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Architecture as optical machine.
A visual deformation through light.

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To Efthimia and her blossoming gardens…

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INTRODUCTION

> ***"Je perçois la Lumière comme la source de toutes présences, et le matériau comme de la Lumière dépensée. Ce qui est fait par la Lumière projette une ombre, et l'ombre appartient à la Lumière. Je perçois un seuil : de la Lumière au Silence, du Silence à la Lumière."*** [1]

The general consideration of architecture as an art closely related to light could be reduced to its conceptualization as an *'optical machine'*; a machine able to capture or reflect light in a way that visually deforms its own geometry and sets the conditions for the emergence of an infinite series of volumetric qualities.
In this sense, architecture expands its limits from the built inhabited forms, to the experimental ephemeral installations, to a static sculpture, further to the moving polyhedral structures and interactive skins or in general, to any three-dimensional set of volumes that is able to create a light-mutable space.

The perception of the well-defined boundaries can be subject to gradual transformations and it is eventually dematerialized by the manipulation of an intangible material, in such a way that the final impression might even result into an ever-changing, fluid-like succession of forms. This material is no other than light.
While its rays deploy in space, light acquires the consistence of a visible object, as well as the volume of a sculpted body that stands out, in contrast to the dark background. The illusion of tangibility is evoked through its projection onto another form, a measurable one, whether this is part of the natural or the built environment. This exploration of surfaces through light could potentially advance to a completely new way of designing different perceptions of spatial realities.
During the last century, the technique of projection mapping has evolved to take up the fields of digital arts, communication, advertisement, cultural heritage and of other experimental uses, such as temporary installations and theatre scenography. Video mapping interventions propose an alternative regard onto the façade, the building or the space in general, via the superimposition of a virtual layer over the real.

In this essay, there will be attempted a cartography of the various ways that the projection of artificial light in recent years has been used by artists, architects, advertisers, creators in general, so as to change the spectator's idea of a geometric volume, to create space and to pass a certain message, in each case under a different perspective and in a different context.

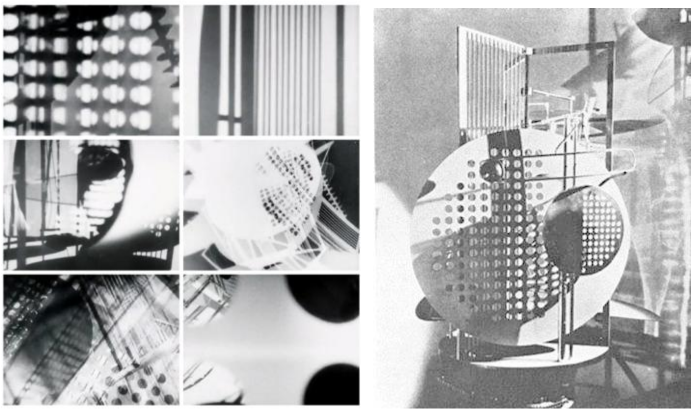
Having this research as our starting point, we will go on to describe the production of two installations that took place during the last year; In the first one we will work on a given space (a wall in Université Paris8) whereas in the second, the project Time Cube, we will reflect on the ways an artist can conceive an ever-changing experimental experience of interactive projection mapping on a geometric form created by himself. How can we achieve a visual reconstruction of the form through light? Moreover, the problematic will extend to reflect on the co-existence of organic forms onto this geometric volume.

[1] *L.I. Kahn,* ***Silence et Lumière: choix de conférences et d'entretiens 1955-1974****. Paris: Éditions du Linteau, 1996, pp.21.*

SCULPTING WITH LIGHT

1/ THE APPEARANCE OF LIGHT ART AND THE *"TOTAL THEATER"*[2]

In the beginning of the 20th century, years before the emergence of projection mapping, Bauhaus artists, such as Lyonel Feininger, Paul Klee and Wassily Kandinsky introduced the examination of artificial light, as the newly acquired, raw material in their works. The two main directions followed were the so-called painters and the sculptors. The first, were mainly interested on the variety of patterns created by a luminous source (though strictly confined onto a screen), whereas the latter would construct an entire environment, integrating both this source and the produced visual effects. The purpose of Light Art according to them was to eliminate the specific art object and to transform the environment into a light-modulating system, sensitive to responses from organisms which invade its presence. One of the first moderns to regard the cityscape during night as "pure pulsating light sculpture"[3] is László Moholy-Nagy.



*img.01: L. Moholy-Nagy, **Light-Space Modulator.** Weimer, 1922-1930.*

During his teaching years at the Bauhaus in Weimar, Moholy-Nagy developed a number of models and theories on film, theater and installation, seeking to include the public as creative force in art. In the context of kinetic art he was experimenting with the students on structures that brought contrasting materials together (such as wood, metal and glass) with the purpose of finding static, as well as aesthetic balance in those self-supporting , non-symmetric object sets. Apart from the study of the movement as a means of creating art, he was among the first to have turned their interest towards the methods by which light could modify, or even subvert the whole notion of sculpture.
"*Light Space Modulator"* [4] (the components of which were the space, the time and the light), was one of the major efforts ever made by members of the Bauhaus team, towards the creation of a totalitarian theater *("total theater").* The construction is a three-dimensional model, of 120 cm total height. On cubic basis, stands a circular platform which, in turn, supports three rotating mechanisms, within the limits of two vertical and mutually perpendicular metal frames. Series of bars, meshes, reflective chrome surfaces, perforated

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*[2] By the term total theater is described "a riveting area where the set of interrelated broken light, sound , motion , form, surface - human in all possible combinations with each other - ends in an organic artwork , allowing the user to take part in the creative process.", as cited in L. Moholy-Nagy, **Total Theatre is the theatre of the future.** London: Thames and Hudson, 1927, pp.300.*

[3] L. Moholy-Nagy, **Total Theatre is the theatre of the future.** London: Thames and Hudson, 1927, pp.153.

[4] Design and construction were both developed and refined during the period 1922-1931 with the aid of electricians, technicians and the architect Stefan Sebök, as well as with the partial funding of AEG, which was the largest supplier of electrical goods at that time, in Germany.

aluminum pieces, a glass spiral, they are all interconnected with cables, each one rotating at different speed and axe, powered by an engine. Despite the claims by some artists of the first period of kinetic art, that machine should be as small as possible, so as not to provoke competition with the sculpture itself, here the flowing energy from the engine to the terminations is evident, thus supporting the truth of the material.
The final form emerges when the artwork evolves into a dark space. The perpetually moving surfaces are illuminated by 70 yellow, green, blue and white lights flashing sequentially at a predetermined rhythmic pattern that the artist calls photo-temporality[5]. This creates a virtual environment, compounded by countless visual combinations of light and shade. The space is occupied by the sequence of fleeting images, as well as shapes that swirl, climb, traverse or chase one another, disappear or transform. Apart from a visual experience, it is also a sophisticated system that replicates and modulates a series of abstract narratives that engage the viewer, using the human kinesthesia and the perception of depth and color. Real movement and real light became media of art. Environment, objects and visitor finally become homogenized in a situation, perceived as a whole.
The unified perception of space and artwork, combined with the effort to engage the public, were the innovations that characterize the work of Moholy-Nagy. The *"Light Space Modulator"*[6], was a dramatically new, dynamic, multimedia application aimed at breaking the traditional forms and envisioned an ever-changing environment free from obvious limits. In spite of the avant-gardism of the idea, the aesthetic autonomy of the object as a work that could occupy a space itself had raised much controversy, mainly because of a theory assuming that the machines are a closed, non-intelligent system with the sole purpose of producing labor. While in movement, the model revealed the contrast between the fluid flows of the shadings against the rigid, spasmodic movements of the metals which produced sharp sounds. However, this intense contrast between the ideal virtual and the purely mechanical system that creates it is exactly what strengthens the character of the project, suggesting the way in which the modern technology of that time could possibly overcome the strength and stiffness in favor of art. The dynamic machines fantasized by the members of Bauhaus did what today's computers do, that is to say being the intermediate stage between processing and projection surface. Moreover, the search for an aesthetic experience had now moved from the concept of an autonomous object, to the tensions of a subjective experience. In 1923, the *"Light-Space Modulator"* had already arisen the problematic of redesigning a fluid moving space with the aid of light, as well as the communication between artwork and audience; the latter was a question that could not be resolved due to the insufficient and undeveloped technology of the era, nonetheless it has evolved into being the cornerstone of the current interactive artworks.

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[5] *J. Burnham, **Beyong Modern Sculpture: The effects of science and technology on the sculpture of this century.** New York: George Braziller Inc, 1968, pp. 292.*

[6] *After the completion of the project, Moholy-Nagy in collaboration with his wife Syvil Nagy created the "Ein Lichtspiel Schwarz Weiss Grau" (Light Display, Black and White and Gray), which is in fact, the film footage of "Light Space Modulator" in action. The film begins with the presentation of multiple rotations of the machine at very close range, so that the boundaries between object and viewer are blurred. This is succeeded by a series of frames, which combine negative and positive parts of the film, creating the sense of a propagating movement. The rate of rotation of the frames increases, in parallel with the number of superimposed planes used at each frame, with the object fetched from a different angle, focal depth, and lighting. The rays of light merge with each other, go brighter or darker, or even reflected and diffused. The different angles of incidence symbolize the time, while the movement from East to West functions as a mimesis of the real world. The shadows and reflections record a landscape, shaped by constantly changing textures and densities.*

2/ PROJECTIONS ON THE ARCHITECTURAL CANVAS

Video projection mapping installations use the superimposition of virtual material onto architecture. This results in the creation of three-dimensional, site-specific projections that accentuate the monumentality and the dramatization of architecture. The elements to be taken into account are the visual elements of the structure, as well as its symbolic framework, if there is one. The boundaries between the realm of digital and the actual, physical space are therefore conflated into a shared experience, widely known as spatially augmented reality environment.
In contrast to the technique of *"trompe l'oeil"*, projection mapping places the images onto strategically crucial parts of the volume, so as they gradually develop themselves into an architectural element and eventually disguise and trick the eye. The images unfold over the faces, as if they were another structural layer, one that is utterly blended with the original. The virtual finally gains its materiality through its deployment onto the real. In the following examples, there will be attempted a presentation, not only from a technical but also from the conceptual point of view, of selected milestones that led to today's immersive, luminous environments.

a/ THE EMERGENCE OF MAPPING

i. The geometry of the real and the disappearance of matter

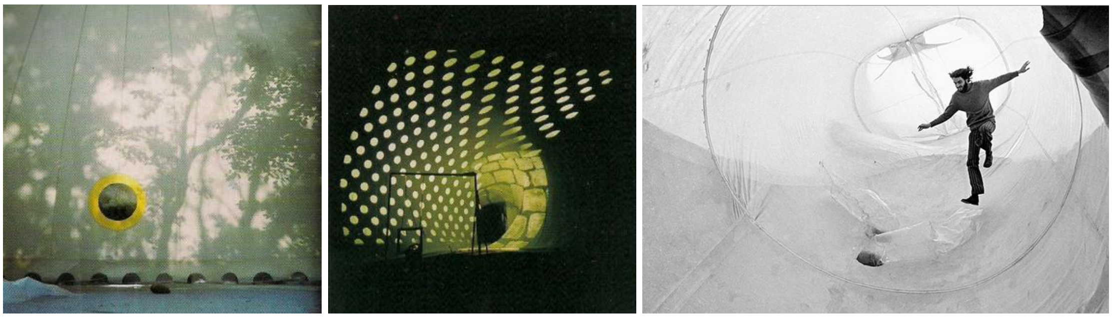
img.02: H.W. Muller, ***Topoprojections.*** *Baux de Provence, 1979.*

The first projections on architecture were nothing more than static images. In the late 70s, Hans Walter Muller, architect of the ephemerae, kinetic artist and mostly renowned for his "Inflatable Structures", began his experimentations on what he named *"Topoprojections"*[7], by adapting the shape of the anamorphic image to the shape of the surface it is projected on. In these works, a slide projector was used to cast simple, geometrical patterns on buildings. The façade was regarded as a whole; consequently the patterns were projected on the entire building, without taking into consideration the distinction between solid material and openings. By this means the perception somebody would have of the space wasn't really adapted on the real volume and the role of mapping was limited to a semi-transparent texturing layer wrapped around the actual building.
A more interesting technique though, practiced a few years later, was the highlighting of the architectural volumes' outline (such as the floor, ceiling and pillars). Although today this can be achieved as easily as the press of the wireframe button on any 3d modeling software

[7] *The "Topoprojections" series was applied to various sites and monuments, as well as ancient quarries: 1979- Les Baux de Provence. 1981- Troyes Cathedral. 1990- Tokyo. 1993- Florence. 1996- New Palace of the Republic in San Marino. 1998- Church of Santo Spirito in Florence.*

program, Muller was the first to actually expose the geometry of the volume, with a real projector, on a real space. His experiments would not end there, as his problematic was extended further: *“So there are no more screens: architecture is the screen. Volume becomes an infinite screen and even changes the image. And why not penetrate these volume-screens, these volux?”*[8]

During the 80s’, the once accentuated pillar would be literally dematerialized by Muller himself, who worked towards the irrational and utopian, deconstructing the orthogonality of the architectural language. The latter would now regard his *“Inflatable Structures”*[9] as a projection surface with the ability to metamorphose, appear or disappear, all of this with the aid of light. Here, the innovation lays on the fact that the geometry of the projection surface is not any more a stiff, vertical plane, but a semi-spherical, transparent volume which was also very sensitive to oscillation. Given the fact that the images were projected from the exterior, they curved so as they could wrap the visitor in an unfamiliar, underwater imitating universe. The dome-like structures would become wondrous scenery, created by the cast images, whether these should be the shadows of the big trees during the day, or the slideshow of captivating graphics during the night.



*img.03: H.W. Muller, **Topoprojections on Inflatables**. Shadows cast during day, night projection and inhabitant, around 1980.*

With the introduction of pneumatic architecture, the theme of disappearance of the matter, as well as of the static architecture comes to a climax. Nonetheless, the notion of weight here is not just material; it is an opposition to traditional constructions, to monumentality, to conservative values, as opposed to ephemerality, nomadism, lightness and transparency. Muller would declare that he couldn’t live anywhere else, than in an inflatable, free from the material constraints of the walls. Its experience seeks to modify perception of the environment, by detaching the body from the orthogonal geometric space. In contrast to the *“Light-Space Modulator”*, where visitors were asked to study the result as mere observers from a specific angle, here they are invited to approach, enter and actually experience the space. Since an intimate relationship between body and construction is required, we could advance to think of this body as the first tool of indirect interaction with the projected image. The spectator is put in a situation where he triggers the transformation of the

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[8] *H.W. Muller, **WHY INFLATABLES?**, in **Techniques and architectures, n°304.** 1975, pp.73-74.*

[9] *“An ‘Inflatable’ is just a skin that not only contains a space, but also separates interior and exterior, appears, disappears and sometimes it even dematerializes. This is why it is such a playful, fantastic, unusual element, far from any traditional technique of construction. It is its origins that fascinate me. Paradoxically, to build an “Inflatable” is practically impossible, technically impossible, and impossible in thought. From the moment when we decide not only to create a sphere but to produce more complex volumes in order to generate interesting forms, we explore the combinatorial mathematics, which allows us to actually create space.” , as quoted in H.W. Muller, **WHY INFLATABLES?,** in **Techniques and architectures, n°304.** 1975, pp.73-74.*

surrounding membrane by his movements. The mesh is under constant distortion and so it is the perception of light and shadow on it.

ii. The spatial correspondence




*img.04: M. Naimark, **Displacements.** Images shot during film, after painting, and with projection, 1980.*
*img.05: A. Hitchcock, **Rear Window.** 1954.*

During the years 1980 to 1984, Michael Naimark initialized the production of a large-scale, environmental artwork, entitled *"Displacements".* The idea was quite simple; project the image of a virtual object, onto the actual, physical object, in order to blur the boundaries between real and movie. Taking place in an interior this time, Naimark created a setting reproducing the stereotypical American living room*;* sofa, chairs, tables, wall hangings, television, computer. He then filmed a 360 degree panorama using a motor to rotate the camera on a tripod situated in the middle of the room. Three performers were living in the space, interacting with the available, everyday objects: studying in front of the computer, playing with the guitar, spinning the globe, lying on the couch or just sitting on a chair. After the shooting, all objects were spray-painted white. Finally, the camera was replaced by a projector, whose movement was totally synchronized with the movement of the film's camera, creating this way a moving movie. The dark environment was gradually lit by a rectangular projection[10] which triggered various narrations and brought objects to life. This revokes the experience of exploring the architectural unhomely with a flashlight, or focusing on environments' details through the monocular. The abolishment of exactly this

[10] *"Many viewers, me included found the rectangular shape frame itself disturbing. Perhaps a circular frame would look more "natural" as it is reminiscent of a spotlight, whose properties are more spatially equivalent to a moving movie. An equally interesting alternative may be to eliminate the frame edge itself, possibly by diffusion". As quoted in M. Naimark,* ***Spatial Correspondence in Motion Picture Display,*** *in* ***SPIE Proceedings, vol. 462, Optics and Entertainment.*** *Los Angeles, 1984.*

rectangular frame will be the quest of all the subsequent artists to come, who work on immersion and projection mapping.
This peephole effect evokes the main concept idea in Alfred Hitchcock's *"The Rear Window"*, directed in 1954. The main character, while confined to his wheelchair, spends his time watching his neighbors through his monocular. The camera pans and rotates accordingly, in order to illuminate selected extracts from a fragmented story.
Back to the *"Displacements" case*, taking advantage of the spatial correspondence between the recorded and the playback space, where each object functions as the projection canvas for its own image, Naimark achieved a convincing illusion of the space. All of the objects appeared highly realistic, in contrast to the actors who didn't, due to the unequal wrapping of their image on the environment. His method, that is called "relief projection", is in reality a precursor of the calibration techniques used nowadays by several artists, in order to match the mesh distortion of real and virtual object. Such an example will be studied later, presenting the case of "*EYJAFJALLAJÖKULL",* realized in 2011.
In his essay *"Spatial Correspondence in Motion Picture Display",* where the starting point are two experiments including *"Displacements",* Naimark fantasizes the ultimate media room;

> ***"The ultimate media room will be indistinguishable from reality. Imagine a real-time 'video flashlight'. The viewer holds a position-sensitive device which controls a projected image, always in front of the device. The image source may be a remote video camera or it may be from a computer database. The viewer IS the camera operator: it is an interactive system".*** [11]

His idea, groundbreaking as it was, engages an environment in an attempt of seeking the total immersion of the visitor. What is more, the novelty in this proposal expands to upgrading the simple spectator, to taking up the role of a co-auteur (as defined by Aziosmanoff), equipped with a tactile object; the visitor would then find himself in the middle of an unseen action that he could activate with the simple push of a button, a state of on and off, 0 or 1. In a way, Naimark's thoughts had already set the ground for an interactive stage design, which would follow years later.

iii. The counter-monument

> ***"The city operates as a monumental stage and a script in the theatre of our way of life, perpetuating our preconceived and outdated notions of identity and community, preserving the way we relate to each other, the way we perceive others and ourselves. An intense presence of historic monuments, advertising, communication media and urban events merge with our own daily personal performance into one uniform aesthetic practice dangerously securing the continuity of "our" culture. Media art, performance art, performative design: they must interfere with these everyday aesthetics if they wish to contribute ethically to a democratic process."*** [12]

One of the pioneers to have worked on the medium's illusionism in the public realm, in order to penetrate beyond selected, monolithic structures of political and social importance (monuments, civic buildings, museums), is the polish artist Krzysztof Wodiczko. His guerilla-like projections have always been used as a means to disturb the order of a seemingly neutral, urban context and wake the public up, from what Barthes has described as the

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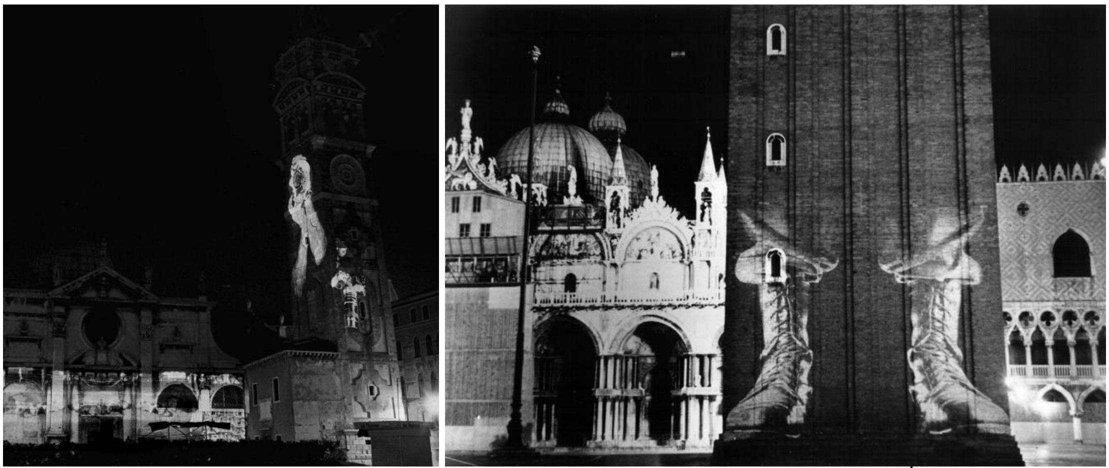
[11] *M. Naimark,* ***Spatial Correspondence in Motion Picture Display,*** *in* ***SPIE Proceedings, vol. 462, Optics and Entertainment.*** *Los Angeles, 1984.*
[12] *K. Wodiczko,* ***Open Transmission,*** *in* ***Architecturally Speaking: practices of art, architecture and the everyday.*** *Edited by A. Read, London: Routledge Editions, 2000.*

"oneiric function"[13] of a building. Here, the focus lies on redefining the way that the modern society of the unleveled information copes with knowledge, memory, its preservation and its loss. A new method of commemorating is being studied, freed from the established monumental forms and the use of noble materials, such as marble and metal. The *"lieux de memoire"*[14] in which this kind of work is introduced, are carefully selected, in order to make people undertake their role as witnesses and bearers of the history of a place.



img.06: K. Wodiczko, ***Screening on Campanile in Piazza San Marco during 42nd Venice Biennale.*** *1986.*

In the bounds of the 42nd Venice Biennale, Wodiczko was the commissioned artist representing Canada. His work consisted of four projections, dispersed in carefully selected spots in the city: the Condottiere Bartolomeo Colleoni Monument at Campo Santi Giovanni e Paolo, the St. Mark's Campanile at Piazza San Marco, the Porta Magna (the main gate to the Arsenal), and on the façade of the church and bell tower at Campo Santa Maria in Formosa. In an unpublished interview he gave during the fall of 1986, he explained that the Campanile in particular had always been one of the most important elements of the urban fabric, because it bore very close liaisons with the neighboring public piazza. The bells would ring to draw attention to the gathering of people under various circumstances: *"official parades, galas, processions, executions, welcoming the troops to their home or seeing them off, accepting or rejecting public announcements, even capitulating to foreign powers"*[15]. Therefore, the duo piazza-Campanile has always been a powerful container of mediated memories.
Using the façade of the latter as canvas on which he would unfold the underlying layer of the specific urban experience, Wodiczko projected at a gigantic scale, a series of alternating, symbolic signs of the piazza's past, as well as of its transformation into Disneyland. A pair of legs wearing army boots appears. It fades out to be succeeded by two hands holding steadily

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[13] *The term "oneiric function" describes the status of a seemingly passive object in our routine gaze, but, at the same time, an object that insidiously imposes on us a certain point of view, lulls us into a dream about the real conditions of life.*

[14] *The term "lieu de memoire" was primarily introduced by the French historian and member of the French Academy Pierre Nora, in his work "Lieux de memoire", written between 1984 and 1992. It depicts "the exact spot where memory crystallizes and finds shelter".*

[15] *K. Wodiczko,* ***Open Transmission,*** *in* ***Architecturally Speaking: practices of art, architecture and the everyday.*** *Edited by A. Read, London: Routledge Editions, 2000.*

a camera in order to take a picture. The ostensible harmless and playful succession of images is eventually interrupted in midnight, by the ringing bells. Apart from reminders of the moment that just passed by, their sound also refers to the layers of reality that have passed and left their scar on the same spot.
Projected at this scale, the image sequences signify a fissure in the city, highlighting the importance of the illuminated spot. Though the numerous slides were altered to match the architectural structure, scale and details, what is of importance here is not the emergence or the distortion of the architectural elements, as seen in the case of the Topoprojections; instead, it is the sociopolitical context that needs to be brought to the attention of the visitor, or the citizen; and since built architecture represents power, these media-augmented structures can inherit the representational power of architecture as well.
Sound, or even better the absence of it plays a crucial role in this work as well. In contrast to today’s spectacles that consider light and sound as two elements intertwined, Wodiczko gives the opportunity to the city to speak for itself. After all, the piazza from its first appearance represents the cradle of Democracy, a place to hear and to be heard. In the case of the Piazza San Marco, the musical conversation comes from two orchestras, competing against each other over a European/American restaurant/operetta repertory. Nonetheless, from times to times, even that is covered by the ring of the bells, driving thus the attention back to the Campanile and to the past.

