PAPER REF # 8109
Proceedings: Eighth International Space Syntax Symposium
Edited by M. Greene, J. Reyes and A. Castro. Santiago de Chile: PUC, 2012.

ESTABLISHING PARAMETERS FOR URBANITY

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KEYWORDS: *Parametric Urbanism, Urban Design, Urbanity, Formality, Space Syntax*

THEME: Methodological Development and Modeling

Abstract

This work deals with a new trend in urban design which has been known as parametric urbanism, emerged from the Zaha Hadid Architects' practice and from the Architectural Association School's academic environment. Parametric urbanism is based on parametric design systems, in which the parameters of a particular object are declared, and not its shape. In this context, the focus of interest is not the form itself, but the parameters which have generated them. Originally developed in aerospace and automotive industries, these technologies have presented a strong impact in the architectural design process, especially for improving the design of building components. In the last few years, parametric design techniques and technologies have been transferred to urbanism, in particular, to large scale urban design, as parametric design systems enable the generation of different alternatives of design by the adjustment of parameters.

However, it is verified that, in spite of the potentialities offered by parametric urbanism to increase the efficiency and quality of urban design proposals, it just applies morphogenetic design, mix of uses and urban density strategies to create urban life. Parametric urbanism just explores formal, environmental and functional parameters to constitute vibrant urban spaces, but these strategies are not enough to guarantee the success of urban spaces conceived to promote urbanity. Although density and mixture of uses are important urban life attributes, they are not enough. For instance, space configuration parameters, investigated by Frederico de Holanda, such as number of entrances per convex space, meters of perimeter of barriers per entrance, percentage of open spaces over total study area, mean percentage of blind convex spaces, square meters of convex space per entrance, economy of urban network, integration and intelligibility are also important. Bill Hillier and his colleagues have argued that space configuration of the urban grids determines patters of movement (natural movement) through the space independent on the attractors. Space configuration parameters, ignored by parametric urbanism, are essential to the understanding of urban dynamics, as well as proposals for new urban forms.

Therefore, this paper proposes alternatives to improve parametric urbanism by introducing space configuration parameters based on urbanity and formality paradigms, formulated by Holanda, who has developed a methodology to measure degrees of urbanity of urban areas. This methodology has been known as Medida de Urbanidade (urbanity value), which varies between 1 (maximum level of formality) and 5 (maximum level of urbanity). Space variables used by Holanda can easily be converted into computation *parameters in order to facilitate its introduction in a methodology of parametric urban design. It can aid architects and urban planners to propose more efficient urban layouts that could better support an integral relationship between occupation and pedestrian and vehicular movement, guaranteeing lively urban areas. We understand that creating urban live is an special problem of space configuration design and argue that urbanity can be parameterized and used as a performance criterion since the beginning of the urban design process to create a potential field to establish active urban spaces.*

This study argues that urbanity can be assessed and can be used as a performance criterion for the planning of urban forms, from the initial stages onwards. It presents a parametric urban design methodology guided by urbanity, based on spatial configuration parameters, whose development was motivated in particular by identification of the limitations of the new trend in urban design that has been called parametric urbanism.

1. INTRODUCTION

1.1 Parametric Urbanism

Parametric urbanism[1] is a new trend in urban design that has emerged from the offices of Zaha Hadid Architects – headed by Zaha Hadid and Patrik Schumacher[2] - and from London Architectural Association School, especially, the DRL (Design Research Laboratory), set up by Patrik Schumacher and Brett Steele. This new model of urban design uses advanced technologies involving digital morphogenesis to plan geometrically innovative and socially vibrant urban spaces, based only on formal, environmental and functional variables.

On the one hand, parametric urbanism is based on parametric design systems, in which "the parameters of a determined object are declared rather than its form" (Kolarevic, 2005, p.253). In other words, the focus is not on form per se but on the parameters that generate it. In these systems objects or configurations are generated or modified simultaneously by attributing values to parameters or altering them. Parametric design systems differ from traditional digital design systems in so far as they retain the capacity of the model to be altered throughout the whole project process and allow a large number of versions to be generated and tested within a controlled digital environment based on simple changes to the value of specific parameters. There are extremely powerful computational tools such as Generative Component (GC) and Digital Project (DP), as well as Maya Mel Script and Rhino Script, which enable parametric modeling to be carried out by way of a *script*.

These tools, "originally developed in the aerospace and automotive industries as a way of enabling the

[1] Although the expression, parametric urbanism, first appeared in the literature in 2006, in David Gerber's Towards a Parametric Urbanism (Gerber, 2006), it had already been mentioned in lectures by Schumacher, and in the DRL Course Guide 05-06, the research agenda of the Architectural Association School of Architecture's DRL (Design Research Laboratory) where Schumacher is a lecturer.

[2] Zaha Hadid and Patrik Schumacher are partners at Zaha Hadid Architects. Hadid is a graduate of the Architectural Association School and Schumacher holds a PhD from Klagenfurt University, and is co-director of the Design Research Laboratory (DRL).

design of complex curves, have for some time now been having a powerful impact on the process of building design" (Ferre, 2007, p.51), especially as a way of perfecting the conception and digital graphic representation of building components. However, it is only in the past few years that these ideas have been adopted by urban design, that is large-scale urban design, on the grounds that they are able rapidly to generate different design alternatives based on simple alterations in the values of specific parameter, thereby allowing different urban scenarios to be generated for later evaluation and facilitating decision-making.

This new model of urbanism uses these tools to build up new complex urban geometries. It applies parametric variation, differentiation and deformation techniques in order to generate geometrically fluid urban fabric and built volumes based on *splines* and NURBS that adjust to the pre-existing urban fabric. It also treats urban agglomerates as a swarm of various buildings, which define a field that is constantly changing and uses the above techniques to achieve this (Schumacher, 2008). Various urban projects produced by Zaha Hadid Architectes in recent years are based on these formal strategies, including One North Masterplan, in Singapore; Zorrozaurre Masterplan, in Bilbao, the Kartal-Pendik Masterplan, in Istanbul and the Thames Gateway Masterplan, in London, UK (Fig. 1).

