International Journal of Environment, Architecture, and Societies
Vol. 01, No. 01, February 2021, pp. 19-30
ISSN: 2775-8540
DOI: 10.26418/ijeas.2021.1.01.19-30

A Space Syntax Guide to Optimize Shopping Mall: A Systematic Review

Andi[1], Ivan Adiel Abednego [2)], Bontor Jumaylinda Br. Gultom [3)]

[1,] Center of Southeast Asian Ethnicities, Cultures and Societies, Pontianak, Indonesia
[2)] Department of Architecture, Faculty of Engineering, Institut Teknologi Kalimantan, Balikpapan, Indonesia
[3)] Department of Architecture, Faculty of Engineering, Universitas Tanjungpura, Pontianak, Indonesia

Manuscript received:
January 25, 2021

Manuscript revised:
February 27, 2021

Manuscript accepted:
February 27, 2021

Date of publication:
February 28, 2021.

Corresponding author:
Name : Andi
Email : andizhangnd@gmail.com

Abstract – The shopping mall is a facility for profit-making with a complex spatial configuration that prioritizes effectiveness in any aspect. Therefore, the spatial configuration of the shopping mall needs more than a rule of thumb or a subjective judgment. Many researchers have conducted studies of shopping mall spatial configuration by the theory and method of space syntax. But, the complexity of space syntax turns it hard to understand or apply in practical use. Due to the complexity of both shopping mall and space syntax, this article intends to create a guide for practical directions to optimize shopping malls. This article review combines and synthesizes the findings of space syntax precedent studies. The method we used in this article is qualitative methods with a comparison based on relevant literature studies and logical arguments related to the shopping mall. As the result, this article has found that the best way to perform space syntax analyses is by using computer software namely DepthMap. Axial, convex, isovist, VGA, and agent-based maps are the available spatial representations for the spatial configuration of the shopping mall. Spatial configurations of the shopping mall can be evaluated by the measurement of connectivity, depth, integration, choice, and intelligibility. This article provides a guide to perform a space syntax in a shopping mall and to read and interpret space syntax analysis into spatial strategies to optimize a shopping mall in several shopping mall aspects. Those aspects are pedestrian flows, horizontal complexity, vertical complexity, tenant type allocation, retail placement, and anchor placement.

Keywords: *space syntax, spatial optimization, shopping mall*

I. INTRODUCTION

The shopping mall, a multi-level commercial building, has many considerations to make it optimal. Firstly, it has an extensive circulation system that can make people difficult in wayfinding or worse scenarios can make people get lost (Zhang et al., 2012). Secondly, shopping malls as a facility for profit-making must be planned to attract more people (Min et al., 2012) and to be more strategic on how the stores arrange to minimize the movement distance (Kong & Kim, 2013). Thirdly, the visual aspect is also important in shopping malls. As a visual strategy, the frontage of retail need to be as wide as possible to be the visual catchment of people sight (Vialard et al., 2017) but it depends on the shape of the circulation because it affects the span of the visual field toward the retail front (Li et al., 2017). Lastly, designing a shopping mall need a resourceful strategy on the placement of the spatial elements such as the entrance, the vertical transition access (elevator, escalator, and stair), and horizontal circulation (the form of the pedestrian ways and corridor) (Li et al., 2017; Zhang et al., 2012). To sum it up, all the shopping mall design considerations describe the complexity of the design thinking process and need a comprehensive solution to manage the space to be more optimal. But recently, all these considerations are still unsolved due to the rule of thumbs (Deb & Mitra, 2020) and the subjective judgment of the architect or building manager (Fujitani & Kishimoto, 2012).

In 1984, space syntax appeared as a new theory for determining the behavior of humans toward space by formulating human social logic into a math equation (Fezzai et al., 2020). Later in the 1990s, the method became commonly used to solve spatial configuration problems in many kinds of building use including shopping malls (Ha et al., 2020). It is found that space syntax first used on shopping malls is in 1996 (Kim, 1996) and the popular trend is increasing from an average of 1 publication per year in 1996 to an average of 5 publication per year in 2020 (Fig. 1). In 2001, Turner (2001) developed a computer software named Depthmap from space syntax theory. This software provides a colorful and informative graphical presentation to help the user in analyzing spatial configuration. So far, all these means space syntax is the most promising comprehensive solution to optimize shopping malls but the practical use of space syntax on shopping malls is still in development. This leads to another problem which is how to use space syntax to optimize a shopping mall.

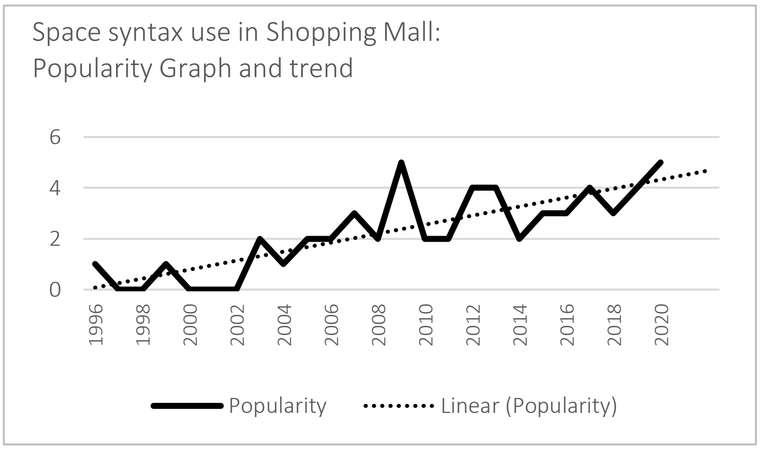

Fig. 1. Popularity trend of space syntax used in the shopping mall

A lot of space syntax precedent study articles have been collected as data. Those studies were conducted at a varied shopping mall around the world. By combining and synthesizing their findings, this review article is created with the purpose to provide a guide to the use of space syntax in the topic of optimizing shopping mall design. The method we used in this article is qualitative methods with a comparison based on relevant literature studies and logical arguments related to the shopping mall.

