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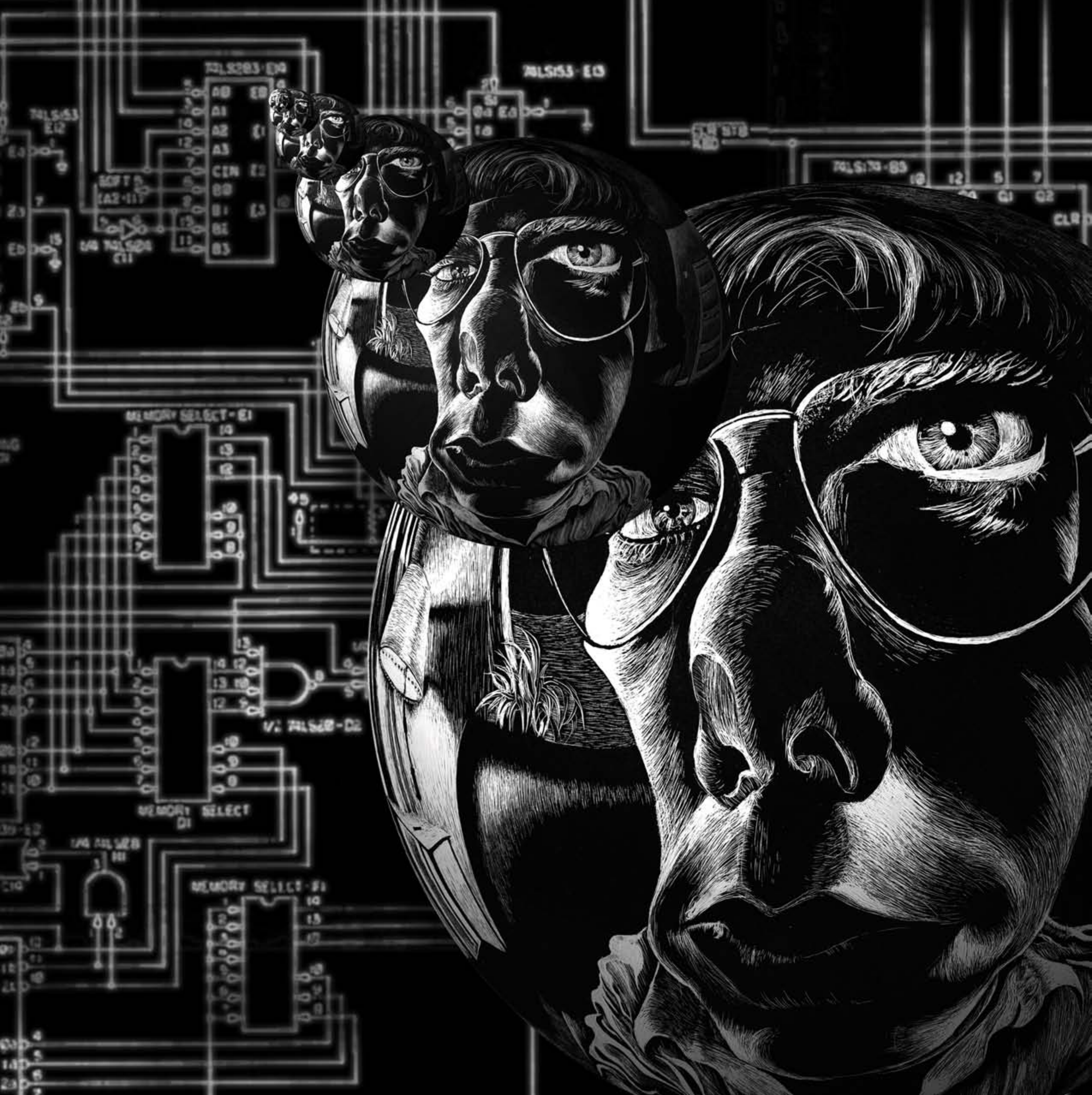

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Metaverse: Building Affective Systems and Its Digital Morphologies in Virtual Environments

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Abstract:

This essay reflects the metaverse as a virtual reality system created by affective and aesthetic computing and its digital morphology through visual mathematics. An appropriate system and its structures can move, changing their shapes as a whole, and produce responsive 3D assemblages answering in simple ways to emotions. The study of behavior and cognition in virtual environments, and to interact with them as a collaborator, is valuable, but we also need someone who gets right into the code to see how it all works and how it may be adapted to his own world, as well as keeping the study focused on the necessity to organize the known geometries in systematized morphological sets to apply them for the creation of affective and aesthetic systems for virtual worlds in 3D platforms, which change and grow, becoming symbiotic assemblages. Certainly, there is a long journey to go on to investigating conditions and evolutionary iterations which may assist the affective computing to approximate to the real world, to go ahead and conquer more and more ambitious digital architectural spaces, but it all are like vectors pointing to such direction.

