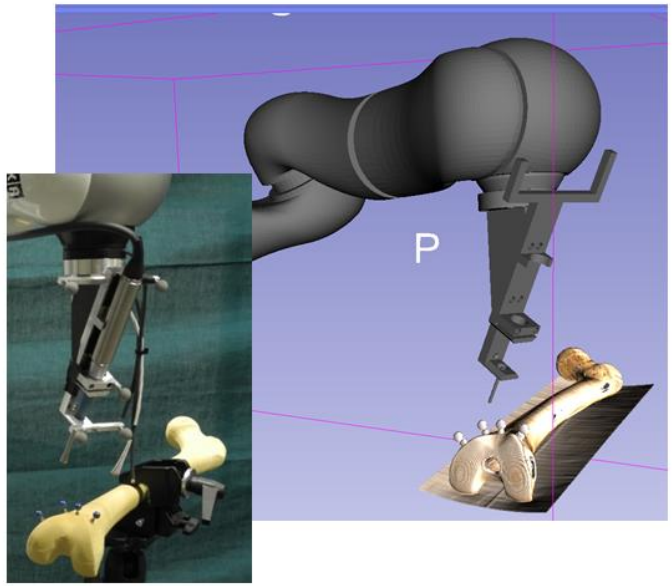
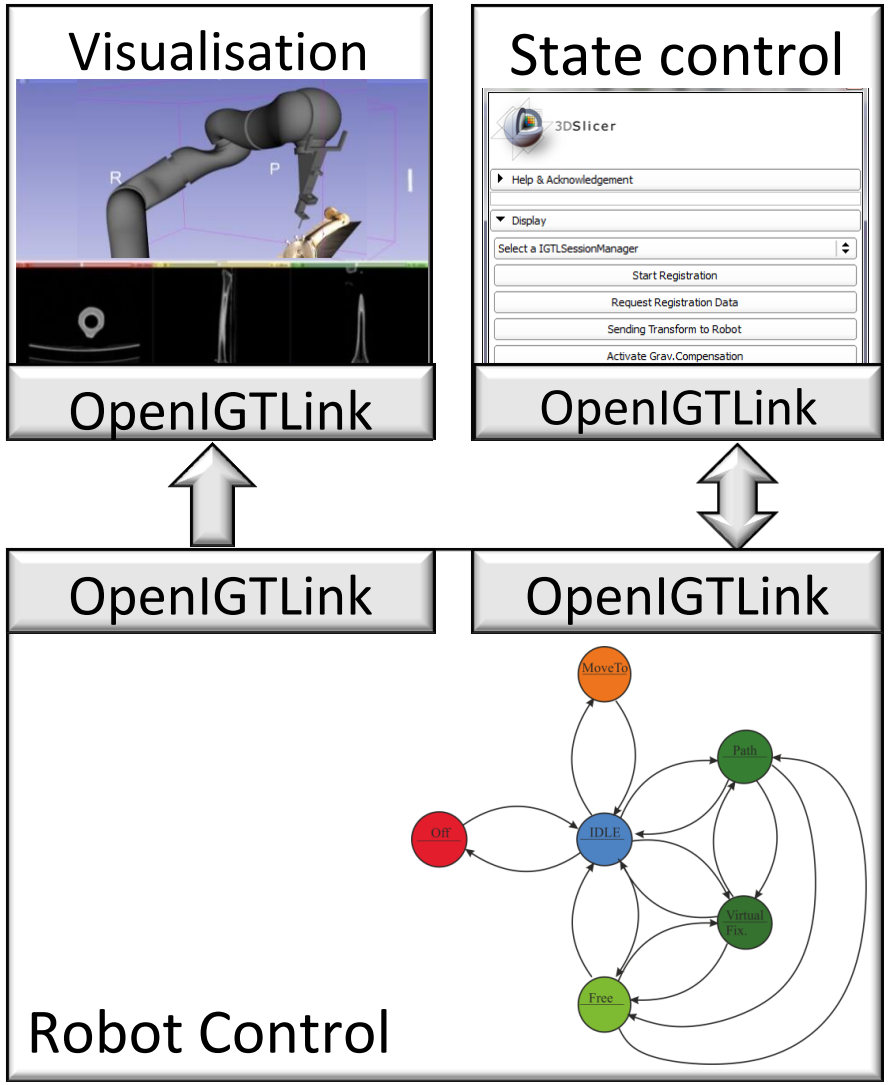


