A Parametric Form Generator - ConGen

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Abstract. This paper introduces a generative design tool for the early design phases. The tool is a prototype plug-in for 3D studio max, based on 3dmax script language. This plug-in generates form alternatives with symbolic representations. Designer sets max and min size values and positional relation rules for different sub-parts of the whole form. After the generation process designers can apply transformation modifiers and materials built in 3d Studio Max to the picked alternative. And get possible 3d form solutions that meet with the constraints of the design problem.

Keywords. Generative Design Tools, 3ds Max.

Introduction

New computational tools for design industry support parts of design process, which are better understood or easily systematized (detailing, cost analysis, production organization etc.). But their integration into the parts of design process which are less understood (early phases of design, conceptual design etc.) is problematic.

Many research works and a few commercial design tools are developed to overcome this problem. However, they still face usage and implementation problems. The main goal of the research is to develop a design tool which can be used to generate conceptual form alternatives driven by contextual constraints.

This paper introduces a constraint based form generator (ConGen), developed as a plug-in for 3dMax design software. It consists of three parts: first, introduces briefly some other from generation techniques, second, presents the architecture and the interface of ConGen, third, illustrates design experiments developed using ConGen.

Related Works

There are many form generation techniques and applications developed for different design areas. Works like, grammar based “3D Shaper” (Wang and Duarte 2002), evolutionary algorithms based “Genr8” (Hemberg and O’Reilly 2004), shows the capabilities of this new computational tools.

Exploring constraints and parametric variations is another active research area about form generation techniques. The commercial design software REVIT (Revit Technology Corporation 2000) uses some of the findings of these researches. It has a parametric change engine, which manage the relations of objects in a building system. Smart Objects (Eggink, Gross and Do 2001), expresses the use of design constraints in a more active way, by using the constraints as object behaviors. The objects on the stage give reaction (by color or opacity changing) to the changes, made by user. But the constraints or object behaviors are not under the control of the user. Xp-Gen (Pak, Ozener and Erdem 2003), a plug-in developed for 3ds Max,
A Constraint Based Parametric Form Generator: ConGen

ConGen is 3DMax plug-in aimed to be used in an early-conceptual phase of design. It is developed using Max’s macro script language. Using 3ds Max as a parent tool has disadvantages like expensiveness, platform dependency, etc. However, its object oriented structure, built-in geometry classes, makes easier to integrate ConGen.

The Architecture of ConGen

ConGen’s form generating mechanism is based on generated values for the specified sub-object parameters. The source of generated values can be user-specified constraints or the target scripts entered by user. Designer, divide the whole design object into parts (sub-objects), which can be the rooms of an house with different functions or the parts of a couch with different material properties. These sub-objects of the whole form are represented through boxes, but the user can draw any form with 3ds Max tools and attach it to these boxes. The specified constraints or the target values, for dimension and position parameters of the sub-objects, define the possible solutions space.

Interface

The user-interface of ConGen uses 3ds Max built-in interface classes (rollout-panels, spinners, buttons, etc.). It consists of four major components:

- Info Panel: This first panel displays information about the creator of the program and version info.
- Dimensions Panel: This panel consists of eight component types. a) Name text-box for each sub-object to enter specified name for the sub-object. b) Color selection box for each sub-object c) Spinners to enter min-max constraint values for the width, length and height properties of each sub-object d) Target text-boxes and buttons for each parameter of sub-objects for entering external script e) Selection button for each sub-objects to attach an external form to the selected sub-object f) Save Settings button to save the dimension settings. g) Load Settings button to load saved dimension settings h) Generate button, for generating sub-objects dimensions between the limits.
- Positions Panel: This panel, consists of three component types a) Spinners to enter min-max constraint values for x, y, z position of each sub-object b) Spinners to enter min-max constraint values for Euclidian transformation degree of each sub-object c) Target text-boxes and buttons for each parameter of sub-objects for entering external script d) Save Settings button to save the position:

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Figure 1. ConGen’s flow-chart
tion settings e) Load Settings button to load saved position settings f) Generate button, for generating sub-objects positions between the limits.

Modifiers Panel: Settings for selected four 3ds Max Modifiers displayed at this panel. There are 4 groups of parameters named with modifier names:

a) Spherify group consists of 2 component types: Spinners to enter min-max constraint values and checkboxes to specify on which object the modifier will be applied.

b) Bend group consists of 4 component types:
   1. Spinners to enter min-max constraint values for bend angle and direction.
   2. A “limit-effect” labeled checkbox, to activate effect limits.
   3. Spinners for entering effect limitation constraint values.
   4. Checkboxes to specify the objects to apply the modifier.

c) Skew group consists of 4 component types:
   1. Spinners, to enter min-max constraint values for skew amount and direction.
   2. A “limit-effect” labeled checkbox, to activate effect limits.
   3. Spinners for entering effect limitation constraint values.
   4. Checkboxes to specify the objects to apply the modifier.

d) Taper group consists of 4 component types:
   1. Spinners to enter min-max constraint values for taper amount and curve.
   2. A “limit-effect” labeled checkbox, to activate effect limits.
   3. Spinners for entering effect limitation constraint values.
   4. Checkboxes to specify the objects to apply the modifier.

Sub-Object Names

When the user runs ConGen, it will create five boxes representing sub-objects. These boxes will have default names such “object01...object05”. But by entering desired names, on the name labeled text-boxes on the dimensions, the user can name the sub-objects freely. After pushing “generate” button, on every panel, the name labels on that panels will be updated.