Figure. 1. One North Masterplan, in Singapore; Zorrozaurre Masterplan, in Bilbao, the Kartal-Pendik Masterplan, in Istanbul and the Thames Gateway Masterplan, in London, UK.

On the other hand, parametric urbanism is based on strategies involving mixed uses and urban density, as a way of promoting the vitality of planned urban spaces, as can be seen in the writings and projects of those who espouse it. However, although density and a mixture of activities are important features of urban life, the theory of the social logic of space (Hillier; Hanson, 1984) has shown that these are not primordial features, since the very spatial configuration of the urban fabric (its system of open and closed spaces) encourages patterns of movement through space, independent of attractors, which are known in the literature as "natural movement" (Hillier et al, 1993). This new model of urbanism thus aims to promote urban life, using only formal strategies, involving mixed uses and urban density and ignoring parameters relating to spatial configuration that are essential for understanding and conceiving of new urban forms.

Although Zaha Hadid and Patrik Schumacher acknowledge that a good urban plan should bring the space to life, the strategies they use are not sufficient to ensure that the urban spaces proposed are successful in promoting urbanity. Spatial configuration parameters, based on the theory of the social logical of space (Hillier; Hanson, 1984), and the paradigms of urbanity and formality formulated by Frederico de Holanda (Holanda, 2002), for example, could be introduced into parametric urbanism as a way of ensuring that urban layouts are proposed that are more efficient in terms of promoting the vitality of urban areas.

1.2 The Paradigms of Urbanity and Formality

In O Espaço de Exceção (2002), Frederico de Holanda has suggested that the various types of human settlement identified throughout history can be plotted using two axes representing age-old socio-spatial paradigms: "urbanity and formality" (Holanda, 2002, p.126). According to Holanda (2002, p.125-126),

> 'Formality' comes from formal, and relates to form – the external limits of the material a body is made of and which gives it its configuration, its specificity—but in such a way that it is spontaneous, abides by established, conventional formulae. Formality is also a way of proceeding that is common practice or routine. In turn, urbanity clearly refers to the city as a physical reality, but also to the qualities of courtesy and affability in continuous negotiations between vested interests.

Holanda (2002) analyzed and compared the morphology of various kinds of settlement: the Maya and the Hopi in the Americas, the Zulus and the Ashanti in Africa, and French castles and Italian city-states in Feudal Europe. He also studied 17 areas in the Brazilian Federal District, including Brasília. He based his analyses on a series of variables relating to *patterns of space,* such as percentage of the total space that is open space; mean convex space; number of entrances per convex space; % of blind spaces; m^2 of convex space per street; the length in meters of islands per entrance; the economy of the urban fabric; integration; intelligibility; the form of the integrating nucleus. He also included variables relating to the *life of the space*, such as: variety of labels; density of labels; relations between labels and patterns of space; interrelations between labels; the real presence of open space; predictability; the relation between the arrangement of internal and external spaces; the extent in space of arrangements; casual *versus* formal arrangements. In order to compare the variables, Holanda (2002) translated each interval found into a scale of 1 to 5, corresponding to maximum formality and urbanity, which the author called the Measure of Urbanity (URB). He concludes that:

> ...formality is consistently characterized by: maximization of open space as a percentage of the total settlement area, a higher mean convex space, a lower number of entrances per convex space, a higher percentage of blind spaces, a greater surface area of space per entrance, a greater length of the perimeter of the islands that define convex spaces, per entrance, both extremely regular and extremely irregular fabric (as opposed to a middle term on this scale), an extremely shallow or extremely deep axial structure (again as opposed to a middle term on the scale), low intelligibility, integrating nuclei that are either concentrated on the periphery or in the core of the system and do not irrigate the settlement as a whole. Urbanity is characterized by the opposite in each category (Holanda, 2002, p. 126).

The spatial variables used by Holanda to measure urbanity (URB) can easily be converted into parameters that can be manipulated computationally in such a way as to facilitate their inclusion in a parametric urban project methodology that aims to propose more efficient layouts that provide an integral relation between occupation of land (base don the definition of ideal localities for various activities) and the movements of pedestrians and vehicles, as a way of ensuring that urban areas are brought to life.

However, the method developed by Holanda is limited with regard to its application to urban project processes, since it is bettered suited as an analytical tool than for the development of proposals. In other words, it applies better to analysis of the physical and social reality of an urban fact than to the design of new artifacts. To apply it, the way it was structured, as part of a project for designing new urban areas would be a complex task, since the model does not parametrically associate special pattern variables to those relating to spatial life, such as density, for example. At bottom, all the data that Holanda (2002) uses to measure urbanity derive from two sources: the axial map and the map of convex spaces. Such maps are drawn up on the basis of the spatial design of portions of the urban fabric. One fundamental piece of data for this method is the number of constitutions (X), or rather, the quantity of transitions between internal and external spaces, which feed into three entrances; the average number of constitutions per convex space (X/C), the quantity of convex space per constitution and the length of the perimeter of obstacles to construction (Ip/X). These data are quantified by Holanda using in situ observation.

However, what can be done when we do not have such information during the urban design process? [3] For example, if we wish to design an environment with the maximum degree of urbanity (equivalent to 5 on Holanda's scale), how many constitutions should be built into the system to ensure that the urban environment achieves this? This is a complex question, because it involves a relation between the number of constitutions, the use and occupation of land, or rather, between spatial pattern variables and variables relating to the vitality of space, which are located at distinct levels of analysis in the method developed by Holanda. It is known that certain uses, by their very nature, require greater interface with public space in order to meet these demands, and thus require a larger number of constitutions than others. For example, if an educational facility fully occupies a hypothetical squared urban block (with an area of 10,000 square meters and a perimeter of 400 meters), would supposedly have fewer constitutions than one where the same block was occupied by affordable housing units or by a small shopping mall (Fig. 2). This is because there is a need for more control of access for the directors, teachers and staff and for supervision of the students (Loureiro, 2000), in contrast to the need for ease of access to products and their display in a highly functional commercial area.