Keywords: metaverse, behavioral mathematics, cognitive science, affective and aesthetic computing

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Introduction

This paper is an attempt to begin to point out the key issues necessary for the development of metaverse as a virtual reality system created by affective and aesthetic computing and its digital morphology through visual mathematics. In this way we can show how physical properties like space, time, light, matter and movement could derive from information processing. That is the virtual reality concept for the development of geometric structural organizations in 3D (n- space) which are able to grow for visual education. The applied cognitive science and cognitive neuroscience has shown that perception may be modified by emotional involvement and may also be tricked by illusions.

Nowadays, to accept or not the metaverse environments in the formal education and training doesn´t seem to be a choice anymore; to do no study and yet know this kind of learning technology exists, is a social irresponsibility. (Gardner, 2007)

Through history we can see the Descartes' conception of time and space that reflects this primacy of the mind. First of all, Descartes maintains that space is infinite and unlimited, and that time is the meaning in with which the human mind accounts for duration (Trusted: 69-70). Sir Isaac Newton's (1642-1727) theories of mechanics are postulated on the ideals of absolute space and time. Due to instabilities in the earth's movement, human beings necessarily depend on "relative time," although an absolute time outside of this relativity exists. Likewise, absolute space exists because, while objects may be moved in relation to each other, space itself cannot be moved (Trusted, 1991).

The research of digital morphologies for the construction of behavior structures through affective computing, exploiting the fabric of morphological growth to be able to change dynamically their forms in a responsive way, may allow mixing virtual and physical realities in social symbiotic ways. It's the reflection of Marshall McLuhan in "Understanding Media", who described a similar process as "implosion" as people are more closely unified through networks in the electronic age. This unification through implosion, for McLuhan, produces a positive sensory connection that allows for a "global village" to emerge. For instance, we know that the mind perceives the conception of perceptual accommodations of space and time in several medias. In this way, we have that the period of the late twentieth and early twenty-first centuries postulating that experiences of time and space outside individual media have become increasingly compressed. "The immediate prospect for literate, fragmented Western man encountering the electric implosion within his own culture is his steady and rapid transformation into a complex and depth-structured person emotionally aware of his total interdependence with the rest of human society" (McLuhan, 1994). To illustrate the depth of contrast, consider the primary axiom of Lee Smolin's book: "There is nothing outside the universe" (McLuhan, 1994). The edifice of science itself is often assumed to rest upon this apparently self-evident statement, yet it is precisely this statement that virtual reality theory contradicts. Indeed the prime axiom of virtual reality theory can be obtained by reversing Smolin's axiom, namely: *There is nothing in our universe that exists of or by itself.* This axiom arises because a virtual reality processor cannot itself, logically, exist within the virtual reality its processing creates. A processor cannot create itself because the virtual world creation could not start if a processor did not initially exist outside it. Hence any virtual reality world, by definition, *must* have existence dimensions outside itself. Many physics theories, like string theory, already suggest that our world has additional dimensions, yet these are, for some reason, still assumed to be in the world, but just "curled up" to be invisible to us. In contrast, virtual reality theory's additional dimension(s) must be outside the virtual reality world. Yet what is the difference between an unknowable dimension that is "in the world" and one that is "outside the world"? Since both are untestable science favors neither view. To postulate that the world is virtual does not contradict science, but rather engages its spirit of questioning. Science is a method of asking questions, not a set of reality assumptions. Science does not require an objective world, only information to test theories against, which a virtual reality can easily provide. Not only can science accommodate the virtual world concept, a virtual world could also sustain science.

Louro and Fraga wrote about a Russian mathematician called Kolmogorov who developed an additive procedure to evaluate the dimension of sets of points. Such procedure led to the future the development of the concept of fractals by Benoit Mandelbrot, allowing the knowledge that sets of similar objects with fractal dimensions seams to better explain many natural processes. At the same time the British zoologist D´Arcy Thompson applied well-known mathematical concepts to study morphologies for the growth of forms in nature. The usefulness of Thompson´ studies for architects and computer artists creating 3D physical structures lies mainly in his approach based on geometry and Newtonian mechanics. Also, his focus on the Fibonnacci series, the Miraldi angle, the logarithmic spiral, and the golden ratio puts him in line with advanced studies in neuro and cognitive sciences, which are pointing toward the hypothesis that there is a logarithmic order imbedded in the neuronal circuits of our brain. (Louro and Fraga, 2008) We have also to consider the proposes in the current physics that seems to approach virtual reality theory in that our physical reality can be simulated by information processing which is calculable. On the other hand, we also recognize that our physical reality uses information processing in its operation to some degree and our physical reality is created by information processing based outside the physical world.