This review covers all articles which have conducted a study on shopping malls at building scale. Those articles consist of 20 articles from 2011 to 2020 (Table 1). Other articles at urban-scale and single-store outlet-scale are not included in this review. Most included articles are empirical study cases about the movement and the behavior of shoppers inside shopping malls. Some articles were trying to find other new variables that possibly affect or affected by the spatial configuration (Al-Juboori & Mustafa, 2014; Aydogan & Salgamcioglu, 2017; Haofeng et al., 2017; Kong & Kim, 2012). Several articles are theoretical, using space syntax to make framework, rules, and models (Deb, 2013, 2014, 2015; Deb & Mitra, 2020) to replace the conventional rules of thumb. And a few articles combine the space syntax method with other methods like multiple regression analysis (Fujitani & Kishimoto, 2012), GIS (Yuo et al., 2013), Q-analysis (Omer & Goldblatt, 2016), and ERAM (Ha et al., 2020).

Table 1. Article by Publication Date

Type of Reference	Publication Date										Total
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Journal Article			1	2	1	1	1	1		3	
Conference proceedings		4	2				3		1		

No. of References	0	4	3	2	1	1	4	1	1	3	20

II. SPACE SYNTAX

Hillier & Hanson (1984) developed space syntax as a theory to replace the shape grammar principles as spatial system organizers in ways more systematic and mathematical. Unlike shape grammar, space syntax is not just developed into a fundamental theory but also advanced methods. Space syntax consists of the measurement system and varied graph models to represent the spatial configuration at any scale (city, district, building, and single space) (Hillier, 1996). To help space syntax researchers and to develop the space syntax method, Turner (2001) design software to perform a set of space syntax measurements in various scales. The software is called DepthMap. It is a computer software analytic tool with communicative graphical representation (Gil et al., 2015). DepthMap was designed to perform VGA map analyses only (Turner, 2004), but later other analyses were added. Now, DepthMap ables to perform a comprehensive analysis of all space syntax maps and measurements.

Space syntax has three fundamental maps to represent the spatial structure based on the scale and the function (Fig. 2). Those maps are axial, convex, and isovist (Behbahani et al., 2017). The axial and convex maps were first purposed by Hillier & Hanson (1984) while isovist maps were purposed by Benedikt (1979). The axial map is often used to represent the macroscale like cities, but the axial map can also represent mesoscale space such as buildings and their layout (Nes & López, 2010; Nes & Yamu, 2018). The convex map represents the mesoscale of space like buildings and districts (Li et al., 2015; Nes & López, 2010). Isovist map represents mesoscale and microscale space like a room with complex shape and has furniture (Benedikt, 1979; Mustafa et al., 2010). These three maps have different functions (Table 2). The axial map represents people's behavior in the way of movement or accessibility (Hillier & Hanson, 1984; Vaughan, 2007). Convex space represents the logic of people's interaction within space (Dawes & Ostwald, 2013; Hillier & Hanson, 1984). Isovist represents the visual field of people as they move around the system (Benedikt, 1979; Farhi, 2009).

Table 2. Spatial Scales and Functions of Each Space Syntax Maps

No	Space syntax Maps	Spatial Scale	Function
1	Axial map	Macroscale, mesoscale, and micro scale	people's behavior in the way of movement or accessibility
2	Convex map	Mesoscale	people's interaction within space
3	Isovist map	Mesoscale and microscale	the visual field of people as they move around the system

Aside from the fundamental maps, there were several additional maps (Fig. 2). They are visibility graph analyses (VGA) (Turner et al., 2001) and agent-based maps (Penn & Turner, 2002). While the isovist map shows the visual quality of certain spaces and certain locations only, VGA shows the visual quality of the entire space in the system. The agent-based map is a simulation of people's movement inside the system (Penn & Turner, 2002). This map was constructed from the VGA maps. The agent behaves based on human visual ability and moves reactively toward the spatial system. Besides, there is a conceptual map called justified-graph (j-graph) which is usually used in space syntax to represent the simple form of the axial map or convex map (Hillier & Hanson, 1984; Lee et al., 2018). J-graph consists of spaces and links which have restructured from the axial or convex map to visualize and analyze the certain quality of the system especially the depth (Klarqvist, 1993).

All the maps above can be used to represent the space of the shopping mall as it had used by space syntax researchers (Table 3). The most chosen map to perform analyses with is the axial map with a rate of 50% of selected articles. In the second and third places, VGA and convex map were quite often used as well, with a rate of 30% and 40%, respectively. Besides the five maps above, there is also a map that was constructed from the axial map, called segment map (Hillier & Iida, 2005). But unfortunately, it can not be used to represent the mall. It is more suitable to analyze the macroscale of space like cities (Al-Sayed, 2018).

