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# 3D GEOVISUALIZATION & STYLIZATION TO MANAGE COMPREHENSIVE AND PARTICIPATIVE LOCAL URBAN PLANS

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**ABSTRACT:**

3D geo-visualization is more and more used and appreciated to support public participation, and is generally used to present pre-designed planned projects. Nevertheless, other participatory processes may benefit from such technology such as the elaboration of urban planning documents. In this article, we present one of the objectives of the PLU++ project: the design of a 3D geo-visualization system that eases the participation concerning local urban plans. Through a pluridisciplinary approach, it aims at covering the different aspects of such a system: the simulation of built configurations to represent regulation information, the efficient stylization of these objects to make people understand their meanings and the interaction between 3D simulation and stylization. The system aims at being adaptive according to the participation context and to the dynamic of the participation. It will offer the possibility to modify simulation results and the rendering styles of the 3D representations to support participation. The proposed 3D rendering styles will be used in a set of practical experiments in order to test and validate some hypothesis from past researches of the project members about 3D simulation, 3D semiotics and knowledge about uses.

## 1. INTRODUCTION

In order to support public participation, 3D City Models are used and abused to visualize urban projects. 3D geo-visualizations are mostly resorted to to help stakeholders understand the evolution of urbanized areas. This type of representation is appreciated as it provides an impression of the visual impact of a new project. Generally speaking, 3D geo-visualization is used to present planned evolution of physical objects such as construction of new buildings or new district layouts which have been designed upstream by architects and/or urban planners. Nevertheless, territorial evolution is not limited to planned changes supervised by public authorities, but also integrates private-planned changes that are regulated through urban planning documents. The participation of citizens in the elaboration of such documents is thus more and more considered as a way to enhance the quality and relevance of urban planning.

Among these documents, Local Urban Plans (LUPs) define the constructibility at the parcel scale through a set of 3D morphological rules that new buildings must respect. LUPs elaboration is relatively strategic as it regulates sensitive topics such as the morphology of new buildings and the possibility to open new areas to urbanization for around a decade. Nevertheless, for non-experts, LUPs are difficult to understand because they are compiled in an inaccessible legal language and because of the difficulty to assess the concrete influence of the underlying constraints on the territory. This is why it is quite complex to design efficient methods for the participation of citizens to the elaboration of LUPs. In this context, the PLU++ project addresses the issue of designing efficient 3D geovisualization system to ease this public participation and notably to simplify the understanding of LUPs regulations.

Designing such a system requires to solve a set of scientific issues that cover three main aspects:

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- **Simulation of built configurations from LUPs regulation**: As the aim is to visualize these complex LUPs textual regulations, it is necessary to represent their morphological constraints with 3D geometric information. In order to provide non-experts with a familiar and meaningful representation of the regulation, we explore in the project the possibility to simulate built configurations.
- **Designing efficient stylization of 3D geoinformation**: Thus, the system requires efficient stylization that enables people to understand if an object is existing or a simulated built configuration (which is only a possible evolution of the territory) and how it could be integrated in the environment, regarding its morphology.
- **Proposing relevant user interactions with the system**: The system has to integrate different possibilities of interactions in order to allow navigating inside the 3D scene, switching between simulations and representations to support efficiently the participation.

As different urban planing issues may be addressed during the discussions about this type of planning document, all the aspects of the system must be adapted to the participation context and users' requirements. The design of such a system is an opportunity to explore the convergence between recent subjects of research from various domains (simulation, 3D semiotics and knowledge about uses) and to confront our current knowledge to a practical use case.

At first, we present a state of the art about the issues raised by the different components of such system (section 2), then we introduce our methodology to mix visualization and simulation aspects to improve the understanding of LUPs (section 3) and we describe a concept of implementation of the system (section 4).

## 2. THE USE OF 3D CITY MODELS FOR PUBLIC PARTICIPATION : APPLICATION TO THE FIELD OF LUPS

In this state of the art, after an initial diagnosis of current practices and their limits, we present the scientific researches and practical system dedicated to public participation notably in the context of LUPs, based on suitable 3D geovisualizations, in order to define our research objectives and to propose a formalization of our pluridisciplinary approach toward participation of citizens to the elaboration of LUPs.