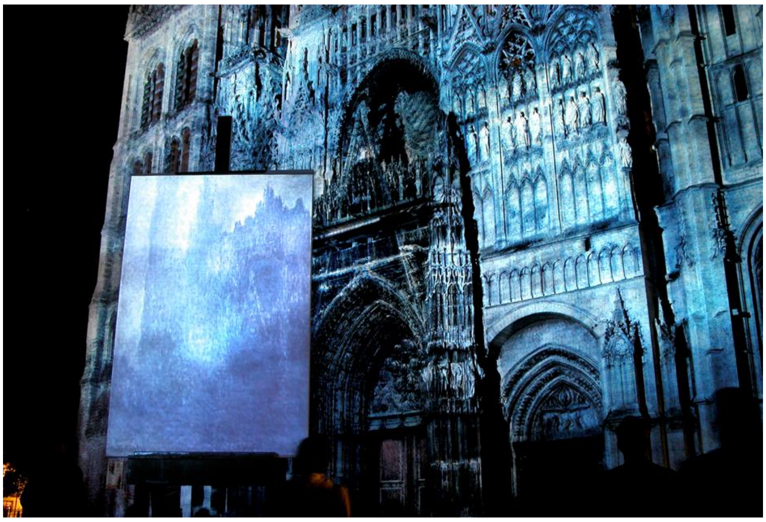
b/ THE LUMINOUS EXTRAVAGANZAS OF THE MODERN METROPOLIS

Taking a few steps further from the initialization of the digital artists to the medium, the first large-scale, 3d video mapping installations in the urban context emerged in the early 2000’s. This was the outcome of multiple factors; high light output projectors became more affordable (major installations could need around 20 projectors), accurate 3d scanners would facilitate the quick and precise documentation of architecture, whereas a number of software programs were spread in market permitting the real-time adjustment and easy calibration of the imagery. In the same time, the technical adversities of such projects (apart from its high cost) would become evident. The offered canvases hid certain restrictions; the façade should have the less possible glass due to mirroring effect issues, moreover it should be light-colored and matte-finished with a good reflectance for a satisfying level of visibility of the projection.
The integration, as well as the behavior of the image in the bounds of the city’s artificial environment, reflect a number of projected spatialities and contribute to the demystification of the built. Nonetheless, this same environment undertakes a thematic mystification, relevant to the plot of the projection’s scenario. The mechanical reproduction of the image carries the ability to weaken the strict, tectonic language of the building and to sketch morphological expansions on the material.
Consequently, the notion of the façade is revisited, in order to present a dissimulating screen of both moving and still imagery. It transforms into a dematerialized, floating plane, whose luminous iconography offers a transitory and ephemeral dimension to architecture, in a way that facilitates changeability and movement. Projection mapping adds new dimensions to the public space. We can therefore talk about an architecture that extends out, onto the city, functioning as a site of communication and interaction, adding up to becoming a newly envisioned public, immersive space.
Creators have now been given the freedom to envisage uncanny realities for the face of the city: they can change colors, volumes, materials, they can accentuate or eliminate elements, and they can even create space where there is just a wall. Nonetheless, all of this is produced by the well-polished demands imposed by the “société du spectacle”. Today it is

not a single artist, but a well-equipped team, working feverishly on the delivery of an even more phantasmagoric than the last one, ephemeral show, hosted either by one of the numerous new technology festivals (such as "Genius Loci" in Weimar, the "Mapping Festival" in Genève, and light festival in Lyon), or funded by a big commercial brand.

i. Notre-Dame de Rouen, Sagrada Famiglia: two different approaches on the lecture of the cultural heritage.

Cathedrals have always been one of the most alluring building types on which to paint with light. This emanates both from their emblematic figure but also from a playful, artistic attitude that aims at using the digital in favor of the valorization of the architectural heritage, while in the same moment reversing the intimidating, monumental facades. Big and impressive in scale, with a characteristic architectural idiom that can feed interesting scenarios (historic facts of the surrounding area, or elements of the building itself are commonly used) and a challenging design to handle as far as it concerns the masks that need to be created, the new tendency necessitates for the gothic, grey, stone canvas to be swept by a fluid, polychrome, animated mosaic, after the sun has set.
The emerging question is eventually the following; how can we redefine the perception of symbolic points of reference in the city with the aid of light? Two of the most reputed spectacles that belong in this category, are the *"La Cathedrale, de Monet aux pixels"* on the Cathédrale Notre-Dame, in Rouen (2004) and the posterior *"Ode à la vie"* on the Sagrada Famiglia, in Barcelona (2012).

*img.07: C. Monet, **Le Portail et la tour d'Albane à l'aube**. 1892-1894.*
*img.08: H. Richard and J.M Quesne (group Skertzo), **La Cathédrale, de Monet aux pixels.** Notre-Dame de Rouen, 2004.*

In 2004, the creative group Skertzo was invited by the city of Rouen to participate in the *"Festival Normandie Impressioniste"*, in order to create a show of lights, part of a European program promoting architectural heritage of cathedrals. The proposal of the Skertzo was to view the Cathedral under the aspect of the passing time, an integral part of the reality, as described by Claude Monet; the artist who would take his easel and come every day, every possible hour, to produce a certain image of the reality, the one that he was seeing the very specific moment. Inspired by the impressionistic brushstrokes, the group re-narrated Monet's style with the aid of digital tools, and then projected the produced image onto the real object, from which it was initially conceived. In a way, this technique brings to mind Michael Naimark, who too projected the image of an object, onto the actual object.

Nonetheless, in Naimark's case, the projected image was an exact replica of reality; here, the interest lies on the distortion of reality, through the lens of the unique perception each individual has over it, each time of each day; if we asked a hundred passers-by to sketch the Cathedral of Rouen, we would end up with a hundred different images, the superimposition of which could lead to a really interesting outcome.
As reference to Monet's artistic routine, an easel is placed on the exact spot where he would paint. The object restores the notion of the scale, adjusts the relation between the human bodies with the body of the city and resembles to a magnifying glass of what is taking place just behind it. What is more, with this gesture, the projection has been detached from the limits of the monumental façade and the interest has jibed towards the relationship created with the citizen or the tourist in the parvis of the church, as well as his redefinition of the spatial boundaries. During the day, the fast pace of the passer-by is interrupted by the easel found in his way; an unfamiliar object in the urban fabric. The eyes roll upwards to redefine an already well known landmark of the city, which has now emerged as the focusing point of attention.

> ***"The parvis becomes what Michel de Certeau has described as a "friction point", that is to say a space where we can practice a variety of actions, far from the imposed code. The façade, a place where the eyes meet, becomes the reference point. Bodies and regards converge towards a surface that captures the collective attention."***[16]

The organic, fluid succession of the semi-transparent images representing the Cathedral in various moments and under different weather conditions, imitates the real interplay of light, shadows and color that either way has been evolving on the facade every day; only this time its translation into an ephemeral spectacle has succeeded in rendering the precipitated passer-by into an observer. The specific intervention on the façade can be considered as a smooth one, where the virtual coexists peacefully with the real, what is more there is a direct correlation between the projection and the building itself.
On the counter side of this example though, is found the multimedia show projection on the façade of the *Sagrada Famiglia*, assigned to the creative group Moment Factory in 2012, in the bounds of the Mercé festival, in Barcelona. *Sagrada Famiglia* is one of the most famous works of Anton Gaudi, who regarded the specific cathedral as the first one, of the many to follow under the same architectural vocabulary; it has a width of 30 meters, an intricately sculpted façade, and a series of emblematic, 100-meter, helical towers. Its construction started in 1884, but left unfinished due to Gaudi's sudden death in 1926. However, the crypt, the arches, as well as the façade of the Birth were all built under his supervision.
The idea for the visual graphics was inspired by a series of colorful, rough sketches, depicting the final outcome as imagined by the architect. Beginning with a sole beam of white light that explodes and splashes all over the building, the façade transforms in turns into a huge fountain of water, a volcano emitting lava, a garden full of green, flowers and butterflies or even an underwater world, themes all too descriptive, that in the end had no conceptual relation with the original vision of the building, as advertised. Although this is a technically integral show, put together by a team of more than a dozen people, using their own calibration software system named X-Agora, as well as sixteen video projectors, thirteen computers and seventy lighting fixtures, the final outcome is nothing more than a visual show that describes the capabilities of the latest technological updates. The superficial

[16] *S. Labelle,* ***Le spectacle 'La Cathédrale, de Monet aux pixels' : réécriture monumentale d'un espace public,*** *in* ***Études de communication, vol. 31.*** *2008, pp.63.*

dazzle of 32.000 witnesses is now possible simply by the explosion of colors, by the intense, rapidly blinking strobe lights and the accompaniment of epic music.

*img.09: Moment Factory, **Ode à la vie.** Sagrada Famiglia, Barcelona, 2012.*

ii. Projections as means of advertisement

During the '00s the acclaim of projection mapping among artists expanded significantly as the technological advancements enlarged the medium's possibilities and made both hardware and software more affordable and thus accessible to the public. One of the domains in which projection mapping has largely infiltrated in the urban context, is advertisement. Though presented in a more flexible way than the harshly installed media facades in all modern metropolises, the projected images still cover the buildings to evolve into a spectacle of consumption that has eventually reached a new level.
Projection mapping is eagerly adopted by the large commercial brands as the prominent, innovative, experiential tool to seduce consumers into buying new products. A series of promotional events is organized, projecting on the façade of the brand's headquarters, or even on the volume of real cars, in the case of the car industry. Otto Riewoldt describes this example using the term "brandscaping", that is to say promoting the brand by creating

unique spaces. In his words: "Brandscaping is the hot issue. The site at which goods are promoted and sold has to reinvent itself by developing unique and unmistakable qualities."[17] Nonetheless, these qualities have degradated in nothing more than a marketing fiesta, so powerful that has an indeed global impact. The ephemeral dimension of mapping reinforces even more the idea of blind consumerism.

img.10: ***Ralph Lauren 4d Light Show.*** *New York, 2010.*

One of the biggest productions of the last years is the Ralph Lauren 4D show, which took place in two scenes, on the company's central offices in London and New York, in 2010. Self-advertized as the first of the luxury brands to have ever attempted this, the production team has incorporated real footage of real products, real models, even real horses, in order to build their narrative on the surface; Belts wrap around the building, ties hang from the roof, models walk the runway, suddenly we find ourselves watching a polo game, Larph Lauren himself waves to the spectators from a window, all in all a spectacle that ends with four giant perfume bottles spraying the audience, while in the same time real perfume is emitted in the atmosphere. Having at their disposal all the latest technology software - a custom-made calibration program named D3, an accurate laser scan to capture the geometry of the buildings, a 30*10 meter green screen to even shoot a real, outdoors polo game – the company came up producing a visual extravaganza that has nothing to do with the building itself and reinforces the idea of the spectator's, observer's and consumer's passive behavior in this mega-public space.

With reference to this example, we could even be talking about a trivialization of the expressions of projection mapping on architecture, which are doubtless long-distant from the artistic side of the medium.

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[17] *O. Riewoldt, quoted in L.Manovich,* ***The poetics of Urban Media Surfaces,*** *in* ***First Monday, Special Issue#4: Urban Screens: Discovering the potential of outdoor screens for urban society.*** *http://firstmonday.org/ojs/index.php/fm/article/view/1545/1460*

iii. Interactivity and public space.

> ***"The great function of the city is to encourage the greatest possible number of meetings, encounters and challenges between all persons, classes and groups, providing a stage upon which the drama of social life may be enacted, with the actors taking turns as spectators and spectators as actors."*** [18]

Conceptually similar to détournement, constructed situations, psychogeography and derive -Situationist practices which aimed at infusing artistic energy in the everyday urban framework, so as to revolutionize the life of the citizen by emancipating the individual consciousness from the alienating conditions of the spectacle- the interactive media art installations too aim to rejuvenate public space through inventive and playful, technologically mediated interactions in which individuals can develop into active participants. The significance of the body activity in relation to the virtual environments has long been mentioned since the '80s, when Myron Krueger reflected on the design of a responsive environment, "in which a computer perceives the actions of those who enter and responds intelligently through complex visual and auditory displays".

The injection of ephemeral artistic zones in the urban realm reappropriates certain elements of the Situationists' critique of the modern city, as well as their theories on revolutionary public interventions. Participatory artistic experimentations, such as *'Perspective Lyrique'* (by the 1024 Architecture, in 2010), the '*Create your Own Kandinsky'* (by Andre Busek, Rico Poschel, Christian Schmidt and Sebastian Stein Metz, in 2012), or the significant '*Body Movies'* (by Rafael-Lozano Hemmer, in 2001), apart from being portals to an optical illusion, they also operate as urban catalysts for joining people in the same activity and creating a temporary community. Such kinds of practices oppose to the privatization of the public space and although they begin from the projection of an image onto the vertical screen of a façade, they eventually reclaim the role of a space, that is to say the public square, as topos of public engagement, interaction and discourse.

In the bounds of the festival *"La Fête des Lumières"* (edition 2010), the Paris-based group *1024 Architecture* produced an architectural mapping, on the façade of the *"Théâtre des Célestins"*[19], in Lyon. It is a site-specific project, tailor-made for this *"théâtre à l'Italienne",* the history of which, as well as its function became inspiration for the luminous iconography. Beginning with a wireframe detection of the building's details, moving on to a game of light and shadows that produces cavities and extrusions, the façade slowly acquires the visible texture of a second skin that weathers, so as to finally reincarnate into a face. As François

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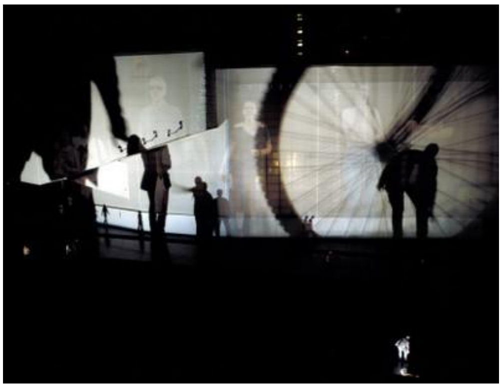
[18] *L. Mumford,* ***The city in History: Its Origins, Its Transformations and Its Prospects.*** *New York: Mariner Books, 1968, pp.298.*

[19] *The origin of its name comes from the foundation of the Order of the Célestins in the 13th century, who formed their monastery in Lyon. The Covent was abolished by the decision of the Pope, on the 30th of September 1778 and during the French Revolution the former church was purchased by an individual who transformed it into an auditorium, by the name of "Théâtre des Variétés". In 1792 it was renamed to "Théâtre des Célestins" and hosted mainly dramas and varieties. The theater was then sold to the municipality of Lyon in 1838, but eventually burned to the ground in 1871.*

In 1873 the Municipality announced a design competition on for the reconstruction of the "Théâtre des Célestins" in order for it to "be appropriate for hosting comedies, farces, dramas, faeries, operettas and similar genres". This theater, designed by the architect Gaspard André, was inaugurated in August 1st 1877. Its façade was decorated with columns, the attic carried carved garlands, lions and angels, while a half dome roof bearing a pediment, crowned the building. In 1880 another fire destroys the roof and the scene. André rebuilds the theater based on the same plans; the only decorative addition are the five statues of the façade, those include the visualization of Comedy and Tragedy. The building went over another renovation in 2005, while it has been dedicated only to the lyric art since 1850.

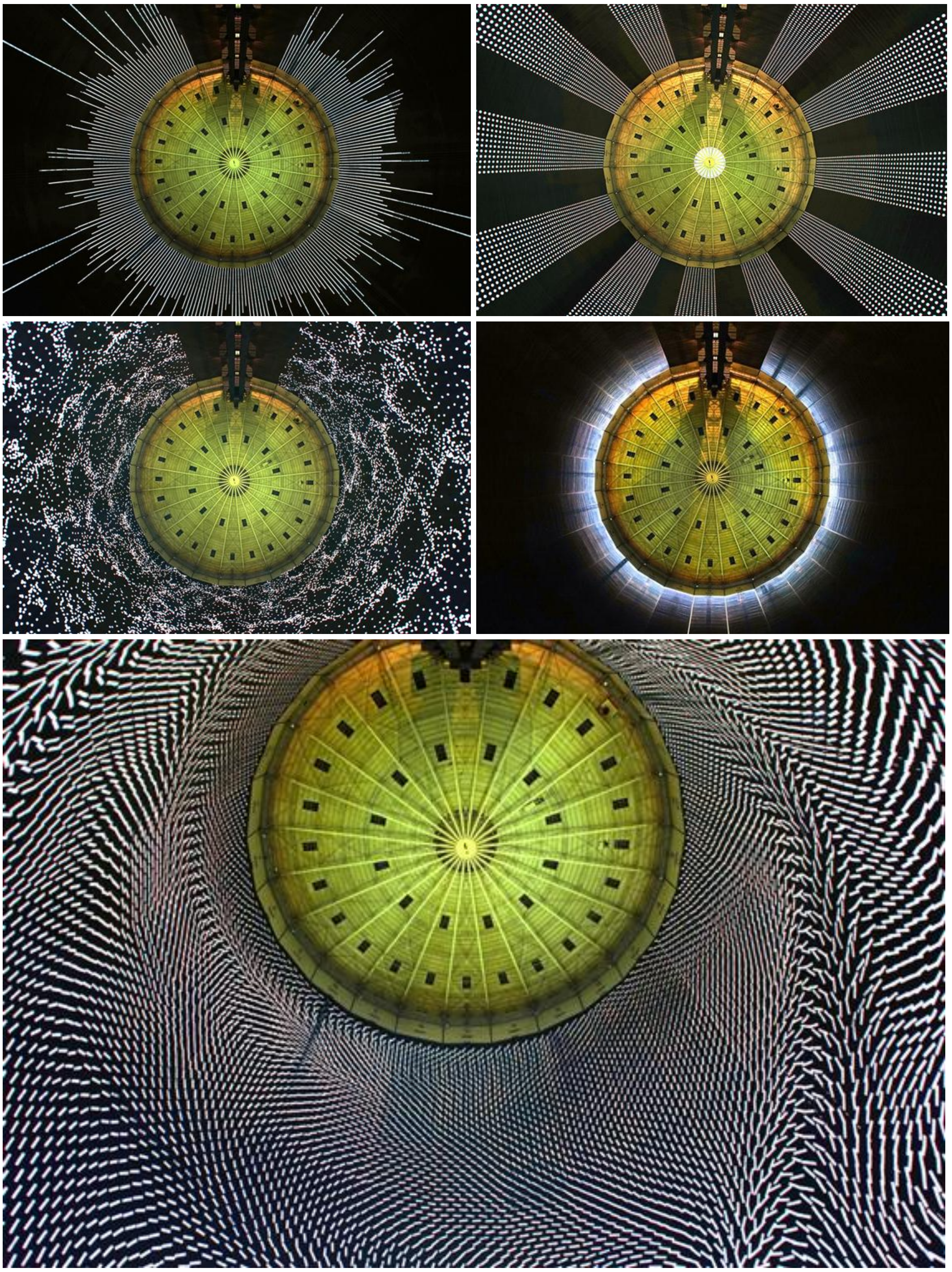
Wunschel points out in the lecture *"Architecture, Light and Rhythm"*[20], the final outcome of this screaming face could be classified more in the range of advertisement. The visual is nothing more than a very common effect in Photoshop; the liquefy filter. However, in this case it is not just a print, but it is applied on a building, that is to say an uneven surface. And this very simple effect, applied on a real surface has the ability to totally change the perception one has of the space, or the environment. Nonetheless, the interesting detail in this project is that for it to evolve, it seeks the participation of the public; that is to say, it uses a very significant tool of the digital arts in general, the interactivity. The spectators, one by one step onto a platform and speak, scream or sing to a microphone. Suddenly, the skin stretches, contracts, retracts, swells, the lips are moving… It therefore becomes evident that it is the audience's voice the factor that controls the visual deformation on the installation.
A more artistic approach though, that fully involves the human body in an augmented reality installation, is the Body Movies, that was exhibited for the first time in Rotterdam, in 2001. The motion of people passing by the location of the installation is captured by cameras, and then translated into a projected shadow that moves in real time. In parallel, photos of citizens of cities around the world are also projected on the building façade; nonetheless, their portraits become visible only when the shadows are cast on them. The project invites the passer-by either in a solo performance, or in a collective interaction with the other sharers of the specific physical location; a play is interweaved between the shadows and the portraits, mirroring the activity of the city in an unconventional way, as the silhouettes are not reflected as is, but as large, distorted shadows. The artist explains the role of the silhouette as follows: *"the shadow*[21] *was not an avatar, an agent, nor an alias of the participant's body, it was remote absence, the exclusion of the body, effected through the body-double, the cut-out, the not-transmitted, the shadow."* By replacing the digital reflection of the individual with a shadow, a transformed visualization is created; one where the boundaries of the human body do not coincide with the virtual replica, creating thus a space of amplified consciousness of one's body, in relation to the others. The importance here lies in using the projected image, as a means to engage people in sharing a common experience, in a common place, adding and subtracting audio-visual elements which autonomously demomentualize the identity of buildings in urban contexts

img.11: 1024, ***Perspective Lyrique.*** *Projection on the facade of the "Théâtre des Célestins", Lyon, 2010.*
img.12: Rafael Lozano-Hemmer, ***Body Movies.*** *Rotterdam, 2001.*

