IJSCIA

International Journal of Scientific Advances
ISSN: 2708-7972
Volume: 3 | Issue: 4 | Jul - Aug 2022 Available Online: www.ijscia.com
DOI: 10.51542/ijscia.v3i4.26

Application of Cutting-Edge Tools in Built Environment Architecture Research: Prospects and Challenges

Fatima Baba Ciroma[1], Musa Lawal Sagada[2*] and Juliet Azuka Obaje[3]

[1,3]Department of Architecture
College of Environmental Studies Kaduna Polytechnic, Kaduna, Nigeria

[1,2] Department of Architecture, Faculty of Environmental Design
Ahmadu Bello University, Zaria, Kaduna, Nigeria

*Corresponding author details: Professor. Musa Lawal Sagada

ABSTRACT

The rapid technological advancements in the 21st century have been galvanized by the development of innovative tools which have aided research undertakings that have yielded breakthroughs whose influence is ubiquitous in human society. At the center of this research are higher institutions of learning like universities and other advanced research institutes. To meet the expected level of output and innovations, these institutions rely on cutting-edge tools for problem formulation and investigation, information dissemination, and data analytics. One such area of research is the built environment in which architecture plays a central role. To be effective, modern architectural designs and practices require the use of cutting-edge tools which are undergirded by technology in order to meet the demands of an evolving human society. It is against this backdrop that this paper investigates the prospects and challenges of applying innovative tools in the field of architectural research for the built environment. Four tools that are tangential to this study are DepthMapX, AutoCAD, MATLAB, and SPSS. The paper will examine these tools and the advantages these tools bring to architectural built environment research, and the likely challenges to be encountered if these tools are to be fully utilized. The context of this study is the tertiary level of education in Nigeria.

Keywords: cutting-edge tools; built environment; modern architecture; DepthMapX; AutoCAD; MATLAB; SPSS

INTRODUCTION

Human society is currently at a level of evolution such that the problems and challenges of daily life have become very complex; this reality has added a strain to all fields of human endeavor, especially in the areas of design which must be done in a sustainable manner. Architecture is one such area that involves the design of structures and the built environment. In order to meet the current realities and challenges of contemporary human society, the practice and teaching of Architecture must involve modern tools which are capable of effective information dissemination and content delivery; this will go a long way in ensuring that the current practitioners of Architecture and the succeeding generation of Architects are properly trained and equipped to meet the challenges of society as they evolve. To be able to meet this noble objective, tertiary institutions and research institutions have a central role to play as they remain the mechanism through which the profession of Architecture can be learned and practiced. It is against this backdrop that it has pertinent for these institutions to actively inculcate the use of modern cutting-edge tools in built environment research and designs.

It has been shown that cutting-edge tools used in research and design have the potential to exponentially increase the level of productivity in any undertaking; this is more so the reality when it is considered that a large number of results can be delivered in a very short time. In this paper, four cutting-edge tools – DepthMapX, AutoCAD, MATLAB, and SPSS will be investigated in the context of their use cases and how their application in Architectural research at the tertiary level of education and research institutes can be a game-changer.

The investigation will also look at the likely challenges that are likely to be encountered in the application of these tools.

CUTTING EDGE TOOLS IN BUILT ENVIRONMENT ARCHITECTURE RESEARCH

Modern architectural designs of structures and the built environment require that the constraints of sustainability, mobility, and minimal environmental impact must be satisfied. As indicated earlier, four cutting-edge tools that can be used in satisfying these constraints include DepthMapX, AutoCAD, MATLAB, and SPSS; this section briefly discusses these tools and their capabilities.

(1) DepthMapX

The DepthMapX is an open source and multi-platform tool used in advanced spatial-visual analysis networks at varying scales (Bartlett School of Architecture, 2021). DepthMapX operates at different scales, from buildings to sections of urban areas and to cities and states. The operation involves the production of a map of spatial elements under consideration and establishing the relationship between them through intervisibility and intersection which are used as the basis for graphical analysis of the derived network (Adi, Marlina, and Rahayu 2019; Lee, Yoo, and Seo 2020; Sen and Baran 2020). The analysis yields variables that have significance in a social context and in an experimental context.

There are three types of graphical analysis involved in DepthMapX- visual analysis, agent analysis, and axial/segment analysis (UCL 2019).

