AUTODESK UNIVERSITY

FAB124945

Robots as Design Interfaces—Toward New Processes Beyond Mass Production

Johannes Braumann
Association for Robots in Architecture | University for Arts and Design Linz

Learning Objectives

- Get insight into non-standard robotic processes
- Understand the potential, but also limitations, of industrial robots
- Learn how to couple visual programming with robotic processes
- Evaluate the presented software interface following the class, using provided version of KUKA|prc for Dynamo

Description

Industrial robots are primarily known from the automotive industry's production lines. The goal of this class is to present robots instead as multifunctional and flexible interfaces between the digital and the physical world that can be used for anything from innovative, large-scale fabrication to immersive virtual reality (VR) simulators. This extension beyond the robots' initial scope is enabled by new software developments that facilitate a seamless workflow from design to machine through Dynamo software and KUKA|prc. Utilizing parametric design tools lets us use robots for mass customization and small lot sizes, rather than mass fabrication. The class will provide an overview on how to utilize industrial robots through Dynamo and Fusion 360 software, and present realized projects by both small to medium-size enterprises as well as international corporations. We'll also look into the future toward new developments that build upon the geometric capabilities of the Forge cloud and couple it with serverless computation and integration with IoT platforms.

Speaker(s)

Johannes Braumann and Sigrid Brell-Cokcan founded the Association for Robots in 2011 with the goal of making robots accessible to the creative industry. RiA acts as a network for creative robot users, connecting them with industry and each other, while also developing accessible software for robot programming and simulation. Both aspects have since gone far beyond the initial scope of creative users, with industry becoming increasingly interested in innovative solutions for mass customization and lot size one. Johannes is the lead developer of KUKA|prc, a solution for controlling and simulating industrial robots from within visual programming environments. It is now being used in a wide variety of industries, enabling customized, parametric production processes beyond CAD-CAM, from multi-axis 3D printing to large-scale building construction. Since 2017 Johannes holds a professorship for Creative Robotics at UfG Linz, working closely with the Ars Electronica Center and KUKA Robotics.

AUTODESK UNIVERSITY

Introduction

Thank you for attending our session on “Robots as Design Interfaces – Towards New Processes Beyond Mass Production”! Within just a few years, robotic arms have become important tools in research, education and now also increasingly construction. We founded the Association for Robots in Architecture with the goal of making robots accessible to the creative industry and pursue that by acting as a network – e.g. organizing the Rob|Arch conferences – as well as by developing accessible interfaces for robotic processes: KUKA|prc – parametric robot control. This presentation marks the initial beta release of KUKA|prc for Dynamo, a visual programming environment by Autodesk that is integrated into Autodesk Revit. We believe that there is a great potential in linking design software with robotic hardware and are intrigued what kind of applications the Dynamo community will be coming up with. To support that development, Individualized Production at RWTH Aachen will be providing tutorials and teaching materials in the close future.
The release of KUKA|prc for Autodesk Dynamo is still in an early stage, however we believe that it is ready for feedback from the community, as the core is identical to the functionality of other KUKA|prc versions. We would greatly appreciate any feedback and suggestions that you may have, either through the forum at forum.robotsinarchitecture.org or via eMail to robots@robotsinarchitecture.org

We would be happy to discuss any projects or possible collaborations with you and hope you enjoy working with robots through Autodesk Dynamo. If you want to deepen your knowledge, consider attending the Rob|Arch 2018 conference and workshops in September 2018!

Best Regards,
Johannes & Sigrid
Founders, Association for Robots in Architecture

Johannes Braumann
Robots in Architecture & UfG Linz
johannes@robotsinarchitecture.org

Sigrid Brell-Cokcan
Robots in Architecture & IP RWTH Aachen
sigrid@robotsinarchitecture.org

Presentation References

The following institutions are featured in the presentation:

Association for Robots in Architecture
www.robotsinarchitecture.org

Individualized Production – RWTH Aachen University
www.ip.rwth-aachen.de

University for Arts and Design Linz
www.ufg.ac.at

KUKA Robotics – industrial robots
https://www.kuka.com

Züblin Timber – high-end timber constructions
https://www.zueblin-timber.com

Silly Sods in the Mud – sailing enthusiasts
https://www.facebook.com/sillysodsinthemud/

