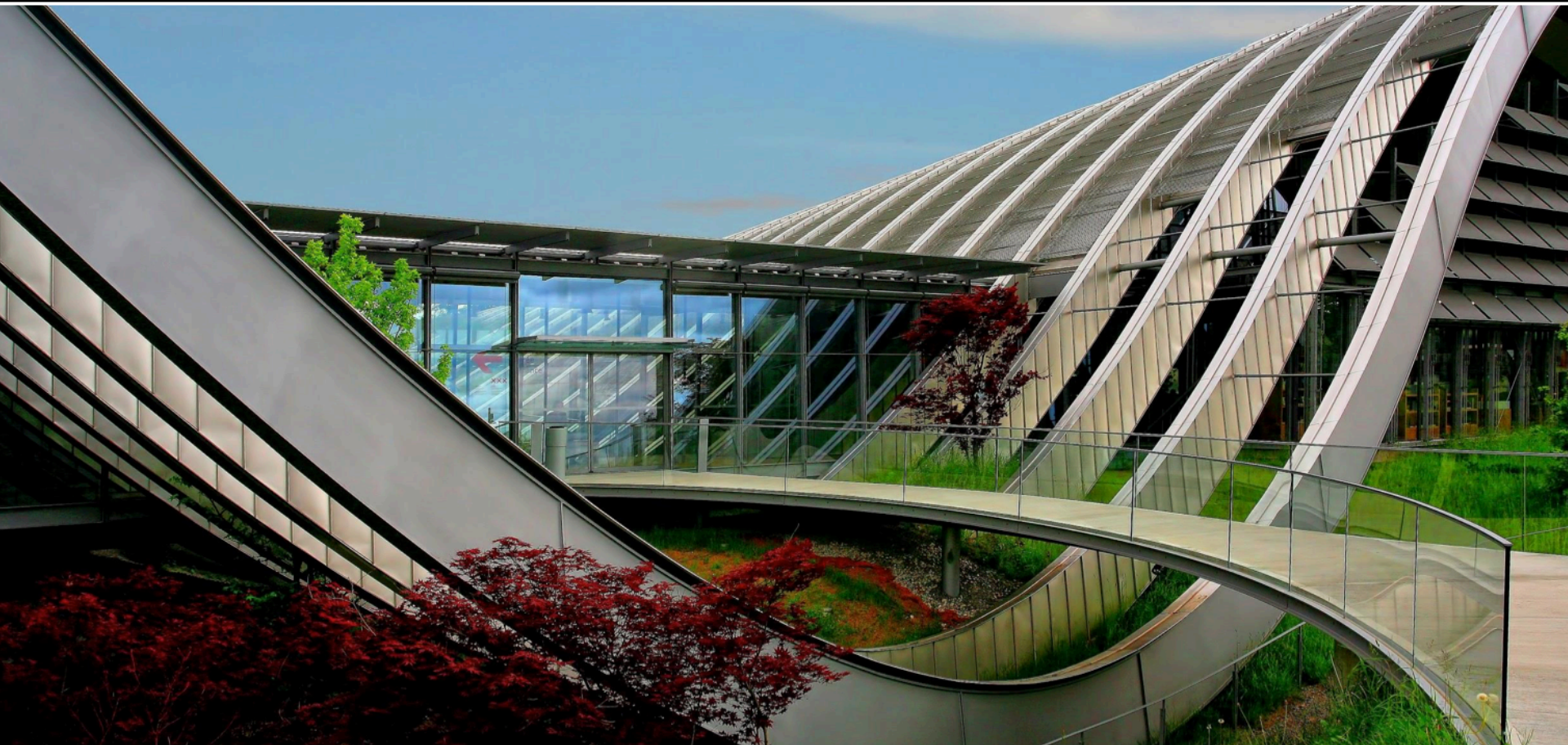


# Context-Oriented Algorithmic Design

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# Algorithmic Design



# CAD Tools

```

1 #lang racket
2 (require (planet aml/rosetta))
3 (backend autocad)
4
5 ;;Projecto de PCA - Torres do Dubai;;
6 ;;Guilherme Ferreira, 69316;;
7 ;;Bruno Ferreira, 69919;;
8
9 (render-dir "C:\\Users\\BrunoF\\Documents\\IST\\5 Ano, 1 Semestre\\PCA")
10 (render-size 1920 1080)
11
12 ;;:Criacao das Dubai Towers.
13
14 ;;:A criação das Dubai Towers divide-
15 ;;:Para cada torre sao criadas as laj
16 ;;:e finalmente os veios.
17
18 (define (dubai-towers a r n fr)
19   (let((pts (cria-centro-torres)))
20     (cria-torre (car pts) 350 a r n fr)
21     (cria-torre (car (cdr pts)) 400 a
22     (cria-torre (car (cdr (cdr pts)))
23     (cria-torre (car (cdr (cdr (cdr pts))))
24
25
26 ;Cria n+1 pontos em torno de uma circunferencia
27 ;p: coordenada do centro da circunferencia
28 ;a: angulo de rotacao inicial,
29 ;r: raio da circunferencia,
30 ;n: numero de divisoes
31 (define (cria-pontos p a r n)
32   (map-division (lambda (fi)
33     (+pol p r (+ a fi)
34     0
35     2pi
36     n))
37
38
39 ;Cria os centros das torres em torno
40 (define (cria-centro-torres)
41   (map-division (lambda (i)
42     (pol 120 i))
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```

#<sweep 11117>  
#<sweep 11120>  
#<sweep 11123>  
#<sweep 11126>  
#<sweep 11129>

# BIM Tools

```

beamTestRkt - DrRacket
File Edit View Language Racket Insert Tabs Help
beamTestRkt (define ...)
Debug Check Syntax Macro Stepper Run Stop

1 #lang racket
8 (define beam-family-1 (load-family "C:\\ProgramData\\Autodesk"
9
10 (define beam-family-2 (load-family "C:\\ProgramData\\Autodesk"
11
12 (define beam-family-3 (load-family "C:\\ProgramData\\Autodesk"
13
14
15 (define beam-family-element-1
16   (family-element beam-family-1))
17
18 (define beam-family-element-2
19   (family-element beam-family-2))
20
21 (define beam-family-element-3
22   (family-element beam-family-3))
23
24 (create-beam (xyz 0 0 0)
25              (xyz 0 10 0))
26
27 (create-beam (xyz 5 0 0)
28              (xyz 5 10 0)
29              #:family beam-family-element-1)

(idstrc '#hasheqv() #"" 266712)
(idstrc '#hasheqv() #"" 266719)
(idstrc '#hasheqv() #"" 266806)
>
Determine language from source
8:2 623.56 MB

```

The screenshot displays the Autodesk Revit software interface. The main window shows a 3D view of a beam element, which is a long, rectangular, dark grey object with a textured surface. The beam is positioned horizontally and is surrounded by other 3D models, including a yellow beam and a grey beam with circular cutouts. The interface includes a ribbon at the top with various toolsets like Architecture, Structure, Systems, Insert, Annotate, Analyze, Massing & Site, Collaborate, View, Manage, Add-Ins, and Modify. The Properties panel on the left shows the 3D View settings, including View Scale (1:100), Scale Value (1:100), Detail Level (Medium), Parts Visibility (Show Original), and Visibility/Graphic options. The Project Browser on the right shows a tree view of the project structure, including Views (all), Floor Plans, Level 1, Site, T.O. Fnd. Wall, T.O. Footing, T.O. Slab, Ceiling Plans, Level 1, 3D Views, Elevations (Building Elevation), East, North, South, West, Legends, and Schedules/Quantities. The status bar at the bottom indicates the current view is at a scale of 1:100 and is in the Main Model.

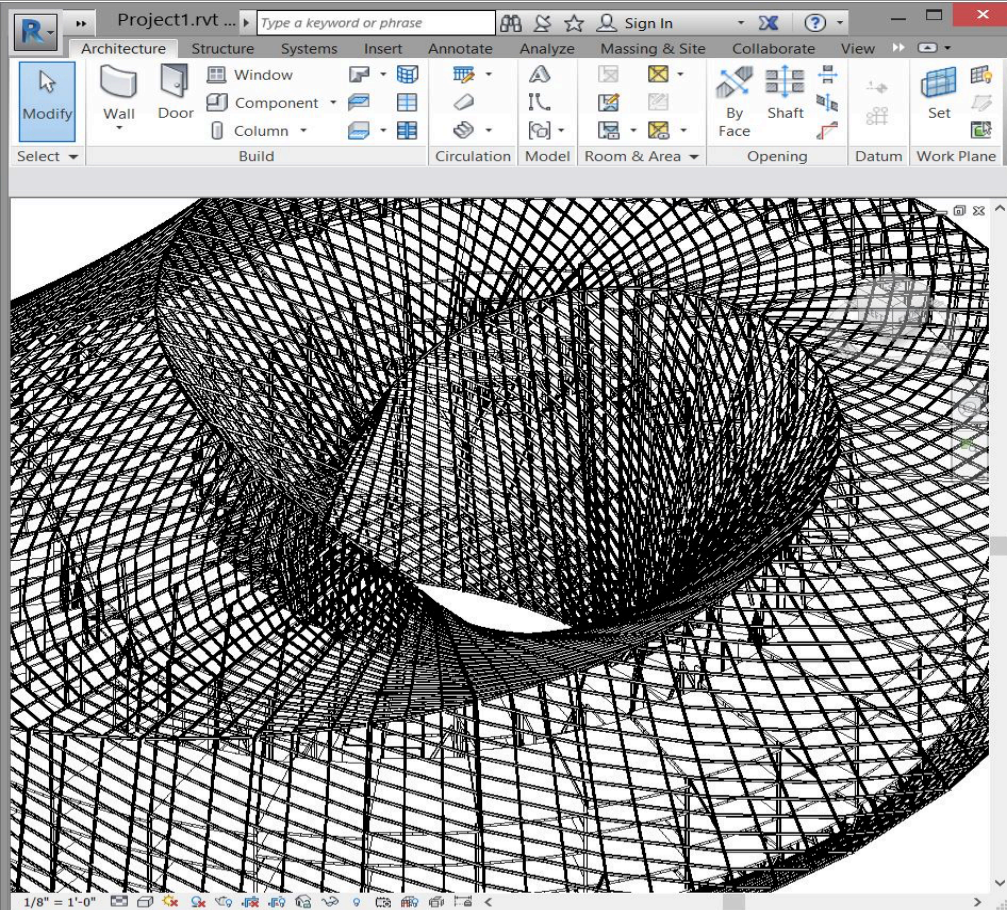


# BIM Tools