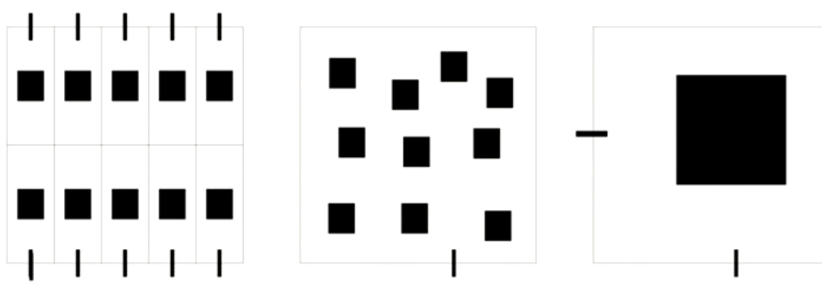


Figure 2. Simulations of patterns of interfaces between interior and exterior of urban block according to types of activity. Left to Right: (1) affordable housing; (2) gated community; (3) school or shopping mall.

We could also provide the example that, if the same block were occupied by a gated residential condominium or by a large "shopping center", there would inevitably be fewer constitutions, although the

[3] In urban design, we are working simultaneously with spatial pattern variables and variables relating to spatial life for the purpose of coming up with proposals. In other words, we are working with a series of mathematical parameters, which ultimately result in specific forms and uses of space, however flexible these may be. Urban design is an essentially dynamic and interactive activity in which the architect is led to design and simultaneously revise the solutions found. If we want the urban design proposals to be capable of supporting and integral relation between use and the movement of pedestrians and vehicles in space, all the variables need to be quantifiable and subject to parameters.

uses would be the same—residential and commercial. This occurs because, in both large commercial areas and high-level private condominiums, the number of entrances is reduced to ensure greater control. In other words, certain categories of use and forms of occupation have fewer constitutions to ensure greater control and isolation from public life.[4] How, then, can this "constitutions project" be managed in such a way that urban areas have the patterns of urbanity desired by the advocates of parametric urbanism? How are urban activities with spatially different numbers of constitutions be disturbed in such a way as to generate the patterns of co-presence necessary for ensuring a high degree of urbanity? How is the number of constitutions for the various uses and urban activities to be calculated?

One possibility is to relate indices for the displacement of pedestrians caused by land use to the perimeter of blocks, because the displacement of pedestrians in the space of the city is almost always related to a certain activity to be carried out at some destination. Heavily used roads mean that people are moving around, taking trips, from one point to another in the urban system (or from one constitution to another) to carry out some activity, even if it is only to move about freely. Relatively busy streets also means large numbers of constitutions, since the more constituted space is, the greater the likelihood that they have high levels of co-presence (Holanda, 2002). Although "planners stil have little information of the movement of pedestrians and the factors that drive them and restrict them" (Agrawal & Schimeck, 2007, p.549), methods for calculating these movements are being consistently developed in the academic field of Transport Engineering, in which they are commonly known as Trip Generating Clusters. TGCs express the capacity of certain uses and urban facilities to cause the displacement of pedestrians and vehicles within the urban structure. These indices can be effectively related to the perimeter of blocks, as a way of calculating the demand for constitutions arising from distinct uses of urban land.

Thus, the number of constitutions, which is extremely important for measuring and promoting urban vitality, is still not a parameter than can be applied in the design of urban areas to ensure patterns of urbanity. The literature has not identified indicators of constitution per use that could be applied to design. To obtain these, we have build up a new model of parametric urban design, guided by patterns of urbanity, which could be applied by parametric urbanism. This model is based on the Urbanity Measure (URB) and the Trip Generating Clusters (TGCs).

2. PROVIDING PARAMETERS OF URBANITY

2.1 Description of the parametric urban design model guided by urbanity

As Batty notes (2007), models are abstractions; simplifications of real things. They allow scientists and designers to explore the world, predict and plan before acting on the physical reality in an irrevocable manner. They are points of contact between theory and reality. Although these devices have their limitations, they are a consistent way of producing knowledge, since they help to test hypotheses and to compare data. The parametric urban design model guided by urbanity presented here is thus exploratory in nature and is based, above all, on simulations.

To identify the best numbers of constitutions for each urban activity, different simulations were run using the model of a hypothetical regular grid of 16 blocks (or islands) with sides of 100 meters, a perimeter of 400 meters and an area of 10,000 square meters. (Fig.3) The grid as a whole has an area of 202,500 square

[4] The harmful effects of this desire for greater privatization on the part of social groups and for urban life have been extensively studied by authors such as Tereza Caldeira, in Cidade de Muros (Caldeira, 2000).

meters and length and breadth of 450 meters. Using this, four distinct simulations were run for the percentage occupation of the façades within each plot, whilst maintaining the core. In the first simulation, the façade occupies 100% of the plot, in the second, 81%, in the third, 49% and, finally, in the fourth simulation, it occupies only 25% of the original area of the plot. The percentage of occupation thus varies from 100 % (a traditional urban plot) to 25% (an isolated building on the plot, which is a typical modern urban plot). This means that the areas of closed (private) space and the perimeters are reduced in size in proportion to the increase in the area of open (public) space. Each simulation thus presents different perimeters and areas of open and closed spaces.

