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Finding of Form

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ABSTRACT

The intention of my thesis is to explore the spatial effect created when multiple forces interact in the formation of space. Instead of modeling the form, an internal generative logic is articulated which then produces a range of possibilities for the "finding of form".

Relationships & Behaviors

As a first step creative relationships are being built between the objects in the space and different behaviors are assigned to them. This way, objects interact with each other rather than just occupying space. New fields of influence are added or new relations made, creating new variations.

Deformation Process

These interdependencies then become the structuring, organizing principle for the generation and transformation of form. The surface boundary of the whole deforms as fields of influence vary in their location and intensity.

Temporal Dimension

The insertion of the dimension of time gives the opportunity to follow and observe the deformation process and establishes a relation of continuity between the objects and the space.

Resultant
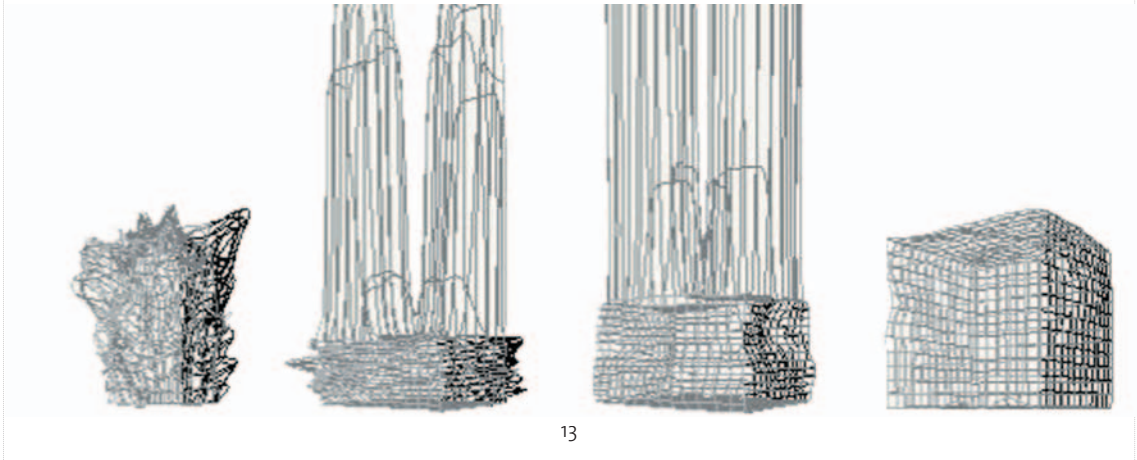object + force / surface + process = spatial result
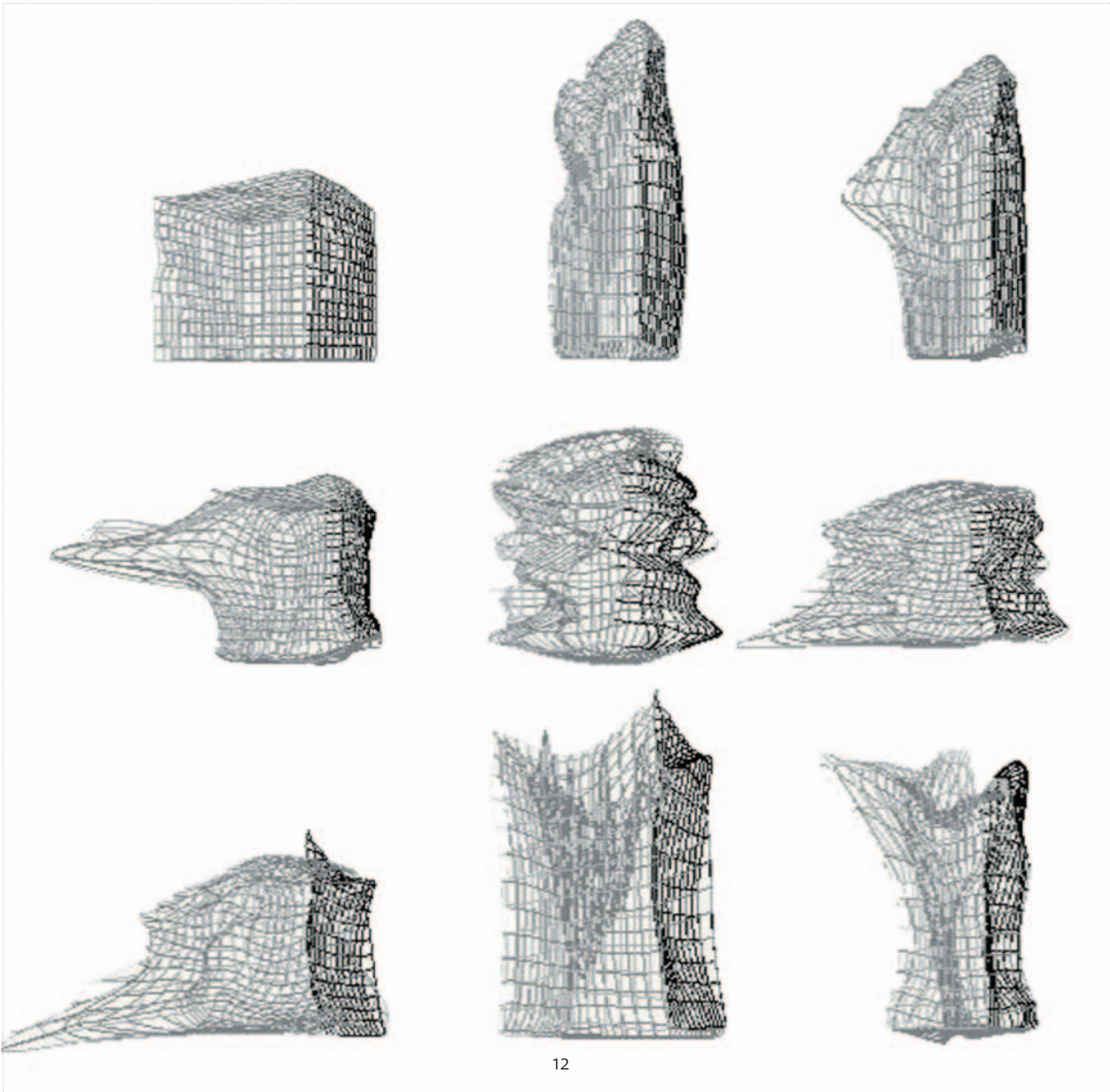
0. Talking about form

"Assumed is an abstract material of ideal deformatibility which can be deformed, with the exception of disruption".

