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A model for parameterization of urban regulations

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Abstract

The recent developments in digital design tools enable not only efficient but also holistic approaches to urban design problems. As the amount of data increases that urban design handle, the tools become more complex to maintain the spatial continuum across scales. In this context, the development of parametric design practices allows the generation of alternative scenarios and testing processes in addition to dealing with a large quantity of information. With reference to urban scale design problems, abovementioned information is closely related to regulatory processes, which mostly consist of text-based documents with 2D representations. This paper explores the use of parametric regulation modeling by presenting a design support model. The proposed model enables the designer to try out alternative scenarios by manipulating parameters and to gather real-time data, which is generated by using the Esri CityEngine software package. The text-based regulations are transformed into parametric form-based components by the proposed parametric regulation-modeling tool. In this regard, local regulations and standards are used for the generation of data-rich parametric 3D models and the evaluation of the alternative design scenarios. The first section provides a summary of the parametric regulation modeling and design guides within the context of urban design problems. The following parts describe the generation of the model as a parametric urban regulation model to support decision-making activities during design.

Keywords
Parametric regulation modeling, Urban design, CityEngine.

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1. Introduction

Urban design is usually located between architecture and planning scales, oscillating and filling a gap (Carmona et al., 2010). Schmitt (2012) describes design research approaches as simulations at different scales within the context of cities, which are building scale (small, S-scale), urban scale (medium, M-scale) and territorial scale (large, L-scale). These different scale problems are interconnected, as output from one can be input to another. Moughtin et al. (1999) distinguish the design cycle for regional planning from the design cycles of town planning, urban design and building design by identifying a feedback from the appraisal stage to the analysis stage, rather than from the decision stage. The relations between the tiers are not necessarily linear or unilateral for digital collaborative working environments. Furthermore, various design activities in built environments take place at different scales from a unit to region with the main actors of individuals to governments.

The recent digital developments in design processes enable holistic approaches to urban design problems. As the amount of data increases, the tools become more complex to maintain spatial continuum with the transformation and analysis of data. The information modelling tools support such holistic approaches at different scales of design practices. Building information model (BIM), geographic information systems (GIS) or city information model (CIM) can be classified under such complex tools that enable data-rich interactive 3D environments, in addition to running various simulations. Urban scale design problems are related to several kinds of data, which can be gathered by GIS (visual) and regulatory processes (text-based documents). In a design process, designers analyze and synthesize such data, which emerges from variety of outputs in various formats. From the perspective of education, novice designers need to manage various kinds of data from different disciplines while building their design knowledge. In order to support novice designer's design processes, an interactive data embedded model is proposed. The proposed model allows designers to generate and test various design scenarios in a limited studio time. In doing so, regulations and standards are used to guide and gather real-time data. Novice designers encounter regulations and standards in terms of the representation of regulations (definitions) and evaluation of their design processes. The regulations and standards are mostly text-based descriptions with the complementary visual representations. Parametric approaches support the transformation of text based descriptions into form-based components to explore alternatives rapidly, as novice designers need the skills of greater critical thinking that is supported by experiential knowledge. Especially at urban scale design problems, the regulations are significant components to shape built environment. The politics of regulations or how regulations shape the built environment is beyond the scope of this study. This study addresses the regulations, as a tool to guide development and achieve desired design solutions, which includes the definitions and calculation methods to evaluate design scenarios by using both spatial and numerical outputs. Esri CityEngine software package is used to generate this model, which is a procedural modelling tool for urban space generation. As a city information modelling software, it provides a parametric design environment for users to generate and manipulate their scenarios.

As an urban design problem, the scope of this study is urban regeneration areas, which constitute a major urban design issue in the cityscapes around the world. On the positive side, urban regeneration enable designers to work with an entire and existing neighborhood as a whole. The model is designed to be adaptable for various urban regeneration design cases. The paper describes the structure of the proposed model as a parametric regulation-modeling tool to support design processes. The first section below provides a summary of the parametric regulation modeling and design guides within the context of urban design problems. The following parts describe the generation of the model, which involves the transformation of regulations into parametric forms as an educational decision support tool.

2. Parametric urban regulation modeling

Regulations are important components of the urban regeneration processes. Design codes and regulations can be considered as systematic precedents in addition to being guides to fulfill requirements. Design strategies, regulating plans, master plans are occurred to "to guide the development process and achieve a range of enhanced design outcomes, while all provide a clear two- or three-dimensional vision of future development form" (Carmona et al., 2010, p.313). Lawson (2004) points out legislators as one of the design knowledge constraints. He put an emphasis of the requirement of the great amount of knowledge to set criteria with the satisfaction of standards and attach these attributes to designs. Lawson (2004) also criticizes the regulations as they are generated for easy measurements rather than what is desirable. However, from the perspective of education, novice designers need to understand regulations and standards and the related concepts and definitions.