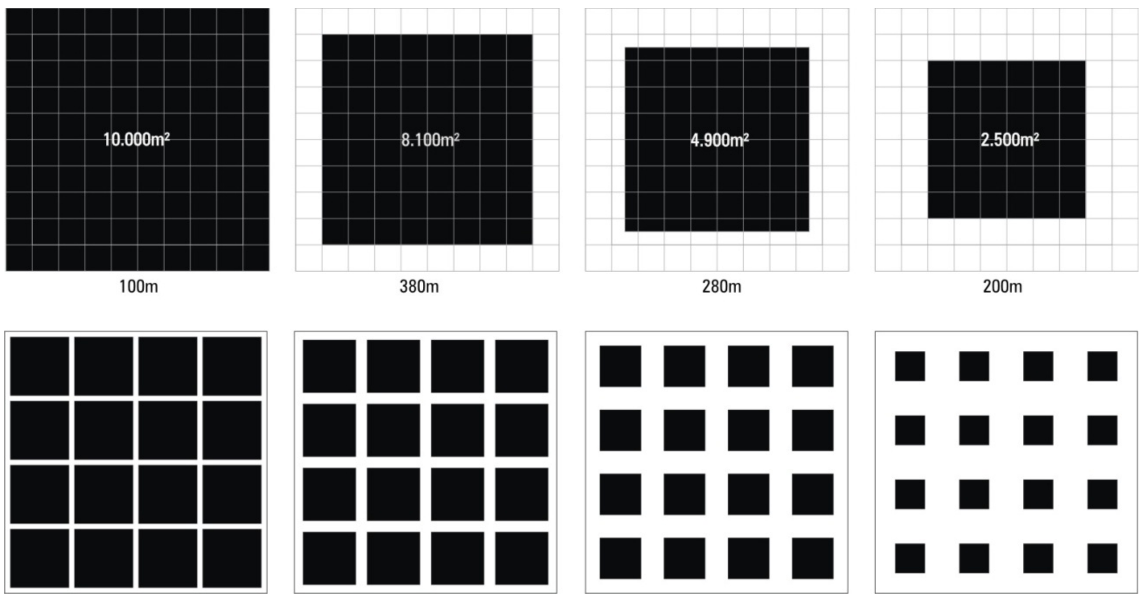


Figure 3. Simulations M01, M02, M03 and M04. Above: Hypothetical 10,000 m^2 areas occupied by urban blocks of varying sizes, 10,000, 8,100, 4,900 and 200m^2 Below: Simulations M01, M02, M03 and M04, generated on the basis of a hypothetical grid of 16 plots occupied by urban blocks with different percentages of occupation of the plot.

The following information was drawn from these simulations: (1º) data on the plots themselves (such as type of façade, area of plot, area of façade, perimeter of façade, public area, private area, percentage occupation); (2º) data on the *grid* in general, such as total area of urban portion, nº of plots or spatial islands, total area of closed spaces, total area of open spaces, total perimeter of façades and total nº of constitutions; and, finally, (3º) data on constitutions.

However, in order to provide data for the third set relating to the constitutions, it was necessary to establish a generating criterion. It was decided to compute the projection of one constitution unit per 10 meters of façade façade. This figure was generally established on the basis of the fact that building codes and urban planning legislation stipulate an extension of 10 meters with as the minimum length for determining the frontages of lots in projects for residential lots. However, this value can be changed, to establish smaller lots, such as those for detached housing units, for example. The total perimeter of the façades in each simulation was thus divided by a factor of 10, giving the total number of constitutions for each simulation – the largest possible number of constitutions that can be established, given the minimal length of 10 meters. Then, the percentage indices for displacement of pedestrians, based on the use of land taken from the NHTS (2001)[5] (Tab.1), were multiplied by the total number of constitutions for each simulation, resulting in the number of constitutions per use. [6] The model thus provides an estimate of the number of constitutions per land use, as shown in Table 2.

Table 1. Frequency, distance and duration of displacement of pedestrians by purpose.

PURPOSE [OF JOURNEY]	FREQUENCY Percentage	MEAN DISTANCE Miles	MEDIAN DISTANCE Miles	MEAN DURATION Minutes
Dealing with personal business/shopping/sending a message, buying something or providing a service.	48%	0.44	0.22	11.9
Recreation, exercising	20%	1.16	0.56	25.3
Moving around	16%	N/A	N/A	19.6
Going to or coming back from school	7%	0.62	0.33	13.3
Going to or coming back from work	4%	0.78	0.25	14.1
Walking dog	3%	0.71	0.25	19.0
Others	2%	0.57	0.22	14.8
Total	100%	0.68	0.25	16.4

Source: Agrawal & Schimek (2007, p. 552).

All the data were put into a parametric spreadsheet[7] (Tab. 2), in which the numerical data are inter-related, in such a way that, by altering the dimensions of the plots or the number of them, all the other dependent information is automatically changed, including information in other spreadsheets, such as the primary syntactic data, spatial urbanity variables and the measure of urbanity, which will be presented later.

[5] It is worth noting that the NHTS data establish categories for purpose of journey that are of no interest to this study. The categories “moving around” and “walking the dog” were thus included in the others category, giving a percentage of 21%.

[6] To see this better, the mathematical equations are given in the spreadsheet itself. (Tab. 2)

[7] The spreadsheet was drawn up using EXCEL (Microsoft Office 2007).

Table 2. Model of parametric urban design by urbanity.

