Parametric design approach to space syntax methodology for designing a master layout

Azad Hadji Khameneh
The University of Adelaide, Adelaide, Australia
Azad.hadji@gmail.com

Abstract: This paper investigates the potential of using parametric software to analyse the attributes of spaces using Space Syntax methodology and implementing the outcomes in an urban design project. This research aims to reveal the attributes of spaces in a proposed site for a new town centre and an aquatic centre development in the town of Rosebud, Victoria utilising Space Syntax methodology. The study specifically focuses on finding the most walkable and visible areas in the existing project site or in the initial design sketches. To locate these areas, this exploration uses the Isovist-field test for visibility and the axial-map test for permeability. Whilst the application of Space Syntax to the case study site provides a vehicle for the research, a key aim of this project is to test the performance of the available software and identify its strengths and weaknesses. The final aim of this study are: revealing the areas with maximum views and vistas and identifying obstacles for views and The axial analysis for permeability can reveal the underutilised spaces in the early stages of design an urban master layout.

Keywords: Space syntax; parametric design; isovist; master layout.

1. Introduction

According to Winston Churchill ‘We shape our buildings; thereafter they shape us’ (speech, 1944). This is an indicator of the interaction between cities and citizens. City spaces and its inhabitants are interconnected and interrelated in various ways. For instance Tim Stonor’s recent studies on the integrity of urban spaces show that almost 80% of all retail shops in London (a significant contribution to revenue generation for the city) are located on 20% of the most spatially accessible (integrated) space. Spaces with less permeability and integrity showing the highest crime rate is also other examples of the interconnection and links between spatial configuration and inhabitant (Stonor, 2013). These type of socio-spatial connections and relations are some of the main drivers for urban planners. Urban planners aim to capture and manage these links not only between spaces and functions but also between social and behavioural connections.

Space Syntax is one of the methods and techniques that help planners to analyse spatial configurations. Over thirty years ago Space Syntax Theory as developed by Professor Bill Hillier and
Professor Julia Hanson in the book The social logic of space (Hillier & Hanson 1984), gained prominence in the field of urban planning. Space Syntax Theory argues about the importance of spatial configuration in human behaviour and efficiency of cities from the inhabitant’s point of view.

On the other hand shift to a computer aided design (CAD) was a major pivot for designers who utilised it in their designs, however, CAD technology is not able to simulate the situation but only can represent it. As Groat and Wang (2002) explain the term Simulation is often confused with the term representation, though they are in actual fact two different concepts. Simulation is more about prediction whilst representation is about demonstrating a scene at one point in time. Parametric design was another shift in the design environment which made a type of simulation possible using computers and software. Combining the CAD parametric tools and Space Syntax theory progresses the capabilities of designers in analysing the spatial configuration in their project and also enhances their ability to analyse existing and future urban spaces. Researchers at the University of TU Delft (Nourian; Rezvani; Sariylidiz, 2013) and TU Wien (Schaffranek 2014) are developing add-ons for Grasshopper that implement Space Syntax methodologies for designing as well. The significance of this combination is to provide designers a tool to assess the existing space and revitalise it through their design. This research study employed Space Syntax methodologies and parametric software tools to create more space analysis diagrams and layout options to provide planners an opportunity to compare alternative initial urban layouts. It provides an opportunity for them to combine the strengths of different options and eliminate weak points in the layouts to achieve the best feasible master plan.

The aim of this research project is to examine a parametric design approach to planning a vibrant town centre based on Space Syntax methodology. The research demonstrates a computational prototyping project which analyses an urban situation and explain a planning process to improve permeability, walkability and liveability in Rosebud a town in Victoria. The study employs Space Syntax methodologies and parametric software tools to generate different layouts to create a better connected town. The process of analysing urban space and generating initial layouts with Space Syntax theory can be implemented manually using several tracing pages, however, the risk of errors occurring increase due to the laborious processes involved. Recent advancements in higher performance computers and softwares involved in the urban analysis and Space Syntax methodology have been able to counter these manual processes. This research investigates the feasibility of using selected software and plugins to generate diagrams and layouts during the early stages of planning based on Space Syntax theory in a case study in Rosebud, Victoria. Parametric design software has become popular in architecture and other design fields. However in the urban planning field this method is relatively new. This research examines increasing efficiency of urban planners by creating more space analysis diagrams and layout options to provide them an opportunity to compare alternatives in a shorter period of time, combine the strengths of different options and eliminate weak points in the layouts to achieve the best feasible final master plan. For instance by analysing the Isovist field on site (the visible area from any nominated spot in a space), designers are able to identify the most visible areas of the site and allocate these areas to commercial and retail to maximise opportunities for businesses. It is recommended to read this study against the files and animations that generated in different software you can find on the ASA or author’s website.
2. Methodology

2.1. Space Syntax methodology

Space Syntax is a method of investigating how inhabitants of a space relate to the space itself and also each other. Space Syntax Theory examines how spaces relate to people, and influences social behaviour. Space Syntax introduces a set of techniques for the analysis of spatial configuration especially where it is a significant aspect of human affairs. Space Syntax methodology provides designers with a tool to simulate the likely effects of their design both in buildings and on a broader urban scale.