### 2.1 3D systems for public participation: uses and limits

Our diagnose is based on the authors' past works in several research project concerning consultation and participative experiments in various settings (windmill development, road construction projects, flood mitigation planning) and on exchanges with practitioners involved in the development in 3D models in France through professional networks[1] and user requirements studies conducted in the professional field (Nielsen, 2004, Nielsen, 2007, Badard et al., 2007, Carneiro, 2011, Pouliot and Daniel, 2011, Méo, 2012). As far as LUPs are concerned, this diagnose is completed with the result of the analysis of tools used by some French public authorities and associations [2]. Inputs from activists in the field have also been analysed[3], through implications of the author in the field of urban planning through action-research.

As regards with the raising of citizens' ability to understand planning projects, 3D geovisualizations have proven their efficiency (Jacquinod, 2014), especially in comparison with 2D maps, in relation to:

- **Their straightforward representation of volumes**, which makes it easier for many users to better grasp the vertical dimension of urban areas, since imagining this vertical dimension from looking at a 2D map requires training;
- **The numerous landmarks they provide** to help users find their way into a 3D spatial model. This, in turn, helps them to get a better grip on technical or "abstract" data (such as LUPs zones and regulations) that are sometimes presented to them, by allowing them to link the location and content of those abstract data with their own knowledge of the area (in the case of inhabitants);
- **The interactive navigation** that they can offer. Users can move around objects and change focus and scale in relation to their ongoing thoughts. In particular, the ability to be able to choose any viewpoint in the 3D scene can be crucial in the understanding of both physical organization of urban areas, their volumetric dimension and abstract data that might that may be presented along with the 3D built environment.

Nevertheless, there are still many aspects of those 3D geovisualizations that need to be studied in order to fully grasp the reasons for their efficiency, especially in collective settings during participatory meetings. Indeed, although numerous scientific works have been conducted on the subject, no consensus has ever been reached on how exactly 3D geovisualizations can contribute to the participation of citizens to urban planning (Bishop and Lange, 2005, Riedjik et al., 2006, Jacquinod, 2014). Beyond the uncertainties regarding the design of a 3D interface and the way to configure its functionalities, in vivo observations of the use of 3D geovisualizations during consultation have shown that their efficiency is both linked to the way they represent the territory (*"representative efficiency"*) and to the way they allow users to use this representation to perform a set of actions in relation to the context their own strategies (*"performative efficiency"*) (Jacquinod and Joliveau, 2014). Those findings are not limited to 3D geovisualizations and confirm previous results concerning the use of visual documents in urban planning (Söderström and Zepf, 1998, Söderström et al., 1999, Söderström, 2000). This highlights the need to adapt participation support system to their context of use and to the specific actions their users need or want to achieve through them through user requirements studies.

In the specific case of LUPs, according to practitioners that have been interviewed, a participation support system including 3D geovisualizations needs to be automated and to offer graphically advanced options at the same time. The lack of those two elements accounts for the currently limited use of 3D models. They are already used by some, but not many, public authorities in order to explain to residents the rules that have been decided upon in an already produced local urban plan. Those models are mostly produced using computer graphics techniques mastered by private firms, involving little automation in the representation of the built structures.so as to 3D models are more seldom used during the consultation process itself, and, when they are, they are rarely resorted to as tools to allow citizens to participate in the making of the morphological rules themselves, but mainly as tools to present thematic debates on general development issues (the space that need to be devoted to transportation, vegetation, ...). This lack of use of 3D geovizualisations in the discussion of LUPs content does not reflect an unwillingness on the practitioners part but is directly linked to the lack of appropriate and usable participation support system that can properly tackle the specific issue of building regulations through several morphological rules. This is why work needs to be done on :

- **Automatization** of the production of digital 3D models from 3D georeferenced data so that planners and architects can use it even without having the technical and can concentrate on debates when a participatory meeting takes place (rather than on a complex parametric system).
- **Graphical versatility**, so as to offer various and advanced styles for 3D representation, so that the graphical styles currently used by practitioners and produced through computer graphics techniques, can be transposed into digital tools that can make the most of existing 3D city models. This requires to define a limited set of useful styles through a user requirement study and to be able to implement them into the systems as ready to use profiles."

In addition, in order to fulfil urban planners requirements, a participation support system needs to be graphically versatile, so as to offer various and advanced styles for 3D representation, so that the various graphical styles that are currently used by practitioners and produced through computer graphics techniques, can be transposed into digital tools that can make the most of existing 3D city models. This requires to define a limited set of useful

[1] The authors are involved in the professional networks created in the professional field to share experience and produce best practices, such as The Ideal Community for 3D buildings and territories (http://communautes.idealconnaissances.com/3dbt/public) and the 3D Ethic Comity (http://3dok.info/WordPress3/).

