Urban and architectural 3D fast processing.

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Introduction

Present computer aided-design tools should be able to assist the former exploration that leads the entire design process. However, present software often calls an immediate actualization of geometrical intentions by forcing the user with pre-set intentional clusters - geometric primitives, textural resources, design procedures... - often uncompromising, with poor intuitive feedback and generally restraining imagination spreadout: "*most of CAD software act like over-equipped hand-drafting assistants, assuming the maturity of the designer as much as the maturity of the project itself.*" [Chupin - Lequay 2000]

We must quote Donald Shön's opinion, who remarks that research should concentrate on computer environments able to enhance user's ability to comprehend, store, manipulate, organize and speculate over project's matter. Many research projects explored this concept, introducing new operating methodologies able to *schematize* introductory projectual investigations, long before any possible geometric formalization.

What we aim to achieve is a computer-assisted generation process of architectural and urban plausible geometries. These self-generated objects are intended to act like "imagination enhancers" serving conceptual exploration of architectural design or providing credible 3D environments in given historical context. Next step, this "pr-object" could not only be the ponderated completion of a pluridisciplinaric integration process but, in an autonomous evolution Darwinian paradigm, the actualization of the most performant genotype, or saying like Celestino Soddu, *a generative project is a concept software that works producing three-dimensional unique […] events as possible and manifold expressions of the generating idea identified by the designer as a subjective proposal of a possible world.* [Soddu 2002]

Some of the research tasks depicted hereby take advantage of recent generative methods developed within the MAP aria research team. They are able to quickly produce architectural and urban geometric simulations, bringing to life wide 3D databases connected to some of the most recent 3D terrain browsers. (Virtual Terrain©, MSN Virtual Earth© or Google Earth©...)

I. INTRODUCING GENERATIVE PARADIGM

1. Form vs. function

In architecture, a modern acception for spatial interdependancies states that **form** should rise from **function**. Since Franck L. Wright, Robert Mallet-Stevens and Ludwig Mies van Der Rohe architectural thought , and enlightened by their sublime work, we believe in such a manichean dogma, wich could be - to be simple - the main contrast to centuries of academism, and by the way a brand new unrestricted field of investigation.

Conversely, most examples of classical architecture appear to be in a complete conceptual opposition, with recurring high geometric-prevalence regarding function. The question is obviously not here to state about the overcome of this conceptual dialog between **form** and **function** but to consider further some *hierarchical* appraisal when we will be brought – in our software - to select initial input data.

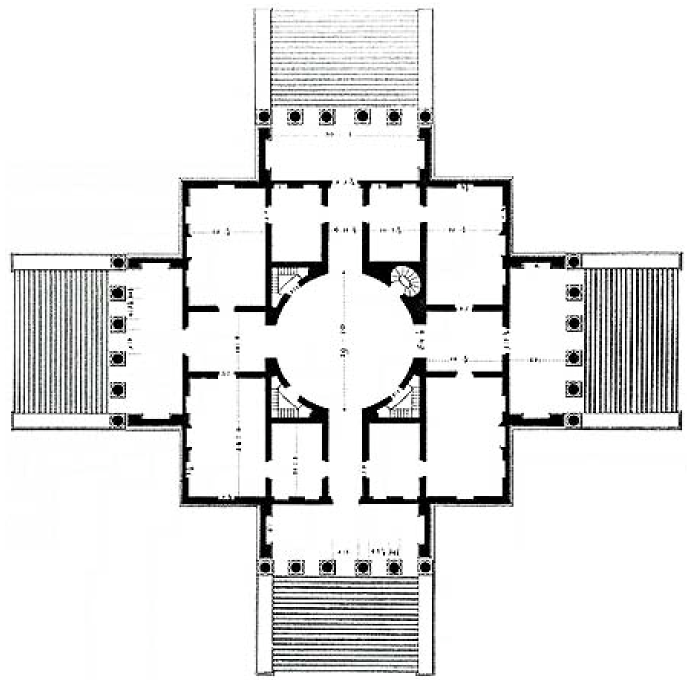

fig1. villa Rotonda map : Andrea Palladio – 1556

In his 'entretien avec les étudiants des écoles d'architecture" even Le Corbusier asserts how difficult it is to arrange a complex spatial distribution within simple shapes. According to this point of view, a profuse geometrical spreadout could rather facilitate the solving of programmatic intricacy… [le Corbu – 1958]

