VISUAL PROGRAMMING AIDED URBAN VEGETATION DESIGN

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Abstract - Advancements in computational design are leveraging Urban Design by reducing human input and increasing multi-layer integration from different discipline into one platform. Therefore in this paper, a design tool has been developed using visual programing to generate vegetation models in urban streets using a bottom-up approach called (Tdesign). The tool provides environmental analysis, construction technical details in order to aid the urban design in the planning stage. City guides and greenery regulations are embedded within the server system of the tools. A case study in Seoul city, south Korea was tested and initial results are gathered and analyzed. The results depict that automatic modeling tool Tdesign is able to produce variety of vegetation models that might aid urban design decision making process. In the future this tool will be simplified for city citizens to use without prior knowledge of scripting in order to shape their city by themselves.

Keywords - Rule Based Modeling, Computational Design, Street Vegetation, Visual Programming

I. INTRODUCTION

With the improvement of the city and the upswing of individuals' expectations for everyday comforts, individuals set forward higher solicitation for the personal satisfaction and lodging conditions which implies more appeal on arranging and structuring of city [1]–[4]. Tree planting on the two sides of a road to deliver an 'overhang conclusion impact' created by the tree crowns, trees can act like a barrier between pedestrians and moving vehicles so as to give a nice enclosure feeling and increase walkability [5-9].

Miller (1997) proposed a Species Selection Model for selecting species for urban use. Important factors in this model include site factors, economic factors, and social factors. However, he did not assign priorities to these factors. Design qualities, longevity, ease of cultivation, and mass propagation were identified as the main criteria in selecting tree species.

Urban sites are the most challenging for good growth conditions; however, a good business sponsor can better ensure the survival and vitality of trees. There is a need for close collaboration between civil engineers and landscape architects from a very early stage, to integrate tree plantings into the process of designing streets to maximize their benefits and avoid potential conflicts with traffic and utilities [10].

Urban designers used the visual programming in order to optimize and analyze urban context such as Grasshopper in Rhinoceros that needs no background in programming and able to do complex computational calculations at a fast rate [11-16]. ENVI-met microclimate tool has been developed to measure the urban object air interaction depending on the fundamental laws of fluid dynamics [17]. Different road and building designs have been studied, in particular the space between the building and the streets is favored by city inhabitants while encased settings or blocked viewpoints are loathed[6],[18-25]. The elements that have extraordinary effect on the daylight and ventilation is the size of street space [26,27].

This paper proposes a unique modeling approach for automated pathway vegetation in urban contexts, in compliance with urban planning regulations, environmental requirements, and best practices, leveraging visual programming and generative design technologies for urban planning processes.

II. RESEARCH METHODOLOGY & OBJECTIVES

The objective of this research is to develop a street vegetation design tool using a multi-agent system called (Tdesign). This system generates context-specific street vegetation design integrated with Environmental analysis and provides construction planning detailed drawings.