	DATA ON PLOTS							DATA ON *GRID*					DATA ON CONSTITUTIONS					
														Nº OF CONSTITUTIONS BY URBAN USE X_{uso}=Ip*TRIP FREQUENCY %				
GRID	Type of Façade	AQ Area of Plot (m^2)	AL Area of Façade (m2)	PL Perimeter of Façade (m)	APR Private area of Plot (m^2)	APB Public area of (m^2)	POQ Percentage occupation of plot (%) P=(AL/AQ)*100	A Total area of urban portion (m^2)	I Nº of spatial islands	Total area of closed spaces (m2)	Y Total area of open spaces (m2)	Ip Total perimeter of Façades (m)	X Total Nº of Constitutions X=Ip/10	Commerce and Services (48%)	Recreation, Sports activities (20%)	School (7%)	Work (4%)	Others (21%)
M 01		10.000,00	10.000,00	400,00	10.000,00	0,00	100%	202.500,00	16	160.000,00	42.500,00	6.400,00	640	307	128	45	26	134
M 02		10.000,00	8.100,00	360,00	8.100,00	1.900,00	81%	202.500,00	16	129.600,00	72.900,00	5.760,00	576	276	115	40	23	121
M 03		10.000,00	4.900,00	280,00	4.900,00	5.100,00	49%	202.500,00	16	78.400,00	124.100,00	4.480,00	448	215	90	31	18	94
M 04		10.000,00	2.500,00	200,00	2.500,00	7.500,00	25%	202.500,00	16	40.000,00	162.500,00	3.200,00	320	154	64	22	13	67

After identification of the total number of constitutions and the number of constitutions per activity all the data necessary for measuring urbanity were extracted using the method devised by Holanda (2002). The first data to be extracted were the primary syntactic data, such as: total area of urban portion (A); total area of open spaces (Y); total number of convex spaces (C); total number of constitutions (X); perimeter of barriers (Ip); number of spatial islands (I); and number of axial lines (L) (Tab. 3). These data represent the basic information needed for the spatial urbanity variables, such as percentage of open spaces over total study area (Y/A); mean convex space (Y/C); mean number of entrances per convex space (X/C); percentage of blind convex spaces (Cb); area of convex space per entrance (Y/X); length of island perimeter per entrance (Ip/X); economy of the urban network (GRA); integration (RRA) and intelligibility. [8](Tab. 4).

Table 3. Primary Syntatic Data.

GRID	Façade	A(m2)	Y(m2)	C	X	Ip(m)	I	L
M 01		202.500,00	42.500,00	40	640	6.400	16	10
M 02		202.500,00	72.900,00	40	576	5.760	16	10
M 03		202.500,00	124.100,00	40	448	4.480	16	10
M 04		202.500,00	162.500,00	19	320	3.200	16	22

KEY:

A – Total area of urban portion (m2); Y – Total area of open spaces (m2); C – Number of convex spaces; X – Total number of constitutions; Ip –Perimeter of barriers(m); I – Number of spatial islands; L – Number of axial lines

Then the axial maps were drawn up (Fig. 4). These maps were submitted to spatial analysis using Mindwalk 1.0 [9] - a computer tool developed by Lucas Figueiredo (Figueiredo, 2004), which provides all the standard syntactic measurements used to analyze axial maps, by way of measurement of the abstract topological properties of such maps.

The aim of the spatial analyses using Mindwalk was to obtain syntactic measurements for integration and intelligibility, which number among the urbanity variables established by Holanda (2002).Although the software does not provided intelligibility directly, it gives values for connectivity and integration, which can be used to obtain this. The intelligibility measure is obtained by simple correlation of the measurements for connectivity and integration of all the axial lines of the urban system, carried out using software capable of performing his calculation[10]. These two measurements (integration and intelligibility) complete the information needed to draw up all the urbanity variables. With this it was possible to measure the urbanity

[8] The variables drawn up by Holanda (HOLANDA, 2002) were described in detail in the previous chapter. These can be used to mesure the urbanity of the urban portions – the urbanity measure (UBR).

[9] Mindwalk is a spatial analysis tool developed by Lucas Figueiredo, in 2005. The software was originally designed for the author's research on lines of continuity in the axial system for his master's degree at the Federal University of Pernambuco's Post-Graduate Program in Urban Development. For more information on the tool, see the software's homepage, at <http://www.mindwalk.com.br/> accessed on 25 Sept. 2009.

[10] The software used to perform the simple correlation was EXCEL (Microsoft Office 2007).

of layouts M01, M02, M03 and M04. The values found are registered in Table 5.

It can be seen that the values obtained display some discrepancies, since the variables represent distinct properties of the system, presented using different scales. While the Y/A variable, for example, has very low values (varying between 0.2 and 0.8), the Y/C variable is quite high (from 1,063.5 to 8,552.6), which makes it difficult to visualize the levels of urbanity and formality. This problem can be solved using the same procedures developed by Holanda (2002, p. 439-454), which he calls normalization. The values obtained were therefore normalized on a scale of 1 to 5, representing the maximum formality and the maximum urbanity respectively.

Table 4. Spatial urbanity variables.

Simulation	Façade	Y/A	Y/C	X/C	Cb	Y/X	Ip/X	GRA	RRA	INT
M 01		0.2	1062.5	16.0	0.0	66.4	10.0	1.0	2.8	0.0000
M 02		0.4	1822.5	14.4	0.0	126.6	10.0	1.0	2.8	0.0000
M 03		0.6	3102.5	11.2	0.0	277.0	10.0	1.0	2.8	0.0000
M 04		0.8	8552.6	16.8	0.0	507.8	10.0	0.5	4.9	0.9560
MAX		0.8	8552.6	16.8	0.0	507.8	10.0	1.0	4.9	0.9560
MEDIAN		0.5	2462.5	15.2	0.0	201.8	10.0	1.0	2.8	0.0000
MIN		0.2	1062.5	11.2	0.0	66.4	10.0	0.5	2.8	0.0000

KEY:
Y/A – Percentage of Open Spaces over Total Study Area; Y/C –Mean Convex Space; X/C – Mean Number of Entrances per Convex Space; Cb – Percentage of Blind Convex Spaces; Y/X – Square Meters of Convex Space per Entrance; Ip/X – Meters of Perimeter of Barriers per Entrance; GRA – Economy of urban network; RRA – Integration; INT - Intelligibility