According to R. Wittkower, the most representative width/height ratios within palladian architecture match the chromatic major musical scale. In this perspective, a C-G major chord could be quoted with a period ratio of 2:3; a C-F major will be quoted as 3:4. In this perspective (and it is interesting to show how the "music interval" notion rests on the latin etymology of *intervallum*, which literally means "between the walls") Deborah Howard and Malcolm Longhair underlined the recurrent use of musical ratios within Palladian architecture, emerging from a systematic frequency analysis of his major villas geometry and noticing that such reports are mesureable horizontally and vertically.

G Stiny and W. Mitchell - above many others - pointed out some parametric grammars able to generate palladian architectural patterns. This approach clearly refers to Prof. Noam Chomsky linguistics experiments and the amazing Palladio 1.0 Macintosh© Hypercard Stack [Freedman - 1990] is a noteworthy example of such a morphological synthesis. This concept is definitely an oldie but it's achievement could nowadays be handled by emerging technologies. The leading action of Vitruvius in such domain - a generative or algorithmic approach to automate the design process - massively influenced renaissance's conceptual contents; philosophers and architects of this period, such as Leon Battista Alberti or Il Rossellino and moreover contemporary theorists - Goethe, Monge, Froebel, Frege and more recently Wittgenstein and Le Corbusier through the research of Iannis Xenakis - certainly considered and applied theoretical aspects of this scheme in their very own work.

Morphologic studies of urban framework gave birth to various investigations; P. Panerai [Panerai - 1992], trying to define precisely "urban framework" (*tissu urbain* in french is closer to "fabric" or "cloth") encloses its peculiar meaning within a combined structural and systemic approach, stating that "*urban framework space closely follows roads, squares, boulevards and lanes spreadout as much as it can be the direct expression of the parcel's reverse influence*"

Beyond the functionalist process that leads architectural and urban design through the correct response to constructive and programmatic needs, we can observe some peculiar design processes guided by specific interdisciplinary connections:

• physical analogies
• structural analogies
• geometric similarities
• multi-scale patterns
• …

In the domain of morphologic analysis – here intended as the backtrack of the conceptual pattern - we must mention the LAF research team, within the architecture school of Lyon (F). What B. Duprat and M. Paulin [Paulin – Duprat 1991] designate as a "morphological factorization of architecture" consists in splitting complex architectural arrangements in visible and pertinent sub-elements. Semantically speaking, this could be achieved in different manners, according to the specific knowledge we are willing to figure out: this is why a geometrical description of an architectural system doesn't necessary match the architectural or even its very deep constructive expression.

"We only could reason on models" stated Paul Valery describing this very peculiar representation mode that supports artificial and symbolic mental depictions. The model, (emerging from the latin "*Modulus*, from *modus*, the measure) is resulting from a schematization process able to select certain discriminant properties of the "real-life system", providing a plausible simulacre, an homotopic functional structure in a given abstraction level. This principle describes the model as a full-interactive set of elements, with it's own organisation, information and knowledge rules.

Noam Chomsky *is the Institute Professor Emeritus of linguistics at the Massachusetts Institute of Technology. Chomsky is credited with the creation of the theory of generative grammar,* *considered to be one of the most significant contributions to the field of theoretical linguistics made in the 20th century.*

2. Apophenic approach, a perceptive disruption.

Pareidolia is a type of illusion or misperception involving a vague or obscure stimulus being percieved as something clear and distinct.

Apophenia is the experience of seeing patterns or connections in random or meaningless data. The term was coined in 1958 by Klaus Conrad, who defined it as the "unmotivated seeing of connections" accompanied by a "specific experience of an abnormal meaningfulness".
"*The propensity to see connections between seemingly unrelated objects or ideas most closely links psychosis to creativity ... apophenia and creativity may even be seen as two sides of the same coin*." [Brugger 2001]

It seems that part of the cognitive (re)construction of depicted artifacts depends on a peculiar misreception of visual data; It's more the unconscious will to project some personal expectations that tend somehow to enhance the perceptual efficiency.

