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LEARNING TOPICS IN URBAN PLANNING AT UFMG: GEOPROCESSING TO SUPPORT ANALYSIS, PLANNING AND PROPOSAL OF THE URBAN LANDSCAPE AT NEIGHBORHOOD SCALE

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Reports the experience of training students in the use of geo-technologies to support the analysis, planning and proposal of the urban landscape at neighborhood scale. Students learned about how to apply spatial analysis models, particularly Multi-Criteria Analysis for identification of potential, vocations and conflicts of interest in land use. They built Decision Tree for structuring Environmental Interest Synthesis, Expansion Interest and Urban Density Synthesis, and Conflicts of interest Synthesis. The three-dimensional representation of the territory was used to support the proposed zoning and urban parameters indicated by the students to conform the designed landscape. For the Urbanist and Architects under formation, our expectation is that they will act in a more conscious manner when creating their projects, undertaking predictive studies on the landscape, since, only then, they are fully able to understand the consequences of the intervention on urban spaces.

KEYWORDS: Geoprocesssing, Urban Parameters, Landscape Design Simulation, Parametric Modeling of Territorial Occupation

INTRODUCTION

It´s important to introduce a timeline: the evolution and current conditions of geotechnology for the management of urban space and the proposal of learning topics of urban planning at the School of Architecture, UFMG, Brasil.

We are living in a odd time for urban spatial analysis, when information technology, and especially of georeferenced information, begins to be largely dominated by sector users, allowing us to use it, in fact, as a tool for diagnosis and application of models predictive, to support decision-making. Besides the maturation in using the tools, we are initiating a new paradigm in spatial analysis and representation, marked by the principles of interoperability between systems, strong investment in communication and provision of tools for projectual propositions simulated in real time.

The present time is a result of the experiences in the past 25 years in urban and environmental studies using geotechnologies. Notwithstanding the use of geotechnology, through the creation of Geographic Information Systems has begun in some countries still in the 60s, we can say that the use of geoprocessing begins, indeed, more widely in Brazil in the late 80s.

Everything starts with CAD/CAM (Computer Aided Design, Computer Aided Manufacturing), which represented a paradigm shift to first decompose the representation of territory in layers of information, by allowing the georeferencing data on a cartesian plane of the territory (which at that time ignored the deformations of Earth's surface) and to allow the simultaneous visualization of layers and layers combination in cartographic communication. Note that although the process is to decompose the reality in variables, here represented by layers, the aim was to promote visual combinations so that the observer compose them on mental syntheses. As remnants of ancient forms of representation, the time of analog design, the difficulties were related to the topological relations on graphical primitives, the lack of

understanding the use of scales on digital mapping that is always in 1:1, and the objective to decompose to compose.

Even at the time of CAD, users began attempts to use tags to associate alphanumeric attributes to graphical primitives, enabling simple queries. Early users needed to use the software programming language to associate with the former manager database (dbase). As a results of this interests emerged software classified as Desktop Mapping, with the association of drawings to data tables, that allowed to answer two questions: "In such a place, what are the characteristics?" And "These characteristics, where are their location?". These new applications, besides working with database, brought the possibility of applying different models to represent the Earth, considering the curvature and allowing the adoption of global geodesic reference and each country geodesic reference and tools to convert from one system to another.

The Desktop Mapping period was the time of the classified maps of queries to the database, so that spatial analysis was broadly supported the development of collections of maps that showed a little more complex portraits of territorial reality, although the development of synthetic processes were still very incipient. Technical reports were characterized by wide collection of thematic cartography, mapping worked mainly as communication product, of individually variables.

Soon there were applications that introduced models between their tools of spatial analysis, as a new step to go further by combining variables in processes of map algebra. The moment was particularly interesting because it allowed the use of logic systems approach in environmental studies and urban studies. It was the time for procedures weighting variables, proposing equations that accounted for the phenomena investigated, scientific investment in decoding studies statistical and geostatistical for the composition of maps of territorial distribution of variables.