Space Syntax as a method for analysing space and its interconnection to a user of the space aims to quantify the quality of space. Quality of space in this context means the attributes of space. Some of attributes from Space Syntax point of view are: a space could be convex or concave, has a larger visible area or less visible area and be more integrated or less integrated with other spaces around. Space Syntax Theory argues that people behave differently in response to spaces with different attributes and this is the reason some spaces become more popular than others or why people have different feelings within different types of spaces. This response to different spaces is possibly a result of people's implicit recognition of different attributes (characteristics) of space. It is not an intentional reaction to space, it means people do not analyse the space while they walk down a street, however, it is a kind of psychological human response to certain characteristics in a space.

Development of Space Syntax methodology is an attempt to explain people’s behaviour as a result of attributes of space. It is a possibility, if Space Syntax is able to define the attributes of the space then create a technique to predict how people will behave in a space. Space Syntax aims to interrogate what constitutes character and attribute of space and as a result suggests how people will respond. For these reasons, this research paper will focus on using Space Syntax methodology as an analytical method for urban planning. Space Syntax Theory takes into consideration the following three main issues, the sense of movement through space, interaction between people in space and seeing ambient space from a point. Space Syntax implements mathematics to produce a methodology which is logically and mathematically provable and repeatable. The purpose of Space Syntax methodology is to create an outcome based on which designers are able to assess their design before construction.

2.2 Methodologies for simulation

For this chapter of experiments a series of software, plug-ins and add-ons are employed to simulate the process of configurational analyses based on Space Syntax Theory for the town centre of Rosebud. Some researchers are studying Space Syntax analysis using Grasshopper within their research (Nourian; Rezvani; Sariyildiz, 2013) however as far as this research paper is aware there is no existing unique software that is able to perform and visualise all aspects of Space Syntax methodology. The main aim of this study is to establish a general rule of procedural steps for using various software and add-ons (based on a given case study) for urban designers to analyse urban spaces. The approach in this research is the use of Grasshopper and its add-ons for the ability to instantly produce more layouts and provide planners an opportunity to quickly make comparisons between these alternate layouts. Although this study will require programming the main aim is to create a convenient process to analyse Space Syntax in urban design.

The process and simulation focuses on the following points:
• Generate the site under the investigation as accurately as possible for analysis.
• Simulate the axial map and analysis of the axial line of the site.
• Simulate and analyse the Isovist phenomena in the site.
• Prepare the initial layouts based on the outcomes of the above simulation.
• Adjust and redefine the initial layouts and simulate them to achieve more layouts.
• Compare alternative layouts to reveal the most effective one or combine the best parts of different layouts to achieve the most appropriate one.
• Design the final master layout.

This is an interactive process; it means after producing each set of analysis planners and architects can debate about the outcome and redefine or adjust all or some parts of the previous design until they believe the outcome has met their criteria. The final stage is to develop the best sketch layout to produce the detailed master plan.

3. Analysis

3.1. Pre-analysis

The first step of the Pre-analysis phase of this investigation is collecting data, information and drawing. Three main sources of information are applied in this study; Mornington council, OpenStreetMap (www.openstreetmap.org) and site visiting. The first drawing investigated for this study was a large CAD file from Mornington’s city council covering all of Victoria’s Southern peninsulas. A careful process of filtering and extracting the essential information from this CAD file is crucial to prepare proper drawings for the area under this investigation. The second source for obtaining data is the OpenStreetMap website. This website encompasses information of many cities and metropolitan areas around the world. Information from this website can be exported into a file which is visually interpretable with Grasshopper’s add-on ‘Elk’.