[20] *Pierre Schneider and François Wunschel of 1024 Architecture, gave the lecture* ***Architecture, Light and Rhythm****, in the Architectural Association in 2013. The link to the video documentation can be found here: http://www.aaschool.ac.uk/VIDEO/lecture.php?ID=2269*
[21] *The shadow interface was a reference to Samuel van Hoogstraten's engraving The Shadow Dance which appears in his Inleiding tot de Hogeschool der Schilderkunst. The engraving, created in Rotterdam in 1675, depicts a light source placed at ground level in such a way that it transforms the shadows of the actors into demonic or angelic figures.*

iv. URBANSCREEN and the modern temple



img.13: URBASCREEN, ***320° Licht.*** *Spatial experience in Oberhausen, Germany, April 2014.*

This section will come to its end, with the most recent, enormously large-scale projection mapping project, entitled "320 Licht", produced by the Bremen-based group, URBANSCREEN.
For the needs of the exhibition *"DER SCHONE SCHEIN" ("THE APPEARANCE OF BEAUTY")*, URBANSCREEN were commissioned to produce an installation within the 120 meters high ***Gasometer*** of Oberhausen, in the heart of the Ruhrgebiet. The creators decided to take advantage of the obviously challenging 20000 square meter surface, and actually play with the feeling of awe one faces when entering the space, while the eyes are struggling to define

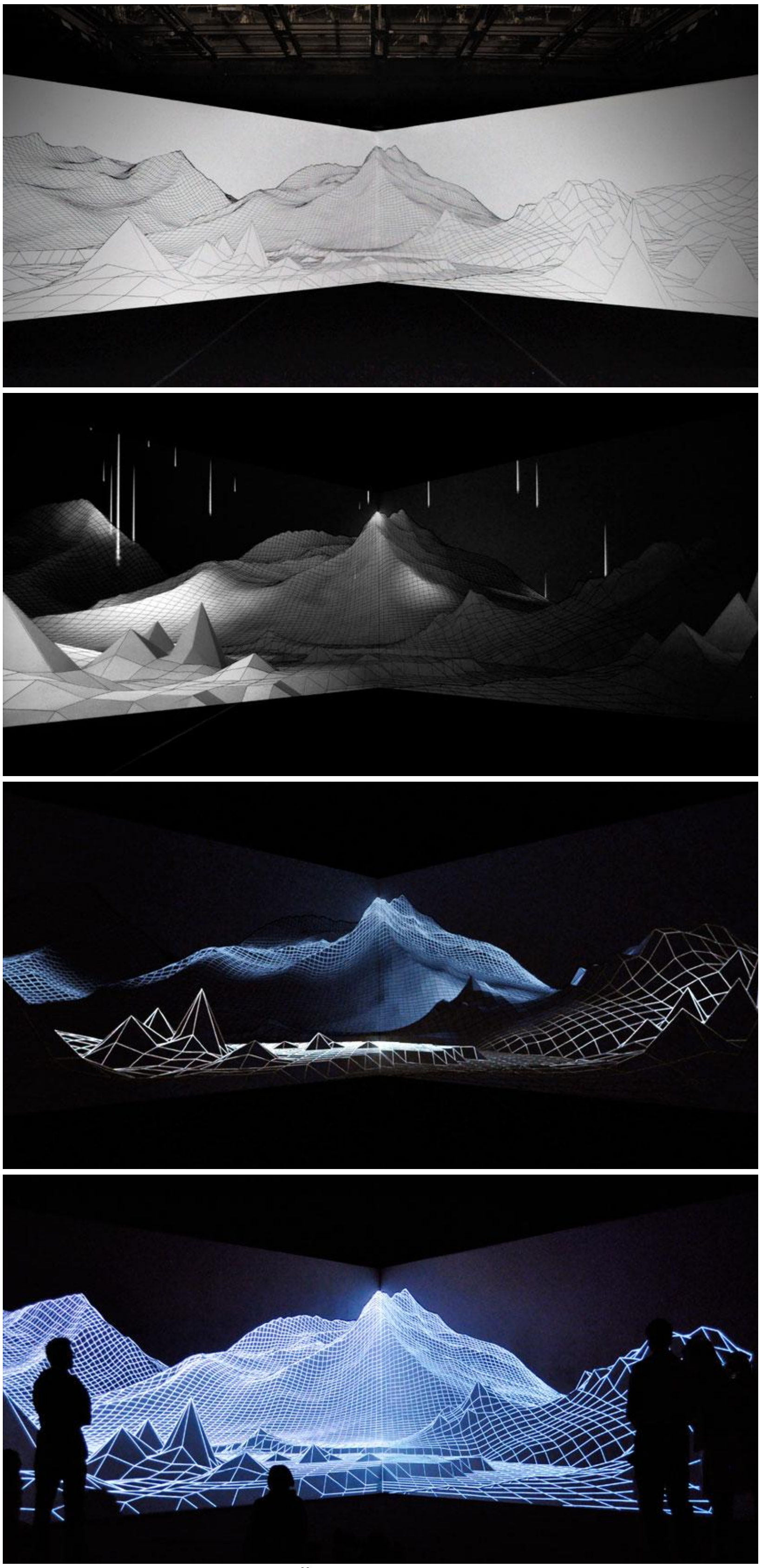
the boundaries that are painted in black tar (fact that helped create illusions unable to work on white surfaces), and try to understand the relative scale.
Having at their disposal 21 interconnected projectors, they wrapped their ideas around a radius of 320 degrees, in order to create an immersive spatial experience of graphics and light that destabilizes the spectator's eye. The unshakeable, cylindrical, metal gas tank gets a 22-minute breath of life that loops over and over. A series of kinetic graphic patterns deploys until the top. Sometimes the structure is orthogonal, with continuous white lines defining volumes approaching or drawing off from the spectator, creating balconies or niches. Some other times these lines become shorter and behave like swarm or iron filings; the interior of the tank transforms into a fluid, wavy membrane, which oscillates similarly to the metal armor of the knights. All these visual effects evolve accompanied by a sound collage of saxophone tones, superimposing and merged with their own echo, as well as with the voice of the visitors.
The size of the space, as well as the accentuated vertical dimension that ends to a semi-dome roof, automatically bring to mind the spirituality one feels inside a cathedral. The person is found alone in a dizzying atmosphere, a constantly deforming volume that plays with the illusion of the space changing scale, expanding and shrinking; in the end, he can't discern the tangible from the virtual. Here, the exaggeration of the scale is used as means for the fascination and intimidation of the public. Could we be actually talking about a new era of iconolatry that celebrates the spatial diffusion of the virtual image?
In the group's words, *"What we are really heading for is to catch the audiences' attraction, leading them into another urban storytelling. If they accept and are not disturbed by excessive realization, the audience can be magnetized as if they were watching a touching movie or theatre piece. The age of the screen is coming to an end. Digital interfaces will dissolve and merge into the social space"*.[22]
Projection mapping is therefore no longer used only for the creation of a simple succession of pictures, but it also undertakes the conception of an entire space.

c/ EXPERIMENTAL USES OF MAPPING IN ART

During the past few years, a vast number of young creators have been working on abstract, artistic approaches over the redefinition of small-scale architectural spaces, with the use of light and shadow. Whether this shall be an abandoned garage, a gallery, a small theatre, a hand-made 3d structure, or even a piece of paper, these creations reflect on the space as the solid, physical layer, on which they superimpose a virtual one.
Another factor that plays crucial part in such kind of installations is the relation between time and space. Therefore, the interest turns towards manipulating the scale of time that the visitor experiences when entering the space, as well as towards creating a micro-spatial-temporal climate through the immateriality of light.
The movement of the viewer in the space in which the piece is placed is fundamental too; how it creates almost mental barriers of light and shadow, where is the light, where one is projecting one's own shadow. It is interesting to see people not to trespass that barrier which is not a physical barrier but a mental one.
The general interest of these experimental efforts lies on breaking the boundaries of the rectangular screen format and on integrating the projection into the surrounding, real world; that is to say projections onto walls, structures, or transparent materials. All in all, there is a focus on the idea of projecting light in the space.

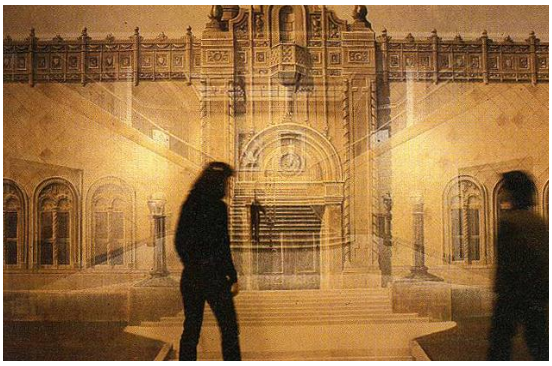
[22] *http://www.urbanscreen.com/about*

i. The revision of trompe l'oeil in the digital era.



*img.14: ANTIVJ, **EYJAFJALLAJÖKULL.** New York, 2012.*

In April 2010, ANTIVJ were invited to participate in a festival organized by the OneDotZero, in the bounds of which they would develop a project from the scratch during their three-week residency, in EMPAC, New York. On the day of their arranged departure, the Icelandic volcano Eyjafjallajökull, begun to erupt, all flights in Europe were cancelled, resulting to the abolishing of the original artistic plan, as well as of the time schedule. With only five days left to work on site, the group decided to forget the idea of projecting on a complex 3d structure and to work with the technique of reverse mapping[23], which would permit them to exploit to the maximum their available setting; two perpendicular, flat panels.
Reverse mapping can be achieved by creating the virtual space in a 3d modeling program, such as Maya or Cinema4d. The still image is then projected on the real environment, and the artist actually draws over the projected geometry. Finally, it is the layer of the projected light that adds depth to the flat visuals.
This technique makes reference to older ones that expanded the architectural space through the illusion of perspective, such as seen in the murals of the *"Villa dei Misteri"*, in Pompeii, or in the various examples of the posterior *Quadratura*. The term *Quadratura*, refers to the technique used in the Italian renaissance baroque to extended architecture through the *"trompe l'oeil"* and perspective constructions generated with paint or sculpture. The technique has been adopted over the more recent years by many artists, such as the North American muralist Richard Haas, who mainly works on neglected spaces, or unfinished facades, with the intention to give sense or enrich a part of the urban context that has gradually lost its own expressive capacities. In 2010, Pablo Velbuena also worked on a revision of the Quadratura, where the light takes up the role of paint.
In the digital era, the immersion proposed by the technique of *"trompe l'oeil"* is even more augmented by a double projection: the first one being the 2d graphics on the wall, and the second one being the games of light, superimposed onto the first.
In the case of "*EYJAFJALLAJÖKULL"*, a wireframe mountain-like landscape was painted directly on the two panels, making obvious reference to the volcano that occupied the news that period. The spectator's point of view in combination with the perspective of the camera, were calculated in such a way that a new reality was actually created in the empty corner. A one-point perspective and a 50mm virtual lens were used, to guide the audience's sight towards the center of the piece.

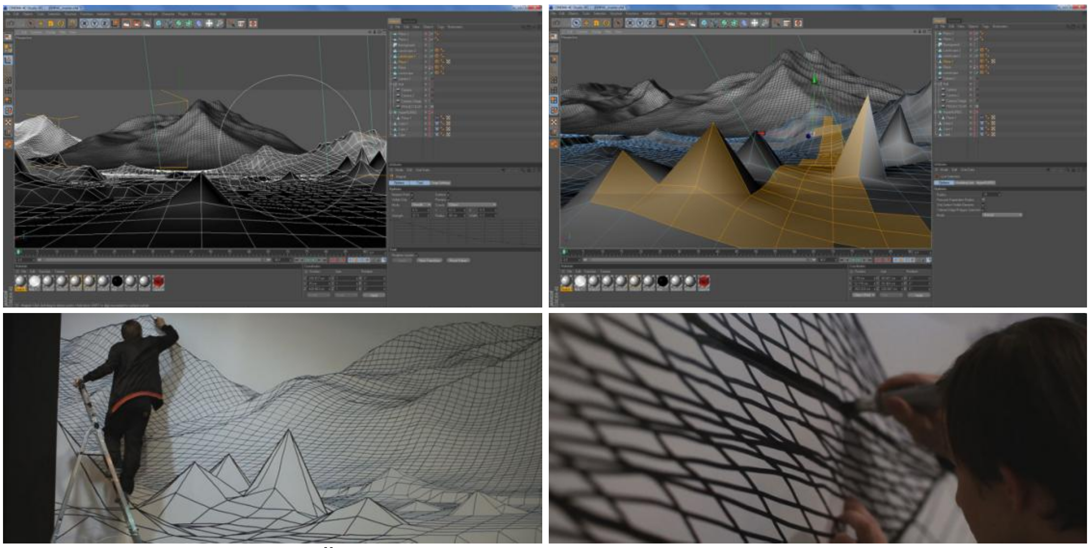



img.15: A. Pozzo, ***Dome of Sant'Ignazio.*** *Rome, 1685.*
img.16: R. Haas, ***Walker Façade Scrim.*** *Created for the exhibition "Eight Artists: The Elusive Image" at the Walker Art Center, Minneapolis, Minnesota, 1979.*

[23] *Joanie Lemercier had already worked with a similar technique in a stage design project he completed for a Dubstep night at the Croft, in 2008. The documentation video can be found in the following link: http://vimeo.com/2690618*

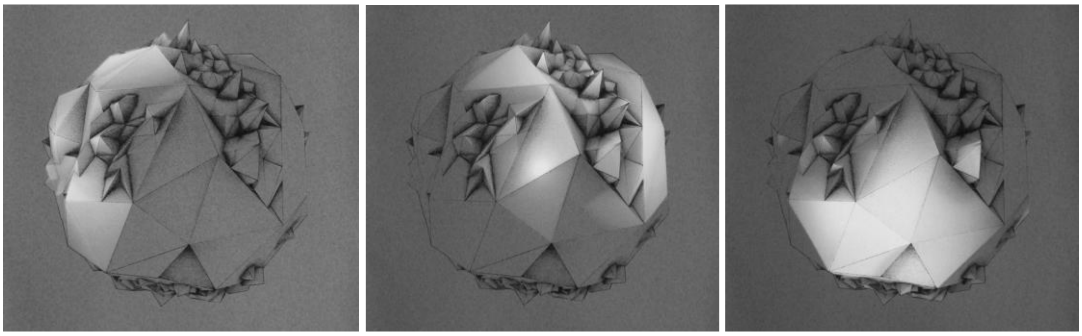
img.17: P. Velbuena, ***Quadratura.*** *Madrid, March 26th-May 9th, 2010.*

The parameter that distinguishes this type of mapping from the others we have been discussing so far is the fact that this is not a project designed specifically for the given space; there are no elements of the space to be highlighted, neither are there any restrictions on where to project on. On the contrary, this could be regarded as a new category of mapping, freed from the 3d support, able to adapt on any given screen. It could also emerge as an innovative scenography technique, adjustable in any space, though its main theme could change according to the scenario.



img.18: ANTIVJ, ***EYJAFJALLAJÖKULL.*** *Reverse mapping, New York, 2012.*

In a more artistic approach, the technique of using light to transform into 3d what only has two dimensions, was recently readopted by Lemercier in a series of Light Canvases he exhibited on May 2014, in Gallery Lemarié Jeudi. A series of triangulated ink sketches acquire body and evolve into polyhedral volumes, the faces of which are gradually explored by an autonomous, invisible torch. The significant difference in this artistic approach is the dipole scale-speed factor. Given the fact that the projection surface has moved in the interior of a gallery, the artwork becomes smaller, so does its distance from the spectator, who can now approach and study it in detail. The minor calibration issues are now evident to the eye; nonetheless they are not of aesthetic importance as they are absorbed by the canvas. What is more, in contrast to the intense and the fast switching patterns used for outdoor projections, here light is used in a more poetic and natural way, similar to a fluid dripping slowly on the volume it reveals. Circulating in the gallery space, one observes five projectors hanging from the wall, revealing the source of life. Could we be talking about an emerging, new kind of art, where each painting is accompanied by its own projector?



*img.19: J. Lemercier, **Light Canvas IV.** Projection mapping on screen print, Gallery L.J., 2014. (Visit to the gallery on May 5th 2014)*

Could we even be talking about exploring new possibilities, by the visual deconstruction of old masterpieces, as in Peter Greenaway's recent series of *"Nine classic paintings revisited"*? Inspired by Lamartine's phrase *"Just because you have eyes, doesn't mean that you see…"*[24], Greenaway creates a dialogue between the fixed (dating back 2000 years) and the moving (dating back 150 years) image, expanding the understandings of the artwork, as well as correcting notions of vision as we perceive them in the 21st century.

*img.20: J. Lemercier, **Light Canvas.** Projection mapping on screen print, Gallery L.J., 2014. (Visit to the gallery on May 5th 2014)*

From Rembrandt and *"The Night Watch*", to DaVinci and *"The Last Supper", or* Veronese and *"*The Wedding Feast at Cana"**,** all the way up to Jackson Pollock, Greenaway's critical iconography of these classical paintings, is actually cast on scrupulously manufactured clones of the originals. Each of these artworks having a different significance, they had to be treated differently and presented in a certain context. For example, in the case of the Last Supper the contrasts of light emphasize on the space, on the solidity and the harmonic association of the 2-dimensional versus the 3-dimensional, as well as on the interplay of the hands and gestures, producing a dawn-to-dusk narration in a form of a highly theatrical work. As Greenaway himself wonders, *"In the digital age, having new ways of storing what we believe to be valuable, how can we even tell what is real and what is illusion?"*[25]

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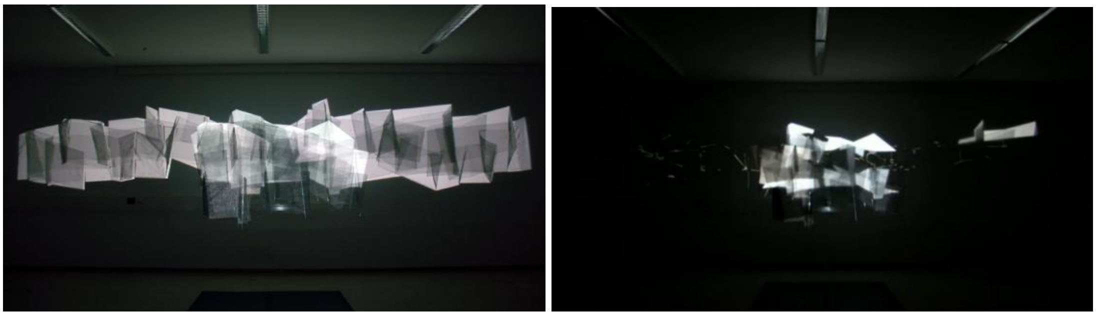
[24] *This phrase was cited by Greenaway, in his lecture **Nine Classic Paintings Revisited**, which he gave in The Avenali Chair in the Humanities, UC Berkeley, on September 14, 2010. The documentation video can be found in the following link: https://www.youtube.com/watch?v=plWSGEAuD_0*

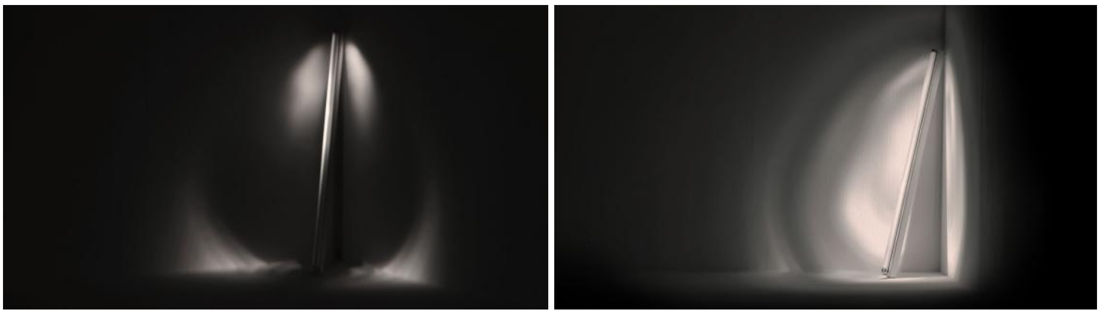
[25] P. Greenaway, ibid. pp.

img.21: P. Greenaway, ***Leonardo's Last Supper: a Vision by Peter Greenaway.*** *Park Avenue Armory, New York, 2010.*

ii. A naturalistic use of the artificial light



img.22: F. Licht, ***2.30AT3.05.*** *Weimer, 2008.*



img.23: F. Licht, ***fla, flav.*** *Weimer, 2009.*

Two more recent examples of molding intriguing spatial qualities by the visual deformation of a structure come from Florian Licht and his Berlin and Stockholm based design studio, *"Lichtundsoehne"*. *"2.30AT3.05"* was created in 2008 and filmed during action, in their studio in Weimar. A light construction fabricated by semi transparent material and fishing line suspends in the middle of the room. Three projectors detect the geometry, sometimes highlighting the edges, sometimes the faces of the mesh, sometimes both. Space, sculpture, light, image and a high-pitched sound become one totalistic experience. Only in the last frame of the video, do we realize that we have actually been tricked; the real construction is only about the one-third of what we think we saw. The layers of the mesh-material actually create a shadow, which appears to be a three dimensional image on the wall. This, combined with a carefully calibrated video projection, creates an impeccable illusion of space and volume expansion. Their small-scale installation *"Fla, Flav"* was presented in 2009, in the Neues Museum Weimar, in the exhibition hall of the Bauhaus-University. The minimalistic composition consisted of a non-working fluorescent lamp leaning on a corner and a video projector.