[2] Two interesting examples of how consultation has been conducted for a local urban plan (and how citizens were involved) : Modification of Paris City LUPs: (https://modification-plu.imaginons.paris/) and Public participation for Strasbourg LUPs (http://www.strasbourg.eu/developpement-rayonnement/)

[3] Civicwise network: https://civicwise.org/fr/

styles through a user requirement study and to be able to implement them into the systems as ready to use profiles.

### 2.2 Constructibility information simulation

Different works intend to ease the comprehension of urban regulation. In (Falquet and Métral, 2005), the authors propose to represent the information from local urban plan by non-geometric information in 3D a model by linking the textual regulation to the concerned features. Some other approaches are based on the production of geometric information from the knowledge contained into the Local Urban Plans. A first method to simulate LUPs regulation is the generation of buildable hulls (El Makchouni, 1987, Murata, 2004, Brasebin et al., 2011). These hulls are generated by a set of morphological constraints and define maximal shapes that ensure that all buildings it contains respect these constraints. The main issue with this approach is that some constraint can not be integrated (Brasebin et al., 2011) and the generated shape is very different from possible buildings and may not be suitable for public participation. Some other authors try to tackle these issues and propose the generation of buildings that respect urban regulation with procedural grammar-based generation (Müller et al., 2006), by footprint extrusion to maximize the built volume (Turkienicz et al., 2008) or by optimization through a set of objects[4]. All these approaches require parameters to define the morphology of one generated building. As the local urban regulations let the possibility to build different types of buildings, it may be limited to provide only one possible building during the discussions. The interactions may be provided by interacting with a set of parametric buildings that respects the local regulation in order to show different allowed buildings possibility (Coors et al., 2009). In (Brasebin et al., 2015), an automatic approach is proposed and aims to study the diversity of the buildings generated. This approach may be used to provide a set of potential and representative buildings allowed by a regulation.

### 2.3 3D rendering: stylization and interaction

To support the participation, many methods of representation are available but there are still challenges concerning their suitability for public consultation and their efficiency for complex spatio-temporal comprehension. A stake for public consultation is the controllability of the 3D representation, by targeted users, on represented data and the way they are represented in the geovisualization. It is not only a problem of human-machine interfaces and interaction but also of how rendering processes may be controlled.

A high level of photo-realism and high level of detail have been the main challenge for 3D rendering and representation, in order to obtain high visualization quality (Drettakis et al., 2007). An opposite view is to consider that photo-realism techniques do not offer optimal solutions for understandable visualizations, e.g. too low contrasts, visual noise, imprecise objects boundaries, ... (Semmo et al., 2010). The evaluation of the usability of 2D and 3D representations for some tasks is at stake in visualization and GI sciences, most of all regarding the effect of photo-realism and abstraction levels (Boér et al., 2013). The relevancy to use photo-realism (photos or virtual reality in 3D) to represent risks has been studied in (Kostelnick and McDermott, 2011). A user study has been conducted to determine the influence of realism level in 3D representations on the confidence in data quality a user may have (Zanola et al., 2009). Expressive rendering allow stylizing 3D models in order to attempt aesthetic purposes or more efficient renderings (notably (Willats and Durand, 2005, Cunzi et al., 2003)) and thus to inject some semantical, geometrical and graphical abstractions.

[4]SimPLU3D project: https://github.com/IGNF/simplu3D

Some methods have been also explored in order to propose to explore the potentialities of the rendering combined with the interaction with the visualization. Three relevant styles to render a 3D urban model (photo-realist, informative and illustrative) have been identified (Döllner et al., 2006), integrated by (Semmo et al., 2012) in a continuum of representations, but they have not been tested in the context of public consultation. Style mixing has been also used to manipulate several styles of 3D models (Talton et al., 2012, Brasebin et al., 2015), while other authors propose to navigate between levels of details (Biljecki et al., 2014). Various Human Computer Interaction techniques, such as Focus+Context approaches (Cockburn et al., 2009), are explored to manage the visual attention of the users. Parametrization of rendering methods to make progressive transitions between various abstraction levels and strategies to distribute this abstraction level, are proposed in the visualization, according to the distance from the image center or to the saliency of rendered objects (Semmo et al., 2012). Various symbol specification methods to interpolate colors and textures between ortho-imagery and vector data (vector & raster styles mixing) are explored in order to control the level of photo-realism in intermediary hybrid maps (Hoarau and Christophe, 2015).

