The study of a space configuration using space syntax analysis
Case study: an elderly housing

Yosica Mariana, Arindra J. Triwardhani, Michael Isnaeni Djimantoro
Architecture Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480

Correspondence author: ymariana@binus.edu

Abstract. The improvement in various aspect leads to prolong the life span of human life, which increasing the number of elderly in the urban areas in return. But the increasing population is not supported by the provision of adequate housing facilities for them. Most of the elderly house in Jakarta, is designed just like for common people without realizing that they had physical and mentally degradation following the age. Therefore, the elderly house need to design with special attention to their daily activity mobility which applied in effective room configuration. The connectivity between the activities is most important element to order the room configuration. This research conduct to search the room configuration in elderly house which can improve their productivity and live quality by using the space syntax theory. The research methods by using the syntactic plug-in in Grasshooper software and analyse the integration, choice, control value and entropy in the activity configuration. The result show that the effective and efficient for elderly house is cluster centralized pattern. The lobby and reception take the important role as the integration aspect and the spatial awareness according to elderly activity.

Keywords: space syntax, room configuration, elderly house, cluster centralized pattern

1. Introduction
The improvement in various aspect leads to prolong the life span of human life, which increasing the number of elderly in the world, including Jakarta, Indonesia. The number of elderly in Indonesia is one of the biggest number, where the increasing population from 5.45% in 1980 to 7.97% in 2000 and predict to 11.34% in 2020. The average life expectancy is also increasing from 68.6 in 2004 into 70.8 in 2015 and predicted to 72.2 in 2035 [1]. The increasing of elderly population should be accompanied by the development of adequate facility for them. The main problem is the facilities is design without considered their condition.

Elderly people definition is for anyone above 60 years old, which have physical and mental decreasing and more dependent to another people. Even though, the elderly welfare is the most important factors to support their life quality, which leads to positive perspective, attitude and behaviour to facing the daily life. The quality of life is individual perception in the community, which is different based on its culture and value regarding the living standards, hopes, happiness, and their attention which integrated in their health, psychological aspect, freedom and their relations with their environment [2].

Therefore, it needs to provide the safety and comfortable facilities to support the quality of life from the elderly, by considering their needs and provide the accessibilities for them. The safety factors not
only focus on fire and environment harrasment, but also safety factors in architectural form design which psychological safety [3]. The room configuration shoud accessible for the elderly in form of the residence, recreational, health factors, and the others.

On the other hand, in the last few years is being developed the space syntax approach in architectural and urban design. The study shows that the space syntax can reduce the ecological footprint that encourage the sustainable ecological in the city. It also shows that the space syntax can increasing the economic sustainability and the social sustainability [4]. Therefore in this research is tried to elaborate the space syntax approach in elderly house design, to maximize the sustainability factors in design.

2. Literature review

2.1 Room Configuration

Room is three dimensional space where the object or something which have position and relative directions [5], and the configuration is the relation which objects connect each other in the structure [6]. So, the room configuration is the relative relation of three dimensional form which consider the human movement [7].

2.2 Space Syntax

The pattern of relationships between spaces known as syntax, interpreted as a pattern of spatial relationships that allow configuration to have a meaning that can be read and understood by everyone. The interesting thing about space syntax is related to the relationship between humans and the space they inhabit. We can see the distinctive characteristics of a society through their spatial systems and the knowledge they possess can be conveyed through space and the organization of the space itself [8]. From an analytical point of view, Space Syntax theory provides a comprehensive and consistent framework for understanding spatial arrangements and their likely human effects, which we can term as social performance of buildings [9]. Space syntax is used to understand space in the form of configuration, especially about the process of its formation and social meaning conveyed [10]. It can be argued that space syntax is the attempt to form a theory of configurations in architecture by generating a theoretical understanding of how people make and use spatial configurations, in other words, trying to identify how spatial configurations express the meaning and social and cultural interactions in the built environment. The pattern and intensity of individual movements is strongly influenced by the configuration of space, even the structure of space can be considered the single determinant that most influences movement in space [7]. To measure interaction in space configuration, space syntax uses several dimensions measured by using the concept of topological distance called depth.