```

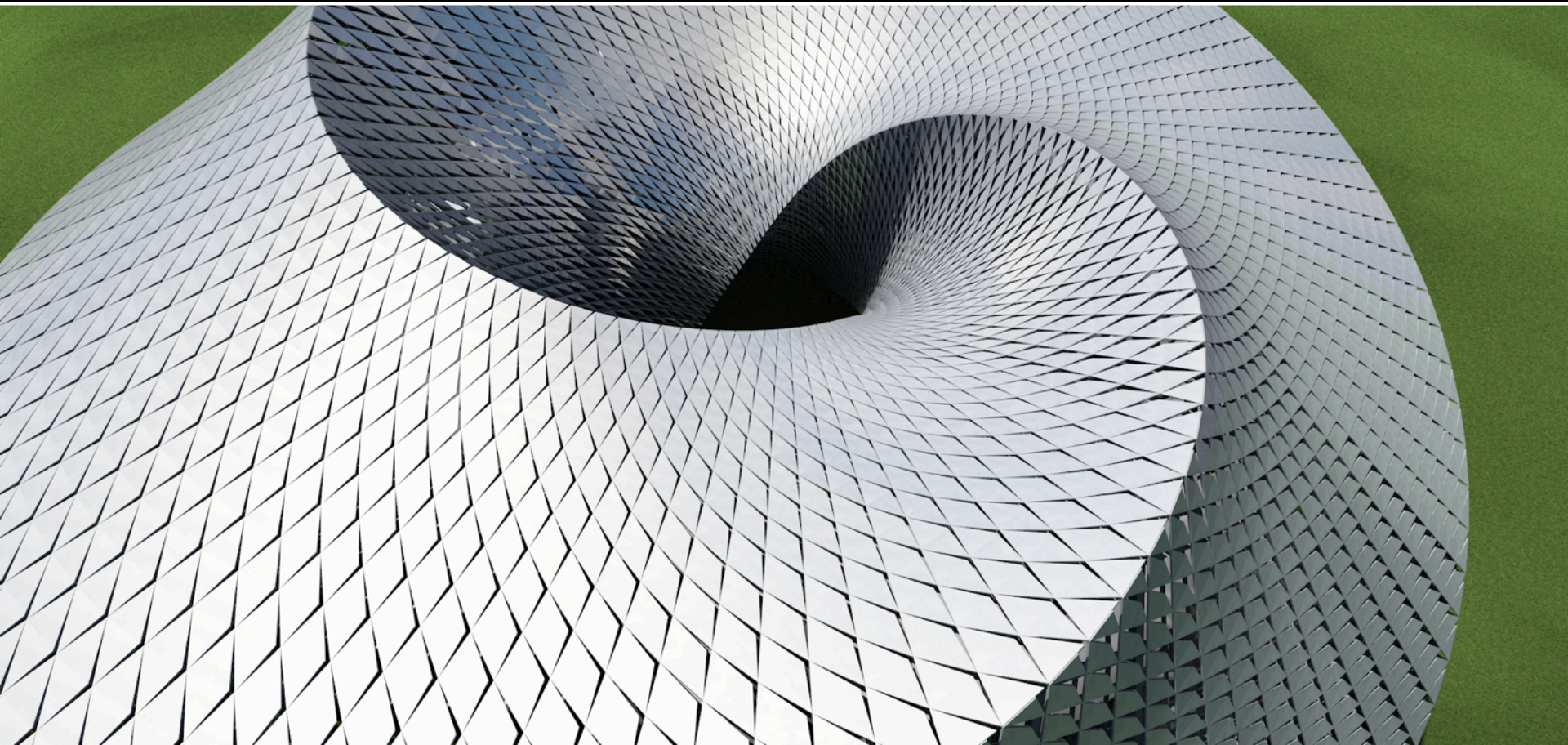
1 #lang racket
438
439
440 ;STEEL FRAMES
441
442 (define (bar pts)
443   (for/list ((p0 pts) (p1 (cdr pts)))
444     (beam p0 p1)))
445
446 (define (rotated-bar pts angles)
447   (for/list ((p0 pts) (p1 (cdr pts)) (a angles))
448     (beam p0 p1 a)))
449
450 (define (frames p)
451   (for/list ((fi (division 2pi 0 n-frames-for-frames #f))
452             (psi (division (/ pi -2) (+ (/ pi -2) skin-rotation) n-frame
453             (bar (list
454                 (+sph (rot-base-point fi) ro-f fi (+ psi psiA))
455                 (+sph (rot-base-point fi) ro-f fi (+ psi psiB))
456                 (+sph (rot-base-point fi) ro-f fi (+ psi psiC))
457                 (+sph (rot-base-point fi) ro-f fi (+ psi psiD))
458                 (+sph (rot-base-point fi) ro-f fi (+ psi psiA))))))
459
460 ;STEEL CONECTIONS
461
462 (define (connections p)
463   (define (ro-f x y) (sqrt (+ (sqr (/ x 2)) (sqr (/ y 2)))))
464   (define (psiA x y) (atan (/ y 2) (/ x 2)))
465   (define (psiB x y) (- pi (atan (/ y 2) (/ x 2))))
466   (define (psiC x y) (+ pi (atan (/ y 2) (/ x 2))))
467   (define (psiD x y) (- (atan (/ y 2) (/ x 2))))
468
469   (define (beam2column p1 p2)
470     (define (dif-almost5? a b) (< -10 (- a b) 10))
471     (define (dif-almost0? a b) (< -1 (- a b) 1))
472     (if (string=? (current-backend-name) "ArchiCAD")
473         (if (and (dif-almost5? (cx p1) (cx p2))
474                 (dif-almost5? (cy p1) (cy p2)))

```





# Complex Buildings

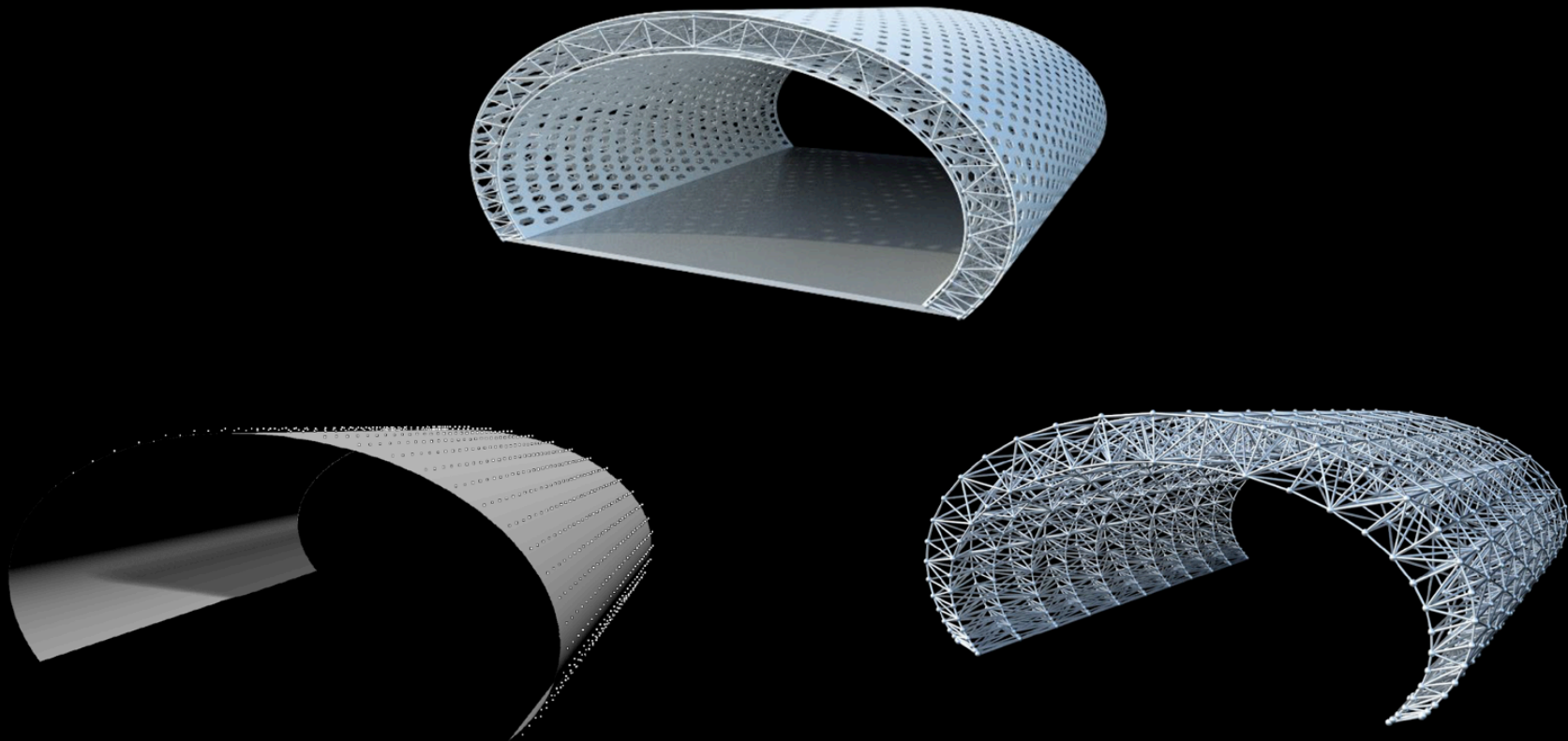


# Complex Buildings





# Need For Analysis

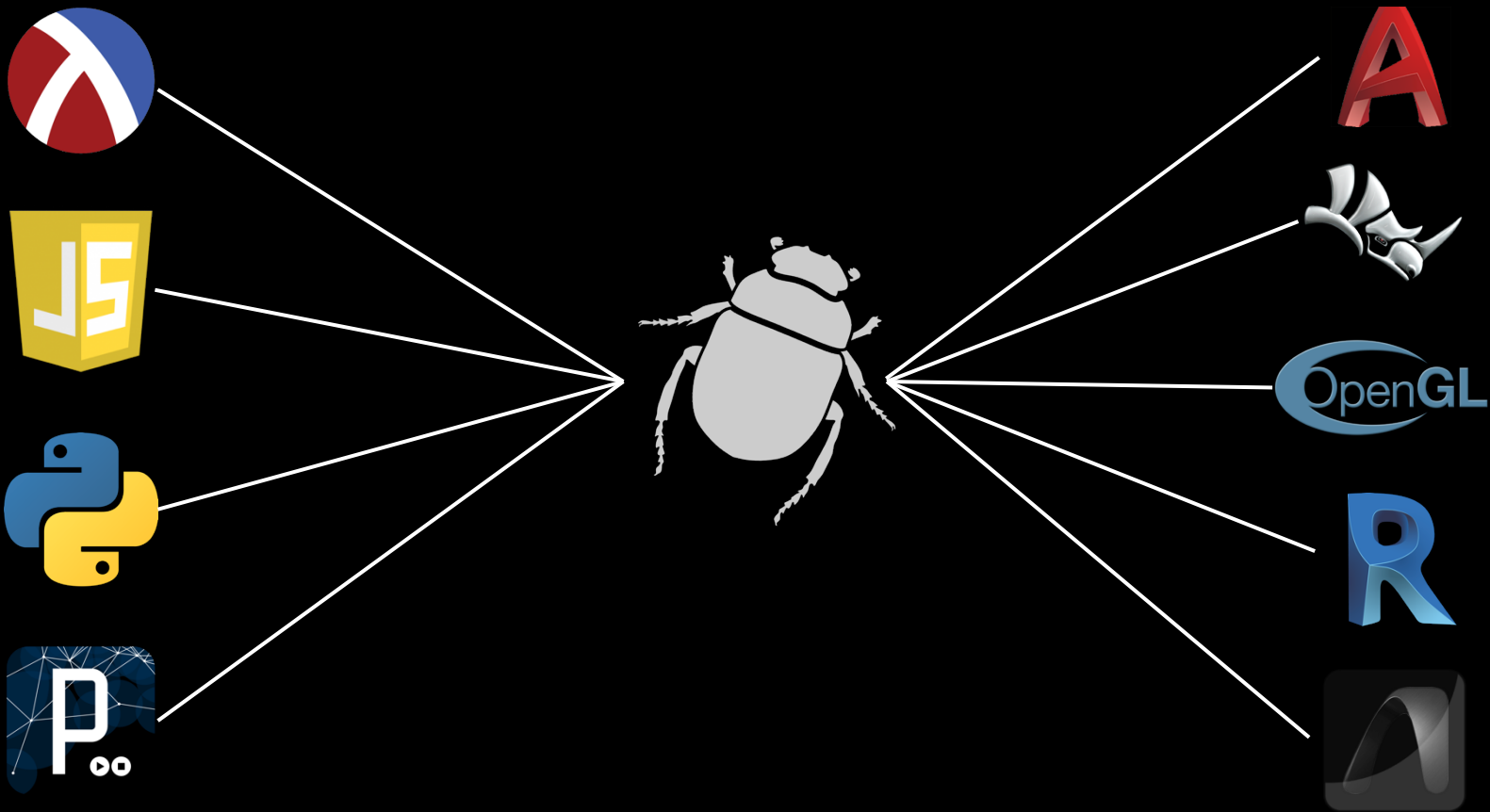




# Several Tools



# Khepri





# Khepri