The old large collections of thematic maps, which targeted communication of isolated variables, or just the maps overlay, were then replaced by syntheses that were portraits of the reality investigated. As every portrait is a model representation of a phenomenon or factor, which follows clippings conceptual, methodological and temporal.

The model is a conceptual cut, since it represents a goal or a way of seeing of a researcher or group of researchers, and their personal views or the fruit of their scientific positions interfere in the choice of variables, in combination mode of variables and assessment of variables involved.

The model is a methodological approach since it accounts for a logic equation or thoughts as proposed route for its research and composition.

The model is a time frame because it accounts for a period or date, because the variables involved are constantly changing, each in its own time scale. And finally, the model is a spatial cut because it choses and delimites an area of research, and depending on how the cut is made is important to consider edge effects and influences of the neighborhood in the installation, presence and diffusion of events and phenomena in territory.

The Geographic Information Systems presents the classical models of combination of variables for facilitated application to map algebra, or allow users to propose their own models, the decomposition of variables into arrays and logical development of combination between them. These process has been so expressive that generated specific software for the employment of certain models, so-called Expert Information Systems. The development of spatial analysis from these new features was significant, but still kept the paradigm of decomposing to compose, to represent and analyse the territory in variables or principal components and to promote the integration of these in order to reproduce the complexity of reality. Once reproduced the territory and its complexity satisfactorily, even though with cutouts simplification inherent in models, the users had in hand a digital tool that compose a

virtual mirror of the territory, that makes possible simulate changes, to built transformations predicts, and to understand values and broadcasts phenomena.

The actual moment is particularly interesting because many users are already using the geoprocessing tools for the collection, storage, representation and analysis of georeferenced data. The Geographic Information Systems and their tools are now widely available and are used to support decision making. It is necessary to emphasize that GIS offers no unique answers or unquestionable results for space studies, but presents points of view, governed by different criteria, which are only to support the decisions because, ultimately, the decisions are still the responsibility of the specialist who chooses and justifies his choices.

For correct use of GIS in spatial analysis, the first step, and one of the most important, is the clear definition of objectives. The mature definition of objectives will guide the choice of variables, the spatial analysis models to be used, and will validate or not the responses obtained. In this sense, the procedures supported by geotechnologies are ways of having reproducible criteria for performing spatial analysis.

With the power of the worldwide web, also the Geographic Information Systems have been adapted to work through the www through the WebGIS applications. Technological development and the interests of users grew exponentially, but there was a further impediment to be overcome: the authorization for broad dissemination and access to collections of data, and to propose a mechanism to control the quality and reliability of spatial data.

In Europe this process has taken over the network INSPIRE, for integrating cartographic collections, wide dissemination of spatial information and to promote Multipurpose Territorial Cadastre. As a mirror of what began to happen in the world, a federal law was published in Brazil that established the National Spatial Data Infrastructure, aiming to promote the authorization of access to data. It is in the scale of national data, and the procedures have to be authorized in the scales of state and municipal data, so that in the future the various sectors of

territorial management will be involved in updating its variables and integration to a large data system.

The recent scenario was then recognition of the potential of Geographic Information Systems, the strength of the processes of communication and exchange of information and the existence of initial legislation supporting to the dissemination of information. In a process that is increasingly integrated and global, geotechnology tools now have to answer to the following values: widespread condition of communication with different sectors of users, wide interoperability conditions, and promoting broad systemic approach for process modeling and construction of interpretive portraits of reality and the simulations of its changes.

Another recent transformation in the technologies of representation of the territory would promote changes in values and paradigms: the arrival of BIM - Building Information Modeling. The BIM process is employed in the fields of representation and project of objects, particularly in the areas of design, architecture and building engineer. The logic of BIM is to compose to decompose, which is exactly the opposite of the logic of SIG, that is to decompose to compose. In the BIM the object is represented as an object in the fourth dimension, and its representation in different plans (plan, section, facade, database, etc.) is the result of automatic decomposition. The proposed changes to the object are reflected automatically to the different forms of its representation.