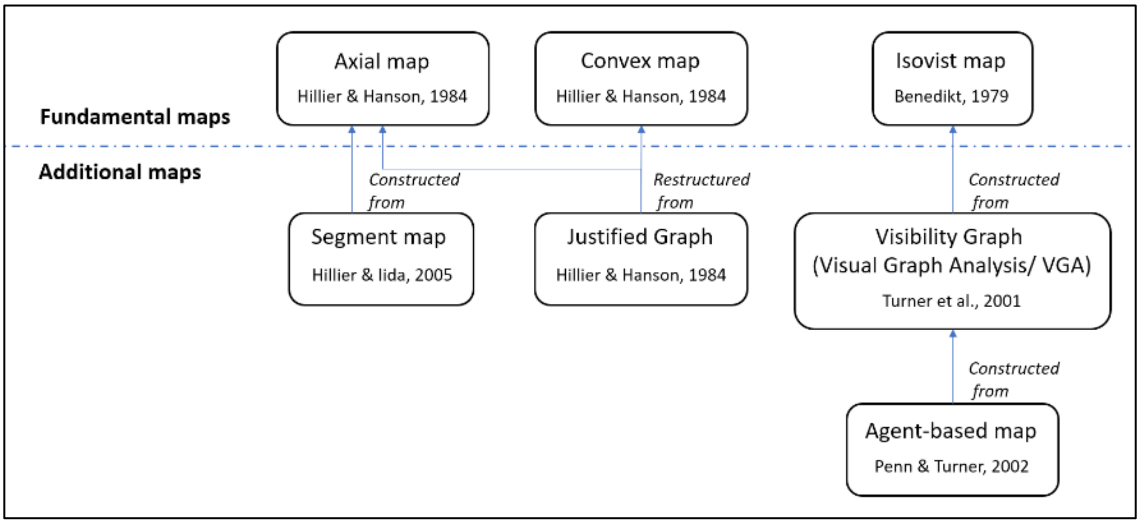

Fig. 2. Space Syntax Maps and Their Origins and Authors

Table 3. Space Syntax Maps Those Used in Shopping Mall Analysis

No	Maps	References	Count of Ref.
1	Axial	Deb & Mitra, 2020; Haofeng et al., 2017; Min et al., 2012; Omer & Goldblatt, 2016; Vialard et al., 2017; Yuo et al., 2013; Zhang et al., 2012	10
2	Convex	Andi et al., 2020; Deb & Mitra, 2020; Ha et al., 2020; Wong & Tam, 2019	4
3	Isovist	Kong & Kim, 2012	1
4	VGA	(Aydogan & Salgamcioglu, 2017; Bai & Yao, 2018; Fujitani & Kishimoto, 2012; Kong & Kim, 2013, 2012; Min et al., 2012)	6
5	Agent-based	Li et al., 2017	1
6	Justified-graph	Al-Juboori & Mustafa, 2014; Deb & Mitra, 2020	2

Space syntax has plenty of measurement types to measure or analyze the spatial configuration. Based on previous space syntax researches on shopping malls, only 5 of all the space syntax measurements were mentioned and used to analyze the spatial configuration of the shopping mall (Table 4). They are connectivity, depth, integration, choice, and intelligibility. Connectivity is a local metric measurement that measures the amount of space that is directly connected to a certain space (Hillier & Hanson, 1984). Depth is a measurement of the distance between two-unit spaces (Hillier & Hanson, 1984). The distance can be interpreted in three different ways, metric (how many meters take to space), topologically (how many turns take to space), and angular (how big the angle takes to space) (Turner, 2007). Integration is a global topological measurement that describes the average depth of space for all other spaces in the system (Hillier, 1996). About 85% of space syntax researches on shopping malls used the measurement of integration (Table 4). Choice measures movement and predicts the potential movement of pedestrians and vehicles, noting that high global choice lies in the shortest path from all origins to all destinations (Hillier, 1996). While integration shows the center of the system, choice shows the betweenness of the system. Intelligibility is a correlation between connectivity and integration. Intelligibility identifies how easy it is for one in a local position to comprehend the global structure (Hillier, 1996). In the shopping mall, Intelligibility shows the ability of user's wayfinding, the higher the intelligibility, the lower the user’s chance to get lost in the shopping mall.

Table 4. Space Syntax Measurements Used in Shopping Mall Analysis

No	Measurement	References	Count of Ref.
1	Connectivity	Al-Sayed, 2018; Aydogan & Salgamcioglu, 2017; Fujitani & Kishimoto, 2012; Haofeng et al., 2017; Min et al., 2012; Omer & Goldblatt, 2016; Wong & Tam, 2019	7

2	Depth	Al-Juboori & Mustafa, 2014; Aydogan & Salgamcioglu, 2017; Bai & Yao, 2018; Deb, 2013, 2014, 2015; Deb & Mitra, 2020; Min et al., 2012; Yuo et al., 2013	9
3	Integration	Al-Juboori & Mustafa, 2014; Aydogan & Salgamcioglu, 2017; Bai & Yao, 2018; Deb, 2013, 2014; Deb & Mitra, 2020; Fujitani & Kishimoto, 2012; Ha et al., 2020; Haofeng et al., 2017; Kong & Kim, 2012, 2013; Min et al., 2012; Omer & Goldblatt, 2016; Vialard et al., 2017; Wong & Tam, 2019; Yuo et al., 2013; Zhang et al., 2012	17
4	Choice	Andi et al., 2020; Aydogan & Salgamcioglu, 2017; Deb, 2014	3
5	Intelligibility	Omer & Goldblatt, 2016; Zhang et al., 2012	2

Space syntax measurement is simulation-based on the general logic of people's behavior. In reality, many factors can affect people's behavior such as culture. Therefore, some studies need behavioral mapping in comparison to the space syntax measurement. There are two behavioral mappings that applicable to the shopping mall study. They are gate count and static snapshot mapping. Gate count is a quantitative method that shows the quantity of pedestrian flows at certain gates in a building or an urban layout (Vaughan, 2007). Gate count is conducted by setting the gates and tally counting the pedestrian who move through the gates (Al-Sayed, 2018). Gate counts allow researchers to collect a great deal of data that can be represented graphically and statistically. Static snapshot or place-centered mapping is qualitative mapping methods. It is conducted to record the use pattern of spaces within buildings and useful for comparing static activities (standing, sitting) and movement (Haryadi & Setiawan, 2010).

III. SHOPPING MALL ASPECTS AND SPATIAL MEASUREMENT

Aspects of shopping mall study in this review are limited to spatial configuration due to the space syntax method. From the selected articles, there are certain aspects of shopping mall those can be analyzed by space syntax (Table 5). They are pedestrian flows, horizontal complexity, vertical complexity, allocation of tenant type, retail placement, and attractor placement (Table 5). The selected articles were classified fairly into each issue. The most discussed issue is the anchor placement. Each of these issues is later discussed more as outlines below.

Table 5. Articles by Topic

No	Issues	No. of Articles
1	Pedestrian Flows	5
2	Horizontal Complexity	4
3	Vertical Complexity	3
4	Tenant Type Allocation	3
5	Retail Placement	4
6	Anchor Placement	6

A. Pedestrian Flows

In the shopping mall, pedestrian flows are the footfall quantities that measure by counting the numbers of a pedestrian on the corridors. A pedestrian flow at a corridor reflects how many buyers or prospective buyer of the store which adjacent to the corridor. By knowing the pedestrian flows, the sales of the store can be forecasted (Kong & Kim, 2012).