Design codes or design guidelines can be considered to be more flexible than the regulations. Some are motivated by user participation. Earlier examples are mostly based on defining urban morphologies. Also they can be described as systematic approaches to urban design problems, which emerge from the precedent cases (Kolodner, 1993). One of the most well known early definitions of code is Christopher Alexander's Pattern Language, which is first published in 1977 as a systematic organization of urban morphology (Derix, 2012). "Responsive Environments: A manual for designers" is another practical book with an aim to introduce design ideas "that the built environment should provide its users with an essentially democratic setting, enriching their opportunities by maximizing the degree of choice available to them" (Bentley et al., 1985, p.9). More recent example is the Smartcode, which is described as "a form-based code that incorporates Smart Growth and New Urbanism principles" (Transect, n.d.). Smartcode is not a digital platform but it is a model to guide design principles. Design guidelines/design codes are not used in definition of the proposed model, however they are considered as potentials for future studies. More flexible environments like parametric urban design aids to understand and generate sustainable and livable urban environments with the knowledge of urban form and its data.

Parametric regulations modeling aids the design process to observe the manipulation of parameters with the outcomes of numeric values like floor area ratio, built are, number of units etc. Modelur, CityCAD, CityZoom, LandXplorar are commercial parametric regulation modeling tools. Some of them can collaborate with other programs like GIS and some of them are standalone programs (Figure 1). Derix (2012) points out they all share the common characteristic of working from a designed masterplan, which includes determined circulations, movement structures and blocks. In other words, the plot development regarding the massing is the common characteristic of such tools. In addition to that as the focus is on parameters for regulations, the detail of models can be limited.

Modelur allows for parameters such as building height, gross floor area and floor numbers to be set and for numerical values such as building area and floor area ratio to be observed (Modelur, n.d.). At the same time, it offers various types of land use with real-time calculation reports (Modelur, n.d.). Although it is known to be an easy tool to use software with online accessibility, its visualization potentials are limited.

CityZoom is a system that "integrates several performance tools that allow the simulation of different attributes related to a planned or existing city" (Grazziotin et al., 2004, p.216). It serves as a platform to operate various building performance models with the aim of optimizing urban planning process (Grazziotin et al, 2004). CityZoom can work with different kinds of data such as freehand draw-

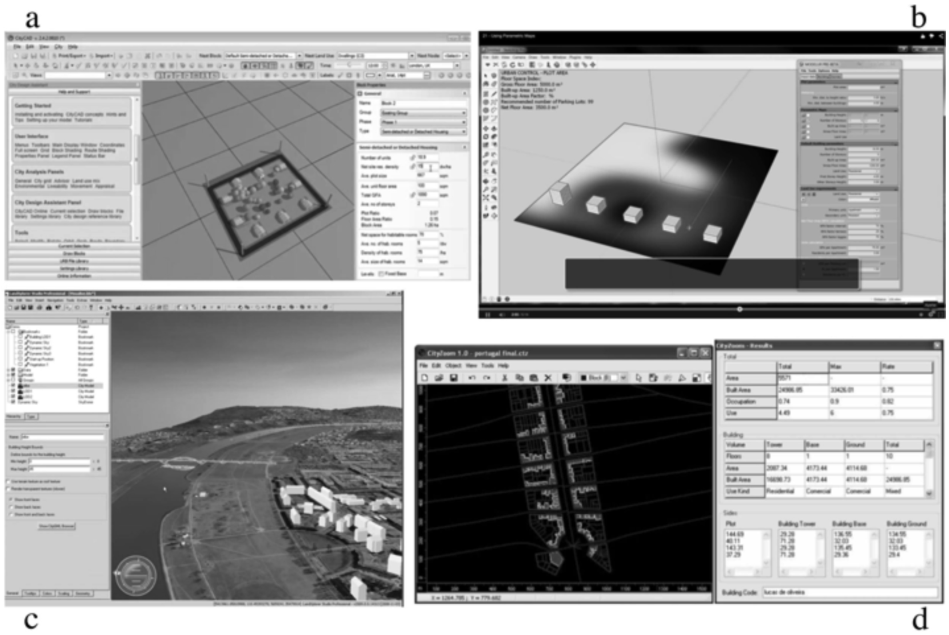

Figure 1. *(a) CityCAD (CityCAD, n.d.), (b) Modelur (Modelur, n.d.), (c) LandXplorar (LandXplorar, n.d.), (d) Cityzoom (Grazziotin, 2004, p.218).*

ings or aerial images in various file formats. It is used for the simulation of potential buildings with urban regulations (Grazziotin et al, 2004). Users can define building regulation related values (setback values, add floor number, floor height, etc.) by an urban regulation editor and also they can observe the numerical outcome of their alternatives as well as their model's visual representations. CityZoom can be defined as a powerful tool to visualize regulation limitations and observe the related numeric data with the defined parameters. However, building detail levels and the lack of other components (like streets, open spaces) only aids to evaluate generated alternatives as the masses of buildings.

CityCAD, "urban design software tool for conceptual 3D master planning of sites" (CityCAD, n.d.), is similar to Cityzoom and Modelur in being a commercial product for the early stages of urban design and allows sustainability, livability and viability analysis. LandXplorer Studio Professional is a product of Autodesk. It is described as an interactive, real-time authoring system that allows, "to visualize 3D geospatial data and to effectively create, analyze, manage and distribute geospatial information" (LandXplorar, n.d.). It integrates with GIS data, 2D Autocad data, 3D models, legends and textures (LandXplorar, n.d.). It can be used in various scales such as large-scale city models or neighborhood scales. Even though, it presents a flexible environment, customization of rules and detailed mass structures cannot be defined. The parametric regulations modeling tools that are described above are used for 3D master planning purposes with real-time data gathering. However, they have limited customization properties to make calculations to analyze. Regarding that the proposed model differs from the parametric regulation modeling tools by the guidance of local regulations and standards and integration of different typologies to generate 3D models with detailed visualizations.