All those renderings and interactions with rendering methods are not explicitly specified in a proper formalism. 3D semiotics is not clearly defined (Häberling et al., 2008) even if some implementations have been proposed to describe graphic 3D parameters applied on a scene in a SLD 3D (Neubauer and Zipf, 2007): the impact of graphic parameters (e.g. material color or light) of such renderings on public understanding and perception is not controlled by now (Brasebin et al., 2015).

### 2.4 Towards a participatory approach: a common framework for a participatory support system

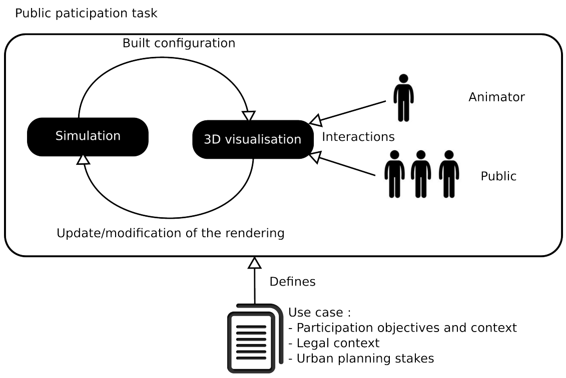



Figure 1. The considered global participation process and the system presented in this paper.

In figure 1, we present our vision of a public participation process. The decision to set up a participation task is defined in order to fulfil a use case. This use case depends on the legal context that fixes the scope of the potential discussions: is it a new LUP or the evolution of an existing one? The discussions are oriented according to urban planning stakes that determine the questions that may be addressed to the public: should we discuss about the densification issues of a district? The preservation of green space? Thus, the use case is determined by these elements and the participation objectives: what does the local administration expect from the participant public? Who is the relevant public?

Different organizations of the participation are possible, the discussions may take place in a meeting room, in situ or on the Internet. According to the type of participation, it may influence the different components of the participation.

- **animators:** an animator may be required in order to ease the discussions (in a room or in an Internet forum) or to interact with the 3D device is the public is not supposed to do it;
- **participants:** people who participates to this task may be resident of the concerned district or public area users;
- **3D device:** computer, video-projector, 3D VR glasses, mobile device with AR representations may be used to display the 3D renderings. The type of device influences the possible interactions and require adaptation to produced renderings. It can be used as thinking material, which raises several technical issues, in particular regarding their content and level of detail.

In this paper, the proposed system (described in section 3) is focused on the production of 3D renderings according to the use case. Thus, the most important challenge of this work is to produce efficient 3D renderings that can be adapted to different use cases and that can evolve during the consultation. We mainly consider two types of basic interactions in this paper: the modification of the regulation scenario and its impact on the presented simulation and the modification of the style of the represented simulated information.

## 3. METHODOLOGICAL APPROACH: 3D VISUALIZATION BETWEEN URBAN PLANNING REGULATION SIMULATION AND COMPREHENSION

Our approach in this project is to consider controllable 3D geovisualizations of urban planning regulation simulation, in order to facilitate the understanding of such urban regulation by citizens. We thus focus on three sub-systems and their tight relations, in order to efficiently design a 3D geovisualization prototype. Figure 2 presents the three following sub-systems and how they interact.

1. the **built configuration simulator**: an existing simulation engine is used to provide 3D built configurations based on knowledge on Local Urban Plans. The geometries produced by the simulator have to be adapted according to tested scenario and according to the type of style applied by the 3D stylizer;
2. the **3D stylizer**: a formalization and an implementation of a generic 3D rendering process based on 3D rendering styles is a new contribution of this project. It provides required geometric specifications to the previous sub-system in order to specify properly how geometric primitives should be rendered by the rendering engine of the 3D geovisualization. This sub-system is based on 3D representation knowledge;
3. the **users' needs knowledge expectations** and needs of potential final users are determined by previous works and a user study to come. This sub-system provides users and context specifications for initial requirements for the 3D geovisualization and also for particular use cases. It defines relevant levers of interaction for the other sub-systems that are relevant to allow according to the context of the participation.