Using space syntax, the previous researchers found several facts about pedestrian flows. Firstly, pedestrian flows are affected by the entrance and the level variation (Zhang et al., 2012). Secondly, pedestrian flows are mainly shaped and affected by the spatial configuration of the shopping mall (Aydogan & Salgamcioglu, 2017; Haofeng et al., 2017). Thirdly, space syntax measurements such as connectivity and integration, both have a significant correlation with the pedestrian flows (Aydogan & Salgamcioglu, 2017). Fourthly, integration measurement on the visibility graph analysis map is the most effective way to represent the pedestrian flow because it is most correlated to the pedestrian flow up to 60% more significantly correlated than other measurements (Kong & Kim, 2012; Zhang et al., 2012). Fifthly, the intelligibility measurement indicates the accessibility of the pedestrian (Omer & Goldblatt, 2016).

Those facts above provide a guide to analyze the pedestrian flows. Analyze the pedestrian distribution of a shopping mall can help us to evaluate the effectiveness of the configuration by indicating how impartially the pedestrian will be distributed. The best maps to analyze it is visibility graph maps (VGA) because pedestrians move and behave based on their vision. Connectivity and integration are the suitable measurements to analyze pedestrian flows, not just because they are greatly correlated, but also they both show the accessibility and tendency of the pedestrian. Using these both measurement values, an intelligibility measurement can be performed to see how complex the configuration.

The findings of previous researches implied some recommendations to gain the optimal configuration. Firstly, better pedestrian flows can be achieved by modifying the position of the entrance horizontally or change the level of the position (vertically). Secondly, when the intelligibility result of the configuration is low (below 50%), the value can be adjusted by changing the spatial shape of the corridor plan. Lastly, pedestrian flows on the higher level floor are lower, so need an attractor on the most top level.

B. Horizontal Complexity

The horizontal complexity of a shopping mall is the complexity of the form of mall spatial configuration per floor level. It is mostly reflected in the mall corridor area. This complexity was generated when architects were designing the shape of the floor plan.

Previous researches on this aspect had found several facts. Firstly, a ring-like structured layout generates higher distribution and provides higher accessibility to the system than a tree-like structure layout (Al-Juboori & Mustafa, 2014) (Fig. 3). Secondly, the circulation route with a long straight path had proven to be a more distinguishable attraction on pedestrian movements and have higher connectivity than the winding path (Aydogan & Salgamcioglu, 2017). Thirdly, the circulation should avoid the uneven bifurcation path and should be symmetrical to make pedestrians distribute evenly (Andi et al., 2020; Z. Li et al., 2017).

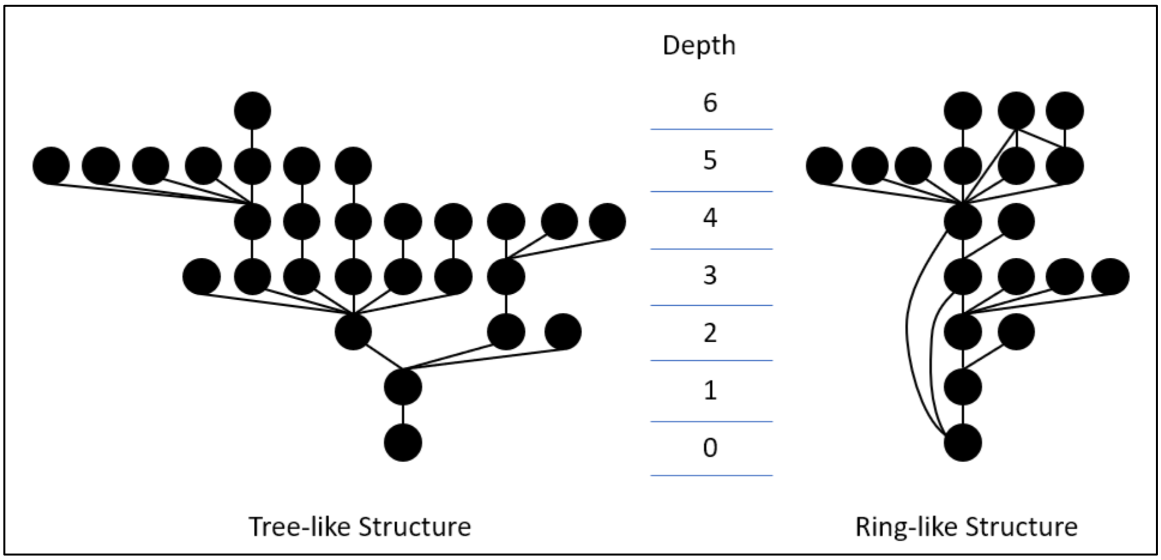

Fig. 3. Justified-graphs of Treelike and Ringlike Structure
Source: Al-Juboori & Mustafa (2014)

Ringlike structures are better than a tree-like structure in a way to provide high distribution at the shopping mall. The ring-like structure was shown by the connection among the non-adjacent room in the justified graph (Fig. 3). In terms of connectivity measurement, the ring-like structure has a higher connectivity value than the tree-like structure. This also indicated the higher connectivity value increases the effectivity of the spatial configuration of malls. In terms of depth, the ring-like structure has a similar depth value to the treelike structure. Therefore depth does not matter in the aspect of distribution. The most important feature of the ringlike structure is the looping routes where pedestrians can move more freely. While tree-like structure only has one-way branches routes. In summary, adopting the ringlike structure in the mall configuration is very recommended.

While trying to adopt a ringlike structure as recommended, a designer can accidentally make an uneven bifurcation path as well. The uneven bifurcation paths distributed the pedestrian flows unevenly. This condition only leaves one of the paths has disadvantages, although the sustainability of shopping mall only can be maintained only by ensuring the wealth of each retail business. This uneven term can be interpreted in aspects of width, depth, and attraction. Wider paths provide a better visual field for the pedestrian, the shallower path is more accessible, and the attraction can attract pedestrians. By equalizing the path on these three aspects the uneven distribution can be avoided. Uneven bifurcation paths leave no issue as long as the disadvantaged path was assigned as a service area instead of a business area.