We can mark out the very famous painting "ceci n'est pas une pipe" by Magritte, for stating how far the interpretation of an object from the object itself could be...

fig 2. « ceci n'est pas une pipe »: René Magritte – 1929

What we can call a "look like" effect consists, in some precise representative paradigm, to act as an imposture, close to perceptive constructed distortions like anamorphosis - a distorted projection or representation which, when wiewed from a certain point, appears regular and in proportion - or "trompe l'oeil" effects. The idea is that - in this case - the effect is not only specifically geometric but more generically perceptive. Furthermore, we can observe that there is a very subjective perceptive limit to the legibility of a significant pattern : we can observe that this limit could have wide interpersonal variations that tend to enhance or weaken perceptual aptitudes. At which point do we percieve credible representations? Are what we percieve as doors, roofs, windows and other single architectural details making sense together, somehow matching some general discriminant criteria? Some interesting Malevitch tectonic assemblyes are "just" geometrical clusters, solely made of boxes, prisms and other cubic primitives. But these primitives - even the significance of this word is proper to sustain the idea of an initiatory process - lead us to make artificial connections able to give sense to such a meaningless *assemblage*.

fig 3. altered readability

We can here depict a very interesting linguistics concept described as *implicit* and *explicit* typology. A culture is a manner of perceiving reality. Perception is, nevertheles, a subjective phenomenon and what we can perceive - and describe - is not reality but a possible, personal reality. One's experience tends to influence his very own perceptive methods. Each cultural content, in a very generic acception - has two components: what can be said (explicit) and what isn't said or expressed because it's supposed to be obvious (implicit). Unspoken concepts are embedded in a bigger cultural context that imply their belonging in an implicit content.

It is clear that all artificial objects created are linked to a more generic implicit content, depending on personal, cultural and subjective factors. The fact is that we can connect them immediately to specific know how's, related to a (g)local tectonic and structural culture. The architectural and/or urban readability of depicted objects depends on a specific cognitive context, provided that all implicit dependancies are fullfilled. According to this point of view, we believe that any representation needs little apophenic projection to be undestood, considering that it embeds in any case an implicit cultural content.

fig 4. plausible or meaningless ? Random-generated rule-based 3D objects

Even a map or a picture obviously implies some deep intrinsic contextual knowledge not to be misunderstood: the difficulty encountered in programming computer-based automatic 3D extraction from 2D images is still a bright proof of the unbeaten superiority of human thought ; this peculiar ambiguity is somehow the cornerstone of the following research task.

II EXPERIMENTING WITH GENERATIVE APPROACHES

1. Integrated fast 3D urban processing system

abstract

The proposal mainly consists in an integrated architectural and urban semiautomatic model-generation pipe, emerging from early research tasks about automatic generation of urban and architectural 2D and 3D patterns. [Saleri 2004]
Our goal in this research task is to rapidly produce "plausible" urban environments, using existing data, such as digital maps, DEM's and aerial photographs with a high-level of detail - 16 or 50 cm resolution.
Early stages of this project produced interesting results, combining complementary modeling techniques, according to demanded LOD (Level Of Detail): For instance, we prefer to use hybrid image-based modeling for relevant architectural objects, demanding high-level recognisability, for close-up views and close detail identification. If not specified, the model generation follows a generic approach.

The semi-automated process involved in rapid 3D-modeling for generic surrounding architecture (architectural sceneries) links two semi-automated generative processes considering separately 3D elevation and facade generation:

• The *3D elevation step* is a geometrical tool that mainly uses initial manual dot plotting on a aerial map and elevates the volume according to some simple contextual rules: number of floors, entresol characteristics and covering type. All we need first is to point out two vertex on the lower ledge of a roof face that will be kept horizontal in the next step of the computational process. Then we designate cw or ccw all of the following coplanar vertices of the same roof face and validate: according to the initial position of the first two vertices, the program builds the geometric layout, adding needed facade textures to side faces, as described in *facade generation step*.

fig 5. local database enhancing : geo-related roof textures and generic facades

• The *facade generation step* consists in the prewrite of a specific Texture LookUp Table, previously filled with "contextualized" facade-like tiles. In this system, the intrinsic coherence of the texture itself depends on the pertinence of single texture patches positionning and invoking. The consistence of this approach is therfore limited by the local applicability of it's generative process: on demand, we need to bring into conformity the initial set of generative rules, in order to match to very local architectural components; we recently experimented such a rule-based generator over the "Vieux Lyon" urban framework, to test the pertinence of the resulting representation. The visual discriminance at a certain distance is quite impressive and locally compares to classical virtual globe urban representations.

fig 6.urban framework fast processing : GoogleEarth© browser 3D upgrade using local database enhancing (see fig 6.)