Here, the projection is not strictly restricted on the mesh of the reclining object; on the contrary object and environment are regarded as whole, rejecting the need of boundaries' specification or meshes' calibration. The interest has been transferred towards the fluid movements of a torch-like light that explores the possible patterns and volumes produced, while it is cast from different angles, as well as when it appears and disappears in a non-rhythmic, random, almost spasmodic tempo. *"Fla Flav"* could be regarded as a modern interpretation of older sculptors' works, the quintessence of which revolved around the interplay between natural light and shadow. One of the most prominent examples would be the Greek sculptor Yerassimos Sklavos, who lived and practiced his art in Paris since 1957, until his death in 1966. Throughout his career, he explored the achievement of harmony in the volumes he created, via the inventive exploitation of a multidimensional light and the movements it evokes. The rays stream within the three dimensions, caress the planes and penetrate even the smallest cavity in order to become incarnate, rather than simply projected on the white marble. The abstract geometries *("The eyes of heaven", 1964),* as well as the organically conceived references to nature *("Psyche", 1961),* create effortlessly the visual illusion of breathing and being continuously remodeled, in a response to the natural light. In his own words,

img.24: Y. Sklavos, ***Psyche.*** *Parc de Vincennes, Paris, 1961.*

> ***"One of my areas of investigation is the relationship and harmony between modern architecture and sculpture in space and light, or the coexistence of the two. Can a sculpture at the same time be architecture, that is, can it be occupied, or vice versa, can architecture be aesthetically autonomous?***
> ***One of the serious problems that concerns me is the quest for and creation of life in the interior of the volumes, and also the movement and balance of volumes and the alteration of shapes of light, especially the composition and harmony of the works, the durability of the material for sculpture over time, and the color and its quality."***[26]

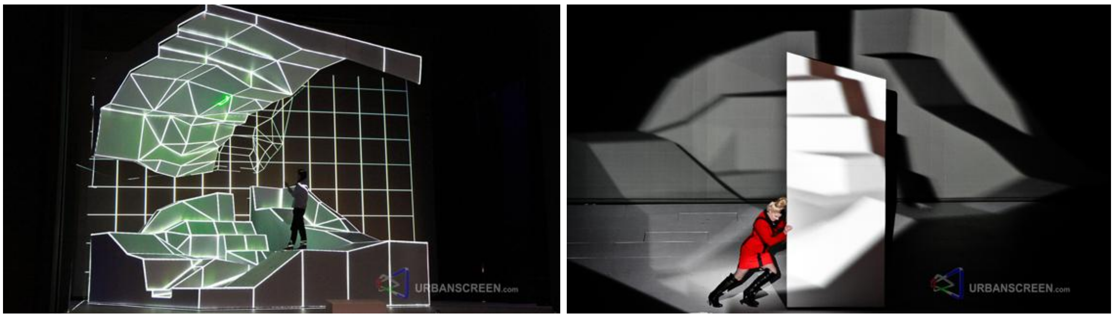
[26] *D. Iliopoulou-Rogan.* ***Sklavos: shaping the spirit, 1927-1967.*** *Athens: Editions of the National Bank of Greece, 1998, pp.78.*

iii. Towards a new kind of stage design

In 1925 Walter Gropius imagined the experience in the "Total Theater" as following:

> ***"An audience will shake off its inertia when it experiences the surprise effect of space transformed. By shifting the scene of action during the performance from one stage position to another and by using a system of spotlights and film projectors, the whole house would be animated by three-dimensional means instead of the flat picture effect of the customary stage. This would also greatly reduce the cumbersome paraphernalia of properties and painted backdrops.***
> ***The playhouse itself, made to dissolve into the shifting, illusory space of the imagination, would become the scene of action itself. Such a theatre would stimulate the conception and fantasy of playwright and stage director alike; for if it is true that the mind can transform the body, it is equally true that structure can transform the mind."***[27]

The possibilities offered by mapping, on the creation, transformation and amplification of the real space, have also encouraged the emergence of a new conceptualization of stage design. Scenography has well taken the leap into getting rid of all the excessive, decorative elements and has given room to light as the determinative factor of the adopted abstract aesthetic. A new type of space is offered, one that integrates its digital double into a hybrid perception of the two realities, where hybrid reality derives from the concurrence of a physical and an electronic reality, coinciding in the same space. In the words of Yona Friedman, *"This double architecture, real and virtual –architecture of memory- enables us to create feasible utopias."*[28]



img.25: URBANSCREEN, ***IDOMENEO.*** *Theater Bremen, Bremen, March 2011.*

img.26: E. Henze, ***The Human Seasons.*** *Royal Opera House, London, November 2014.*

[27] *W. Gropius quoted in S. Burt and C. Barker,* ***IOU and the New Vocabulary of Performance Art.*** *in* ***Theatre Quaterly, vol. X, n° 37.*** *1980, pp. 72-73.*

[28] *Y. Friedman quoted in , Y. Ait Kaci and N. Mestaoui,* ***Realites Hybrides.*** *Edition iDEALiD, pp.25.*

The examples are numerous, among them laying the sets for the opera *"IDOMENEO"* presented in the Theater of Bremen in 2011 and the epitome of scenography abstraction, the ballet performance *"Human Seasons"* presented in the Royal Opera House in 2014. In the first case, yet another example of the URBANSCREEN, the group decided to combine the projections with a multilevel, polyhedral, portable construction they designed themselves. The perpetual sequence of the moving images, along with the -able to rotate and move-structure, provided the scene with a variety of backgrounds for the performers to work on and around; from a simple edge detection, evolving to a frenzy-moving sea, to mountains, or to splashing waves, the final outcome was an ever-changing, yet minimal landscape.
With a free space of 9.2m high, 15m wide 16m deep, the *"Human Seasons"* set design consisted of six autonomous gold and black panels, divided into golden ratio proportions. Four projectors are illuminating the background and sides walls, coordinating a fluid transition from the geometrically shaped construction to the augmented, blurred shadows that split the monoliths *(Modeling and projector simulation of the stage was created using vvvv and After Effects).* As we have already seen in Lemercier's and Greenaway's works, here as well, time plays a significant role in the perception of the space. The stage transforms gradually, subjected to subtle changes, creating places to hide, reveal and highlight.

With these two examples comes to end a short overview of the last century's quest towards an immersive, hybrid environment. Projection has evolved from a simple membrane on a surface, into an experienced space; a means of publicity, or propaganda; a means of reacquisition of public space; a new means of creating art in general.

3/ THE FIRST EXPERIMENT: PROJECTION ON A WALL

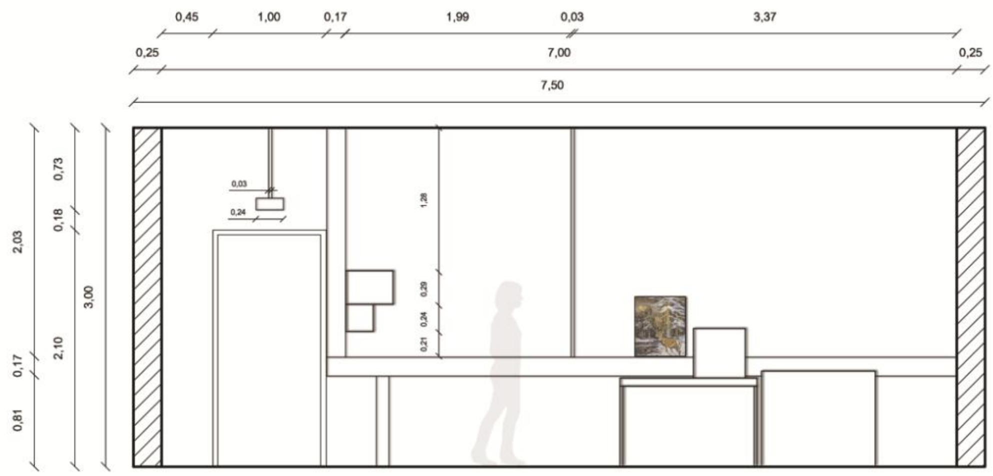
(The project was realized by Theodorou Ino, Georgakopoulou Nefeli, Kourkoulakou Sophia and Zamplaras Dionysis, during 02/12/2013-17/12/2013)

i. Project overview

Our first experiment on the technique of projection mapping was carried out during a two-week period, in December. The goal was to invite the visitor to an exploration of the space, with the purpose of vivifying the elements of which it comprises. A history of what could be happening in a fictious parallel universe would then be set in motion in a form of a puzzle, to be completed by pre-recorded animations. The installation uses a fish-eye projector and a kinect.

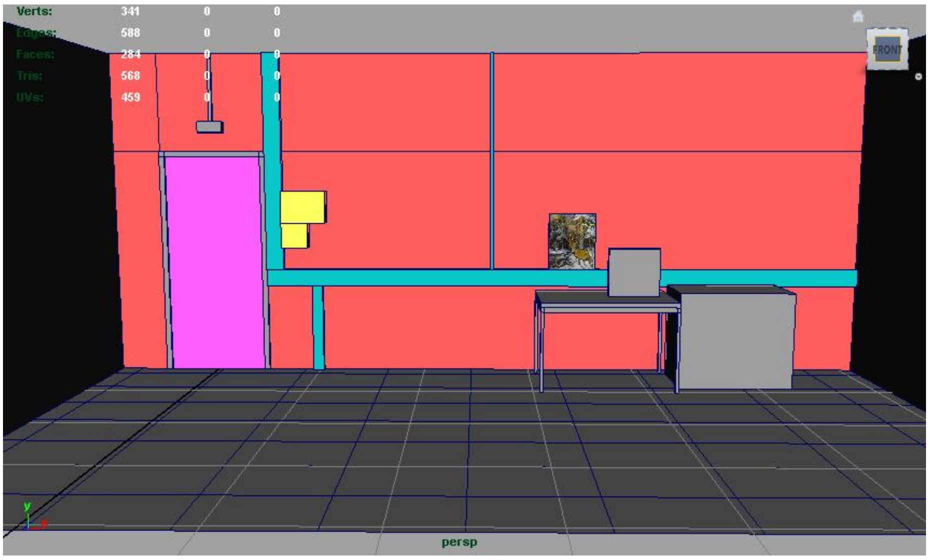
The initial desire was to use a derelict space that could create a mysterious atmosphere, both for us to be inspired for an interesting scenario, as well as for the visitor to be intrigued and eager to participate in the spatial wandering. Nonetheless, for technical reasons –that is to say, easy access to electricity and to projector- we chose to work in the auxiliary room, next to the salleM1, in the department of ATI. The room in question is a space of 7.50m * 3,50m, filled with a series of workstations all along its perimeter, that couldn't be removed, fact that automatically made our task harder. What is more, as we hadn't really experienced the specific space, nor did we have any memories attached to it, we decided to project on the only wall that actually bore some architectural elements to work with; a door, an exit sign, two electrical panels and an elongated plastic protrusion. This approach falls under the category of projection mapping that uses the existent architecture, as canvas to project on.

img.27: ***photo of the space, December 2013.***



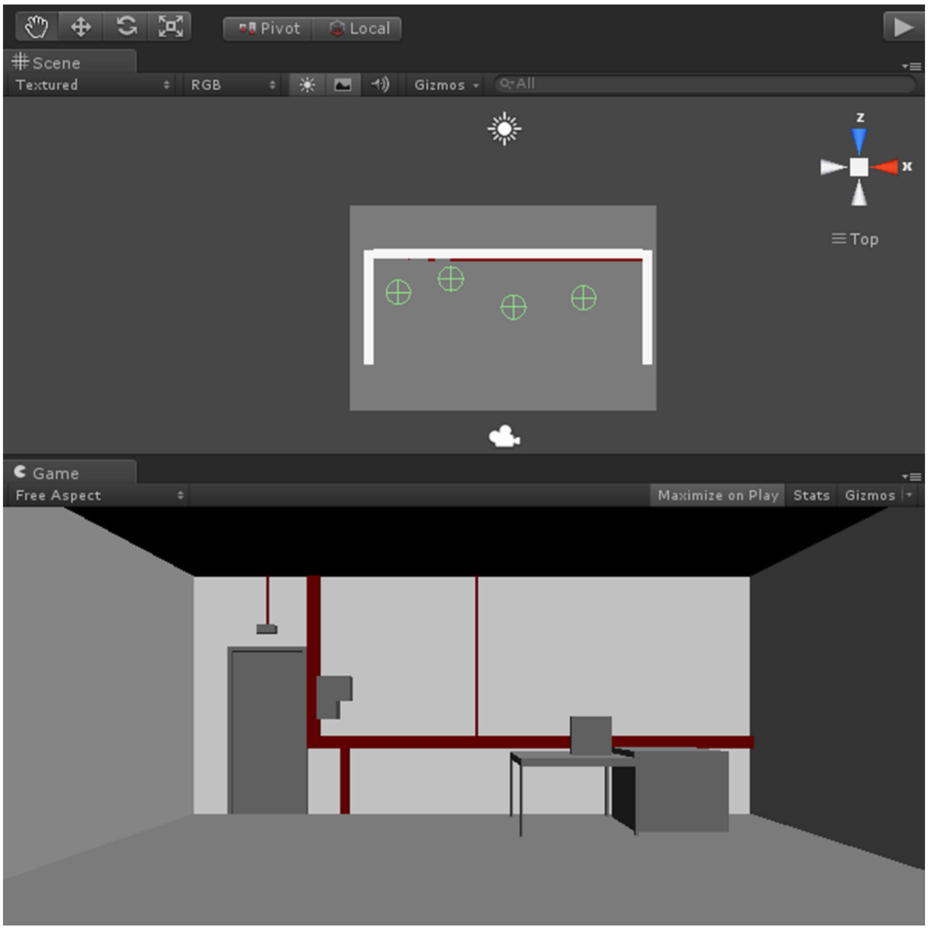
img.28: ***front view of the space - design in Autocad.***

The first task was to take measurements of the space and its details, in order to create the accurate virtual model in Maya. Four zones of interventions were chosen and assigned to each one of us.



img.29: ***model in Maya3d - with 4 different colors are highlighted the 4 intervention areas.***

The model was then imported in Unity3d. After experimenting with the possible movements of the body in the provided space, the colliders for each animation were fixed in place.



img.30: ***model of the space imported in Unity 3d, with colliders added.***

The research on the calibrating software programs, led us to the choice of the mac version of vpt7, as it is the only software that can use input from a camera in Unity, via the support of the Syphon framework. In addition to that, Unity3d can send OSC messages to vpt7, which means that the triggering of events in a Unity scene could control various parameters of the projection, such as the activation/deactivation, movement, rotation, or the scale of the layer, as well as certain image effects.

Overview of OSC messages to and from VPT 6
VPT main page

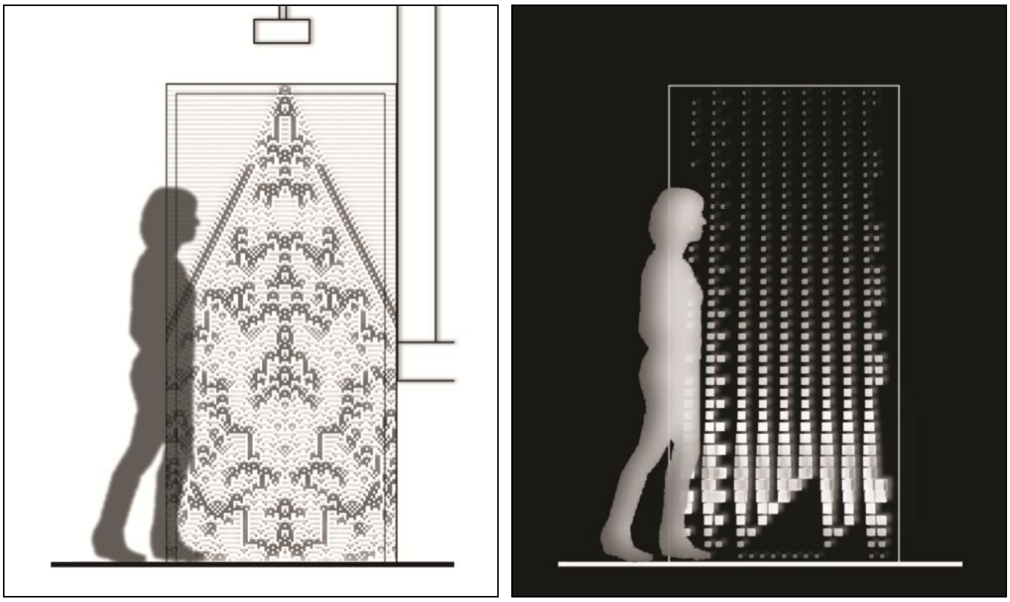
OSC messages to VPT (default receiving port: 6666)

osc	**value**	**description**
/moviesource101 (->108)		access moviesources 101-108
../video	string	name of video file
../rate	float	1. is normal rate, - is backwards
../trig	trig	trig video to start from the beginning
../scrub	0. -> 1.	scrub through video frames
../in	0. -> 1.	loop inpoint
../out	0. -> 1.	loop outpoint
../loop	0-3	0:off,1:loop,2:loop backnforth,3:play once
../loopreset	trig	reset loop points
../loopreport	0 or 1	report when video reaches end of loop
../unique	0 or 1	0:still image, 1:video
../unirefr	integer (33->)	refresh rate of still image in milliseconds
../argb	0 or 1	0:source with alpha, 1: no alpha (default)
../start	trig	
../stop	trig	
../dim	0-12	0:adapt 1-12: check dropmenu in sourcecontrol
../vol	0. -> 1.	
../pan	0. -> 1.	
../clipnr	0->	0:off, 1-> clipnr in dropmenu of the source
../random	trig	select random clip from source folder
../last	trig	select last clip in source folder
../autostart	0 or 1	start clip when loaded or not
../refreshfolder	trig	checks sourcefolder for new content
../jitmovie	max message	communicate directly with the jit.qt.movie object
/layer1(->32)		access layer 1-32 (or 16)
/activelayer		access active layer
../fade	0. -> 1.	
../pos_x	float	

Our knowledge at that time did not permit us to take advantage of this feature, as a result we came up with the idea of calibrating the Unity scene directly by tweaking the parameters of the Main Camera, so as to achieve the settings of the projector; distance from the wall, height position, angle of view and focal length. The result was satisfying enough in the center of the projection but the distortion was obvious towards the edges, fact that limited the useful projection surface as shown below.

img.31: ***actual useful projection surface – design in Autocad.***

For my part of the projection, I was assigned with the surface of the door, a rectangle of 2,10m * 1,00m. The idea was simple; consider the surface as the grid on which to create a series of elementary CA that illuminate gradually, as if the plane tears apart into small holes.



img.32: ***ideas on the intervention.***

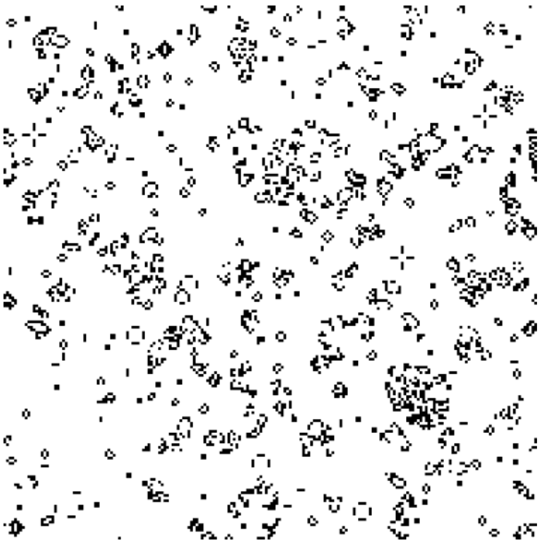
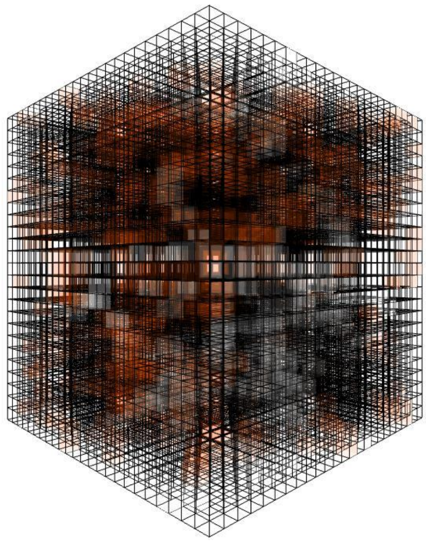
ii. The Cellular Automata

> ***"Over and over again we will see the same kind of thing: that even though the underlying rules for a system are simple, and even though the system is started from simple initial conditions, the behavior that the system shows can nevertheless be highly complex. And I will argue that it is this basic phenomenon that is ultimately responsible for most of the complexity that we see in nature."***[29]

The pioneers of CA were John Von Neuman and Stanislaw Ulam, who introduced them in the late 40's combining their researches towards the creation of self-replicating systems and the modeling of crystal growth accordingly. The first simplified model was a 2d cellular automaton, with 29 possible colors for each cell and *complicated rules specifically set up to emulate the operations of components of an electronic computer and various mechanical devices.* Neuman's idea was that by setting the initial configurations, a Universal computation could be reached in this Cellular space he had created. Consequently, any computer algorithm would be solved. CA became more popular in the '70s, when John Conway came up with the Game of Life; a two-dimensional, grid-based model of the of cells' evolution, which with a simple set of rules could exhibit complex behavior. Every cell interacts with its 8 neighbors and transforms in relation to their number, in the next time step. Game of life is an example of totalistic CA (*the state of the cell depends on the sum of the values of the cells in its neighborhood)*, where the possible values of the cell are 0 or 1.

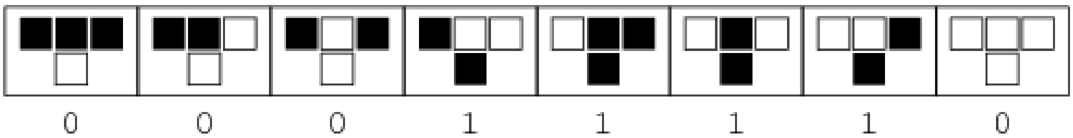
<u>Cornway's rules are as following:</u>
Sum of neighbors<2 → if alive, the cell dies form under-population
Sum of neighbors=2 → if alive, the cell survives to the next time step
Sum of neighbors=3 → any cell becomes alive
Sum of neighbors>3 → if alive, the cell dies from over-population

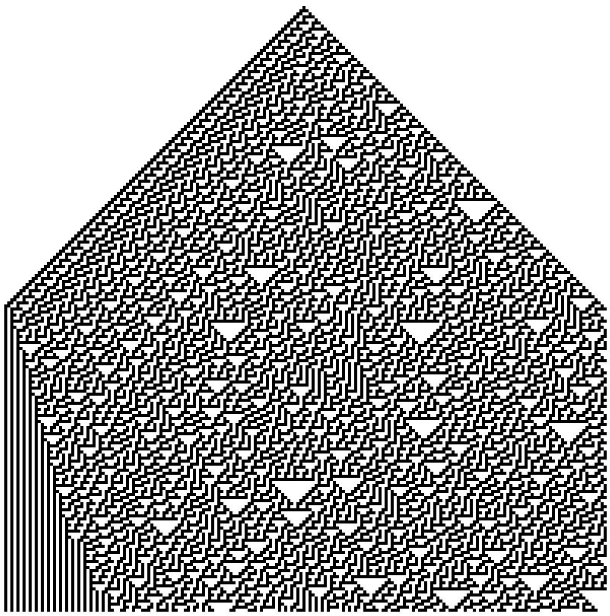
[29] *S. Wolfram.* ***The nature of Code.***

img.33: ***2d game of life – scripting in Processing.***
img.34: ***3d game of life: the production of cells is activated by text – scripting in Processing.***

During the '80s the CA were studied extensively by Stephen Wolfram, who came up with the idea of the Elementary CA rules (also known as Wolfram Rules) which are furthermore classified according to the complexity they exhibit. Elementary CA are one-dimensional, the interactions appear in a local level, and the state of the cell in the next time step is defined by its current state, as well as by the state of its two neighbors. Since the two possible values are 0 and 1, and the neighborhood consists of 3 neighbors, there are $2^3=8$ possible combinations of the neighbors (patterns for a neighborhood), and $2^8=256$ possible rules. For example, Rule 30 is as follows:





img.35: ***rule 30 (in the first generation there is one cell alive in the middle) – scripting in Processing.***

For the needs of the project, a Python script of elementary cellular automata created by random rules was written. The script was based on a Processing code, as taught by Tassos Kanellos and Anna Laskari, on 09/04/2013, in the bounds of the course *"Networking platforms for interactive projects"* during the first year of the Master.
What is more, my limited knowledge on Python, led me to search for tutorials on the internet, mainly for syntax comprehension reasons. The ones that helped me in particular were the following:
Beginning Python for Maya by Zurbrigg
(http://zurbrigg.com/maya-python/category/beginning-python-for-maya)
and the ***Artist's Guide to Python Scripting in Maya*** by Digital Tutors
(http://www.digitaltutors.com/tutorial/1405-Artists-Guide-to-Python-Scripting-in-Maya).

