Project Fractal Case Studies: Massing, Panelizing and Space Planning

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Learning Objectives

- Strategic massing within Revit/Dynamo to convey ideas in Project Fractal
- Using Project Fractal in a pitch
- Designing bias into the script / limitations of relationship models
- Getting Project Fractal to use node libraries that aren’t currently supported

Description

Over the last year, our team of Innovative Technology Development has assisted on several proposals Stantec pursued in the last year. City of Toronto put out a large request for proposals to build teams to address a multitude of parameters for the new developments east of downtown Toronto. Another project was Austin Oaks where we looked at value engineering on façade options. We additionally looked at Space Layout for Department of General Services for the City of Sacramento. The key concepts being explored in this document include:

- An overview of Project Fractal and Dynamo Studio
- How to leverage and organize Dynamo Studio graphs to play well in Project Fractal
- Working with Revit Content in Dynamo Studio
- Condensing information down for a design bias within a script
- Outlining best practices for what is worth the pitch in a marketing effort, not being too academic
- Working with node libraries that aren’t currently supported in Project Fractal
- Understanding several good uses for Project Fractal in proposal projects
Dynamo Studio provides many uses for Project Fractal and there are ways to

Your AU Experts

Aubrey Tucker is the Innovative Technology Developer for Stantec, across architecture and engineering business lines. He is an Enabler, Technologist, International BIM Speaker, University Lecturer & Revit Expert with an extensive career with skyscrapers, hospitals, education, airports and technology. Aubrey's interests are in great Design, Art, Parametric Modeling, Computational Design, Rapid Prototyping, Digital Fabrication, Virtual Reality/Full Immersion hardware & software, 4D - 5D construction modeling/accountability and all the technology required to process these concepts. Aubrey's overarching goal is to utilize the latest in hardware, software and digital paradigms to create smart work within the built environment.

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Jason Santeford is the Architecture Discipline Lead for British Columbia at Stantec, overseeing project delivery and quality for Stantec’s four British Columbia offices (Vancouver, Victoria, Kelowna, Kamloops). A licensed Architect in both the US and Canada, Jason has been working in the industry for almost 20 years with extensive experience on large, complex projects delivered through multi-office collaborations using a variety of digital platforms. Jason is an advocate for the intelligent application of technology to the practice of Architecture in order to achieve greater accuracy, quality, and efficiency in the process of design and delivery of project documents. In addition to his role as a technically literate design professional, he has contributed to the buildingSMART Canadian Practice Manual for BIM as a Chapter Lead writing about how to achieve BIM support and commitment from project stakeholders.

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Achintya Bhat is a computational designer at Stantec who works within the Innovative Technology Development team. She has a background in engineering and data visualization. She has been a part of the script development in this course and is helping to push the development of data driven design with Aubrey across all of Stantec.

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Alyssa Haas is a member of the Innovative Technology Development team with a background in Architecture focusing on computational approaches and digital project delivery. Her recent work at Stantec as a computational designer involves the application of visual scripting, in platforms such as Dynamo and Grasshopper, to design problems with the aim of integrating computational methodologies into workflows across the corporation.

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1. Site massing study

1.1 Setting the Parameters
For any Fractal study, the first step is to identify the parameters that will be used to generate alternatives. In this massing study, the total floor area for each building type determines the massing of each Building. In this study, we have kept the outline of the buildings fixed. Hence, the Total Floor area for each building type decides the number of floors and the height for each Building.
1.2 Creating Site and Building Outline

There are two ways of creating site/building outline for this study. One way is to import SAT files with the outlines for the buildings or sites. The imported geometry are nurbs curve which can be converted to curves as shown below.

Or the other method is to create outlines in Dynamo by Points as shown below:
1.3 Creating Massing Options
The total floor area for each building type is divided per building of that particular type based on the ratio of the building outline surface area and total floor area of the building type.

The total floor area gives the number of floors for each building and the total height of the building. The building mass can be created by extruding the building outline as a solid as shown below.
The floors can be created by offsetting the floor surface according to the number of floors. The floors created automatically change with the change in the total floor area.
2. FSR Massing Study

In this project, we set up a simple script to develop a massing model showing the height and size of a building with levels for site feasibility study for different FSR while meeting the building height and site offset requirement.

For this study, the main parameters are FSR, Site dimensions and the site offsets.
The script first takes the Site dimensions and sets the Building base dimension based on the offset requirement for the site which can be set by the user or the script will run for all the possible options. Once the Base has been set, it again sets the tower dimensions based on the offset from the building base boundary. Again the offset for the Tower dimensions can be set by the user or the script will assume and run for all possible combinations. The user can select the Building core dimensions.

![Diagram](image)

The output of this study gives us the total residential area, retail areas, the building height and the number of floors for different base and tower dimensions. The output alternatives can be filtered for building height or FSR and exported as csv as shown in Figure 13 and Figure 14. To get the output parameters as one of the parallel coordinated on Fractal, we can name the output watch nodes. Fractal shows watch nodes with custom names as the parallel coordinates.

