Animating the Design Studio

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Computer animation is based on software that is optimized to show transformation or change. For the animator, such change may represent the movement of people, objects or light, or a series of events comprising a short story. Studying change is also a designer's interest in objects made to transform or respond to varied environmental or phenomenal conditions. In addition, the study of change can be focused on the process of design itself, a series of steps taken in the making of a geometrical model for a building project. In this last sense of change, animation technology offers a means to retain and rework the distinct history of how one "upstream" or early design decision impacts the evolution of a design as it is refined "downstream". Moreover, when customized through a macro program, animation technology can more easily allow for early "upstream" design decisions to be revisited and modified with minimal disruption to "downstream" moves that had initially followed. That is, a designer can revise a geometrical modeling decision made at an earlier moment in a design process without having to completely redo other dependent changes to the model that had previously followed that moment. This paper reports on how animation software, rather than more typical CAD software, was harnessed to facilitate a design studio. Macro programming an animation system exploited its core technology to provide access to a more process based approach to modeling.

Keywords: *Computer Animation; Design Decision Making; Key Frames; Macro Level Programming; Geometrical Modeling; Design Studio.*

Modeling Process as well as Geometry

Computer aided design in its present state of the art seems to be moving away from the construction of a geometrical model as a one way linear process. Given that each part of a geometrical model is set into place in an ordered sequence, a number of existing CAD technologies already help to make the construction of the model more easily revised. For example, increasingly common to most CAD systems, parametric solid modeling includes a process in which a set of primitive shapes may be subtracted from, intersected with or put in union with each other as a first step in an easily mutable process. That is, with a parametric solid modeler, a subsequent modification made just to the original primitive shapes, such as their position, rotation or scale, is automatically propagated to the resulting Boolean shape. Similarly, software developed for animation offers additional flexibility in modeling.

Animation software provides as its core engine a way to automate and capture transformations in a three-dimensional model. Different states in the development of the model can be recorded in parallel to distinct phases of the design process. Moreover, revising upstream decisions in a design process can automate downstream outcomes through potentially four different strategies:

1. Animating the history of design decisions.
2. Animating the model as a physical process.
3. Animating an analog to the design project.
4. Animating movement relative to experiencing the model.

The Experiments

Two studio settings, one still in preparation and the other recently concluded, provided a pretext for testing the role of animation. The studio in preparation is a short interdisciplinary graduate design studio that will occur soon after this paper's publication deadline. The studio involves incoming students with little or no design background. The design problem will involve investigation of a hilly site. The second studio was a fourth year undergraduate options studio and concurrently a final independent graduate studio concluded in spring 2006. The design problem, the design of a children's museum and an adjoining skateboarding park, created an opportunity to envision an environment for a client who needed to continually facilitate change after construction. The client is in part a design decision maker often setting into place alternative physical environments after occupancy.

Historical Context

The idea that a computer might be used to capture and revisit design decision making was recognized in early computer aided design research. For example, Tom Maver at Abacus (the Architecture and Building Aids Computer Unit at Strathclyde) encoded design changes in a decision tree to record and allow for revisiting the full design process (Maver, 2000). Other approaches, such one based upon knowledge base systems, attempted to capture information from precedents that could be automatically applied to generating design solutions. For example, the KES knowledge based system was tested for its capacity to help automate the placements of desks in a room according to precedents (Miller, 1990). Yet, in these of these systems, the automated use of a decision tree (e.g., Abacus) or of precedents (e.g., KES) is imperfect since the geometrical modeling engine perhaps doesn't typically focus on holding onto progressive geometrical models of a particular design.

In contrast, animation software more completely embeds into its core technology the ability to record change to a geometrical model. In particular, a key frame records a state of the physical model. A new key frame captures each new state of the model. Thus, any number of key frames can be used to capture changing states of the model. Putting together and retaining varied sequences of key frames can be used to quickly revisit the "upstream" and "downstream" evolution of a geometrical model. In addition, a macro programming language can further articulate and encode the process of constructing the geometrical model. The process of making a model can be revisited or restructured through modest changes to the macro program. Taken together, the animation software and its macro programming language provide a way for a studio to more tangibly manipulate the process of making the geometrical model (see note 1).

