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DEVELOPMENT OF THE INTEGRATED APPLICATION SOFTWARE FOR SPATIAL ANALYSIS TECHNIQUES BASED ON VISUAL PERCEPTION

MINSEOK KIM
Department of Architecture, Pukyong National University
lado7595@gmail.com

ABSTRACT

This study aims to develop an analysis application software for spatial analysis techniques based on visual perception. Spatial analysis techniques based on visual perception refer to the methodologies which focus on human perception and behavior, especially on visual perception in architectural & urban spaces to analyze and interpret the spaces. Typical examples of such techniques include Isovist, Visual Access & Exposure (VAE) model (Archea, 1984), Visibility Graph Analysis (VGA) technique, etc. There are applications developed earlier and used widely such as DepthMap, Syntax 2D, OmniVista, VAEpc, etc. However, there is the inconvenience of using different applications for different analyses reflecting various standpoints. Therefore, in this study it is aimed to develop an analysis application software in which Isovist, VAE model, and VGA technique are integratedly implemented as an AutoCAD 3rd-party application using ObjectARX technology. AutoCAD 3rd-party applications are 'add-on' applications loaded and run on AutoCAD, which effectively utilizes the powerful vector-based processing of AutoCAD and overcomes the weakness of existing analysis applications. To put it concretely, the newly developed application consists of three modules, which are Isovist module, VAE module, and VGA module. The Isovist module implements original Isovist, directed (or partial) Isovist, original/directed Isovist along path. The VAE module implements VAE model, weighted & layered VAE model, and Directed VAE model. The VGA module implements VGA, Evacuation Cost Evaluation Method (ECEM), and Angular & Cellular VGA. These methodologies commonly take vantage points as units of analysis, and the function to easily arrange vantage points is built in to the software.

KEYWORDS

Spatial Analysis, Analysis Software, Visual Perception, Software Development, VGA

1. INTRODUCTION

Spatial analysis software developed vis-à-vis the theoretical and methodological advances include Axman, Pesh, Depthmap, Axwoman, Confeego, Syntax2D, OmniVista etc. Most of these software were written to perform analysis of the theory of interest at the time of development. As a result, researchers are left with software that are different in OS environment, UI, and data input/output format. For this reason, researchers struggle to apply different analysis theories which would have only enriched their studies. Another problem with the current software is that they were written for very specific research interests, thus being exclusive to other researchers and non-researchers such as architects.

Therefore, this study makes an attempt to develop an analysis software that is generally accessible to those in the architectural and urban planning field by having the software operate within AutoCAD, which is arguably the most widely used CAD system in the field, and also have the software implement various analyses integratedly, thus allowing the user to easily compare analysis results from different theories. Doing so, we can be expecting a better distribution of spatial analysis theories to the architectural and urban planning field, not only within academia but to practice as well.

This study focuses on spatial analysis techniques based on visual perception, excluding those based on convex spaces or axial lines. This is because visual perception-based models share theoretical similarities, thus can expect synergistic effect from an integrated analysis package. This study will be carried in the following order: First, analysis techniques based on visual perception will be reviewed alongside their respective analysis software in order to set the development outline of the new software. Secondly, key features and user interfaces will be set. Finally, the developed software will be tested its utilization by being used to analyse architectural space.

2. SOFTWARE DEVELOPMENT OUTLINE

2.1 REVIEW OF CURRENT ANALYSIS TECHNIQUES

It was Gibson's ecological theory of perception that gave birth to the spatial analysis methodologies based on visual perception dealt in this study. According to Gibson, visual information of the surrounding environment is passed on to the human agent in the form of 'ambient optic arrays,' which are processed and thus reacted to. That is, the invariant structure of ambient optic arrays not only provide information on one's surroundings but also make possible for the human agent to interact with his or her surroundings. (Lee, 2004) Gibson's arguments resonated with those in the environmental psychology & behaviour field, stimulating studies and attempts to quantify and analyse visual information of the environment, which are being further reviewed below.

The Isovist was organized as a by Benedikt (1979). Isovist is the viewpoint-specific geometric shape of the space that can be seen by the human agent, taking the form of a closed polygon. To quantitatively describe an Isovist, Benedikt proposed several indices including area, perimeter, occlusivity, circularity, etc. Later, it was continuously developed by other researchers, such as the Directed or Partial Isovist, which reflects the directionality of vision.