# Outline

- System Overview
  - Requirements
- Set up KUKA Sunrise control
  - Install Example
- Install LightWeightRobotIGT
- Run Example

# System Overview - Interface Concept




Robot as element of IGT system

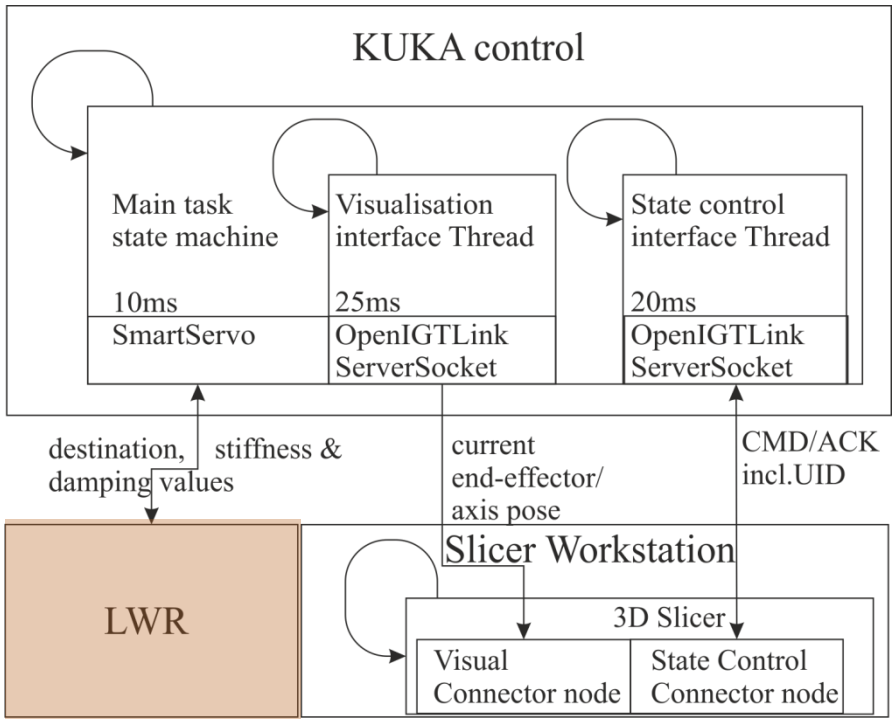
Separate visualisation & state control interface

OpenIGTLink based

- Small foot print & widely used
- Open protocol for IGT

State machine for intuitive and direct control

# System Overview




Slicer workstation

- 3D Slicer module *LightWeightRobotIGT* as state control

KUKA control

- Java robot application
  - Visualisation & state control interface thread
  - State machine thread

KUKA Light weight robot (LWR)

# System Requirements

Requirements

- Robotic system
  - KUKA sunrise control & LWR iiwa
  - KUKA Sunrise.Connectivity Smart Servo
  - Notebook/Desktop PC with Sunrise.Workbench 1.0
  - LWROpenIGTIF package including exemplary state machine

- Slicer Workstation
  - 3D Slicer 4.3.1 64 Bit
  - See http://www.slicer.org
  - Point-to-point ethernet connection to Sunrise control (use the same notebook/desktop PC for the Sunrise Workbench and 3D Slicer)

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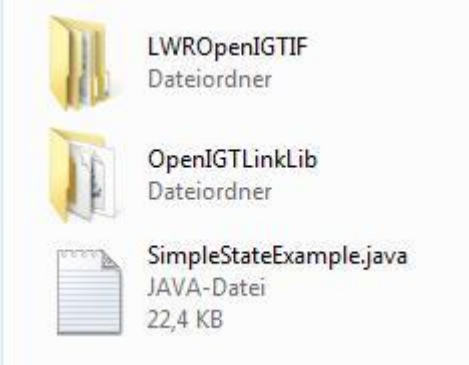
# Installing LWROpenIGTIF