Animating the history of design decisions

In the first example, the evolving states of the model are captured through an animation sequence. Having the entire history of the model's transformations made explicit allows re-engaging them in a way to interject modest changes. A macro program helped to isolate part of the transformations for more abstract and higher level control.

The summer graduate design studio engages a landform with small-scale interventions. A pathway is to be built within a hillside. The hillside itself has been modeled with standard Digital Terrain Model-

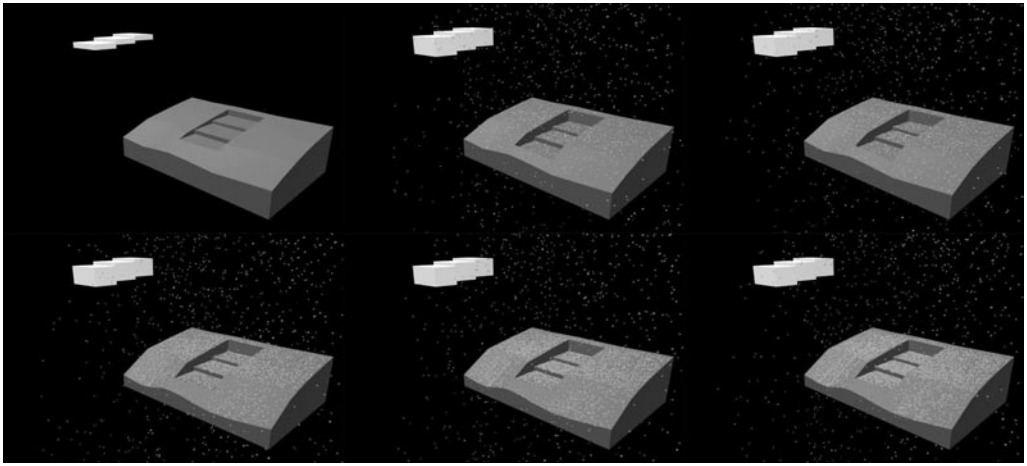


Figure 1
Sequence of images left to right and top row to bottom row show progressively greater cuts into terrain, lowering of topological lines and increasing rainfall(white dots barely visible in figure)..

ing (DTM) software. A few topographic lines from the DTM have then been reproduced in a smaller scale study of one aspect of the path and imported into an animation program (Maya). Several steps were included in the construction of the model:

1. rebuilding topographic lines to establish grading,
2. creating a landform surface generated from the topographic lines,
3. a Boolean subtraction of the landform surface from a solid box,
4. slabs subtracted from the land form to generate a path, and
5. rain water simulation through particles which are subjected to a gravity field and which collide with the landform.

Within the images excerpted above from an animation sequence, the stages of the construction process have been subjected to further revision (Figure 1). These revisions targeted earlier and later parts of the modeling process, and included

1. changing the topographic lines to simulate regrading,
2. resizing the slabs used to cut into the ground, and
3. increasing or decreasing the intensity of the rain water.

Each of these changes facilitates an automated reconstruction of dependent parts of model. We see through animation the relative impact of any of these changes (i.e., re-grading the slope, resizing slabs) on the design of the hillside pathway without having to entirely rebuild earlier constructions. A simulation of rain gives a sense of how water would be retained on the site. The animation shows a designer where to find the "sweet spot" in which the grading is at just the right slope so as to both limit runoff and at the same time prevent excessive ponding of water.

In a second exemplar for the summer studio, a fountain is created with two sets of water jets that interact. In one instance of the fountain, the two sets interact in a kind of oscillation of higher to lower height levels. In a second instance of the fountain, the height of the water projected from one set of jets rises gradually to equal the constant height of the water projected from the second set of jets.

The animation shows the different shapes for the two water fountain instances at comparable moments in time (Figures 2 and 3). A parameter for water pressure and timing is put into the algorithm that controls the water for each set of jets. The construction of the model also includes a basin, a collision boundary for the water, as well as the volume of water in and location of the jets. On the one hand, the

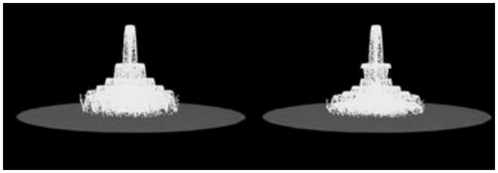


Figure 2
Fountains compared at earlier state of water jet movement, with first fountain on left and second fountain on right.

