
**064-0026-00L: COMPAS II**

Introduction to Computational Methods for Digital Fabrication in Architecture

**TODAY**

intro

course overview

team

dfab toolbox

datastructures

# intro

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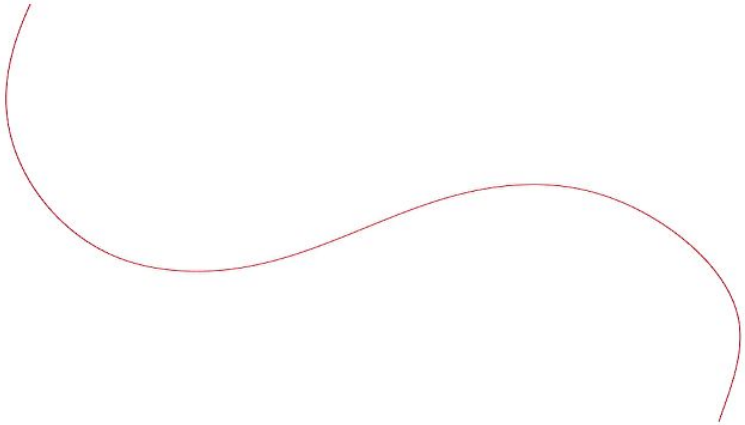
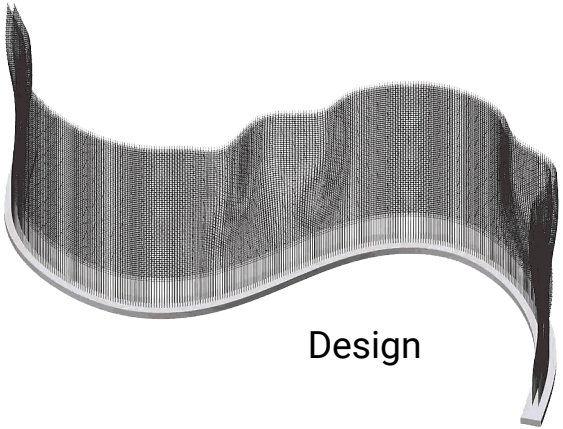
# Computational design