3. CityEngine as a city information modeling tool

Esri CityEngine is a well-known procedural modeling software package that enables parametric design. By using CityEngine, designers can quickly create virtual environments that fulfill visualization of required functions. On the other hand, by manipulating rule-defined parameters, generated models can be manually transformed. The procedural logic in modeling cities depends on L-systems and generation of two-dimensional patterns, which is achieved through the application of shape grammars (Parish & Müller,

Table 1. The main components of the model.

Buildings	Residential and Commercial Buildings	Residential
		Commercial
	Facilities	Educational facilities
		Health Facilities
		Accommodation facilities
		Religious Facilities
		Public Facilities
Streets	Vehicle Road	
	Bicycle Path	
	Sidewalks Street parking	
Open Spaces	Green Areas	Children's Playground
		Parks
		Open sports area
	Parking Lots	

2001). The integration with ArcGIS geo-database files is one of the main capabilities of the software, which enables users to use required urban data. Through real-time visualization, it gives opportunity to observe reactions of certain moves on manipulating parameter values both as visualization and data gathering. Recent examples on CityEngine enable users to observe performance of buildings or regulatory processes. Two of these examples are Redlands Redevelopment plan (Esri Redland Redevelopment plan, n.d.) and Auckland City Plan (Esri Auckland City Plan, n.d.), which supports users to observe different scenarios. Especially Auckland City Plan project is used to generate alternative scenarios for different regulatory acts of governments (Esri Auckland City Plan, n.d.).

4. The transformation of regulations and standards into the proposed model

The model is aimed to be a responsive tool for novice designers with data rich 3D visualization to alter between different design ideas by manipulating parameters. The transformation of regulations and standards into rules are one of the main issues in creation of the model. Accordingly, 'Standardized Building and Zoning Regulations' (SBRZ) (T.C. Çevre ve Şehircilik Bakanlığı, 1985), 'Regulation on Preparation of Spatial Plans' (RPSP) (Resmi Gazete, 2014), 'Dimensioning and Design Principles of Urban Roads' (DDPUR) (for street generation) (Turkish Standards Institution, 1992), "Cars – Design Criteria of Auto Parking Facilities in Urban Areas" (Turkish Standards Institution, 2013) and "Auto parking regulations" are used in the model as a guide to generate alternative scenarios. As regulations and standards consist of text-based descriptions, they cannot be fully transformed into rules due to program limitations, semantic conflicts or some regulation exceptions. The model has three main components based on SBZR and the operating logic of CityEngine, which are built environment (facilities and buildings), networks (streets) and open spaces (Table 1).

Basically the model consists of the computer generated architecture

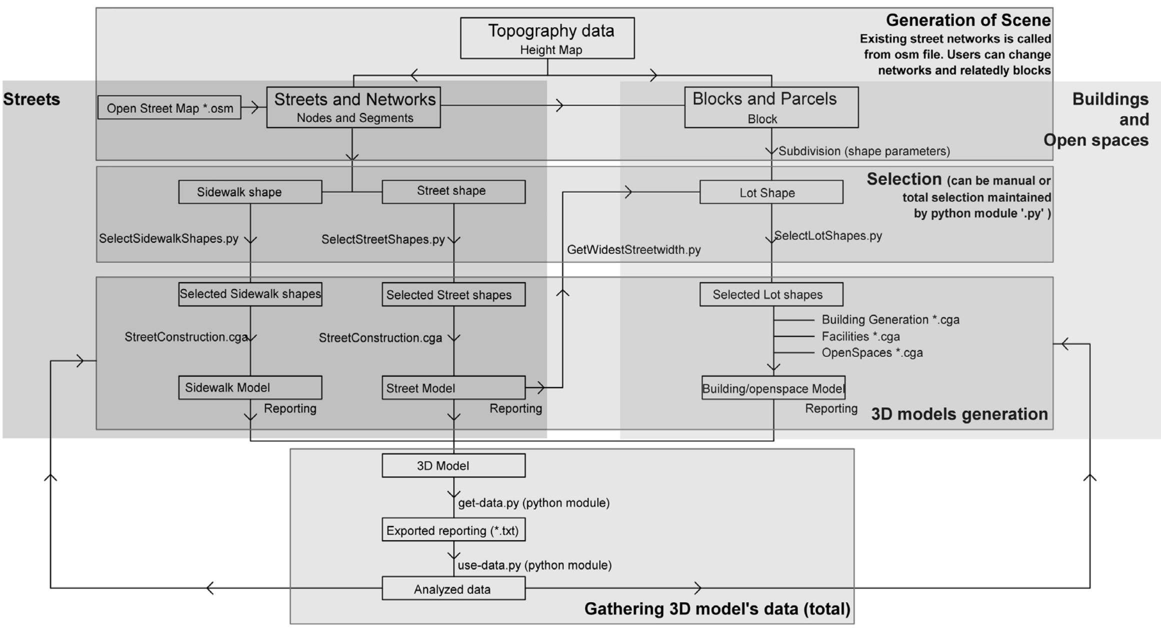

Figure 2. The model's workflow.