Yoshikawa and Ueda describe that *calculable universe hypothesis states* that physical reality can be simulated by information processing. Calculable here does not mean deterministic, as processing can be probabilistic, nor does it mean mathematically definable, as not all definable mathematics is calculable, e.g. an infinite series. Many scientists accept that the universe is calculable in theory, as the Church-Turing thesis states that for any specifiable output there is a finite program capable of simulating it. If our universe is lawfully specifiable, even probabilistically then, in theory, a program could simulate it (though this universal program might be bigger than the universe itself)(2007).

This hypothesis does not say the universe *is* a computer, but that it could be simulated by one, i.e. it does not contradict objective reality. In other hand, the *calculating universe hypothesis* states that the universe uses information processing algorithms to create reality, e.g. quantum mechanical formulae. Supporters of this view are a minority, but include mainstream physicists like John Wheeler, whose phrase "*It from Bit*" suggests that objects ("it") somehow derive from information ("bit"). Now information processing does not just *model* the universe, it *explains* it. While a computer simulation *compares* its output to the physical world, in a computer explanation the information processing *creates* reality, i.e. the latter is a theory about how the world actually works. Now the world is not just *like* a computer, it *is* a computer (Yoshikawa and Ueda, 2007).

In this way, after our initial consideration, the dynamical images describe the building of digital morphologies to metaverse as a rich opportunity to present some creative process in the thought of computational artists who plan before virtual worlds constructs. Therefore, in order for artificial intelligence to equally deal with interactions in the symbiotic assemblages between virtual environment, between a user and a virtual environment, and between users, we regard each of the elements - virtual environments, users, and so on. We let these elements form independent modules, and also let the interactions between them form modules connecting them. On other hand, in the same direction, let's remember what was explained by biologist Humberto Maturana (1980), that "Living systems are units of interactions; they exist in an environment. From a purely biological point of view, they cannot be understood independently of the part of the environment with which they interact, the niche; nor can the niche be denned independently of the living system that occupies it." Moreover, "when an observer claims that an organism exhibits perception, what he or she beholds is an organism that brings forth a world of actions through sensory motor correlations congruent with perturbation of the environment in which he or she sees it [the organism] to conserve its adaption (Maturana, 1980).

Inside digital's heart

The environments of 3D platforms in the virtual worlds with physical realm of buildings/objects may allow the development of symbiotic constructions that can be explored in order to discover new shapes for affective computing and its digital morphology. As Louro and Fraga (2008) state:

Computing technology is becoming pervasive in our environments. It is a well-known fact that human perception of space and time is determined by culture and change with new inventions. Psychological and neural cognitive sciences have shown that perception may be modified by emotional involvement tricking illusions. It is a challenge for cognitive scientists, computer artists, designers, architects and physical-mathematicians to conceive digital morphologies to be applied in responsive buildings/objects, which, associated with affective interfaces, may create unfathomable qualities for future built immersive environments and artworks.

To build and discover new shapes for affective computing in virtual worlds, the mathematics is the most important tool in either simple or complex worlds. Actually geometry is the key for these immersive environments to unite creation and algorithmic development for education through affective computing. Immersive Education, today, combines applied cognitive sciences, interactive 3D graphics, 3D platforms, trade and technology in simulation games, digital cinema, and visual poetry, augmented reality, mixed reality, artificial life, and teletransport, among others. As Santiago says "Mathematics is the language of science, and anything we do with a computer must have a mathematical construct on which it is based" (Santiago, 2005). To understand the concepts behind computer graphics and to most effectively use software to create effects, it is important to know basic algebra, trigonometry, geometry, calculus, and linear algebra. Math is the language of science, and many effects are based on the scientific reality we experience every day. Applying the mathematically correct solution the first time is much more effective. Math is the language of science, and many effects are based on the scientific reality we experience every day.

Paul Fishwick (2003), in his paper called *Exploring Multiple Visualization Perspectives with Aesthetic Computing,* says: "In computing, the finite state machine (FSM) is ubiquitous, found in lexical scanners for language parsers and scripting languages, and in behavior encodings for artificial agents in interactive games." Let's consider the following Moore machine M (fig.01):

• M =< Q, I,O, _, _ >

• Q = {S1, S2, S3}

• _ : Q × I ! Q, _(Si, 0) = Si for n 2 {1, 2, 3}, _(S1, 1) = S2, _(S2, 1) = S3, _(S3, 1) = S2

• I = {0, 1}

• _ : Q ! O, _(Sn) = Sn, n 2 {1, 2, 3}

Fig.01 - Moore Machine M

The machine has 3 states (S1, S2, and S3) with an input value of 1 achieving a change in state. An input of 0 leaves the machine in the same state. The machine oscillates between two states S2 and S3 after it gets a jump start from S1, and a subsequent stream of ones.