Visual analysis operates at the building and small urban scales, and the analysis is used in assessing the accessibility of a point in several ways. At its core are isovists which are polygons that represent the accessibility of an area from a location and the paths traced by the isovist to the location under consideration represent how the view of the location changes when moving through space (Krukar et al. 2020; Sengke and Atmodiwirjo 2017; Wiener et al. 2007; Xiang and Papastefanou 2019). The isovists, therefore, form the core of Visibility Graph Analysis (VGA) which is the art of performing visual analysis with DepthMapX, and they form the mechanism by which a dense grid is converted to a graph of points which are intervisible. Key parameters which isovists provide in visual analysis include connectivity, point first moment, point second moment, area, and perimeter (Krukar et al. 2020; Sengke and Atmodiwirjo 2017; Wiener et al. 2007).

Agent analysis involves the creation of "virtual people" called agents or animals which are released into the environment as pedestrians and allowed to make decisions on where to move within it. The behavior of the agents is guarded by access to visual accessibility information of its current location from the visibility graph; the information obtained is used as the basis of choosing the next destination. It has also been observed in practice that agent analysis produces better correspondence than traditional measures of point visibility graphs in terms of the correspondence with where actual people move (Koutsolampros and Varoudis 2017; Turner 2007).

The axial/segment analysis involves starting with an all-line map which joins all the vertices of isovists or diagonals through the centers of isovists. The axial analysis in particular directly relates to human activity in urban space and this has been the reason the analysis has been far successful in the representation of human movement in urban centers and cities when compared with metric distance techniques (Pont et al. 2017; Turner 2007). The segment analysis is related to other types of analysis in space syntax in the context that it runs through angular measurements of all forms of graph. It is fundamental to the understanding of land-use and socio-economic factors in space syntax analysis (Kolovou et al. 2017; Turner 2008; Yamu, van Nes, and Garau 2021). A specialized form of the segment analysis is the angular segment analysis which divides axial lines into segments and records the sum of the recorded angles starting from the initial segment to another segment of interest within the system. Conceptually, the angular sum is the cost of a trip through the graph, and the cost is determined by find the possible minimum path of travelling from one segment to another; this is an optimization process (Oliveira dos Santos and Fontgalland 2021).

The three types of analysis performed by DepthMapX are shown in figure 1, where it can be seen that any of the types of analysis can occur once the necessary .dxf image is imported. Figure 2 shows an example of a visibility analysis using DepthMapX.

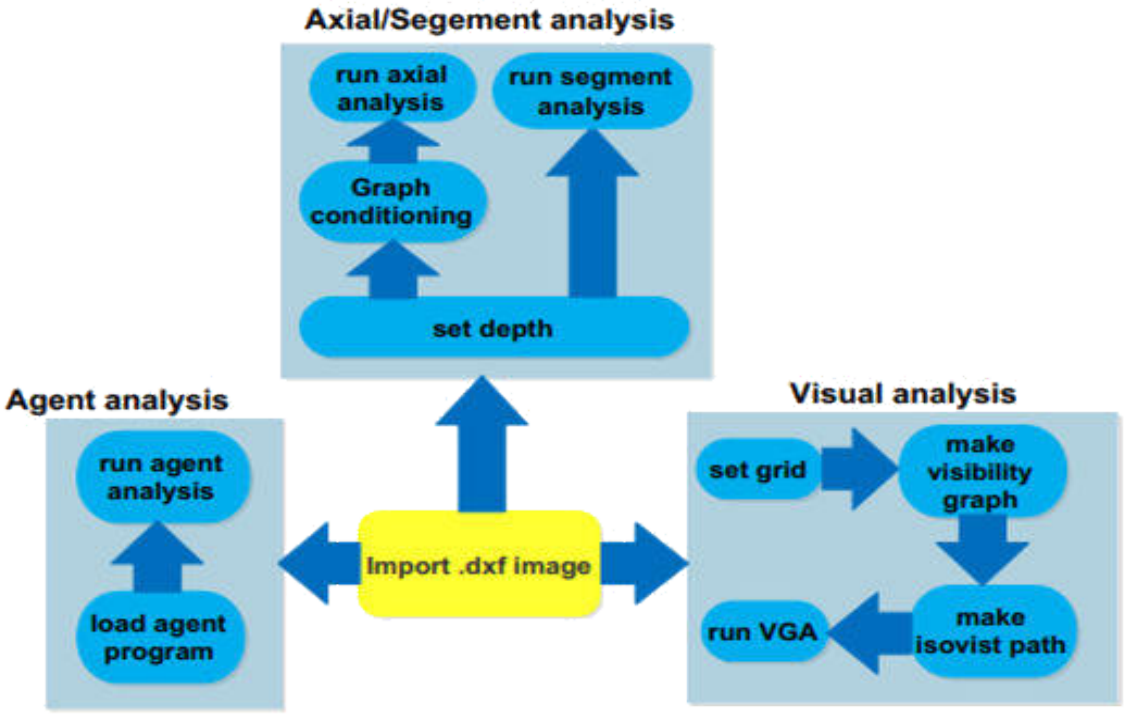


FIGURE 1: Types of analysis performed by DepthMapX
Source: Researchers compilation, 2022