Greg Lynn, "Architectural Curvilinearity, The Folded, The Pliant and the Supple.

"Form follows means, means follow tools, tools yield to desires, and desire is everything".

*Asymptote*

0.1 Architecture in the Digital era

Since the Baroque era of the 17th century, architects have been trying to cast off the Cartesian grid and traditional notions of beauty and proportion in architecture. Today' s digitally educated architects are equipped with software initially created for other purposes - for advanced aviation, animation and even shoe design. Powerful computers allow architects to visualize buildings of unprecedented complexity. That has liberated designers, as never before, from the age-old dominance of the right angle.

The "*Natural Born CAADdesigners*" chose to concentrate on the formal possibilities inherent in the digital revolution -- hence, "folds" (complex buildings made of many diverse elements), "blobs" (really curvy forms) and radically transformed "boxes."

In the conceptual realm, computational, digital architectures of topological, non-Euclidean geometric space, kinetic and dynamic systems, and genetic algorithms, are supplanting technological architectures. Digitally driven design processes, characterized by dynamic open-ended and unpredictable but consistent transformations of three-dimensional structures, are giving rise to new architectural possibilities.

Contemporary approaches to architectural design are digitally enabled and digitally driven. Computer software helps architects envision and depict their ideas, control and simplify complex calculations, and test alternatives. In fact, the digital realm can administer, unify, and streamline the architectural process from conceptualization to construction.

Thanks to the fact that architects' computers can be linked with manufacturers' computers and robotic fabricating equipment, we can now produce structures, surfaces and shapes that we simply could not have built before. To a great extent, computers have made many of today's large, truly innovative architectural projects--buildable.
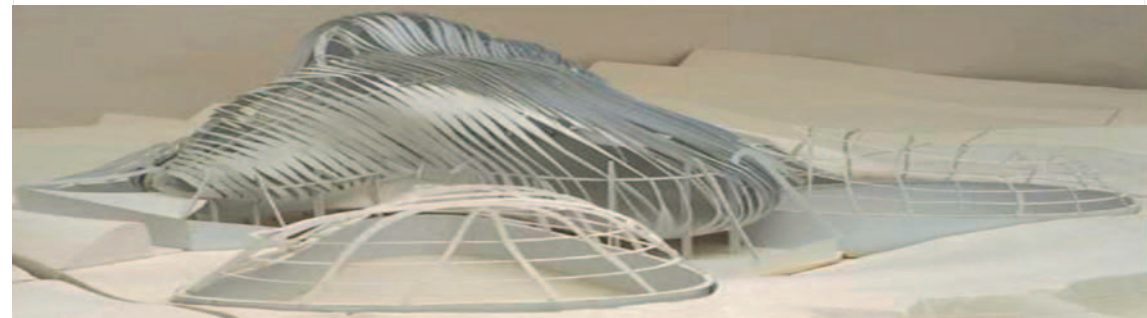
0.2 New Vocabulary

Folding: a design strategy that departs from Euclidean geometry of discrete volumes represented in Cartesian space, and employs topological conception of form and the "rubber-sheet" geometry of continuous curves and surfaces as its ultimate expression.

It is one of the many terms and concepts, such as affiliation, smooth and striated space, pliancy, and multiplicity, appropriated from Deleuze's work "The Fold". The Fold or *le pli*, as defined by Deleuze, posits a post-structuralist notion of space "made up of platforms, fissures, folds, infills, surfaces and depths that completely dislocate our experience".

Topology (mathematical definition): a study of intrinsic, qualitative properties of geometric forms that are not normally affected by changes in size or shape, i.e. which remain invariant through continuous one-to-one transformations or elastic deformations, such as stretching or twisting – torus, Mobius strip, Klein bottle.

This quality of homeomorphism is particularly interesting, as focus is on the relational structure of an object and not on its geometry- the same topological structure could be geometrically manifested in an infinite number of forms.

"In the realm of form, the stable is replaced by the variable, singularity by multiplicity".
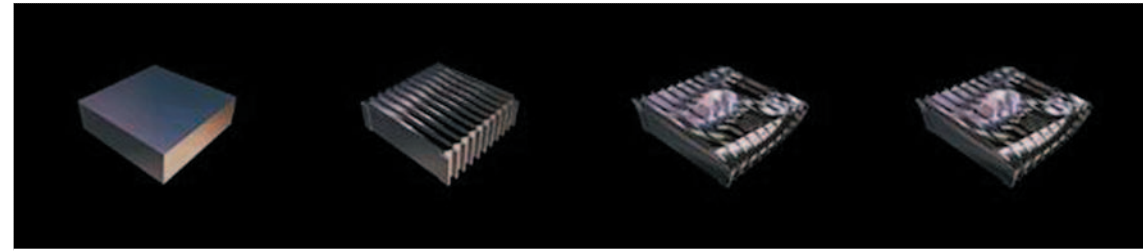
Digital morphogenesis: instead of modeling an external form, designers articulate an internal generative logic, which then produces, in an automatic fashion, a range of possibilities from which the designer could choose an appropriate formal proposition for further development.

Morphing: smoothly interpolating two different states of formal aggragation into one continious shape. Its importance is the capability of mutation and transplacement of certain characteristics of one configuration into other unlimited instances. It involves a transformation between objects of completely different shapes, sizes and forms.