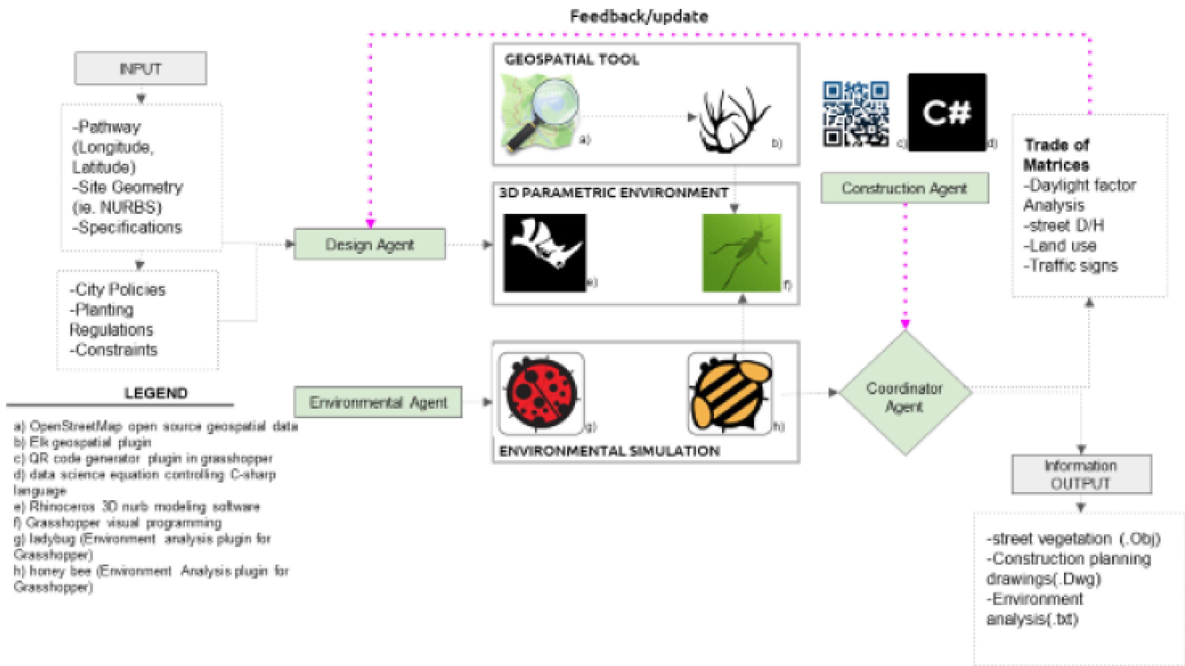

Figure 1 Diagram illustrating the components of the Tdesign System for methodology framework prototype

The bottom-up approach in design of urban elements like trees where all surrounding constraints are considered from the beginning, can help decision makers by providing them with solutions that are already optimized.

A. Tdesign tool for tree configuration

Tdesign has four key components: a) design agent; b) environmental agent; c) construction agent; and d) coordinating agent as shown in Figure 1. The design agent contains a collection of user initially specified design parameters; for example, target pathway, seating preferences, vegetation preferences. The agent generates alternative street vegetation scenarios based on input from the consumer and limited by the urban context, city codes, and vegetation planting equations enforced by the construction officer. The environmental agent is used as an informative tool to provide insight into the livability and comfort within the path before and after each proposed landscape design. Tdesign then runs the simulations for the building and determines the optimal solutions among the various objectives. The designs created are graded based on the trade in matrices and then passed on to the coordinator agent. The goal of the development agent is to find the best urban design solution for street vegetation within the specified multiple targets. The environmental agent's aim is to decrease the lux value of (CDA) while at the same time raising the daylight comfort of especially trees moving through vegetation and measuring its effect on the surrounding. The coordinator handles interevent communication, completion of processes, and passing of data.

In this study, the component "radRose" within the ladybug library-see Figure 1 component h)- was used to measure the field of view of pedestrians when walking along the path with specific tree distribution scenario [11]. In our case buildings and vegetation, this view investigation section takes a user-determined visual plane, field of view bottom, and separation break point to check for view interference from input geometries. The effect is a returned percentage of unimpeded perspectives and a series of vision cones with related ranges and angles indicating the level of visibility from a given place. This research helps the consumer to understand how much the pedestrian sees, or how much street vegetation blocks the field of view. This model can also be used to determine whether, when grown up, the tree or vegetation will in future block traffic signals for vehicles to avoid this in the planning process. To coordinate the tree planting construction process, each tree has a unique identification which corresponds to a QR code. The QRcode is a 2-dimensional barcode, in which black and white dotsrepresent the tree ID. For construction, some data can bestored within the tree barcode, such as the spatialcoordinates, tree type, and tree I d and volume of soilrequired for each tree. Before logistics begins, the QRbarcode can be attached to the tree and giving informationto the construction works for the unique information ofeach tree at any time simply by scanning the code andusing the QRcode generator tool created by the API [20].

B. Rule Extraction Module

In order to control the design outcome, city regulations and urban green standards are translated and converted into mathematical equations as shown in Table 1. Tree Impact group have already developed user friendly equations from Australia

vegetation standards. This paper imports these equations into the visual programming for design output control.
Diameter at Breast Height (DBH) is an effective tree scale and urban mass identifier. In various situations, when deciding on choices, it is necessary to determine what the DBH could be the point at which the tree formed. It is significant that trees are planted far enough away from structures and other urban fixtures to permit the tree to grow normally, without future harm to the surroundings; and without harm to the roots. The greater the development tree will at last be, the greater the recompense that ought to be made.

Equation number	Rule legislation source	Objective	RULE	Rule No.	Standard	explanation
(1)	Rules from Gov	Distance between trees (TDT)	TDT = 6 ~ 8 m	Act on the Creation and Management of Streets in Seoul Article 7	Criteria of Planting Materials of Garosu	The gap to the plants is 6 ~ 8 m
(2)		Distance between tree and road	Min. PD= 1m	Chapter 2 (Creating a street tree)Article 4	(Vegetation Reposition Location)	Minimum distance from the road and pathway border to the center of street tree ≧ 1m
(3)			PD >=2m			plant a tree on a road without a sidewalk ≧ 2m from the edge of the road
(4)	Rules from standards	Calculate Diameter at Breast Height (DBH)	Type A: DBH = 2.5% expected tree height	Australian Standard appendix D: 2303:2015	"Tree stock height and calliper	DBH estimates indicate that DBH ranges as a percentage of tree height from 2.0 percent-3.0 percent for tall slender-growing species to 5 percent-6 percent for tree-growing species, with general species somewhere between them.
(5)			Type B: DBH = 4% expected tree height			
(6)			Type C: DBH = 5.5% expected tree height			
(7)		Calculate PD according to DBH	$PD = 3.5 x DBH$	Australian Standard for the Protection of Trees AS 4970-2009	Development Sites	PD is assessed from the planting pit centre

Table 1 Urban street vegetation rules and standards conversion

The Australian Trees Impact Group [28-30] developed equations to calculate the planting distance to the closest urban object. Not whether the PD created in these formulas is for estimation only and not accurate, they are only used to guide the street landscape tool suggested in this paper as shown in Table 1- "(7)."