![Figure 11](image)

![Figure 12](image)
Figure 13

<table>
<thead>
<tr>
<th>B</th>
<th>R</th>
<th>S</th>
<th>T</th>
<th>U</th>
<th>V</th>
<th>W</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSR</td>
<td></td>
<td></td>
<td>Tower Level</td>
<td>Base Area (Retail+Office)</td>
<td>Total Gross Area</td>
<td>Building Height</td>
<td>Amenities</td>
</tr>
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<td>10.3</td>
<td>1</td>
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<td>177204</td>
<td>696616</td>
<td>170</td>
<td>43451</td>
</tr>
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<td>177204</td>
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<td>177204</td>
<td>699297</td>
<td>180</td>
<td>40161</td>
</tr>
</tbody>
</table>

Figure 14
3. Façade Value Engineering

The purpose of this study was to use generative design to develop façade options for different pricing range to help the design team choose the best façade option to suit the client's budget. In this study, the material cost is used as the controlling parameters and design seed number to randomize the placement of the panels on the wall surface. Also, to restrict the number of permutations and computations, we created three material zones on each side. The panels were subdivided into three lists.

To create the panels, we initially used a Lunchbox node to create panels from the wall surface using U and V values. But since Fractal does not work with custom nodes, we can feed the x, y, and z coordinates for panel vertices as strings and then create surface from points to build each
The script takes the input cost for each type of panel and calculates the number of panels of each type. After this, it creates a sub list of panels of given number from each material zone on the wall and assigns the color coding for the material to visualize the material selection. The Design Seed slider here makes sure that all possible combination of panel placement is considered and randomizes the panels during each iteration.

Figure 17
4. Austin Oaks Sunshade Study
4.1 Introduction

In this lesson, the techniques used in the creation of a sun-shading exploration tool in will be outlined. Design exploration through Dynamo, an algorithmic modelling platform for Autodesk Revit, will be used to enable an in-depth exploration by automating the modelling of various configurations. Collaboration between design team members and the clients will be enabled by the cloud computational design tool Project Fractal by Autodesk.

4.2 Objective

4.2.1 Vision

Leverage computation to explore building components aesthetics and metrics by consultants and clients to inform design decisions. Automate modelling processes to allow for fast turn-around on visualization for multiple options. Generate data reports for all explored options for comparison of key metrics.

4.2.2 Goals

- Develop a dynamo tool to automate sunshade modelling to test various configurations.

- Create a collaborative platform through Project Fractal to test limitless configurations for cost and aesthetics.
4.3 Workflow and Application

4.3.1 Application through Revit and Dynamo

Revit masses are used as the basis for the sunshade application in dynamo. A surface is then picked from the mass for the sunshade application. Edges are then picked from the surface and subdivided to generate the spacing and length parameters for the sunshades.

Figure 20: Austin Oaks Building 7

Figure 21: Austin Oaks Building 7 Mass for Sunshade Application in Grey
Alternate methods of subdivision were used on each edge to allow for greater design control. The horizontal edge was subdivided by evaluating parameters on a curve. This allows for direct design control over the vertical datums in the sunshade system. The designer can add or subtract parameter points to control the number of vertical subdivisions. On the vertical edge a subdivision by length is used to control sunshade density. A system could be built using only the parameter evaluation method or the length method based on the design intent for each application.

![Figure 22: Mass with Sunshade Subdivisions](image)

### 4.3.2 Geometry Creation and Controls

Attractor points are used to modulate depth and rotation of the sunshades. The attractor point method uses distances measured from the attractor point to the center-point of each of the sunshades to increase or decrease the sunshade depth and add a rotation factor. The range of the collection of distances are then remapped or inverted to produce the subtractive or additive effect over the entire sun shading system. This produces a gradient effect around each attractor point of either additive or subtractive geometry i.e. depth of sunshade or rotation. Point locations can then be changed to affect the look and respond to performance requirements at different areas. For example, the designer may choose to use a subtractive point in the location on the wall where there is more opacity in the wall and the sun-shading effect isn't as necessary. An additive point may be used where there is less opacity or where there is increased solar exposure. In this application, a jitter effect was also created by generating a list of random numbers and using those values to augment rotation across the sunshade system. The jitter effect can be increased or decreased and adds an extra layer of visual articulation into the system.
4.3.3 Analysis and Metrics

Algorithmic modelling methods lend well to the synthesis and analysis of data throughout the design process. Values that were generated by the attractor point logic to control the depth were constrained to a discrete number of depths corresponding to the manufacturing range of the sun-shading product. Linear feet of sunshades were calculated at each specified depth and costs were applied such that each output delivered corresponding cost data. The figure below shows sunshade depth types keyed out by color from yellow to red with the yellow sunshades having the greatest depth and the red the least depth. For each depth, a cost multiplier was defined and applied to each of the corresponding lengths of that type of...
sunshade. Data can then be scheduled to produce material take-offs or in the example below can be used to generate detailed cost estimates.

