

# Sequential Analysis on the Intensity of Store Information to the Commercial Street - from the Viewpoint of Pedestrian Movement -

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## Abstract

Stores along commercial streets display their information to the outside using their facades facing the street to attract pedestrians, who are potential customers. Pedestrians, who are visitors to the commercial area, are exploring stores to meet the purpose of their visit. During this process, pedestrians experience the city space. This paper proposes a methodology for the sequential analysis of a commercial street from the viewpoint of pedestrian movement based on business type, which might be the most important factor for the formation of the atmosphere of a certain street, and location relationships between the pedestrians and stores on a street. To construct a quantitative model, the distribution of stores was first divided into a certain unit considering the recognition distance of pedestrians. In a divided unit, the business type of each store was replaced with a different point source individually and stacked vertically according to the location inside the building. By calculating the sequential change in intensity of the point sources, a final analytical model was obtained as the standing point of pedestrian movement. For the case study, the developed model was applied to Jungang-ro and Myeongdong-gil in Myeongdong and verified that the difference in store influence on pedestrians depended on the width of the street or number of floors where the store was located.

**Keywords:** commercial street; sequential analysis; information intensity; store influence

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## 1. Introduction

### 1.1 Background and Purpose of Study

In central areas with many pedestrians walking up and down, stores that reflect the characteristics and needs in the area naturally form a commercial street. Visitors to a commercial street experience the city through the activities from the stores most suitable for their needs that they find as they walk along the street, such as shopping, drinking tea or eating at a restaurant, etc. In this sense, commercial areas are not only the place for consumption and exchange in the city, but also play an important role in providing a place to experience the vitality of the city.

Stores along commercial streets display their information to the outside using their facades facing the street to attract pedestrians inside, who are potential customers. Various types of information on stores can be found easily in a commercial street. A large front window glass is used to allow pedestrians to look into the shop and a signboard or sometimes a display

stand is placed on the street to attract the attention of pedestrians. The way of blurring the boundary between the street and store can also be seen, such as leaving the entrance door open for business or setting up tables on the street for an open-air café, to encourage pedestrian flow inside the store.

Pedestrians enjoy such atmosphere and experience the commercial space by recognizing a continuously changing streetscape as they walk along the street. In other words, space is perceived not at a fixed point but in the process of recognizing the change in visual perception as we move. For pedestrians, the type of business of a store plays the most important role in determining the characteristics of the commercial street among the assortment of factors of a commercial street.

Pedestrians can see so-called fashion streets, where clothing or fancy stores that follow fashion trends are gathered, or food streets, where restaurants, pubs or bars are lined up. The experience of pedestrians on the commercial street is influenced by the composition of the diverse stores that the pedestrians come across while walking along the street as they search for stores that meet the purposes of their visit.<sup>1</sup>

From this point of view, to extract the dominant characteristics of the commercial street from the consecutive arrangement of various stores, the following

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( Received October 7, 2014 ; accepted June 25, 2015 )

approaches will be applied to simplify the attributes of the various stores according to the business type. The changing influence of the stores in the locational relationship with a pedestrian will then be quantified. This study aims to develop an analytic model that can be applied to a commercial street and a case study will be implemented to verify its applicability.

### 1.2 Methodology and Scope of Study

To convert the business types of stores to the quantitative data available, a method to examine the attributes of the stores in a certain divided unit and turn them into a standardized arrangement format will be proposed. The divided unit from the continuously lined stores means a physically possible recognition range of people considering the distance between the standing point of a pedestrian and the borderline of the stores. The methodology of this model is to quantify the intensity of store information based on the location relationship of the store arrangement with pedestrians. As a pedestrian moves in a certain direction, the basic unit within the recognition range of the pedestrian moves along the street in the same direction. During this moving process of pedestrians, the model will calculate the changing influence of each business type of stores under the entire store arrangement on the street and convert them into index data for a comparison.

Finally, the developed model will be applied to a real commercial street to evaluate its suitability as an evaluation tool for commercial streets in view of each business type. From this procedure, the structure of store arrangement from the viewpoint of pedestrian movement will be analyzed and the characteristics of a commercial street according to the business type distribution of the stores will be drawn out.

