Quantitative Analysis on the Spatial Configuration of Korean Apartment Complexes

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Abstract

The objective of this research is to investigate the periodic changes in external spatial configuration of Korean apartment complexes and their planning concepts with quantitative spatial analysis methodology, for the purpose of comparatively analyzing the results with the relevant social, economic climate of its period. Based on the axial map analysis method, we established a spatial configuration analysis model of apartment complexes by setting the relevant analysis indices and criteria for periodic, spatial classification. One-way ANOVA was applied to the periodical indices of integration and PD for each spatial component, and then the periodical mean values of the indices for each spatial component were calculated to make comparisons across the periods. The results revealed that differing planning initiatives according to each period were not only reflected in the spatial configuration of the apartments in their entirety, but that it was also possible to extract key elements in planning which made up the apartments in that particular period.

Keywords: apartment complex; spatial configuration; Time-series analysis; spatial analysis; space syntax

1. Introduction

Apartments are listed as one of the most common forms of housing in Korea since the nation's founding. Starting with the capital city of Seoul, the building of apartments has grown incredibly since the 1960s, and today it has become a major part of Korean society accounting for over 60 percent of home ownership. The history of Korean apartments has been in keeping with Korea's modernization. According to the demands of different periods, various planning methods have been attempted and applied to apartments, and such changes of planning trends have been reflected in the spatial configuration of apartment complexes as well as that of apartment units. Thus, by investigating the periodic changes in spatial configuration of apartment complexes, it will be possible to identify differences in their planning concepts across time, and grasp the historical background of the living culture at that time.

Most existing studies, dealing with the historical changes in apartment units and complexes, used qualitative research approaches such as case classification, other than quantitative approaches such as statistic methods. The former approaches fundamentally allow the subjective intervention of researchers, which would be unsuitable if research targets have a large structure and the differences between them cannot be easily grasped with researcher's insight. As mentioned above, apartments are the predominant type of housing in Korea with great variation of types. Thus, examining the diachronic changes of Korean apartments across time requires the introduction and application of a more quantitative, objective research methodology.

A research methodology that quantitatively examines the configuration properties of architectural and urban spaces based on the interrelational properties of space is called quantitative spatial analysis methodology. By adopting this methodology, it is possible to numerically define the topological centrality, accessibility, and circulation efficiency of a specific spatial component within the spatial structure. Also, one can overcome the subjectiveness and arbitrariness often shown in existing qualitative studies, attaining objectiveness and scientific clarity. Many researchers have attempted to interpret the social implication of architectural/urban spaces using spatial analysis, some of which included identifying typologies of spatial interrelationship within a single housing unit. However, no time-series approach has been made yet that deals with the spatial structure of collective housing including apartments, at the complex-scale level.

This research assumes that periodic features are reflected not only at the housing unit level, but also in the configuration of the whole apartment complex.
2. Quantitative Analysis of Spatial Configuration

2.1 Spatial Analysis Methodology

Spatial analysis methodology refers to a technique that quantitatively analyzes a spatial structure, which means a topological structure in terms of the configuration of spatial components. Spatial analysis methodology in this context is defined as a technique that addresses the spatial structure and quantitatively analyzes a spatial structure, using the spatial analysis method set as a foundation, we will establish a spatial configuration analysis model for apartment complexes by setting the relevant analysis index, periodic classification, and spatial components. Integration and point depth are used for the analysis index, and the time frame from 1960 to 2009 is divided into six periods for periodic classification. The spatial components are set as boundary, complex entry, retail entry, apartment entry, playground, exercise facilities, parks and recreational, schools, etc. Through the developed analysis model, each selected complex is analyzed and its findings are interpreted from a social, economic perspective.