```
(provide spatial-truss
 spatial-truss-insert-apex)

; (backend rhino 'delete)

; spatial truss

(define truss-knot-radius 0.2)
(define truss-knot sphere)
(define (truss-knots cs radius) (map

(define truss-bar-radius 0.07)
(define truss-bar cylinder)
(define (truss-bars cs1 cs2 radius)

(define (spatial-truss curves (knot
 (let ((as (first curves))
       (bs (second curves))
       (cs (third curves)))
   (list
    (truss-knots as knot-radius)
    (truss-knots bs knot-radius)
    (truss-bars as cs bar-radius)
    (truss-bars bs (drop-right as
                               (truss-bars bs (drop-right cs
                                               (truss-bars bs (rest as) bar-r
                                               (truss-bars bs (rest cs) bar-r
                                               (truss-bars (rest as) (drop-ri
                                               (truss-bars (rest bs) (drop-ri
    (if (empty? (odddr curves))
        (list
         (truss-knots cs knot-radi
         (truss-bars (rest cs) (dr
        (list
         (truss-bars bs (first (dr
         (spatial-truss (drop curv

; spatial truss insert apex

(provide spatial-truss-insert-apex)

; utils

(define (cross-product c1 c2)
  (xyz
   (* (- (xyz-y c1) (xyz-y c2)) (+ (xyz-z c1) (xyz-z c2)))
   (* (- (xyz-z c1) (xyz-z c2)) (+ (xyz-x c1) (xyz-x c2)))
   (* (- (xyz-x c1) (xyz-x c2)) (+ (xyz-z c1) (xyz-z c2))))))