(2) AutoCAD

AutoCAD is a design tool which is ubiquitous in industry and it is widely used by architects, city planners, project managers, engineers, and graphic designers. It allows for the rapid drawing of 2D and 3D images with a high degree of accuracy (Zhang and Gu 2017).

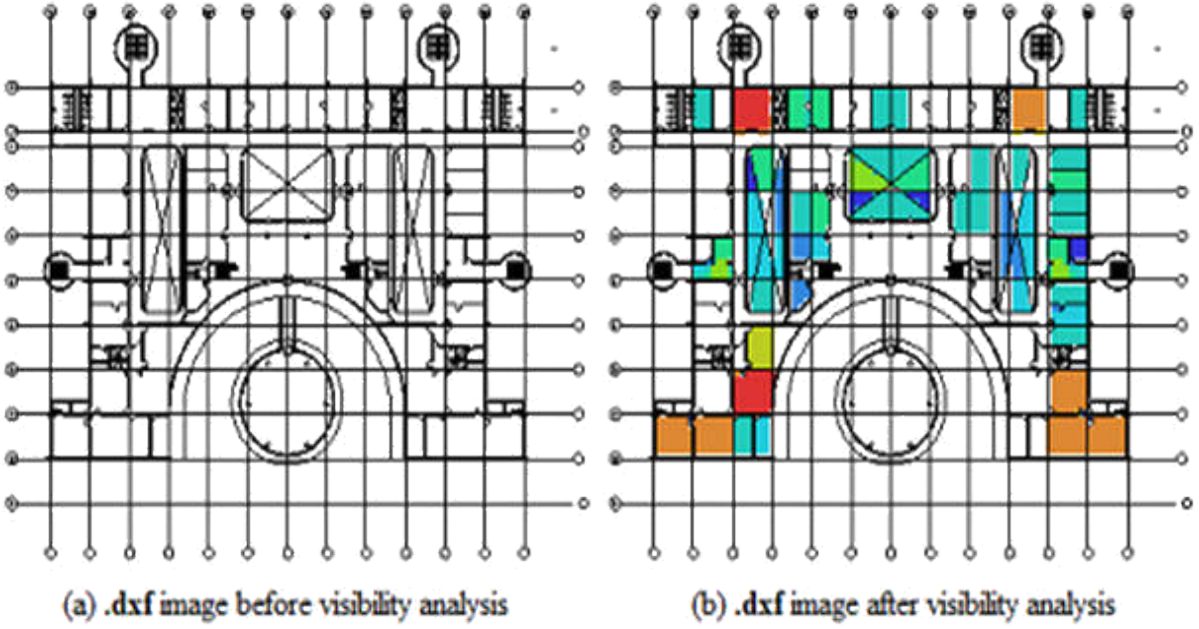


FIGURE 2: Visibility analysis using DepthMapX
Source: Researchers compilation, 2022

One major advantage AutoCAD has is its universal polyline primitive among elementary graphic ones; this makes it possible to have parts, segments, and arcs with varying initial and final widths. It also allows the curves of polylines to be rounded with a given radius of curvature (Khoroshko 2020). As a result of this advantage, AutoCAD is able to perform automatic generation of sections and facades from plans, automatic placement of doors and windows in walls, and automatic of rooms and their associated areas (Mohamad and Alfuraih 2019; Ziden, Zakaria, and Othman 2012)

As indicated in literature, AutoCAD has a very high job-market demand and it is widely used in higher institutions of learning (Indera Irawan and Affandi 2017).

It is well-adapted in performing almost any kind of graphic works. There are different use cases in AutoCAD, and these include (Khoroshko 2020):

i. Interior design and planning of space
ii. Architectural and engineering drawings
iii. Production of topographical maps
iv. Stage decoration
v. Ship design
vi. Conceptual drawing of electronic, chemical, mechanical and aerospace products.

Figure 3 shows an example of using AutoCAD in architectural design. From the foregoing, it can be seen that AutoCAD plays a definite role in the design world and being an electronic tool, it has a significant impact on productivity.