With the existing spatial analysis method set as a foundation, we will establish a spatial configuration analysis model for apartment complexes by setting the relevant analysis index, periodic classification, and spatial components. Integration and point depth are used for the analysis index, and the time frame from 1960 to 2009 is divided into six periods for periodic classification. The spatial components are set as boundary, complex entry, retail entry, apartment entry, playground, exercise facilities, parks and recreational, schools, etc. Through the developed analysis model, each selected complex is analyzed and its findings are interpreted from a social, economic perspective.
map. Axial map associates an axial line to a unit space to represent built space into a network, mostly used in the context of analyzing external spaces in city- or neighborhood-scale streets. Convex map associates a convex space to a unit space, mostly used in the context of analyzing internal spaces in a building. Grid map associates a grid point to a unit space, widely used in analyses ranging from internal spaces in a building to medium scale complexes, mainly applied to open plan built space.

2.2 Literature Reviews

As noted above, spatial analysis methodology has drawn attention as a quantitative, objective research methodology, and as an alternative to existing qualitative, subjective, and non-scientific approaches employed in the architectural planning research field.

It is not so hard to find housing related studies that employed spatial analysis methodology. Hanson (1998) used the space syntax to interpret and build a typology of the spatial configuration of housings in Banbury, England and in Normandy, France. Orhun et al. (1996) used a similar approach as Hanson to work on the typology of the spatial configuration of traditional Turkish houses and to interpret its social, regional meaning.

Also, Jaepil Choi's research is especially worth of notice. He used space syntax to demonstrate that the Korean traditional lifestyle has lasted through the times of transformation where Korean traditional housing was replaced by apartments (Choi, 1987). He also used space syntax to analyze periodic changes in the characteristic of Korean apartment units, through which he found that their planning trends reflected the socio-economic factors over time. In that research, Choi et al. took a time-series approach to analyze 4LDK and 3LDK apartment units built after the 1960s in the Seoul metropolitan area. They classified the analysis periods into four, the first period being when the first large-scale apartment complexes appeared in Korea, the second when large-scale complex construction by the private sector started and became heated, the third when the new town projects and apartment design competitions were held, and the last when new cities were developed and the two-million housing project was underway. They extracted periodic changes in configurational properties from inner spaces of apartment units and resulting changes in the life pattern, to conclude that the socio-cultural issues at that time, such as the rise in nuclear-family households, a shortage of housekeepers, the increase in two-income families, etc., are reflected in the physical form of housing (Choi et al., 1996a; 1996b).

On the other hand, there are few time-series approaches to analyze the spatial structure of external spaces at the apartment complex-level. Recently in Korea, various attempts are being made in planning for external spaces of apartment complexes for the purpose of improving the quality of life, such as creating a green and eco-friendly environment including landscape, adding outdoor service facilities, and so on. This comes from rising interest in planning external spaces as public domains. Thus it can be said that external spaces of apartment complexes reflect the socio-cultural features of the times, just as single housing units do. However, there is hardly any research associating the configurational changes in external spaces of apartment complexes with changes in the social situation. In this study, focusing on the spatial configuration of external spaces in apartment complexes, the quantitative examination of the hierarchy of socio-cultural functions and meanings inherent in the spaces will be made using spatial analysis methodology.

3. Analysis Model and Methods

This research focuses on analyzing the spatial configuration of apartment complexes from the viewpoint of pedestrian movement. Thus it will be carried out by adopting the axial map among network representation methods available in spatial analysis, mainly utilizing indices of point depth and integration for analyzing accessibility and circulation efficiency on the spatial configuration of apartment complexes.

This research established analysis models and methodologies in order to conduct a time-series analysis on the changes that have occurred in the spatial configuration of apartment complexes. Based on the axial map method of network-based spatial analysis, we set up the analysis indices for measured values, categorization as a standard for compiling the measured values, and periodical classification set according to apartment complex's moving-in time as an independent variable. The details are as follows.

First of all, raw data for the subject of interest was gathered and structured prior to establishing an analysis model. As mentioned in the introduction, the scope of data survey included complexes located in Seoul, with ten or more apartment buildings. We did a complete enumeration survey on every case fitting the above criteria. As a result, a digital database including general information and spatial configuration data for a total of 360 apartment complexes was constructed.