The scientific constriction of this artifact consists its contextual urban and architectural possible transposition ; the pertinence of generative rules should balance between a wide low-level geometric descriptors adaptability and a high-level of detail handling. If the low-level descriptors are too generic we won't be able to build a satisfying architectural diversity, and though, resulting geometries will look too similar. On the other hand, it will be quite impossible to specify with such a generic approach the immense variety of architectural or urban expression; therefore we will have to handle carefully any prior semantic discrimination in order to avoid uncontrolled and meaningless geometric spreadouts.

2. Physical cellular automata

abstract

This research task involved some post graduated students within the architecture school of Lyon; it emerges from a collective functional approach to generative processes as new projectual strategies. The scientific goal of this teamwork clearly aims to arbitrate very present questions about the pertinence of computer aided design tools in conceptual, constructive and more universally about representation processes in architecture and urban planning.
Early development stages of this project consider basic nurbs primitives within Autodesk Maya© 3D environment as structural guidelines for spatial specific allocation. Using Autodesk Maya's© embedded physics engine, the idea consists in assign specific attraction/repulsion attributes to scene objects according to their respective architectural programmatic connections. In this case, and within a specific generative process, we can generate a large number of plausible solutions responding to an initial set of connection rules. We can for instance force some elements to be attracted by specific allocation needs, like a panorama, some attractive topological configuration or - more trivial - the connection with existing power plants or road networks.

Declarative modeling.

Declarative modeling is quite a recent modeling technique, far from classical modeling techniques like geometric parametric or primitive-based modeling. First introduced in 1989 by Michel Lucas, its recent rise is due to novel projectual needs emerging from architecture design and furniture planning. Declarative modeling is able facilitate the design process through the implicit knowledge of former physical, geometric or dimensional rules. In order to simplify what becomes an interactive settlement of a 3D scene we may introduce implicit relative-positionning sets of rules such as physical properties and non-overlapping constraints.

As a matter of fact we find, in the former structure of the research task introduced as a collaboration with Vincent Berger [Berger – Saleri 2005] and other post-graduated students within the architecture school of Lyon, the main aspects of the declarative modeling inputs, listed below as **description**, **generative** and - last - **evaluation** phase.

• **description phase**: typically the foremost properties formulation phase that takes place within a specific UI, able to gather initial sets of input data. It's inner structure could match the natural language paradigm or other intuitive descriptive schemes.

• **generation phase**: this step computes plausible solutions matching initial inputs collection. User can formulate an initial query through a definite assets cluster that will be translated in some low-level computational constraints. The system should then be able to generate all the plausible solutions according to the initial model request. However, if the original description is inconsistent, the system can either return an incongruous solution or no response at all.

• **evaluation phase**: initiates the user-guided appraisal process, considering wether or not the suggested solutions consistently match initial needs. It should deliver an appropriate feed-back interface able to re-launch the generative phase with significant increase of computational constraints pertinence, so as to recursively enhance the generative solutions.

The environment description is achieved through the description of a set of properties, as stated above. "Properties" are intended here as known descriptive elements, formerly defined by the user during description phase. The system described below finds its solutions through the pseudo-random agglutination of physical active 3D metaballs: our experiment gives concrete espression to initial inputs with the use of appropriate 3D geometry: multi-purpose nurbs spheres - called metaballs - within an Autodesk Maya© 3D physical solver environment. "Appropriate" means here the direct connection between size, mass, friction and attraction/repulsion characteristics - embedded within the nurbs spheres properties - and the architectural programmatic initial set-up.