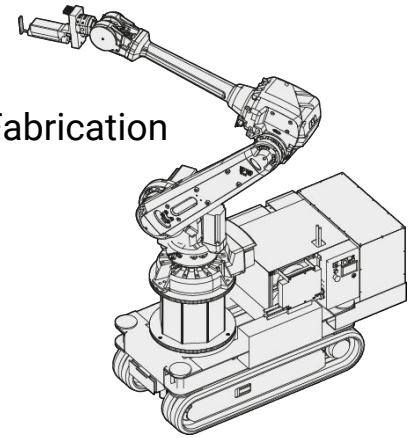


# Design to fabrication

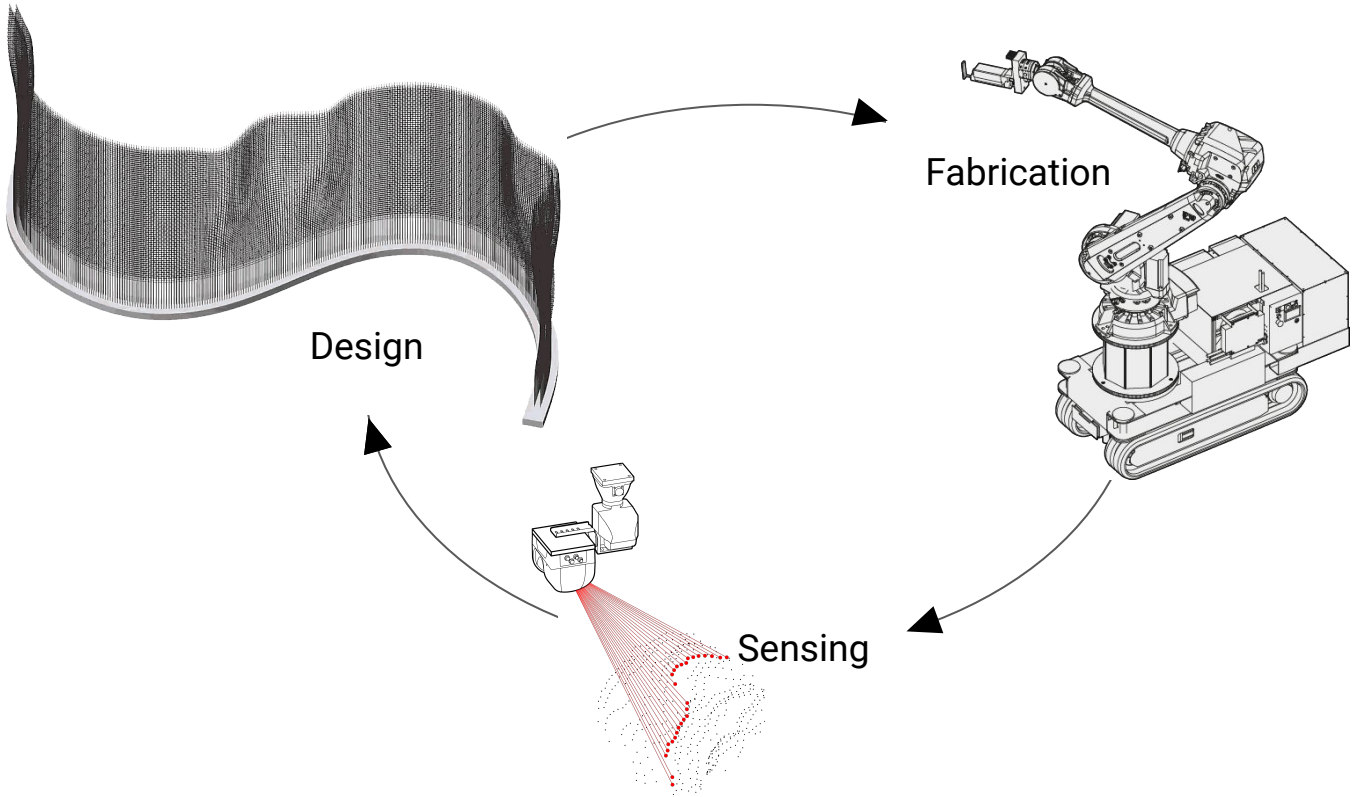


Design

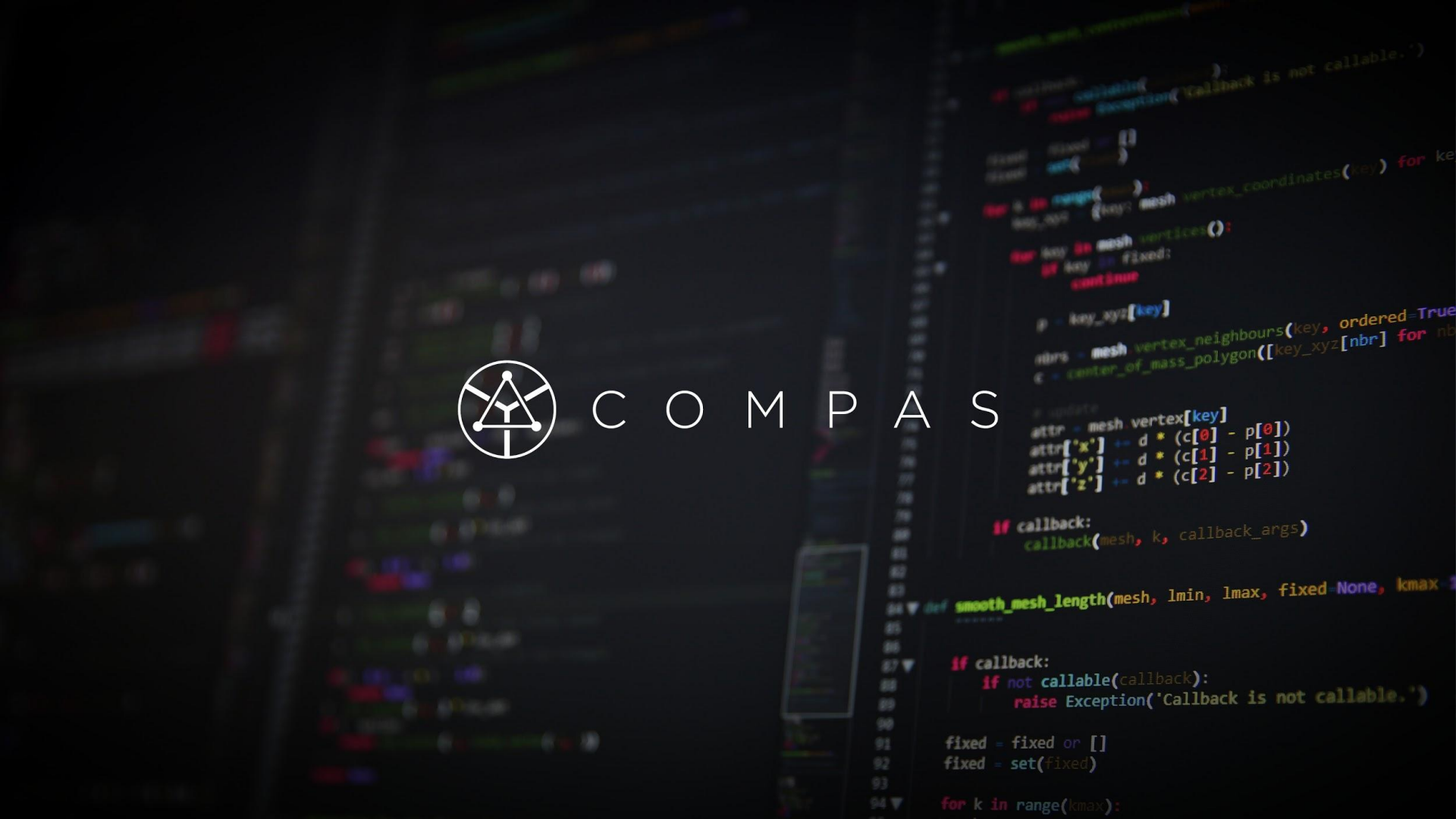
Fabrication



# Design to fabrication



# Interdisciplinarity


COMPAS

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| Lecture | Date | Session content |
|---|---|---|
| 01 | 24.02. | Introduction |
| 02 | 03.03. | Robotic fundamentals |
| 03 | 10.03. | Robot models |
| 04 | 17.03. | ROS & MoveIt in the design environment |
| 05 | 31.03. | Path planning |
| 06 | 14.04. | Assembly of discrete elements I: model |
| 07 | 21.04. | Assembly of discrete elements II: plan |
| 08 | 28.04. | Robot control with COMPAS RRC |
| 09 | 05.05. | Assembly of discrete elements III: execution |
| 10 | 12.05. | COMPAS SLICER: Basics |
| 11 | 19.05. | COMPAS SLICER: Advanced |
| 12 | 26.05. | Advancing computational research |
| 13 | 02.06. | Closing |

Gain the ability to **model**, **plan** and **execute** robotic fabrication processes such as discrete assemblies and additive manufacturing using Python.

# Quiz time!

https://**menti.com/v6sma1enzp**

# Assignments and grading

## Assignments

Weekly coding assignments
Submit using pull requests to course repo
Each week, the assignment of previous week is due
Submission deadline, Wednesdays 9AM

## Grading

Coding assignments graded on problem solving
Coding style not part of grading, but included in feedback
Course graded as average of all assignments

# More information

**Office hours**

Every friday, 13:00-14:00
Request via slack

**Links**

*Course materials*
https://github.com/compas-teaching/COMPAS-II-FS2021

*Slack*
https://join.slack.com/t/compasii/shared_invite/zt-mi3kyo2f-aMdyGCKubeTfKnKPdczpcQ

*Forum*
https://forum.compas-framework.org

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# Team

Dr. Romana Rust

Joris Burger

Dr. Beverly Lytle

Ioanna Mitropoulou

Gonzalo Casas

Philippe Fleischmann

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# Installation

https://tiny.cc/compas-ii

compas-teaching / COMPAS-II-FS2021

Watch 3 | Star 0 | Fork 0

Code | Issues | Pull requests | Actions | Projects | Security | Insights

main | 1 branch | 0 tags | Go to file | Code

gonzalocasas Add git and update env — 6dd698e — hour ago — 10 commits

| | | |
|---|---|---|
| .github/workflows | Add git and update env | 1 hour ago |
| lecture_01 | Add lectures folders | 22 days ago |
| lecture_02 | Add lectures folders | 22 days ago |
| lecture_03 | Add lectures folders | 22 days ago |
| lecture_04 | Add lectures folders | 22 days ago |
| lecture_05 | Add lectures folders | 22 days ago |
| lecture_06 | Add lectures folders | 22 days ago |
| lecture_07 | Add lectures folders | 22 days ago |
| lecture_08 | Add lectures folders | 22 days ago |
| lecture_09 | Add lectures folders | 22 days ago |
| lecture_10 | Add lectures folders | 22 days ago |
| lecture_11 | Add lectures folders | 22 days ago |
| lecture_12 | Add lectures folders | 22 days ago |
| lecture_13 | Add lectures folders | 22 days ago |
| .editorconfig | Initial commit | 28 days ago |
| .gitignore | add environment.yml | 12 days ago |