Non-linear systems: systems capable of self-organization, and thus that can spontaneously create order, through often more than one equilibrium state, bifurcation points and transitions from one stable trajectory to another. They are autonomous and certain generic properties may appear despite differentiated systems and contexts.
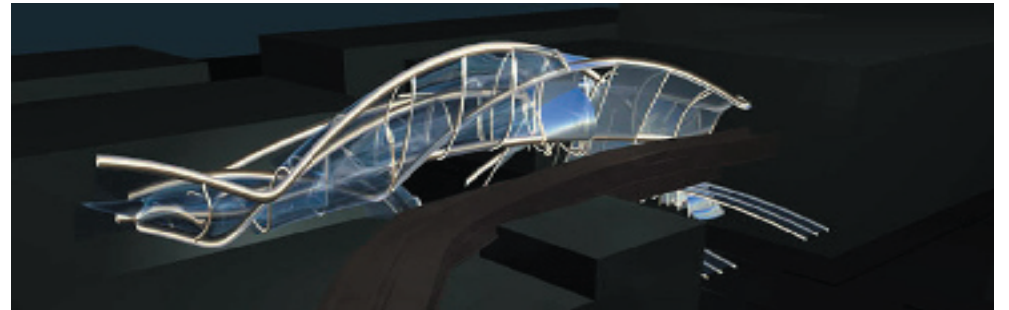
"dunescape", SHop architects
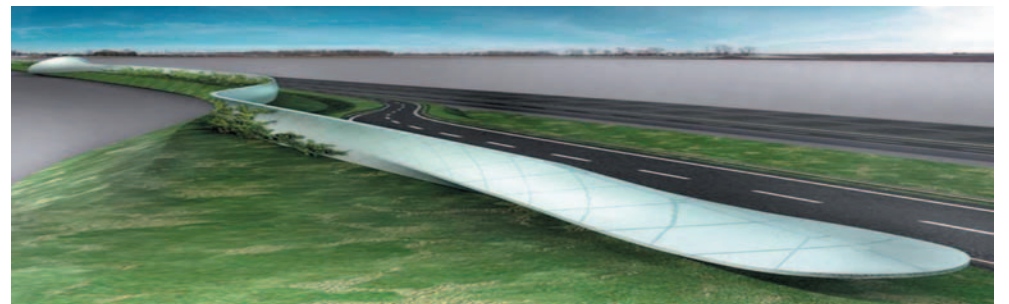

"mobius house", UN studio
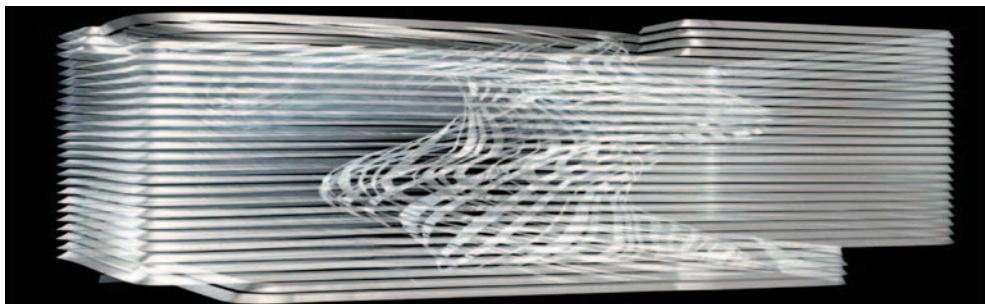
18
"cocoon", Franken architects

"opera house", Coop Himmelblau

"triple bridge gateway", Greg Lynn

19
"sound barrier", ONL

"A space exists when one takes into consideration vectors of direction, velocities and time variables. Thus space is composed of intersections of mobile elements. It is in a sense actuated by the ensemble of movements deployed within it."

Michel de Chateau, The Practice of Everyday Life,1984

"It is the very effectiveness of ants, creatures with relatively limited cognitive skills but with a highly advanced capacity for social coordination, that illustrates the extraordinary potential of "swarm logic" as a means to address social problems. Collectively these ideas come under the heading of 'emergence', a term popularized to describe a development in scientific explanations of the universe, but one that expands to all aspects of social life.
... Constantly mutating, emergent systems are intelligent ones, based on interaction, informational feedback loops, pattern recognition and indirect control. They challenge the traditional concept of systems as predetermined mechanisms of control, and focus instead on their self-regulating adaptive capacity."

Neil Leach, "Swarm Tectonics: A Manifesto for an Emergent Architecture," Latent Utopias, 2002

1 The Concept

The concept of my thesis is to explore the possibilities of creation or manipulation of the architectural space through dynamic evolutions of its parameters and properties.

In that context the main interest is to specify which kind of parameters, properties and geometries can contain and control the process of "formation" of the space and articulate an internal strategy which then produces a range of possibilities for the "finding of the form".

My interest is to provide spatial qualities by allowing the objects within the space to contribute to its formation or deformation. As a first step, creative relations are being built and different behaviours are assigned to the objects. Through their interelations and their interaction with the surrounding surfaces, emerges a spatial assemblage. This way the form dissolves into a field of relationships controlled by parameters, properties and topologies.

It is then the parameters of a particular design that are declared, not its shape. By assigning different values to the parameters, different objects or configurations can be created. A configuration at any moment is a temporal transformation of simultaneous uniqueness. Every change or differentiation is a result of the combination of virtual forces selected and exerted on given forms. Unfulfilled intentions, accidents, and collisions contribute also to the formation. While the transformation is taking place new unexpected forms emerge by a number of feature operations (creation, deletion, modification).

1.1 Nomads

I call nomads the objects I use to dominate the space. In computer science – object oriented programming - they would be called agents. Agent systems, consisted of artificial weeds and vermins (species) , are used to analyse and compare structures, places and urban environments.

In my research, the nomads – virtual agents - represent architectural elements such as the wind, the light, the flow of people, the temperature or even pieces of furniture with internal codes of behaviour "esoteric attributes" and external codes of influence, "exoteric attributes".

Each nomad is not bound to a particular place but its movement is marked by vectorial displacements. The nomad is dispersed in space. The space of the nomadic explorers, marked by events along a path, is being redefined while they are seeking to satisfy their desires and fulfil their goals.

1.2 Relations and Behaviours

"Cosmic space contains energy, contains forces, and proceeds from them [...] An energy or force can only be identified by means of its effects in space, even if forces 'in themselves' are distinct from their effects."
Nietzschean space

In my research, well defined design strategy means carefully assigning the desired behaviour to the agents and defining their interrelationships. The physical properties of objects, such as mass (density), elasticity, static and kinetic friction (or roughness), are also defined. Forces of gravity, wind, or vortex are applied, collision detection and obstacles (deflectors) are specified, and dynamic simulation computed. Objects interact with each other instead of just occupying space.

Their behavior over time cannot always be explained because it is the complex web of interdependencies and interactions that define the operation. In addition, the whole is always open to variations as new fields of influence are added or new relations made, creating new possibilities. The addition or substraction of a particular kind of information can dramatically affect the simulation.