(CGA) rule files, Python scripting modules and the components like images 3D objects to generate the 3D visualization (Figure 2). Rule files are assigned to shapes to create models in which default values are assigned as rule-defined values. From the inspector menu, predefined parameter values can be observed and be manipulated by sliders. After generating a 3D model of an area, existing model's reports can be extracted by using the python module like population, density or household number.

4.1. Buildings

The building rule consists of two types of buildings, which are residential/commercial buildings and facility buildings. The common parameters for all building types consist of the model display, topography adjustment and facade construction. The model display includes mass, envelope and detailed display of the model. Different colours are assigned to mass display mode, based on the code of usage type defined in RPSP. Users can decide the function of a building by selecting the building usage type from parameters. The components of a 3D model of a building is described under three parts regarding the related regulations and standards, which are parcel limitations, building envelope and building parameter.

4.1.1. Parcel limitations

The model's all rule files have the properties of parcel limitations based on SBRZ. Accordingly, four main zones are defined in SBRZ, which are 'commercial and residential areas', 'industrial areas', 'small industrial areas' and 'except residential urban areas'. As mentioned beforehand, the focus is limited to residential urban regeneration the zone type of 'commercial and residential areas' is constituted in detail. The basic parcel limitations consist of the parameters of the parcel width and the parcel depth. Based on SBRZ parcel width and depth minimum values are given in Table 2 and 3. While applying a building rule to a shape, the rule checks whether it fulfills minimum required values, which consists of the values of parcel depth and width based on the zone type. If the values are not fulfilled the requirements, the green areas are generated by the rule.

Table 2. *Parcel limitations – Parcel depth.*

Parcel Depth		
	Without Frondyard	With Frontyard
Commercial and Residential Areas	> 13m	> Frontyard distance + 13 m
Small Industrial Areas	> 5 m	> Frontyard distance + 5 m
Except Residential Urban Areas	> 40 m	
Industrial Areas	> 30 m	

Table 3. *Parcel limitations – Parcel width.*

Parcel Width				
		Attached	Detached	Corner parcel
Commercial and Residential Areas	Up to 4 Floors	> 6 m	> both side yards distance + 6 m	> side yard distance + 6 m
	Up to 9 Floors	> 9 m	> both side yards distance +9 m	> side yard distance + 9 m
	10 and more	> 12 m	> both side yards distance +12 m	> side yard distance + 12 m
Small Industrial Areas		> 5 m	> both side yards distance +5 m	> side yard distance + 5 m
Except Residential Urban Areas	> 40 m			
Industrial Areas	> 30 m			

Other than urban zone type, the existence of front yard is also a parameter in parcel depth definition (Table 2). Parcel width limitations depend on building's settlement that includes being corner parcel or being attached or detached building type. Also, building floor numbers are another determining parameter defined in rules (Table 3). According to related regulations, front yards are defined whether they exist or not. Therefore, the rule has two cases, which are 'without frontyard' and 'with frontyard', users can choose either one of them.

Table 4. Set back values extracted from SBRZ.

Street Setbacks	Up to 4 Floors	5 Floors and more	More than 60,5 meters
Front	5m		15 meters + (0.5 * each additional floor number)
Back	3m	3 meters + (0.5 * each additional floor number)	15 meters + (0.5 m * each additional floor number)
Left	3 m	3 meters + (0.5 * each additional floor number)	15 meters + (0.5 * each additional floor number)
Right	3 m	3 meters + (0.5 * each additional floor number)	15 meters + (0.5m * each additional floor number)

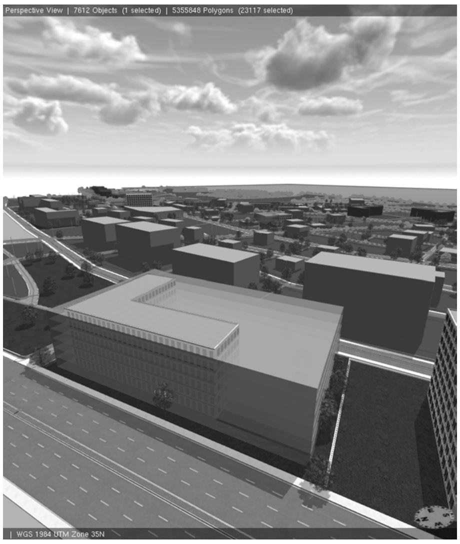

Figure 3. The envelope with L-shape footprint.

4.1.2. Building envelope

The limitations of building construction area are described in the envelope definition, which includes the information of setback distances based on building floor numbers. According to SBRZ, the envelope of a building consists of the extrusion of setback limitations. The minimum setback values related to building floor numbers and maximum heights are displayed in the Table 4. In the model, the setback values are appeared as rule-defined values unless the designer needs to change manually.

The setback values, building floor numbers, ground floor height and upper floor heights are the parameters that affect the envelope, in addition to being interconnected. Another parameter for the building construction is being detached or attached building that are defined based on regulations. In rule, depending on the choice of building type "attached" or "detached", the side setbacks set as being active or passive. The envelope option can be observed by selecting model display mode as 'envelope', which presents building with semi-transparent envelope (Figure 3).