All of these aspects and relevant procedures to build responsive virtual environments with high technologies in modeling and characters development must work as close to exactly pas modeled for its computing to be effective in its applications. To illustrate the influence of social relationships on emotions, Picard uses Roseman, Antoniou, and Jose in their 1996 study: "Roseman and his colleagues constructed a model in which a small number of appraisals interact to give rise to seventeen emotions." (Picard, 2000)

Our studies, based on a long work by Louro about *behavioral mathematics*[1], allowed us to consider technical images inside virtual environments, through behavioral mathematics in the creative process, numeric-topological expressions, describing all the morphologies that are working on the aesthetical computing. In this way, Santaella wrote: Conceived as a science of knowledge of how a sensitive issue, as we recall Baumgarten, the founder of aesthetics is not confined to what has been understood the art of speech ("the art of beauty ","fine arts"), but to understand how knowledge of aesthesis to study gnoseologia a feeling or perception of sensible, logical knowing the inevitable (Santaella, 2007).

In this way, Paul Fishwick wrote about a new area that is called *aesthetic computing*. "Within this area, there is an attempt to balance qualitative with quantitative representational aspects of visual computing, recognizing that *aesthetics* creates a dimension that is consistent with supporting numerous visual perspectives" (Fishwick, 2003).

Affective Computing[2] – Keep Walking

Actually the latest studies in the virtual world have to consider artificial intelligence as a mix between digital games and digital cinema through emergent technologies and digital Medias. For these environments, virtual platforms with high quality graphics and a good human-computer interaction (HCI), must reflect a dynamical repertoire of procedures aggregating mathematical concepts such as self-similarity, fractal dimension, quaternion algebra, geometric systems allowing growth, and maximum movement with the use of minimum forces which have not, yet, taken shape. Such a set of procedures may become a very useful tool for educational computer and training, exploring new affective images and characters for architectural design processes and for industrial advertisement initiatives. The research of mathematical morphologies to build structures (Peirce, 1990; Serra, 1988), using

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[1] behavioral mathematics is a numerical-topological representation, imagetic and dynamic, which simulates affectivity through computational codes to approximate cognitive models of realistic behavior in immersion environments or interaction.

[2] Affective Computing: The research area concerned with behavioral artificial mathematics that relates to simulating emotion. Affective computing expands HCI by including the emotional communication and caracterization of character, together with the appropriate tools of mathematical modelling of affective information.

the fabric of morphological growth and also allowing them to change dynamically their forms in responsive ways, may mix virtual and physical realities in symbiotic constructs.

Such repertoire will be of great help to systematize the huge amount of possibilities that emerged after many years looking for mathematical morphologies that would be appropriate to build dynamical physical and virtual structures. To research changeable morphologies for dynamic spatial 3D structures, it is necessary to explore algorithms for growing structural shapes, using random and automated processes, and for the development of kinetic systems to provide the movements of their physical parts.

This paper may make a difference in how to use potential improvements to researchers and developers, in ways to involve a given technique, focusing on how they might create and construct affective and aesthetic computing in their own virtual environments.

Joe Bates—who works with emotions and moods for animated characters—in his communication at ACM, describes how to make agents believable by giving them the illusion of life, and designing them to be able to influence their audience as deeply as they would if they were real (Bates, 1994). There are a lot of signals representing emotions and moods inside virtual environments, describing some of the pieces of an affective system. Picard (2000)related that theorists tell us that emotions usually last for less than a minute or two, while moods can last much longer. Cognitive expectation is important in these constructions, it on architectural planning for signal representations in virtual environments. To Picard all these influences can be represented by a simple nonlinear function applied to the inputs of an emotional system. The proposed function is a “sigmoidal nonlinearity” (fig.02) described by the equation

$$y = \frac{g}{1 + e^{-(x - x_o)\,/\,s}} + y_o$$

Fig. 02 - sigmoidal nonlinearity

Finally, let “f” be a function that controls the temporal decay (fig.03) of on emotion intensity, and let “g” be a function that constrains the emotion intensity to lie between zero and its saturation value. The new intensity is then a function of its decayed previous value, its elicitors, and influence from other emotion intensities:

$$I_p(-1) = g\left(f\left(I_p\,(t-1)\right) + \sum_{l+1}^{4} \varepsilon_{p,l} + \sum_{m=1}^{p} (\,\alpha_{p,m} - \beta_{p,m}\,)\, I_m\,(t)\right)$$

Fig. 03 - function that controls the temporal decay

To create, developing or to constructing up emotion and behavior with scenarios and characters in metaverse, and to bring them to life, it is necessary to keep focus on affective and aesthetic computing and its mathematical morphologies based on cognitive reasoning[3] within a social context. The visual dimension of artificial intelligence through affective procedures in the virtual environments is not only guaranteed to engage the surfer but also, if carefully constructed, it can demonstrate, inform and arise interest, motivation, and so on, inside environment, where from a world of reality or fantasy the categories and strategies for developing the effects will remain essentially the same, even as technology moves forward, providing new and better tools and systems to implement them.