About

*No description, website, or topics provided.*

Readme

MIT License

Releases

No releases published

Packages

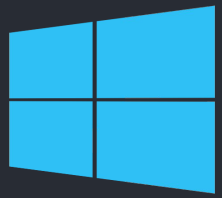
No packages published

Contributors 2

gonzalocasas Gonzalo Casas

beverlylytle

⌘ + SPACE

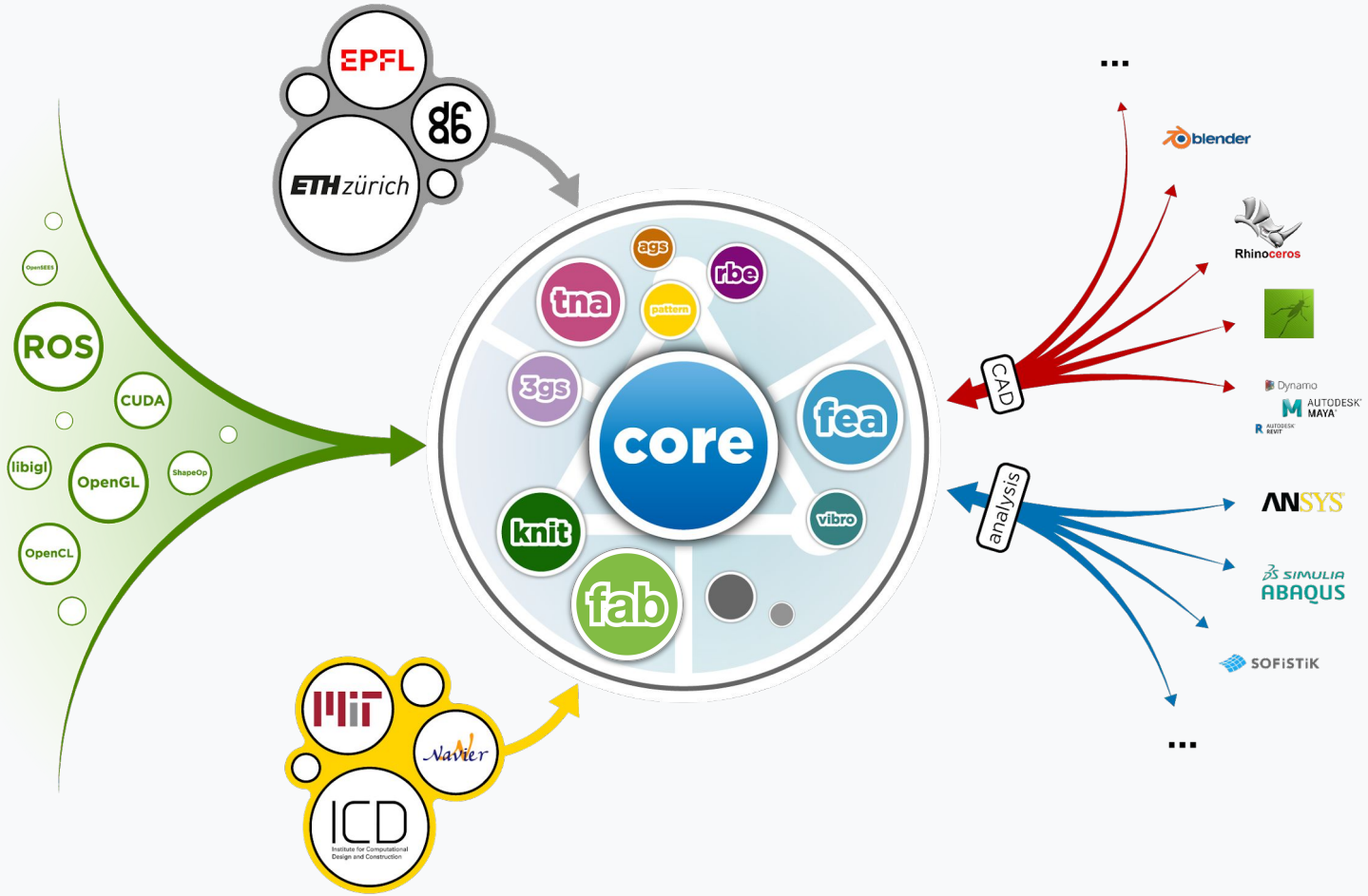


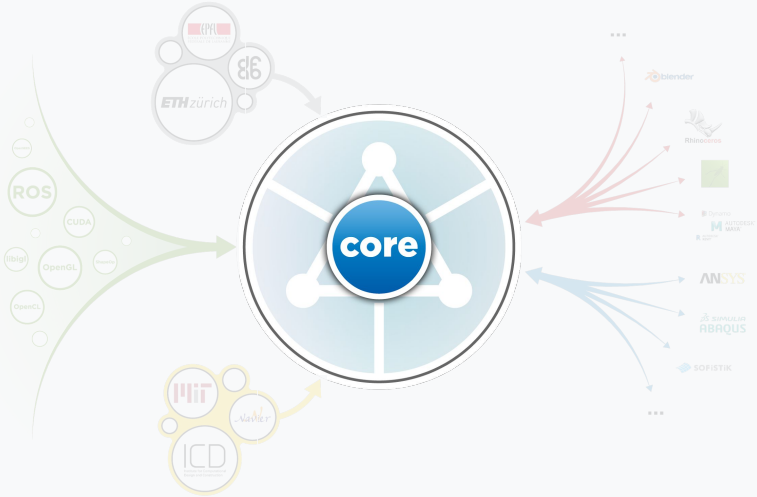
Terminal

Anaconda Prompt

```
(base)  conda config --add channels conda-forge
(base)  cd path/to/COMPAS-II-FS2021
(base)  conda env create -f environment.yml
(base)  conda activate compas-fs2021
(compas-fs2021) conda install python.app
```

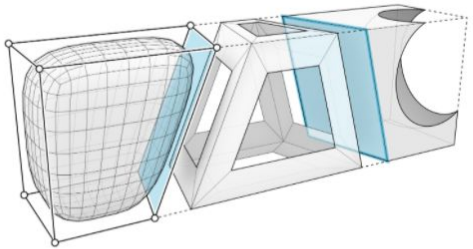

Create environment
(base) conda config --add channels conda-forge
(base) cd path/to/COMPAS-II-FS2021
(base) conda env create -f environment.yml
(base) conda activate compas-fs2021
(compas-fs2021) conda install python.app


EPFL
ETH zürich
ROS
CUDA
libigl
OpenGL
ShapeOp
OpenCL
ags
rbe
tna
pattern
3gs
core
fea
knit
vibro
fab
MIT
Navier
ICD
Institute for Computational Design and Construction
...
blender
Rhinoceros
Dynamo
AUTODESK MAYA
CAD
analysis
ANSYS
SIMULIA ABAQUS
SOFiSTiK
...