The next step is cross-referencing the previously mentioned obtained documents to identify any inconsistencies for any further modification. The ultimate goal for this stage is to produce a DXF file including the networks and the town of Rosebud. To achieve this goal the information extracted from these sources (Mornington Bay Council and OpenStreetMap website) need to be manually (through CAD programs) redrawn and simplified. The reason for this is plug-ins and add-ons of Rhinoceros are not directly cross compatible with interpreting the exported data from sources which contain a large number of curves and lines. Moreover, another complication is the disconnection between two lines or curves, resulting in an unsuccessful outcome. The best solution for this issue is to redraw (trace over) this obtained data in ArchiCAD or AutoCAD and export the result as a DXF file. In future, the ideal solution is to upgrade the plug-ins and add-ons to be able to tackle this issue and be able to use the files directly from other sources without the need to manually redraw.

3.2. Analysis

The analysis in this study has two main parts: axial-map analysis and Isovist field analysis. The first step in the process examines the existing network situation of the town of Rosebud. For the proposed examination, the DXF file that was generated through the Pre-analysis phase is then imported into the Depthmap software. The outcome of the axial line test on the proposed site revealed a poor integration of pedestrian accessibility between both sides of Point Nepean road which runs at an angle along the
grid. Currently, the over 50 metre wide Point Nepean road creates a physical barrier for pedestrian accessibility from both sides, which and acting as an obstruction to permeability. Several proposed alternative road configurations have been examined to determine the most successful one which shown on Figure . All proposed axes tested use Space Syntax methodology and the outcomes are compared against each other. It provides a guideline for designing the next axes leading to the next stage.

Figure 1: Point Nepean Road with over 50 metres width and proposed site on the isolated side of Town

During the site analysis and site visit three main hotspots were identified for the town of Rosebud. The first hotspot is the food precinct on the south side of Point Nepean road; the second one is the Sound Shell (a shell like stage for music performances) on the North side of the Point Nepean road and lastly is the Rosebud Jetty located farthest from the site. These three hotspots formed a straight axis. Hotspots in the context of this analysis are attraction points for people. The site visit demonstrated that the food precinct is the most crowded place in the town and the sound shell is the place for various kinds of performances especially during summer. By preparing a connection between these three points hypothetically, a vibrant and active axis will form. The axis will maintain the flow of people and create a pedestrian movement path between nodes and the aquatic centre can enhance this phenomena. All these factors can theoretically create an active town centre for Rosebud.

Further examination of this axis reveals the potential for pedestrians’ activity. The test also showed that the proposed site for aquatic and town centre can be enhanced by making multiple connections from the existing road on the south side of Point Nepean road to the site. Figure 2.
The second examination of the proposed site is the Isovist-field. Isovist is the visible area from a single observation point and it continuously changes while an observer moves through space. For the site project the best integrated axial lines, mentioned above, have been used as the main guideline for initial sketching for the town centre master plan. These initial sketches for the master layout have interpreted this guideline into pedestrian movement. See Figure 3. This newly created pedestrian movement on the town centre acts as the ‘lifeblood of its urban spaces’ (Stonor, 2013).
At this stage, three main pedestrian movement paths which extract from initial sketch were tested for the Isovist-field which were utilised by Rhinoceros and Grasshopper. The Isovist-field investigation can be used for redefining or changing the master layout or the building on site to achieve the best visual integration. The first movement path is the axis from the food precinct to the sound shell as the pedestrians’ main access for the project. The second one is the north point access which indicates the direction towards the capital of Victoria, Melbourne. This axis has another importance on the site; it demonstrates the sea channel which all ships use to sail from the Ocean to Port Phillip and Melbourne. See Figure 4.

Figure 4: Isovist-field for the intersection point of two axis that forms centre of civic plaza

The Isovist-field can parametrically change, these parameters in this study research are the observer’s point of view and the radius of the observer’s depth of field. This study fixes the depth of field to a 500 metre radius and automatically changes an observer’s point of view. The axial map and Isovist-field test generates an initial layout for the master plan of Rosebud centre. This initial sketch which is supported by several tests developed to design a final master plan for the town centre of Rosebud and its aquatic centre. See Figure 5.
4. Application of analysis

This section investigates the application of axial and Isovist-field analysis in the field of urban design. This study discusses the above mentioned analysis to assist urban designers to gain a better understanding of their design before proceeding with large budget projects. This analysis is also applicable towards the process of revitalisation or remodelling of an existing urban area which uncover the elements that are under performing. These analyses provide evidence for designers and decision makers to support or reject a design or urban design strategy.

For example, the study on Isovist-field for the Rosebud town centre project proposal discovered that area A, (See Figure 6) was most visually accessible within the site and also from the commercial strip on the southern side of Point Nepean Road. Thus, appointing area A of the site for retail and commercial activities can further promote the growth for business. Additionally, this will vastly improve the project as whole to activate the civic centre. These analyses result in redefining land use and enhance the brief of the project to increase the chances of prosperity of the project from a financial point of view.
Figure 6: Master layout has designed based on Isovist and axial analysis. Area A shown in light red colour.