Straight path routes are easier to access and have shorter distances in every way of space syntax distance determinators (metric, topological, and angular). In metric, a straight path has a shorter distance than a winding path. In angular, a straight path has a smaller angle turn than a winding path. In topological, turning in a path can be counted as a turn, while a straight path has zero turns. This fact is correlated with space syntax theory. Therefore, applying more straight paths into the system can improving the quality of the configuration in both space syntax measurement and the effectiveness on real conditions.

C. Vertical Complexity

The vertical complexity of a shopping mall consists of the level variation, vertical transition, and entrance placement. The level variation is the spatial attribute that affects the depth of the system. Vertical transition is the connection between levels. It can be defined as an escalator, lift, or stair. An entrance is a starting point and exiting point for a pedestrian. An entrance can be defined as the main entrance, secondary entrance, and the entrance from even the parking area.

Researches on vertical complexity found several facts as follows. Firstly, Zhang et al. (2012) found that pedestrian flows near the entrances and vertical transitions are greater than other spaces far from them. Secondly, it is found that stores on the middle floor tend to have the highest pedestrian flows while stores on the highest floor tend to have the lowest pedestrian flows (Ha et al., 2020). Thirdly, High visual connectivity on the vertical transition improves the efficiency of the vertical path (Li et al., 2017).

Most shopping malls have an entrance placed on the ground floor. This leaves the highest on the end of the circulation system or the deepest place. Based on the integration theory, it is reasonable if the highest level has the lowest pedestrian flow. Therefore, it needs a strategy to improve the pedestrian flow. By placing the vertical transition near the entrance, the pedestrian will be easily guided to the higher floor. On contrary, it can make the other place the ground floor left to be explored by the pedestrian. Thus, improving the visual quality near the vertical transitions will be more acceptable than placing it near the entrances. Common strategies of visual improvement near the vertical transition are by making a lobby and by creating void inter-floors.

D. Tenant Type Allocation

In general, a shopping mall has four types of tenants. They are retail facility, convenience facility, F&B (Food and Beverage) facility, and family restaurant (Min et al., 2012). Tenant type allocation has the same purpose as tenant mix which is achieving a better shoppers' flow and stimulating impulse shopping (Yiu et al., 2008). While tenant mix is a shopping mall strategy by creating a composition of several types of tenants in a floor or certain zone, tenant type allocation is a strategy by placing certain tenants in a proper place based on its characteristics. Tenant type allocation is much affected by the spatial configuration (Haofeng et al., 2017). The wrong placement of the tenant type in the system can impact the sales of the tenant and can lead to vacancy (Kong & Kim, 2013).

Based on space syntax research articles, each tenant type has its own best location. The retail facilities should be placed on the space with higher integration and connectivity value because they have the lowest chance to attract users (Min et al., 2012). F&B facility can be placed on the space with lower integration and connectivity value or the space with varied value because it is not much affected by the characteristics of spatial (Kong & Kim, 2013). Convenience facilities could not be found in sites with high integration (Min et al., 2012). Convenience facilities and family restaurants are considered to be facilities with a strong purpose and a characteristic similar to a key tenant. Therefore, it should be placed on the space with the lowest integration and connectivity value as attractors (Min et al., 2012).

The findings above can be inferred that the best location of a tenant type is based on the aspect of attractiveness and purpose. Retail facilities have no attractiveness and no strong purpose. That is why they are so dependent on the best location. Where the best location is the most accessible location. Retail-type facilities should put in the priority. F&B facilities commonly appear with low attractiveness but they have a strong purpose. They provide users basic need which is eating, drinking, resting, or could also social need. The F&B type facilities can be placed on the second priority. Both convenience facilities and family restaurants have strong purposes and high attractiveness. These types of the tenant should put in less priority and strongly not recommended to put on space with high integration

E. Retail and Anchor Placement

Sumanta Deb progressively developed a formal model of bid-rent based on store location within shopping mall using space syntax as a guide to place a retail (Deb, 2013, 2014, 2015; Deb & Mitra, 2020). This model helps shopping mall managers to set the objective value of rent to maximize the profit of every retail. The theory is based on how far a store from the customer density. The nearest shop to the customer density gets a higher rent price. Customer density is the scale of customer numbers based on accessibility where the most accessible shops in a particular arrangement will generate more customers (Deb, 2013). The accessibility is relying on spatial configurational variables (metric distance and cognitive distance) (Deb & Mitra, 2020). Metric distance is a simple measurement of the distance from the center of the mall (Deb, 2014). Cognitive distance is the measurement of the number of turns or changes of direction a path has to the center of the mall (Deb, 2014). This distance is measured by integration space syntax measurement where the higher the integration the lower the cognitive distances.

When it comes to renting value, rent decreases with increasing of metric distance from the center, and rent increases with decreasing of cognitive distance or increasing integration value (Deb, 2013) (Fig. 4). By combining the graph of the distance toward rent, Deb developed a four-cell graph model (Fig. 5). This model is separated into 4 cells. As it is numbered in Fig. 5, the first cell is the location where maximum customer density and it is the best location for higher sales (Deb, 2015). The 4th cell is inelastic or the location with the lowest sales and lowest customer density (Deb, 2015). The other two cells have moderate customer density (Deb, 2015).