on-size
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Determine language from source
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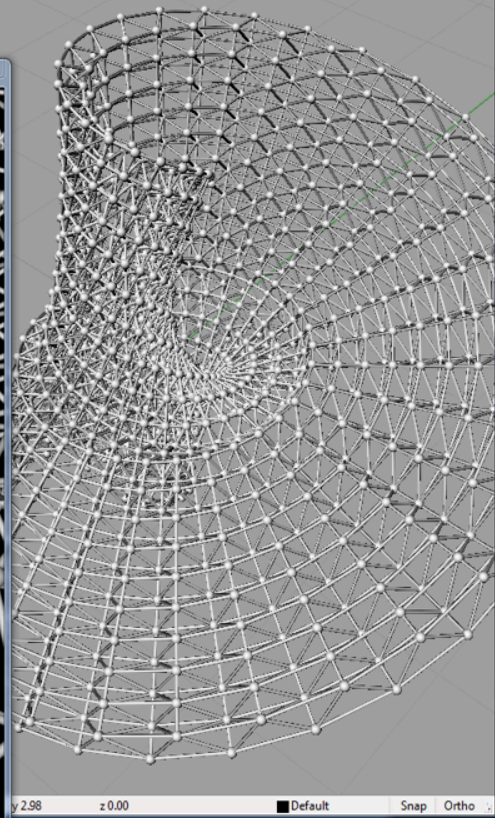
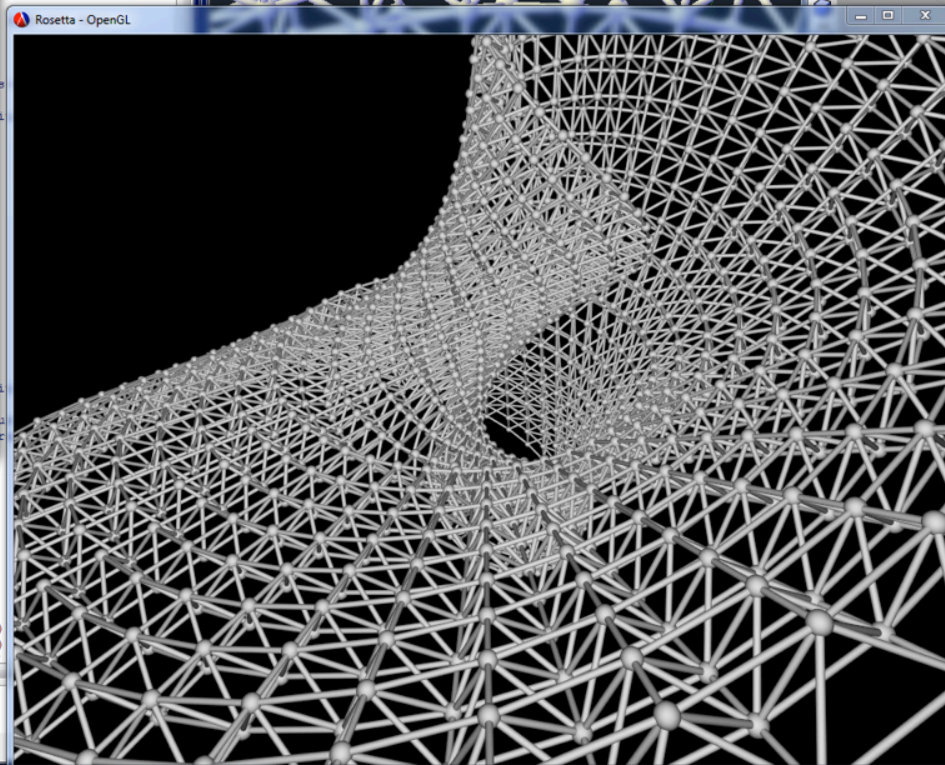
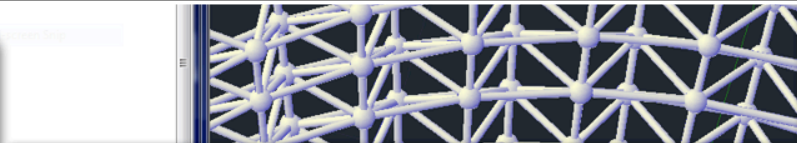
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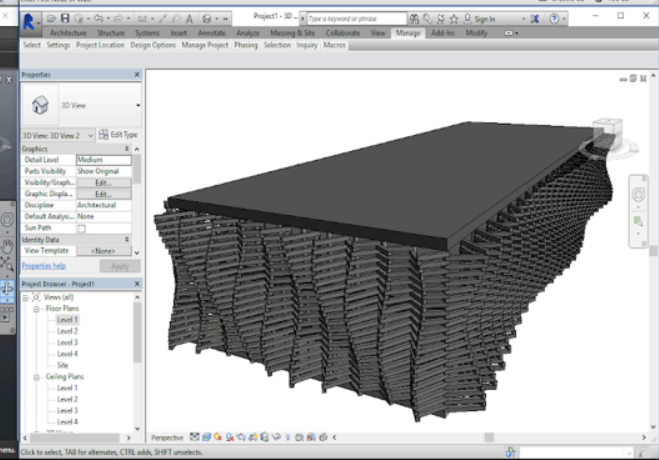
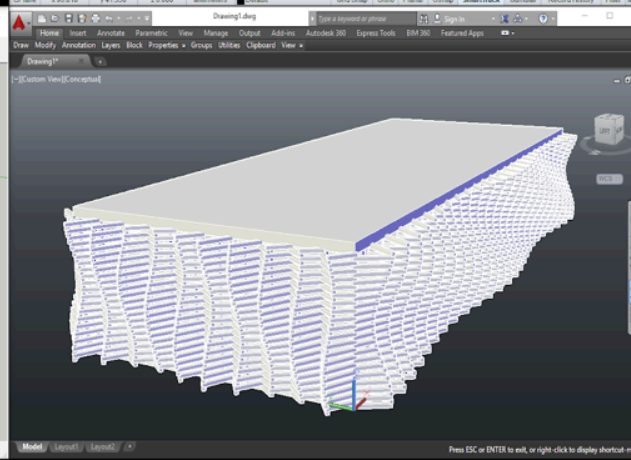
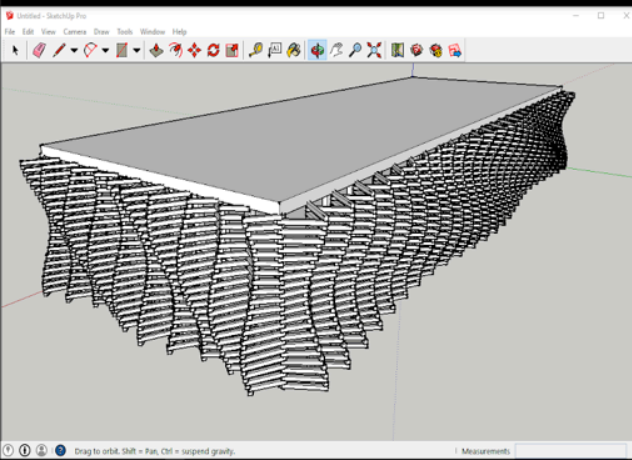
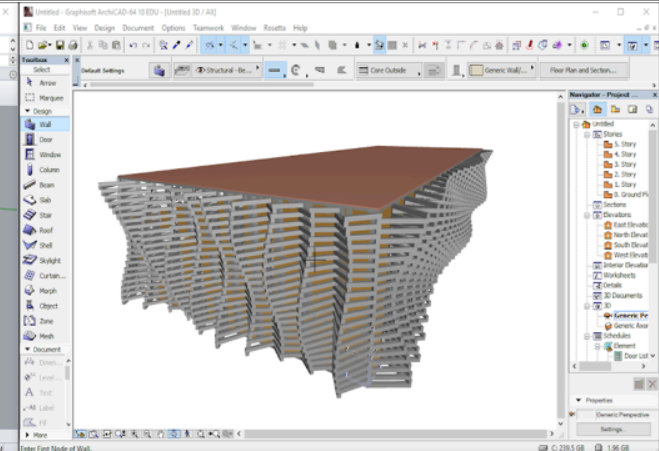
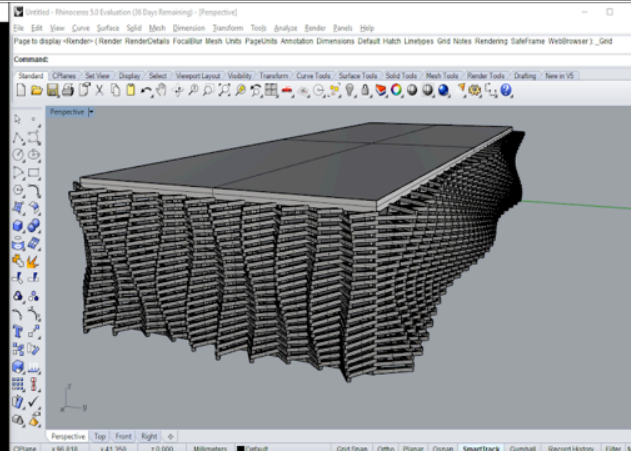
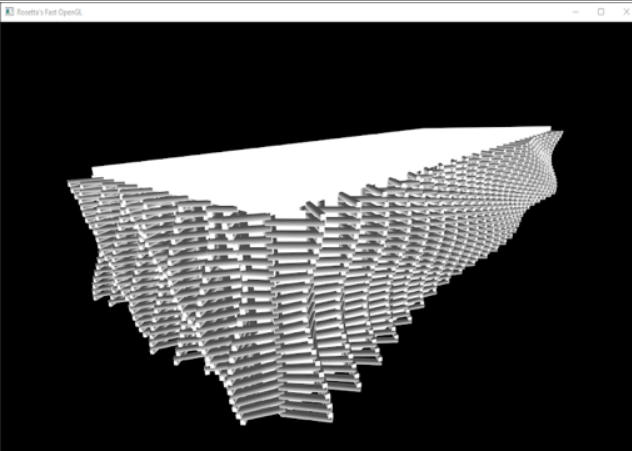
# Khepri