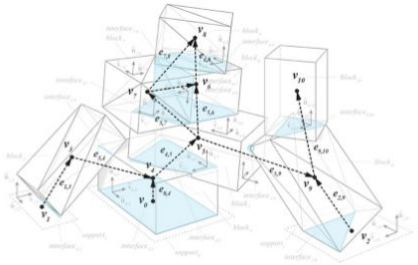



# COMPAS

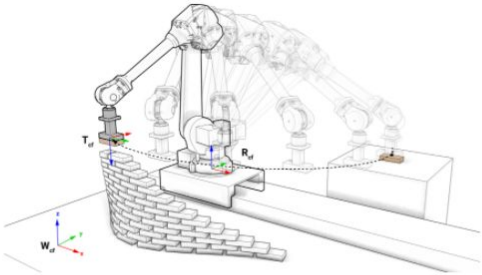
Cross-platform
Pure Python
MIT license



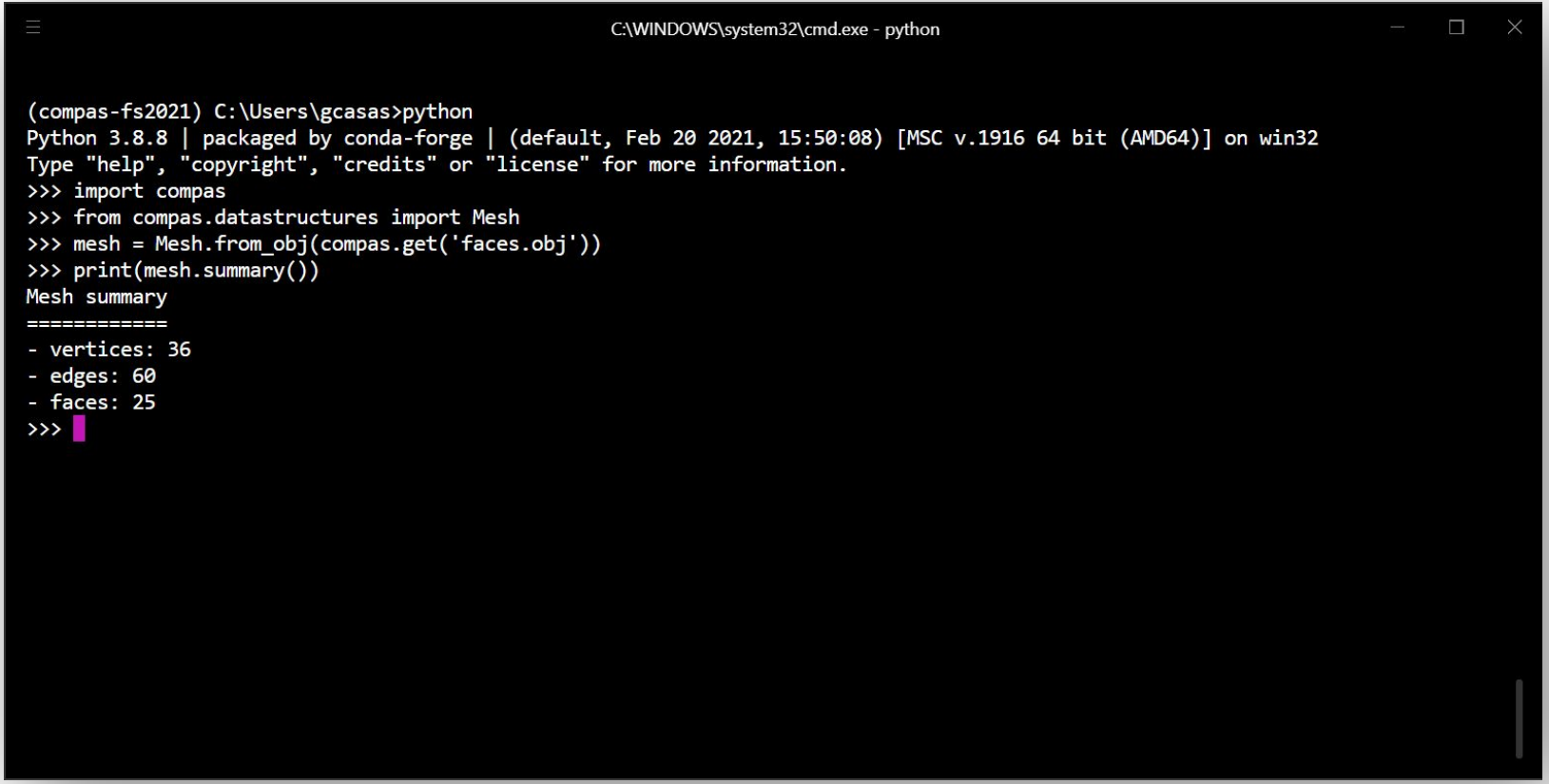
geometry



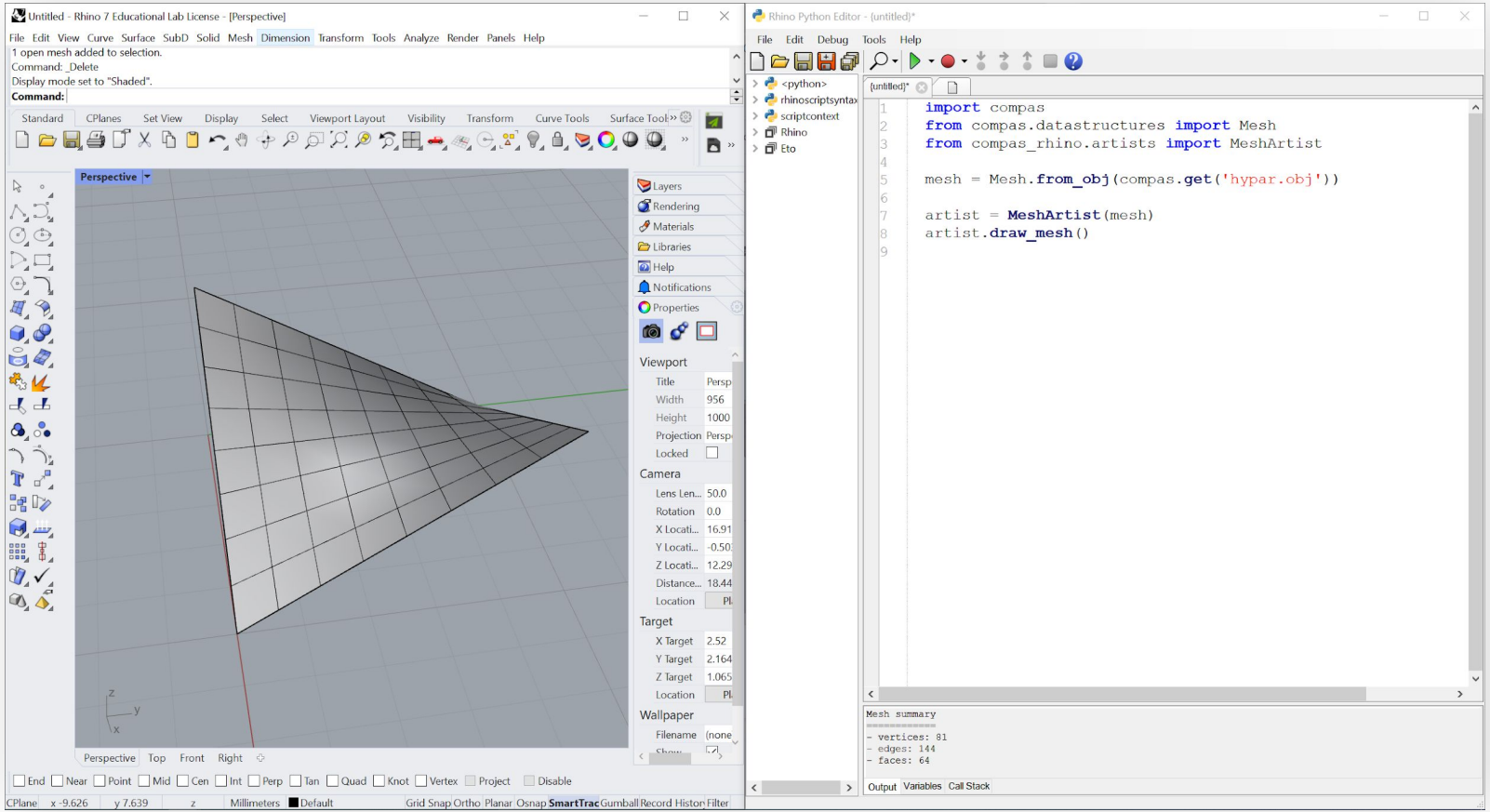
data structures

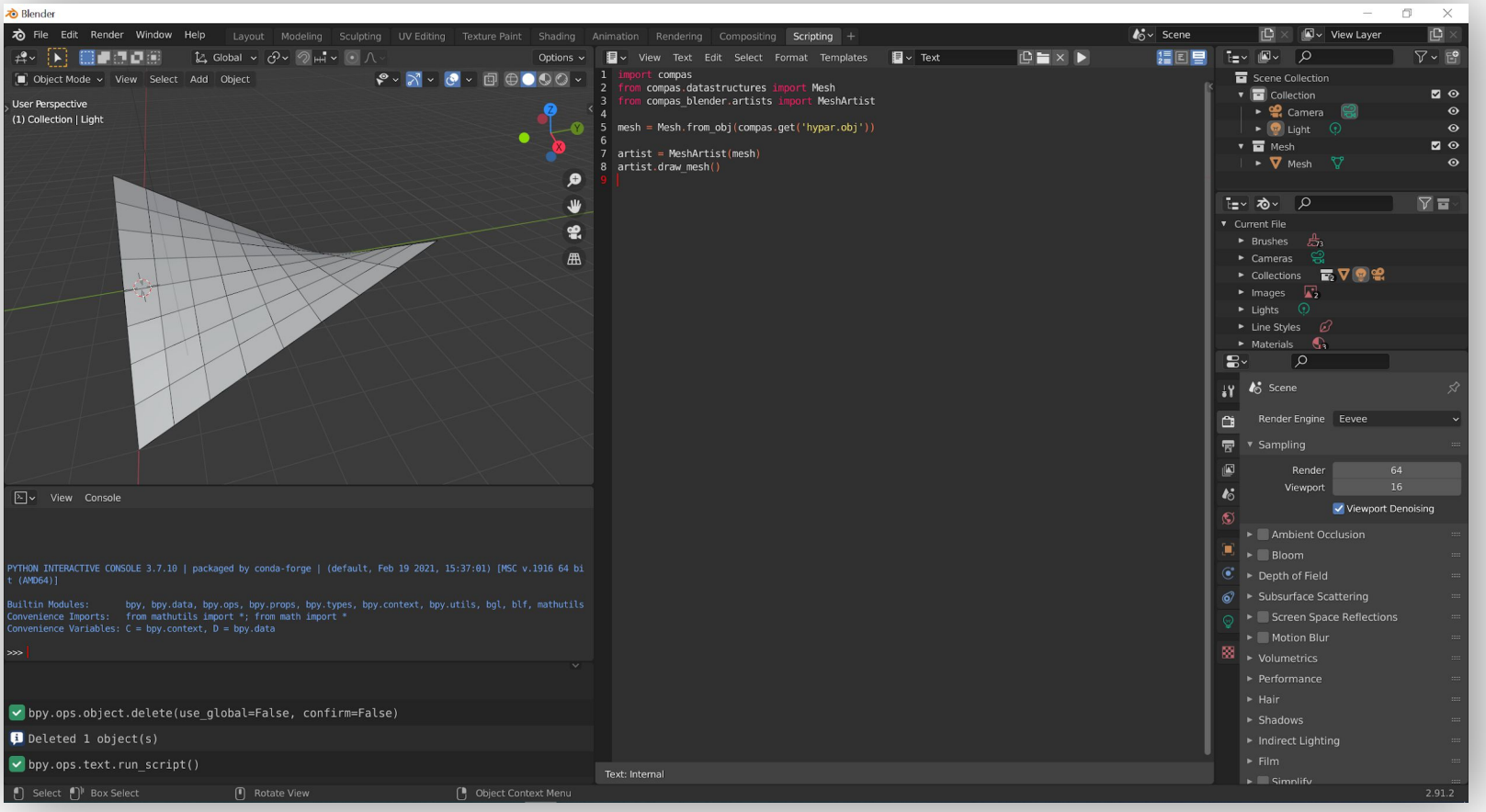


robots


C:\WINDOWS\system32\cmd.exe - python
(compas-fs2021) C:\Users\gcasas>python
Python 3.8.8 | packaged by conda-forge | (default, Feb 20 2021, 15:50:08) [MSC v.1916 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> import compas
>>> from compas.datastructures import Mesh
>>> mesh = Mesh.from_obj(compas.get('faces.obj'))
>>> print(mesh.summary())
Mesh summary
============
- vertices: 36
- edges: 60
- faces: 25
>>>


dr_numpy.py — compas-dev
FOLDERS
compas-dev
compas
build
data
dist
docs
libs
src
compas
__pycache__
com
datastructures
files
geometry
interop
numerical
__pycache__
_alglib
alglib
algorithms
descent
devo
dr
drx
__pycache__
__init__.py
drx_numpy.py
fd
ga
lma
mma
pca
solvers
topop
__init__.py
linalg.py
matrices.py
operators.py
utilities.py
plotters
robots
rpc
topology
utilities
viewers
__init__.py
_os.py
COMPAS.egg-info
compas_blender
compas_ghpython
compas_hpc
compas_revit
compas_rhino
temp
tests
.bumpversion.cfg
.editorconfig
.gitignore
.travis.yml
CONTRIBUTORS.md
LICENSE
dr_numpy.py
from __future__ import absolute_import
from __future__ import division
from __future__ import print_function
import compas
try:
from numpy import array
from numpy import isnan
from numpy import isinf
from numpy import ones
from numpy import zeros
from scipy.linalg import norm
from scipy.sparse import diags
except ImportError:
compas.raise_if_not_ironpython()
from compas.numerical import connectivity_matrix
from compas.numerical import normrow
__all__ = ['dr_numpy']
K = [
[0.0],
[0.5, 0.5],
[0.5, 0.0, 0.5],
[1.0, 0.0, 0.0, 1.0],
]
class Coeff():
def __init__(self, c):
self.c = c
self.a = (1 - c * 0.5) / (1 + c * 0.5)
self.b = 0.5 * (1 + self.a)
def dr_numpy(vertices, edges, fixed, loads, qpre, fpre, lpre, linit, E, radius,
callback=None, callback_args=None, **kwargs):
"""Implementation of the dynamic relaxation method for form findong and analysis
of articulated networks of axial-force members.
Parameters
vertices : list