![Diagram of Depths by Colour](image)

**Figure 25: Diagram of Depths by Colour**

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>COST/LNFT</th>
<th>TOTAL LENGTH (FT)</th>
<th>COST ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot;</td>
<td>100$/lnft</td>
<td>450</td>
<td>45,000.00</td>
</tr>
<tr>
<td>8&quot;</td>
<td>107.5$/lnft</td>
<td>580</td>
<td>62,350.00</td>
</tr>
<tr>
<td>10&quot;</td>
<td>115$/lnft</td>
<td>590</td>
<td>67,850.00</td>
</tr>
<tr>
<td>12&quot;</td>
<td>122.5$/lnft</td>
<td>771</td>
<td>94,448.00</td>
</tr>
<tr>
<td>14&quot;</td>
<td>130$/lnft</td>
<td>1011</td>
<td>131,430.00</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>401,078.00</strong></td>
</tr>
</tbody>
</table>
4.4 Collaboration and Computation through Project Fractal

4.4.1 Dynamo to Project Fractal Workflow

Project Fractal by Autodesk extends the workflow through a web interface and improves collaboration between team members and aids in the demonstration and exploration of the dynamo script. The underlying logic in dynamo is fed to a clean web interface where users can explore the design. The interface in project fractal is much easier to manage for non-dynamo users as locating specific control nodes within the visual scripting interface is not required. Project fractal also allows users to explore the design remotely, and does not require a Revit or Dynamo install which opens exploration up to a wider variety of users.

Exporting to Project Fractal can only occur through the stand-alone Dynamo Studio and is only able to export logic from core Dynamo Nodes. This limits the ways in which the Dynamo script can be authored and results in some intermediate cleanup steps between modelling in the Revit environment to the Dynamo Studio environment. Work-arounds do exist to get manage some of the limitations currently in place. For example, the mass that was used in the Revit model to define the surfaces for the sunshade application must be recreated in dynamo studio as Project Fractal only supports the stand-alone Dynamo studio. Subsequent versions of Project Fractal may be more sophisticated and may address some of these limitations going forward.
Figure 27
Figure 28
4.4.2 Generative Studies through Project Fractal

Project Fractal allows the user to experience various design iterations by allowing the user to manipulate sliders that define key parameters in the Dynamo script. At the top of the interface is a graphic that represents the inputs and any corresponding output metrics generated for each iteration. This becomes very useful for analyzing cost for example as every iteration produces a cost value that can be weighed. Ideally this tool could be used to allow the designer to develop a sun-shading solution that met the aesthetic criteria while developing an understanding meaningful cost implications. This immediate feedback following the generation of a solution allows for quick exploration and immediate improved understanding of the relationship between the system’s aesthetic and cost for each iteration.

Brute force computation can also be used to generate a great number of iterations for analysis. The designer can choose to run a cross product analysis which will go through many design iterations defined by the designer. The output can then be sorted and selected from. The designer could alternatively select several favorite iterations and run the generation again. This would yield solutions that would use the preferred iterations as a starting point and modulate their parameters within a certain acceptable range producing varied output similar to the output tagged as favorite.

4.5 Future Development and Application

Further development of this methodology could include studying alternative geometry control methods, for example possibly image mapping or sun intensity data. Passing the information to project fractal in both instances would require some work-arounds. Tools for performance
analysis could also be leveraged to understand the performance results of each iteration. Autodesk insight could be tested first for basic performance analysis. More detailed performance data could be generated through Honeybee, an environmental performance tool for Dynamo.

4.6 Conclusion

This workflow demonstrates how designers can use algorithmic modelling to build simple but sophisticated models that can be iterated quickly. The implicit data generated through this modelling process empowers the designer to make better informed decisions and allows them to explore a greater variety of options. This combination of quick model production and data output can be applied to various design problems and can allow for a robust workflow. Tools such as Project Fractal can be used to make the design process more accessible by using a web interface and can allow for collaboration between multiple stakeholders in the project.

5. Running Space Layout in Project Fractal

Implementing Space Layout in the programming phase of the project requires that the user pushes their own site outline information and program document into Dynamo. The site outline file required by the Space Layout graph is in the ACIS (.SAT) format. One way of achieving this is to create an additional Dynamo graph to generate the site outline file. The .SAT file generated using the Dynamo graph was easily linked into the Space Planning graph. The graph was then passed to project fractal and could run with the users input data.

Aubrey did anyone try and export a .sat from revit for use in Dyanmo? Did it work?
By integrating Dynamo for Revit workflow concepts into the execution of a project, data entry and repetitive work can be streamlined to improve efficiency and productivity across all disciplines, and through various phases of the project. Proper graph generation, automation, and data management will allow project teams to isolate tasks, facilitate collaboration, and enhance communication to optimize project delivery.
Helpful References

Dynamo
http://dynamobim.org
https://forum.dynamobim.com/

Revit API

Python Standard Library
https://docs.python.org/2/library/index.html

Jeremy Tammik – The Building Coder
http://thebuildingcoder.typepad.com/

C# & VB.Net Code Converters