### 1.3 Review of Related Studies

Sequential analysis on a street space is necessary because the experience of a pedestrian is obtained by their spatial movement. Against this background, related studies have been conducted to analyze continuity of streetscape.

Oikawa (1983) developed a methodology to analyze quantitatively all the facade factors separately based on the area ratio of each factor. In addition, he examined the diversity of continuous facade factors on both sides of the street by applying the methodology to a commercial street. As shown in Fig.1., the change in the distribution of each factor was described continuously by sliding the window in a certain width, which was formerly set up as a basic unit for analysis.

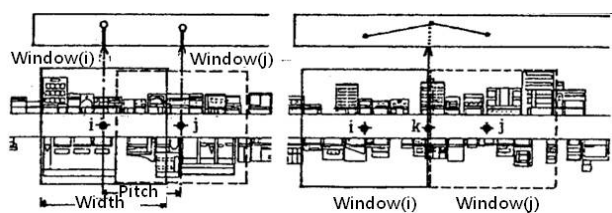


Fig. 1. Quantification of Facade Factors by Window Unit (Oikawa, 1983)

Hayami (1997) regarded sequence landscape as a series of scenes and implemented an image analysis of the change in the concentration value of a street's image screen taken from a moving viewpoint using the method of signal processing in a Fourier Transform. Ikeda (2004) used the continuous record technique that described continuously the change in the spatial components of street space to extract the impressive spatial components.

Yoon (2009) constructed a network structure of a connection relationship between the street and store based on the location of the store entrance, as shown in Fig.2. With the constructed street network to which after all the necessary spatial attributes are given, the hierarchy of the pedestrian volume on the edges of the network structure (divided street unit) was extracted by implementing a pedestrian multi-agent simulation.

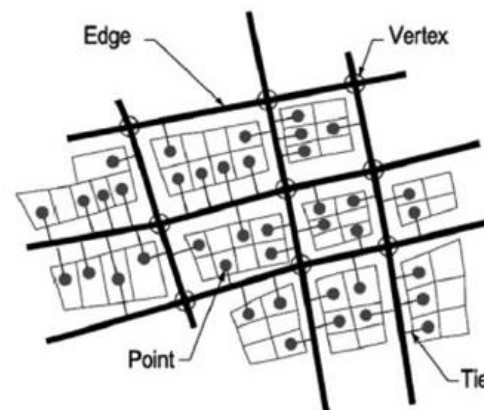


Fig. 2. Connection Relationship between Street and Store (Yoon, 2008)

For commercial street targeted studies, sequential analyses of the facade factors of a building or the attributes of a store from the viewpoint of pedestrians can be determined by establishing the relationship between the building or store and street. The intensity of store information is affected by the floor of a store and the length of the facade that faces the street because human being's visual perception is limited. This study suggests a method to quantify the attributes of stores shown on the facades of buildings facing commercial streets from the perspective of pedestrians walking on the street.

The attributes of stores are classified according to their business type from the information on stores from the ground floor to the top floor of the building, and standardized to be converted into a multi-layer arrangement within a certain divided unit.

To set up this basic unit for analysis, a virtual window with a certain size will be defined considering the possible recognition distance and range of pedestrians. Based on this procedure, sequential analysis of the arrangement of store attributes on both sides of the street will be possible.

## 2. Construction of Spatial Information

### 2.1 Classification of Store Attributes

Through a field survey of the commercial facilities in the analysis target area, the attributes of the stores were examined to patternize the characteristics of the major business types. In this study, the stores were classified into 7 types considering the characteristics of the business types in the target area — clothing stores, shoe stores, cosmetics stores, accessories stores, restaurants, service stores and miscellaneous stores, as shown in Table 1. A code number from 1 to 7 was given to each classified business type.

Table 1. Classification of a Store's Business Type

Code	Category	Subcategory
1	Clothing	Men's Wear, Lady's Wear
2	Shoes	Bootery, Sports shoes
3	Cosmetics	Cosmetics, Skin-care store
4	Accessories	Accessories, Jewelry, Watches
5	Food & Beverage	Cafe, Fast Food, Restaurant, Bar
6	Service	Beauty Parlor, Clinic
7	Miscellaneous	Others, etc.