XYZ coordinates of the vertices.
edges : list
Connectivity of the vertices.
fixed : list
Indices of the fixed vertices.
loads : list
XYZ components of the loads on the vertices.
qpre : list
Prescribed force densities in the edges.
fpre : list
Prescribed forces in the edges.
lpre : list
Prescribed lengths of the edges.
linit : list
Initial length of the edges.
E : list
Stiffness of the edges.
radius : list
Radius of the edges.
callback : callable, optional
User-defined function that is called at every iteration.
callback_args : tuple, optional
Additional arguments passed to the callback.
Notes
For more info, see [1]_.
References
.. [1] De Laet L., Veenendaal D., Van Mele T., Mollaert M. and Block P.,
«Bending incorporated: designing tension structures by integrating
Proceedings of Tensinet Symposium 2013,Istanbul, Turkey, 2013.
Examples
.. plot::
:include-source:
import compas
from compas.datastructures import Network
Git branch: master, index: ✓, working: 10●, Line 33, Column 1


Untitled - Rhino 7 Educational Lab License - [Perspective]
File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels Help
1 open mesh added to selection.
Command: _Delete
Display mode set to "Shaded".
Command:
Standard CPlanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools
Perspective
Layers
Rendering
Materials
Libraries
Help
Notifications
Properties
Viewport
Title Persp
Width 956
Height 1000
Projection Persp
Locked
Camera
Lens Len... 50.0
Rotation 0.0
X Locati... 16.91
Y Locati... -0.50
Z Locati... 12.29
Distance... 18.44
Location
Target
X Target 2.52
Y Target 2.164
Z Target 1.065
Location
Wallpaper
Filename (none
Perspective Top Front Right
End Near Point Mid Cen Int Perp Tan Quad Knot Vertex Project Disable
CPlane x -9.626 y 7.639 z Millimeters Default Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter
Rhino Python Editor - (untitled)*
File Edit Debug Tools Help
<python>
rhinoscriptsyntax
scriptcontext
Rhino
Eto
(untitled)*
1 import compas
2 from compas.datastructures import Mesh
3 from compas_rhino.artists import MeshArtist
4
5 mesh = Mesh.from_obj(compas.get('hypar.obj'))
6
7 artist = MeshArtist(mesh)
8 artist.draw_mesh()
9
Mesh summary
- vertices: 81
- edges: 144
- faces: 64
Output Variables Call Stack