Normalization is a mathematical procedure that consists of the application of a set or rules as a way of correcting and/or simplifying a certain set of data, generating relational files. This technique generates unequivocally identifiable records and simplifies the way data are filed. Holanda (2002), however, uses a specific kind of normalization, which is better known in the literature as polynomial adjustment. The author takes the maximum value, the median, and the minimum value for each analytical variable and plots these on the x axis of a graph. Then, he takes 1 (corresponding to maximum formality), 3 (the median between 1 and 5) and 5 (the maximum urbanity) and plots these on the y axis of the same graph. He uses these to plot three points on the Cartesian graph. Using a statistical computer tool, ASP, he finds a second degree polynomial function, which he calls the normalization equation. This equation corresponds graphically to a curve that tends to pass through the three points (HOLANDA, 2002, p. 315, 373, 440). It is thereby possible to make the values vary only between 1 and 5. According to Holanda (2002, p. 441), ASP was developed by Raul Ferraz et al. in 1991. We made various attempts to find up-to-date versions of this software, with no success. We therefore sought to identify tools that could carry out the same procedures. We opted for the Origin. 8.0 software[11], a tool that is widely used to solve statistical problems and which performs polynomial

[11] Origin 8.0 is a statistical software package developed by OriginLab, which produces data analysis tools and tools for the production of graphs for use in the fields of engineering, statistics, and the natural and exact sciences. For more information on the tool, see: <http://www.originlab.com/> accessed on 15 Jan. 2009.

and exponential adjustment techniques, which is why we chose to use it. It was thus possible to normalize the spatial urbanity variables.

By way of illustration of the normalization process using Origin 8.0, we describe here the case of the variable relating to mean number of constitutions per convex space (X/C) – the third analytical category. According to the codification created by Holanda (2002), X corresponds to the total number of constitutions and C to the total number of convex spaces of the urban portion in question. The values found (16.0 – 14.4 – 11.2 – 16.8) are used to establish the maximum value, the median and minimum value, which are 16.8, 15.2 and 11.2 respectively. Using Origin 8.0, we plotted the graph as follows: on the x axis, the maximum value (16.8), the median (15.2) and the minimum value (11.2) for the X/C variable; on the y axis the values for maximum formality (1), the median of the values for maximum urbanity and maximum formality (3) and, finally, the value for maximum urbanity (5), following Holanda (2002). The software automatically makes these values correspond and locates the three points on the Cartesian graph: P1 (16.0 , 1); P2 (15.2 , 3) and P3 (11.2 , 5). Then it performs the polynomial fit, using a curve (the normalization curve) which passes through the three points. This curve is a second degree polynomial function: $Y=-12.2 + 3.03571\,X – 0.133393\,X^2$. This function was then inserted into the spreadsheet of spatial urbanity variables, generating the values: 5.0 - 4.0 – 2.2 – 1.0.

Table 5. Normalization equation for spatial urbanity variables.

VARIABLE	NORMALIZATION EQUATION (Polynomial fit)
Y/A	$Y = 6.33333 - 6.66667\,X + 1.20860^{-14}\,X^{2}$
Y/C	$Y=6.90216 – 0.00195\,X + 1.46883^{-7}\,X^{2}$
X/C	$Y=-12.2 + 3.03571\,X - 0.133393\,X^{2}$
CB	Y=1
Y/X	$Y=6.23079 - 0.01977\,X +1.86568\,X^{2}$
IP/X	Y=5
GRA	$Y=6.14286 - 0.42857\,X - 0.71429\,X^{2}$
RRA	$Y=1.33345 - 2.31286\,X - 0.4859\,X^{2}$
INT	$Y=4 - 1.63959\,X -1.56745\,X^{2}$