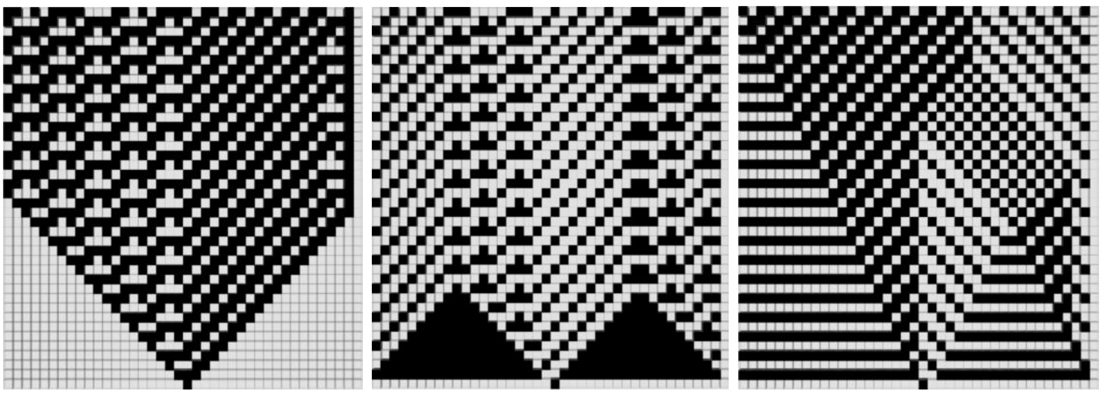
- ***Creation of a random initial rule***

```
def creationRule():
  for i in range(0, 8):
    seed= r.randint(0,1)
    myRule.append(seed)
```

- ***Creation of the neighbors***

```
def voisinage():
  myNextGen = { "000":myRule[0], "001":myRule[1], "010":myRule[2], "011":myRule[3],
"100":myRule[4], "101":myRule[5], "110":myRule[6], "111":myRule[7] }
  number= 0
  mesNextCouleurs[0]= mesCouleurs[0]
  for j in range(1, rows):
    mesNextCouleurs.append( [] )
    for i in range(0, columns-1):
      a= mesCouleurs[j-1][i-1]
      b= mesCouleurs[j-1][i]
      c= mesCouleurs[j-1][i+1]
      voisins= str(a)+str(b)+str(c) # voisins est un STRING
      for key in myNextGen.keys():
        if key==voisins:
          mesNextCouleurs[j].append(myNextGen[key])
      mesCouleurs[j][i]= mesNextCouleurs[j][i]
```

So far, the script led to the static representation of various automata rules.



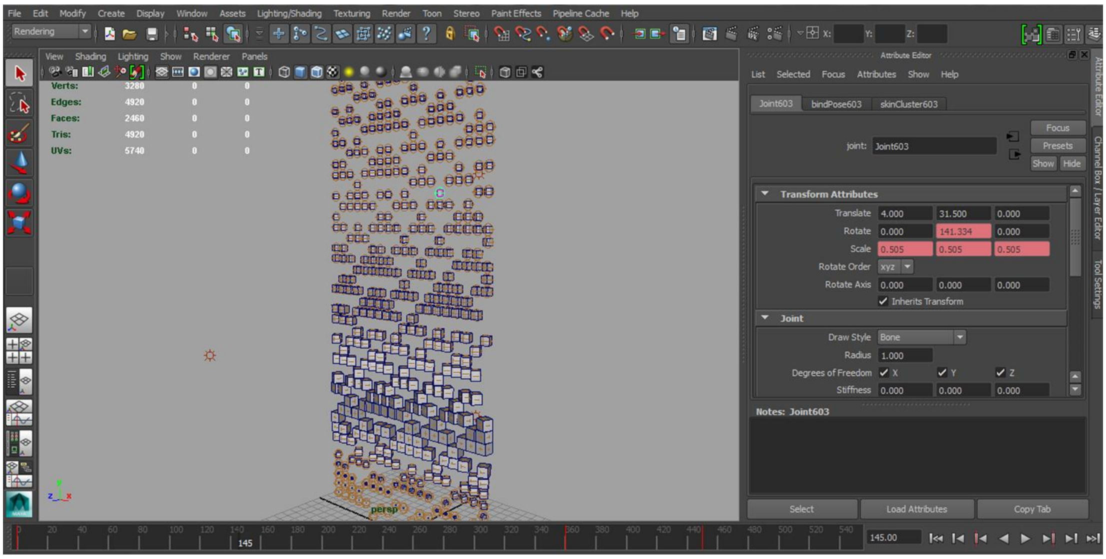
img.36: ***Wolfram random rules (in the first generation there is one cell alive in the middle) – scripting in Python for Maya.***

With the addition of a few lines, the x,y,z scale attributes were connected,

```
cmds.connectAttr(mesNoms[j][i][0]+".scaleX", mesNoms[j][i][0]+".scaleY")
cmds.connectAttr(mesNoms[j][i][0]+".scaleX", mesNoms[j][i][0]+".scaleZ")
```

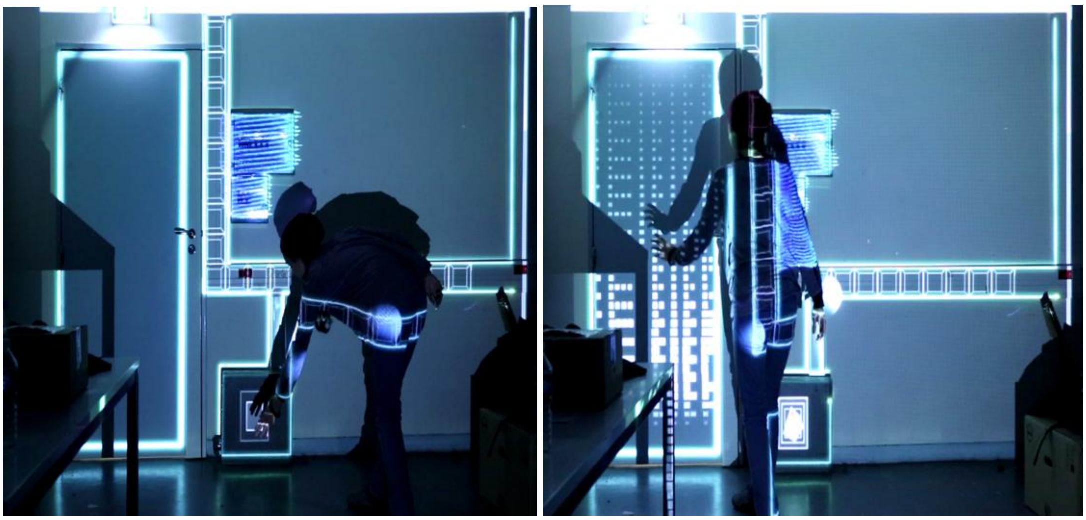
and there was added animation in the scale, as well as the shader of the cells.
Unfortunately shader animation in Maya is not imported in Unity as well.

```
cmds.setKeyframe(mesNoms[j][i][0], attribute= "scaleX", value=1.0, ott= "spline", t= 50+10*j)
cmds.setKeyframe("blancShader"+str(j), attribute= "transparency", value= 0.0, ott= "spline", t= 50+10*j)
cmds.setKeyframe(mesNoms[j][i][0], attribute= "scaleX", value=0.0, ott= "spline", t=150+10*j)
cmds.setKeyframe("blancShader"+str(j), attribute= "transparency", value= 1.0, ott= "spline", t= 150+10*j)
```

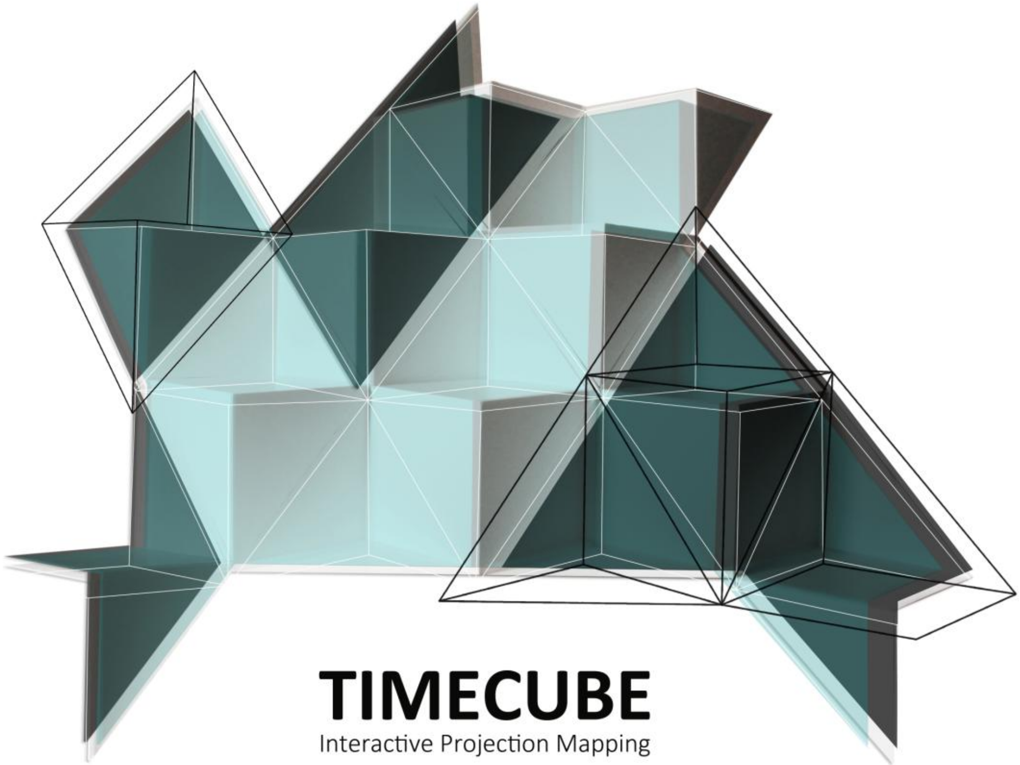


img.37: ***cellular automata animation, Python-Maya.***

The animations were stored as prefabs in the Unity scene. Every time the trigger is entered, a random prefab is created.



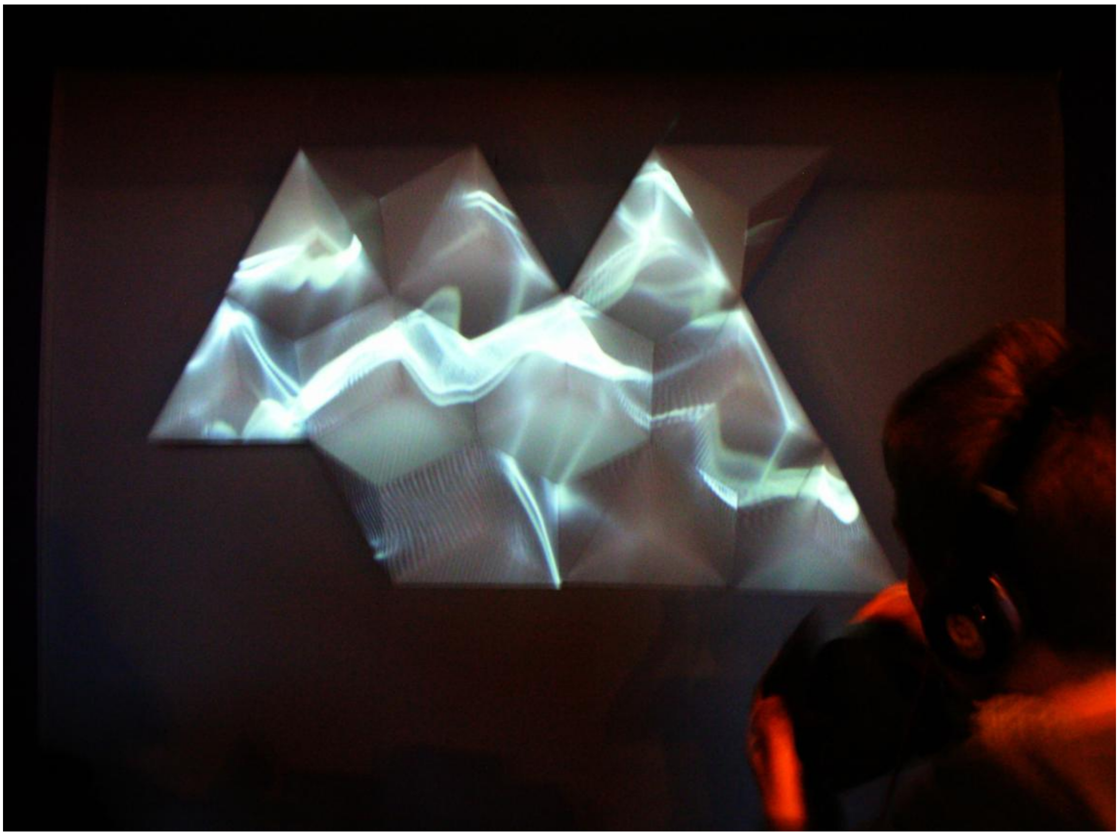
img.38: ***the final outcome***.



TIMECUBE was realized by Theodorou Ino, Georgakopoulou Nefeli, Kourkoulakou Sophia and Zamplaras Dionysis.

1/ TIME CUBE: overview of the project

TimeCube is an interactive installation that combines the exploration of a digital world, with the visual deformation of the real space, via the technique of projection mapping. Part game, part visual experiment, visitors are invited to affect the optical result, by manipulating one single object, a cube-shaped clock. The installation itself consists of a polyhedron structure made from white cardboard, as well as a tactile interface which contains an Arduino board.

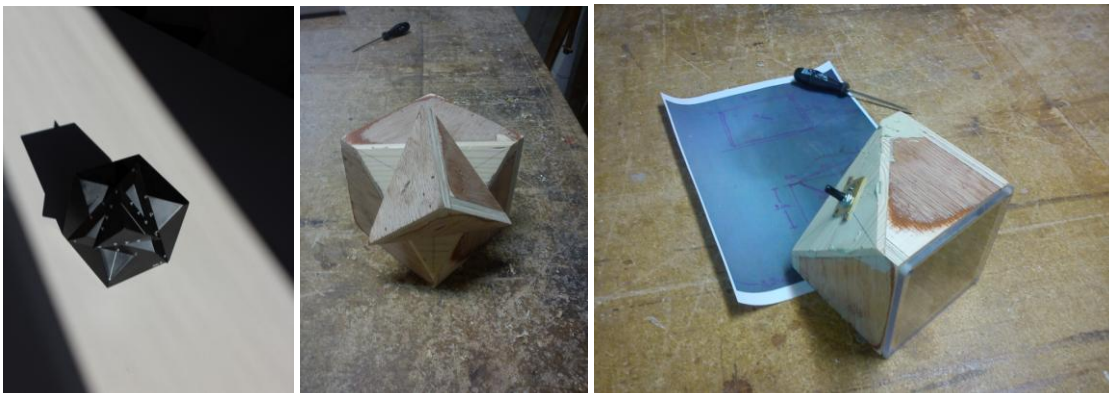


img.39: ***Matheo playing with the TimeCube during "Laval Virtual", April 2014.***

A discovery in the bazaar of the Porte de Clignancourt, a vintage, black, plastic clock from the '80s named 'Time Cube', provided us with the concept based on which we would realize our project. An endless loop of four abstract worlds, created in Unity3d, deploys on the structure. Each one of them has its own perception of time flow, its own rules and physics, as well as graphic aesthetic. The visitor, trapped in the space-time continuum of this abstract universe, is asked to navigate in the space, in order to explore the ways on which he can intervene on the elements of which it comprises and in the same time observe the variety of patterns that emerge.

His only means to do that is through playing with the cube and with the rotating pyramid that has been cut from one of its corners. Inside the object there has been placed an Arduino board, connected with Unity3d via the Uniduino plug-in. Its disequilibration freezes the passage of time in the Unity environment. The rotation along the X and Y axes gives values to an accelerometer, which controls different elements in each world, such as the light, the sound, or the movement of certain objects. What is more, the pyramid is connected to a rotary encoder. Its rotation controls the progress of the time, speeding forward or backwards, in this way the narration of each scene, as well as the sequence of the scenes as a whole is affected. In the same time a random, pre-recorded animation is

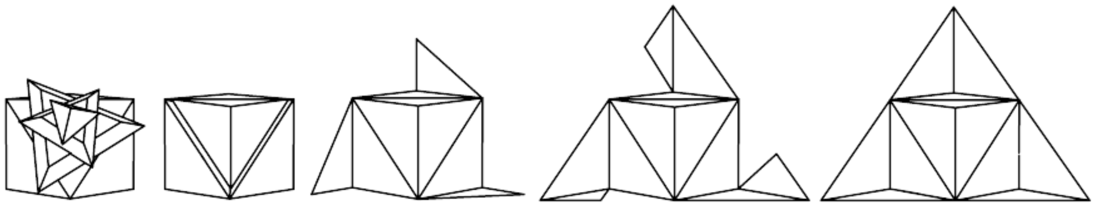
triggered; this effect interrupts the visibility of the Unity environment, furthermore, it is used to make it more comprehensible for the player that he has achieved a change in the flow of the history.
The projections are calibrated with the use of VPT, an open source program which is able to use the output of other applications, such as Unity3d, via the Syphon framework. The triggering of events in Unity3d sends a message to Syphon via OSC, thus activating or deactivating the projections.



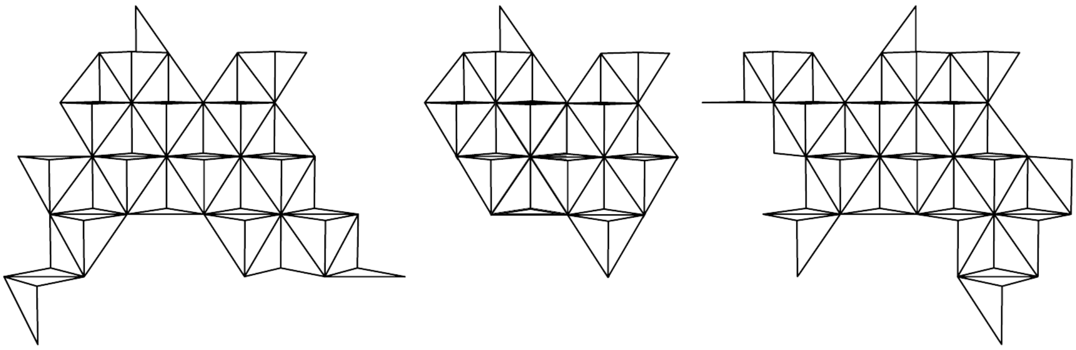
img.40: ***the original TimeCube and the new model, created in Spyro's carpentry workstation, on April 4th 2014.***

i. The structure

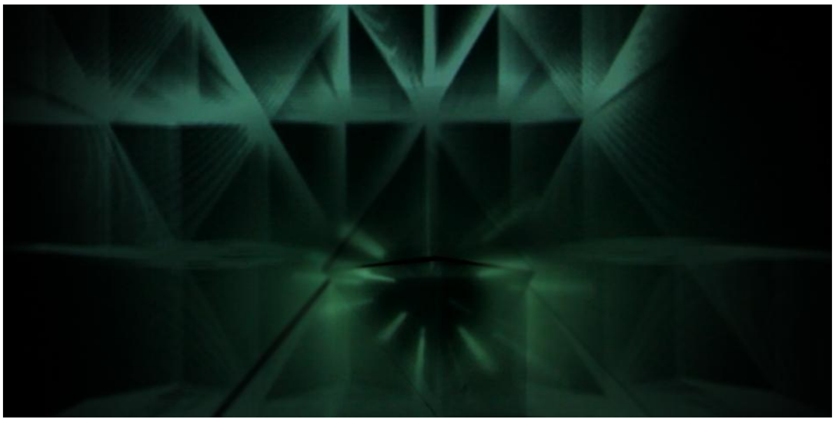
The consideration of the projection surface and the medium of interaction as two integral and in the same time complementary parts of the installation, led to a design that could produce a visual dialogue between them.
The study of the detached, revolving pyramid as a significant means of unraveling the time and evolving of the narration, led to the decision that this should be the object to function as the structural unit of the requested construction. We then advanced to wonder; how could this unit unwrap and emerge in time, in order to create an intricate form? The initial shape produced was a pyramid, consisting of four, smaller, isosceles ones.