Blender
File Edit Render Window Help
Layout Modeling Sculpting UV Editing Texture Paint Shading Animation Rendering Compositing Scripting
Scene
View Layer
Global
Options
Object Mode View Select Add Object
User Perspective
(1) Collection | Light
View Text Edit Select Format Templates
Text
import compas
from compas.datastructures import Mesh
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mesh = Mesh.from_obj(compas.get('hypar.obj'))
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artist.draw_mesh()
Scene Collection
Collection
Camera
Light
Mesh
Mesh
Current File
Brushes
Cameras
Collections
Images
Lights
Line Styles
Materials
Scene
Render Engine
Eevee
Sampling
Render
64
Viewport
16
Viewport Denoising
Ambient Occlusion
Bloom
Depth of Field
Subsurface Scattering
Screen Space Reflections
Motion Blur
Volumetrics
Performance
Hair
Shadows
Indirect Lighting
Film
Simplify
View Console
PYTHON INTERACTIVE CONSOLE 3.7.10 | packaged by conda-forge | (default, Feb 19 2021, 15:37:01) [MSC v.1916 64 bit (AMD64)]
Builtin Modules: bpy, bpy.data, bpy.ops, bpy.props, bpy.types, bpy.context, bpy.utils, bgl, blf, mathutils
Convenience Imports: from mathutils import *; from math import *
Convenience Variables: C = bpy.context, D = bpy.data
>>>
bpy.ops.object.delete(use_global=False, confirm=False)
Deleted 1 object(s)
bpy.ops.text.run_script()
Text: Internal
Select
Box Select
Rotate View
Object Context Menu
2.91.2

```python
# Rhino
import compas
from compas.datastructures import Mesh
from compas_rhino.artists import MeshArtist

mesh = Mesh.from_obj(compas.get('hypar.obj'))

artist = MeshArtist(mesh)
artist.draw_mesh()
```

```python
# Blender
import compas
from compas.datastructures import Mesh
from compas_blender.artists import MeshArtist

mesh = Mesh.from_obj(compas.get('hypar.obj'))

artist = MeshArtist(mesh)
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artist = MeshArtist(mesh)