The strength of the fourth dimension in the procedures of representation, proposition, simulation and spatial intervention in reality were already expected. The look in azimuth representations was already a strong trend, compared to the zenith look (cartographic representation). Bring the user to the understanding of dynamic and interactive maps already announced as a trend. Studies on mind maps in order to shape the representations and to know how to structure the relationship between the visible reality and virtual reality (represented reality) had returned to the interests (they began the 60s and 70s), and the principles of augmented reality were very well accepted .

We were then one step closer to living a new paradigm in geotechnology, to blend the SIGs conditions and interests of BIM, with extensive investment in technology representation, so that the tools favored the proposition of projects in real time (for augmented reality) and that users can compose their landscapes by processes of parameterization. The processes of applying parameters in the composition of an urban landscape are, ultimately, the translation of laws determinations and legal rules for the construction of the possible scenarios resulting from those established limits and references.

Appearing initially in gaming applications, whose ability to communicate information is significant, begin to be available in the market software that will allow, in the near future, the integration of the principles of GIS and BIM, but having as main support function for project design in augmented reality and for the handling and simulated landscapes resulting from parameterization processes. It's a new paradigm, a new way of working with spatial information. In the absence of a new term that represents this new phase, this new paradigm, we propose the term "Parametric Modeling of Territorial Occupation".

From this new moment, of this new paradigm in the territorial representation in urban management, fundamental tools will be developed in order to get the expected balance of sustainable human occupation of the territory.

The new technological conditions will support, especially, territorial governance processes, as they will act as a bridge of communication between the technical sectors, administrative sectors and the community, as the new occupation and uses of the territory can be simulated, discussed and communicated properly. It's a is a further step for participatory planning, because there will be broader understanding of the condition and proposed regulations. It is a hope that science and technology will be called to cooperate in decision making and ensure that the anthropic occupation of the environments will seek dynamic equilibrium.

Geoprocessing on Urban Planning Workshop: Local Planning Problems

Recently, a new Architecture and Urbanism night course was created at the Escola de Arquitetura, Universidade Federal de Minas Gerais (Architecture School at the Federal University of Minas Gerais). Since it emphasizes urban planning, it differs from the daily course, which has a focus on building project. This new emphasis makes fundamental that students familiarize themselves with geoprocessing tools, in order to acquire abilities that will make them able to: present their planning in a georeferenced manner, use satellite images, treat images with digital processing for territorial and urban planning, explore resources from Geographic Information Systems and, specially, develop analyses and representation models for urban spaces.

As an example of the course's goals, we present the experience of the thought module "Urban Planning Workshop: Local Planning Problems", discussing issues to a district scale. The students were involved in gathering primary data, examining the data regarding its spatial components, and afterward proposing a settlement type that would model urban landscape in a sustainable manner, respectful to community values and to the environment. Geoprocessing is a fundamental tool in mapping territorial characteristics and investigating conflicts of interest within a specific area, using multi-criteria analyses.

This module holds as pedagogical aims: the construction of a conceptual base for studies on landscape, environment, planning, and spatial perception; training on survey activities; storage, treatment, and representation of spatial data; tuition on spatial analyses methodology; diagnostics, prognostics and propositions of spatial intervention, with the use of geoprocessing; and, finally, the study of public policies and legislations regimenting urban settlements, regarding their contexts.

We picked the Vale do Sereno district, which is located in a frontier area between two municipalities: the Minas Gerais state capital municipality, Belo Horizonte, and the Nova Lima municipality. The district is still not densely populated, but it suffers from an expressive

pressure for urban transformation and growth, and it is being heavily impacted by vertical growth and by the settlement rate, despite its conflicting principles to environmental interest and to the preservation of what is a notable landscape. Reasons for this growth reside in its being the most economically interesting region for selling real estate within the Metropolitan Region (Região Metropolitana – *RMBH)* of Belo Horizonte, and since urban regulations (presented at the development plan of Nova Lima) authorize this intense growth and transformation on the urban landscape.