Figure 3
Fountain compared at later state of water jet movement, with first fountain on left and second fountain on right.

general form of the water coming out of the fountain was initially established through a geometrical modeling process. On the other hand, the form is easily regenerated by modification of a macro program to control water pressure and timing.

The study of the fountains demonstrates how a computer macro may express a controllable aspect of a form making process and how it may also be used in combination with an animation system. Changing the macro's structure automatically modifies the increasing volume and changing shape of water appearing over time in an instance of the fountain.

Animating the model as a physical process

In the museum studio, a somewhat distinct design method grew out of a particular student's interest in a kind of kinetic interplay between a set of interacting forms. The formal composition had transformed as if the basic massing elements were knocking into and bouncing off of each other. Startup placement and the initial momentum of the shapes can put into effect a chain of events determining their final arrangement. In a further study completed with the student after the studio's final review had actually concluded, simulated objects were given mass, friction and velocity within a space constrained by a boundary. Set into motion in an animation, the collisions yielded interesting alternatives including one set of forms that was close to that of the final design project (Figure 4).

Animating an analog to the design project

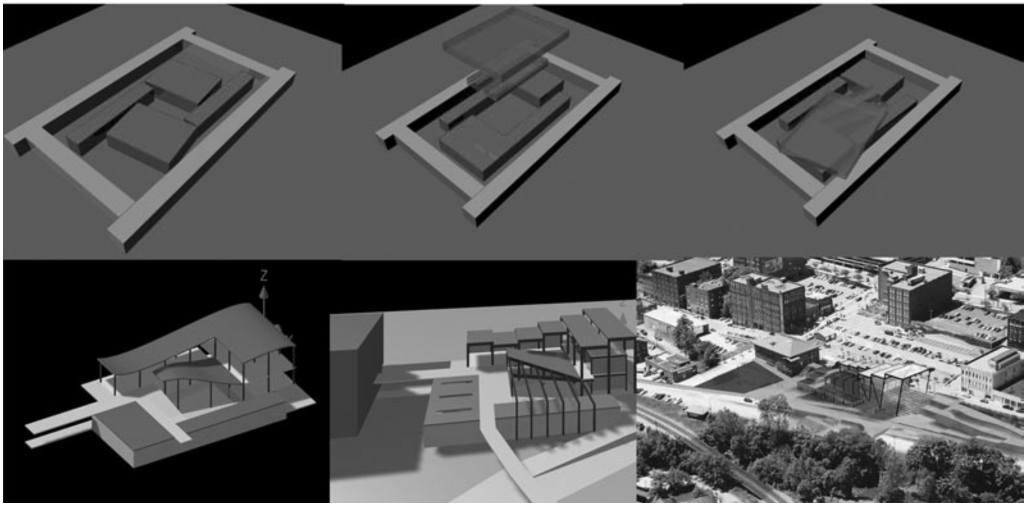
Animating an object that is suggestive of or abstractly simulates the behavior of building elements may lend itself to alternatives in design. One of the elements of the museum project was an adjoining skateboard park. The design of one project incorporated a spiral ramp leading down from an upper street level to the skateboard park sitting below the museum. In a recreation of the student's design process, the turns of the spiral and slope were developed algorithmically. The algorithm was run three distinct ways. The model and animation was thus automatically regenerated three times. In each case, a sphere was put into motion down the spiral ramp, and the resulting speeds and trajectories studied as to which of the three approaches might lead to the best possible skateboard experience.

The same student developed a somewhat complex mechanical arrangement would allow a child to manipulate a solar shading system through a series of gears. This arrangement was animated after the precedent study of a guitar tuner. The simulation involved setup of the gear ratios parametrically. One of the intentions of the project was to provide an example of physical forces that would be manifest in the museum's architecture as a part of its learning program. The computer model was constructed with parametrically controlled animation of varied conditions. That is, movement of the solar shades and other parts were re-visited in the design by adjusting the gear's parameters. The final project settled on one set of gear ratios developed by the student.

Animating movement relative to experiencing the model

Movement through a space or simulation of transformations that occur day-to-day within a built work of architecture lends itself to further refinements in design. This is perhaps the most common use of animation in design today, the "walk through" that is sometimes shown to a client to simulate the experience of being in a place. That such an experience is truly like being in a building is questionable. Steen

Figure 4
Physical forms capturing momentum reconstructed after a formal design exercise, Elizabeth Garrett, 402 Design Studio.