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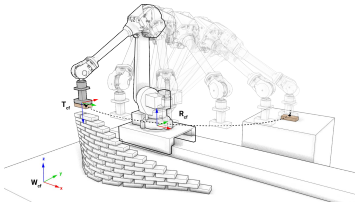
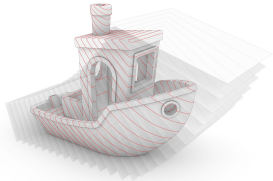
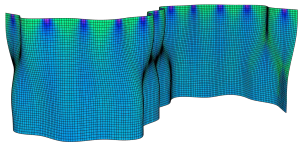


compas_fab

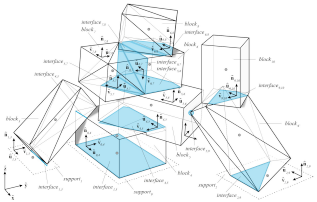
compas_rrc



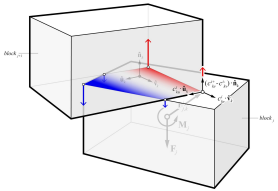
compas_slicer



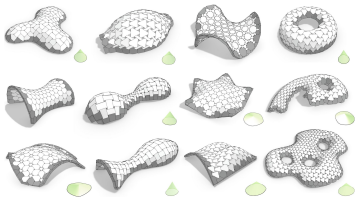
compas_fea



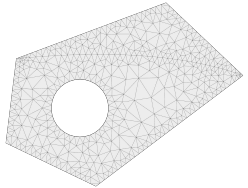
compas_assembly



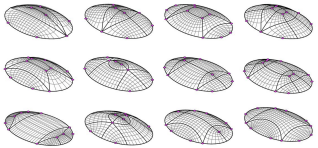
compas_rbe



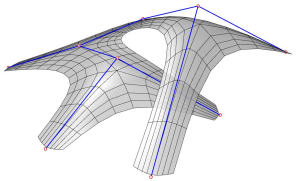
compas_tia



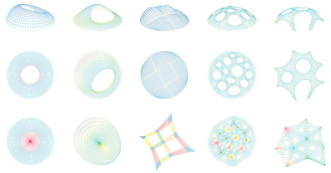
compas_triangle



compas_singular

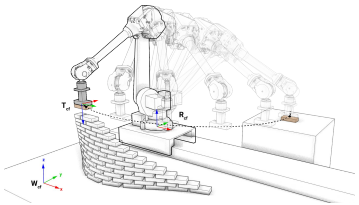


compas_skeleton



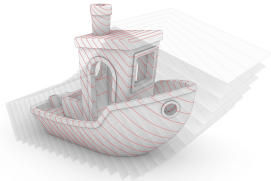
compas_tna


compas_rv2

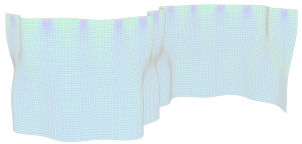


compas_fab

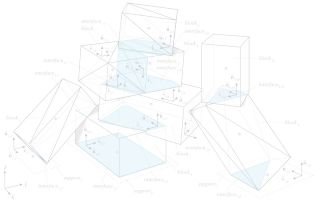
compas_rrc



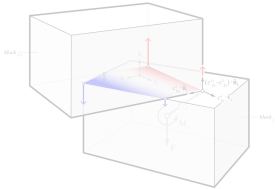
compas_slicer



compas_fea



compas_assembly



compas_rbe



compas_tia



compas_triangle



compas_singular

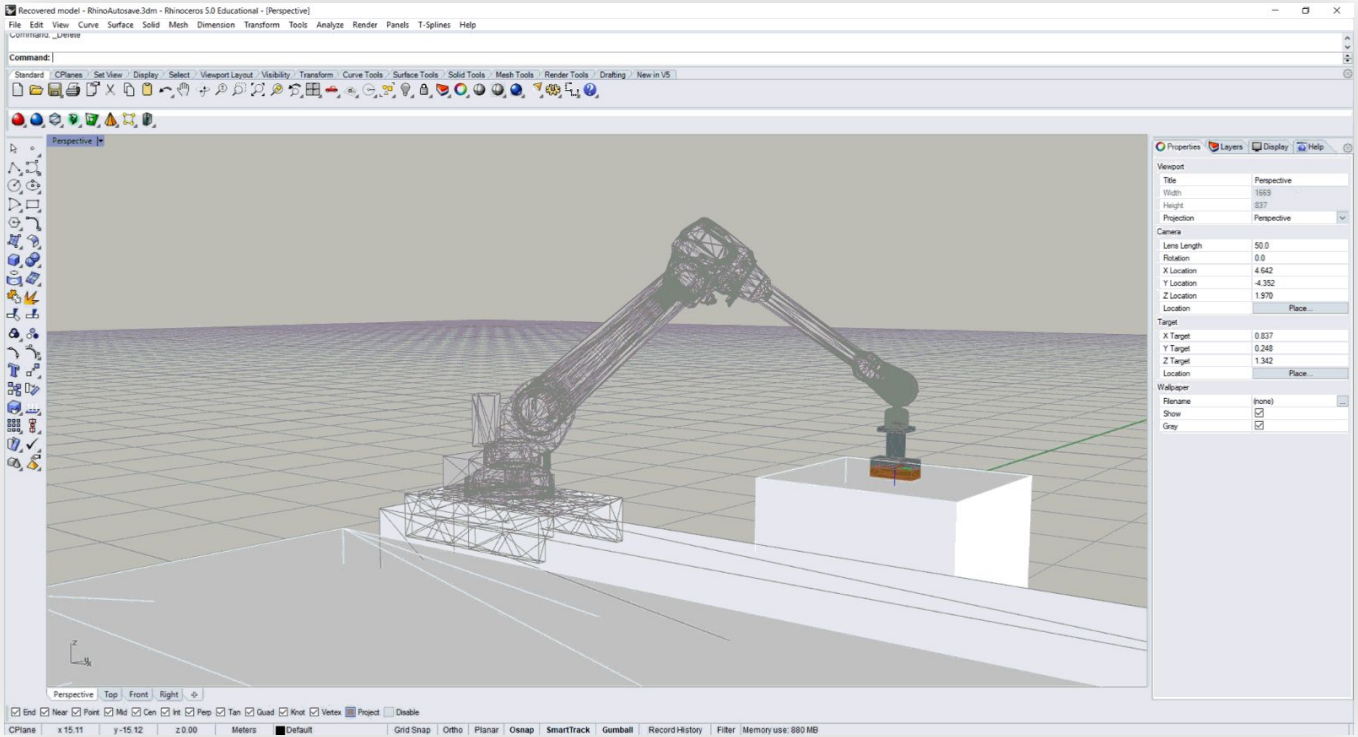


compas_skeleton



compas_tna

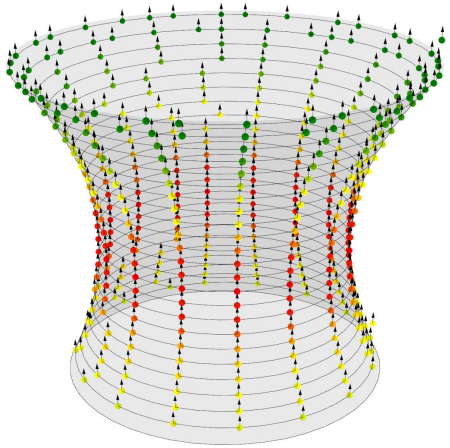
compas_rv2

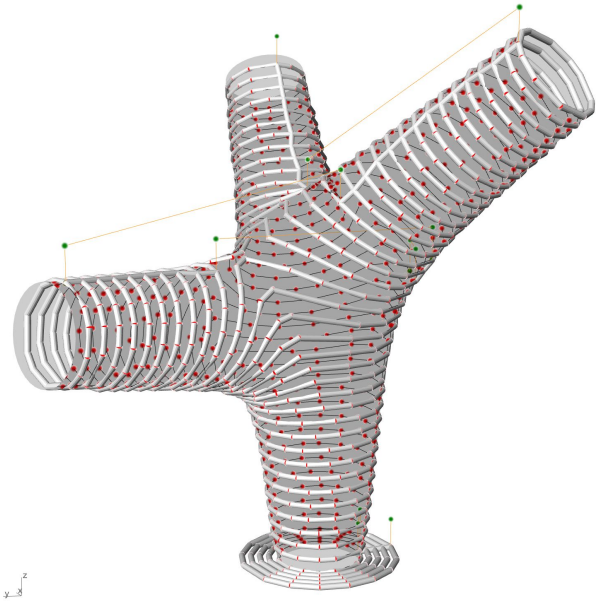


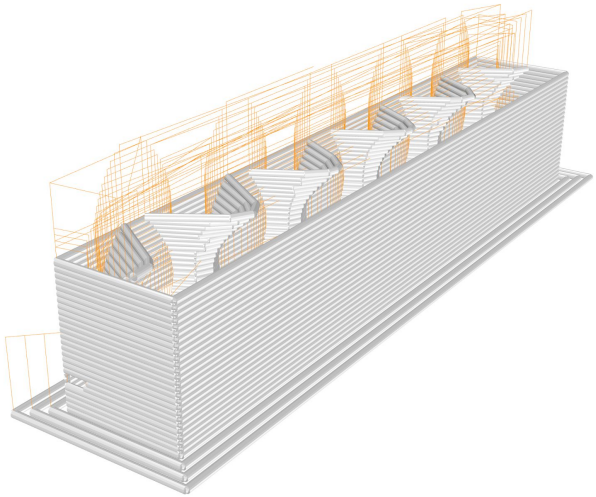

**COMPAS FAB**

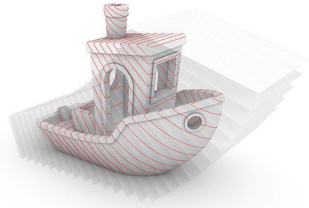
Robotic fabrication package

ETH zürich



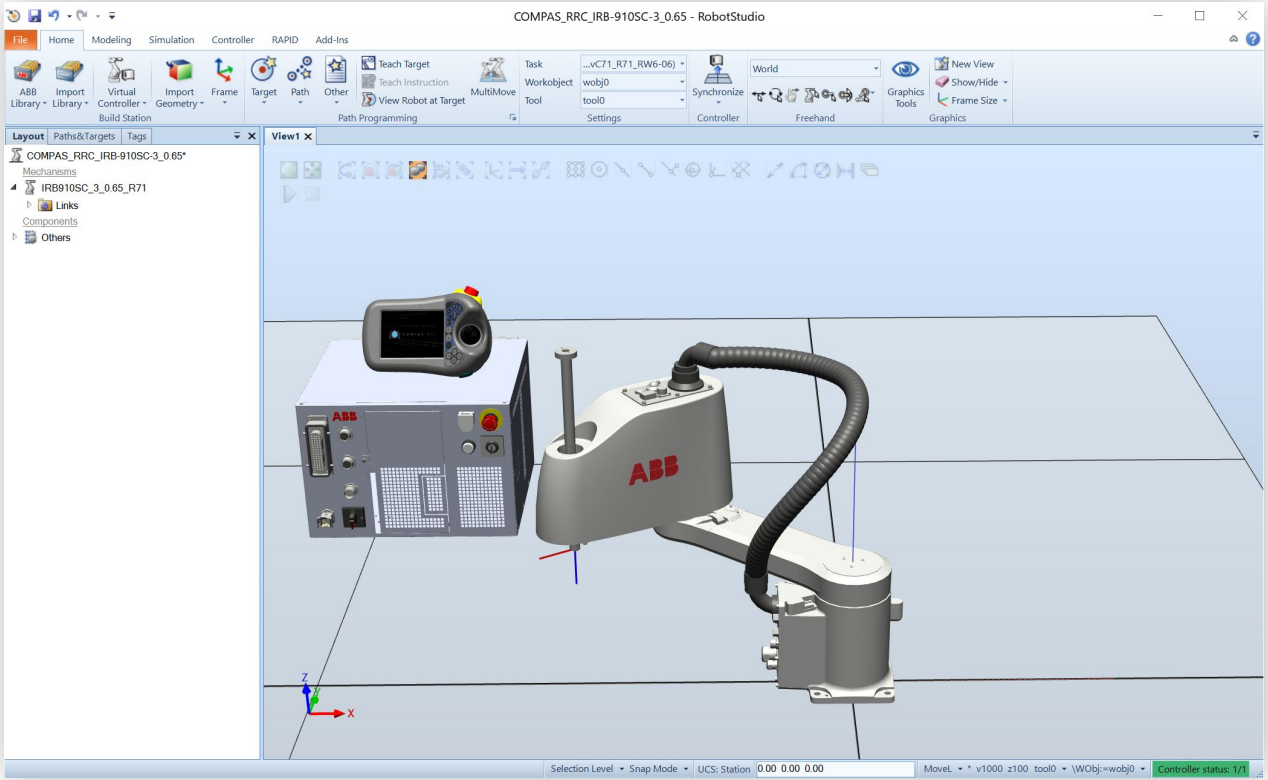






**COMPAS SLICER**

Slicing package for FDM 3D Printing



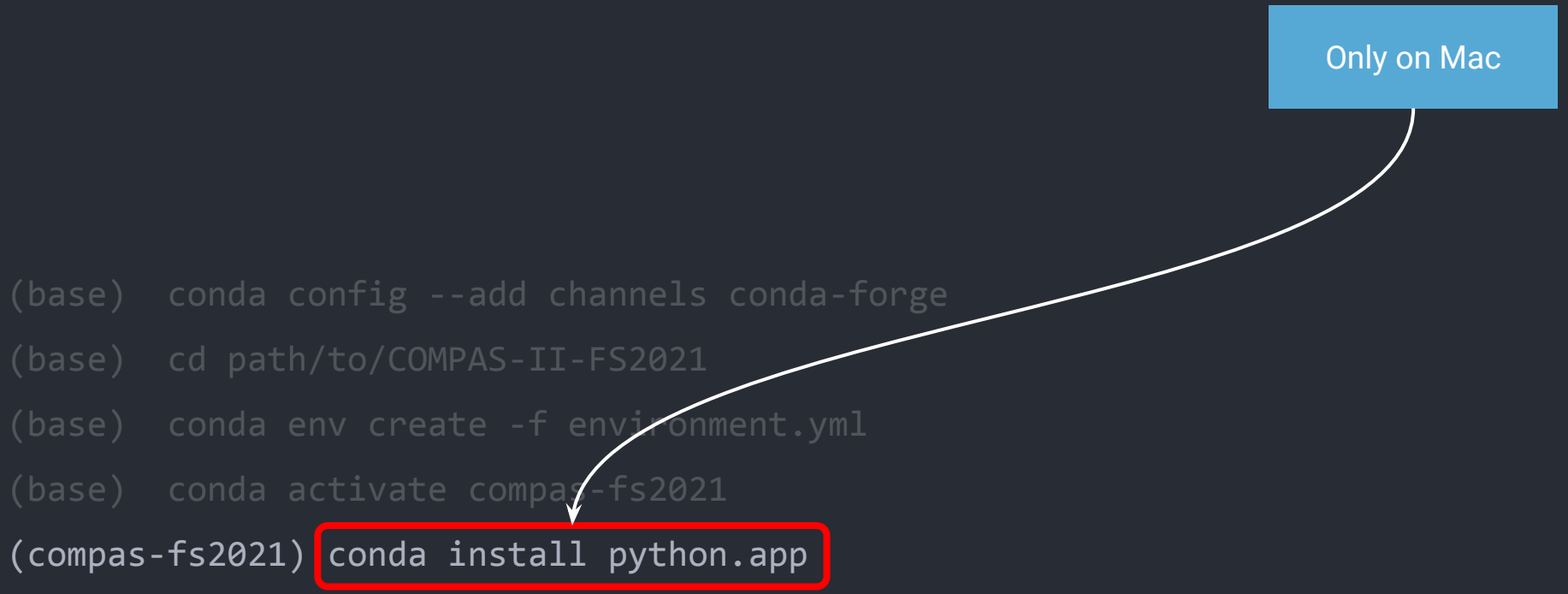

**COMPAS RRC**

Robot control for ABB robots

# Installation

https://tiny.cc/compas-ii


Activate
(base) conda config --add channels conda-forge
(base) cd path/to/COMPAS-II-FS2021
(base) conda env create -f environment.yml
(base) conda activate compas-fs2021
(compas-fs2021) conda install python.app


Only on Mac
(base) conda config --add channels conda-forge
(base) cd path/to/COMPAS-II-FS2021
(base) conda env create -f environment.yml
(base) conda activate compas-fs2021
(compas-fs2021) conda install python.app

Restart Rhino