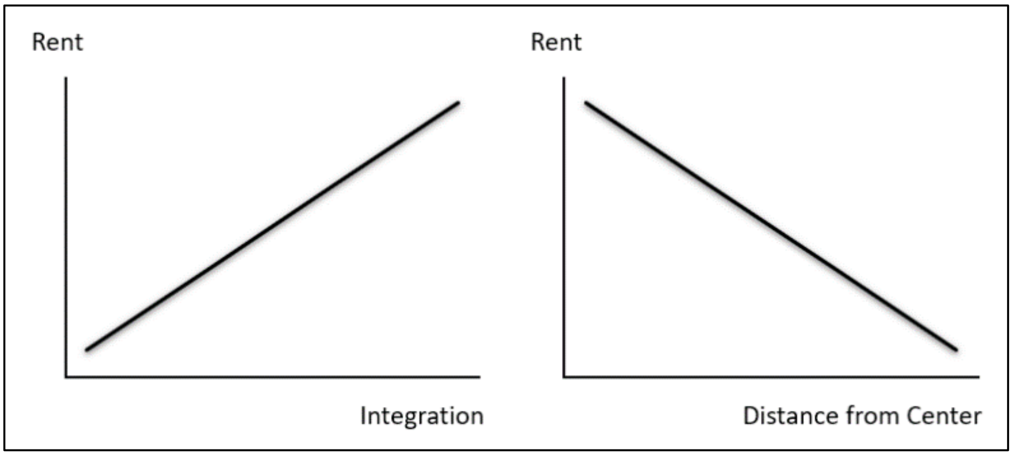

Fig. 4. Rent Density Relationship

Source: Deb (2013)

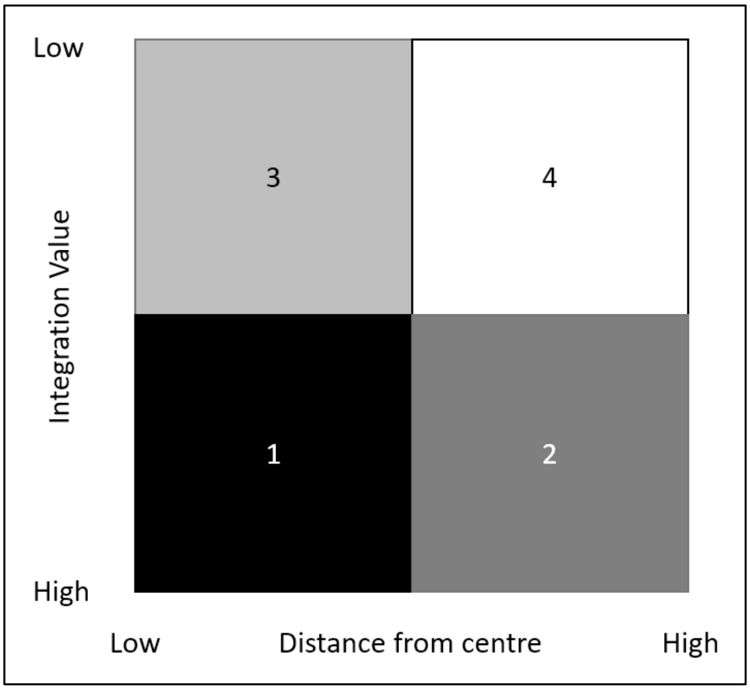

Fig. 5. Density distribution throughout the spatial configuration
Source: Deb (2015)

In a shopping mall, the natural movement will only provide good sales for some particular location due to the spatial configuration (Hillier, 1996). This unequal development needs to be negated by placing an attractor or magnet and equalizing the spatial potential (Deb, 2013). Placing an attractor can help to balance the distribution of pedestrian flows (Bai & Yao, 2018). Modern shopping mall design is generally based on the gravity model to create artificial flows of pedestrian movement between the large competing stores that work as magnets or anchors where spaced between small cellular stores (Haofeng et al., 2017). This is where most dumbbell-shaped shopping malls had done their business (Andi et al., 2020).

To equalize the customer density, there are some strategies for each different cell (Fig. 6) except cell 1. The strategy for cell 2 is to create attractors as the spaces are highly integrated but located at a higher distance from the center or the access point (Deb, 2015). The strategy for cell 3 is to enhance visibility and place proper signages to influence customer flow in that area because they are closer to the access point but integration is low (Deb, 2015). The strategy for the 4th cell is placing a proper anchor and the stores that have positive externality with the anchor store is necessary (Deb, 2015).

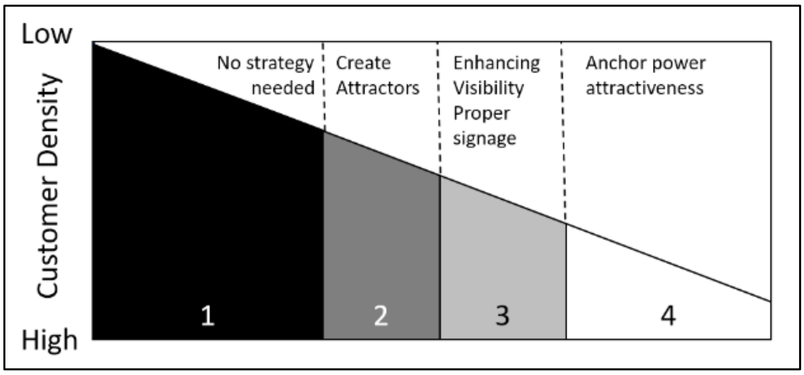

Fig. 6. Spatial equalizing strategy
Source: Deb (2015)

IV. CONCLUSION

This review article synthesized all findings of space syntax studies on shopping malls and analyzing them with the related theories to create a guide to use space syntax in the topic of optimizing shopping mall design. Based on the result and discussion, we know space syntax as a theory and method have the capability to evaluate and optimize a shopping mall design. A researcher or designer can perform space syntax analyses on a shopping mall by using computer software namely DepthMap. They can use axial, convex, isovist, VGA, and agent-based maps as the spatial representation of the shopping mall spatial configuration or choose one of those to achieve a particular analysis purpose. They can measure the space using connectivity, depth, integration, choice, and intelligibility as effectiveness indicators. To correlate the space syntax data with actual data as data validation, they can perform space syntax behavioral mapping like gate count or static snapshot.