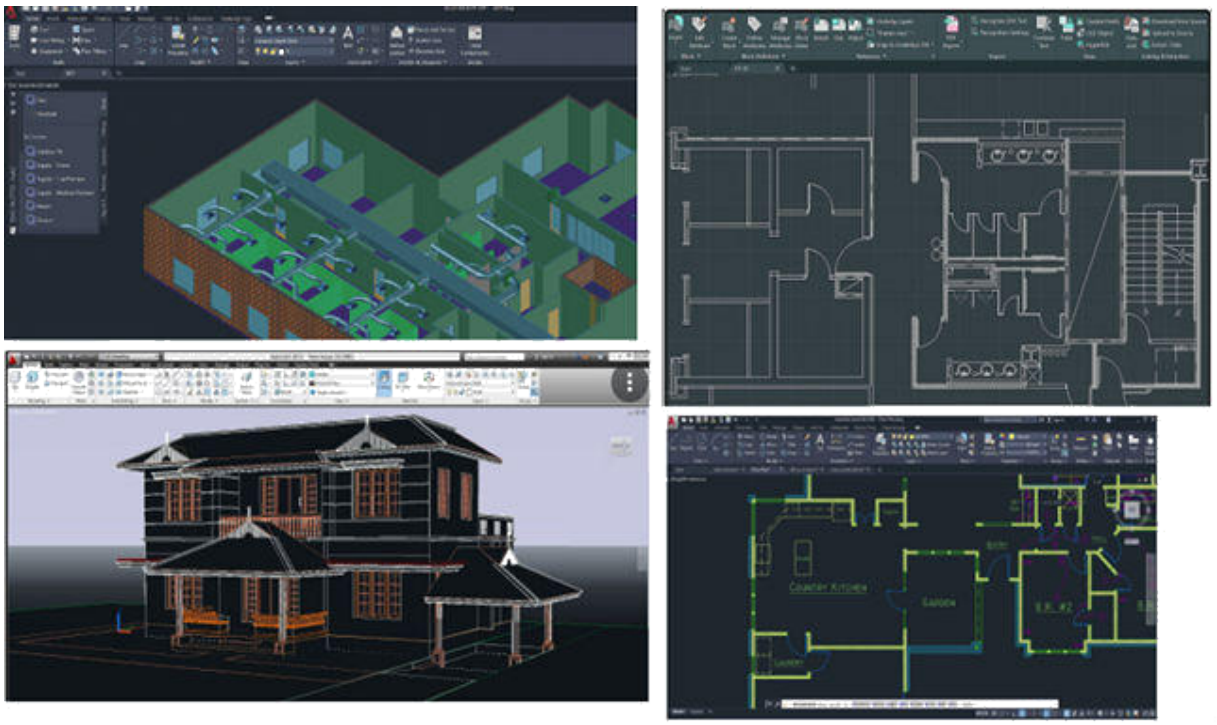


FIGURE 3: AutoCAD in architectural design
Source: Researchers compilation, 2022

(3) MATLAB

MATLAB is a simulation tool used in the analysis and performance evaluation of designs in order to ascertain of such designs have met the specifications at the on-set. It is a powerful tool used in all technical fields including architecture to gain insights into designs. MATLAB is made of different specialized toolboxes which handle different technical areas of designs (Ibrahim 2011; Majid et al. 2013; Ogan and Ibibo 2015; Warren 2014). This approach has made MATLAB a robust tool with very strong presence in industry and education. MATLAB integrates numerical, symbolic and excellent visualization capabilities within an intuitive programming environment; hence, architects and other design gain deeper insight into their work through the exploration of this capability (Ibrahim 2011; Majid et al. 2013; Ogan and Ibibo 2015). Due to the central role MATLAB is playing in design and technical industries, there is a growing requirement by employers of graduate schools on the knowledge of MATLAB as an essential skill. Moreover, the on-going revolution in higher level of education has made it essential that students must learn MATLAB as an industry-standard software (Majid et al. 2013; Warren 2014). Figure 4 shows an example of MATLAB programming and data visualization.