" ... the instrument used by computers is projection, its purpose is mutation. But its product is simulation. "
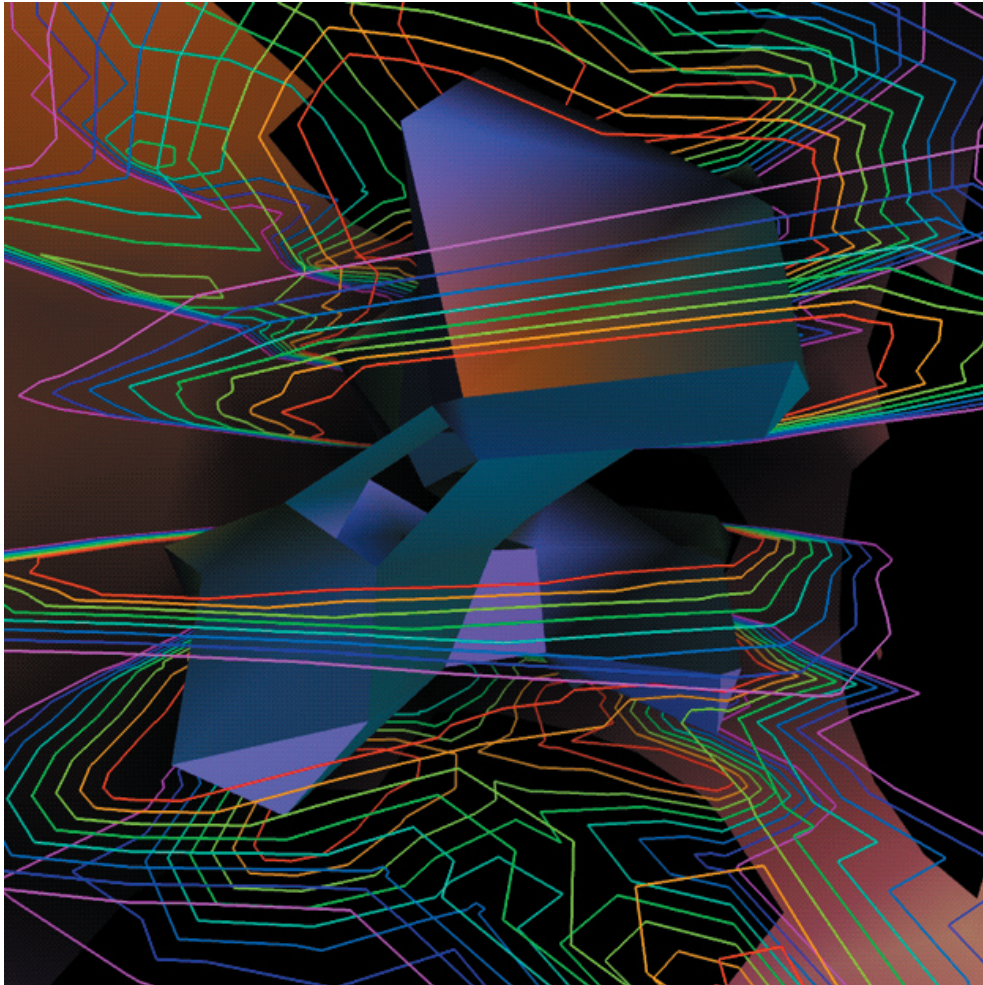
1.3 In Motion

" The parameters used to describe architectural space, have for too long been timeless, inert and static – lacking parameters of evolution, movement and dynamics."

Greg Lynn, "Geometry in Time"

" Time is a necessary alienation, being the medium in which the subject realizes himself while losing himself, becomes other in order to become truly himself ".

Hegel

The insertion of the dimension of time gives the opportunity to follow and observe the deformation process. An animation shows the relation between space and time and allows the designer to freeze the flow / stop the process. Every frame of the animation represents a variation of the primitive form with simultaneous uniqueness, a temporal transformation which the designer can choose for further development.
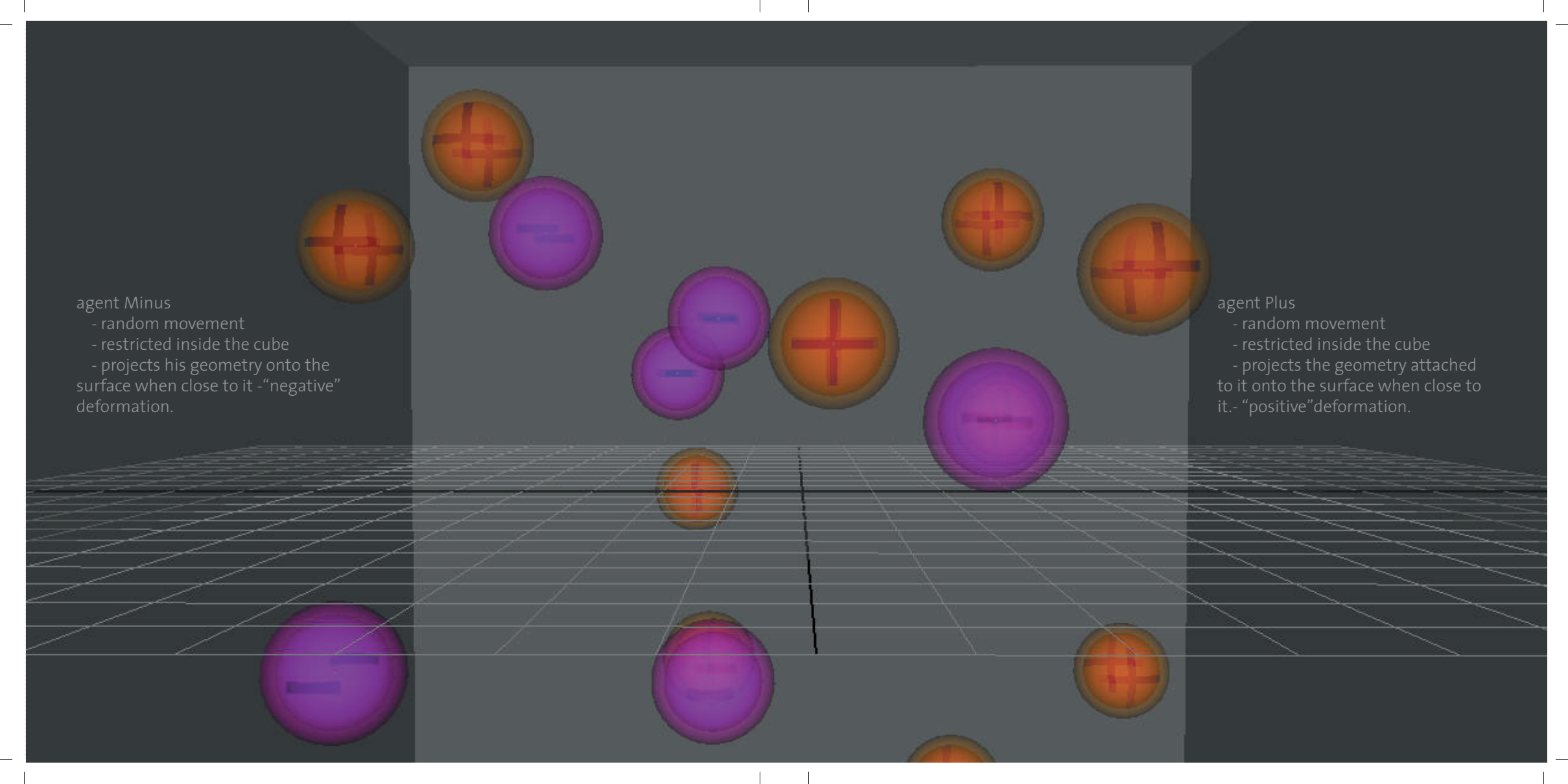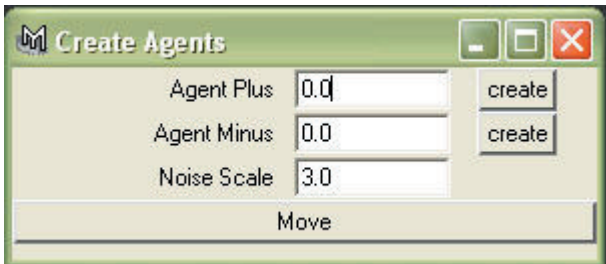
2 In Practice