The Visual Access & Exposure (VAE) model is a spatial analysis technique proposed by Archea (1984), focusing on the quantification of seeing and being seen by others within an environmental setting. Archea assumes that the human agent continually adjusts his or her behaviour according to the visual information of the built environment. The VAE model derives quantitative indices of the visual information such as Visual Access (VA) and Visual Exposure (VE). The VA of a certain point is the frequency of the human agent observing others, while VE is the frequency of the human agent being observed by others.

Cho and Kim (2011) extended the VAE model to a 3-dimensional setting and furthermore applied differential weighting for the vantage points within a visual field, thus naming the model Weighted & Layered VAE (WL-VAE), and Lim and her colleagues (2017) proposed Directed VAE (D-VAE) applying the directionality of vision to VAE.

Turner and his colleagues (2001) developed the Isovist model into a Visibility Graph where the graph/network of the visual connections is brought into consideration. The Visibility Graph considers each vantage point as a node, which has an edge to all vantage points within the node's Isovist field, forming a graph/network. Visibility Graph Analysis (VGA) is the configurational analysis based on Visibility Graph, which derives indices such as connectivity, mean depth, integration, similar to Space Syntax.

Meanwhile, Kim (2006) applied ERAM onto Visibility Graph, resulting in Visibility ERAM model. ERAM is an analysis that utilizes Eigenvector Centrality mainly used in Social Network Analysis. (Choi et al., 2003) Choi and his colleagues (2007) applied Point Depth onto Visibility Graph to evaluate evacuation efficiency of a spatial setting. This is referred to as Evacuation Cost Efficiency Method (ECEM). Kim and Choi (2009) applied angular weighting onto VGA, thus Angular VGA.

2.2 KEY POINT OF SOFTWARE DEVELOPMENT

The above techniques have in common the assumption of points in space, vantage points, where human agents can be potentially present, and that they quantify the spatial characteristics based on visual perception. Furthermore, the techniques have in common that the vantage points are set at regular intervals, implementing Gibson's concept of 'ambient optic array' by means of a grid system of observation positions. Such similarities allow the feasibility of an integrated software that this study attempts to develop.

Analysis tools	Implementing techniques	Characteristics
Syntax2D	Isovist, VGA, Axial Map	Raster-based, Graphic UI
OmniVista	Isovist	Raster-based, Graphic UI
SaIsovist	Isovist	Vector-based, command-line UI, ACAD add-on
SaVAE	VAE, WL-VAE, D-VAE	Vector-based, command-line UI, ACAD add-on
Depthmap	Isovist, VGA, ASA, ...	Raster-based, Graphic UI, the most widely used
SaVisibility	VGA, V-ERAM, ECEM, A-VGA	Vector-based, command-line UI, ACAD add-on

Table 1 - Existing analysis software

The currently used analysis software are listed in the above table with the implemented techniques and characteristics. Considering the pros and cons of the software, the key points of the newly developed software were set as the following: First, the new software implements all analysis techniques based on visual perception, including Isovist, D-Isovist, VAE, WL-VAE, D-VAE, VGA, V-ERAM, ECEM, A-VGA, etc. Secondly, the newly developed software takes the form of an AutoCAD 3rd party application, by which the powerful vector image processing and the accumulated UX of AutoCAD become available. Thirdly, the newly developed software implements a user friendly graphical user interface including dialog box, menu, etc.

3. RESULTS

Based on the aforementioned key points, a new software was written. The software is named 'SA Visibility United', where 'SA' means 'Spatial Analysis', and contracted as 'SaVisibilityUtd'. SaVisibilityUtd runs on the Microsoft Windows family of operating systems, supporting both 32-bit and 64-bit environments, and it is an AutoCAD 3rd party application, or an AutoCAD add-on. SaVisibilityUtd runs on AutoCAD versions 2007 to 2016. All commands have their own Dialog boxes (Fig.2), and are available through a main menu (Fig.1) of 'SaVisibilityUtd'. The layers that the software uses are listed in table 2.

