SYSTEMS-THINKING

Formalization of parametric process

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Abstract. This paper details a design process focused on explicit
digital parametric modeling as an integral system-outcome design.
This investigation isolates and alters a simple geometric form
cylinder) in a constructed architectural design method. Systems are
deefined as logical, sequential operations inherent to the resultant
effects. These operations within each system are composed of various
parameters, singular entities containing or referencing data. Given
specific data, operations are preformed culminating with
responding outcomes. The two main components of this research
pertain to object extraction and transformation. A single grain silo
(cylinder), as the architectural/geometric object under examination, is
tested using a system of varied parameters inputted into the program
Grasshopper, an “explicit history” graphic plug-in for Rhinoceros.
This application is utilized to digitally manipulate parameters as
objects in a nodal arrangement. Throughout the operations execution,
this isolated silo will be transformed into a multitude of versions, then
regrouped into the original cluster of silos to expose the implications
from patterning, adjacency, and repetition given the proximity of the
each silo and its new parametric characteristics. As the various
parameters in specific operations affect the system as a whole, so is
each adjacent silo in proximity given the same or similar operation?
This then is translated and reflected in the outcome. This research
seeks to explore design process by applying constant digital 3-D
reductive geometric, modular forms inviting systems thinking in
parametric environments that can lead to architectural design
implications. By focusing on the technical aspect of the
parameterization and valuing functionality rather than style, the
process becomes focused on formal qualities as the system-outcome
relationships. This research tests the “aesthetic implications” of a
varied mode of digital design, namely the investigation of an
architectural process utilizing parametric design.
1. Explicit History as parametric process

Given an existing parametric condition of a silo represented as a cylinder, formal exercises test the cause and effect relationships of scripted process. Using Grasshopper, an environment for creating and editing parametric relationships directly linked to the modeling interface of Rhinoceros software, this research tests systems-outcome thinking for the reusing of an existing structure which is based on a primary object, a cylinder. Grasshopper, an explicit history plug-in for Rhinoceros, is an interface for controlling attributes parametrically embedded in Rhinoceros software. (Grasshopper Main Page, 2008) Grasshopper is structured with specific definition files that link to the main model in Rhinoceros and are analogous to functions. (The Grasshopper Primer) When mapping a new definition to plug within the main interface, the effect is immediately translated in the referenced model. As a result the effect of any component, parameter, or composite, is transposed to either an existing reference model or creates its own. Because the validity of the parametric process is tested in this research, Grasshopper is used as a generative tool rather then a modifier. This method of testing has also resulted in a more effective and malleable construct for versioning of a system-outcome relationship. Composing and versioning a given system as is displayed in Figure 1 has become an integral part of this research.

![Figure 1. Silo parametric control definition.](image)

The definition in Figure 1 presents the necessary components and parameters to construct a rectangular silo grid. Each circle is created, extruded, and positioned via user-controlled variables mapped within the definition. Furthermore, this silo cluster definition can be used as an input for the broader system to generate the entire mapping for the existing site.

These components within Grasshopper’s definitions can be aided by individual inputs to alter the outcome. Each of these inputs are based on primitive values seen in Figure 2.
In Figure 2 a single distribution of points is mapped about an origin. Much like a cylinder these points reference the central z-axis to graphically present the outcome. When combining the two previously mentioned definitions, a cylinder can begin to have appendages about its central z-axis. This is both pertinent and useful given the existing field of cylindrical silos. The radial redistribution in Figure 2 also allows each node to be independently positioned. Referencing each appendage for a given silo provides a method for micro-managing the system-outcome of a single silo transformation. Micro managing provides a method for unique transformations to occur. This mapping can be applied to the test cylinder to allow for radial distribution and clustering of openings and connections to make porous the existing grid of silos. With parametric manipulations attributed to each object of a definition, the outcome can vary and be recorded.

2. Silo

An imperative component to this research is not only to use this silo structure as a parametric test case but also to investigate the process of parametric manipulation and catalogue attributes that are applicable for the performance of the architectural design process as a whole. Throughout this research a number of definitions mapping specific parameters and components have been used. Each definition applies to part of the infrastructure for manipulating the existing grain silo site. First, operations occur on a single cylinder, later these individual definitions are multiplied and grouped. The latter phase of this research groups definitions and inherently individual cylinders result in new connections and system-outcome relationships. These connections emerge given the proximity of each silo to one another. The proximity of each silo is subsequently
governed by a series of control points or parameters, single entities containing or referencing data. In Figure 3 a single silo is defined by mapped components receiving data from parameters. This silo is then divided and re-presented with extensions about new specified nodal division points.

![Silo Surface division and attachment](image)

The nodal positioning applied to this definition presents an alternative method to that in Figure 2. This definition displays the division of a single silo along the z-axis with nodes placed at each vertical division and simultaneously divided into radial segments along the circumference. With nodes placed in a more structured method, attachments are applied (highlighted in Figure 3). Unlike the previous definition, the mapping structure addresses each attachment with the same result. Each is placed the same distance away from the vertical axis of the cylinder and in this case placed along the periphery. Due to the close proximity of the grouping of silos in the existing condition, as will be discussed in the next part of the research, this attachment will overlap with adjacent silos affecting the independent conditions of both silos.