- Download *LWROpenIGTIF* at GitHub including STL-files of the LWR (*RobotModel*)
  - https://github.com/tauscherSw/LWROpenIGTIF.git
- Add the *LWROpenIGTIF* and the *OpenIGTLink* folder to your sunrise project source folder
  - Example: C:\Devel\KUKA*YourSunriseProject*\src
- Add the *OpenIGTLinkLib* folder to the project folder
  - Example: C:\Devel\KUKA*YourSunriseProject*
- Add the *SimpleStateExample.java* file to the application source folder
  - Example: C:\Devel\KUKA*YourSunriseProject*\src\application
- Synchronize the sunrise workbench with the sunrise control



# Installing LWROpenIGTIF

- Get connected to the KUKA sunrise control via remote desktop
  - If you need help on this, ask your KUKA support
- Set environment variables and path to the SWIGigtutil.dll directory
  - Path is: C:\KRC\ApplicationServer\Git*YourSunriseProjectName*\OpenIGTLinkLib
- Close remote desktop connection
- Copy the STL-folder somewhere on your Slicer Workstation
- Software documentation of the LWROpenIGTIF classes can be found here:
  - https://github.com/tauscherSw/LWROpenIGTIF.git

# Customizing LWROpenIGTIF

Before running the example you should

- Change the current tool data in the SimpleStateExample.java according to the load and geometry of your tool
- Check if the default start position q = { *0.0, 30.0, 0.0, -60.0, 0.0, 90.0, 0.0*} is safe. **WARNING: There is no safety check!**
- Have experience with the robot and the robot control

```
final double translationOfTool[] ={ -40, 10, 207 };
//{ 54.5, 0.1, 211.6 };

//and the mass in kg
final double mass = 0.6;

//First rough guess of the Center of Mass
final double centerOfMassInMillimeter[] =
{ -5, 0, 50 };

ImesTool = ServoMotionUtilities.createTool(imesLBR,
           "ImesTool", translationOfTool, mass,
           centerOfMassInMillimeter);
ImesTool.attachTo(imesLBR.getFlange());
```

Before starting the example you can

- Adjust the cycle times of the different threads according to your needs

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# Installing LightWeightRobotIGT

- Download 3D Slicer 64-Bit Version 4.3.1
- Install 3D Slicer
- Install LightWeightRobotIGT Extension using the Extension Manager
  - http://www.slicer.org/slicerWiki/index.php/Documentation/4.3/SlicerApplication/ExtensionsManager

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- **Run Example**

# Start Connection

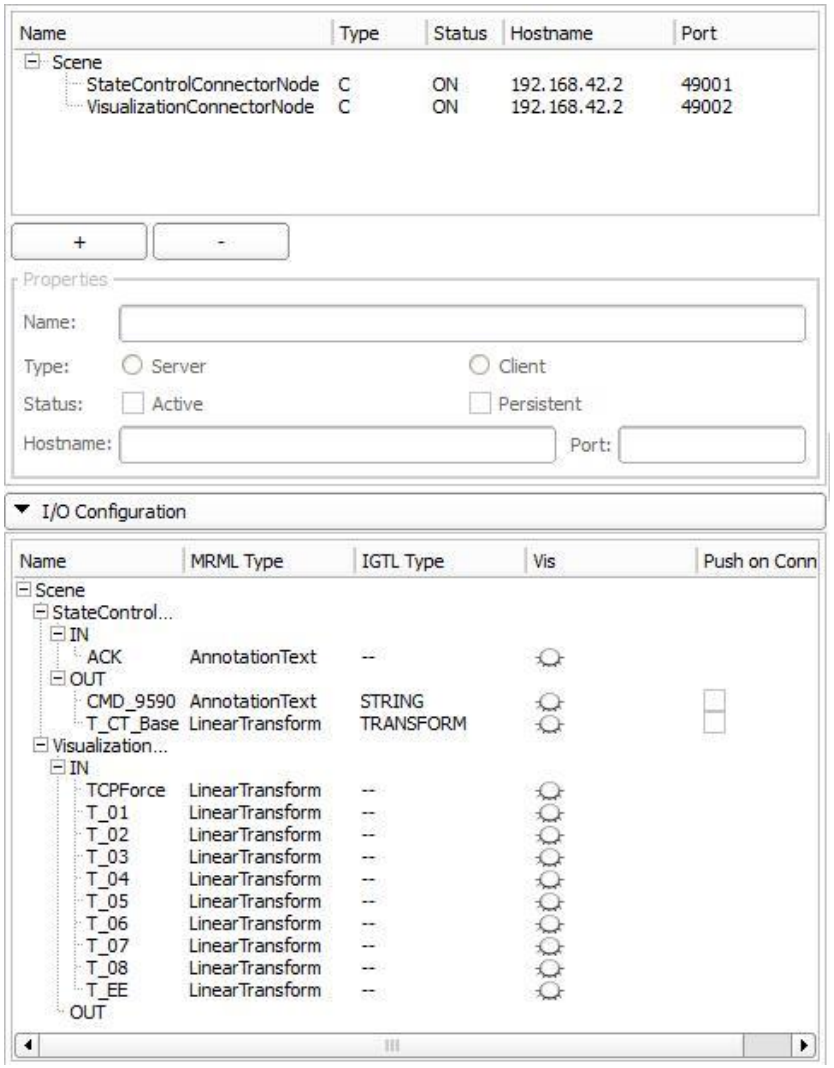
Open 3D Slicer on the Slicer Workstation