### 2.2 Data Coding

For the first step to quantify the information on stores, the facades of the buildings on a single street side will be divided horizontally into a certain unit and vertically into a certain cell related to the floor level of the building (Fig.3.). If the store information appears in a divided cell, the business type of the store will be replaced with a point source of light, which originates from the thought that the intensity of store information transmitted to a pedestrian could be regarded as the illuminance of a point source.

The cell will remain blank if no information appears. When multiple business types appear in a cell, the business type that occupies the largest area in the cell will be accepted. After the business types of every cell are decided, a code number will be given according to each business type. The size of the unit is considered to be set up according to the facade width of the store facing the streets in the analysis target area.



Fig.3. Examination of the Store Attributes<sup>2</sup>

## 3. Analysis Method

### 3.1 Division of Recognition Range

Because human beings have limited visual perception in space, it is necessary to set a limit on the recognition range. In this study, a fixed size of virtual window was applied for setting the range. The window

size is defined up to 15 m considering the visually perceivable distance of pedestrians. Two windows are considered as one set, as shown in Fig.4., in that the store attributes appear on both sides of the street. This pair of windows is moved at an interval of one unit to examine the attributes.

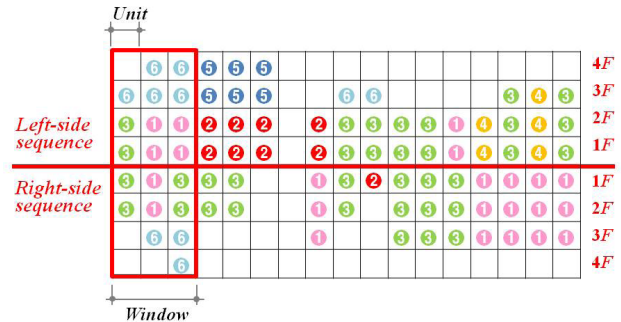


Fig.4. Division of Recognition Range (Window)

### 3.2 Intensity of Store Information

The schematic diagram of Fig.5. explains the geometric relationship between a pedestrian moving in the center of the street and the point sources in the window representing the store attribute. Regarding the intensity of store information sent to a pedestrian as the illuminance of a point source, equation (1) could be used to calculate its intensity. In this sense,  $E$  is defined as the intensity of store information to the pedestrian.

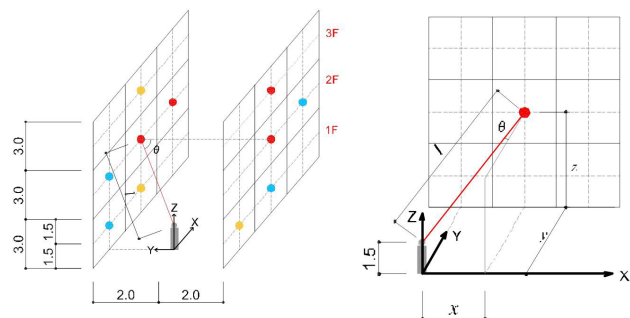


Fig.5. Geometric Relation of Store Information and Pedestrian

$$E = I_{\theta} \times \frac{\cos \theta}{l^2} \quad (1)$$

where,

$\theta$  : incidence angle between the perpendicular line and the line between the point source and the pedestrian,

$I_{\theta}$  : point's intensity,

$l$  : distance from the pedestrian to the point source of information (m)

$E$  is proportional to the cosine of the incidence angle, and inversely proportional to the square of the distance.  $E$  has a higher value if the distance between the store attribute and pedestrian is shorter and the incident angle by the light ray is smaller. Therefore, the store influence value can explain the fluctuations



of intensity depending on the store's floor location and distance from the pedestrian.