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[3] This condition as implemented as rules in Elliott’s Affective Reasoner System. Clark Elliott of DePaul University.

In the other hand we have to consider that affectivity happens by dynamical effects in our vision systems. At this point the affective and aesthetic computing can be implemented through emotion and behavior based on the devices of the project. The research developed by Louro (2007), with emotion and behavior in immersive games, digital cinema and visual poetry, as metaverse, has demonstrated the fundamental importance of the field in the creative process. The study of Mutable Architectures has aroused possibilities for constructing interaction with emotion and behavior through mathematical morphology of digital animation by numeric-topological systems. Before describing applications in the next point, there is an important distinction to be made regarding the scope of digital morphology in the metaverse, otherwise, in the visual mathematics and physics inside them, that is presented by quaternion`s algebra theory, who decides rotation and translaction of rigid bodies in the virtual worlds. The affectivity, aesthetics, movement and complex dynamics systems, through rules and principles from code computing, emerged by numeric-topological expression behind the creative process in the project, as a computational intelligence become highly associative and intertwined with architecture design. Another important application that involves affective computing requires attention to the following issue in how to recognize/expresse/develope the best visual system.

Consider the image below that generates affective states which include social rules of interaction developed by studies on creative process. Let`s look at a frozen image of a Metaverse where we can interact with the virtual environment called: Mutable Architectures and Caracolomobilis.

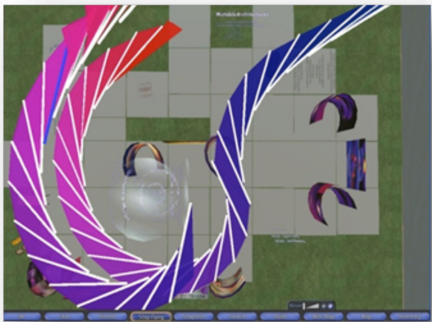


Figure 1. Mutable Architectures

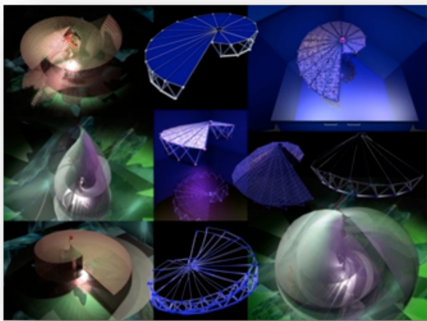


Figure 2. Caracolomobile and Nanoshelters

The Caracolomobile's structure is composed of a set of varied pyramids that unfolds forming a logarithmic curve.

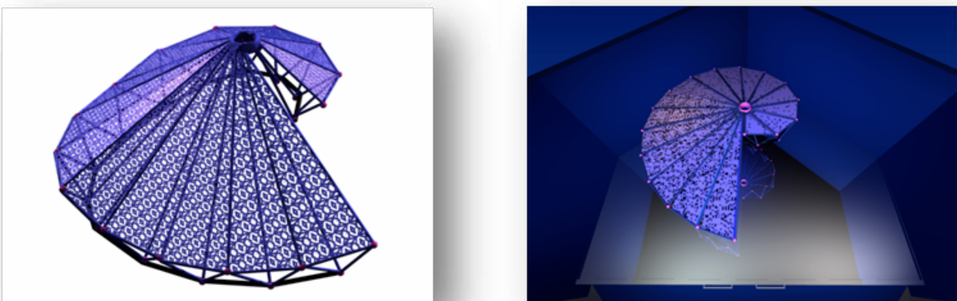


Figure 3. & 4. Caracolomobile: simulation of the open shape, view from above

Metaverse as Dynamical Repertoires:

Meanwhile, as we describe in this paper, the cognitive expectation is important in these virtual construction planning because the dynamical effects will be designed by imagetic perceptual analyses. The study from Picard (2000) focused on affective computing through signal representations in virtual environments was an important contribution to the applied cognitive science. In an effort towards the development of characters and scenarios for metaverses that we will demonstrate in the future, morphologies allowing moving parts of buildings to change elements of their physical structures themselves have not yet begun to be addressed. The hypothesis we work with is that it is possible to use behavioral mathematical for generating affective and aesthetical forms and procedures for the design of dynamic and flexibly assembled spatial 3D structures as parts of responsive symbiotic artworks in the metaverse. We are interested in applying this methodology to the more general problem of modeling applied cognitive systems. A dynamical modular repertoire of procedures includes:

- the study of possible new materials to replace mechanical devices in built spatial 3D structures;
- learning, decision making, perception, and goal-seeking as aspects of AI in cognitive behavior that cover mathematical framework of animation in virtual worlds;
- the search for patterns for growth, extension, development and expansion of such structures.