Homo Digitalis – digital media project
http://www.homodigitalis.tv

Red Bull Arch - sculpture
https://www.3dkunst.at

AA at Hooke Park – university research
http://hookepark.aaschool.ac.uk

Artis Engineering – prototyping and fabrication
http://www.artisengineering.de

Tylko – customized furniture
https://tylko.com

Knotty – robotic knitting startup
http://www.knotty.pl

IAAC – university research
http://www.iaac.net

+LAB – silkworm 3D printing
http://www.piulab.it

Branch Technology – large-scale 3D printing
http://www.branch.technology

Foster & Partners – high-end architecture
https://www.fosterandpartners.com

Print-a-Drink – liquid-in-liquid 3D printing
http://www.printadrink.at

See-It – VR robotic entertainment
https://www.see-it.tech

Robotic Woodcraft – research project
http://www.roboticwoodcraft.com

Autodesk FORGE – CAD cloud
https://forge.autodesk.com/

Installation

AS THE AU SYSTEM DOES NOT ALLOW US TO UPLOAD FILES, PLEASE DOWNLOAD THE SOFTWARE FROM HERE: https://1drv.ms/f/s!AtgYyPhhrKrMnJ4C8rE48xO2B1g_kw

The link will expire by the end of 2017.

KUKA|prc is compatible with the most recent version (1.3.x) of Autodesk Dynamo. Autodesk Dynamo is available as a standalone software (Autodesk Dynamo Studio) or as a free plugin to Autodesk Revit.

- Autodesk Dynamo Studio: https://www.autodesk.com/products/dynamo-studio/overview
- Autodesk Revit: https://www.autodesk.eu/products/revit-family/overview
- Autodesk Dynamo for Revit: http://dynamobim.org/download/

Free 30-day trial versions can be downloaded from the links above.

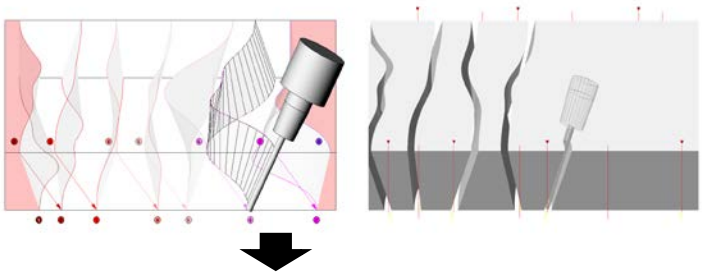
Please use the KUKA|prc for Dynamo installer that is available through the link on top. The publicly available version at robotsinarchitecture.org/kukaprc only works within McNeel Grasshopper. A public beta version of KUKA|prc for Dynamo will be provided in the near future and will be available through the regular package manager.

Further Tutorials and Examples

A range of tutorials and examples is provided along with that download. In collaboration with Autodesk, the Chair of Individualized Production (RWTH Aachen University, Prof. Sigrid Brell-Cokcan) is developing course materials and in-depth tutorials. These will be made available with the public release of KUKA|prc for Dynamo at http://ip.rwth-aachen.de.