Open LightWeightRobotIGT module

- Modules->IGT->LightWeightRobotIGT
- Set path to the folder containing the STL-files
- Check if the IP-address of the robot control is set correctly; default is 192.168.42.2

Start *YourProject* on the robot control

- Check if the connection was successful
  - on the SmartPad (Control Panel of the robot control)
  - or in the OpenIGTIF 3D Slicer module (Modules->IGT->OpenIGTIF) status of the to connector nodes should be *On* (see figure)



# Start Visualization of Robot and Force Vector

Click *Load Robot STL* (green)

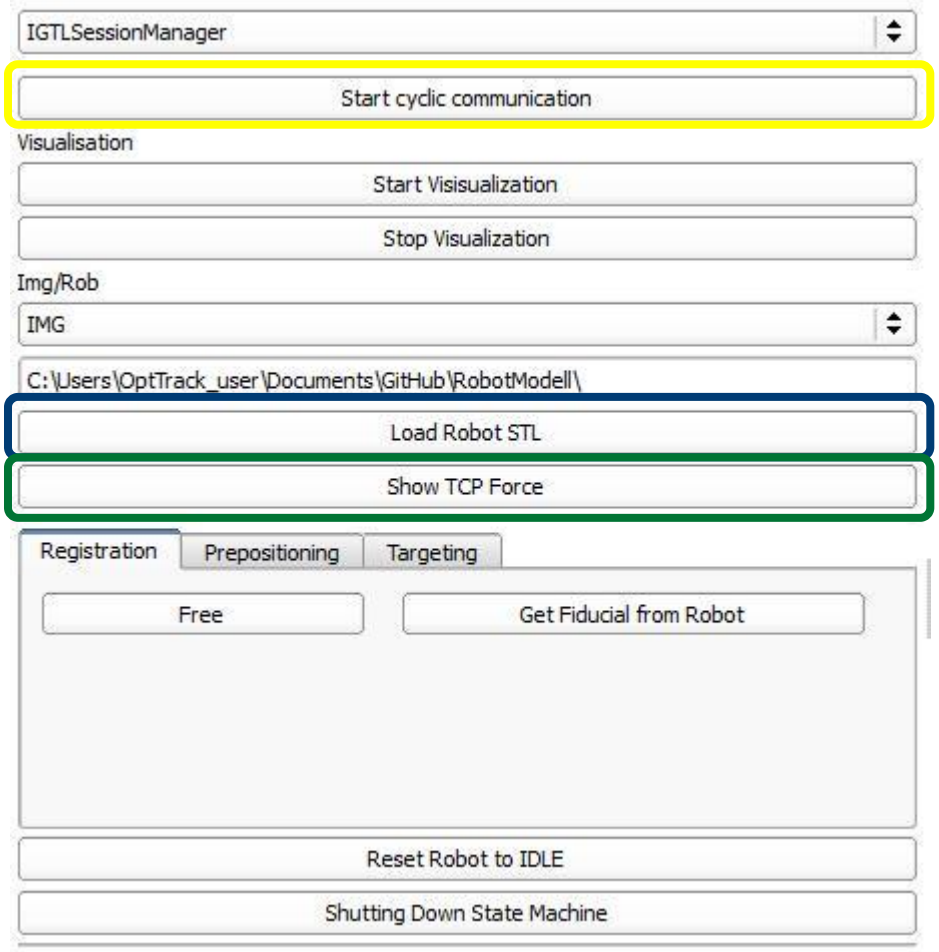
- Now the robot should be visualized in the 3D view