Such repertoire will be of greater help to systematize the huge amount of possibilities that have emerged after many years looking for the behavioral mathematical that would be appropriate to build dynamical physical and virtual structures. Patterns for growth may be based on the proliferation of similar modules creating 3D lattices by packing polyhedrons (Williams, 1979) in similar ways to crystals and also looking for similar structures at the natural world around us. To develop repertoires based on the latter it is necessary to look for:

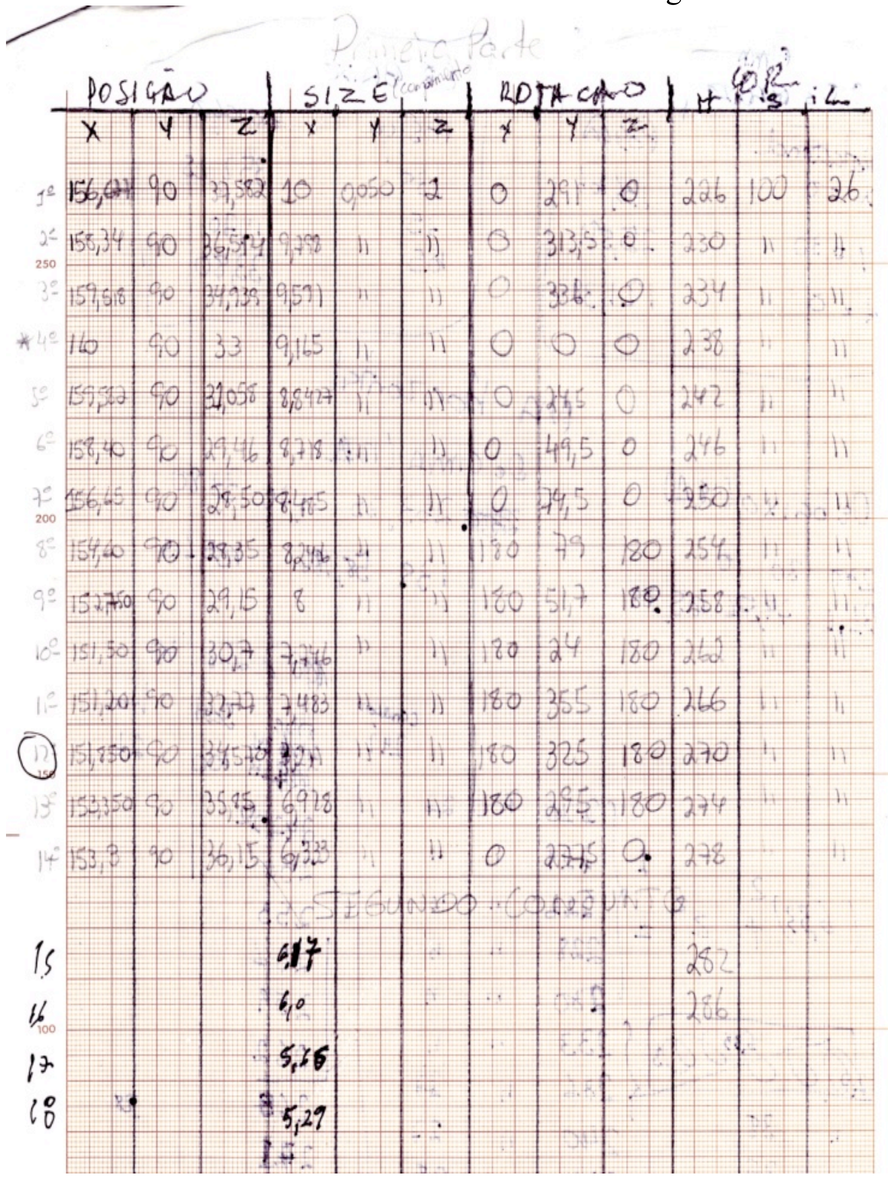
- sets developed by repeating variations of basic configurations which will create articulated shells and cocoons;
- geometrical configurations which allow movement provoked by minimum forces;
- ways to use gravity as part of the process of moving things for energy savings;
- the creation of systems based on the repetition of slightly varied objects forming logarithmic configurations usually known as spirals.