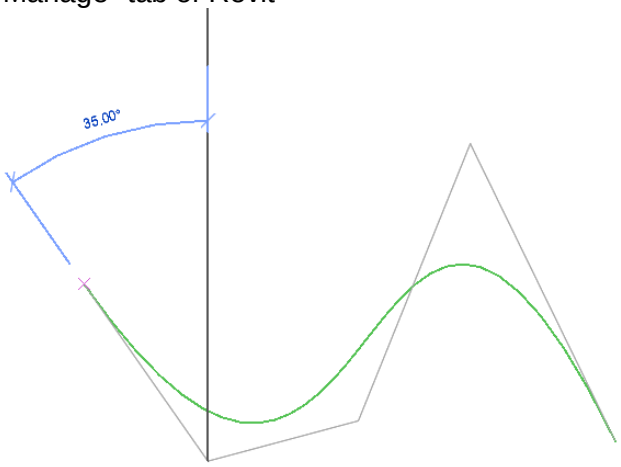
First Steps with KUKA|prc for Dynamo

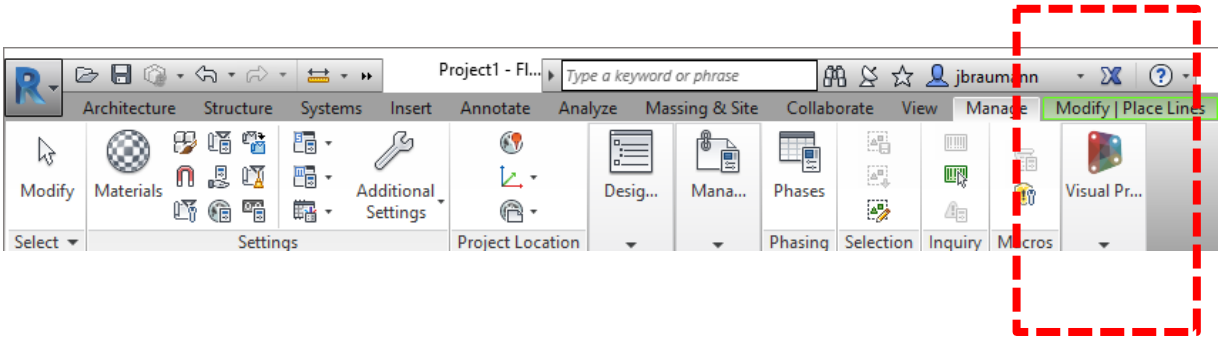
Robots basically work like CNC machines: The first step is generating toolpaths (from geometry, from other data…), and the second is translating that data into a format that the machine can understand.



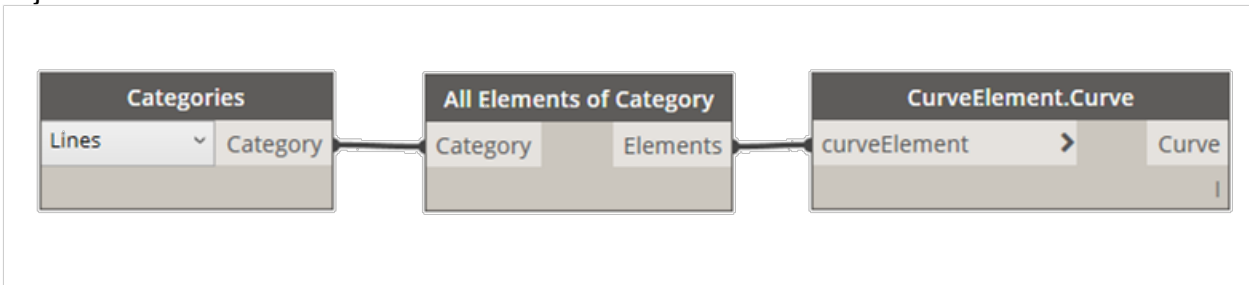
```
&ACCESS RVP
&REL 1
&PARAM TEMPLATE =
C:\KRC\Roboter\Template\vorgabe
&PARAM EDITMASK = *
DEFDAT kukaprc_project
;FOLD EXTERNAL
DECLARATIONS;%{PE}%MKUKATPBASIS,%CEXT,%VCOMMON,%
P
;FOLD BASISTECH
EXT;%{PE}%MKUKATPBASIS,%CEXT,%VEXT,%P
EXT  BAS (BAS_COMMAND  :IN,REAL  :IN )
DECL INT SUCCESS
;ENDFOLD (BASISTECH EXT)
;FOLD USER EXT;%{E}%MKUKATPUSER,%CEXT,%VEXT,%P
;Make here your modifications
;ENDFOLD (USER EXT)
;ENDFOLD (EXTERNAL DECLERATIONS)
INT CR_GENNUMBER = 525475
INT CR_ANSWER
```

In this example we do not generate the geometry generatively, but rather draw a simple curve in Autodesk Revit. Start by drawing a curve in Revit or import it from another CAD software.
Start Dynamo from the “Manage” tab of Revit