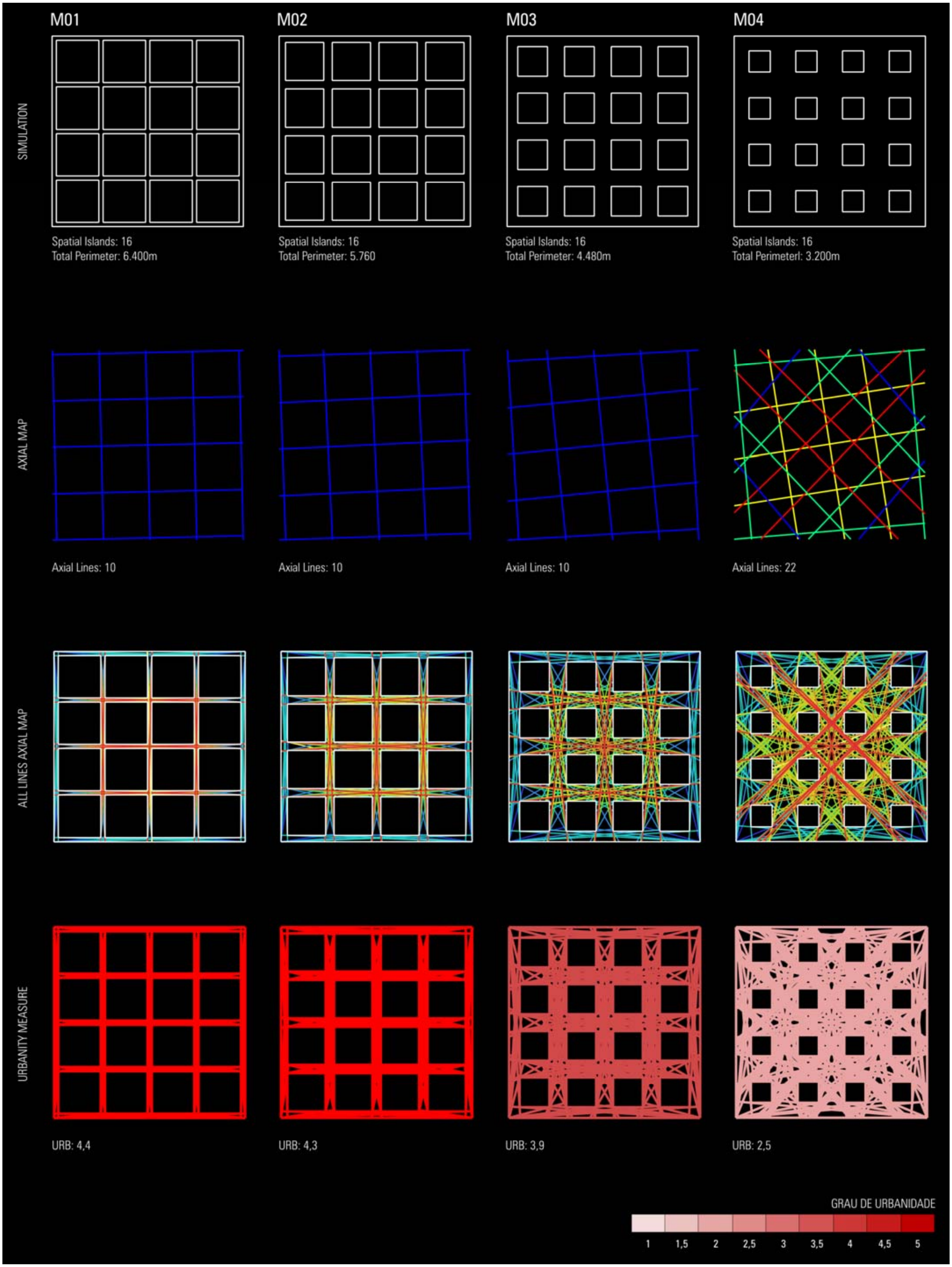
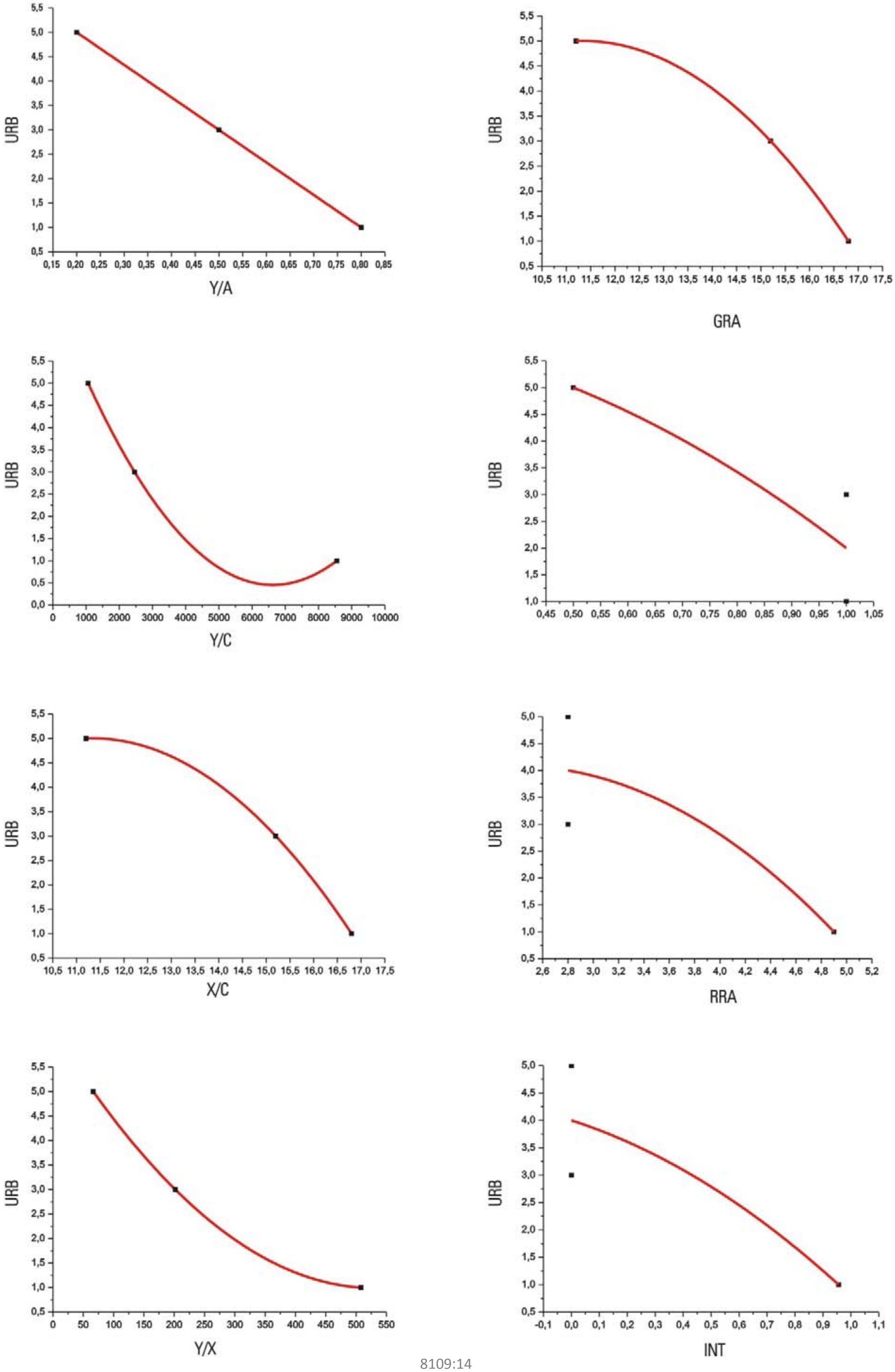

M01
M02
M03
M04
SIMULATION
Spatial Islands: 16
Total Perimeter: 6.400m
Spatial Islands: 16
Total Perimeter: 5.760
Spatial Islands: 16
Total Perimeter: 4.480m
Spatial Islands: 16
Total Perimeterl: 3.200m
AXIAL MAP
Axial Lines: 10
Axial Lines: 10
Axial Lines: 10
Axial Lines: 22
ALL LINES AXIAL MAP
URBANITY MEASURE
URB: 4,4
URB: 4,3
URB: 3,9
URB: 2,5
GRAU DE URBANIDADE
1
1,5
2
2,5
3
3,5
4
4,5
5

Figure 6. Polynomial fit graphs with normalization curves.