After knowing how to perform a space syntax analysis, an architect or researcher have to know how to read and interpreted the result as indicators of an optimal shopping mall. There are six aspects that indicate the optimal shopping mall. They are pedestrian flows, horizontal complexity, vertical complexity, tenant type allocation, retail placement, and anchor placement. To achieve an optimal shopping mall design, there are guides from each aspect that we can learn about. They are as following below:

1. Pedestrian flows are represented by integration analyses. It can forecast sales of the store adjacent to the flow. Modifying the position of the entrance of changing the spatial shape of the corridor can change the pedestrian flows. There is also a non-spatial strategy to modify the flows, that is by placing an attractor.
2. The horizontal Complexity is the complex shape of the spatial structure of the floor plan mostly on the corridor area. The most optimal shape that a shopping mall floor plan should adapt is a ring-like structure with many straight paths and no uneven bifurcation path.
3. The vertical complexity of the shopping mall is complex configuration due to the multi-level building. The pedestrian flows within floors can be modified by moving the entrances and vertical transition. The best way to improve pedestrian flows on the highest level is by enhancing the visual connectivity of the place near the vertical transition like provide a lobby, or create a void along with the vertical connection of each floor.
4. Tenant type allocation is a spatial strategy of placing a certain type of tenant in the most beneficial space to achieve better pedestrian flows. Tenant types priority were indicated by the ability to attach user and the purpose of the tenant. The highest priority should be set to the tenant type with low attractiveness and weak purpose such as retail facilities.
5. Retail and anchor placement follow the rule of customer density. Customer density is measured by integration and depth from the center of the mall. The highest customer density is defined by space with the highest integration and closest to the center of the mall. The best location for placing retail is at the space with the highest customer density, while the best place for placing the anchor is at the lowest customer density.

REFERENCES

Al-Juboori, U., & Mustafa, F. (2014). Assessing the Efficiency of Functional Performance of Shopping Malls in the Kingdom of Bahrain. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 5(3), 143–165.*

Al-Sayed, K. (2018). *Space Syntax methodology*. Bartlett School of Architecture UCL: London.

Andi, A., Zain, Z., & Andi, U. F. (2020). Study on Spatial Configuration of Mall (Study Case: Matahari Mall and Ayani Megamall in Pontianak). *ARSITEKTURA, 18(2), 265–276. https://doi.org/10.20961/arst.v18i2.43471*

Aydogan, H., & Salgamcioglu, M. E. (2017). Architectural Morphology and User Behavior Relationship in Shopping Malls: A Comparative Case Study On Forum Shopping Centers inIstanbul Through Syntactic Analysis. *Proceedings 11th International Space Syntax Symposium, 11, 408:1-408:21.*

Bai, X., & Yao, S. (2018). Exploration of a New Method of Spatial Analysis to Predict the Pedestrian Pattern in the Circulation Spaces of Shopping Centers: The Case of Shenzhen. *International Journal of High-Rise Buildings, 7(2), 171–183. https://doi.org/10.21022/IJHRB.2018.7.2.171*

Behbahani, P. A., Gu, N., Nichols, J., & McGinley, T. (2017). Space Syntax in Design Curriculum. *Back to the Future: The Next 50 Years, 51st, 539–548.*

Benedikt, M. L. (1979). To Take Hold of Space: Isovists and Isovist Fields. *Environment and Planning B: Planning and Design, 6(1), 47–65. https://doi.org/10.1068/b060047*

Dawes, M. J., & Ostwald, M. J. (2013). Applications of graph theory in architectural analysis: Past, present and future research. *In Graph theory: New research. Nova Science Publisher's, Inc. https://nova.newcastle.edu.au/vital/access/%20/manager/Repository/uon:16007*

Deb, S. (2013). The Spatial Economic rationale for Optimum Rent, Area and positioning of Spaces in Planned Shopping Centres. *Pacific Business Review International, 5(10), 95–102.*

Deb, S. (2014). A Framework for Positioning of Shops in Planned Shopping Centres A Framework for Positioning of Shops in Planned Shopping Centres. *National Research Journal of Sales & Marketing Management, 1(1), 1–13.*

Deb, S. (2015). Spatial Logic of Tenanting Decision of Planned Shopping Centers: A Conceptual Approach. *JIS Management Vista, 9(1), 54–61.*

Deb, S., & Mitra, K. (2020). Spatial Logic of Shopping Malls: Application of Space Syntax in understanding Economics of Architecture. *Creative Space, 7(2), 109–117. https://doi.org/10.15415/cs.2020.72009*

Farhi, Y. B. (2009). Experiencing Urban Spaces: Isovists Properties and Spatial Use of Plazas. *Courrier du Savior, 9, 101–112.*

Fezzai, S., Fares, R. B., Boutouata, F. E., & Benachi, N. (2020). Investigating the Impact of Spatial Configuration on Users' Behaviour in Shopping Malls Case of Bab-Ezzouar Shopping Mall in Algiers. *International Journal of Built Environment and Sustainability, 7(3), 23–35. https://doi.org/10.11113/ijbes.v7.n3.507*

Fujitani, M., & Kishimoto, T. (2012). A Study About The Pedestrian Distribution in the Commercial Buildings by the Location of Stores and the Structure of the Walking Space. *Proceedings 8th International Space Syntax Symposium, 8, 94:1-94:18.*

Gil, J., Varoudis, T., Karimi, K., & Penn, A. (2015). The space syntax toolkit: Integrating depthmapX and exploratory spatial analysis workflows in QGIS. *10th International Space Syntax Symposium, 10th, 148:1-148:12.*

Ha, S., Jang, S., Yang, K., & Ro, S. (2020). ERAM as a complementary method of Spatial Syntax: Comparison of methodologies by linking spatial analysis with income-producing efficiency for a retail outlet in South Korea. *International Journal of Urban Sciences, 24(4), 516–531. https://doi.org/10.1080/12265934.2020.1742190*

Haofeng, W., Yupeng, Z., & Xiaojun, R. (2017). The Spatial Performance of Multi-Level Shopping Clusters A Case Study of Nanshan Commercial Cultural District. *International Journal of High-Rise Buildings, 6(2), 149–163. https://doi.org/10.21022/IJHRB.2017.6.2.149*

Haryadi, & Setiawan, B. (2010). *Arsitektur, lingkungan, dan perilaku: Pengantar ke teori, metodologi, dan aplikasi* (1st ed.). Yogyakarta: Gadjah mada University Press

Hillier, B. (1996). *Space is the machine: A configurational theory of architecture.* Cambridge: Cambridge University Press.

Hillier, B., & Hanson, J. (1984). *The social logic of space.* Cambridge: Cambridge University Press.