img.41: ***unwrapping the Time Cube.***

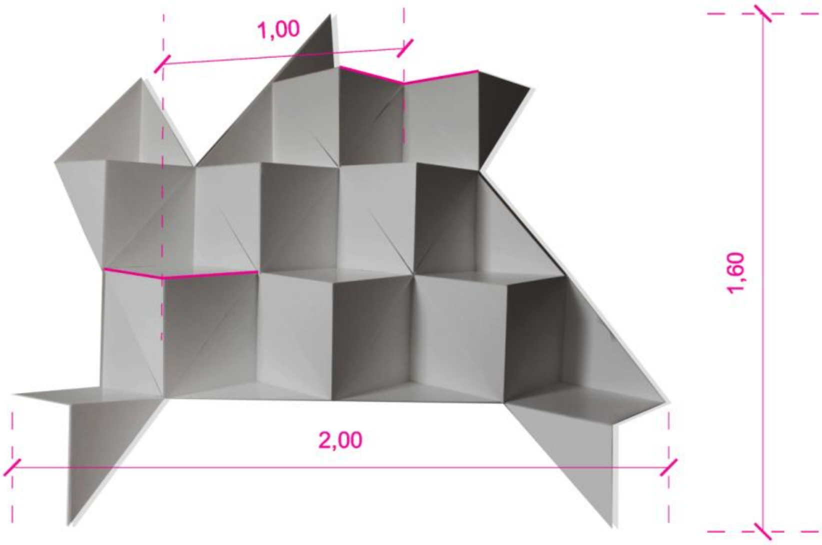


img.42: ***further unwrapping, experimentations on the form.***



img.43: ***projection on the structure and its expansion on the wall.***

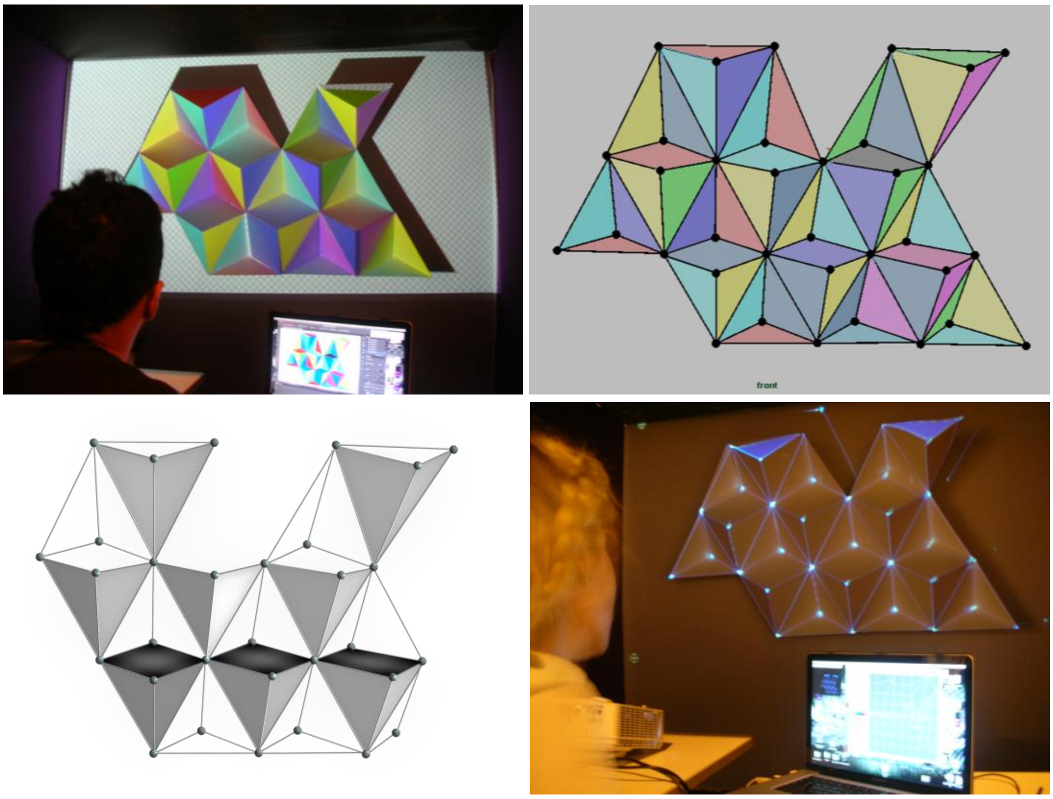
After building up the model of width=90cm and height=65cm, we began experimenting on the mapping part; in the beginning this was a simple edge detection animation. We then went on to expand the projection out of the boundaries defined by the structure, but sticking to a logic that followed the geometry of the authentic volume. The result was an interesting combination between the real structure and an illusionistic perspective on the wall. Volume was created were originally existed nothing but a plane.
Nonetheless, when the unity scenes were projected, the constatation was immediate; for them to exist organically on the surface, they all needed to be centered in the middle and take up the whole structure. There were two options; either we would increase the scale of the same design, or we would actually construct the fake volumes that until that moment were only light on the wall. Considering that a more complex geometry would offer us more capacities on the visual deformation of the model, we went on to further unwrap the pyramid and repeat a pattern where one extrusion is surrounded by three intrusions. The dimensions of the final structure were h=160cm, l=200cm, d=100cm.
The outcome not only enhanced the visibility of the Unity scenes, but also allowed us to delve deeper into the concept of the four worlds that co-exist in the same universe; if we could consider our structure to be this universe, we would then be able to separate it into four zones, in each one of which would be mapped every world accordingly. In this way, the visitor explores both the virtual environment and the existent surface, by gradually illuminating the faces of the latter.



img.44: ***the final geometry of the projection surface.***

ii. The reverse mapping technique

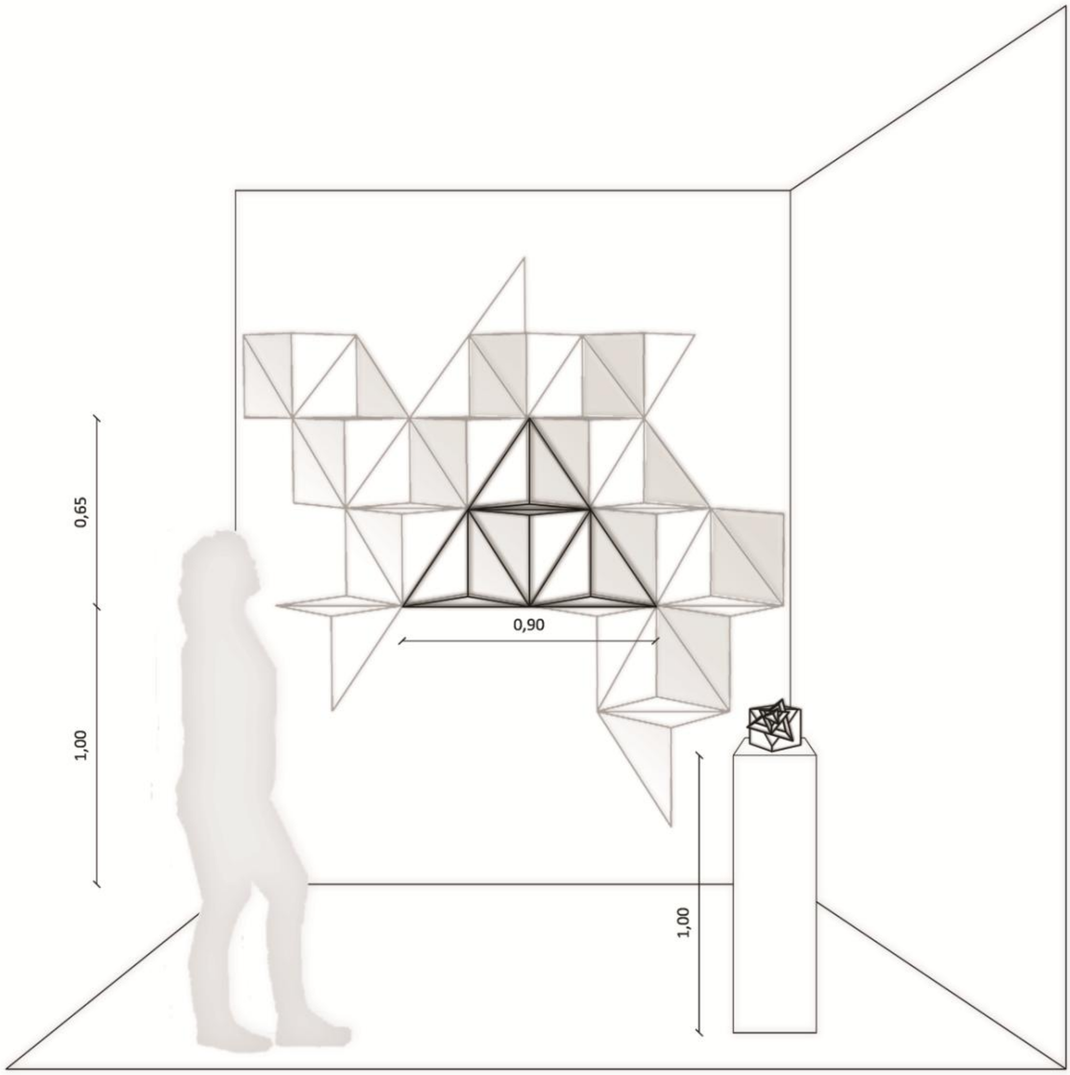
One of the obstacles that had not been overcome yet was the non precise correspondence of the lens characteristics between the camera of the 3d modeling program and the projector. Certain software for projection mapping, such as VVVV and Resolume, permit the import of the virtual model directly in the program, as well as the use of plug-ins like the Projector EX(9), which facilitate the procedure of aligning the real world scene, with the virtual one. Nonetheless, the software we were using (vpt7) did not have such a feature. Nonetheless, various animations still needed to be exported from Maya; moreover, due to the fact that they were based on the exact geometry of the structure, it was necessary for another solution to be found.



img.45: ***reverse mapping procedure - photo documentation from Laval Virtual, April 2014.***

Inspired by the reverse mapping technique used by Lemercier in "*EYJAFJALLAJÖKULL*", we decided to inverse the calibration process as well. After having installed the structure and secured the projector, a Photoshop (or After Effects) image would be created, defining each face with different color. This image would then be used as image plane in an orthographic camera (for example the Front View one). A model without depth, made from polyPlanes, polyCylinders and polySpheres would then be created from this view, so it would fit exactly on the edges indicated by the background image. From this point and on, we were able to create any possible animation, designating different outlines, illuminating various faces or corner points of the existing structure, creating multiple perceptions of its form. The animations would then be used to be projected as masks on the real model. Any slight declinations that resulted from small mistakes in the first step of the calibration would then be very easily corrected by tweaking the mesh of the layer, directly from vpt7. This procedure, although time-consuming, permitted us to have a stored animation in Maya and all that needed to be done would be to align the elements with the grid of the image, every time the installation was set up in a new place.

iii. *"Semaine des Arts" - "Laval Virtual": Two spaces, two different experiences*

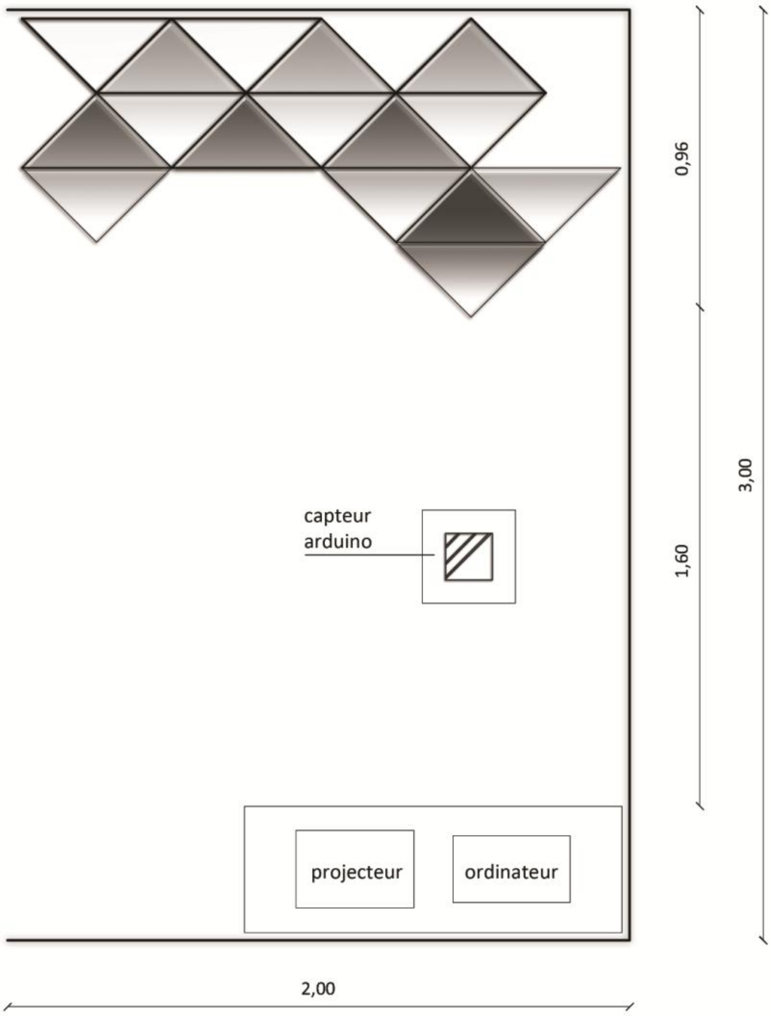


img.46: ***the original proposal of the installation - perspective view, design in AutoCAD.***

The initial conception for the setup of the installation placed the structure in a vertical position, in a height of about one meter from the ground. At a distance of another meter there was placed the TimeCube prominently, on a tall pedestal, in order to invite the visitor to play with. Nonetheless, the implementation of the idea both in the space provided by the University for the *"Semaine des Arts"*, and in the booth provided by the festival *"Laval Virtual"*, ended up quite differently.
In the first case, we had to cope not only with a wall that bore a screen, but also with a projector already hung from the ceiling, the raycast area of which started at the height of 160cm. Both factors were non changeable. As a result the structure was lifted to the predefined height with the aid of an improvisational base from tables and chairs. Given that the height of the projection had changed, the distance of the TimeCube interface, and consequently the distance of the user from the structure, had to increase as well. The result was quite satisfying, although due to the fact that the installation was hosted in the same room with three more, the level of immersion achieved was low; what is more, the placement of the polyhedral surface at such a height, demanded from the viewer to distance himself from it. In other words, the outcome could be categorized in the bounds of a

collectively attended spectacle, rather than a one-user experienced as it had originally been designed.

In the case of the *"Laval Virtual"*, we were given a free space of 200cm*300cm to work in. A metal truss that traversed the separating panels permitted us to suspend the structure with fishing line at the initially wished height of one meter. Nonetheless, the depth of the structure, along with an indispensable table for the technological equipment, limited the space for the visitor significantly. Moreover, the TimeCube was now placed on a wooden stool of only 50cm height, and at a distance of less than a meter from the projection surface. Although our first impression of the spatial composition was rather disappointing and claustrophobic, the surprise came from a visitor's subversive movement. While all of this time, we had been thinking of experiencing the projection standing in front it, he picked up the Cube and asked "May I seat?" By shifting the center of gravity, the visitor was now seated on the low stool, lifting his regard upwards to the center of the projection. With this move, another crucial detail came to light as well. Due to the fact that the metal truss was at a distance of 20cm from the wall, the structure had an inclination of some degrees, and this was the reason the viewer while seated, at such short distance, could be totally immerged in the piece.
These observations illustrate how the setup of an installation can influence our impression of room and place, as well as serve as an enhancement or not of the experience as a whole.

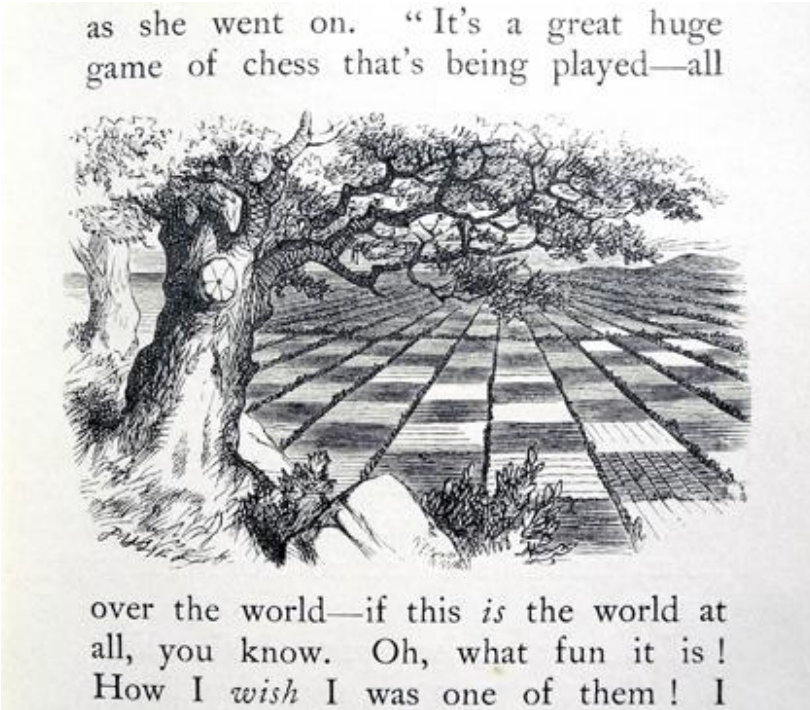


img.47: ***the original proposal of the installation - top view, design in AutoCAD.***

2/ THE HABITATION OF ORGANIC FORMS IN THE GEOMETRIC STRUCTURE

"La nature, une fois traitée par l'homme reçoit un ordonnancement géométrique intelligent, maitrisable."[30]

Up to this point, the mentioned examples of mapping onto structures (the experiments on TimeCube included) involved the visual emergence and manipulation of geometrical elements found on the architectural canvas itself. The following section is going to cope with a problematic that arouse in the course of the TimeCube project.



img.48: John Tenniel, ***The chess.*** *Illustration for "Alice through the looking glass", around 1865.*

The fore-above image, taken from the illustrations of *"Alice through the looking glass"*, is a representation of the garden of living flowers.

> ***"For some minutes Alice stood without speaking, looking out in all directions over the country — and a most curious country it was. There were a number of tiny little brooks running straight across it from side to side, and the ground between was divided up into squares by a number of little green hedges, that reached from brook to brook. 'I declare it is marked out just like a large chessboard!' Alice said at last."***[31]

The metaphor of the geometrical regularity is represented here by the chessboard; this is the orthogonal grid, on the boundaries of which are evolving, even though they are restricted, the plants.
What if we used our polyhedral, geometric canvas as host of a projected artificial garden? What will be the visual results achieved both for the structure, as well as for the perception of the digitally created organic forms mesh? What are the demands for a successful cohabitation of both?

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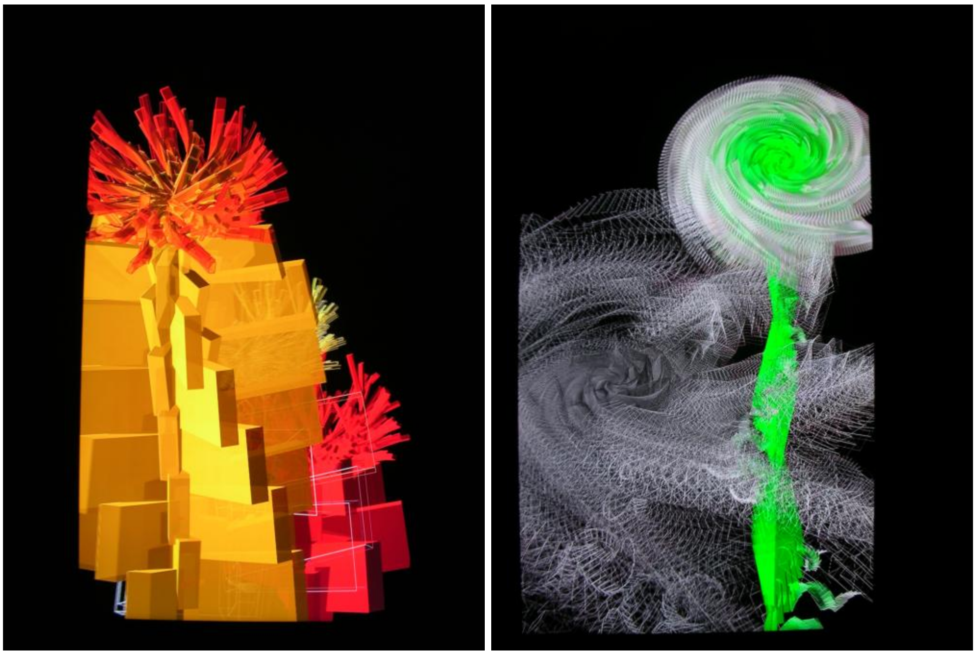
[30] *Ireland, Robert.* ***Le paysage envisagé.*** *Gollion: Éditions Infolio, 2009, pp.15.*
[31] Lewis Carol, ***Alice through the looking glass***. CHAPTER II, The garden of live flowers, 1865.

i. Two gardens blossom in Paris

The scientific field of artificial life deals with the study, as well as the creation of artificial systems that imitate or express the properties of living systems. Numerous digital artists, such as Karl Sims or William Latham have taken up the role of Phytourgos, experimenting with various complex systems, in order to combine biological life with electronics. The lines to follow are going to make special reference to the experiencing of two exhibitions visited during the past few months in Paris, which affected my regard over our group project. The first one being the *Fractal Flowers* by Miguel Chevalier, hosted by the 'Centre des Arts Enghein-les-Bains', in November 2013, while the second one is a retrospective presentation of Christa Sommerer's and Laurent Mignonneau's works, that took place during their exhibition in Galerie Charlot, in January 2014. Despite the fact that the starting point for both of the creators was the inspiration from a continuously evolving flora, the final outcome ended up being a different approach, in terms of technique and aesthetics.
In the first case, Chevalier has created two living canvases, each one of them hosting a flower; they are named 'Pixacantha Baudelairis' and 'Lilus Arythmeticus' accordingly. Beginning from a mere rectangle that multiplies itself, rotates, changes color and augments in scale, the two flowers gradually evolve, flourish and expand out of the limits set by the plasma screens on which they are presented. This approach is not an interactive one, but even though the seed is always the same, the rules of growth are generated randomly by some software. In Chevalier's words, *"I reveal flowers pushed to the extreme of their geometric forms. We are here in a very intriguing vegetal universe on the edge of three worlds: the mineral, the animal and the robotics. The flowers acquire a true monumentality due to their geometric shapes and at the same time an evanescent aspect, a after only a few seconds, they evaporate into the air."*[32]
Eau de Jardin is an interactive work inspired by the triptychs of Claude Monet's *Water Lillies*, as these latter are exhibited in the "Musée de l'Orangerie" in Paris. The installation includes a projection screen, as well as semi-transparent pots, in the shape of ancient Greek amphorae, hanged from the ceiling. Inside, root various plants such as water lilies, lotuses, bamboos or even cypresses, the branches of which have started to occupy little by little the already confined space of the gallery. The visitor, in the specific case this was me, intimidated at first, gently touches the plant, only to realize that this touch is the vivifying power which initializes the projected drawing of the plant's virtual clone, on the screen. The impact of the visitor's gesture is even more amplified by the fact that pots are now hanged and not fixed, as in the case of 'Interactive Plant Growing'; here, even the slightest touch results in an oscillation.
Visitors are invited to approach, caress and push or even pull them, in a few words use the sense of touch, in order to trigger the development or destruction of the virtual ecosystem.
On the opposite wall, a jungle of ferns, grasses and mosses flourishes gradually and most important, accordingly to the intensity of touch, as well as the electrical potential difference of the visitor. This way, the algorithms that determine the morphological characteristics (stem length, branching angle, stem curvature and color of the branches) are given values real-time by the viewer's actions during the plant's growing. As cited by the curator of the exposition, *"The virtual lake in 'Eau de Jardin' becomes a mirror to the reality of virtuality. As Monet succeeded in creating two layers of virtuality by blurring the borders between 'real' interpreted plant images and their reflected image in the water's surface, 'Eau de Jardin' tries to create several layers of virtuality by blurring the borders between real plants, virtual plants on the screen and their reflected virtual image in the virtual water's surface."*[33]

---

[32] *http://www.miguel-chevalier.com/fr/index.html#fractal-flowers-2014-ceret*
[33] *http://www.galeriecharlot.com/fr/expo/78/Christa-Sommerer-Laurent-Mignonneau*



img.49 : M. Chevalier, ***Fractal Flowers.*** *Centre des Arts Enghein les Bains, 2013.*
(Visit to the Center on October 8th 2013)

img.50 : C. Sommerer, L. Mignonneau, ***Eau de Jardin.*** *Gallery Charlot, Paris, 2014.*
(Visit to the gallery on January 8th 2014)

img.51: C. Monet, ***Le matin aux saules.*** *1914-1926.*

ii. Creating branching structures

> ***"Imagine a round room; its walls adorned with a water landscape dotted with…plants. The transparent colors are sometimes green, sometimes verging on mauve. The silent, dead-calm water reflects the blossoms floating on it; the colors are fluid, with marvelous nuances, ephemeral as a dream."***[34]

In the search for a way to create an organic, branching structure, a number of experiments with recursive geometries and l-systems were initially conducted in Processing, due to the familiarity with the specific programming language.