Once objects are placed about the surface of the cylinder using the reference node, each object is individually contested and explored as in Figure 4.
In Figure 4 a single attachment is mapped onto the surface of the cylinder referencing the central “z” axis. This referenced object becomes an applicable form for openings and connections between and around silos.

As each additional object adds to or engages with the referenced cylinder the positioning and direction of these objects take primary roles for adjustment and manipulation of the outcome. In Figure 5 the object attached to the cylinder is transformed with reference to z-axis of the cylinder.

This cubic volume revolves around the central axis while still maintaining independent parametric controls for scale and magnitude. This axis becomes the common element to reference position to a given silo. Mapped around a central “z” axis, the silo is connected with additive and subtractive appendages. Each is offset to protrude through the surface of the cylinder. This skin is altered on both to interior and exterior spaces across multiple silos.
As these individual definitions affect a single silo, similar mapping is applied to the group of clustered silos. In order to organize the design of multiple cylinders using a single definition, embedded objects such as the single silo definition are necessary for both reference and manipulation. The mapped definitions displayed in Figures 1-5 display a few of the necessary components and parameters to test individual cases for altering the existing structure. Each of these definitions builds upon the geometric structure of the cylindrical form to provide fuel for generating a formal silo system.

3. Volume

Although the individual cylinder is the focus as the test object in this particular analysis, 70 silos exist on the site. Two equal groups of interconnected cylinders reside in a regular grid, divided by a volumetric space. In the first part of this research, a single silo is isolated, manipulated, transformed, and versioned. Testing continues with grouping based system-outcome definitions. In Figure 6 silo clusters are both defined and positioned relative to one another.

Within this silo cluster mapping definition a specific component references the silo as a cylinder with its individual parameters. This object is then given coordinates in an array prescribed by the parameters controlling the group as a whole. Once the existing cluster of silos is constructed from position, magnitude, and scalar attributes, the placement and manipulation previously affecting each individual silo can be applied to the whole.

After the initial mapping occurs for an individual silo, potential relationships occur from connections between the single silo and an additional object, surface, or point. In this new array of cylinders, placement of these new adaptations needs to be addressed, because many of them overlap and interconnect creating new special conditions. In Figure 7 the
connection between two silos is presented to display overlap not only in the existing structure of the cylinders themselves, but also in the additive objects referencing each individually transformed silo.

Displayed in Figure 7, a test connection between two silos is presented with subordinate additive objects overlapping. In this portion of the definition, the connection of a parameter and its corresponding reference point is shown. When applied to each silo system individually, a larger outcome is possible across the grid of cylinders. As the system by which objects and components are altered, so is the outcome that is made visual.

External and irrational influences also affect the spatial understanding of a single cylinder. Some of these are parameters relating to connections between adjacent cylinders fulfilling requirements for entry, circulation, or place making. Others are specific to the site and can be uniformly mapped, such as sun and wind patterns. Ultimately, the spatial experience is the test of the implications of the parametric process. The views and procession through the spaces is part the evaluation of this physical construct and needs to be addressed. In Figure 8 a series of silos is explored to see rotational adaptation to these external parameters.
Each additional object is mapped referencing only one cylinder. In this figure each silo arranged within the definition to correspond to its necessary placement in the model. Each silo has also adopted similar appendages to its surface. With these common additive and subtractive objects in place, the site-specific sun or wind pattern can be applied. This allows for an understanding of the relationship between the exterior and interior of the physical outcome. Figure 9 shows a more detailed mapping of a single cylinder with in a grouping of peripheral objects.

In Figure 9 each object is individually controlled while still referencing a connection relationship to its corresponding silo. For each individual object added, prescribed parameters control the position, direction and magnitude about the vertical axis of the cylinder. Although each parameter controlling a component is a scalar input to the object, it too can receive information in
the mapping of the definition. This can be achieved by externally overriding a mathematical function in an individual or cluster parameter. Mapping and managing the clusters of silos with parameters permits both macro and micro control over the formal implications of the visual representation of the physical construct.

4. Conclusions

Parametrically generated forms have aesthetic value related to the nature of the generative process, (Terzidis, 2003). This research presents the same qualities of formal explorations using existing architectural conditions. Specific to this research, each silo has been subdivided in the “z” axis corresponding residential inhabitation. The space has been divided into equal radial segments around the circumference of cylinder. This provides the module for alterations to individual modifications. It also leads to holistic transformations in the silo systems as well as the network.

In this research specific software has been explored through a concentrated investigation based on strict parametric modeling. Formal and geometric qualities including shape, magnitude, scale, and position have become the focus of this research and the fundamental core of each definition. The inherent characteristics of each object existing on the site are explicitly controlled within a single definition to test various outcomes. This is a test case for a specific site, while also focusing on a particular shape, the cylinder. These methods are not translatable to other shapes. The cylinder has served as the generator for manipulation. Any other shape would mandate a fundamentally varied approach. The cyclical method of isolation and regrouping is particularly relevant to these objects. Nonetheless, this research is generally valid and appropriate toward examining the dilution of the separation between formal versus purely aesthetic and functional processes.

References