Hillier, B., & Iida, S. (2005). Network and Psychological Effects in Urban Movement. In A. G. Cohn & D. M. Mark (Eds.), *Spatial Information Theory (pp. 475–490). Springer. https://doi.org/10.1007/11556114_30*

Kim, S. (1996). A Spatial Analysis of Shopping Mall Design in the North American Urban Context. *Journal of the Architectural Institute of Korea, 12(11), 39–49.*

Klarqvist, B. (1993). A Space Syntax Glossary. *Nordisk Arkitektureforskning, 6(2), Article 2. http://arkitekturforskning.net/na/article/view/778*

Kong, E. M., & Kim, Y. O. (2012). Development of Spatial Index Based on Visual Analysis to Predict Sales. *Proceedings 8th International Space Syntax Symposium, 8, 76:1-76:13.*

Kong, E. M., & Kim, Y. O. (2013). Examination of Spatial Characteristics Influencing Sales by Tenant Types in Shopping Malls. *Proceedings of the 9th International Space Syntax Symposium, 9, 18:1-18:17.*

Lee, J. H., Ostwald, M. J., & Gu, N. (2018). A Justified Plan Graph (JPG) grammar approach to identifying spatial design patterns in an architectural style. *Environment and Planning B: Urban Analytics and City Science, 45(1), 67–89. https://doi.org/10.1177/0265813516665618*

Li, X., Lv, Z., Zheng, Z., Zhong, C., Hijazi, I. H., & Cheng, S. (2015). Assessment of lively street network based on geographic information system and space syntax. *Multimedia Tools and Applications, 76(17). https://doi.org/10.1007/s11042-015-3095-2*

Li, Z., Tang, G., & Dai, H. (2017). Optimizing Multi-Level Shopping Mall Design Using Agent Simulation Based on Visual Perception—Taking Taskin Square in Changsha as an Example. *DEStech Transactions on Social Science, Education and Human Science, 3, 336–344. https://doi.org/10.12783/dtssehs/msie2017/15457*

Min, S. Y., Kim, C. J., & Kim, Y. O. (2012). The Impacts of Spatial Configuration And Merchandising on The Shopping Behavior In The Complex Commercial Facilities. *Proceedings 8th International Space Syntax Symposium, 8, 66:1-66:15.*

Mustafa, F. A., Hassan, A. S., & Baper, S. Y. (2010). Using space syntax analysis in detecting privacy: A comparative study of traditional and modern house layouts in Erbil city, Iraq. *Asian Social Science, 6(8), 157. https://doi.org/10.5539/ass.v6n8p157*

Nes, A. van, & López, M. (2010). Macro and micro scale spatial variables and the distribution of residential burglaries and theft from cars: An investigation of space and crime in the Dutch cities of Alkmaar and Gouda. *The Journal of Space Syntax, 1(2), 314. http://joss.bartlett.ucl.ac.uk/journal/index.php/joss/article/view/296/pdf_25*

Nes, A. van, & Yamu, C. (2018). Space Syntax: A method to measure urban space related to social, economic and cognitive factors. *The Virtual and the Real in Planning and Urban Design. Routledge, Taylor and Francis group, 136-150. https://doi.org/10.4324/9781315270241-10*

Omer, I., & Goldblatt, R. (2016). Using space syntax and Q-analysis for investigating movement patterns in buildings: The case of shopping malls. *Environment and Planning B: Urban Analytics and City Science, 44(3), 504–530. https://doi.org/10.1177/0265813516647061*

Penn, A., & Turner, A. (2002). Space Syntax Based Agent Simulation. In M. Schreckenberg & S. D. Sharma (Eds.), *Pedestrian and Evacuation Dynamics (pp. 99–114). Springer-Verlag. http://www.springer.de*

Turner, A. (2004). *Depthmap 4: A Researcher's Handbook*. London: University College London. http://www.vr.ucl.ac.uk/depthmap/depthmap4.pdf

Turner, A. (2007). From Axial to Road-Centre Lines: A New Representation for Space Syntax and a New Model of Route Choice for Transport Network Analysis. *Environment and Planning B: Planning and Design, 34(3), 539–555. https://doi.org/10.1068/b32067*

Turner, A. (2001). Depthmap: A Program to Perform Visibility Graph Analysis. *Proceedings of the Space Syntax 3rd International Symposium, 3.*

Turner, A., Doxa, M., O'Sullivan, D., & Penn, A. (2001). From Isovists to Visibility Graphs: A Methodology for the Analysis of Architectural Space. *Environment and Planning B: Planning and Design, 28(1), 103–121. https://doi.org/10.1068/b2684*

Vaughan, L. (2007). The spatial syntax of urban segregation. *Progress in Planning, 67(3), 205–294. https://doi.org/10.1016/j.progress.2007.03.001*

Vialard, A., Ingleby, T., & Ring, P. (2017). Fight for Frontage: A Shopping Mall On A High Street. *Proceedings 11th International Space Syntax Symposium, 11, 119:1-119:20.*

Wong, J. F., & Tam, K. K. L. (2019). Spatial identity of fashion brands: The visibility network in complex shopping malls. *The IFFTI 2019 Conference Proceedings, 168–185. https://fashioninstitute.mmu.ac.uk/ifftipapers/paper-85/*

Yiu, C.-Y., Xu, S. Y., & Ng, H. C. (2008). Space allocation and tenant placement at high-rise shopping malls. *Journal of Retail & Leisure Property, 7(4), 315–324. https://doi.org/10.1057/rlp.2008.22*

Yuo, T. S., Lin, Y.-C., Wu, J.-H., & Huang, K.-Y. (2013). Shopping Centre Spatial Complexity, Management Efficiency and Tenant Mix Variety. *National Science Council, 1–17. https://ideas.repec.org/p/arz/wpaper/eres2013_46.html*

Zhang, L., Zhuang, Y., & Dai, X. (2012). A Configurational Study of Pedestrian Flows in Multi-level Commercial Space: Case Study Shanghai. *Proceedings 8th International Space Syntax Symposium, 8, 44:1-44:16.*