Figure 1: "Vale do Sereno" Landscape – expressive settlement growth

This study was undertaken using Multi-criteria Analyses, spatial perception research, and proposition of a settlement typology, which considers existing conflicts and local landscape context. The students were instructed to use geotechnologies as a support tool for visualizing and communicating their urban intervention proposals, also simulating their effects on the resulting landscape.

Methodology for Urban Planning, supported by geoprocessing – Multi-criteria Analyses

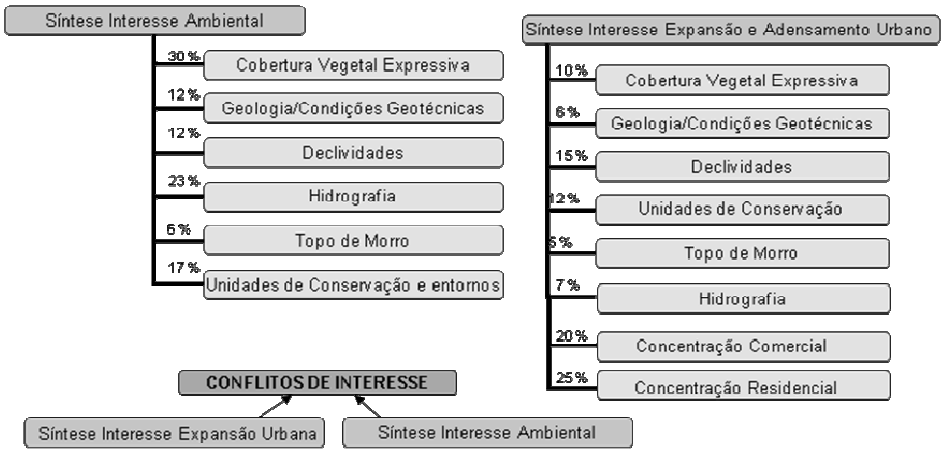
With the aim of making maps *Environmental Interest Synthesis* and *Urban Expansion Interest Synthesis*, different variables where selected for each. Variables were mapped initially as ordinary themed maps, which were later turned into potential surfaces for the theme's distribution, according to their relevance for each of the syntheses. A Decision Tree is built as a flowchart combining variables through map algebra. In this specific work, the algebra used was pondered average, by giving weights for combined variables and grades for their legend components.

In order to allocate weights, which demonstrate the relative importance of each variable to the analyses, we chose to undergo a consultation, aiming to obtain an opinion average, for maximizing the consensus using the *Delphi* method. The process was organized in the following manner: the students gave their individual opinions on the hierarchical position of each analyses variable. After the gathering of opinions, we presented the opinion average and mode to the group, and each individual gave out a second opinion, altering or not their first one. Then, a new medium was calculated, being then used as a reference for the variable's weights. This process is known as "knowledge driven evaluation", meaning the incorporation of opinions gave out by informed people regarding the situation under evaluation, about specific aspects of the phenomena and their variables. The students, since they participated in field work and interviews with locals, had knowledge on the factors interfering in the area's characteristics. It is considered that 'the specialists view is calibrated' and, also, that statistically speaking, the higher the number of variables, the smaller will be the probability of a random result, since fluctuation decreases.

Grades, in turn, are values attributed to each legend component within themed maps, defined according to the relevance degree each variable/occurrence holds, and regarding a specific goal. In the case of the *Need for Environmental Protection synthesis*, grades meant how much each spatial occurrence is important for preservation. As for the *Expansion Interest and Urban Density Synthesis*, grades attributed show how much each spatial occurrence is adequate for population density and settlement

Once partial *Need for Environmental Protection synthesis* and *Expansion Interest and Urban Density Synthesis* are created, it is beneficial for the urban planner to compare the analyses, in a way to identify potential transformations, conflicts of interest, and new land use possibilities.