In order to put my idea into practice I decided to use Maya and Mel, as I wanted to work in a 3D environment and follow the whole process through an animation. I also soon decided to use Maya particles engine as my virtual nomads / agents. Maya particles are mass points on which fields (such as gravity or vortex) can apply forces. These forces change particles position in space. My intention was to give them some intelligence and let them, in a way, act by themselves. As a first step, i use simple actions and deformations.

The desired result would be a behavioural animation showing the particles – which represent selected architectural elements- interacting with each other and with their environment causing different deformations to the surrounding surfaces.

The creation steps
-        build up the characters - give them a form in order to recognise them in space.
-        define their desires / goals - specify the motivation for their actions, combine or change them over time.
-        Define the action they take when they reach their goal – deform, transform, collide, die.
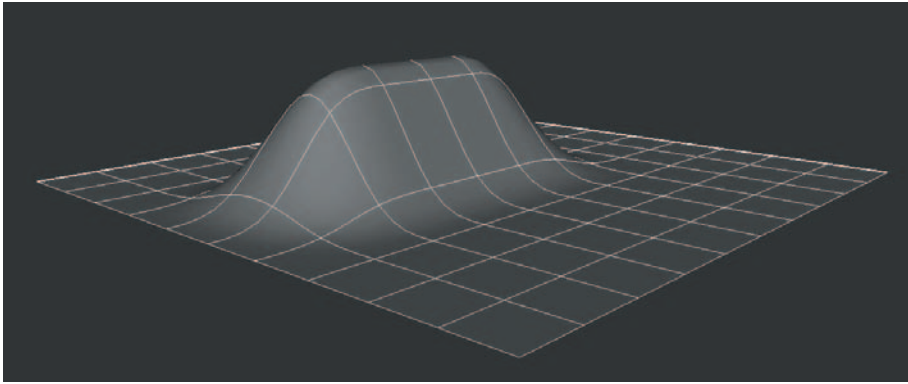-   provide them with sensors that help them read the space and act

agent Minus
   - random movement
   - restricted inside the cube
   - projects his geometry onto the
surface when close to it -"negative"
deformation.

agent Plus
   - random movement
   - restricted inside the cube
   - projects the geometry attached
to it onto the surface when close to
it.- "positive"deformation.

agent Plus deforming the surface
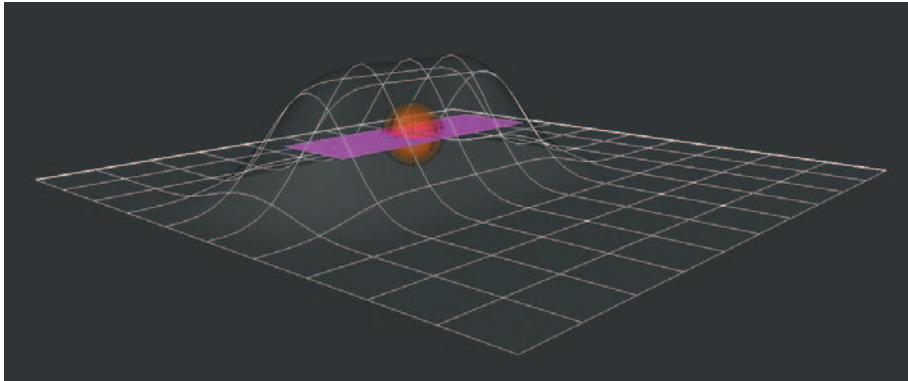
agent Plus deforming the surface