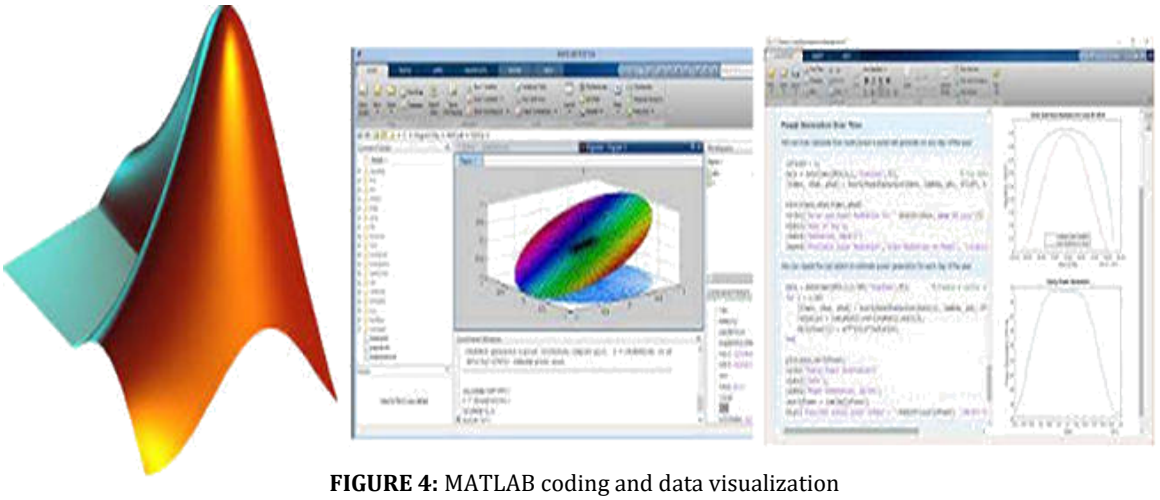


FIGURE 4: MATLAB coding and data visualization
Source: Researchers compilation, 2022

(4) SPSS

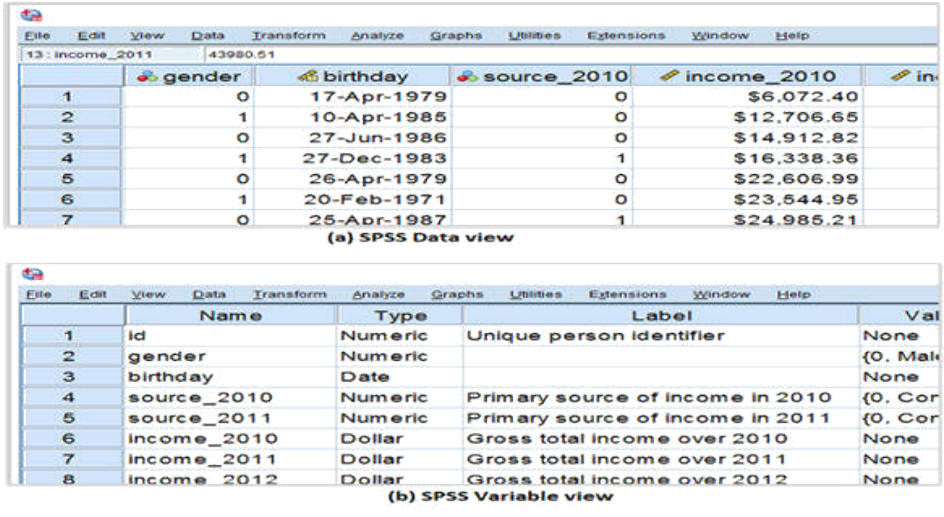
SPSS is a statistical package used for complex data analysis. The acronym stands for Statistical Package for Social Sciences. To analyze complex data, SPSS enables the editing and sorting of a cocktail of data types which include customer database, scientific research data, structural design data, architectural design data, and engineering design data (Gogoi 2020; Ozgur, Kleckner, and Li 2015; Perry et al. 2014). These data are usually found in spreadsheets, plain text files, SQL databases, and metadata formats.

One of the key areas for the application of SPSS is data obtained from social sciences and behavioral sciences. This is very tangential to the field of architecture and built-environment design because the social, cultural, and behavioral lifestyle of people are critical factors which are always considered by architects in making designs which meet the contemporary needs of society.

From an operational perspective, SPSS is well-adapted for performing statistical data operations at an enterprise level; this is very important in designs where large amounts of data are generated. SPSS also makes it possibly makes it possible to keep calculated statistical values and generated graphs separate from raw data- a feature like this is very important in design verification (Ozgur et al. 2015). Figure 5 shows a data and variable view in SPSS.

RELATIONSHIP BETWEEN DepthMapX, AutoCAD, MATLAB, AND SPSS

There existsa strong relationship between DepthMapX, AutoCAD, MATLAB, and SPSS. For the sake of brevity, we will refer to these tools as quartet-tools in this paper. A good understanding of the interdependence between these tools is tangential in delivering quality and reliable designs using a modern approach. Figure 6 shows in graphical form how this interdependence can be visualized.