Figure 2 - Decision Tree for structuring Environmental Interest Synthesis, Expansion Interest and Urban Density Synthesis, and Conflicts of interest Synthesis



Identification of potentials and conflicts of interest

Once the syntheses for urban expansion interest and for environmental interest were created, they were compared in order to promote the identification of areas where settlement potential is clearly defined, where there are conflicts of interest, as well as were there are specific conditions of interests and potentials.

The logic used in this analysis is also matrix analysis, for which possible combinations are identified, and the results obtained.

Figure 3 – Combination Matrix Conflicting Interests – Urban & Environmental Interests

URBANO

AMBIENTAL	A	MA	M	MB	B
A	C	C	Ac	A	A
MA	C	C	T	A	A
M	Us	T	T	T	Ai
MB	U	U	T	SC	SC
B	U	U	Ui	SC	SC

C - conflict
U - urban settlement
A - environmental protection
SC - non conflict
Us - sustainable urban settlement
Ai - environmental protection with investment
Ui - urban settlement with investment
T - potential for change

Studies on landscape perception as an assistance tool for image planning

Once the area is characterized according to their potentials, restrictions, possibilities and conflicts of interest, we moved on to the next step. Landscape perception interpretation and representation was undertaken, according to Spatial Perception and Cognition theory. The goal was to lay a foundation for the following phase, which was a project for land use and projection of the resulting new landscape for the district. This stage aimed to understand not only values involved, not only from the technical point of view, but also regarding landscape identity values.

As theoretical bases, classical authors were discussed, such as Kevin Lynch (1997), with *The image of the city*, and Gordon Cullen (1983), with *Urban Landscape*. Lynch's readings gave helped them perceive place through their structuring elements, mental map creation, legibility conditions, landscape identity and singularity. Cullen's readings instigated identification of place's cognition, considering one's insertion in a landscape and the proximity of all points of view that it encompasses. Both approaches facilitated them to identify the district's *genius loci,* what characterizes its landscape, what is valued by the community, and must be considered by urban projects.

In order to students benefit the most, we used field work, interviews with the community, and the making of expressive images, both by hand drawings and digitally altered photographs, capturing the landscape's place essence.

Figure 4 – Drawings representing landscape's essence

CONCLUSIONS – URBAN ZONING PROPOSALS AND THE

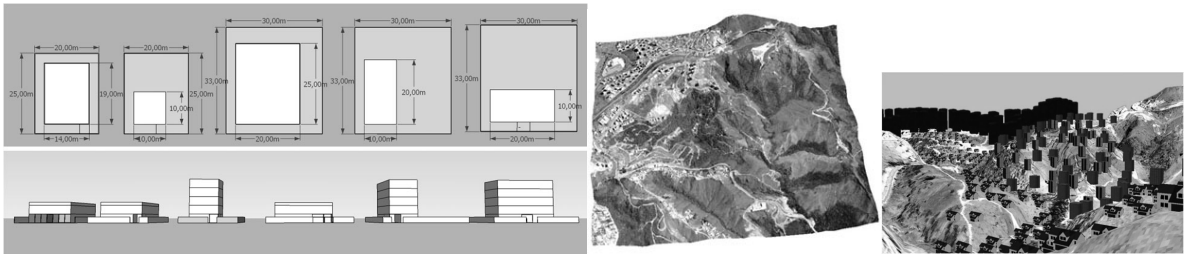
PARAMETRIC MODELING OF TERRITORIAL OCCUPATION

The drawing and landscape perception field step was important to slow down the time spent in observing and apprehending landscape, while the students understood their main characteristics and values, they could also mature their reflections on their urban zoning proposals.