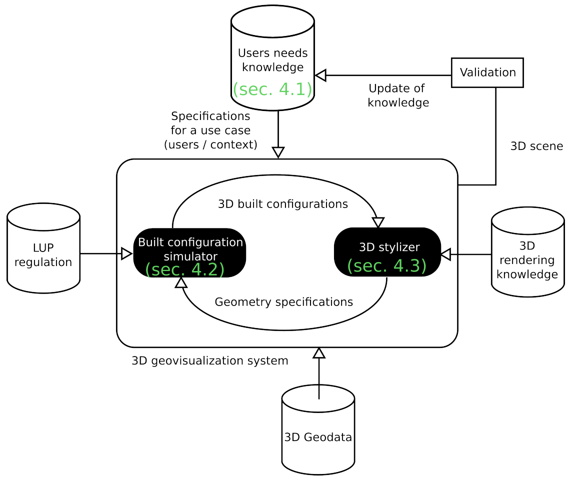



Figure 2. Pipeline of the global approach.

Even if we will focus on each sub-system separately in the next section, we claim for an interdisciplinary and integrated approach in order to be able to design an effective 3D geovisualization system.

## 4. THE DESIGN OF A 3D SYSTEM BASED ON EXPLICIT RENDERING STYLES

Previous work regarding users and uses requirements give us clues to make some initial propositions about the 3D scene to represent and rendering styles to specify. Firstly, the users requirements according to the needs are presented (section 4.1). They are used as specifications to define expectations and potential interactions about 3D geodata and simulated built configuration (section 4.2), the renderings styles applied to these data (section 4.3).

### 4.1 Uses and users requirements

The study of user requirements in the PLU++ project is threefold and is realized through: **a preliminary study** based on previous works; **interviews with practitioners** that are currently conducted and **direct observation** of uses of the proposed device during the experiments to come, so as to produce knowledge on its efficiency in collective and collaborative settings. Four main aspects have been highlighted so far through the preliminary study in terms of visualization styles:

1. **Abstract stylization for simulation results (simulated built configurations)**: rendering styles need to allow end users to understand they are viewing an abstract proposed urban morphology. Thus, a specific work has to be done both by producing generic geometrical shapes and schematic styles, so that users understand they are dealing with abstract data, that exists to feed their thoughts, but that will not be realized as such in real life.
2. **Simplified representation of the surroundings**: in order to help users to understand and evaluate simulation results, the surrounding objects, that is to say the morphology of existing built structures, should not be represented with too many details, so that only the existing urban morphology is considered as a whole. This is important so that users understand that what is at stake isnt the precise design of individual buildings.

3. **Providing homogeneous LOD visualisation**: considering the many morphological aspects that are not prescribed through LUPs and their morphological rules, and taking into account the need for landmarks for users to find their way into the 3D model, it is expected that the context is represented with more details than the focus. Nevertheless, the difference in LOD between the focus and the context should not be too important to provide a certain homogeneity. Thus, users will not focus on irrelevant building details when they express their opinion. This homogeneity should be achieved by trying to give, through the 3D representation, a sense of urban morphology at the district scale and an explicit reading of the proportions between free space and occupied space.

4. **Providing complete 3D scene**: Finally, the possibility to display both a set of objects from the existing environment, in relation to the focus of the LUP (i.e. topography, building, roads, vegetation), and abstract data such as parcel limits or existing zoning is expected. If users see an incomplete scene they won't be able to understand and infer spatial knowledge.

Those requirements need significant work both on the simulation and stylization sides.

### 4.2 Geographic data and built configurations simulation

Providing a suitable 3D geovisualization system requires relevant 3D data notably building configurations that represent LUPs regulation (section 4.2.1). As the aim is to provide an interactive system, the possibility of interactions with the built configurations is discussed in section 4.2.2.

#### 4.2.1 3D geodata to support LUPs public participation

**Simulated built configurations** The core of this approach is to make public benefits from information concerning constructibility by providing a set of built configurations according to a tested regulation. These simulations provide possibilities about what can be built at the scale of a parcel.

In the context of this work, the built configurations are generated with SimPLU3D [5] Open Source library. The built configurations from SimPLU3D is composed by a set of homogeneous objects (i.e. belonging to a same object class) and the system proposes a built configuration composed by a set of n objects where n is determined by the system.

The global process of the library is explained in figure 3 and requires several inputs:

- **3D geodata**: this 3D database represents necessary existing features to check the regulation and are integrated in SimPLU3D model;
- **LUP rules**: these rules describe a set of geometric constraints that the built configuration have to respect. Both model and rule formalization are described in (Brasebin et al., 2016);
- **an input parcel** as the simulation is proceeded parcel by parcel;
- **a building strategy** that includes, an **optimization function** in order to choose the best built configuration according to a given measure and **configuration parameters** that indicate which class of objects composes the built configuration and what are the characteristics of these objects.