Scripts - mel

makeProfilePlus – this script creates the geometry that is instanced to the particle/agent Plus.
makeProfileMinus – this script creates the geometry that is instanced to the particle/agent Minus.
createAgentsui – this script creates a UI window requesting the number of agents created and the size of their vectorial movement.
*makeParticlePlus* – this script creates the particles / agents Plus and assigns them their behavior and their goals.
makeParticleMinus – this script creates the particles / agents Minus and assigns them their behavior and their goals.
isInside - this script is checking whether the particles / agents are within the specified distance from their goal.
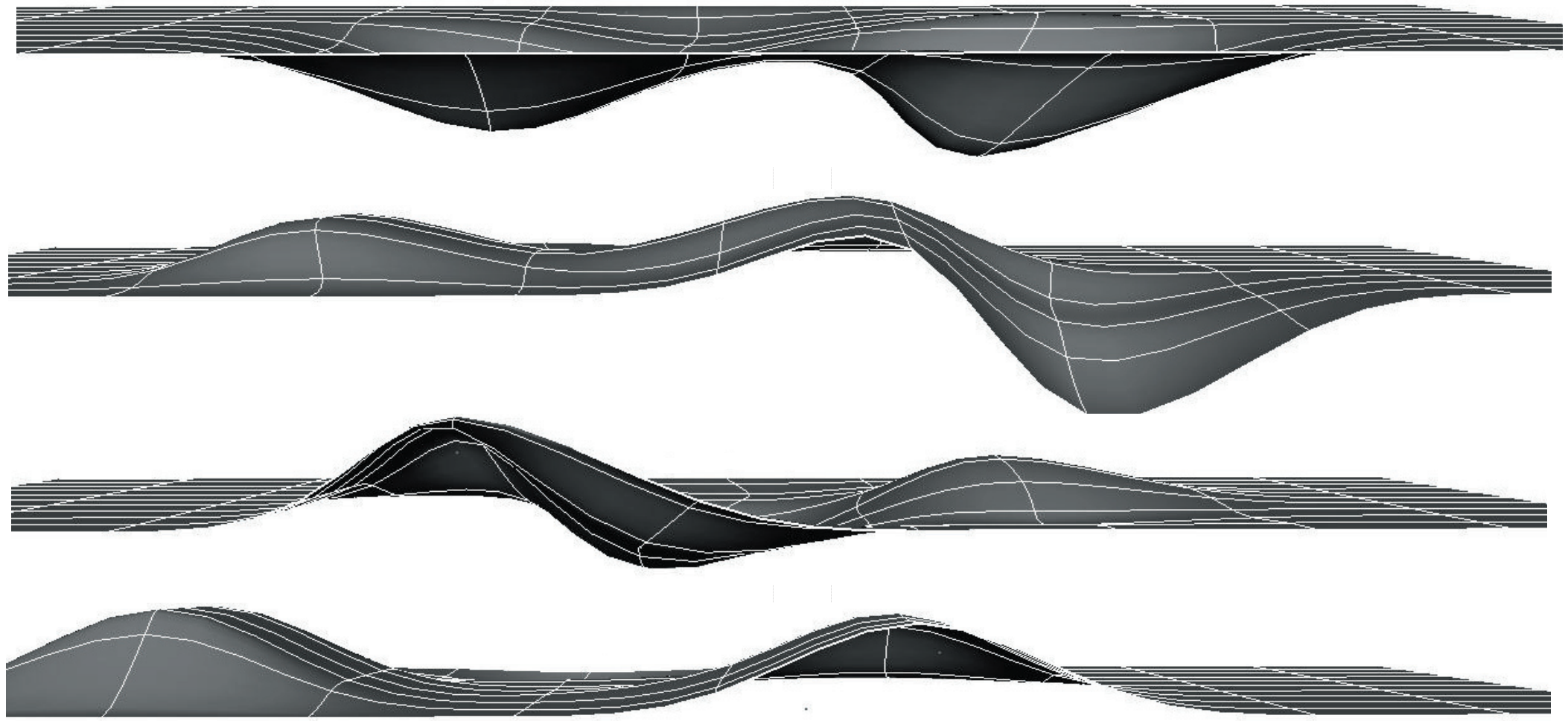*follow* – this script specifies the target to follow for the agents.
randomove - this script assigns to all selected agents (particles) in the scene a random movement. A noise vector, the size of which is given by the designer in a UI, controls the step of this movement.
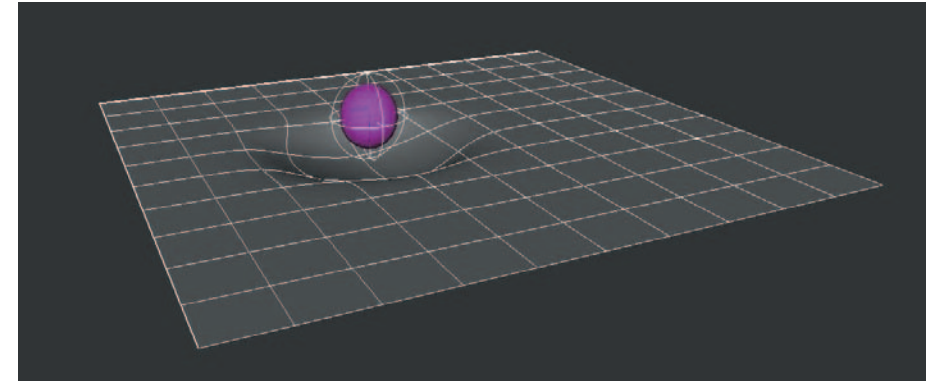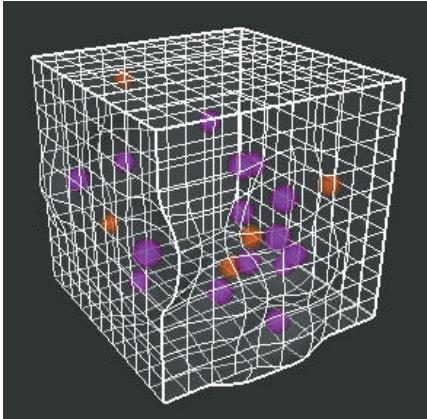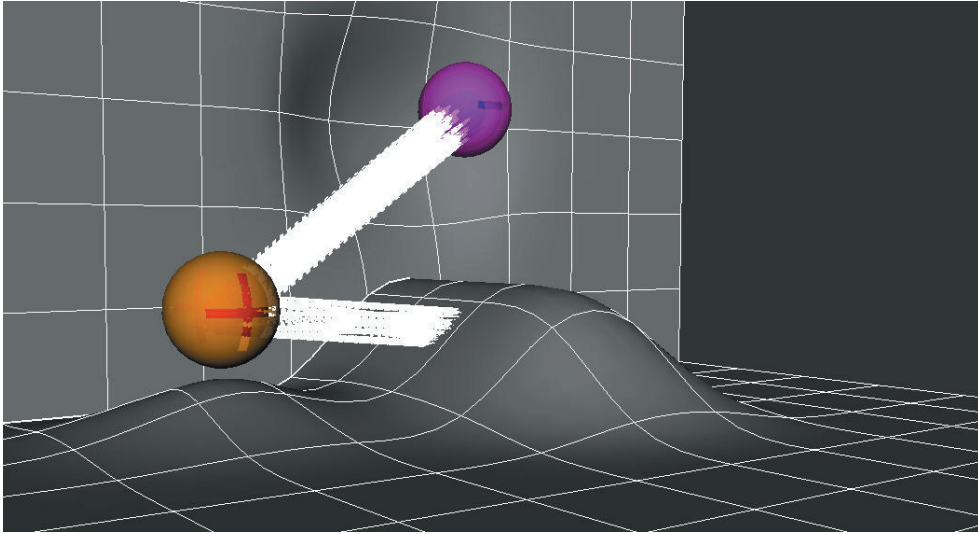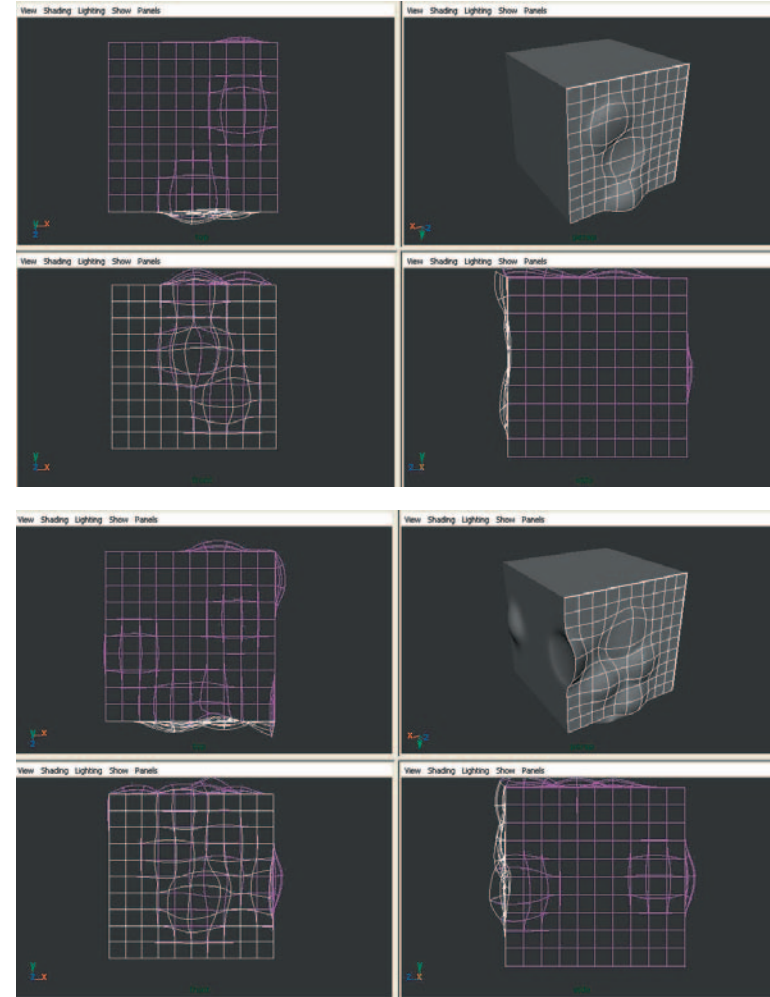