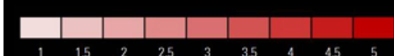


The same procedure was followed for all the spatial urbanity variables. The functions found for each variable are reported in Table 6. The corresponding graphs are given in Figure 5. Each equation was likewise inserted into the spreadsheet thereby allowing the data to be normalized. The results of this process are given in Table 6, where Y/An, Y/Cn, X/Cn, Cbn, Y/Xn, Ip/Xn, GRAn, RRAn, INTn correspond to the normalized spatial urbanity variables and URB (the Urbanity Measure) corresponds to the arithmetic mean of all the normalized spatial variables. The URB thus expresses the degree of urbanity of the urban portion under study. To facilitate visualization of these levels, we have codified the spreadsheet by coloring the urbanity variables using a color scale that varies from red to white: the more urban the *grid*, the darker the shade of red, the more formal the lighter. This was then used to produce an urbanity map (Fig. 4 and Table 6).

Table 6. Urbanity Measure

Simulation	Façade	Y/An	Y/Cn	X/Cn	Cbn	Y/Xn	Ip/Xn	GRAn	RRAn	INT	URB
M 01		4.9	5.0	2.1	1.0	5.0	10.0	5.0	4.0	4.0	4.4
M 02		3.9	3.8	3.7	1.0	4.0	10.0	5.0	4.0	4.0	4.3
M 03		2.2	2.3	5.0	1.0	2.2	10.0	5.0	4.0	4.0	3.9
M 04		1.0	1.0	0.9	1.0	1.0	10.0	5.8	0.9	1.5	2.5
MEANS		3.0	3.0	2.9	1.0	3.1	10.0	5.2	3.2	3.4	3.8

KEY:
Y/An; Y/Cn; X/Cn; Cbn; Y/Xn; Ip/Xn; GRAn; RRAn; INTn are the normalized spatial urbanity variables and URB is the urbanity measure, corresponding to the arithmetic mean of the normalized spatial variables.



The model thus allows us to visualize the degree of urbanity of urban areas. It is a parametric tool that allows for the manipulation of the spatial design of urban layouts, visualizing the effect of these operations on patterns of urbanity. Decisions regarding use, such as the distribution of urban activities, can be guided by this model during the design process. In order to show the number of constitutions per activity, the model makes it possible to orient the distribution of land uses so that the plots have more or less constitutions, as a way of creating a potential field for determining which areas are more urban and which more formal. On the other hand, decisions that involve problems regarding modes of land occupation, such as the design of open and closed spaces and the choice of building types, may also be guided by the model, with a view to establishing patterns of urbanity or formality. Certain operations relating to the design of urban forms, such as the distortion of fabric, have significant configurational implications and interfere in levels of urbanity and these can be foreseen and controlled using the model. When, for example, parametric urban design distorts the urban fabric, it ignores the implications of these operations in terms of patterns of urbanity, which could be included by the use of this tool.

3. FINAL CONSIDERATIONS AND FUTURE DEVELOPMENTS

One of the main limitations of this model of parametric urban design guided by patterns of urbanity is that, like the Measure of Urbanity (URB), it also homogenizes patterns of urban vitality, because the urbanity index refers to the grid as a whole. Although the urban fabric has high urbanity indices, within its structure, there may be areas or roadways that are more formal or more urban. Holanda isolated parts of the Brazilian Federal District, the better to observe the urbanity of the various networks that make it up. However, it would be more interesting to establish procedures for analysis of the constituent parts of the urban network on the smaller scale, of the street, the square, the block and so forth.

One possible development of this model would thus be to measure the urbanity of a segment of a roadway or a convex space, which would allow for more precise visualization of the gradients of urbanity in the urban structure. This would be a fundamental step, because, knowledge of the more urban and more formal roadways, as determined only by the spatial configuration, the distribution of urban uses could then be guided more adequately in such as way as to follow it, whilst maintaining the balance in the levels of urbanity of the structure as a whole. For example, spaces or stretches of more formal streets and avenues could be more ceremonial spaces for more formal uses, while more urban spaces could be used for commercial and residential uses, without interfering in the pattern of urbanity of the area as a whole.

Another possible development would be the design of a specific computer tool that would allow urbanity to be measured in a more practical and interactive manner. In fact, parametric modeling tools allow for an interface with spreadsheets, which facilitates the manipulation of data to visualize alterations in the two- or three-dimensional model instantaneously, although it is rare for spreadsheet editing software to contain more complex statistical procedures, such as normalization of data by polynomial and exponential fit. This procedure is still carried out using specialized statistical tools, such as Origin 8.0 and the equations are later inserted in the spreadsheet. However, if the spatial urbanity variables are altered, the normalization equations need to be re-calculated.

The aim of this paper has been to provide parameters for the configurational variables for the measurement of urbanity drawn up by Frederico de Holanda. Variables relating to use have been included, thereby generating quantitative indicators of constitutions that can be used to realize the full potential for vitality of the urban environment. Urbanity is not just something that can be measured qualitatively, but, rather is an attribute that can be measured quantitatively, and is thus susceptible to the use of parameters and can be used as an objective criterion for performance to be included in parametric urban designs from the very outset, with a view to designing more efficient urban forms.

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