The fractal geometry

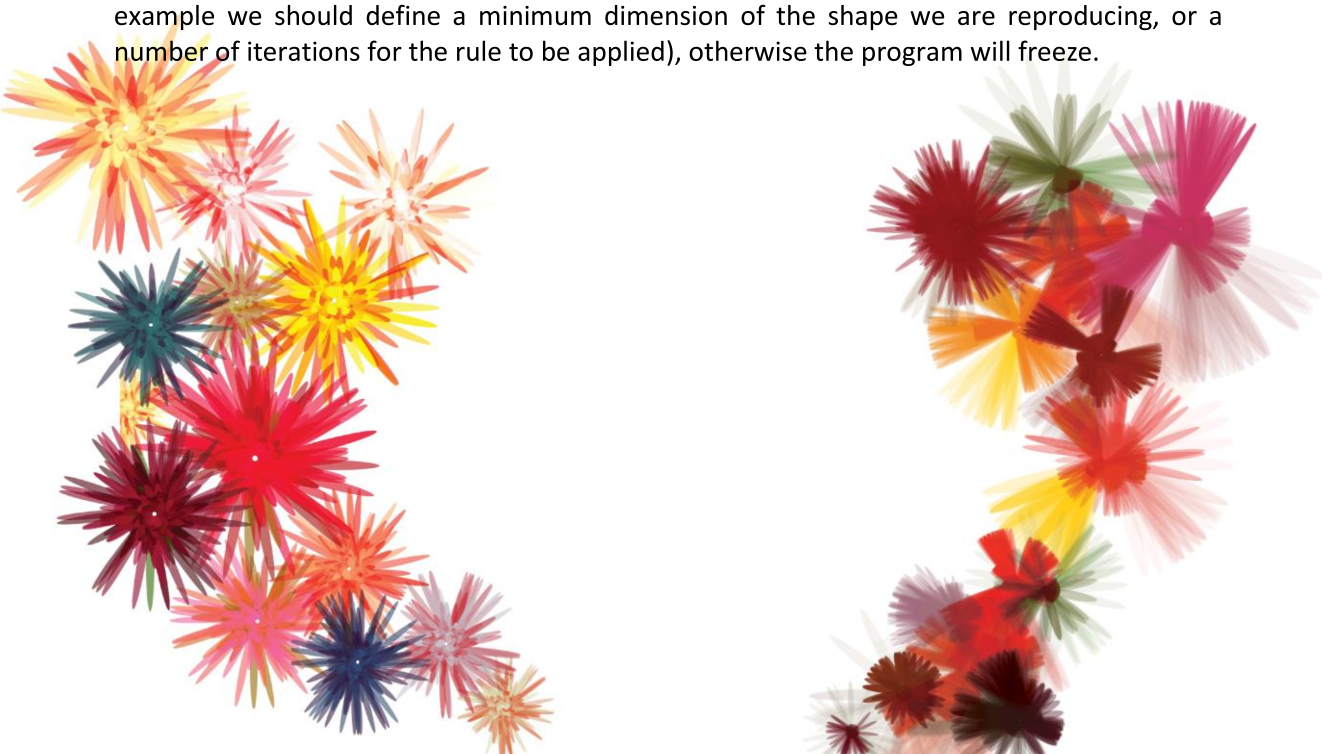
In 1975, Benoit Mandelbrot introduces the word *'fractal'*, from the Latin word fractus that means broken and irregular. In *"The Fractal Geometry of Nature," he defines a fractal as "a rough or fragmented geometric shape that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole."*

The fractals combine the characteristics of self-similarity, fine structure at small scales and recursivity.

As far as it concerns the ***self-similarity***, this means that the parts of a fractal have the same structure as the whole, but in smaller scale. If the parts are exact replicas of the whole, we are talking about deterministic fractals, whereas in the case of the existence of a random factor, we are talking about stochastic fractals.

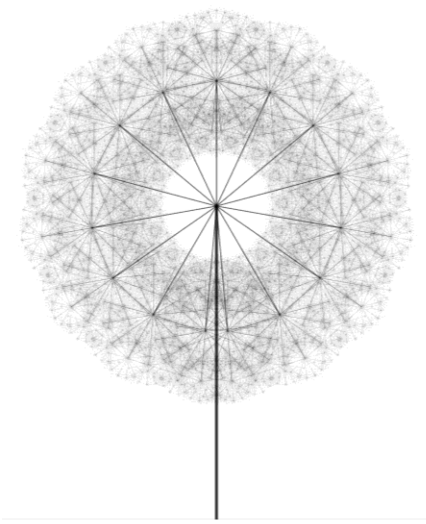
The ***fine structure at small scales*** means their form is irregular or broken, in all the recursive scales; the fractal cannot be described by the Euclidean geometry.

Recursion is the procedure of the repeated application of a rule, on the produced results. In programming, we need an exit condition that will stop the rule of repeating itself (for example we should define a minimum dimension of the shape we are reproducing, or a number of iterations for the rule to be applied), otherwise the program will freeze.



img.52: ***recursive ellipses: flowers - experimentation in Processing.***

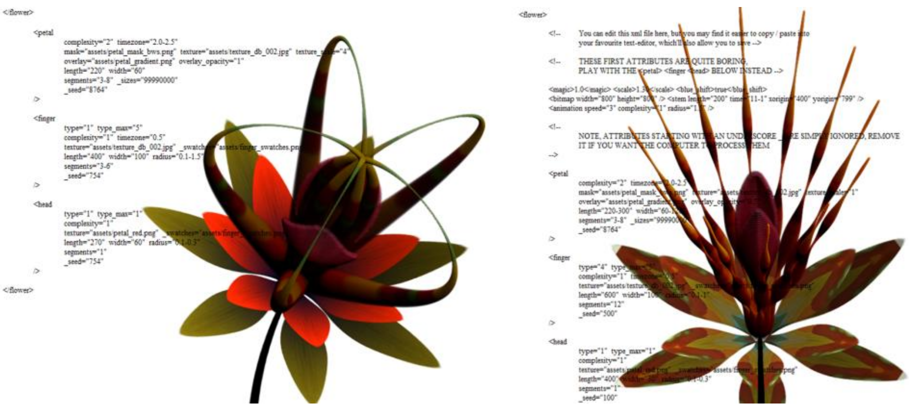
[34] *M.Guillemot,* ***Claude Monet,*** *in* ***La Revue Illustrée 13*** *(March 15, 1898), as cited in* ***Monet's Years at Giverny: beyond Impressionism.*** *Editions: The metropolitan Museum of Art, 1978, pp.25.*



img.53: ***living pissenlit in cimetière du Père-Lachaise, December 2013.***
img.54: ***recursive fractal tree: the virtual pissenlit - experimentation in Processing.***

img.55: ***stohastic fractal trees combined with ellipse recursivity at the end of the branches - experimentation in Processing.***

Another interesting tool I ran into my research on how to draw a plant, is the Bloom Flower Tool by Daniel Brown; a tool to create living, virtual flowers, accompanied by an editable XML template, which one can tweak in order to achieve variations in the results. The results however cannot be exported for further use.



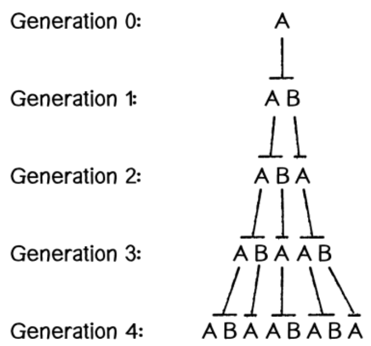
img.56: D. Brown, ***BBC Bloom Flower Tool****, online tool using XML.*

A short introduction to L-Systems

In 1968, the biologist Aristide Lindenmayer published a two-part article entitled "Mathematical models for cellular interaction in development", in the Journal of theoretical Biology. In this article, he formalized the description of an axiomatic, grammar-based system to model the growth pattern of plants. These string-rewriting systems, known as L-Systems, are primarily a chain of characters, which evolves in time, in accordance to a certain set of rules. The principle is that since the growth in organisms occurs in parallel stages in each time step, the re-writing process will be applied simultaneously to every letter of the current chain of characters.

L-Systems comprise of three main components; the Alphabet, the Axiom and the Rules. The ***Alphabet*** includes all the valid characters that can form a chain of characters. The ***Axiom*** is a distinguished chain of characters that characterizes the initial state of the system, and from which starts the re-writing process. The ***Rules*** specify for each letter of the Alphabet ("predecessor"), what will be its state in the next generation ("successor"). The re-writing process starts from the axiom and then applied recursively on each new generated chain of characters. One of the simplest L-Systems examples is the one proposed by Lindenmayer for modeling the growth of algae.

In this case, the Alphabet is: A B, the Axiom is: A and the rules are: (A→AB) and (B →A).

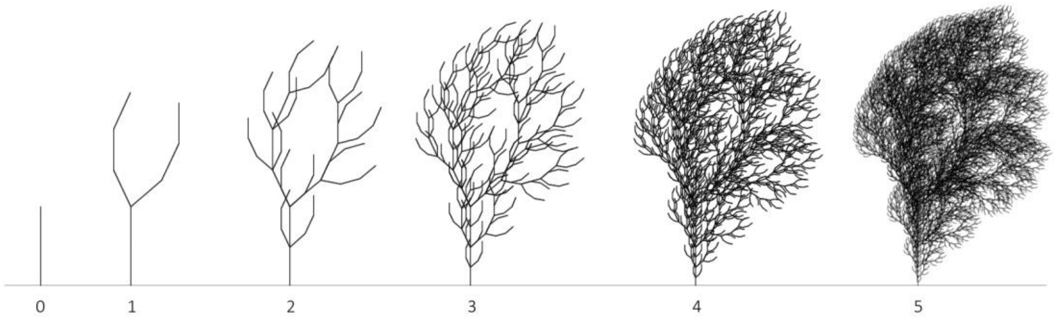


In order for the L-Systems to visually represent a branching structure, they should also be related to drawing instructions.

Let us consider a more complex Alphabet: FG+-[] , Axiom: F, Rule: F → F[+F]F[-F]F , ϑ=25,7

The instructions are as follows:

F: draw a segment of length l and move forward
G: move forward (without drawing a line)
+: turn right ϑ degrees
-: turn left ϑ degrees
[: save current location
]: restore previous location



img.57: ***L-System evolution in 5 generations - script in Processing, by Daniel Shiffman.***

iii. The Unity Scene

"To isolate a specific moment, by painting a subject only once, was to deny one aspect of reality: the passage of time." [35]

The formation of L-Systems is based on the notion of evolving generations and on the transformation of a chain of characters (that eventually is depicted on geometry as well) in discrete time intervals, via an iterated function. Therefore, time is considered to be an integral part of the study on generative systems.
What if we were to use a growing plant in one of the looping Unity environments? The changes of its geometry could then function as point of reference for the passage of time in this virtual world. Such an example is to be discussed in this section.
My limited experience in Python, in combination with the knowledge I had just acquired from the fore-mentioned exercises in processing, led to the compilation of a simple though adequate script, in order to be able to produce a variety of animated branching structures by alternating certain parameters, such as the length of the segments, the rotation angle, or the number of iterations. The animated models would then be imported in Unity as .fbx format.

Exporting a compatible animation from Maya to Unity3d - technical issues

myRule= {'F': "FF-[FF*F*F]"}
myAxiome= "F"
Iterations= 7

From the models produced in Maya, the one chosen for experimentation in Unity was the above, as it provided an interesting visual effect, as well as it created a nest-like space for the camera to navigate in.
The structural component is a polyCylinder, of diameter r. The radius of the top face is multiplied by 0.9999, stored as radius for the next iteration, where it is multiplied by 0.9996, so as for the branches at the edges to be thinner, thus more realistic.

[35] ***Monet's Years at Giverny: beyond Impressionism****. Editions: The metropolitan Museum of Art, 1978, pp.12.*

```
base= cmds.polyCylinder(name="monCylinder0", sx=3, r=0.05, height=a)
cmds.scale( 0.9999, 1.0, 0.9999, (cmds.select(base[0]+".f[5]")), ocp=True)
```

Nonetheless, the 7 iterations created 46.656 polyCylinders, corresponding to 1.024.914 faces and an .mb file of 67MB, impossible to import in Unity3d.
The following code alterations reduced the size significantly.
The first step was to reduce the geometry. The top and bottom faces (that were either way invisible) were deleted, and the segments in the X axes were cut down, leaving us with a 3-faceted polyCylinder.

```
base= cmds.polyCylinder(name="monCylinder0", sx=3, r=0.05, height=a)
cmds.delete( base[0]+".f[3]", base[0]+".f[4]" ) # on efface les faces qu'on ne voit pas
```

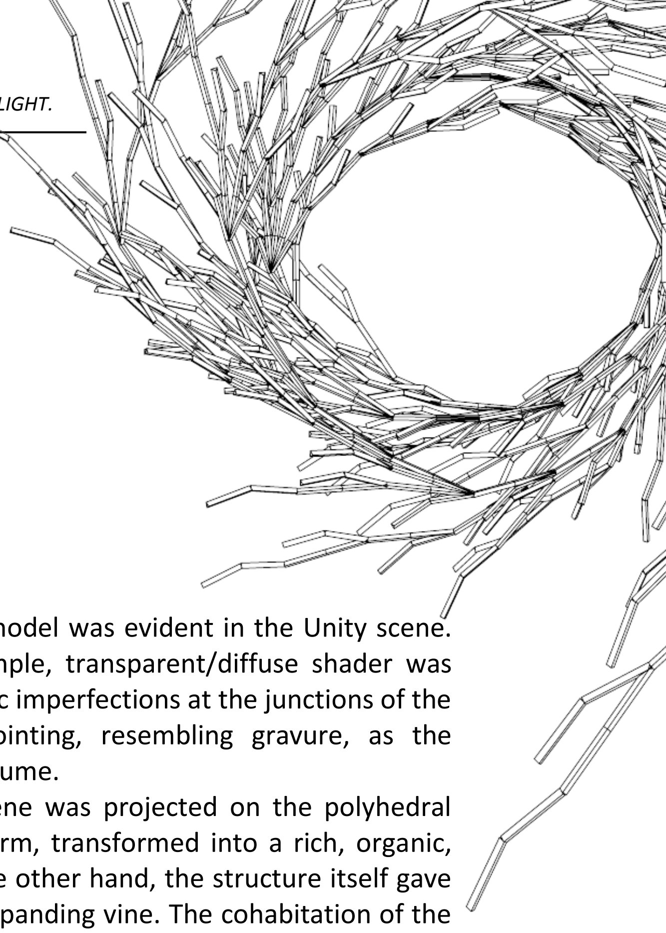
Although the number of faces dropped to 132.144, the file was still too large to import. A test with 6 iterations was performed, giving the result of 23.331 faces, 7.776 polyCylinders and a file of 10MB. This attempt was satisfying in terms of size, nonetheless since the 7th iteration was omitted, the expansion of the intricate shape along the X axis, was now lost.
An interesting observation though led to the solution. Since the polyCylinders created after the 4th iteration didn't really interweave between them, but only added length to the existing branches, I should come up with a way to increase geometry during the first iterations, and reduce it (as unnecessary) during the latter.
As a result, the original script:

```
for i in range (1, iterations):
    myRule= { 'F':  "FF-[$F$F*F*F]"}
```

became:

```
for i in range (1, iterations):
    if (iterations<=4):
      myRule= { 'F':  "FFF-[$F*F]"}
    elif (iterations>4):
      myRule= { 'F':  "FF-[$F*F]"}
    elif (iterations>6):
      myRule= { 'F':  "[$F*F]"}
```

producing finally the following result of 4.960polyCylinders, 12.000 faces and a file of 6MB:



The outcome was very satisfying, as far as the form is concerned. Nonetheless, there were certain reservations on the aesthetic part of the Unity scene, due to the low-poly geometry that in reality looked rather fragmented, as shown in the image on the right.

Importing the model in Unity - building the scene

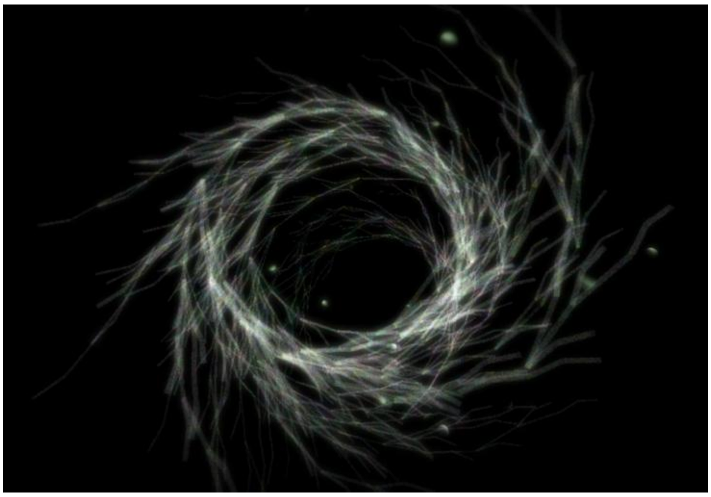
As already suspected, the low-poly geometry of the model was evident in the Unity scene. Various materials were tested, but in the end a simple, transparent/diffuse shader was chosen, in order to trick the eye and hide the geometric imperfections at the junctions of the polyCylinders. The general impression was disappointing, resembling gravure, as the transparency led to the 3d model losing its sense of volume.

Nonetheless, the surprise came the moment the scene was projected on the polyhedral surface. The otherwise pale, clumsy, constructivist form, transformed into a rich, organic, smooth geometry that embraced the structure. On the other hand, the structure itself gave the impression of having been occupied by a fluidly expanding vine. The cohabitation of the two geometries was, indeed, working surprisingly well. The use of certain filters on the camera, such as the Fisheye, corrected the distortion to a certain degree and the result improved even more.

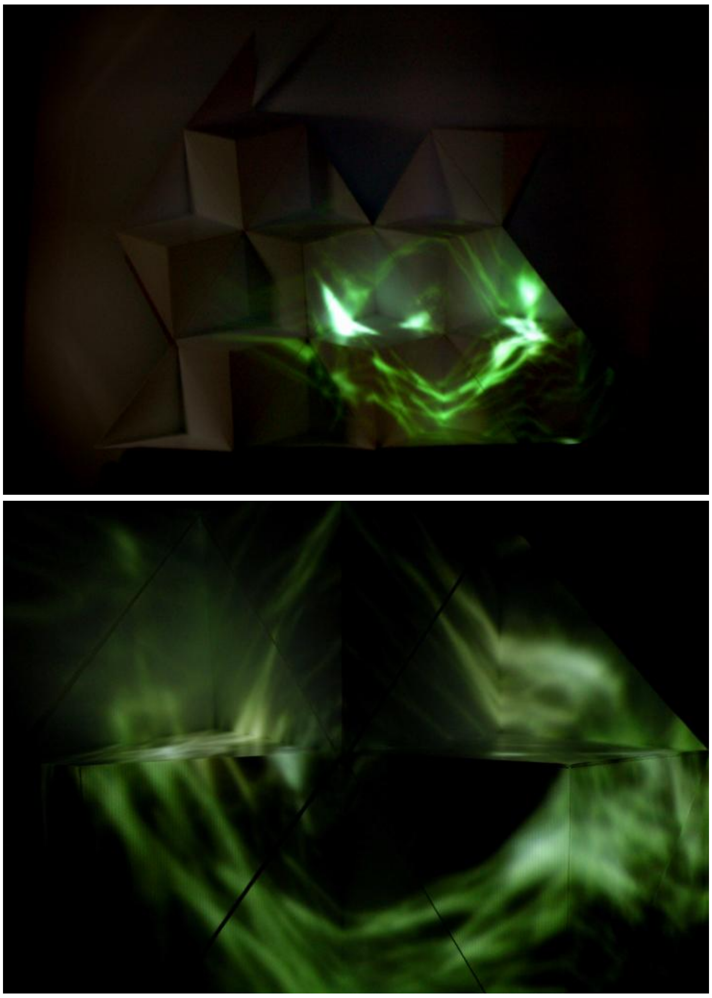
Another issue that came up was the lighting of the scene. Apart from the directional light used (with intensity flicker and color change scripts attached), and since the envisaged environment was a nature-resembling one, the idea of using a flock of birds, with a spotlight attached to each one of them, came up. For the needs of this, I was based on the *CrowFlocker* Script found on the asset store of Unity3d (link provided in the appendix). Sticking to the low-poly geometry already used in the scene, I created an abstract bird made from two planes, added animation and exported it as .fbx. Instead of material, there is a Mesh Particle Emitter attached to the meshes, which strengthens the oneiric atmosphere.

img.58: ***draft sketch in Photoshop and test with lights in Unity Scene***.