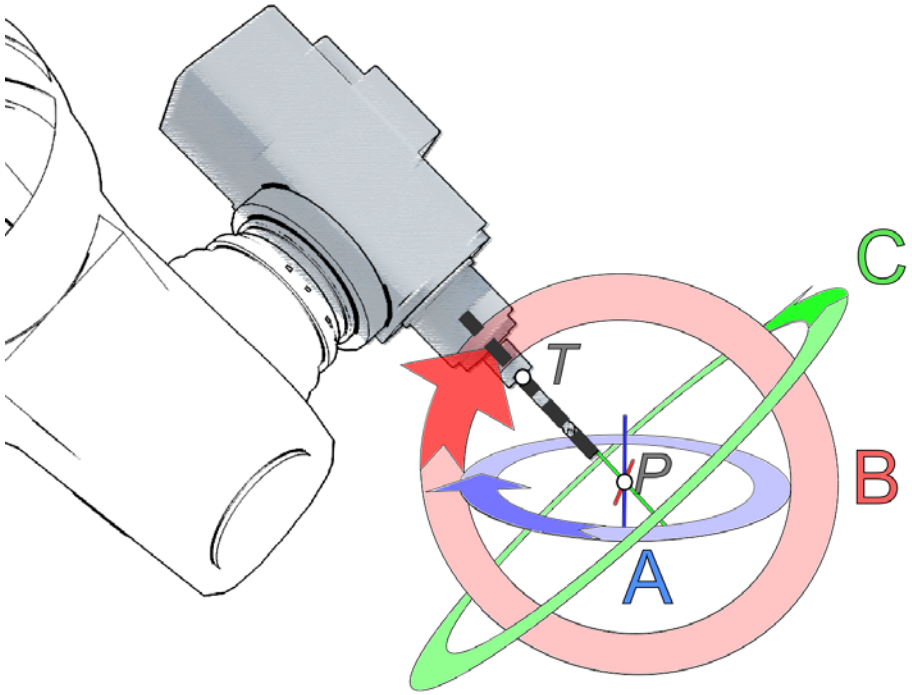


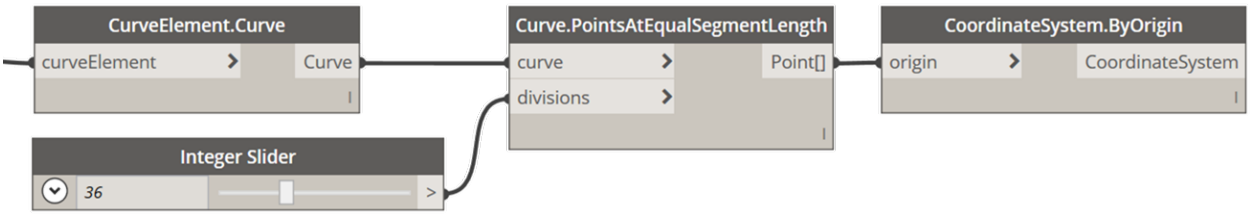


Use standard Dynamo/Revit components to get your Revit geometry into Dynamo. Below we simply import all objects that fit the category “Lines” and then turn them into Dynamo “Curve” objects.