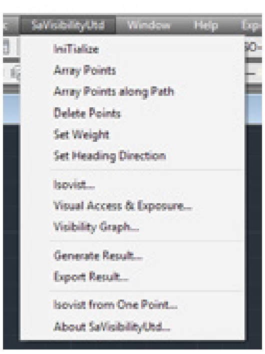
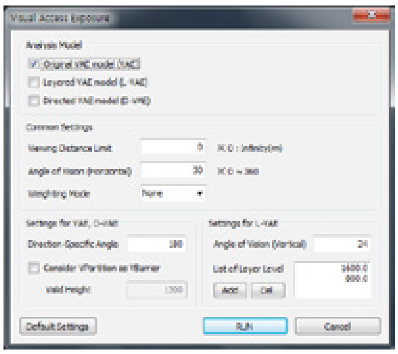


Figure 1 - Main Menu



Dialog box of 'Visual Access & Exposure'

Layer	Characteristics
SA_SPoint	Layer for vantage points.
SA_VBarrier	Layer for visual barrier lines such as walls.
SA_VPartition	(for L-VAE) Layer for visual barrier lines with a specific height(THICKNESS) each.
SA_VGlass	(optional) Layer for transparent barrier lines such as glasses.
SA_SLink	(optional) Layer for virtual lines of visibility btw. two vantage points

Table 2 - Layer list used in SaVisibilityUtd

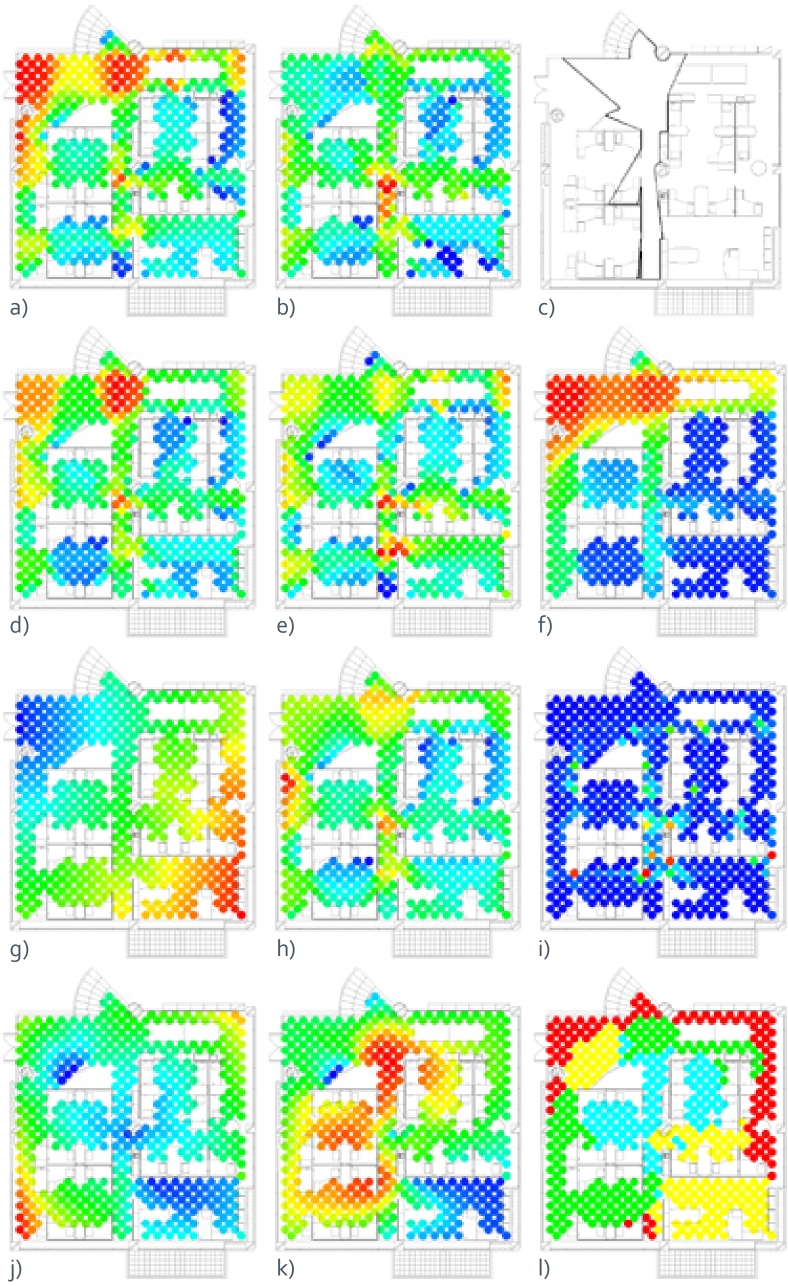


Figure 2 - Generating analysis results: (a) Isovist-Area, (b) Isovist-Occlusivity, (c) Isovist-polygon, (d) VGA-Control, (e) VGA-Integration, (f) VERAM-ERAM, (g) ECEM-EC, (h) AVGA-Integration, (i) AVGA-Choice, (j) VAE-VA, (k) VAE-VE, (l) VAE-Quart