3. Methodology

The research methodology can be explained as a technique that is used to analyze the collected data. The collected data should be related to the statement of the objectives and problems. The methods to obtain the data in this research were literature review and space syntax. Space syntax method deploys plug-in Grasshopper on Rhino3D application. The methodology using the algorithm that developed by Nourian, which need several the input to calculate the output [11]. This methodology tried to investigate the value of integration, choice, control value and entropy, the results obtained from these parameters will explain the relationship between one rooms to another and also various layout of the configuration space adapted to the relationship based on the point of view each room. Explanation of parameters as follows:

- Integration provides a measure of the privacy of a space. The higher the number appears, the more likely it is to be communal, and the lower the show the more private the space is.
- Choice shows how often a space allows to be skipped on the way to other spaces in the configuration, which is due to the nearest distance from other spaces around it.
- Control value indicates how strong a room in a configuration relates to other spaces in terms of superiority.
• Entropy shows the level of space accessibility. The higher the entropy value, the more difficult it is to reach other spaces of the space and vice versa.

4. Results and Discussion
4.1 Bubble diagram
Bubble diagrams are used to represent the desired inter-spatial relationships that are then analyzed with four space syntax sizes above, so that an alternative space with space will potentially increase the social interaction of its users and its relation to the surrounding space. (See figure 1)

![Bubble diagram for elderly facilities](image)

**Figure 1.** Bubble diagram for elderly facilities

| ROOM | INTEGRATION VALUE | ROOM | INTEGRATION VALUE | ROOM | INTEGRATION VALUE | ROOM | INTEGRATION VALUE |
|------|-------------------|------|-------------------|------|-------------------|------|-------------------|
| 24   | 0.946             | 1    | 1.389             | 11   | 1.481             | 31   | 1.646             |
| 2    | 0.966             | 3    | 1.434             | 25   | 1.481             | 27   | 1.709             |
| 16   | 0.966             | 10   | 1.434             | 7    | 1.559             | 29   | 1.852             |
| 26   | 0.966             | 13   | 1.434             | 9    | 1.559             | 0    | 2.778             |
| 4    | 1.022             | 14   | 1.434             | 18   | 1.559             | 2     | 2.963             |
| 30   | 1.058             | 15   | 1.434             | 19   | 1.559             | 6    | 3.556             |

Table 1. Integration measurement results with plug-in grasshopper-syntactic
The table above shows the results of integration measurements which will lead into the privacy level of a space. The higher the number that appears, the more communal and conversely the lower the existing number the more private the space. From the integration measurement results obtained the most communal space results where space is most often accessed in terms of relationship to another space in the configuration is the space (6) with the highest integration value of 3.556 the lobby space and reception, while the most private space is the space (24) with the lowest integration value of 0.946 in the medical space. Looking at the results of integration measurement, the potential to improve the social quality is in lobby area and reception, lounge and residential unit area.

**Table 2. The result of control value measurement with plug-in grasshopper-syntactic**

| ROOM | CONTROL VALUE | ROOM | CONTROL VALUE | ROOM | CONTROL VALUE | ROOM | CONTROL VALUE |
|------|---------------|------|---------------|------|---------------|------|---------------|
| 7    | 0.083         | 17   | 0.1           | 26   | 0.5           | 27   | 1.226         |
| 9    | 0.083         | 11   | 0.143         | 3    | 0.643         | 32   | 1.5           |
| 18   | 0.083         | 28   | 0.333         | 21   | 0.643         | 22   | 1.583         |
| 19   | 0.083         | 30   | 0.333         | 29   | 0.667         | 0    | 3.017         |
| 20   | 0.083         | 8    | 0.417         | 2    | 1             | 12   | 7.226         |
| 10   | 0.1           | 31   | 0.417         | 5    | 1.083         | 6    | 7.41          |
| 13   | 0.1           | 4    | 0.5           | 11   | 1             | 1    |
| 14   | 0.1           | 16   | 0.5           | 25   | 1             | 1    |
| 15   | 0.1           | 24   | 0.5           | 23   | 1.143         |

Control value indicates how strong or dominant a room is in a configuration relating to other spaces. The higher the number indicates the more dominant the space is in the overall configuration. From result of measurement of control value, it is found that space (6) is the most dominant space, with the highest control value equal to 7.41 followed by space (12) with control value equal to 7.226 and space (0) equal to 3.017.