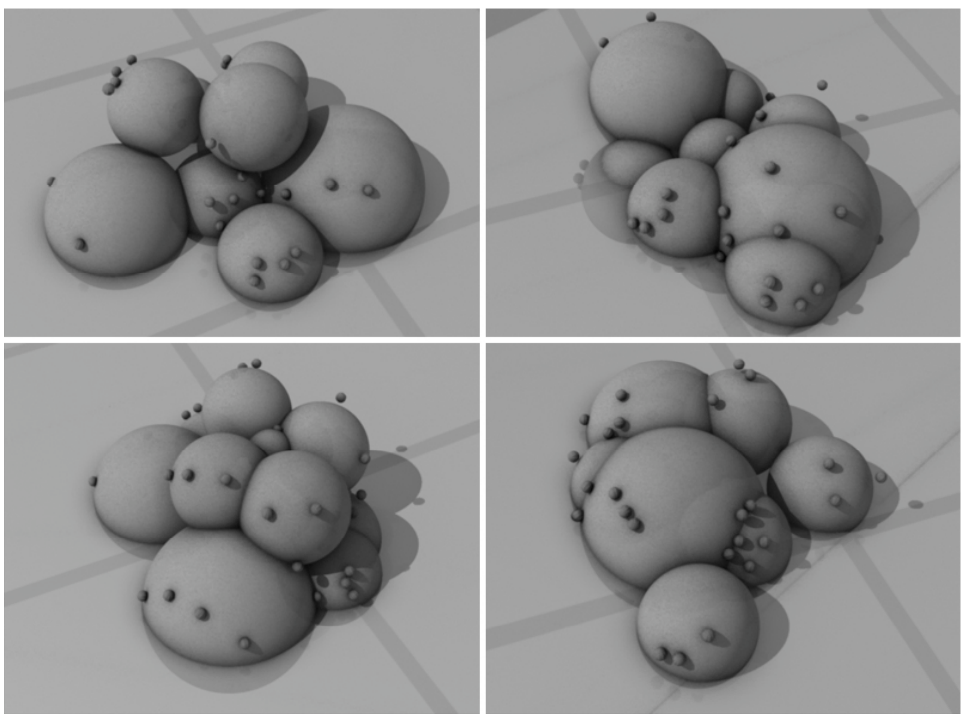

fig 7. initial metaball spreadout : major cluster + natural light activators.
(V. Berger – R. Saleri 2005)

This means that we can model and handle immaterial connections and relationships between architectural in and outdoor spaces. For instance, the "kitchen metaball" will be most effectively connected to other servant spaces, such as carports or pressoirs as the living room will be more likely attracted by lobbyes and main entries. Eventually, servant metaball clusters may be also connected to specific outer-spaces - backyards, secundary accesses... - as served clusters could be

attracted by delightful points of views or major driveways.
These initial sprouts also embed natural-light activators: clusters of 3D points are generated at a distance in strategic positions: towards sun-path or around a nice panorama or an attractive topographic configuration. They will stick to the main metaball cluster according to their initial position and create dimension-related openings through upcoming walls.

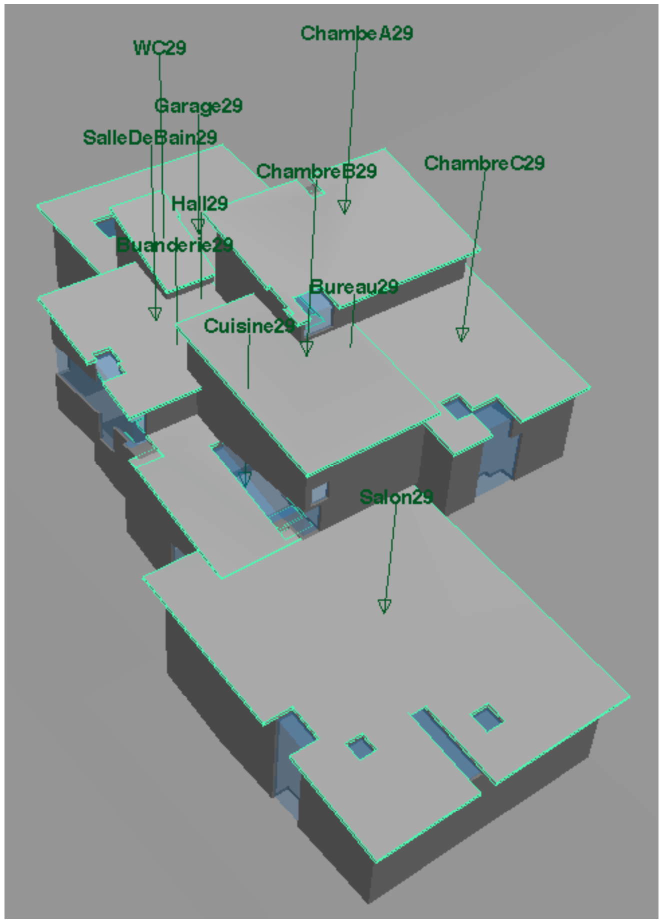

fig 8. geometric transform of former metaballs cluster. The "light activators"visible as small dots on fig 7.generate rectangle-shaped openings.