```
(compas-fs2021) python -m compas_rhino.install
(compas-fs2021) python -m compas_rhino.install -v 7.0
```

intro
course overview
team
dfab toolbox

# datastructures

# Primitives & Shapes

compas.geometry

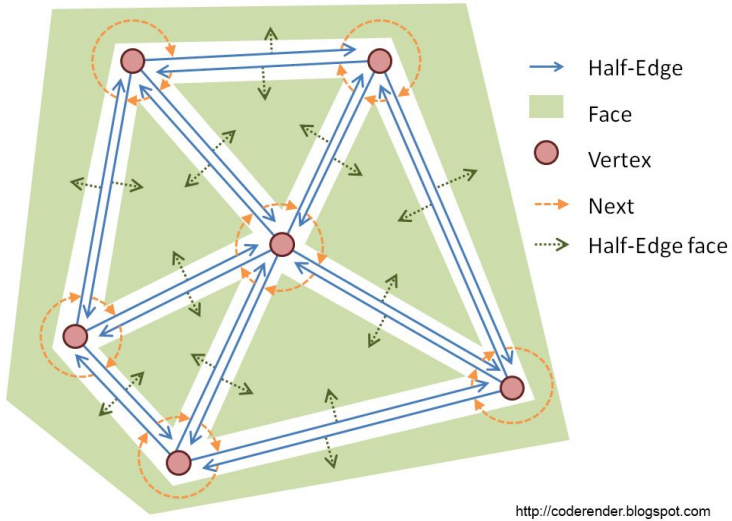
- point, vector, line, plane, circle, polyline, polygon, frame
- transformation, translation, rotation, scale, reflection, projection, shear
- box, sphere, polyhedron, torus, cone, capsule

| Object | Python | COMPAS |
|---|---|---|
| point | `point = [0, 0, 0]` | `point = Point(0, 0, 0)` |
| vector | `vector = [0, 0, 1]` | `vector = Vector(0, 0, 1)` |
| line | `line = [0, 0, 0], [1, 0, 0]` | `line = Line(point, point)` |
| plane | `plane = [0, 0, 0], [0, 0, 1]` | `plane = Plane(point, vector)` |
| circle | `circle = ([0, 0, 0], [0, 0, 1]), 1.0` | `circle = Circle(plane, radius)` |
| polyline | `polyline = [0, 0, 0], [1, 0, 0], [1, 1, 0], [0, 0, 0]` | `polyline = Polyline(points)` |
| polygon | `polygon = [0, 0, 0], [1, 0, 0], [1, 1, 0]` | `polygon = Polygon(points)` |
| frame | `frame = [0, 0, 0], [1, 0, 0], [0, 1, 0]` | `frame = Frame(point, xaxis, xyp` |

# Mesh

compas.datastructures

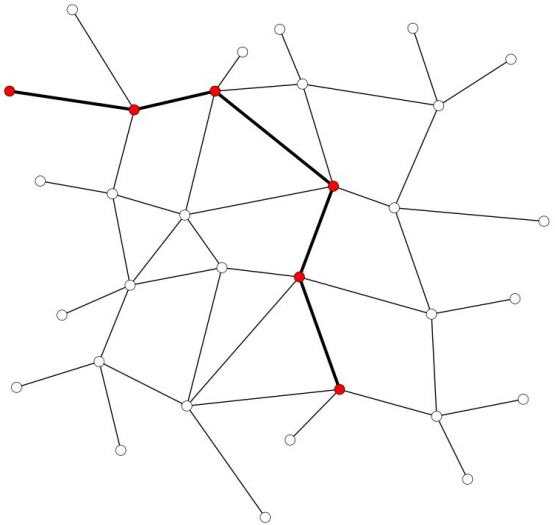
- CAD-agnostic
- half-edge data structure
- support for n-sided polygonal faces
- open or closed, polygonal surfaces
- custom attributes at mesh, vertex, edge and face



# Network

compas.datastructures

- directed edge graph data structure
- graph: topological
- network: geometric implementation of graph
- custom attributes at network, node and edge
- networkx support



# Remote Procedure Calls

compas.rpc

# Next week

- Make sure examples run on your machine
- Ask for help if needed
  - Slack
  - Forum
- Next week:
  - Robotic fundamentals

# Thanks!