4.1.3 Building parameters

Basically building parameters consists of two types of buildings, which are commercial/residential buildings and facilities. When a building rule file assigned to a shape, building floor numbers are given randomly between the values of 1-4 floors, up to 4 floor is defined to be a default value. Users can also choose between the options of 4-9 floors and 10 and more, which changes the parcel width limitations as well. Residential and commercial buildings are defined in the same rule file. Population data is extracted from the residential building's definition by calculation of the values of gross floor area and average floor space per person.

Technical and social infrastructures are defined as facilities in general, which are classified as educational, health, accommodation, social and cultural, religious and public facilities based on regulations. Color codes for density and building functions and walking distances that enable visual evaluations in addition to understanding and using legal color codes. In addition to defined facilities, multi-storey parking garage is defined under facilities CGA rule file. Based on TS-10551, multi-storey parking limitations set as parameters such as maximum-minimum capacity of cars, floor numbers, ground floor heights and upper floor heights in addition to calculation of car capacity.

The walking distance is generated as a transparent circle with a radius data, which is assigned as walking distance value. By walking distance, users can visually observe walking distances to certain facilities/green areas, which consists of a transparent circle with radius parameter as a distance value (Figure 4). Based on the type of the facility walking distances defined as: playground 500 m, high school 1500 m, open sports area 500 m, kindergarten 500 m, elementary school 500 m and secondary school 1000 m. Users can observe the minimum legal requirements of walking distances by the predefined values. Also, the walking distance values can be manipulated by selecting custom mode.

The legal color representations support novice designers to observe the legal colors of zoning and density. Different colors are assigned to mass display mode depending on their usage type based on RPSP legend of usage of areas also same colors are used in the envelope display mode (Table 5). Another legal color representation is the density, which is calculated from the total data.

4.2. Networks (streets)

The streets are generated based on the “Dimensioning and Design Principles of Urban Roads TS-7249” (DDPUR). Street construction rule consists of two parts. The first part is the general part, which includes texture, sidewalk, green area, bicycle, crossing and roadside parking parameters (Figure 5). Users can determine the existence, values and location of these components. For instance, parameters of crosswalks consist of width, location (start or end of the street) and distance from start or end of street. Bicycle road parameters consist of the existence of bicycle road (on/off) and being whether the one way or two way bicycle road. The dimensions and the color of the bicycle road are gathered from the regulations of the designing and building the bicycle ways, bicycle stations and bicycle parking in urban roads. Based on that, minimum total width of a one-way bicycle road is 160 cm including 50 cm safe distance and dividing strips. The minimum two-way bicycle road width is defined 270 cm as default value. In addition to that the color blue is assigned to the bicycle road based on related regulations. Crosswalk as an important component to determine human traffic defined in the street construction. The parameters of crosswalk consist of the width of crosswalk, the location of crosswalk (start or end of a street) and the distance from start or end of a street. The width of crosswalk is defined as 2.5 meters depending on the definition of the minimum crosswalk width for residential area urban roads in the DDPUR. On the other hand, users can change the value by manipulating the crosswalk width parameter.

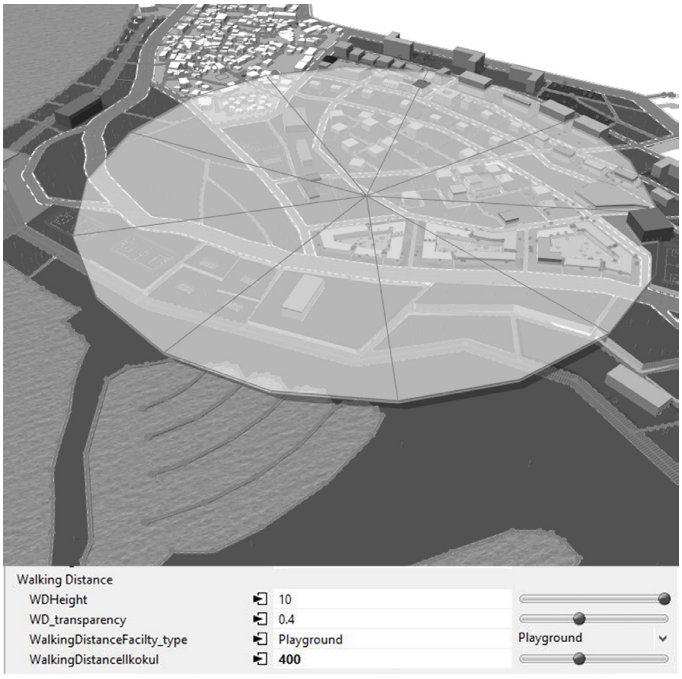

__Figure 4.__ Walking distance circle and its parameters.

__Table 5.__ Building functions and their designated colors based on RPSP.

Educational facility	"#008fff"
Health facility	"#00a9e6"
Accommodation facility	"#ff7300"
Religious facility	"#73d4ff"
Government facility	"#6699cd"
Social and Cultural facility	"#73d4ff"
Car parking	#b2b2b2
Commercial	#e00021
Urban Growth Area Residential	#fffa26
Existing Settlement Area	#8c541a
Green Space	#249c22

The second part contains the parameters of street generation depending on type. The streets are generated based on the “Dimensioning and Design Principles of Urban Roads” (DDPUR). DDPUR presents the minimum lane widths related to urban road types, which consists of four main urban road types: orbital road, urban district connection road, urban district collector road and urban district road. Based on