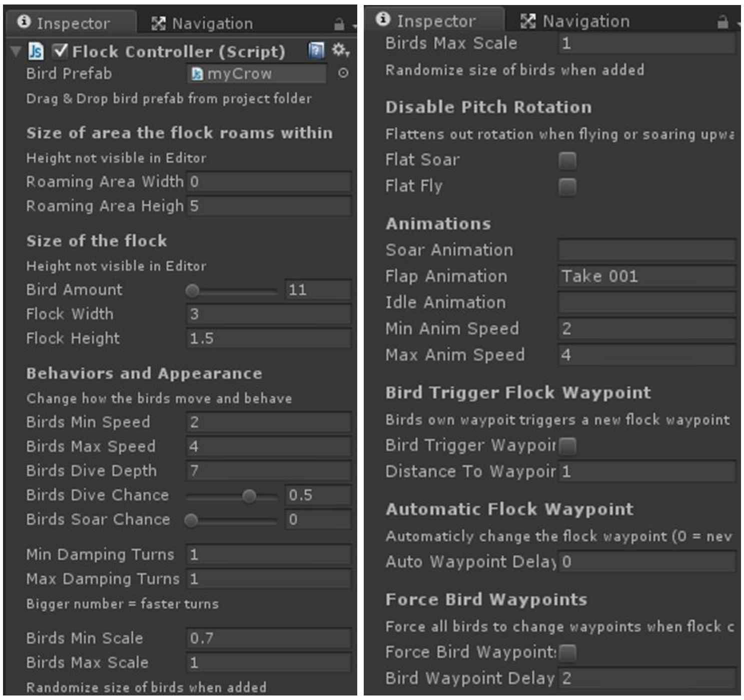
The visitor is invited to play with the TimeCube, in order to control the growth of the branch. Whenever the TimeCube is destabilized, the growth stops. Whenever it regains its equilibrium, the growth continues from the moment it was interrupted. If the accelerometer is rotated along the x axis, the user navigates in this space, dives in the branching nest, or takes his distance from it. If the accelerometer is rotated along the y axis, the user takes control of the birds' movement and is able to further illuminate the geometry. The animation lasts 45 seconds. With 24fps, the visitor can freeze the growth in any of the 1080 frames, with the camera in any possible distance from the model; this combined with the ability to control the flock of birds, results in an infinite game of light and shadows on the structure, which needs time to understand and conquer. With the use of only one mask along the perimeter of the structure, the branch could take up the whole volume, as long as the camera approaches it. The most interesting deduction of this experiment though, is not the way the structure is deformed by the light, but how the otherwise low-poly model acquires volume depth through its visual distortion on the planes.



img.59: ***l-System: low poly model, as seen in Unity Scene****.*

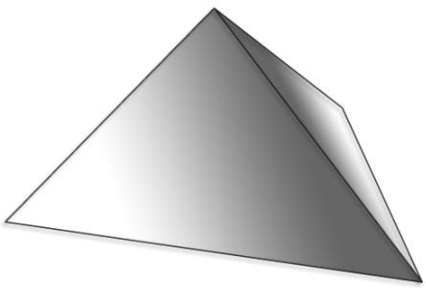


img.60: ***l-System: rich volume geometry, as seen through projection****.*



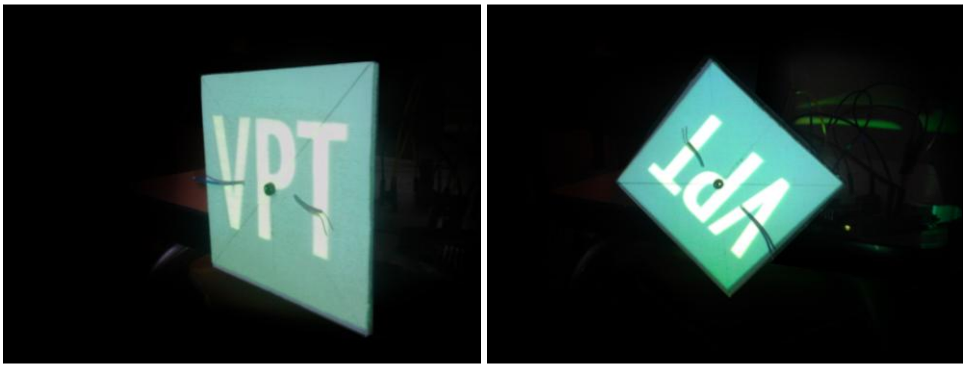
img.61: ***parameters of the CrowFlocker Script***.


img.62: ***lighting test during the "Semaine des Arts"***.


img.63: ***low-poly "bird" in Maya.***

3/ THOUGHTS FOR FURTHER RESEARCH

One of the problematics that emerged after the completion of the TimeCube project was a study on how the mapping could work on a real-time changing volume. What if the user, instead of interacting only with the visuals, could also affect the shape of the projection surface? In the case of TimeCube he could actually unwrap the volume by rotating the triangular planes. What if we gave the user total control of the space he is in? We could reinvestigate by digital means what Muller did with his *“Inflatables”* thirty years ago.
In collaboration with Nefeli Georgakopoulou, we took the first step in this direction by performing a simple test of simultaneous rotation of a plane, along with the calibration of a projection within its boundaries. For this purpose we used an Arduino board, with a servo motor and a potentiometer attached on it.
For the first experiment we worked on the direct control of the vpt layer by the potentiometer (which would control the servo motor as well). The initial idea was to map the values of the potentiometer to the servo, and then map the values of the servo to the corner pin values of the vpt layer. Due to the fact that this would be a tricky task to perform for the four corners, we decided to work on a HC Gilje’s script for sending data from arduino to vpt, in order to be able to use the potentiometer for feeding with the same rotation values both the servo and the vpt layer, in parallel. Contrary to our previous works, in this case we used vpt5, as in the version vpt7 there is no osc command for the layer rotation.
Performing a rotation of the servo along the Z axis, we observed that the calibration of the layer was indeed working for a square/rectangle surface, but this was not the case for a composite, polygonal one. What is more, when we tried to rotate the servo along the X or Y axis, the projection was not calibrated. Both of these faults were due to the fact that the center of rotation of the servo and the one of the vpt layer did not coincide. As a result, given that vpt has no option for changing the pivot point of the layer, the completion of complex projects is considered an aggravated procedure with the specific software.



img.64: ***synchronized calibration with rotating plane, along Z axis.***

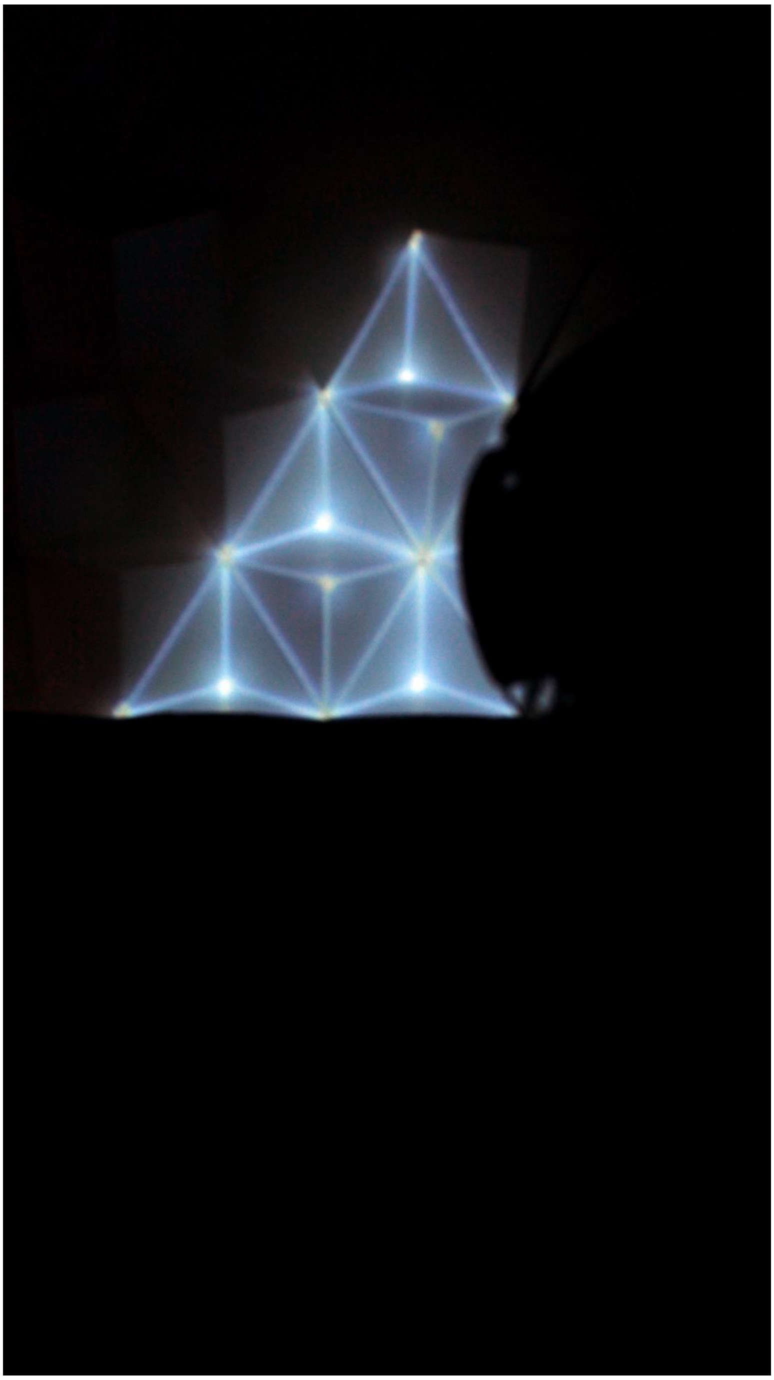
Our second attempt was to use Unity in order to control the vpt layer. In this case, the values of the potentiometer were mapped to the servo: *int new_servo_pos =(int)pinValue.Remap(0, 1023, 0, 180);*
and then the values of the servo were sent with osc message to the layer:*OSCHandler.Instance.SendMessageToClient("vpt5","/layer1"+"/roty" ,rotation);*
A third way would be possible, by using the potentiometer to rotate a virtual plane in Unity, on which we would have assigned a movie texture; then, the Main Camera would be used as input in vpt via Syphon. However, this works only in mac.
All in all, a more exquisite project would require another approach, with the use of software like vvvv or Resolume that support the import and easy calibration of complicated volumes.

CONCLUSION

In the bounds of this essay, we focused on the various ways projection mapping and artificial light in general have been used in the domain of digital arts during the last century; from the very first attempts being static images trying to follow the volumes' geometry, to the most recent approaches that contemplate on a totalistic transformation of experiencing the real space, the medium has been adopted by several creators, in different eras and contexts with the purpose of reconstructing reality by bringing to life a common space where material and virtual are utterly fused.

While in the first experiment we worked with an already existent space, in the TimeCube project it was us who set the conditions to be changed. Therefore, in the latter the interest was turned on testing how an orthogonal structure with clear geometry, could undertake various visual redefinitions, guided by the decisions of the visitor; working both with videos based on the geometry, as well as with more organic figures in order to observe the impact on the form.

The step to follow is the creation of a fully interactive environment, where both image as well as form will be controlled by the user. The result could ultimately be the synchronized choreography of a breathing space.



img.65: ***Evi playing with the TimeCube during the "Semaine des Arts", March 2014.***

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PHOTO SOURCES

img.01: Screenshots from ***www.youtube.com/watch?v=ymrJLhSeIlk***
img.02: ***http://www.icem-pedagogie-freinet.org/node/25150***
img.03: ***http://www.icem-pedagogie-freinet.org/node/25150***
img.04: ***http://www.naimark.net/projects/displacements/displ_i3.html***
img.05: ***http://selfstyledsiren.blogspot.fr/2012/05/for-love-of-film-iii-preview-rear.html***
Img.06: ***http://www.fundacjaprofile.pl/tree.php?id=627***
img.07: ***http://fr.wikipedia.org/wiki/S%C3%A9rie_des_Cath%C3%A9drales_de_Rouen***
img.08: ***http://www.skertzo.fr/portfolio/rouen-2/***
*img.09:****http://www.designboom.com/art/projection-on-the-facade-of-gaudis-sagrada-familia-by-moment-factory/***
img.10: ***http://www.yatzer.com/Ralph-Lauren-4D-Experience-Behind-the-scenes***
img.11: ***http://www.1024architecture.net/en/2010/11/perspective-lyrique/***
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*img.16:****http://www.artnet.com/usernet/awc/awc_workdetail.asp?aid=424207055&gid=424207055&cid=75244&wid=424268044***
img.17: ***http://www.pablovalbuena.com/selectedwork/quadratura/***
img.18: ***http://www.creativeapplications.net/environment/eyjafjallajokull-vvvv-events-environment-inspiration/***
img.21: Screenshots from ***https://www.youtube.com/watch?v=CFTs_6C919g***
img.22: ***http://lichtundsoehne.de/2011/10/2-30at3-05-3/***
img.23: ***http://lichtundsoehne.de/2011/10/fla-flav/***
img.24: ***http://1956christos-theofilis.blogspot.fr/***
img.25: ***http://www.urbanscreen.com/usc/948***
img.26: ***http://www.creativeapplications.net/vvvv/the-human-seasons-by-david-dawson-set-design-by-eno-henze/***
img.48: ***http://www.victorianweb.org/art/illustration/tenniel/lookingglass/2.3.html***
img.51: ***http://www.musee-orangerie.fr/***
img.56: ***http://www.play-create.com/id.php?013***

Images 19-20, 27-47, 49-50, 52-55, 57-65, are photos, designs and renders, from personal record.

APPENDIX

Appendix 1: Python Script - CELLULAR AUTOMATA

```
# Ino Theodorou_AC_ANIMATION_RANDOM RULE

import maya.cmds as cmds
import random as r # but: creation d'une random serie des cellules
cmds.file(new=True, f=True)
cmds.modelEditor("modelPanel4", edit=True, displayAppearance="smoothShaded",
wireframeOnShaded=False, displayTextures= True, displayLights="default")
cmds.playbackOptions(fps = 1, loop="continuous", max = "50sec", min = "0sec")

### DECLARATION #### ce sont les objets que je vais utiliser
myRule = [] # une vide liste--- dans cette liste je cree mon rule
mesCouleurs = [[]] # une vide liste--- dans cette liste je stocke le COULEUR DE CHAQUE CELLULE
mesNextCouleurs = [[]] # une vide liste temporel, qui stocke les couleurs de la nouvelle generation
mesNoms = [[]] # une vide liste--- dans cette liste je stocke le NOM DE CHAQUE CELLULE
rows= 42
columns= 19

### CREATION ###

# creation du RULE INITIAL--- AVEC UTILISATION DU RANDOM SEED
def creationRule():
    for i in range(0, 8):
        seed= r.randint(0,1)
        myRule.append(seed)
        print (str(myRule) )

# creation des SHADERS
def blanc():
    for j in range(0, rows):
        cmds.sets( name="blancMaterialGroup"+str(j), renderable=True, empty=True)
        cmds.shadingNode("lambert", name= "blancShader"+str(j), asShader=True)
        cmds.setAttr("blancShader"+str(j)+".color", 1, 1, 1, type='double3')
        cmds.setAttr("blancShader"+str(j)+".glowIntensity", 0.25 )
        cmds.surfaceShaderList("blancShader"+str(j), add= "blancMaterialGroup"+str(j))

# creation des CUBES--- sans shaders
def creationCubes():
    for j in range(0, rows):
        mesNoms.append( [] )
        mesCouleurs.append( [] )
        for i in range(0, columns):
            mesNoms[j].append( cmds.polyCube( n = "Cube" + str(i+1) ) ) # stocker le nom du Cube déjà créé
            mesCouleurs[j].append(0) # c'est une valeur pour initialization, on va la changer plus tard
            cmds.move(i-columns/2, j, 0)
            cmds.connectAttr(mesNoms[j][i][0]+".scaleX", mesNoms[j][i][0]+".scaleY")
            cmds.connectAttr(mesNoms[j][i][0]+".scaleX", mesNoms[j][i][0]+".scaleZ")
            cmds.setKeyframe(mesNoms[j][i][0], attribute = "scaleX", value=0.0, ott = "spline", t=0)
            cmds.setKeyframe("blancShader"+str(j), attribute= "transparency", value= 1.0,ott= "spline",t=0)
mesCouleurs[0][int(columns/2)]= r.randint(0,1) # c'est ma cellule centrale, une condition initiale
```

```
# creation du Voisinage
def voisinage():
   myNextGen = { "000":myRule[0], "001":myRule[1], "010":myRule[2], "011":myRule[3], 
"100":myRule[4], "101":myRule[5], "110":myRule[6], "111":myRule[7] }
   number= 0
   mesNextCouleurs[0]= mesCouleurs[0]
   for j in range(1, rows):
      mesNextCouleurs.append( [] )
      for i in range(0, columns-1):
         a= mesCouleurs[j-1][i-1]
         b= mesCouleurs[j-1][i]
         c= mesCouleurs[j-1][i+1]
         voisins= str(a)+str(b)+str(c) # voisins est un string
         for key in myNextGen.keys():
            if key==voisins:
               mesNextCouleurs[j].append(myNextGen[key])
         mesCouleurs[j][i]= mesNextCouleurs[j][i] # je remplace le valeur du mesCellules[j][i+1], avec la 
valeur des mesNextCouleurs[j][i]

# apply the SHADERS
def applyShaders():
   for j in range(0, rows):
      for i in range(0, columns):
         if mesCouleurs[j][i]==1:
            cmds.sets( str(mesNoms[j][i][0]) , e=True, fe= "blancMaterialGroup"+str(j))

            cmds.currentTime(10+150*j)
            cmds.setKeyframe(mesNoms[j][i][0], attribute= "scaleX", value=1.0, ott= "spline", t= 50+10*j)
            cmds.setKeyframe("blancShader"+str(j), attribute= "transparency", value= 0.0, ott= "spline", 
t= 50+10*j)
            cmds.setKeyframe(mesNoms[j][i][0], attribute= "scaleX", value=0.0, ott= "spline", 
t=150+10*j)
            cmds.setKeyframe("blancShader"+str(j), attribute= "transparency", value= 1.0, ott= "spline", 
t= 150+10*j)

   print ( "-"*32 + "\nmyRule: " + str(myRule) )

##############################

creationRule()
noir()
blanc()
creationCubes()
voisinage()
applyShaders()
cmds.currentTime(0)

#END OF SCRIPT
```

Appendix 2: Python Script – L-SYSTEMS

```
# Ino Theodorou_L-SYSTEMS_ANIMATION

import maya.cmds as cmds
import random as r
cmds.file(new=True, f=True)

camera= cmds.camera(centerOfInterest= 5.0, position= (23.886, 2.0, -11.396), rotation= (4.800,
115.200, 0.0)) #camera=myCamera[0],---> modelEditor
cmds.setAttr("cameraShape1.backgroundColor", 1.0, 1.0, 1.0, type="double3")
cmds.modelEditor("modelPanel4", edit=True, camera=camera[0],
displayAppearance="smoothShaded",  wireframeOnShaded=False, displayTextures= True,
displayLights='default') # default modelPanel4 (the perspective view)
cmds.playbackOptions( fps = 4, loop="once", min = "0sec", max = "45sec", ps=24 )

# mes donnees
iterations= 7
listeRotate= [] # une vide liste des rotations
listeTranslate= [] # une vide liste des positions
mesCylinders= [] # une vide liste pour stocker mes objets
a= 0.5 # la taille du polyCylinder
i=1

# creer le trunc
base= cmds.polyCylinder(name="monCylinder0", sx=3, r=0.05, height=a) # le premier etape c'est la
base
mesCylinders.append( cmds.ls("monCylinder0", type="transform") )
#print cmds.polyCylinder( "monCylinder", q=True, r=True )
cmds.scale( 0.9996, 1.0, 0.9996, (cmds.select(base[0]+".f[5]")), ocp=True) # base[0] ---> monCylinder
cmds.delete( base[0]+".f[3]", base[0]+".f[4]" ) # on efface les faces qu'on ne voit pas
cmds.move(0, -a/2, 0, base[0]+".rotatePivot") # on deplace le Pivot de ROTATION
cmds.move(0, -a/2, 0, base[0]+".scalePivot")
cmds.select(base[0])


def generation(iterations):
    myAxiome= "F"
    print "myAxiome initial est: ", myAxiome
    for i in range (1, iterations):
        if (iterations<=4):
            myRule= { 'F':  "FFF-[$F*F]"}
        elif (iterations>4):
            myRule= { 'F':  "FF-[$F*F]"}
        elif (iterations>6):
            myRule= { 'F':  "[$F*F]"}
        newAxiome = ""
        for char in myAxiome:
            try:
                newAxiome += myRule[char]
            except:
                newAxiome += char
        myAxiome = newAxiome
        #print "iteration:", i, "---> myAxiome devient:", myAxiome
    return myAxiome
```

```
def l_system(myAxiome, i): # fonction l_system---recursive
   for char in myAxiome:
      if char == 'F':
         cmds.duplicate() # on duplice le cylindre
         cmds.move(0, a, 0, relative=True, objectSpace=True) # on deplace # SOS---relative=True
         cmds.scale(0.9996, 1.0, 0.9996, relative=True, objectSpace=True)
         mesCylinders.append(cmds.ls("monCylinder" + str(i), type="transform"))
         i= i+1 # an deis F, kane ola ta parapano, kai ayxsise to i kata 1

      if char == '+':
         cmds.rotate(10, 0, 0, r=True) # si on a un "+", faire rotation de 10 degrees  # ou r.randint(20,25)
      if char == '-':
         cmds.rotate(r.randint(-15,-10), 0, 0, r=True)  # si on a un "-", faire rotation de -20 degrees
      if char == '*':
         cmds.rotate(25, 0,0, r=True)
      if char == '$':
         cmds.rotate(0, 0, -20, r=True)
      if char == '[': # si on a un "[", on stocke la rotation et la position actuelle
         listeRotate.append(cmds.xform(rotation=True, query=True))
         listeTranslate.append(cmds.xform(translation=True, query=True))
      if char == ']':
         cmds.xform(rotation=listeRotate.pop()) # on recupere la rotation stocke
         cmds.xform(translation=listeTranslate.pop())

def creation(iterations):
   myAxiome= generation(iterations)
   l_system(myAxiome, i)

def applyShaders():
   cmds.sets( name="blancMaterialGroup", renderable=True, empty=True)
   cmds.shadingNode("blinn", name= "blancShader_0", asShader=True)
   cmds.setAttr("blancShader_0.color", 0.600, 0.0, 0.0, type="double3")
   cmds.setAttr("blancShader_0.transparency", 0.0, 0.0, 0.0, type="double3")
   cmds.surfaceShaderList("blancShader_0", add= "blancMaterialGroup")
   for i in range(0, len(mesCylinders)):
      cmds.sets( mesCylinders[i] , e=True, fe= "blancMaterialGroup")

def anim():
   for i in range(450, len(mesCylinders)):
      t=0
      cmds.setKeyframe( mesCylinders[i], attribute = "scaleY",  ott = "spline", value= 0.0, t=0.5*i-450) #
t=i*10
      cmds.setKeyframe( mesCylinders[i], attribute = "scaleY",  ott = "spline", value= 1.0, t= 0.5*i-
450+0.5) # t=i*10+10

#############################

creation(iterations)
applyShaders()
anim()
cmds.currentTime(0)


# END OF SCRIPT
```

Appendix 3: C# code used in Unity: servo control and communication with vpt

```
# script by Nefeli Georgakopoulou & Ino Theodorou

using UnityEngine;
using System.Collections;
using Uniduino;
public class ServoSlideControl : Uniduino.Examples.ServoSlideControl { }

namespace Uniduino.Examples
{
	public class ServoSlideControl : MonoBehaviour
	{
		public Arduino arduino;
		private GameObject cube;
		public int servo_pin = 9;
		public int servo_pos=0;
		public int potpin = 0;
		public float spinSpeed = 0.2f;
		public int pinValue;

		void StartHandler ()
		{
			OSCHandler.Instance.Init();
		}

		void SentToClientOscScale(int rotation)
		{
			OSCHandler.Instance.SendMessageToClient(
"vpt5","/layer1"+"/roty" ,rotation);
		}

		void Start ()
		{
			arduino = Arduino.global;
			arduino.Log = (s) => Debug.Log("Arduino: " +s);
			arduino.Setup(ConfigurePins);
			ConfigurePins ();
		}

		void ConfigurePins ()
		{
			Debug.Log("set pin mode");
			arduino.pinMode(servo_pin, PinMode.SERVO);
			arduino.pinMode(potpin, PinMode.ANALOG);
			arduino.reportAnalog(potpin, 1);
		}

		void Update ()
		{
			pinValue = arduino.analogRead(potpin);
			int new_servo_pos =(int)pinValue.Remap(0, 1023, 0, 180);
			Debug.Log (new_servo_pos);
			if (new_servo_pos != servo_pos)
				{
```

```
                        arduino.analogWrite(servo_pin,
(int)new_servo_pos);
                        servo_pos = new_servo_pos;
                    }
                transform.localEulerAngles = new Vector3(0,-servo_pos,0);
                SentToClientOscScale (servo_pos);
            }  //ends Update

        }  //ends MonoBehaviour
} // ends namespace Uniduino.Examples
```