Eiler Rasmussen writes about the difference between pictorial representation and sensing a place first-hand in his book “Experiencing Architecture”. Yet, the first-eye viewpoint camera still gives perhaps a sufficient likeness to the real experience so as to meaningfully engage design issues. For example, it may show how movement through a building creates a kind of kinetic visual composition as objects appear to change in their spatial relationships to one another. Similarly, the movements of objects in a building might be viewed from a stationary observation point. In one project, the student laid out the potential arrangements of set of transforming wall elements. These modulating elements were set in motion in a number of different ways. The animations were generated through giving each object mass, initial velocity, an orientation and friction, and the resulting effects studied (top two images of Figure 8). Changing the starting point and velocity of each shape in the sequence lent itself to alternative variations all experienced from the single observation point. This study led to a design that incorporated wall elements (bottom of Figure 8) intended to be in motion in the final built project.

Implications of the Case Studies

The examples of this paper suggest ways in which the computer may begin to exploit the formative thinking behind what a designer may otherwise build as a disconnected series of models in a CAD system. A limited number of exercises were done mostly as a post-studio activity with help from some of the students. The methods used are currently under further consideration. The idea of studios using computer-

Figure 5
Experiential skate board ramp, Ryan Hughes, 802 Independent Design Studio. All ramps have the same number of spirals. The ball falling from the tallest ramp hit the ground first,

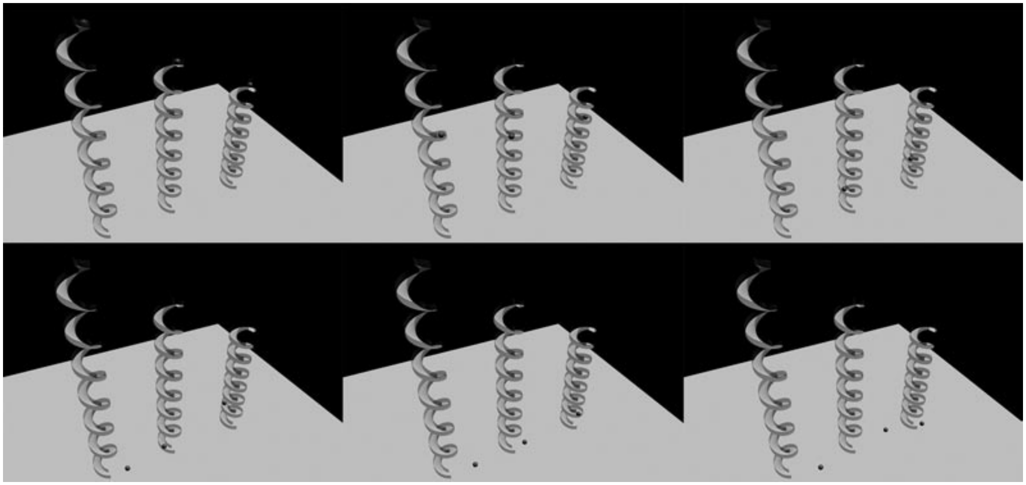
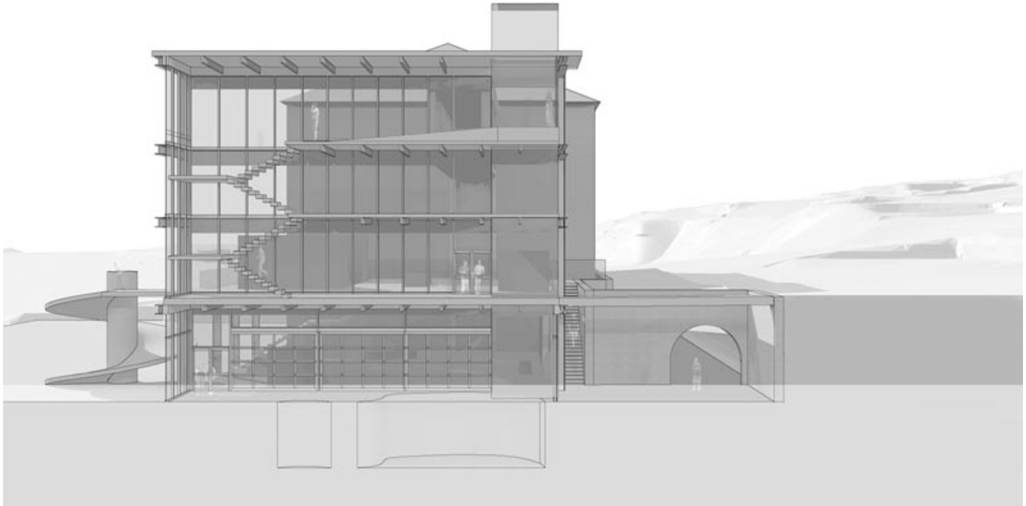