On the other hand, we could initially state about inner functional conflicts between listed spaces; these conflicts can merge from accoustic or environmental pollutions or more generally from structural discordancies or incompatibilities. Such properties will indeed activate repulsive reactions between metaballs or heterogeneous sub-spaces when mismatching combinations are found out.
Through given input classes, we will generate - with such a pseudo-random process - lots of different geometric solutions, but all of them structurally isomorph. This automated operation explores possible solutions within a conceptual pattern that works in a simulated "real life" design process. Functions, properties and connections are somehow modeled inside a former input graph that will structurally return many plausible solutions relatively to intentional programmatic needs.

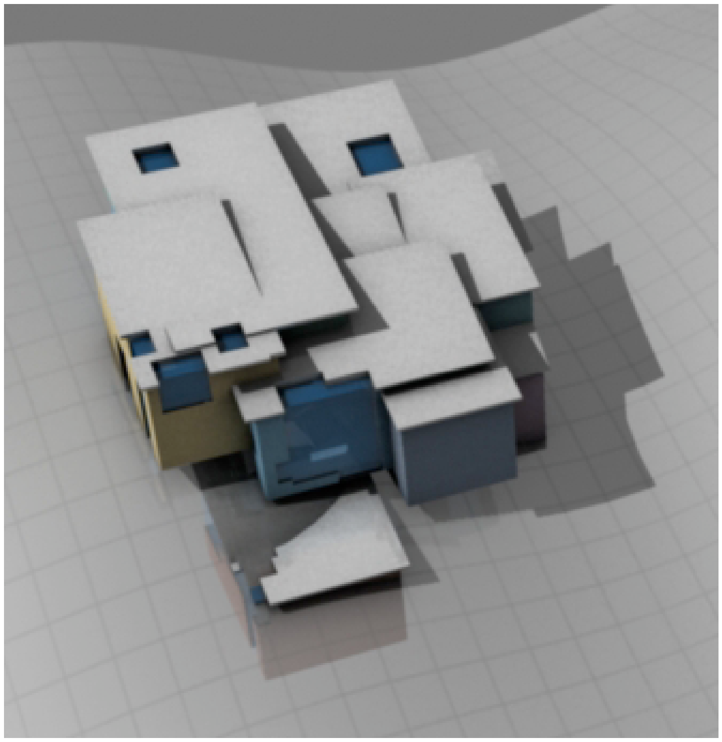

fig 9. external view of resultant process .

This could be a very tectonic rebuild of "cellular automata" concept. Former metaballs suit well to geometric self-investigation: the sphere shape brings an optimal surface/volume ratio and therefore the maximum combinational freedom. Computation time is normally less than a minute; it depends on the number of metaballs clusters, the complexity of the initial constraints graph and the number of recursive solving processes involved. At the end of the evaluation phase the user can test-freeze the final solution, which consists in a geometric transformation of metaball clusters in respective size-related boxes. Successive boleean operations will then substract inner material and hollow out openings with subsequent environmental connections as seen on fig 9.
It's our belief that such mechanism could shortly be implemented to help handle conceptual issues within product design and/or urban planning, as soon as we will be able to digitally master the homotetic nature of human genius :o)

Conclusion

We believe that the scientific goal of such a research task doesn't consist in trying to replace the architect's central responsability within the design process. On the contrary, one should consider the interest of such innovative paradigm to offset increasing complexity of today's architect's activity. It's usefulness will balance between morphologic synthesis within geometric simulation tools on one hand and and the secret hope of a possible instrumental operability in the field of urban and architectural management and design process on the other.
Fortunately it seems that young professionals tend to easily endorse the mutability of emerging technologies and therefore they should be more prepared – in future - for embracing the increasing intricacy of surrounding world in order to grant a sustainable balance between needs and resources…

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