**Table 3. The result of choice with plug-in grasshopper-syntactic**

| ROOM | CHOICE | ROOM | CHOICE | ROOM | CHOICE | ROOM | CHOICE |
|------|--------|------|--------|------|--------|------|--------|
| 30   | 69     | 9    | 75     | 129  | 25     | 147  |
| 1    | 71     | 10   | 75     | 31   | 129    | 27   | 183    |
| 4    | 71     | 13   | 75     | 32   | 133    | 22   | 193    |
| 7    | 71     | 14   | 75     | 2    | 135    | 0    | 537    |
| 18   | 71     | 15   | 75     | 3    | 135    | 12   | 701    |
| 19   | 71     | 16   | 75     | 21   | 135    | 6    | 851    |
| 20   | 71     | 17   | 75     | 5    | 139    |
| 24   | 71     | 26   | 75     | 23   | 139    |
| 29   | 73     | 28   | 93     | 11   | 147    |

Choice is the third measurement done. This parameter indicates how often a room allows to be skipped on the way to other spaces in the configuration, which is due to the nearest distance from other spaces around it. The result is that room 6 is the most commonly used space in each trip to take up another space with a choice of 851, followed by space 12 with a choice of 701 and space 0 with a choice of 537.
Table 4. The result of entropy with plug-in grasshopper-syntactic

| ROOM | ENTROPY | ROOM | ENTROPY | ROOM | ENTROPY | ROOM | ENTROPY |
|------|---------|------|---------|------|---------|------|---------|
| 0    | 1.361   | 21   | 1.593   | 5    | 1.642   | 25   | 1.738   |
| 6    | 1.394   | 23   | 1.593   | 24   | 1.642   | 16   | 1.797   |
| 1    | 1.483   | 27   | 1.604   | 8    | 1.655   | 26   | 1.797   |
| 12   | 1.5     | 9    | 1.638   | 31   | 1.655   | 30   | 1.811   |
| 7    | 1.54    | 10   | 1.638   | 28   | 1.685   | 32   | 1.959   |
| 18   | 1.54    | 13   | 1.638   | 4    | 1.701   | 29   | 2.002   |
| 19   | 1.54    | 14   | 1.638   | 2    | 1.708   |      |         |
| 20   | 1.54    | 15   | 1.638   | 22   | 1.73    |      |         |
| 3    | 1.593   | 17   | 1.638   | 11   | 1.738   |      |         |

The final measurement result is entropy which indicates the level of space accessibility. The higher the entropy value, the more difficult it is to reach other spaces of the space and vice versa. And seen from the measurements, spaces (0) and (6) are spaces with low entropy values that make it the most accessible space, while spaces (29) and (32) are the most difficult to access rooms. This is because both areas are service areas that are not intended for the public.

From all measurements of space-syntax it can be concluded that lobby & reception have the most important control in the configuration of this building, although it is still too general. In dominant areas, social interaction between the elderly tends to be higher than in other rooms. In addition, the results obtained can be identified that the highest mobility also occurs in the lobby & reception area where the elderly circulation becomes centralized by clustering the cluster space and this indicates wayfinding in the overall configuration, making it easier for the elderly to the other spaces with the achievement of distance the furthest distance of maximum 400 meters. This parameter is very important for the elderly who already have a decline in mental or physical function.

5. Summary
Space syntax theory has been used to reveal intrinsic values in spatial configuration in this elderly residential building. Integration, control value, choice and entropy are the basic dimensions in space syntax that can be used as a fairly effective and efficient tool for explaining relationship patterns in spatial configurations. The results of the measurements can be concluded as follows:
1. The effective and efficient spatial configuration for elderly housing facilities is as cluster centralized pattern to facilitate mobility of the elderly.
2. The area of lobby and reception have a high degree of integration and connectivity, since those areas have the highest flow traffic.
3. The integration and connectivity of the lobby and reception is significant to determine the accessibility and spatial awareness for an elderly housing.

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