agent minus deforming the surface

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The agents should maintain a specified distance from their goal / target when they reach his area.

A desired number of agents is created in the given space. They start wandering looking for their target. Their movement and the forces between them deform the surrounding surfaces.

Massive is the premier 3D animation system used for generating crowd-related visual effects and character animation, based on artificial life technology.

The realism of the Massive shots in The Return of the King has set a new standard for large scale crowd scenes in motion pictures.

The *Havok* Game Dynamics SDK includes a character kit that allows you to easily insert physical characters into your game. Humans and monsters can now react naturally in physical environments, saving artists from having to animate multiple different reactions.

3 Examples

Assigning behaviors to virtual characters and animating their interaction is a common technic used widely in the film and game industries.There have also been many attempts to programm bahavioral animation and agent-like systems in Maya, although it is not an object - oriented software.

The examples that follow are two plug-ins for Maya, one used in computer games for character creation and the other one created by a Maya user for simulating a bugs system.

Although it would probably be possible to use the second plug-in for the purposes of this research, unfortunately it was discovered when there was a serious time shortage.

As a next step, it would be to try to use the bug system within an architectural context where the bugs would represent specified architectural elements, move in a 3D environment and cause different deformations to the surrounding surfaces, according to the design strategy created by the architect.

3.1 Game Industry

AI.implant

AI.implant, from BioGraphic Technologies in Montreal, Canada, has a sophisticated animation control engine that introduces AI to the computer game and video media character development process.

AI.implant contains a number of features, including productivity tools for managing crowds (either as agents or characters); an interface between the game engine and AI.implant; the ability to design and edit character-assigned AI algorithms, behaviors, character states and sensors in the developer's modeling system of choice; a GUI for the AI designer to work within.

Essentially, AI.implant provides autonomous character control for the game engine and rendering system, which in turn provides animation and locomotion control -- and some behavioral decision making -- for autonomous characters (agents) in the game.

Agents can make decisions based on what they know about their environment. The decision-making process takes the form of binary decision trees (BDT). The agent can maintain data (like a memory), and accept input from the environment via Sensors, and then apply them to a BDT to determine the action or behavior to execute. This process is outlined in the set of partial screen shots that describe setting up an autonomous agent, assigning a sensor and creating a BDT for the agent to use to decide what to do.

An AI.implant world consists of autonomous agents, but also nonautonomous characters and objects. These can be used to represent walls, moving doors, tunnels, constrained areas, surfaces, paths and obstacles (formed by using waypoint objects) and interact with autonomous characters.
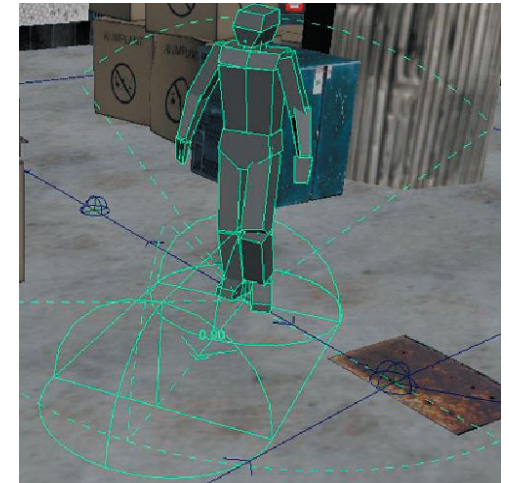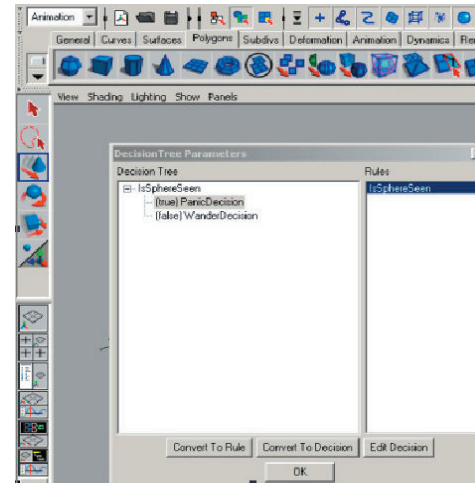
3.2 The bugs
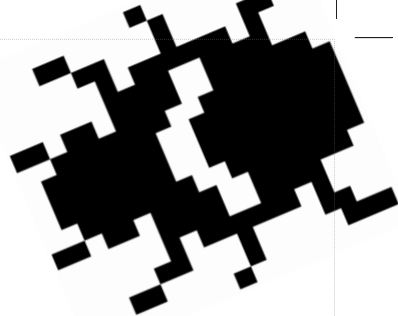
brainbugz is a set of A|W Maya nodes and commands that enable you to use behavioural animation techniques on particles.
In behavioural animation mass-points, referred to in this document as „bugs", are not forced from the outside, forces are self applied based on physical attributes and one or many behavioural rules.
The "bugs" have certain Physical (like bug radius, maximum force, desired speed, inverse desired steering force) and Field of View (like use sensor range, sensor range, use sensor angle, sensor angle) attributes.