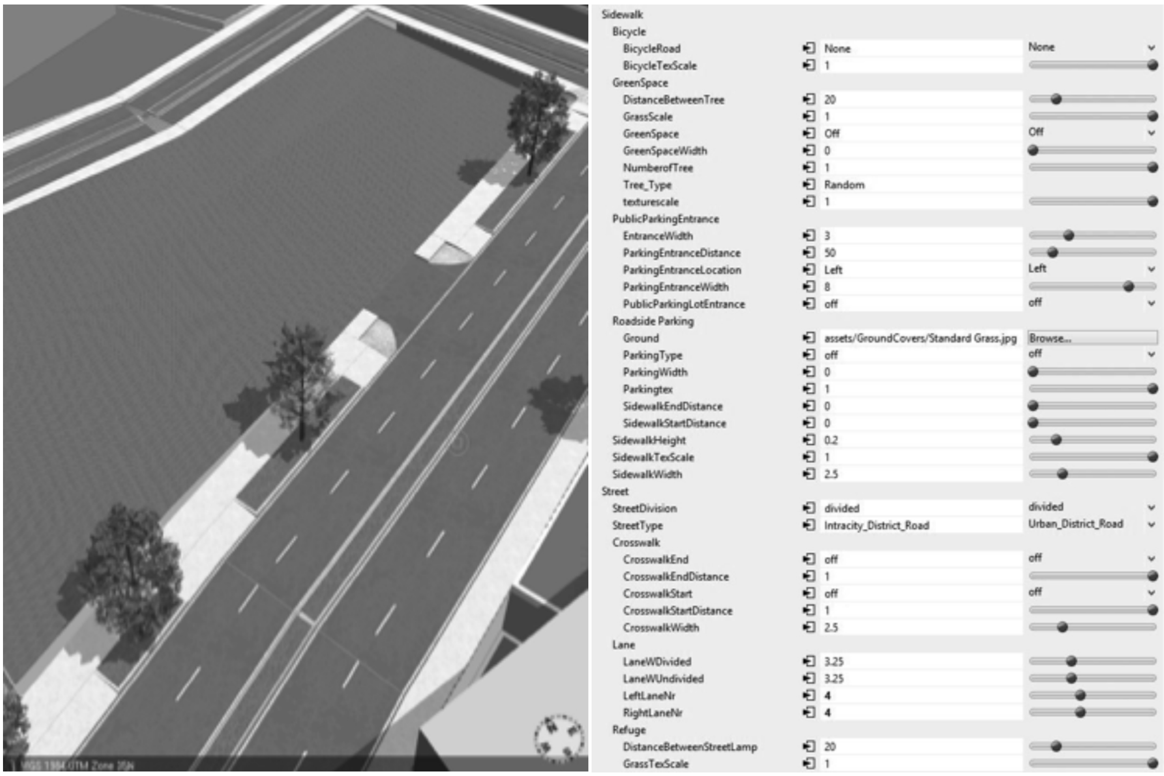

Figure 5. *The street parameters.*

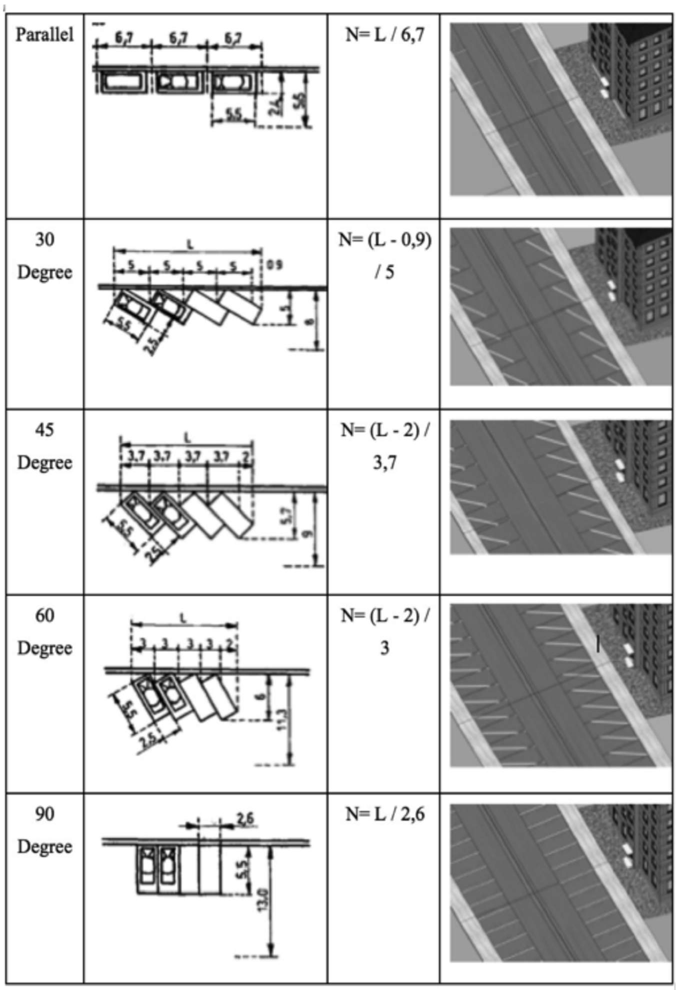

Figure 6. *Roadside parking types.*

the road types, lane widths are changed also can be observed in reports section. Each road type has the parameters of street type (divided/undivided), lane parameters (lane number, lane width divided/undivided), refuge (texture green/concrete, width) and service road (left and right, on/off).