SaVisibilityUtd implements various analysis techniques proposed by various scholars, while allowing accessibility to the techniques in a familiar interface by running within AutoCAD. The strengths of the software are:

SaVisibilityUtd allows an easy comparison of the different analysis techniques. Because all analysis and visualization takes place within a singular user interface that is familiar to those in the field, comparison can be made at a glance. This is a great improvement from the current status where different platforms and different user interfaces were needed for different analysis techniques. This should be seen as an improvement in 'research environment.'

Because SaVisibilityUtd runs within AutoCAD, it utilizes all the powerful features of AutoCAD that people in the architectural and urban planning field have become accustomed to, thus providing familiarity. This should break the barrier between those in and out of the spatial analysis community.

With SaVisibilityUtd, all analysis data are contained in the DWG format and thus can be managed together with architectural drawing data in one file. Furthermore, all analysis data can be exported to DXF format as well as XLS, TXT, and CSV. By using DXF format, data can be exchanged between other spatial analysis software and graphic software. This opens up the possibility to utilize features that were not available in SaVisibilityUtd.

4. CONCLUSIONS

The newly-developed software 'SaVisibilityUtd' takes the form of an AutoCAD 3rd party application, thus taking full advantage of AutoCAD's user interface, data structure, and familiarity. By replacing the software that had their own platform and interface, the workflow is simplified, thus allowing accessibility to those outside of the spatial analysis field. By using DXF format, analysis data and drawing data can be combined and be exchanged between other spatial analysis software and graphic software. In sum, the software should contribute to the pervasion and utilization of spatial analysis in architectural practice.

ACKNOWLEDGEMENT

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2016R1C1B1011374)

REFERENCES

Archea, J. C. (1984), *Visual Access and Exposure: An Architectural Basis for Interpersonal Behavior*, Ph. D. Dissertation, The Pennsylvania State University.

Benedikt, M. L. (1979), 'To take hold of space: Isovists and Isovist fields'. In *Environment and Planning B*, Vol. 6 (1).

Cho, Y., Kim, M. (2011), 'Study on the Development of a Spatial Analysis Software Implementing WLVAE Model'. In *Journal of the Architectural Institute of Korea : Planning & Design*, Vol. 27 (5).

Choi, J., Cho, H., Choi, H., Hwang, Y. (2003), 'Spatial configuration analysis using the eigenvector ratio of adjacency matrix'. In *Journal of the Architectural Institute of Korea : Planning & Design*, Vol. 19 (11).

Choi, J., Kim, M., Choi, H. (2007) 'Evacuation efficiency evaluation model based on euclidean distance with visual depth'. In: Kubat, A. S., Ertekin, Ö., Güney, Y. I. and Eyübolou, E. (eds.), *Proceedings of the Sixth International Space Syntax Symposium*, Istanbul: ITU Faculty of Architecture, 041.

Kim, M. (2006), *The ERAM Model Based on Visibility of Space*, Masters Dissertation, Seoul National University.

Kim, M., Choi, J. (2009) 'Angular VGA and Cellular VGA : An exploratory study for spatial analysis methodology based on human movement behavior'. In: Koch, D., Marcus, L. and Steen, J. (eds.), *Proceedings of the Seventh International Space Syntax Symposium*, Stockholm: Royal Institute of Technology, 054.

Lee, M. (2004), 'J.J. Gibson's ecological perception theory and appreciation of paintings : In comparative analysis with R. Arnheim's theory'. In *The Journal of Aesthetics and Science of Arts*, Vol. 19.

Lim, L., Kim, M., Choi, J., Zimring, C. (2017), 'Seat choosing behaviors and visibility: library reading rooms for studying environments as a case study'. Forthcoming.

Turner, A., Doxa, M., O'Sullivan, D. & Penn, A. (2001), 'From Isovists to visibility graphs: a methodology for the analysis of architectural space'. In *Environment and Planning B*, Vol. 28 (1).