Suppose that the intensity of a point source is constant regardless of the store attribute,  $I_\theta$  in equation (1) can be replaced by a constant value  $k$ .<sup>3</sup> In a certain section of a commercial street,  $E_i$ , the sum of intensity of store information value for a business type of store  $i$ , is calculated by sliding the window by one unit throughout the entire path.

$$E_i = \sum k \times \frac{\cos \theta}{l^2} \quad (2)$$

where,

$i$  : attribute of the store

$k$  : constant value

$l$  and  $\cos \theta$  are calculated using equations (3) and (4) based on the location relationship between the pedestrian and store attribute that is replaced by a point source of light in Fig.5.

$$l = \sqrt{x^2 + y^2 + (z - 1.5)^2} \quad (3)$$

$$\cos \theta = \frac{y}{l} \quad (4)$$

where,

$x$  : length of a unit,

$y$  : 1/2 of the mean width of the street,

$z$  : height from the ground level to half of the floor height

For example, suppose that  $x$ ,  $y$  and  $z$  of Fig.5. is 5 respectively,  $l$  from equation (3) is  $\sqrt{5^2 + 5^2 + (5 - 1.5)^2}$  and  $\cos \theta$  from equation (4) is  $5 / \sqrt{5^2 + 5^2 + (5 - 1.5)^2}$ . If  $I_\theta$  is 1 in equation (1), the value of  $E$  will be calculated as follows.

$$E = I_\theta \times \frac{\cos \theta}{l^2} = 1 \times \frac{5}{(\sqrt{5^2 + 5^2 + 3.5^2})^3} \approx 0.01018$$

Because  $E_i$  is the sum of intensity of store information value for the entire length of a commercial street, it cannot be used as an index for comparison among streets with different lengths. Therefore,  $E_i$  should be divided by the number of windows for the target street. This calculated value was defined as an index of the store influence,  $SI$ .

$$SI = \frac{E_i}{n} \quad (5)$$

where,

$n$  : number of entire windows for the target street

The  $SI$  index is affected by physical elements, such as the width of the street and number of floors of a building. The index tends to be higher if the number of stores on the facade increases.

## 4. Case Study

### 4.1 Outline of Target Area

The target area selected for the experiment was Myeongdong (Fig.6.), an enclosed commercial district with Eulji-ro, Nadaemun-ro, Toegye-ro, and Samil-ro in Seoul, Korea.<sup>4</sup> This area is a representative central commercial area with various types of store, which can show the diverse fluctuation of intensity of store information to the commercial streets.

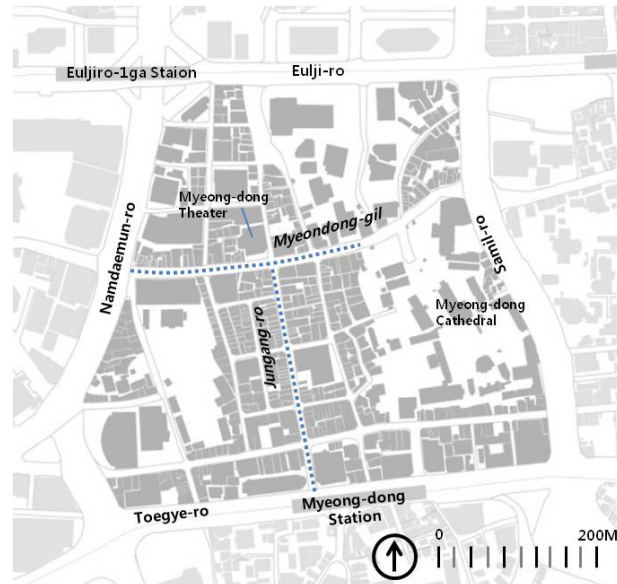


Fig.6. Overview of Myeongdong District

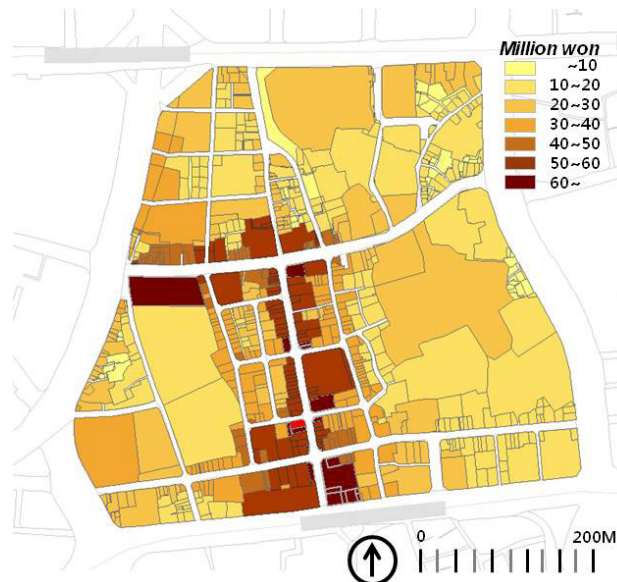


Fig.7. Declared Land Price per 1 m<sup>2</sup> in Myeongdong (as of 2011)