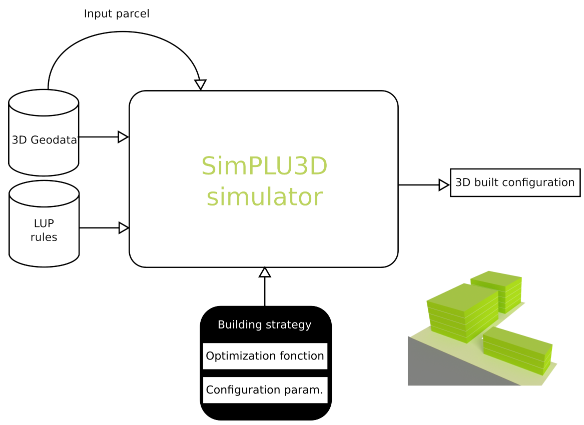
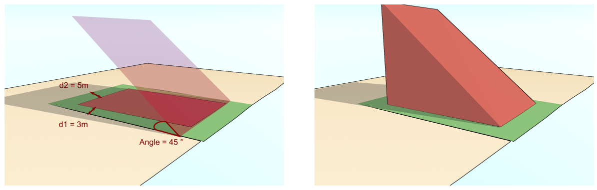



Figure 3. Built configuration generation with SimPLU3D.




(a) Direct representation of constraints

(b) Buildable hulls

Figure 4. Two possible information to indicate the constraints of the regulation.

As these built configurations only represent one instance of what can be built on a parcel, some extra geometric information may be added into the final scene in order to geometrically highlight the influence of regulation constraints according to the use case. In figure 4, there are two other possibilities that represent these constraints: a direct geometric representation of the constraints and a buildable hull.

**Regulation oriented features** In order to understand the influence of the constraints, it is necessary to represent the feature concerned by these constraints. A 3D model that contains a set of necessary features is presented in (Brasebin et al., 2016) and is used in our approach. The model mainly describes information about properties (Cadastral parcel, basic property unit, cadastral boundaries), buildings, relief, roads and legal documents (zone, rules). These objects may be used and selected according to their relevance to the use case.

**4.2.2 Possible interactions with built configurations** Before preparing the participation, the organizers can choose a set of levers that may be activated during the discussions.

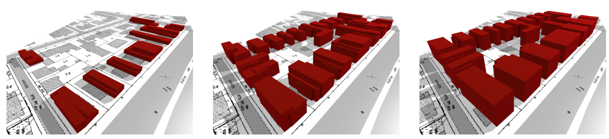


Figure 5. Different simulation results by adjusting some regulation parameters.

A first lever is to offer the possibility to change the input regulation of the simulation. According to the aim of the participation,

[5] SimPLU3D website: https://github.com/IGNF/simplu3D

the organizers may propose upstream different regulations scenarios to discuss or let participants co-construct new regulations by adjusting regulation a set of parameters (figure 5). The simulator generates new built configurations according to these inputs.

Another lever is the opportunity to adapt the aim of the built configurations to the scope of the participation. It may be processed by parameterizing the building strategy. By choosing an adequate optimization function, the simulation can be linked with a urban phenomenon linked with the participation (i.e. by proposing built configurations that optimize solar energy to incite the development of this kind of energy). The shape of the built configurations may be adapted in order to produce a required LOD (figure 6) or level of generalization of built configurations or to be coherent with type of existing urban fabric (i.e. by generating individual houses).

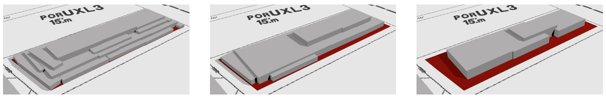


Figure 6. Different simulation with different level of generalization.

### 4.3 Specification of rendering styles

According to previous highlighted guidelines coming from literature and previous analysis of public participation, we propose to specify specific rendering styles of a 3D scene composed by simulated buildings in an existing environment.

**Specification of four rendering styles** We propose to specify three typical rendering styles: a photo-realist style and two abstract styles, i.e. typical and discreet. Their main visual characteristics and the related graphic parameters for each type of rendering style are the following:

- **photo-realist**: this style is made up of the visual properties of the ortho-image texture (colors, global luminance, resolution, ...) and the method to patch this texture.
- **typical**: this style is made up of some visual properties, typical from the 3D scene: mainly a set of natural colors coming from the ortho-imagery or known field characteristics of walls and roofs. Surfaces are represented by plain colors, and strokes by visible thin black lines.
- **discreet**: this style is made up of a transparency level and white color for surfaces, and a light representation of strokes (black dashed or dotted lines, low thickness).