Click Start cyclic communication (yellow)

- Cyclic communication with the state control is now active
- Robot colour changes due to the current state (colour coding see state machine description in Tutorial: LightWeightRobotIGT-Introduction)

Click Show TCP Force (blue)

- A 3D arrow is now shown at the tool center point



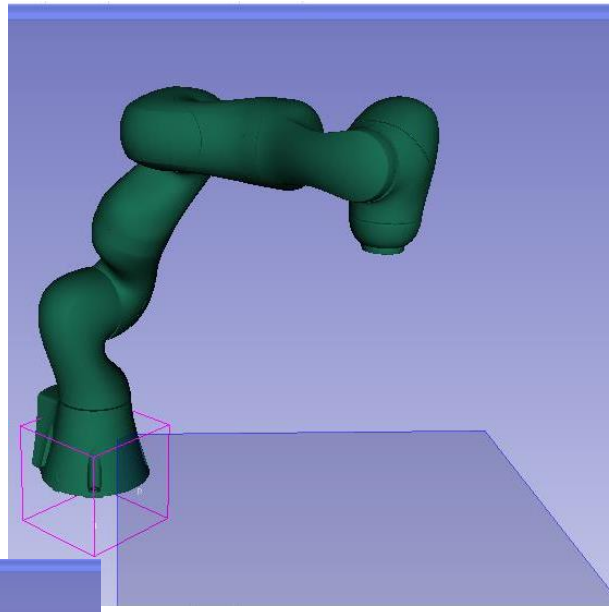
# Switching between states

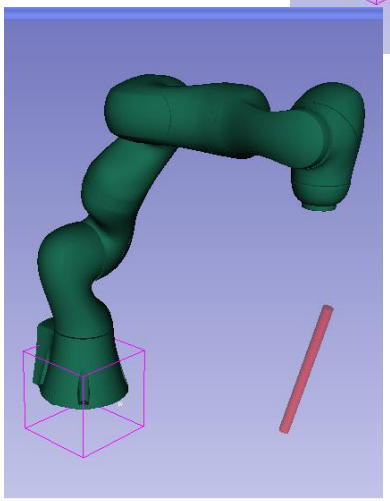
Click on different states as you like

- **WARNING:** Check if the default **position** of the virtual fixtures is **safe** and that the robot is not in the **locked zone** of the virtual fixtures

Now you can :

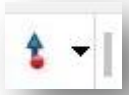
- Change to Free, Idle, Path and VirtualFixtures
- Visualise active Virtual Fixtures in Slicer (see figures)
- **NOT** set the robot to MoveTo state; Therefor, you need to register/send the T_CT_Base transform to the state control (see next page)





# Registration – Workflow I

- Load Dicom data/STL file of the target object
  - See example: Femur phantom with sphere fiducials
- Define fiducials in a fiducial list using *Create-Fiducial* 
- Set robot to *Free* mode (click *Free* in registration tab)
- Move robot to fiducial of physical object
- Click *Get Fiducial from robot* (in registration tab)
- Repeat this step for all fiducials



# Registration – Workflow II

- All points are saved in the *Fid_list* annotation node
- Use *Fiducial Registration* module (see figure)
  - Fixed landmarks: *F*
  - Moving landmarks: *Fid_List*
  - Save transform=> *T_CT_Base*
- The Matrix *T_CT_Base* is automatically send to the robot control when its value is changed
- Check if the registration was successful
  - Robot is now visualized in relation to target
  - Move To enabled (carefully use this state!!)

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