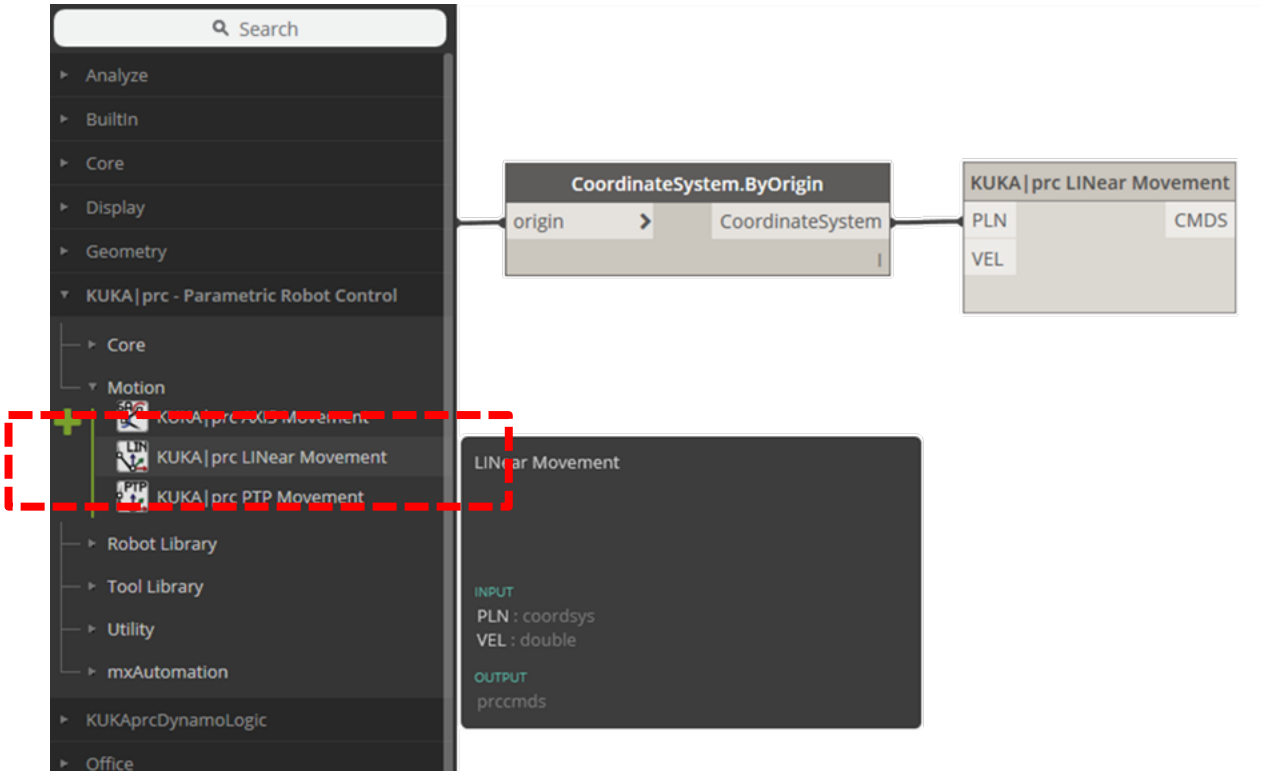
The robot itself cannot deal with curves, instead we need to divide a curve into separate movements, with the position and orientation of the tool set for each movement. We represent the position and orientation with a coordinate system.