The screenshot displays a 3D architectural software interface with the following components:

- Properties Panel (Left):**
  - 3D View
  - 3D View: (3D) Edit Type
  - Graphics:
    - View Scale: 1:100
    - Scale Value: 1:100
    - Detail Level: Medium
    - Parts Visibility: Show Original
    - Visibility/Graphics...: Edit...
    - Graphic Display O...: Edit...
    - Discipline: Coordination
    - Show Hidden Lines: By Discipline
    - Default Analysis D...: None
    - Sun Path:
  - Identity Data:
    - View Template: <None>
    - View Name: (3D)
    - Dependency: Independent
    - Title on Sheet:
  - Buttons: Properties help, Apply
- Project Browser (Left):**
  - Views (all)
  - Floor Plans: Level 1 through Level 20
- Tool Palette (Center-Left):**
  - Marquee
  - Design: Wall, Door, Window, Column, Beam, Slab, Stair, Roof, Shell, Skylight, Curtain..., Morph, Object, Zone, Mesh
  - Document: Dimension, Level D..., Text, Label, Fill, Line, Arc/Circle, Polyline, Drawing, Section, Elevation, Interior..., Worksh..., Detail, Change, More
- 3D Viewport (Center):**
  - Left: Wireframe view of a cylindrical building with a grid on top.
  - Right: Shaded view of the same building, colored in a light tan/brown.
  - Top: A small 3D orientation cube with 'RIGHT' and 'UP' labels.
- Project Browser (Right):**
  - 31. Story through 0. Story
  - Sections
  - Elevations
  - Interior Elevator
  - Worksheets
  - Details
  - 3D Documents
  - 3D
  - Generic Pers
  - Generic Ax**
  - Schedules
  - Project Indexes
  - Lists
  - Info
  - Help
- Status Bar (Bottom):**
  - 1:100
  - Main Model
  - System tray: C: 86.6 GB, 6.58 GB



# Khepri







**One script for all models**

# Context-Oriented Programming



# COP

---

- > Behavioral Variations
- > Layers
- > Activation mechanism
- > Context
- > Scoping

# Objectives

---

- > Present and compare COP
- > Combine COP with AD

# Related Work



# Aspect-Oriented Programming

---

- > Cross-cutting concerns
- > Aspects
- > Pointcuts, Join Points, Advice



# Subject-Oriented Programming

---

- > Subjects
- > Subject-activation
- > Subjective Dispatch

# Context-Oriented Programming

---

- > Contexts
- > Contextual Dispatch

# ContextL

---

- > Common Lisp
- > Dynamically Scoped Layer Activation
- > Layered Generic Functions
- > Layer-in-class and class-in-layer



# ContextL

---

```
(deflayer employment-layer)
```

```
(with-active-layers (employment-layer)  
  ... contained code ...)
```

```
(define-layered-class employer  
  :in-layer employment-layer ()  
  ((name :initarg :name  
         :layered-accessor employer-name)))
```

# ContextPy

---

- > Python
- > Dinamically Scoped Layer Activation
- > Decorators
- > Layer-in-class

# ContextPy

---

```
class Slab:

    @around(a3DLayer)
    def generate(self):
        return extrusion(surface_from(self.path),
                          self.thickness)

    @around(a2DLayer)
    def generate(self):
        return self.path
```



# ContextJ

---

- > Java (source-to-source compiler)
- > Dynamically Scoped Layer Activation
- > Reflection API
- > Layer-in-class

# ContextJ

---

```
class Employer{
    String toString() {
        return "Name: " + name;
    }

    layer Address {
        String toString() {
            return proceed() + "; Address: " + ...
        }
    }
}
```

# Lambic

---

- > Common Lisp
- > Predicate Dispatch
- > Activation with Predicates
- > Different modularization



# Lambic

---

```
(defgeneric factorial (n)
  (:predicates < = >))
```

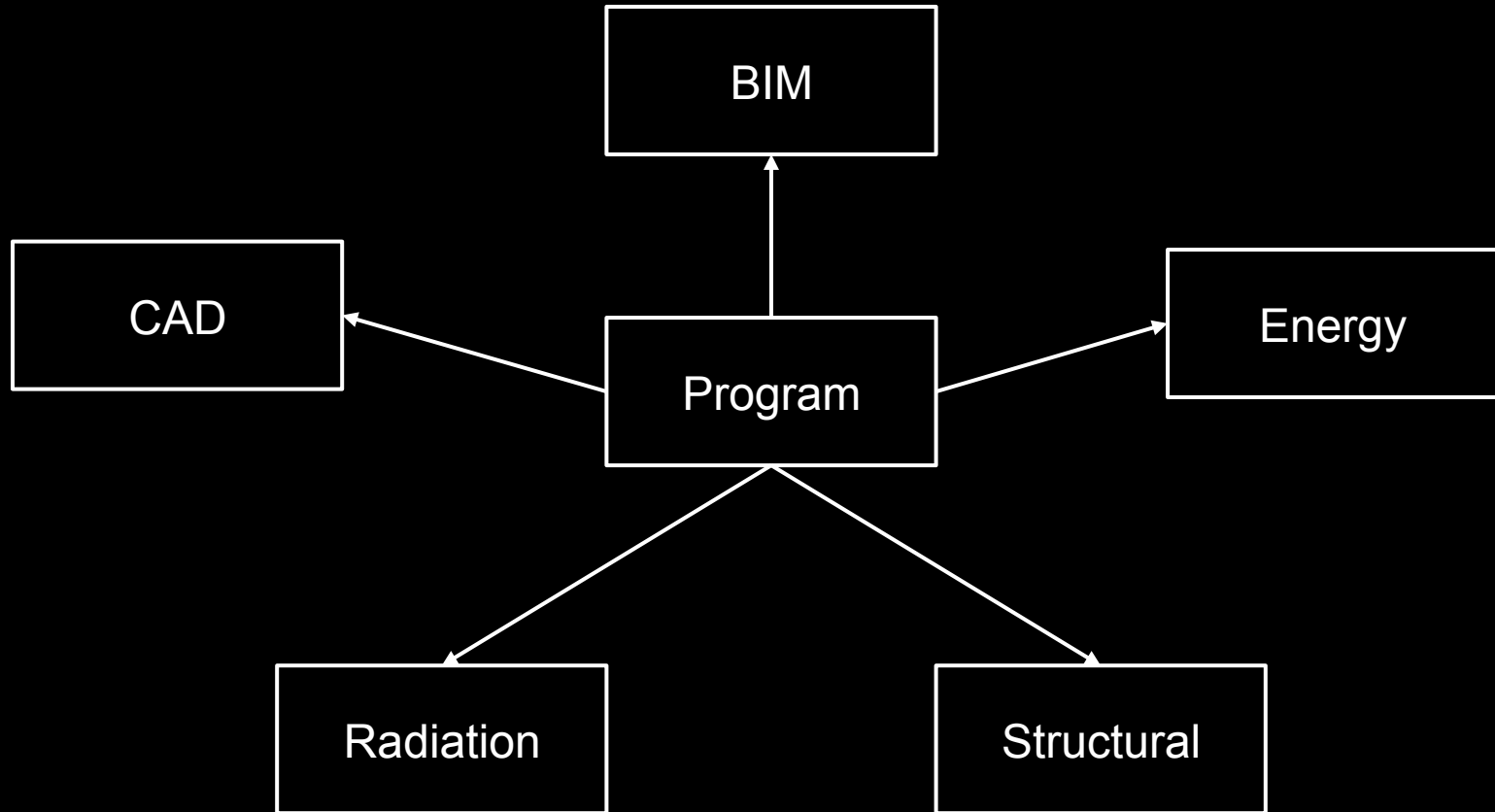
```
(defmethod factorial (n)
  (:when (> n 0))
  (* n (factorial (- n 1))))
```

```
(defmethod factorial (n)
  (:when (= n 0))
  1)
```

