Getting started with Generative Design for AEC

Kean Walmsley
Platform Architect & Evangelist, Autodesk Research

kean.walmsley@autodesk.com | @keanw | keanw.com
## About the speaker

**Kean Walmsley**

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Position</th>
<th>Location</th>
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<tbody>
<tr>
<td>2012-2016</td>
<td>AutoCAD</td>
<td>1998-2000</td>
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<td>2016-...</td>
<td>Research</td>
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<td>2006-...</td>
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<td>Through the Interface</td>
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Autodesk Research into Generative Design
A320 Bionic Partition
Research into Generative Design for AEC
Generative Architectural Layout
Autodesk Toronto at MaRS
+ Productivity
  - Adjacency
  - Work-Style
  - Low Distraction
  - Daylighting
  - Views to Outside
  - Interconnectivity

+ Collaboration
  - Jewel Box
  - Vertical Connection Stair
  - Workshop / Lab
  - Mezzanine
  - Cabins
  - Conference Rooms
  - Kitchen / Social Hubs

+ Buzz
3 floors
48,000 square feet
11 meeting rooms
6 multi-purpose rooms
11 phone booths
250+ people
25+ teams
1. Multiple types and sizes of amenity spaces surround each neighborhood to break up space and reduce distraction, leading to better scoring for productivity.

2. Residual irregular-shaped areas become semi-private informal social spaces that, while performance neutral, were unexpected, interesting design elements and well-received by the clients.

3. Diagonal line between neighborhoods allows fitting more meeting rooms while giving each neighborhood its own character.

4. Non-orthogonal, non-parallel boundaries obscure sources of distraction (desks in adjacent neighborhoods & high buzz corridors) to improve productivity scores.

5. Back alley connection between neighborhoods, leading to better score for adjacency preference.

Generative Space Planning
AU 2017 Exhibit Hall
1) Define boundary conditions

2) Generate primary routes

3) Subdivide regions with minimal grid

4) Locate anchor programs

5) Join grid cells to accommodate anchor program area requirements

6) Allocate remaining cells to small programs
buzz = \sum_{i=0}^{n} \text{routes length}_i \times w_i,

w = \text{amount of traversals in each route}

n = \text{number of nodes}

adjacency = \sum_{v \in G} \text{length} (\text{edge}_{v_i,v_j}),

v = \text{vertices}

G = \text{graph of all sites with adjacency requirements}
CS239262 – Generative Urban Design: a collaboration between Autodesk Research and Van Wijnen
Kean Walmsley & Lorenzo Villaggi | Thursday, Nov 15, 1:30-2:30pm – Delfino 4004, Level 4
Building

Exhibit Hall

Neighborhood
Autodesk tools for Generative Design in the AEC space
Evolutionary algorithm outperforms deep-learning machines at video games

Neural networks have garnered all the headlines, but a much more powerful approach is waiting in the wings.

by Emerging Technology from the arXiv July 18, 2018
REFINERY: OPTIMIZATION AND OPTINEERING FOR DYNAMO
Refinery’s Optimization Engine

- Based on the O2 engine developed by Autodesk Research’s The Living
  - Used successfully for the various projects shown previously
- Employs the NSGA-II genetic algorithm
  - Meta-heuristic algorithm for multi-objective optimization
- Relies on bio-inspired operators such as mutation, crossover and selection
  - Population-based, so maintains & improves candidate solutions
Fig. 2. NSGA-II procedure.
Implementing your own generative workflows
Your Dynamo graph needs to tell Refinery about its inputs and outputs
LIKE THIS
RANDOMIZE
CROSS PRODUCT
OPTIMIZE
Create Study

Generation Method
Optimize

Inputs

Tile Orientation
64.0072592725752

Width Offset
0.842796528119514

Length Offset
0.379896299965274
RANDOMIZE
RANDOMIZE
CROSS PRODUCT
CROSS PRODUCT
How it works

• You can run Refinery from Dynamo for Revit or Dynamo Sandbox
  ○ Tasks are executed by Refinery server using DynamoCLI
    ▪ Limits what can be accessed or performed inside Revit
      • Use Data.Remember nodes to cache inputs into the graph
        ▪ Refinery server currently runs locally but will move to the cloud
  • Selecting a solution sets the parameters in Dynamo (for Revit)
Demo
Getting started

• Download Refinery from the Beta site
  o [https://beta.autodesk.com/key/refinery](https://beta.autodesk.com/key/refinery)
  o Works with Dynamo 2.0.2 or daily builds of 2.1
• Still in Beta, so expect some quirks
  o Known issues include a large amount of graphical data generated
    ▪ Check `%appdata%/Refinery` if running out of disk space
  o Provide feedback on where you want us to go with it!
## Spatial Truss Optimization

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<th>DYNAMO PROJECT</th>
<th>SPATIAL TRUSS DEFORMATION</th>
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<th>AUTHOR(S) / CREATION DATE</th>
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<td>Dieter Vermeulen, Autodesk / 2018.10.26</td>
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<td>MeshToolkit</td>
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<td>DynaShape: needs to be installed from this link: <a href="https://forum.dynamobim.com/t/dynashape/11666">https://forum.dynamobim.com/t/dynashape/11666</a></td>
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BES224265 – Structural Dynamics: Optimized Design and Fabrication Workflows
Dieter Vermeulen | Wednesday, Nov 14, 8:30-10:00 AM – Lando 4206, Level 4
Recommendations

• Get started now on building up skills and IP for generative workflows
  o Dynamo expertise will be even more valuable in the future
    ▪ There’s a thriving DynamoBIM community to tap into
  o Start small, such as with today’s tiling example
  o Graphs get complicated quickly
  o Maintaining discipline will help
    ▪ Relevant learnings from the Van Wijnen project in Thursday’s 1:30pm class
      • CS239262 - Generative Urban Design: a collaboration between Autodesk Research and Van Wijnen (Delfino 4004, Level 4)
• Think about “closing the loop”: gathering data to help future iterations