Roadside parking limitations are also defined in this part based on 'Cars – Design Criteria of Auto Parking Facilities in Urban Areas'. Depending on that standard, 5 main parking types are defined (Figure 6). Also, since the dimensions of different parking are defined, generated roadside parking car capacity is calculated within the CGA rule file. Calculated car capacities are reported in the same name with other parking capacity data for exported data reports.

4.3. Open areas

The open areas consist of green area and parking lots, which can be selected after applying the open space CGA file to a shape. Open parking lots have the same definitions with the green areas in terms of the division of the parcel but with different texture. The data that is gathered from the generated open parking area consists of the total area

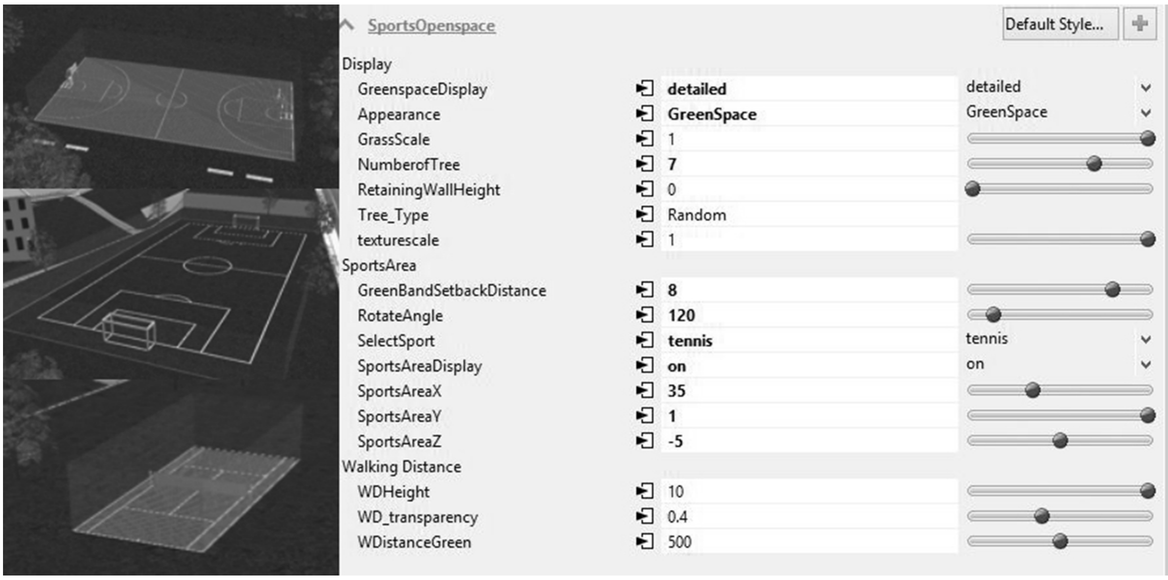

Figure 7. *Open sports area with the parameters.*

of the parking space and the car capacity of the generated area. In order to calculate car capacity 28 m^2/car is used as an approximate value, which is gathered from related regulations.

The numeric data of green spaces and their number can be observed in the reports section once the whole area is selected. Also, under the definition of open areas, football, tennis and basketball areas inserted to the project with the standard sizes, which supports novice designers to generate 3D model with the correct dimensions rapidly (Figure 7).

4.4. Analysis of generated scenarios: Calculations based on regulations and standards

The real-time reports that stem from the generated models can be observed under two ways. The first one is the report data from the selected 3d models, which are defined under CGA rule files named as primary data. The values of the floor area ratio, gross floor area, ground area ratio, parcel width, parcel depth and parcel area for building construction are gathered by primary data generation. In addition to that for residential areas, the data of population, unit numbers and generated car parking numbers are also defined in these rule files. The population data helps to generate secondary data such as gross residential density, unit number and the demand of car parking place. The calculation of population depends on the type of the residential building as single-family housing or multi-family housing. For single-family housing and pre-defined typologies Parker Morris Report's (1961) minimum dwelling size values are used to calculate population (Towers, 2005). For the others, the average floor per person value is used to calculate population, which is set as 30 sqm per person. Since this value is interchangeable depending on the location, it is defined as a parameter to be manipulated. The unit number can be calculated by population and Turkey's average household value which is 3,6 people/unit (2014's data) from Turkish Statistical Institute. This value used as an input to calculate the demand of car parking space in the secondary data gathering process.