Myeongdong has the highest land prices in Korea, which has a direct effect on the rents of commercial stores.<sup>5</sup> Jungang-ro and Myeongdong-gil are major commercial streets composed of small sized lots with high declared land prices in this area as shown in Fig.7.

Because Myeongdong Catholic Cathedral, several office buildings and shopping centers are located on these roads, there are a considerable number of large-scale land lots. On the other hand, inside the district, small-scale deep and narrow land lots generally form the commercial street.<sup>6</sup> For this reason, large high-rise buildings are located on the major roads that form the boundaries of the district, whereas 3 to 5 story buildings are located on the commercial street inside the district. The district also has double spatial structures.<sup>7</sup>

#### 4.2 Overview of Analysis Target Street

For the experiment target, two major streets of Myeongdong, Jungang-ro and Myeongdong-gil, which best show the commercial characteristics of Myeongdong, were selected (Fig.8.). An analysis of the store influence on the commercial street from the viewpoint of a pedestrian is considered suitable because both streets are creating pedestrian-only shopping space by traffic control.



Fig.8. Images of the Two Main Streets

Table 2. summarizes the physical conditions of Jungang-ro and Myeongdong-gil. The unit size for the analysis was set to 5 m considering the average facade width of a building in the target streets and the measuring window for the analysis includes three units (15 m).

Jungang-ro stretches from Myeongdong subway station to the Myeongdong Art Theater, which has a total length and width of 300 m and 10 m, respectively, and most buildings have five or less stories. The street forms a human-scale space for pedestrians.<sup>8</sup> Most land lots on Jungang-ro have a size of 150 m<sup>2</sup> or less, excluding where large-scale shopping centers are located. The buildings are also small; 27% of them are 2 to 3-stories and 50% are 4 to 5-stories. In addition, they make a horizontal landscape of continuously connected buildings in between the attached wall. The average facade width of the buildings and stores are approximately 7 m and 3 to 5 m individually. A majority of the stores are small excluding a few large-scale shopping centers.

Myeongdong-gil stretches 315 m from its gate on the Nadaemun-ro side to the direction of Myeongdong Catholic Cathedral. The width is 15 m, which is larger than that of Jungang-ro. The buildings have heights ranging from 2 to 16 stories. Compared to Jungang-ro with small-scale stores on the narrow street, there is a

different liveliness on Myeongdong-gil because large sized buildings, such as a few large-scale shopping centers, a UNESCO building and the Myeongdong Theater, are located on both sides of the street.

Table 2. Physical Conditions of the Target Streets

	Jungang-ro	Myeongdong-gil
Street Width	10 m	15 m
Street Length	300 m	315 m
Number of Store Attributes	308	231
Number of Measuring Windows	58	61

#### 4.3 Distribution of Stores According to the Business Type

The distribution of store attributes on the two main streets was examined using the basic unit, the cells standardized according to the business type (Fig.9.).<sup>9</sup> The clothing business type showed the highest ratio on Jungang-ro, followed by cosmetics and shoe business types. A large number of restaurants are located on the upper ground floor. On the other hand, in Myeongdong-gil, the service business was the highest, followed by clothing and restaurant business types. In the case of the service business type, more stores were located on the upper ground floor than the ground floor facing the street.