The Australian Forest Norm (AS 4970-2009) covers the Structural Root Zone (SRZ) and defines it as "the tree stabilization needed area." The rule was transformed by a tree-impact group into an equation and embraced as linked to in equation in this paper street vegetation design tool"(8). The trees in the urban cities have to be enclosed with roots buffers to avoid adverse infrastructure impacts. However, the size of the tree pit should be adequate with the tree type and size otherwise it might lead to the risk of tree falling or withering. As analyzed from the storm events, the trees that fall had their roots pulled with them because it was planted in a compromised box near infrastructure which severely restricted tree's natural growth. The estimation of the optimum SRZ for growing tree species at each particular infrastructure site involves therefore an automated street landscape design method that includes layout preparation.

Tree class	Tree Height	Species included	Remarks
Type A	30~60m	Maidenhair tree, Metasequoia glyptostroboides, American sycamore	Big, slim wildlife
Type B	15~30m	Yoshino Cherry, Castanopsis sieboldii, Japanese maple	Common plants Average height trees (mostly applicable)
Type C	3.5~15m	Tetradium daniellii, Crepe-myrtle, Japanese camellia	QuillBot will have your text rewritten. First write or paste anything here and then click Quill It.

Table 2 Tree categories depending on their scale (height, canopy diameter and DBH)

A minimum recommended distance to the tree is determined before allowing the installation of the root buffers (RB). For the tree to live, this distance is defined by a circular safe space, and the root buffer should be placed outside the space. This logic can help designers, urban planners to allocate sensible tree spaces to consider them in the planning stage. The minimal range from the stems center to RB to the roots boundary (MD), as shown in equation "9). FSI All spaces filled by items above and below are determined and have a vital effect on each other in the urban setting, hence the amount of soil available for the plants planted in the streets should be estimated and regarded in the street plants design method. The industrial soil is compacted in the traditional way, and then spread to the tree pits that sometimes affect soil chemistry to be less than required. A adequate quantity of soil should be given for the tree to survive in the long term otherwise, due to inadequate urban soil, it may wither or fail to thrive.

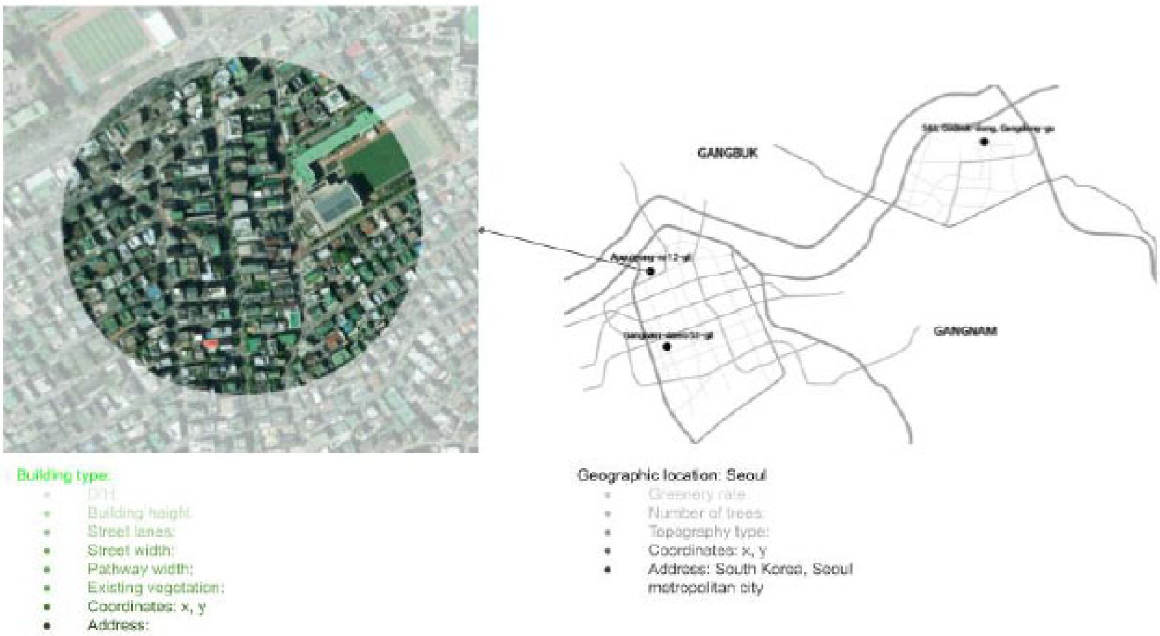

Figure 2 Case study's geographic location

The tree impact group developed a balance formula from NATSPEC Specification for Landscape Trees and Australian Standard 2303:2015 for calculating the Appropriate Soil Volume (RSV) as follows:

A variation of Size Index sometimes called the "Field Size Index "(FSI) – see table 1," (10) "equation- where FSI is equivalent to Tree Total Height (TH) (m) divided by DBH (mm).