Coloring Sub-Objects

After running ConGen within 3ds Max, the sub-objects will have the default color (blue) in the program code. Users can select specific colors for...
each sub-object through using color selection button, from the dimension panel. The sub-objects on the viewport will be updated after using “generate” button.

Setting the Dimensions and the Positions

In the dimensions panel, there is a constraint couple (min. & max.) for each three parameters of each sub-object. These parameters are the width, length and height of a sub-object. In the positions panel, there is a constraint couple (min. & max.) for each four parameters of each sub-object. These parameters are x-y-z positions and Euclidian transformation degree of a sub-object. After specifying constraints, user run the program through “generate” button and ConGen applies generated random values to the parameters.

Sample code below, shows the basic generating mechanism:

Object01.width = random o01_w_min.value o01_w_max.value

Applying Target Scripts

Both in dimension and position panel, there is a target labeled text box and an arrow button to open a bigger text window. Through this text editor, user can enter an additional script in max-script language, to specify a special value generating mechanism for that parameter. The entered script will be executed in ConGen’s code. Therefore an irrelevant operation (adding a sunlight tool, making render settings etc.) can also be conducted within this piece of code.

Table 1. Sample Target Scripts

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object01.width</td>
<td>30</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Object02.width</td>
<td></td>
<td></td>
<td>$object01.width+20</td>
</tr>
<tr>
<td>Object03.width</td>
<td>100</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Object04.width</td>
<td></td>
<td></td>
<td>500-$object01.width-$object03.width</td>
</tr>
<tr>
<td>Object05.width</td>
<td>$(sexternal01.max.x- sexternal01.min.x)-50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Attaching Free Forms Created in 3ds Max Environment

ConGen uses box objects for form generating. But, there is an option to attach selected forms created with 3ds Max tools, to these boxes. After clicking the selection button of any sub-object, the selected geometry and the sub-object will be a unified mesh. This mesh has no width, length and height parameters any longer. Width, length and height values will be generated through x-scaling, y-scaling or z-scaling on that mesh.

Proposed Usage and a Design Sample: the Couch

ConGen is developed to be used in different design areas. Our proposed methodology can be used for many different purposes. The design methodology for the following experiment is:

Exploring existing design solutions and defining different and shared features

For the selected design problem, random samples from different furniture brands are selected. Through analyzing selected samples, sub-objects, shared rules and major differences between them are extracted. Six sub-objects of each design are identified:

Base, Two Arms (mostly symmetric and with same dimensions), Cushion, Back, Foots

Setting limits and relations for sub-objects

In this step, user sets constraint values for dimension and position parameters of sub-objects. This is the only knowledge that ConGen will use in the generation process. The constraint value decisions which will be used in this step are not the final decisions. During the generation process, the user will turn to this step, and will test the limits through value changes.

The main difference factor between sample couch designs, aside material and color usage is the different dimensions of sub-objects. Another
difference factor is the positional and dimensional relations of sub-objects. For example, relation of the base and the cushion differentiate in every sample. In some samples the cushion length is more then the base, in another they are unified. In the same manner, in some examples the arms and the back are unified, in another they are separate. Feets has in each design another usage and meaning. Therefore designing of feets is left to the detailing step.

 Generating form alternatives

After entering constraints for sub-objects parameters, form generation can begin. The generation process consists of three steps. For generating dimensional variations, the user pushes the generate button on the dimensions panel, then for generating positional variations, generate button on the positions panel and finally for applying 3ds Max modifiers, the generate button on the modifiers panel will be used. On each generating operation only one alternative will be displayed. When a generated alternative wanted to be kept, the user can copy it easily, and that copied design will not be affected by following operations on the active sub-objects.

 Selecting and Detailing

After generating sufficient alternatives, form selection can be made according to the user needs, material criteria or an expert decision. Structural and functional details will be elaborated after the selection. Photo-real renders of final design can be developed with 3ds Max presentation tools.

Figure 5. illustrates a detailed design solution from a selected form of Figure 3. The sub-objects of the couch were materialized with red velvet. Structural elements are added to hold the arms and four cylindrical feet to carry the whole couch.

Future Work

ConGen can be developed in two directions: The first one is to create a platform independent version with another software language such as Java3D. In this case, 3dMax’s powerful drawing tools, its good render engine and the high quality tree dimensional working environment can not be used. But in an independent environment, special tools to support early design phases and new geometry classes can be developed. The second direction is building a better integration with 3ds Max and using other features of Max that are not involved yet in the generating mechanism of ConGen. Some of these development possibilities are:

-Leaving the sub-object count under the control of the user, with giving the possibility to define new sub-objects.

-Using Max’s animation abilities, to better ex-
explore parametric variations and their impacts over the whole form.

- Adding material parameters to ConGen’s sub-objects, to being able creating variations with material and color choices.
- Adding an import mechanism, to apply ConGen’s sub-objects relation constraints to Max’s object motion controllers. So the user can explore the effects of changes made on viewport in real-time.

Despite of these possibilities, the real development will be grounded on the feedbacks of the designers who will use ConGen in their active design processes. New tools such as ConGen can further develop if only designers changer their attitudes toward computational tools from using them as design automators to using them as design generators.

References

Pak, B.; Ozener, O.; Erdem, A.: 2003, Xp-GEN.A randomized design tool for non-deterministic digital design methods in architecture and visual design, eCAADe 2003, Vienna