File Edit View Data Transform Analyze Graphs Utilities Extensions Window Help

13 : income_2011 | 43980.51

	gender	birthday	source_2010	income_2010	in
1	0	17-Apr-1979	0	$6,072.40	
2	1	10-Apr-1985	0	$12,706.65	
3	0	27-Jun-1986	0	$14,912.82	
4	1	27-Dec-1983	1	$16,338.36	
5	0	26-Apr-1979	0	$22,606.99	
6	1	20-Feb-1971	0	$23,544.95	
7	0	25-Apr-1987	1	$24,985.21	

(a) SPSS Data view

File Edit View Data Transform Analyze Graphs Utilities Extensions Window Help

	Name	Type	Label	Val
1	id	Numeric	Unique person identifier	None
2	gender	Numeric		{0, Mal
3	birthday	Date		None
4	source_2010	Numeric	Primary source of income in 2010	{0, Cor
5	source_2011	Numeric	Primary source of income in 2011	{0, Cor
6	income_2010	Dollar	Gross total income over 2010	None
7	income_2011	Dollar	Gross total income over 2011	None
8	income_2012	Dollar	Gross total income over 2012	None

(b) SPSS Variable view

FIGURE 5: Types of views in SPSS
Source: Researchers compilation, 2022

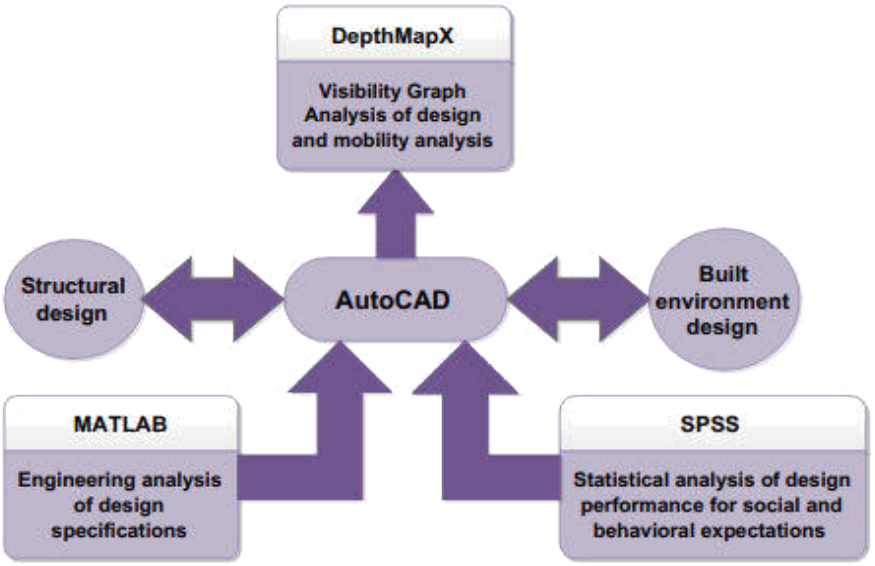


FIGURE 6: Interdependent relationship between quartet-tools
Source: Researchers compilation, 2022

The relationship revolves around AutoCAD as the central tool. Information is retrieved from a design performed using AutoCAD and then cascaded to the appropriate tool for analysis. An AutoCAD design generates a .dxf image file which serves as an input to DepthMapX for Visibility Graph Analysis (VGA) as shown in figure 1. The design specifications in AutoCAD are passed to MATLAB which performs complex engineering computations using well-established mathematical equations to determine from an engineering perspective if the design is feasible. Data from AutoCAD is also passed to SPSS to perform behavioral statistical analysis in order to determine if the cultural and social expectations from the design have been met.

It is our view that the approach shown in figure 6 provides a unique and predictable design approach which can make architectural designs meet modern engineering and social expectations. However, in as much as there are prospects in this approach, challenges also abound; the next sections present these prospects and challenges.

PROSPECTS AND CHALLENGES OF APPLICATION OF CUTTING-EDGE TOOLS (FINDINGS)

The application of cutting-edge tools in modern architectural designs as shown in figure 6 comes with a lot of prospects and challenges as it is driven by technology. This section elucidates the prospects and the challenges.

(1) Prospects of Application of Cutting-Edge Tools

Prominent among the prospects of the application of cutting-edge tools is the potential for capacity development among instructors and students. Increased capacity as a result of the ability to use the quartet-tools will make both instructors and students competitive in a modern world whose demand for better ways of doing things is rapidly changing.