The project proposals again face them with geotechnologies, since we required from them that all processes were undertaken in tridimensional representations, in a way they could have control over their project proposals, develop more effective forms of communication to locals, and simulate their results for prediction studies.

The students presented, as final products, maps specifying the zoning proposed for the district, justifying each settlement type, regarding previous analyses. Along with this map, they also made tables presenting urbanistic parameters indicated for each zone, such as: minimal plot size, building setbacks, maximum building rate, land use coefficient, maximum building height, terrain quota by habitation unit, plot's permeability rate, etc. In order for them to control their propositions, we asked them to attach tridimensional simulation drawings to the tables, so that they would really understand the meaning of those values, within a prognostic study of landscape intervention (Figure 8).

Figure 5 – Urbanistic Parameters – Simulation of landscape intervention



The students worked in tridimensional models during all the process, in order to simulate their proposals over urban landscape. Through tridimensional landscape simulation, it is possible to predict possible consequences of the urbanistic parameters proposed by zoning.

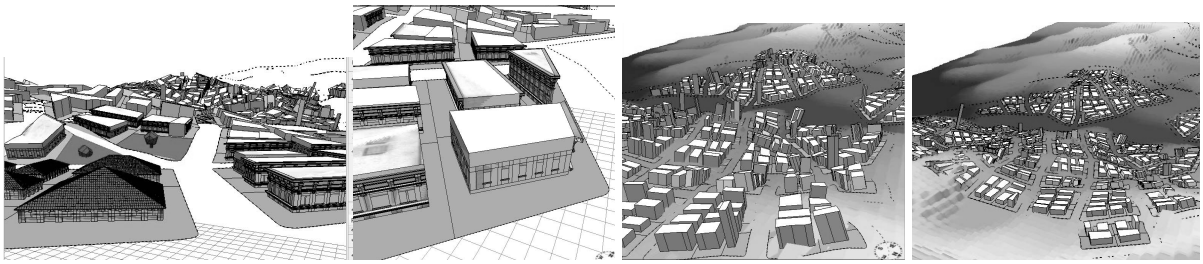
The main goal of investments made towards geotechnologies is the increase of communication with local communities, hoping to make the results of Municipal Development Plans and Urban Occupancy and Zoning Laws comprehensible. This allows the community to place themselves as fundamental agents in the production of their own urban space. And as for the Urbanist and Architects under formation, our expectation is that they will act in a more conscious manner when creating their projects, undertaking predictive studies on the landscape, since, only then, they are fully able to understand the consequences of their intervention on urban spaces.

Since we have explained the students the importance for the urbanist to have dominion over the landscape proposal thar he designed, to achieve to simulate the consequences of proposed urban parameters, we decided to investigate geotechnologies that give support to this process.

After understood the moment that we are in the employment of geotechnology, as discussed in the introduction of this article, we identified thar we are in the doors of a new paradigm in the representation of territorial landscape: the combination of values of GIS (Geographic Information System) with the BIM (Building Information Modeling), and the importance of promoting the following features: wide interoperability, expressive communicability condition and excellent graphical interface for different users involvement, employment of Parametric Modeling of Territorial Occupation.

In search of tools that could support us to take these new concepts and values to the students, we identified new software in the market, and we are living the experience of using a parameterized model to make simulations in real time, testing the results from the urban landscape applications and parameter settings.

Figure 6 – Urbanistic Parameters – Application of Rules in Parametric Modeling of Territorial Occupation



The applications available today are not yet fully ready to be used in urban planning, since they were originally created for use in games, and there is still a long and demanding work to decode the thinking of urban regulations for the simulation in augmented reality, and promotion of its variations in real time. The GIS Lab team at the School of Architecture from the Federal University of Minas Gerais is committed to building scripts that translate the rules of composition of the landscape, from zoning tables and their parameters. Our expectation is that after this important step of programming and modeling work developed, there will be a basis for supporting municipal governments and community control and management of the urban landscape, with a view to promote, in fact, designed spaces within the parameters of sustainability.

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