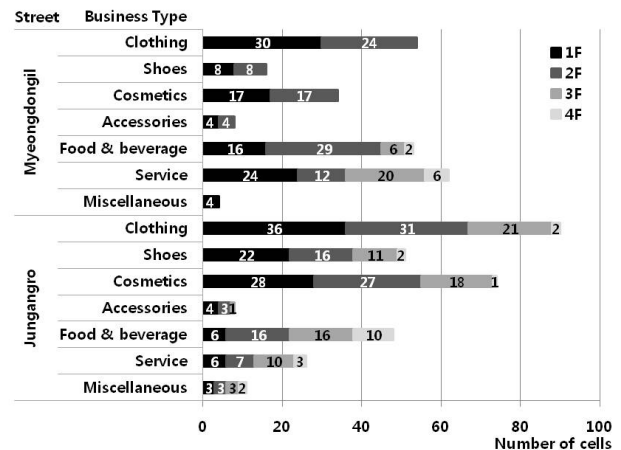


Fig.9. Distribution of Business Types

A majority of store types on the ground floor, which is directly accessible from the street, were clothing, shoes and cosmetics (Fig.10.). If such business types were on the upper ground floor, most cases were one store with more than 2 floors with a staircase directly connected to the ground floor. Such business types have a close relationship and direct interaction with the street.

On the other hand, in the case of restaurant and service businesses, 78% and 66% of the stores were located on the upper ground floor. In such business types, there is a tendency of being visited more by pedestrians with a concrete purpose rather than those with an occasional interaction with the street.

#### 4.3 Analysis of Store Influence

A field survey was conducted on the business type of store from the first floor (ground floor) to the fourth



Fig.10. Distribution of Business Types on the Ground Floor

floor on the target streets. A walking path was set in the direction from Myeongdong subway station to Myeongdong Theater on Jungang-ro and from Nadaemun-ro to Myeongdong Catholic Cathedral On Myeongdong-gil.<sup>10</sup> Fig.11. and Fig.12. show the analysis results of the store influence on Jungang-ro and Myeongdong-gil.

The store attributes were standardized in an arrangement with a point source of light, as displayed on the top. Intensity of store information of each business type ( $E_i$ ), which was calculated by sliding the window by one unit along the store arrangement, is displayed with a fluctuation in graph. From the center line, the upper part represents the fluctuation in  $E_i$  of left side facades, and the lower part represents right side facades. A thick line above the center line represents the sum of fluctuations of both the left and right sides of the facades.

In the graph of the total intensity of store information ( $\sum E_i$ ), although the value decreases temporarily at the intersection point where the store attributes disappear, it shows a certain value continuously throughout the entire path in both Jungang-ro and Myeongdong-gil.

The store influence index ( $SI$ ), the mean  $E_i$  for the entire path was approximately two times higher on Myeongdong-gil than on Jungang-ro, which explains that the store information on building facade was less on Myeongdong-gil than on Jungang-ro.

In the  $SI$  value of Jungang-ro, clothing stores (0.060), cosmetics stores (0.051) and shoe stores