Another example of how these analyses form the urban design in this project is the axial map analysis for walkability. Although the Isovist-field analyses indicates visual access to area A, the axial map shows that area A is not easily accessible for pedestrians in regards to walkability. For instance, area A is easily visible from the southern side of Point Nepean Road, however, because of current poor permeability of Point Nepean Road physical access is affected. The reason for this repercussion is the large width of Point Nepean Road and the fast vehicular traffic that travel along it. The axial map analysis, See Figure 2, simulates a more walkable area from the southern side to the northern side of the road if road conditions were to change. The above investigations result in a new design for the master layout of Point Nepean Road.

These new conditions of the road are:

- To provide two alternative routes for the vehicles which need to travel faster.
- To reduce the width of Point Nepean Road to ten metres.
- Shared zones for Point Nepean Road with a maximum speed limit of 10kph for vehicles.
- Using cobblestone flooring and speed limit signs to indicate to motorists that Point Nepean Road is a shared zone for vehicles and pedestrians.
- Plant trees to produce shading for pedestrians using the road.
- Increase the footpath width on the commercial side to 8 metres to make the area more accessibly convenient for customers and retail owners.

These types of analyses provide the city authorities a tool to evaluate the planner’s design against Space Syntax methodology. Most times designers are pre-occupied with many other aspects of the project and are not fully engaged or understanding the bigger picture of the design in relationship to the
surrounding context or the impacts that their design makes on the site. In some cases, some designs that Architects propose for the project are flawed as Isovist and axial-map analyses are able to reveal inconsistencies and contradictions in their design stages. As an example, a cantilever in a project which is independently and aesthetically appealing blocks the view of a landmark for pedestrians, or a well-designed shopping centre without strong integration to the surrounding environment will have problems in leasing shops.

5. Future direction

This study examined the usage of parametric software and Space Syntax theory in design of a master layout from a real project. This experiment reveals the advantages of employing Space Syntax methodology for analyses of space configuration with parametric software and using the outcomes to design more vibrant and active urban spaces in accordance to the guidelines of the project. Despite being in the early stages, there are some individuals who are currently working on finding more convenient methods of conducting Space Syntax analyses utilising parametric software.

The type of issues raised in this research study that demands further investigation include, among others;

- Designing plug-ins for Grasshopper to demonstrate Isovist-field in 3D and analyse the volume of a project instead of its 2D floor plan.
- Designing plug-ins for Grasshopper to graphically visualise the outcomes of analysis rather than numerical values.
- Collaborating with designers of existing plug-ins to upgrade them in terms of being more effective and user friendly. For example some features of particular plug-ins are incompatible when files with many lines or layers are applied to them.
- Designing a single plug-in that incorporates the essential analyses from different plug-ins merged into one. Preparing an easy step by step manual or road map to use all of the above mentioned software and plug-ins in master layout designs to aid designers in implementing all the analyses more effectively.

6. Conclusion

A solid understanding of space attributes is the key factor for designers to create space configurations that meet the purposes of a project. Interpreting the intangible attributes of space to the tangible with an analytical method of decoding the quality of space configuration is the primary aim of Space Syntax theory. As Hillier says, ‘Configuration seems in fact to be what human mind is good at intuitively, but bad at analytically’ (Hillier, 1996). This research study conducted analyses under Space Syntax methodology and utilises the outcome to design a better living environment for residence for the town of Rosebud.

This experiment showed the feasibility of the combination of Space Syntax methodology for the analysis of the space configuration and parametric software. This provides planners and designers with a powerful tool to analyse their existing project for revitalisation or new design. These outcomes are used to evaluate their final urban design which in turn helps the designer produce a more accurate result in line with the purpose of the project. This research study shows the feasibility of this process through a case study and clarifies the existing opportunities and weaknesses as well. The next step is to make the
opportunities more accessible and clearer for designers to tackle the weaknesses and obstacles in the process as outlined in previous chapters.

The potential benefits are numerous. First this approach can maximise views and vistas and identify obstacles which might restrict these. Second the use of axial analysis can avoid the creation of “dead space” which is rarely visited by pedestrians and can become a location for crime or vandalism. Third the identification of hot spots where pedestrians’ activities is high can signal the best location for facilities and shops where maximum economic value can be exploited.

The future development of Space Syntax, building on the analyses outlined here, has the potential to assist designers to improve amenity, commercial value and public satisfaction at various scales of projects.

References