# Comparison

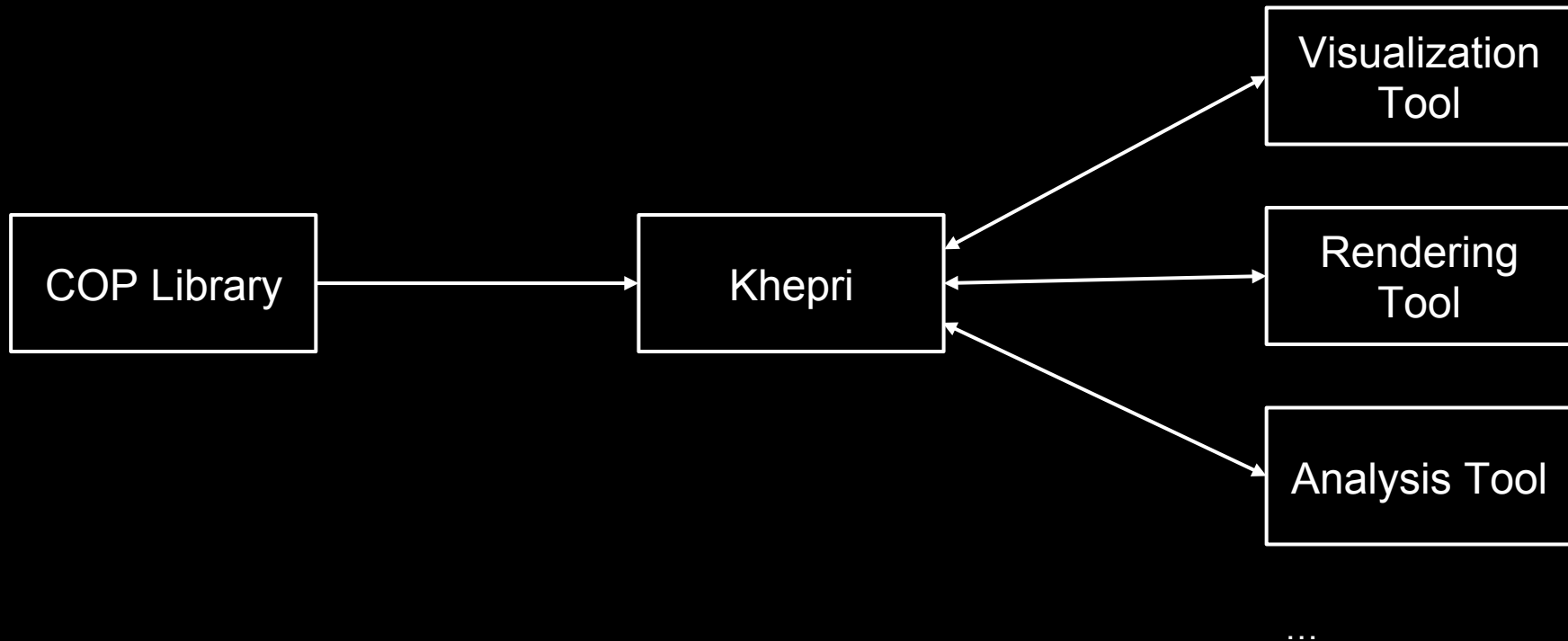
	Base Language	Implementation	Layer Activation	Modularization
ContextL	Common Lisp	Library	DSA	LIC, CIL
ContextScheme	Scheme	Library	DSA	CIL
ContextErlang	Erlang	Library	Per-Agent	Erlang Modules
ContextJS	JavaScript	Library	Open Implementation	LIC, CIL
PyContext	Python	Library	DSA, Implicit	CIL
ContextPy	Python	Library	DSA	LIC
ContextJ	Java	S2S	DSA	LIC
JCop	Java	S2S and Aspect	DSA, declarative, conditional	LIC
EventCJ	Java	S2S and Aspect	DSA	LIC
JavaCtx	Java	Library and Aspect	DSA	LIC
ContextR	Ruby	Library	DSA	LIC
ContextLua	Lua	Library	DSA	CIL
ContextS	Smalltalk	Library	DSA, indefinite	CIL
Ambience	AmOS	Library	DSA, global	CIL
Lambic	Common Lisp	Library	-	-
Subjective-C	Objective-C	Preprocessor	Global	LIC

# Context-Oriented Algorithmic Design





# Implementation



# Implementation

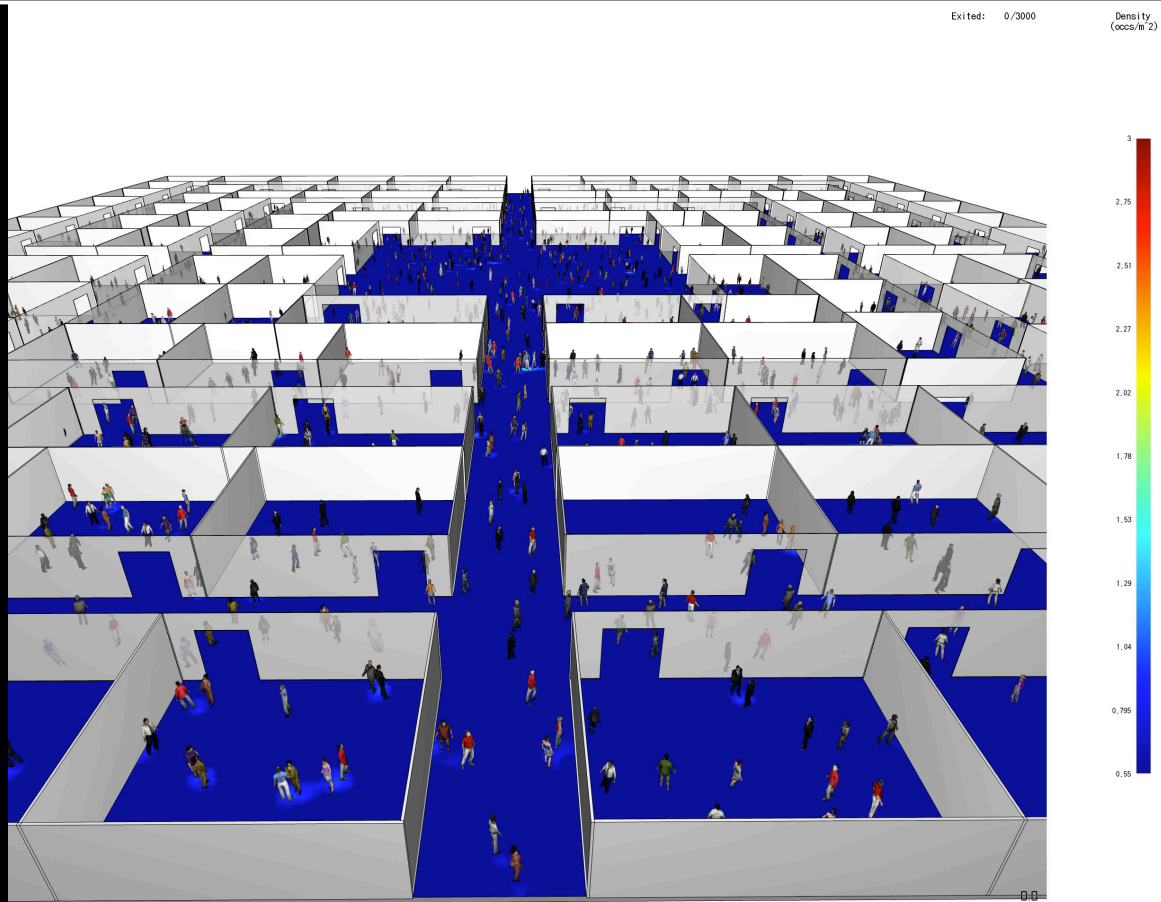
---

- > ContextScheme (adapted to Racket)
- > Khepri

# Case Study



# Case Study





# Original Version

---

```
(define (shop-2d ...)  
  (...  
    (line ...)  
    (rectangle ...)  
  ...))
```

```
(define (shop-3d ...)  
  (...  
    (right-cuboid ...)  
  ...))
```

# Original Version

---

```
(define (mall ... shop ...)  
  (...  
    (shop ... )  
    ...))
```

# COP Version

---

```
(define (shop p v l w)
  (...
    ((wall) p0 p1 wall-thickness wall-height)
    ...
    ((door) ((wall) p2 p3 wall-thickness wall-height)
             p4 p5 wall-thickness door-height))))
```