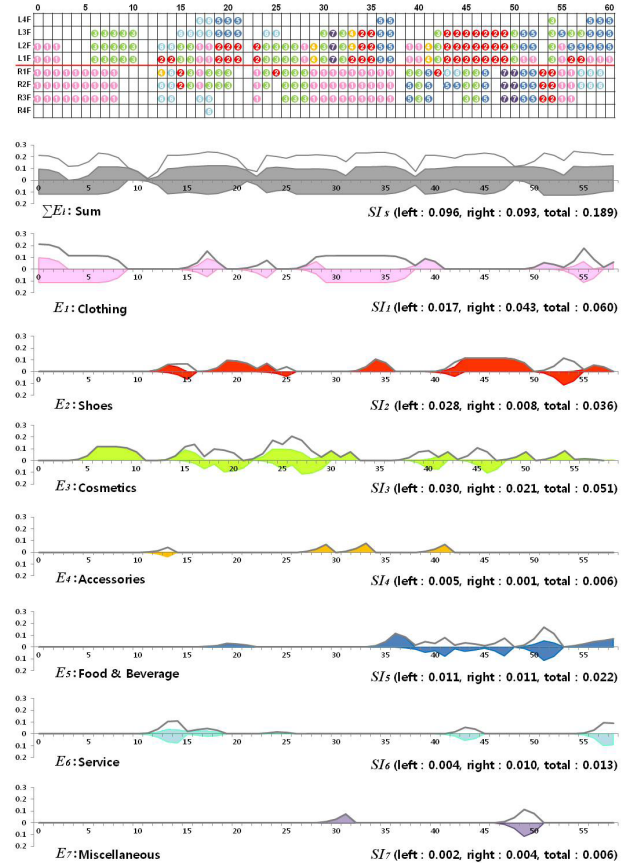


Fig.11. Analysis of the Store Influence on Jungang-ro

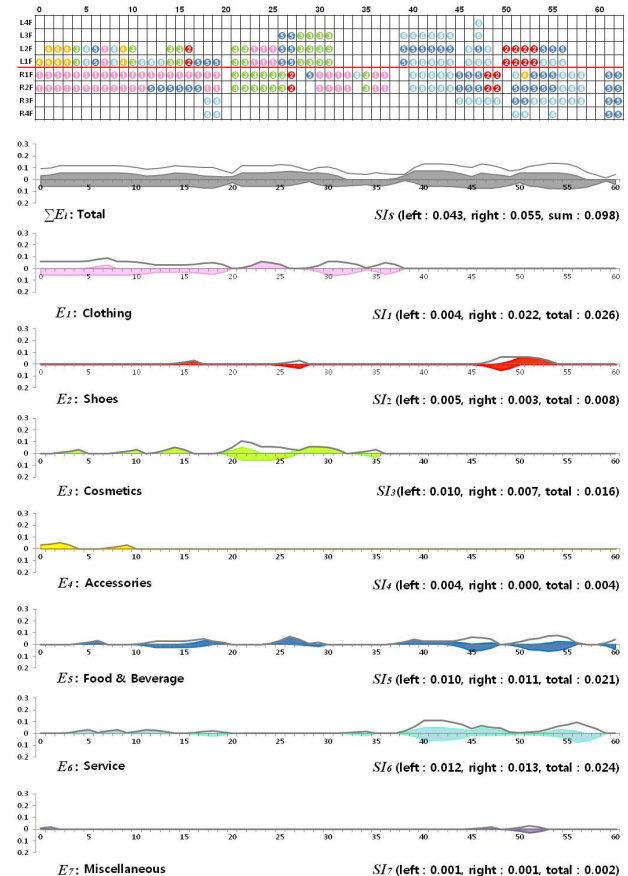


Fig.12. Analysis of the Store Influence on Myeongdong-gil



(0.036) showed a high result. The clothing store with the highest  $SI$  value showed two times higher  $SI$  value on the right side (0.043) than that on the left side (0.017), and the wavelength of  $E_l$  converged on a certain section. This indicates that a certain section of the street is strongly influenced by large-scale clothing stores, such as shopping centers.

The  $SI$  of the top 3 business in Myeongdong-gil showed little difference, 0.026, 0.024 and 0.021 for clothing, service and restaurants, respectively. Extracting the dominating business types is difficult but the wavelength distributions of the  $SI$  value for clothing sales and service business were separated clearly by Myeongdong Theater (between unit 32 and 38). The service business showed a higher number of point sources of light (54 for clothing sales and 62 for service business) but the  $SI$  value was higher in clothing sales than in the service business. This can be explained from the tendency that clothing stores are mainly on the ground floor and service businesses are on the upper floor. In other words, the clothing stores at the walk level have a stronger effect on the street.

## 5. Discussion and Conclusion

Human experience in urban space is obtained in the process of perceiving continuous changes in the streetscape on the path of movement. If the change in buildings along the streets is the most important factor of the spatial sequence, the business types of the stores on building facades will be the largest factor that determines the characteristics of a commercial street.

Visitors to commercial streets experience urban space as they are exploring stores to meet the purpose of their visit or attract their attention. During this process, the experience of the visitor was formed sequentially because such experience is accompanied by movement through walking.

This study suggested a methodology to describe the characteristics of a commercial street by examining the relationship between the business type of store and street that is the most influential factor determining the ambience on a commercial street. For quantitative analysis of such a relationship, stores on a street were classified according to their business type in a certain divided unit, and replaced with the standardized arrangement of a point source of light for the calculation of intensity of store information. The store attributes replaced by the arrangement of point sources were converted to the intensity of store information toward a certain point in the street, which indicates the intensity of store information by business type with the wavelength for the entire path. The  $SI$ , which is the average store influence throughout the street, was calculated to extract the factors that dominated the characteristics of the commercial street by a quantitative comparison among business types.