For dynamic growing spatial 3D structures to be used as parts of architectural spaces it is very important to study patterns for their extension in the three dimensions of space. The structure final shape may be more opened or closed, sparsely or densely spiraled. This behavior becomes a very big physical problem for builders since they have to deal with another powerful force: the gravity. This problem increases when movement is added to the structure itself. Therefore, the larger the structure the bigger are the tensions the sections of structural elements are subjected to. As Galileo stated more than 400 years ago, for an ant to become the size of an elephant it would also need to lose its morphological characteristics becoming heavier and bulkier. The same problem has hunted architects and engineers for ages and has defined all the technologies developed until today. The combination of such families of patterns will define the final shape of the structure and will provide the procedures to automate the production of the kinetic systems that will move the elements. It is important to notice that a growing structure, being irregular in relation to its mass, will tend to look for physical equilibrium. Such situations convey that the structural center of mass is improperly located in relation to its geometrical center, a fact that needs to be addressed from the beginning of the design process, so it will not become vulnerable and a huge problem.

The use of such cognitive reasoning is the base of the Mutable Architectures and Caracolomobile artwork. This computer interface is a surface created aiming to instigate participation. It integrates the participants' actions with real time computer processing. The movements of both surfaces use the same sinusoidal equation. For instance, 'Caracolomobile' and Mutable Architectures go further into these concepts by adding affective interfaces to control some processes happening inside the metaverse. The following images will demonstrate the embodiment calculus reasoning in the creative process before implementing computer programming to the metaverse.

Every scenario and character characterization, which has affective inherent attributes and physical properties determined by the generator, and are sometimes called internal influences. In the other hand, the external influences are those to which the system being simulated is subjected. In this way those influences can be phenomenon like wind, gravity or collision on objects which the behavior of the affective system reaches due to its current attributes.

The reasoning through calculus can open minds and bring cognitive effects through emotion and behavioral mathematics inside of animated 3D images.



Primeira Parte

	POSIÇÃO			SIZE			ROTAÇÃO			H	S	L
	X	Y	Z	X	Y	Z	X	Y	Z			
1º	156,[illegible]	90	37,582	10	9,050	1	0	291	0	226	100	26
2º	155,34	90	36,514	[illegible]	"	"	0	313,5	0	230	"	"
3º	159,518	90	34,[illegible]	9,571	"	"	0	336	0	234	"	"
4º	160	90	33	9,165	"	"	0	0	0	238	"	"
5º	159,[illegible]	90	31,056	8,8424	"	"	0	24,5	0	242	"	"
6º	158,40	90	29,46	8,718	"	"	0	49,5	0	246	"	"
7º	156,45	90	28,50	8,455	"	"	0	74,5	0	250	"	"
8º	154,40	90	28,35	8,246	"	"	180	79	180	254	"	"
9º	152,750	90	29,15	8	"	"	180	51,7	180	258	"	"
10º	151,30	90	30,7	7,746	"	"	180	24	180	262	"	"
11º	151,20	90	32,29	7,483	"	"	180	355	180	266	"	"
12	151,150	90	34,5[illegible]	7,2[illegible]	"	"	180	325	180	270	"	"
13º	152,350	90	35,[illegible]	6,928	"	"	180	295	180	274	"	"
14º	153,3	90	36,15	6,323	"	"	0	[illegible]	0	278	"	"
	SEGUNDO CONJUNTO											
15				6,17						282		
16				6,0						286		
17				5,26								
18				5,27								

Figure 7. Draft sheet calculations of rotation, translation and colors, to be implemented in computer codes generating images