Figure 6
Cross section showing skateboard ramp, Ryan Hughes, 802 Independent Design Studio.



aided design has well been established. However, the use of macro-level programming in conjunction with animation to seek out design alternatives is not common in the experience of this author.

More dynamic control over the process of modeling can be closely facilitated by a core technology that focuses on change. The animation software used, Maya, has as a designated feature, a "history" option, that tracks parametrically driven modifications to the model. Key frames can also be used to describe the states of an object if the transformations are developed by hand. The moveable wall system in figure 8 used co-dependent keys as way of expressing the relationship between moving parts and

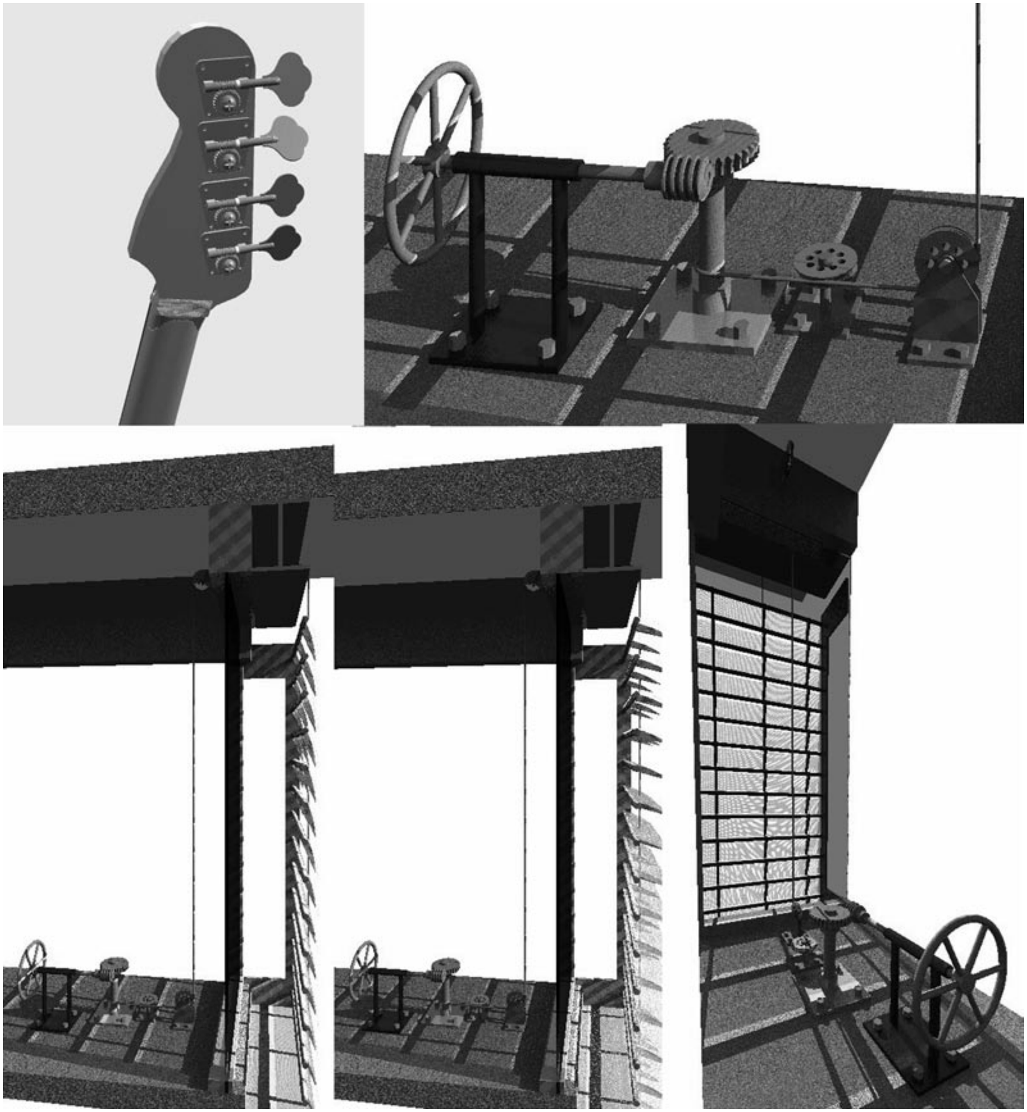
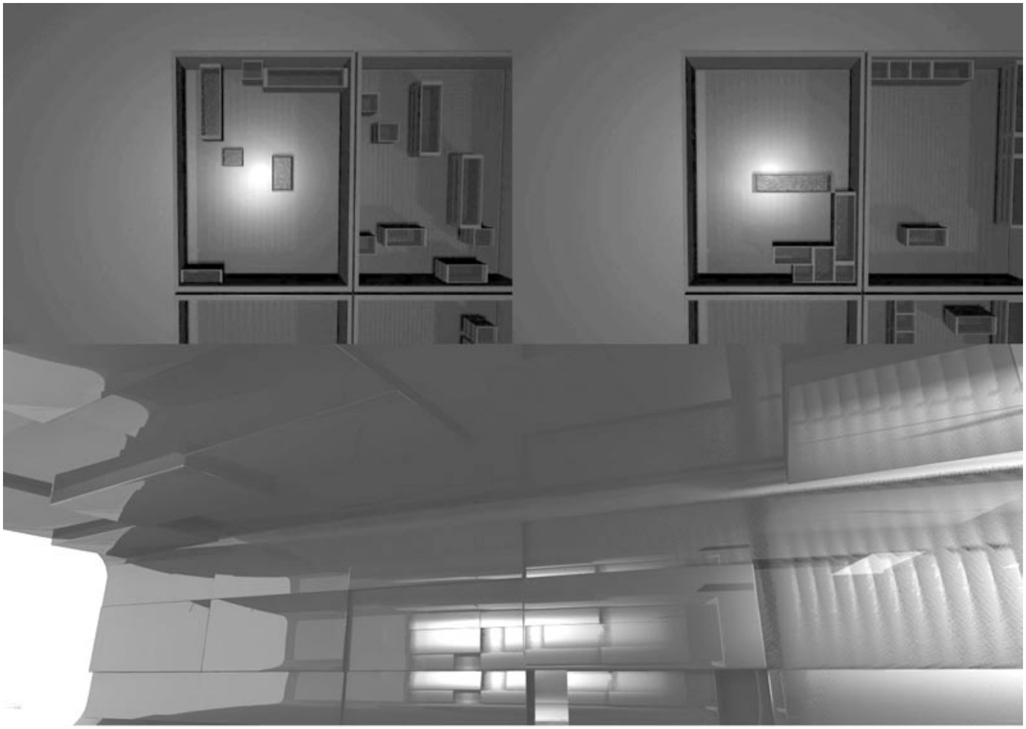


Figure 7
Pulley system that drives louvers based upon guitar tuner, animated with parametric control, Ryan Hughes, 802 Independent Design Studio.

didn't require a macro. One part re-key framed in one direction influenced the movements of another part. More explicit control was achieved in other examples through macro programs.

The experience level of most design students would suggest the use of simple key framing in conjunction with parametric modeling rather than macro level programming as a means to capturing design alternatives. Yet, combining animation with a short macro program provides a potentially more

Figure 8
Two frames above of early study model, and in a later refinement, a frame from an animation of a more complex mobile wall system, Thomas Kelley, 402 Design Studio.



effective way to harness a process. The macro itself is perhaps a true encoding of a design process that can be expressed and revisited with the use of animation.

Notes

1. These examples were based upon varied uses of commercial software. Maya was used and in a number of cases, such as the fountain example, modified through its MEL macro programming language. Microstation was also used to generate some of the more complex geometry that was ported or replicated in Maya.

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