The calculation of car capacities and the needed car space is related to each type of rule file since different type of data is extracted to calculate these values. The definition of rules of parking lots is referenced from Turkish Standards Institute's "Cars – Design Criteria of Auto Parking Facilities in Urban Areas (TS10551)" and "Auto parking regulations". Depending on standards, two main types of auto parking are defined. The first one is building parking lots (closed or open) the other one is public parking facilities. In this study, especially public parking facilities are defined which consists of two types, which are roadside parking and off-

Table 6. *The requirements of facility areas depending on population. Simplified from RPSP.*

Educational Facilities	Kindergarten	0.50 m²/person (min 1500 m²)
	Primary School	1,5 m²/person (min 4000 m²)
	Middle School	1,5 m²/person (min 5000 m²)
	High School	1,75 m²/person (min 6000 m²)
Social open and green spaces		10,00 m²/person
Health facilities area		1,50 m²/person
Social and cultural facility area		0,50 m²/person
Religious area		0,50 m²/person
Technical infrastructure (except street and parking)		0,50 m²/person

Table 7. *The second type of reports.*

Area Total	m2	
Population		
Density	Persons per Hectare	
Green Space per Person	m2	
Generated Facilities Type		
High School Area	m2	
Kindergarten Area	m2	
Primary School Area	m2	
Middle School Area	m2	
Health Facilities Area	m2	
Accommodation Facilities Area	m2	
Religious Facilities Area	m2	
Public Facilities Area	m2	
Green Space Area	m2	
Social and Cultural Facilities	m2	
Residential Area	m2	
Commercial Area	m2	
Required areas for facilities based on population		
Kindergarten	m2	Minimum area: 1500-3000 m2
Primary School:	m2	Minimum area: 4000-7000 m2
Middle School	m2	Minimum area: 5000-9000 m2
High School:	m2	Minimum area: 6000-10000 m2
Social Open and Green Area	m2	Minimum area: 6000-10000 m2
Health Facilities	m2	
Social and Cultural Facilities	m2	
Religious Facilities	m2	
Technical Infrastructure (except street and car parking)	m2	
Parking Space		
Parking Space Demand	nr of cars	
Parking Space Number	nr of cars	
Lack of parking space	nr of cars	
Exceeding parking space	nr of cars	

street parking. The reports section includes the value of number of needed car space and the number of generated car space. The value of the generated car space is calculated in three different components. The first one is the multi-storey parking garage in the facilities rule file. The second one is open parking lot defined in open space construction. The last one is roadside parking defined in street construction. Underground parking garage is not defined. For comparison of the need of cars and existing car capacities, the required number of auto-parking is determined by the rules taken from regulations as: For residential every 3 units, commercial areas for 50 m², accommodation facilities, the number of parking space changes depending on type like hotels every 5 room; pensions every 4 room; hostels every 5 room. For social/cultural/sports facilities every 30 seating, education facilities 400 m², health facilities 125 m², religious facilities 300 m², government facilities 100 m². For accommodation facilities and social/cultural/sports facilities room number and seating number can be given manually. The others can be calculated from area value or unit value that is described above.

The second way of gaining report data is to export report data with the python script as text file, which helps to make calculations for the total area. The data from rule-generated reports are used as input to maintain these calculations. In order to that, two python scripts should be used after the generation of whole area. The first script works as getting total values from the generated area as a text file. The second python script calls back this text file and based on the gathered values, makes calculations. The outcome of these calculations can be defined under two parts, the first part consist of the existing situation like the values of the total parcel area, total population, household number, density, generated parking space, green area per capita and generated facilities' values.

Density value can be assigned to shapes as an object attributes which aids to represent density by righteous colors defined by regulations in density display mode. Depending on RPSP, technical and social infrastructure minimum area needs are defined according to population density. The population intervals are defined as 0 -75000, 75001-150000, 150001-500000, 501000 and more. As the study area is limited to neighborhood scale, the part from a city, the default values are given according to minimum population as guidance for novice designers. The related values are presented in Table 6. Based on population data that is gathered from the model (calculated from residential buildings) the approximate minimum requirements for technical and social infrastructures are calculated by running python script. These report data is used to generate minimum necessity of facilities.

The second part consists of the requirements calculated from the values from the former calculations, which are the demand of car parking space, demand of the facilities and their minimum requirements. Table 7 presents the second type of data gathering for overall evaluation. These calculations aid novice designers to observe the numeric outcomes of their design decisions and to reevaluate them if it is needed in addition to stand by their design while it is evaluated.

5. Conclusions

The complex design problems of urban regeneration, characterized by administrative processes as much as physical and socio-economical transformation, require multidisciplinary approaches and participatory processes. The proposed model, a responsive design tool built on the procedural logic of CityEngine, introduces some means for a collaborative, not yet participatory, process to be of use in the educational context. Users can generate and test different design scenarios by receiving visual and numeric outputs on the spatial qualities. The real-time data supports decision-making processes by allowing designers to understand and become aware of the implications of their design scenarios. The definitions of the parameters and calculations are emerged from the local regulations and standards, which are used to guide novice designers in order to be informed rather than to limit them. Since novice designers need to manage large amount of data in a limited time frame, the proposed data integrated model supports their design process to have a deeper understanding of the relevant concepts, while building their design knowledge.

The model differs from other parametric regulation tools by customization of local regulations to evaluate design scenarios. Moreover, as an educational platform, it enables novice designers to familiarize with the terms and legal representations (color codes, walking distances). The transformation of regulations includes not only the definition of parameters, but also the analysis components such as the walking distance feature. The information that emerges from the standards supports the design process by rapid generation of components with the correct dimensions like dimensions of different kinds of car parking space or standard sizes of open sports area.

However, the proposed model has several limitations regarding the transformation of all regulations and standards into the model due to technical limitations. Another limitation is the lack of the components of urban circulation system, which is planned to be resolved with further studies. The structure of model enables the integration of improvements that consist of different analysis scripts or pre-defined components. For future studies, the model can be transformed into a participatory tool with the support of the future design codes and guidelines.

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