A case study on Jungang-ro and Myeongdong-gil in the Myeongdong district was conducted to verify the applicability. The case study showed that the difference in store influence depended on the width of the street or number of floors where the store was located.

The analysis methodology suggested in this study can be used to extract the attribute with the largest influence on the street by evaluating the multilayered structure of the store arrangement on a commercial street from the viewpoint of a pedestrian to identify the factors that determine the characteristics of a commercial street. Possible areas for improvement can also be identified.

To secure the universality and stability of the proposed methodology, it is essential to improve the model up to a general one that can be applied to other commercial streets through more experiments. In detail, the universality of systematic categorization of the business type is necessary. Because the categorization of the business type of store in this study was based on a special composition in Myeongdong, there is a limitation on application of the categorization method to other commercial streets. Therefore, classification of the business type of store needs to be systematized to apply the methodology to other commercial streets. In addition, the model needs to be applied to an analysis of not only a linear street but also a complicated street with a network structure.

## Notes

<sup>1</sup> Yoon (2008, 2010) developed the network based multi-agent simulation model from the hypothesis that pedestrian movement can be considered as an outcome of the configuration of street network and the location of specific attractions such as stores. The pedestrian simulation was applied to the commercial district of Shimokitazawa, Japan and performed on the basis of the information collected from target area examinations. The comparison between the resulting outcome of simulation and the actual pedestrian volume data showed a strong correlation, which means stores affect the choice of pedestrian's path.

<sup>2</sup> The left photograph contains the building facades in Gwangbok-ro, the commercial street in Busan.

<sup>3</sup> If there is a special condition among business types in the target area, it is possible to put weight on each intensity of information according to the store attributes. In this study, it was assumed that there was no difference among business types of stores and the amount of store information displayed toward the street; this study assumes  $k=1$  for all business types.

<sup>4</sup> Myeongdong is the largest commercial district in South Korea, which was formed during the late Joseon Dynasty period. This place has played a role as a fashion street and has become an international commercial street that is visited most frequently by foreign tourists as cosmetic sales businesses targeting foreign tourists and manufacturer-direct-sale type global clothing brands have recently made their way onto this street.

<sup>5</sup> In Myeongdong, there is a land lot with the highest declared land value in Korea. The value is KRW 623 million per  $m^2$  as of the year 2011. At the site, a 3-story cosmetic sales store is located at the moment. Despite the high rent, the reason for opening a store in this area is that it is possible to expect business profits and advertising effects in the nation's most central area with a floating population. In addition, a store in the area is expected to play a role as an antenna shop that might be able to identify the taste and preference of consumers in an accurate and fast manner.

- <sup>6</sup> Land lots of 1,000 m<sup>2</sup> or more comprise 60% of the total area of the district, whereas the number of land lots with such a size is only 5.5% of the total number of 848. In contrast, the number of land lots of 90 m<sup>2</sup> or less comprises 53.7%, 18.6% for 90~150 m<sup>2</sup>, 13.7% for 150~300 m<sup>2</sup>, showing that small-scale land lots of 300 m<sup>2</sup> or less comprise 86%.
- <sup>7</sup> Buildings with 5 stories or less comprise 75% of the total buildings. (3 stories or less: 42.6%, 4~5 stories: 31.7%, 6~10 stories: 12.7%, and 11 stories or more: 5.4%)
- <sup>8</sup> Ashihara (1984) suggested the ratio of the street width (D) to the building height (H) as an index that represents feeling of enclosure for street space. The boundary of D/H=1 has a variable node for space quality. If D/H is less than 1, the street is considered to provide people with friendliness. The D/H ratio of Jungang-ro is 0.5~0.7, which shows that the street provides pedestrians with a pleasant ambience.
- <sup>9</sup> Classification of the business type of a store was based on a field survey conducted in October 2011.
- <sup>10</sup> To buildup the analysis data, the photos such as in Fig.8. and Fig.9. were taken at every 5 meters in sequence along the target streets. Street views provided by the Internet portal sites such as 'Naver' and 'Daum' were used to supplement the site survey photos.
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