For each style colors may also vary between walls and roofs, in order to easily distinguish these surfaces.

**Focus+Context of the 3D scene** We propose to use the specified rendering styles not on the whole scene but to differentiate the simulated buildings and the rest of the environment. So, we define the *focus* as a set of simulated buildings, integrated into a *context* represented by the other objects of the scene. These styles are visible whatever the camera and the zoom level are: we propose to manage abstract vs. photo-realist styles, and various abstract styles. According to the level of contrast we finally want to evaluate, we could manage a low or high difference between the two rendering styles of focus and context.

**Possible co-visualizations for public participation** Our first attempt is to manage the context, from an abstract style to a photo-realist style. Then, we aim at considering various parameters of the abstract styles in order to render the focus. Other visual properties could be also parameterized while differentiating surfaces (walls, roofs) in the representation, i.e. different colors, different styles.

Figure 7 presents three types of combination of co-visualization of styles: the focus is represented by a typical style with appropriate colors regarding the ground truth, and a context varying in generalization from discreet styles (transparent generalized blocks) to a photo-realist rendering.

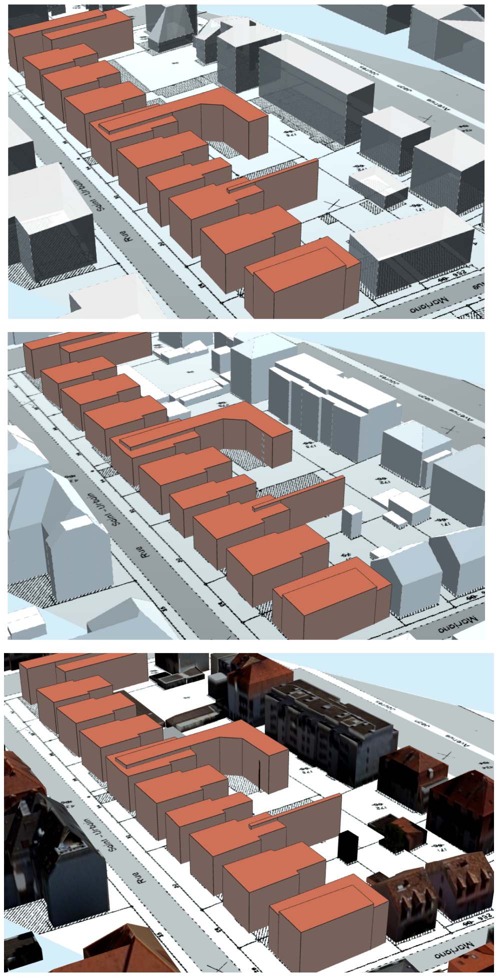


Figure 7. Progressive generalization of the context, with a typical focus: upper image: discreet buildings (generalized blocks); middle image: discreet buildings (preserved building shapes) ; lower image: photo-realist buildings.

Figure 8 presents two examples of a discreet style, differentiating walls and roofs (in the upper image) or not (in the lower image), in a photo-realist context.

Figure 9 presents two examples of a mixed style for the focus (typical walls and photo-realist roofs), in two different contexts (discreet and photo-realist): walls are represented by a typical style whereas roofs are represented by a photo-realist texture.

The potentiality of abstract styles is huge according to the graphic parameters we may manage: shapes, transparency, colors, differentiation of walls and roofs are sufficient to generate very different rendering styles. For instance, each category of the discreet

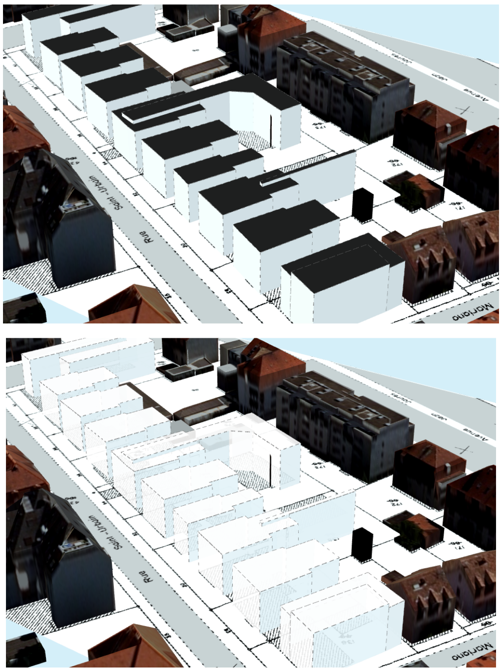


Figure 8. Visual effect of the differentiation of walls and roofs discreet style in a photo-realist context: upper image: differentiation between walls and roofs; lower image no differentiation.