A second prospect is the entrenchment of efficiency, speed, and accuracy in architectural designs. The quartet-tools provide efficient mechanisms by which architectural designs can be performed where tasks can be quickly performed with a high degree of accuracy and verified, which would otherwise take longer if antiquated techniques are used.

The use of the quartet-tools carries the prospect of ensuring quality education are delivered by tertiary institutions which actively deploy and utilize them in course content delivery.

This will have a positive impact on the rating and public perception of such institutions. Also, research degrees awarded by such institutions are likely to receive global and regional recognitions because of the quality of research outputs and publications that are likely to be associated with such degrees.

The value-chain associated with technological advancement is another benefit of using the quartet-tools. The deployment of such tools in tertiary institutions will inevitably trigger the creation of collaborating training institutions which will partner with tertiary institutions in delivering on-demand and job-specific training in the use of such tools. This rollover benefit is the creation of employment by the collaborating institutions and the creation of a demand for equipments and logistics needed for the content delivery of such tools.

(2) Challenges of Application of Cutting-Edge Tools

There are a number of challenges which are likely to be encountered in the application of the quartet-tools, and the main challenge is funding. These tools are very expensive even though institution pricing exists for most of them. The paucity of funds affecting tertiary institutions is a major reason which the acquisition of such tools and the human capacity training expenses on the use of such tools will be a problem.

Secondly, the lack of political will and enabling government policies have been a contributing factor for the inability of tertiary institutions to key into the idea of using the quartet-tools as the necessary support is not likely to be available.

Another major challenge is the absence of physical infrastructure in tertiary institutions which will support the effective deployment and utilization of the quartet-tools. Such infrastructure includes purpose-built laboratories specifically designed and constructed for the operation of such tools. Even where institutions have made effort in this regard, the near-complete absence of electricity is a challenge which makes such infrastructure ineffective for the intended purposes.

A subtle but important challenge in the application of cutting-edge tools is the operation of obsolete educational curriculum by tertiary institutions which did not envisage the need for the deployment and utilization of quartet-tools in course content delivery at the time of their formulation.

As a result of this, lecturers and instructors in tertiary institutions have never seen the need to key into the reality of using the quartet-tools in order to be competitive in a changing world.

CONCLUSION

The use of cutting-edge tools in course content delivery at tertiary institution level will continue to be a dominant factor if quality education is to be achieved. This paper has been able four of such tools which are very critical to the field of architecture and built-environment design. The paper examined each of the tools- DepthMapX, AutoCAD, MATLAB, and SPSS; the capability and purposes of these tools were highlighted, and a relationship was established on how these tools are interdependent in the delivery of modern designs by architects during structural and built environment design. The prospects and challenges of using the quartet tools were discussed especially in the Nigerian context.

REFERENCES

[1] Adi, A. F., A. Marlina, and P. Rahayu. 2019. "The Study of Connectivity at Jalan Slamet Riyadi, Surakarta Using the Space Syntax Analysis." IOP Conf. Series: Earth and Environmental Science 447:1–10.

[2] Bartlett School of Architecture. 2021. "DepthmapX Development Team. (2017). DepthmapX (Version 0.6.0) [Computer Software]." Retrieved (https://github.com/SpaceGroupUCL/depthmapX/)

[3] Gogoi, P. 2020. "Application of SPSS Programme in the Field of Social Science Research." International Journal of Recent Technology and Engineering 8(5):2424–27.

[4] Ibrahim, D. 2011. "Engineering Simulation with MATLAB: Improving Teaching and Learning Effectiveness." Procedia Computer Science 3:853 – 858.

[5] Indera Irawan, M. R. and H. M. Affandi. 2017. "A Case Study of Autocad 2d Engineering Drawing Performance Among Furniture and Product Design (Bfpd) Students." Proceeding of the 3rd International Conference on Education 3:49–57.

[6] Khoroshko, A. L. 2020. "The Research of the Possibilities and Application of the AutoCAD Software Package for Creating Electronic Versions of Textbooks for 'Engineering and Computer Graphics' Course." TEM Journal 9(3):1141 - 1149.

[7] Kolovou, I., J. Gil, K. Karimi, S. Law, And L. Versluis. 2017. "Road Centre Line Simplification Principles for Angular Segment Analysis." Pp. 163.1-163.16 in Proceedings of the 11th Space Syntax Symposium.

[8] Koutsolampros, P. And T. Varoudis. 2017. "Assisted Agent-Based Simulations: Fusing Non-Player Character Movement with Space Syntax." Pp. 164.1-164.13 in Proceedings of the 11th Space Syntax Symposium. Lisbon.