The trees irrigation device is out of reach of this inquiry. However, the irrigation of the freshly planted tree is important for the tree to survive. Most short-term irrigation issues tend to do with inadequate or insufficient amount of irrigation for the trees. Therefore, in the quantity taken off from the trees after layout, a data sheet is created that calculates the watering volume and frequency required for each type of plant included in this research to direct the

building agent on how to irrigate or water the newly planted trees. Right 'root crown' condition is key to the trees' long-term achievement.
The arrangement of the trees' underlying roots developed to accommodate subterranean existence. Thus, the tree's portions above the ground have advanced across the ground to live and grow. The junction where certain subterranean parts or more ground parts converge is known as the 'root crown' and it is just wise that the root crown would be at ground level directly. If this is the case, it is common for trees to be overpotted during the nursery stage and/or planted too deeply at the site. Excessive root crown position may impact the tree and nearby spaces and cause issues including: girdled roots, a mat of fibrous roots, sealed off the tap root with site soil and decay of the collar. In the nature, the root crown can be buried for a variety of reasons, including: Trees planted too deeply, Subsidence, Trees planted too low on a sloping site, Root Balls covered in silt as a result of watering.

Figure 3 System Outputs and environmental analysis of the case study

III. EXPERIMENTAL RUNS

A site with medium-rise building form in Apgujeong-ro 12-gil, Seoul city, South Korea was selected to test Tdesign system methodology. This neighborhood's pathway is chosen in accordance with the environmental output to runthe system design software, a prototypical method, to produce a street vegetation model.
This system uses commercially developed modeling software Rhinoceros and Grasshopper plug-in as a platform to run the agent simulations [21], [22].Python and grasshopper visual programming language are used to control the multi agent process as illustrated in Figure 1. The system workflow steps are as following:

1. The user sets input parameters and the interface agentruns initialized. To determine the best tree locations the program applies the environmental agent. At each iteration the system produces a unique model in which the position of the trees provides the surrounding with daylight comfort. The models developed for lighting analysis are transferred to DLA and CDA.
2. When the environmental analysis is successful, the models generated are rated and forwarded to the building agent to apply the metrics terms of the regulatory equations. Then, it produces the detailed drawings for the planting stage of the building.
3. The building agent assigns formula understandingsto control various variables and describes the algorithm feature as follows: a) eq1 and eq7 control the distance between trees; b)eq2 and eq3 measure the length between tree crown and the centerline of the street depending on the tree type; (c) eq4, eq5 and eq6 cluster trees based on the D / H of the neighborhood buildings and measure the breast height diameter; (d) eq8 calculates the root structure zone needed for each cluster of tree types in line with the infrastructure or restriction specified by the user; e) eq9 installs the root barrier at the shortest distance between the road and the

tree stem; and f) eq10 calculates the volume of soil required for each tree node type defined in the preceding formulas as shown in Table 1.

4. The outputs of the coordinator agent are: street vegetation design model, technical drawings for construction planning, environmental analysis and take off quantity, as shown in Figure 4.

The Tdesign's goal is to initially look for the solutions created for design aesthetics and environmental efficiency based on various configurations and variable design parameters. To check the viability of the models the most effective tests are passed on to the construction supervisor. The feedback loop adjusts and utilizes the inputs into the algorithm consequences at by iteration.

IV. DISCUSSION AND NEXT STEPS

The Tdesign system is successfully tested with a pilot study that provided an intuition of how one design parameter can affect the output generation and system behavior in an urban context. More data analysis and case study are required to further improve the heuristic method, and the workflow between different agents, to build Tdesign tool further. A full automation system is next step. In order to generate a better version of street vegetation using heuristic functions the constructability raking feed back into the device needs to be built further. It is important to analyze each individual parameter separately by running iterative simulations for each and testing its behavior and effect on the system. Finally, the device should be reviewed on current street vegetation, and its practicality should be checked against the available traditional street vegetation modeling methods.

ACKNOWLEDGEMENT

This research was supported by Haenglim Company for Architecture and engineering services. Architecture department in Chung Ang University in Seoul City had a noticeable impact on guiding and developing this design tool.

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