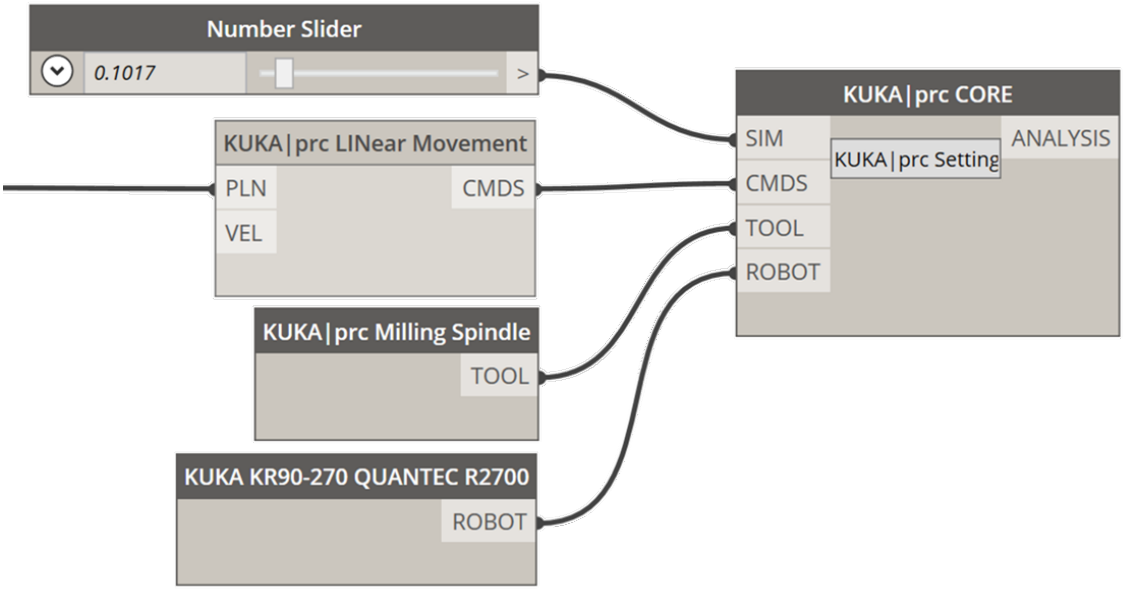


The robot supports multiple kinds of movements, the most important ones are LIN and PTP movements. LINear movements connect the coordinate systems with a straight line. They are best when accuracy is needed. PTP movements connect coordinate systems with the least amount of axis rotation. They are fast, but do not follow a straight line. For this example, we get

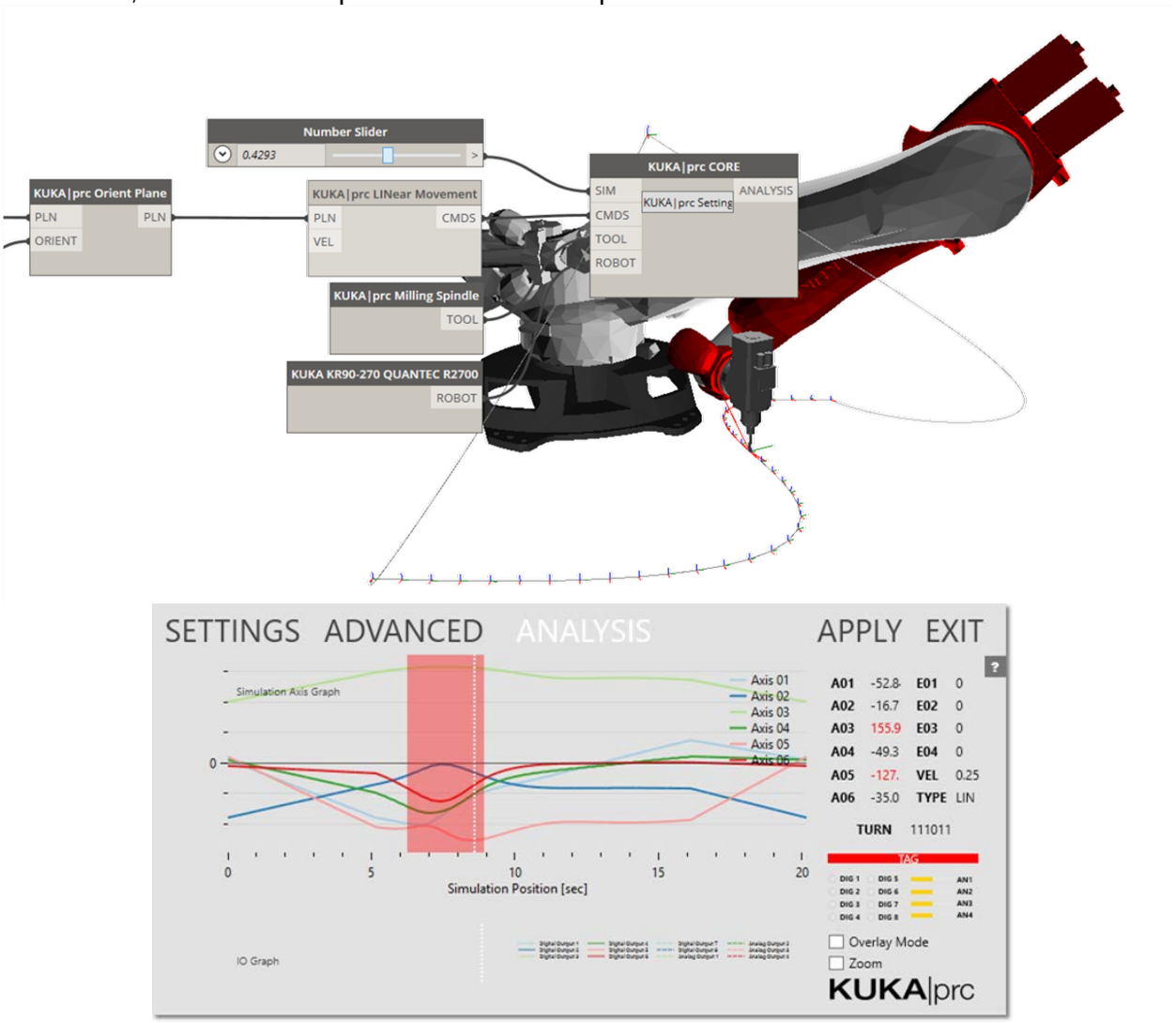
a LIN Movement from the KUKA|prc / Motion section on the left and connect the coordinate systems.