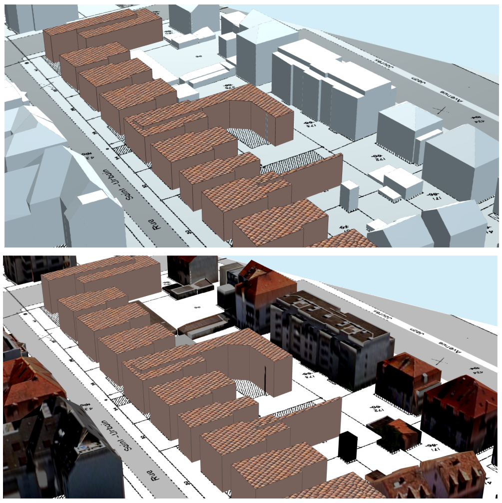


Figure 9. Mix style for the focus and various contexts. upper image: discreet context; lower image: photo-realist context.

and typical rendering styles, we can provide very different results on the simulated buildings. Moreover, we see in the last images of figure 9 that styles (abstract or photo-realist) may be mixed in the focus, in order to help participants to consider new buildings in their proper environment but also the visual effects of the simulation of regulation.

Our purpose is to present those possible co-visualizations to targeted users, as a result of a regulation simulation scenario: the suitable rendering styles will be selected upstream, according to the context of the use case, requiring to enhance a particular information or targeting specific users. In the context of public participation, the system is used by performing the following steps. First, a set of built configurations is simulated according to the themes to be discussed during public participation. For example, two sets of configurations may be simulated if discussions are focused on the comparison between two regulations. More sets may be simulated if discussions are focused on fixing regulation parameters values. Then, styling levers are defined according to the expected interaction with the tool during the participation process (i.e. exploring several scenarios). Finally, a graphical interface is created in order to allow the participation animator to load the 3D scene with simulated configurations and to render buildings with a predefined style. If the possibility to change the styles is offered, the animator can handle the styling levers in order to ease the understanding of the participants. Thus, he can change the style from a discreet one, to discuss about building morphology, to a more typical one, to talk about the integration to urban fabric.

## 5. CONCLUSION AND FUTURE WORKS

In this article, we present users requirements, possibilities of data simulation and 3D stylization to properly visualize simulation results, in the context of public participation. Our approach is a pluridisciplinary work that integrates aspects taken from simulation, 3D stylization and users' knowledge. We provide design guidelines for a suitable 3D geovisualization system and rendering styles specification to visualize simulated built configurations.

We have now to proceed to the experiments with practitioners (decision-makers, urban planners, citizens) in order to validate the various levers we have on simulation and stylization aspects, to refine our propositions. First, we aim at conducting interviews in order to specify the use context of the participation: which are its objectives (elaboration of a new LUP or discussion on urban planning based on existing LUPs, step of the participation, ...), requiring what kind of specific data and simulation rules and which type of questions for citizens. Those interviews will be supported by provided visualizations, in order to validate their suitability in terms of represented data and the way and level of stylization: the main question is which styles combination(s) are useful for an objective of participation. This step of acquisition of operational knowledge will help to next specify the required types of interaction between the participants and the system, or an animator and the system, to better understand the regulation at stake. Interaction tasks on data (for instance, display attributes), rules (for instance, see the rules in their initial form), simulation results (for instance, modify simulation rules), and the final visualization (for instance, hide type of objects).

An example of a future evolution of the system concerns the simulation of other objects, such as vegetation and parking spaces. They are concerned by this type of regulation: they have also a crucial importance in the effects of the rules as they are directly included in mathematical ratio into the regulation documents. In the future, we plan to offer the possibility to simulate simultaneously different types of objects if they are required by the use case. The ability to compare and mix multiple sets of rules has also been cited as a key element since urban planners, when they design rules, have to diagnose previous rules such as generic rules that apply to the whole country or specific ruling derived form thematic legislation (preservation of coastal areas, urbanization in mountainous zones, ...).

Thus, one interesting challenge will consist in representing different categories of simulated objects and to make people understand that all these objects are potential and not effective future.

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