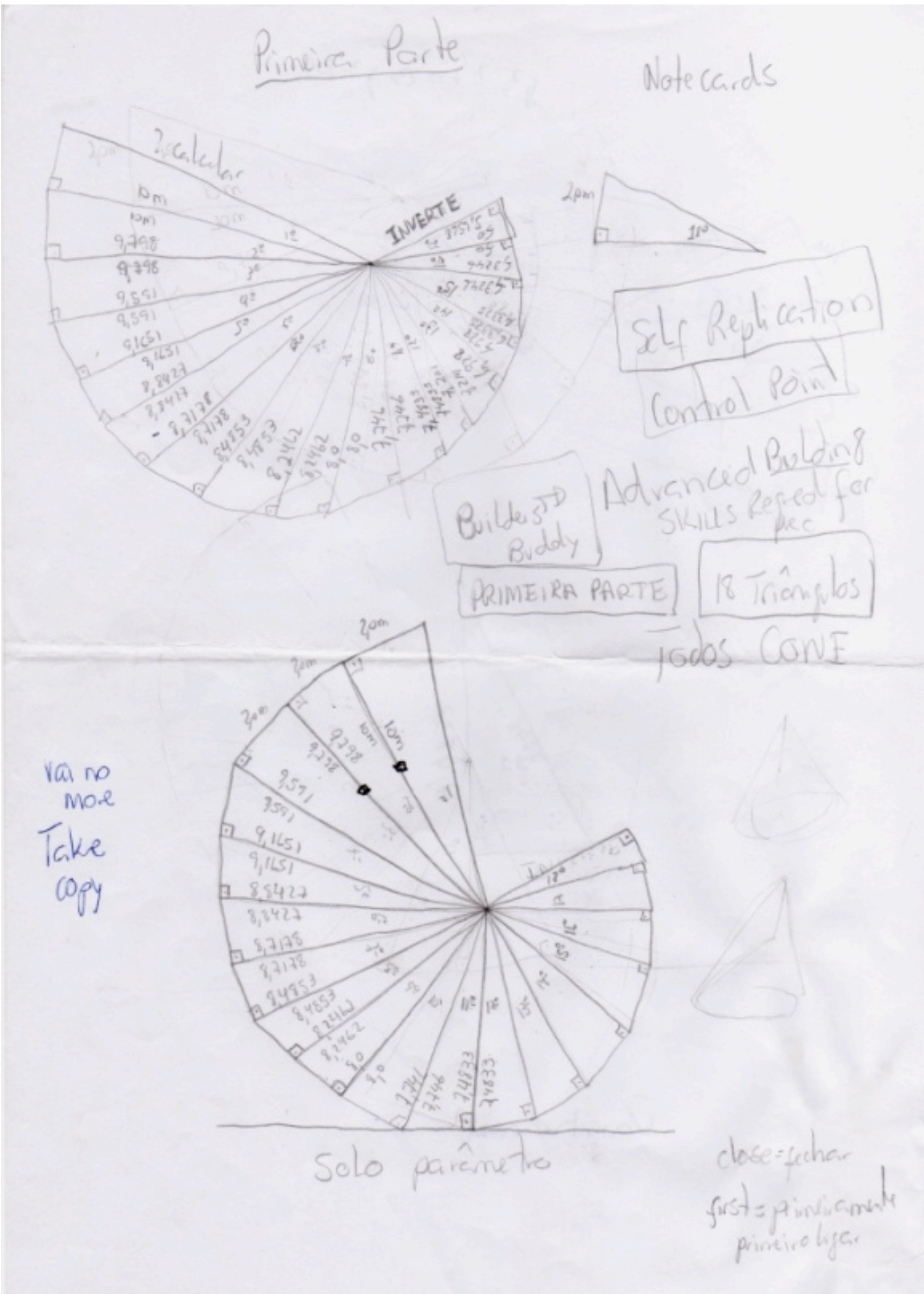


Figure 9 Sheet Draft: Calculation of angles to test physical prototypes, which precedes the interaction design for the environment of immersion

These images, also, show the hidden mathematics in the human creative process, different calculus line for angles and movements that will implement the computational codes for constructing the immersive virtual world.

Conclusion

The simulation of emotion in virtual environments can be fairly simple or extremely complex. It is the behavior mathematics of real-world objects that we are trying to simulate in the computer, a controlled environment by artificial intelligence through affective and aesthetic computing.

Finally, in general, a virtual world's maximum event rate is fixed by the allocated processing capacity, but in our real world, the fixed maximum that comes to mind is the speed of light. That there is an absolute maximum speed could reflect a maximum information processing rate, and in digital processing, if a world is virtual, everything in it must be digitalized. Plank's discovery that light is quantized could then generalize not only to charge, spin and matter, but also to space-time.

This article should inspire us and inform us, in a way that leads us to reflect in work about virtual environments and, above it all, it shall remind us of how it feels to be someone who can change lives through the power of affective computing and its mathematical morphology. As Louro, (2007) wrote:

To research about computing effects, affective and aesthetic, in immersive virtual worlds, and its morphology mathematical construction for dynamic spatial 3D structures, it is necessary to explore applied cognitive science and all related fields such as: behavioral mathematics, imagetic perceptual analyse, artificial intelligence, algorithms for growing structural shapes, for using random and automated processes, and for developing kinetic systems to provide the movements of their physical parts."

Attempts to clarify what behavior mathematics and affective computing means in the cognitive applied science should start by the acknowledgment of the term's meaning, as the interactivity of these terms can cause an interaction human-computer successful in the virtual immersive environments, transforming the passive receiver of information into the active participant and collaborator in virtual worlds.

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