Now get the KUKA|prc CORE component, that deals with all the simulation and code generation. In addition to the movements, you will need to define the tool (in that case the Milling Spindle component) and the robot type (in that case a KUKA Quantec).
To move through the simulation, get a number slider with a range between 0.0 and 1.0.



Moving the slider will move the robot through the program. Red positions cannot be reached by the robot. Changing the curve in Revit should immediately update the robot simulation. If you click on the “Settings” button and go to the “Analysis” tab, you will see a graph of the axis movement, to aid with the optimization of the toolpath.



After setting an output directory in the Settings window, you will receive an *.src file that contains the simulated movement. You can copy that file to the robot and execute it there. Take care that the values of the tool and base are the same in both simulation and reality. Advanced users can also stream data directly to the robot through the KUKA mxAutomation interface.

AUTODESK UNIVERSITY

Support

For support and assistance, please post your questions on the official Robots in Architecture forum at forum.robotsinarchitecture.org

Questions involving confidential or highly individual projects can be directed to johannes@robotsinarchitecture.org

We kindly ask you to report bugs and problems that you may be encountering in this early software release!

Further Resources

Support and Questions
http://forum.robotsinarchitecture.org

KUKA|prc Tutorials
http://forum.robotsinarchitecture.org/index.php/board,2.0.html

Videos
http://www.vimeo.com/robotsinarchitecture/videos

News
http://www.facebook.com/robotsinarchitecture

Video tutorials
https://www.youtube.com/channel/UCH166BcWXSEYoTwiZGVLy3w

Blog by M. Meier, UMichigan
http://mkmra2.blogspot.com

Becoming a Member of the Robots in Architecture

The yearly membership fee is 350EUR/year and provides you with the following benefits

- Access to the member version of KUKA|prc for research and teaching
- Access to the Rob|Arch eBooks through SpringerLink (a ~320EUR value)
- Reduced registration fee for the Rob|Arch conferences

Memberships extend to an entire institution. For example, all staff and students of a member-university can use KUKA|prc on their private PCs and laptops, there is no formal limit on the number of software seats.
To become a member, simply contact us at robots@robotsinarchitecture.org and provide a billing address.
For commercial applications, a commercial license is needed. Contact us with some details on what you want to achieve as well as if you anticipate needing any custom development at robots@robotsinarchitecture.org so that we can develop a custom offer for you.

About Robots in Architecture

Sigrid Brell-Cokcan and Johannes Braumann founded the Association for Robots in Architecture in 2010 with the goal of making industrial robots accessible to the creative industry. Towards that goal, the Association is developing innovative software tools such as KUKA|prc (parametric robot control) and initialized the Rob|Arch conference series on robotic fabrication in architecture, art, and design which–following Vienna in 2012, Ann Arbor in 2014, and Sydney in 2016 – will be held 2018 in Zurich. Robots in Architecture is a KUKA System Partner and has been validated as a research institutions by national and international research agencies such as the European Union's FP7 program.

Recently, Sigrid founded the new chair for Individualized Building Construction at RWTH Aachen University. Johannes is heading the robotics lab at UfG Linz and leading the development of KUKA|prc. Their work has been widely published in peer reviewed scientific journals, international proceedings, and books, as well as being featured in formats such as Wired, Gizmodo, Süddeutsche Zeitung, and RBR.

Rob|Arch 2018 Conference

September 10-15, 2018: Rob|Arch 2018 Conference
@ETH Zurich, Switzerland
www.robarch2018.org