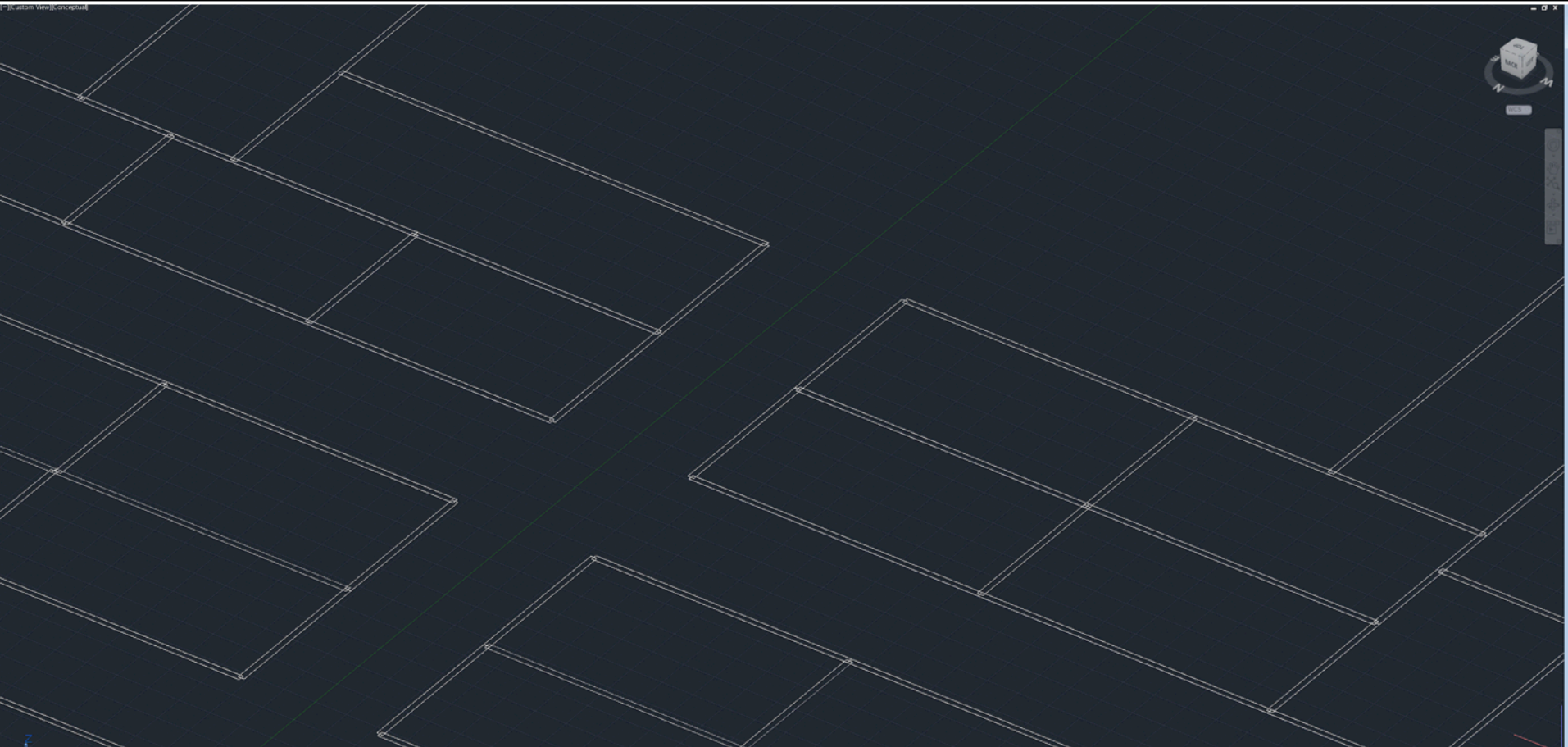
# COP Version

---

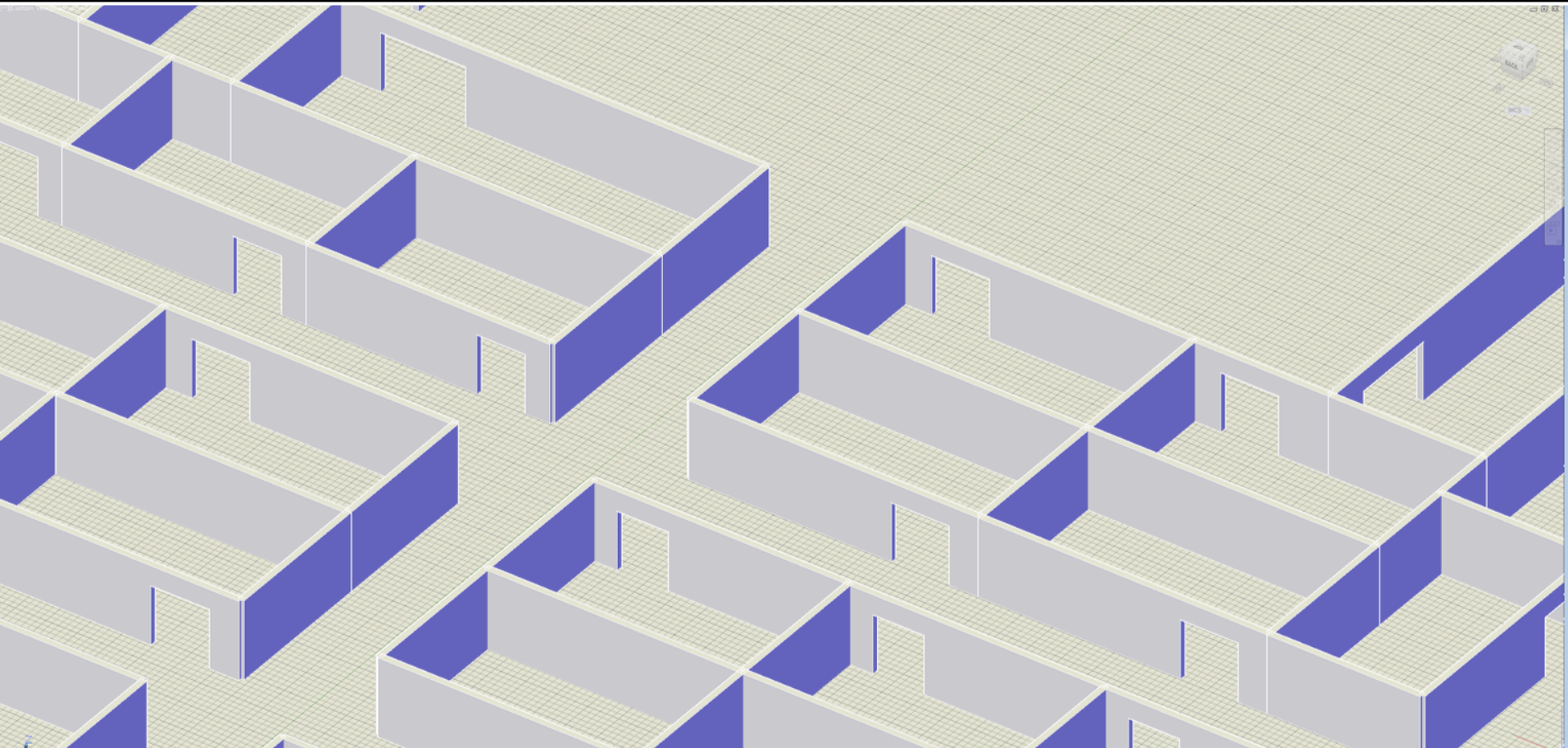
```
(with-layers (2D)
  (mall (xy 0 0) 100000 12000 25000 7000 7000 4))
```