[9] Krukar, J., C. Manivannan, M. Bhatt, and C. Schultz. 2020. "Embodied 3D Isovists: A Method to Model the Visual Perception of Space." EPB: Urban Analytics and City Science 0(0):1–19.

[10] Lee, S., C. Yoo, and K. W. Seo. 2020. "Determinant Factors of Pedestrian Volume in Different Land-Use Zones: Combining Space Syntax Metrics with GIS-Based Built-Environment Measures." MDPI Sunstainability 12(8647):1–15.

[11] Majid, M. A., Z. A. Huneiti, W. Balachandran, and Y. Balarabe. 2013. "Matlab as a Teaching and Learning Tool for Mathematics: A Literature Review." International Journal Of Arts & Sciences 6(3):23–44.

[12] Mohamad, G. M. H. and M. Alfuraih. 2019. "Design Automotive Components by CAD Software; AutoCAD and SolidWorks; a Comparative Study." Journal of Engineering Research and Application 9(5):13–20.

[13] Ogan, C. and G. Ibibo. 2015. "Utilization of Matlab as a Technological Tool for Teaching and Learning of Mathematics in Schools." International Journal of Mathematics and Statistics Studies 3(5):10–24.

[14] Oliveira dos Santos, G. G. and I. L. Fontgalland. 2021. "Use of Space Syntax through the Map of Segments for Diagnostic Integration and Choice Normalized in the City of Campina Grande - Brazil." Research, Society and Development 10(1):1–12.

[15] Ozgur, C., M. Kleckner, and Y. Li. 2015. "Selection of Statistical Software for Solving Big Data Problems: A Guide for Businesses, Students, and Universities." SAGE Open 1–12.

[16] Perry, Z. H., A. Barak, L. Neumann, and A. Levy. 2014. "Computer-Based Learning: The Use of SPSS Statistical Program for Improving Biostatistical Competence of Medical Students." Hindawi - Journal of Biomedical Education 2014:1–9.

[17] Pont, M. B., K. Ahrné, A. Gren, A. Kaczorowska, and L. Marcus. 2017. "Integrating Visibility Graph Analysis (Vga) With Connectivity Analysis in Landscape Ecology." Pp. 157.1-157.18 in Proceedings of the 11th Space Syntax Symposium. Lisbon.

[18] Sen, E. and M. Baran. 2020. "Examination of Traditional Residences in Bitlis on the Zeydan District Scale in the Context of Space Syntax Analysis Techniques." SAGE Open 1–16.

[19] Sengke, M. M. C. and P. Atmodiwirjo. 2017. "Using Isovist Application to Explore Visibility Area of Hospital Inpatient Ward." IOP Conf. Series: Earth and Environmental Science 185:1–7.

[20] Turner, A. 2007. "UCL Depthmap 7: From Isovist Analysis to Generic Spatial Network Analysis." Pp. 43–51 in UCL Depthmap.

[21] Turner, A. 2008. "Getting Serious with DepthMap: Segment Analysis and Scripting." 1–45.

[22] UCL. 2019. "Introduction to UCL Depthmap 10." 1–60.

[23] Warren, C. 2014. "MATLAB for Engineers: Development of an Online, Interactive, Self-Study Course." Engineering Education 9(1):86–93.

[24] Wiener, J. M., G. Franz, N. Rossmanith, A. Reichelt, H. A. Mallot, and H. H. Bulthof. 2007. "Isovist Analysis Captures Properties of Space Relevant for Locomotion and Experience." Perception 36(7):1066–83.

[25] Xiang, L. and G. Papastefanou. 2019. "Isovist and Psycho-Physiological Stress at the Pedestrian Level: A Real-Time Measurement Case Study in a High-Density City." Pp. 463–71 in REAL CORP 2019 Proceedings. Tagungsband.

[26] Yamu, C., A. van Nes, and C. Garau. 2021. "Bill Hillier's Legacy: Space Syntax—A Synopsis of Basic Concepts, Measures, and Empirical Application." MDPI - Sustainability 13(3394):1–25.

[27] Zhang, R. and Y. Gu. 2017. "Research on AutoCAD Secondary Development and Function Expansion Based on VBA Technology." IOP Conf. Series: Earth and Environmental Science 69:1–7.

[28] Ziden, A. A., F. Zakaria, and A. N. Othman. 2012. "Effectiveness of AutoCAD 3D Software as a Learning Support Tool." IJET 7(2):57–60.