They also have the following **bug steering desires**:

heading direction- causes the bug to head in the direction specified
wander - for adding a little randomness to a bug's motion (or a lot)
seek - causes the bug to align its orientation towards the specified target. If a bug continues to seek, it will pass through the target, then turn back to seek it again.
moth seek - same as seek, except that the bug is moving in orbital paths around the target, much like a moth buzzing around a light bulb.
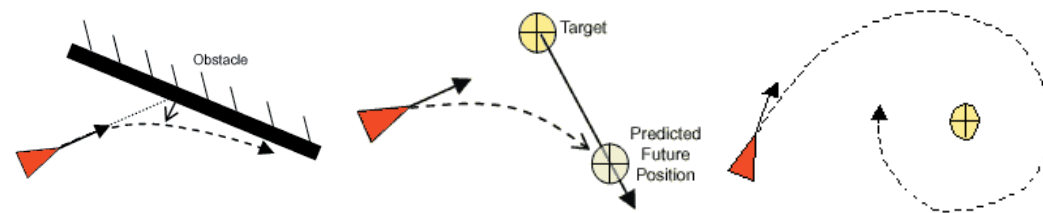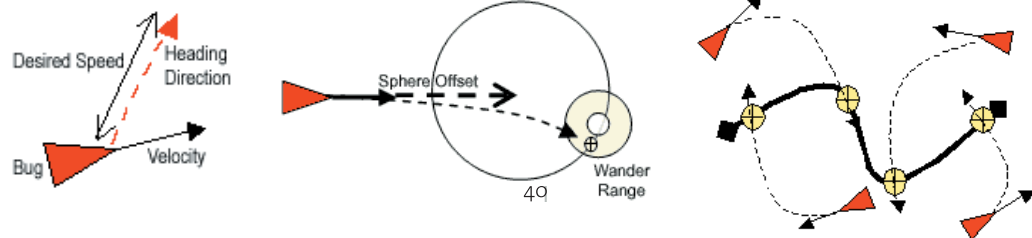
arrival - is identical to seek behaviour when the bug is far away from the target, but if the target is in a predefined distance (Stopping Radius), the bug will try to slow down and eventually stop at the target.
pursuit - is identical to seek behaviour except the bug tries to predict where its target is moving and tries to intercept the targtes path.
shadow - is identical to seek behaviour when the bug is far away from the target, but if the target is in a predefined distance (Shadow Range), the bug will try mimic the movement of the target.
follow - bug estimates its future position on its current heading, then seeks the closest point on the curve / surface / mesh to this future position.
obstacle avoidance - prevents the bugs from bumping into obstacles .Every bug has a probe of a specified length attached at its front, if this probe touches one of the specified obstacles, then it will try to steer away.
alignment - steering desire forces the bug to align itself with the bugs in its viewing range.
cohesion - Bugs with this desire will try to approach and form a group with other nearby bugs by heading for the average position of these bugs
separation - this steering desire can be used to prevent bugs vom crowding together, it forces the character to steer away from the other bugs nearby
keep distance - will force the bug to keep the defined distance to the nearest of the nearby bugs

These steerings desires can be cleverly combined and attached to a number of bugs, so these bugs are no longer simple physical objects, but become autonomous characters.

"One cannot rely on the control of the computer, but must understand the conceptual potentialities of this medium to employ it schematically and with systematic human intuition."

Greg Lynn, "Form"

"Aerodynamics has advantages for things that move, but is hardly essential for things that don't. Curves are relevant to quantum physics and strands of DNA, but not particularly handy for floors and walls".
"... Hardly a real stimulus for a new typology, let alone a new architecture. Soap and whiskey evidently stimulate more architectural renewal than hardware and software".

Willem Jan Neutelings, "Blobs, pixels and push-up bras"

4 CONCLUSION

The chalenge of this thesis was to experiment with a new design strategy and a new way of thinking in general. It was not aiming at offering a specific architectural solution but at exploring the connection between the context of space and the design process. In this approach, the architect is not designing the space itself but the relation between its elements – its parameters, its constraints, and its dynamics. Therefore, this research is process oriented and not a form study.

Using a computer simulation does not suggest abandoning the craft of drawing by hand – something unlikely to ever happen- but exploring the digital capabilities the architects now have and the wide range of new architectural shapes that were impractical before the computer. In addition, although it seems that it involves an automatic and, kind of, arbitrary process for generating the form, the truth is that the input of the parameters, the decision making for their interdependencies and any design interventions belong to the architect. The result might be impredictable cause of the different interacting forces but that is what makes this design process interesting.

The use of the parameter of time is another crucial issue. The aim is not that the architecture should move or be animated in the final manifestation as a real building, but rather that the process leads to architecture through the use of animation.

Unfortunately, the factors of time restriction, software complexity and unsufficient programming skills prevented from having a final form and therefore evaluating the consequences of this design strategy.

However, from a technical point of view, the above mentionned examples from the game and the film industry reveal that behavioural animation is possible and already applied to different fields and its application to experimental architectural projects is only a matter of self- motivation, devotion and time. The parametric ability, the dynamic animation and visualization possibilities of MAYA are quite sufficient but the software cannot be expected to deal with "real world" architectural design in all of its complexity.

From a conceptual point of view, this project should be perceived as an experiment with an open outcome. The scope of the research does not include any thoughts on the materials, structure or construction of the actual spatial result and therefore it only stays in the conceptual sphere. It attempts to explore the issues of process driven design methodology in an experimental nonlinear mode of time and parameters of the space.

If a useful connection between the context of space and a computer driven design process can be formed, essential questions would be:

Can the space in the design process be dynamic and animated while the space of the final building is static?
Is there an optimal point in time for freezing the process?
What are the aesthetics of computer generated and data - driven architecture?

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