# COP 2D

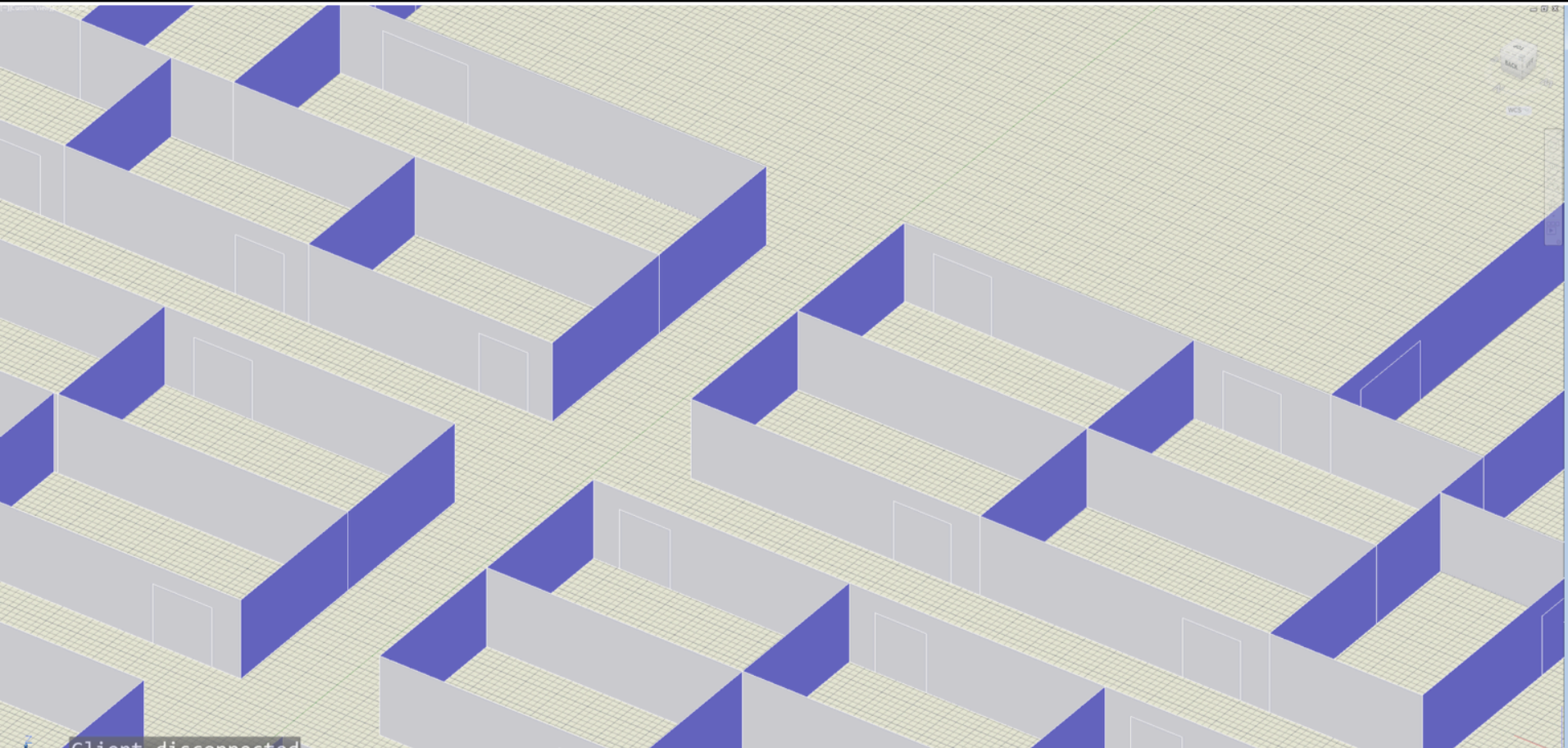


# COP 3D

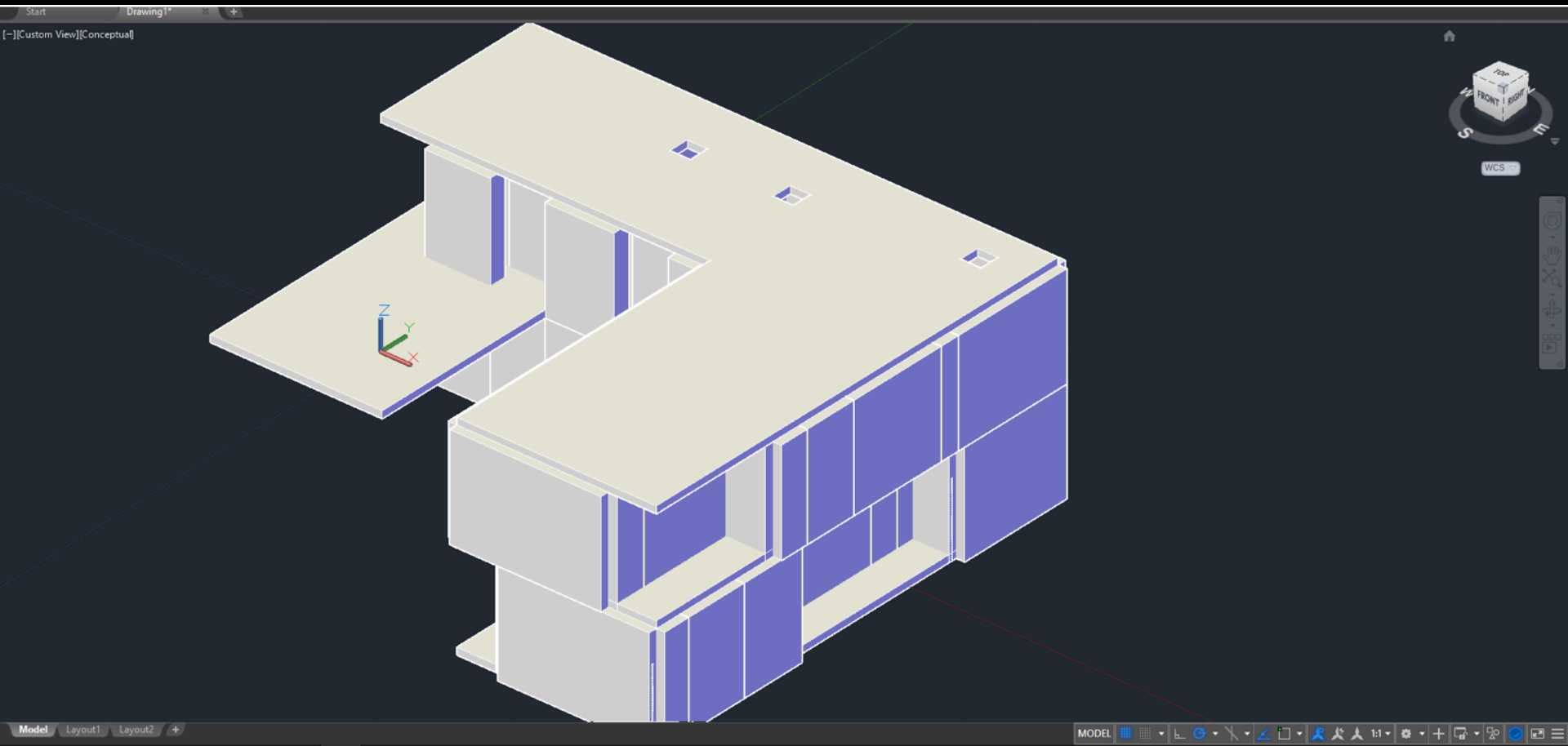




# COP Analysis

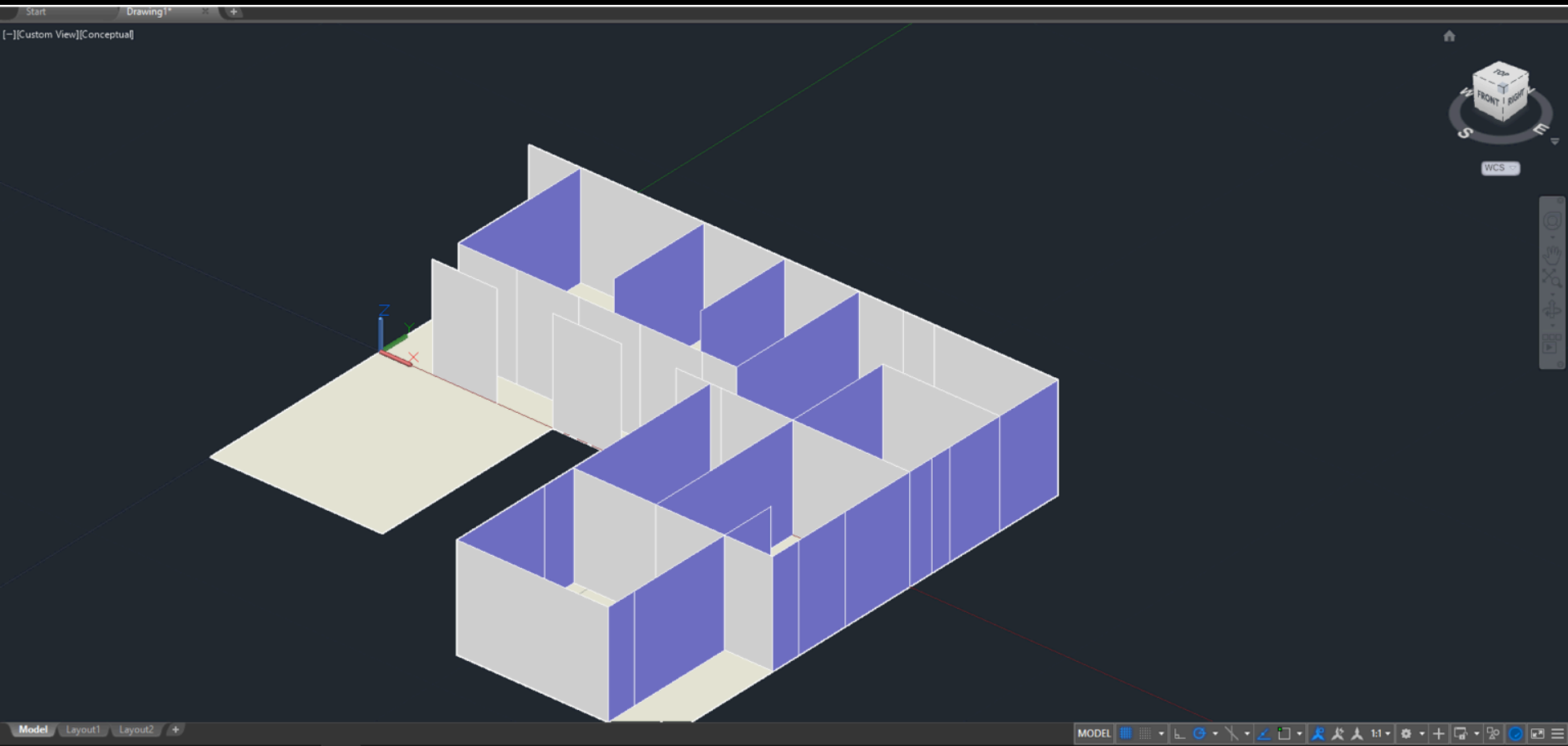


# Partial Modelling





# Partial Modelling



# Advantages

---

- > Reduces the code
- > Dynamic context change

# Evaluation



# Evaluation

---

- > Higher-order or not?
- > Implicit or Explicit Activation?
- > Performance?

# Future Work





# Thank you!

Questions?

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antonio.menezes.leitao@tecnico.ulisboa.pt

<https://algorithmicdesign.github.io/>