Secondly, based on the data gathered as above, the scope and principles were established to represent each complex into an axial map. Theories related to spatial analysis mentions the need to minimize the edge effect that may be possible during the analysis, by creating a belt-shaped buffer zone around the given location with a specified width. A 400m width buffer zone employed in this study is in response to the 'Regulation for establishing a general planning of an apartment complex development', which is based on the neighborhood unit concept suited to circumstances in Korea. Such a buffer zone is expected to be sufficient in reflecting the mutual influence between an apartment complex and its local surroundings with respect to the
household lifestyle. As principles for representation, this study established a pedestrian-centered protocol and a classification rule of axial lines according to category items explained hereafter.

Thirdly, the main indices for analyzing spatial configuration were selected, which are integration and point depth. Through the integration index, it is possible to estimate the degree of topological centrality of a certain unit space, that is, the degree of movement efficiency from one unit space to another. In addition, point depth enables understanding of the degree of accessibility or openness of a specific unit space toward the outside of the complex, since the index is measured from unit spaces placed at the periphery of the complex. This study adopted the integration index as originally defined, and the point depth index as standardized. That is, point depth value calculated from the complex's periphery as a root is divided by the mean depth of the shortest path. Such a new index is called standardized point depth (PD).

Fourthly, external components of an apartment complex, such as apartment buildings, playgrounds, retails, footpaths, and other external facilities, were categorized according to its use or function, and such categorizations were named spatial components. The pedestrian-centered protocol equally is applied here, which explains why parking lots were excluded from the category items as they can be largely interpreted as footpath space. The spatial components set in this research are shown in Table 1.

Fifthly, the overall period of Korean apartment history from the 1960's to the present was classified into 6 sub-periods, the standard for which was basically set in reference to Choi's researches (1996, 2004). The difference between this study and Choi's is that the sixth period from 2001 to 2009 was added. The latest period has significance as the findings from the complex planning may provide a reflection of society's pursuit of a green environment for health. Such a classification allows carrying out a comparative analysis between the configurational properties of apartment complexes in each period and the social phenomena or changes in government policies of that period. The classified periods are shown in Table 2.

Based on the classification, all the subject complexes are periodically classified according to the moving-in time of each complex.

4. Results
4.1 Analysis Results
With the analysis methodology mentioned above, we drew up axial maps for all the subject complexes and conducted spatial analysis for them using 'S3 axial analyzer' application. To the results, we applied statistical approaches to examine the changes in spatial configuration according to each period. One-way analysis of variance (ANOVA) was applied to

![Fig.2. Example of Axial Map](image-url)
the periodical indices of integration and PD for each spatial component, and then the periodical mean values of the indices for each spatial component were calculated to make comparisons across the periods.

The results of ANOVA are shown in Table 3., which was conducted in order to verify that the periodical changes for each spatial component were significant, and if so, what patterns it reveals.

Table 3. Significance Results of the ANOVA Across Periods

| Items            | Integration | PD  |
|------------------|-------------|-----|
| Boundary         | 0.002       | 0.011|
| Complex Entry    | 0.046       | 0.125|
| Retail Entry     | 0.004       | 0.000|
| Apartment Entry  | 0.039       | 0.000|
| Playground       | 0.060       | 0.554|
| Exercise Facility| 0.419       | 0.299|
| Parks/Recreational| 0.083     | 0.202|
| School Entry     | 0.108       | 0.004|

The result in Table 3. shows that boundary, complex entry, retail entry, and apartment entry displayed significant changes in periodical integration. In the case of retail entry and apartment entry, as both integration and PD reveal highly significant p-value in periodical changes, it is reasonable and worthy enough to take note of the changes and characteristics in the configuration of the two items hereafter.

Next, for each spatial component, mean values of integration and PD for each period were compared. A higher integration value for a certain spatial component (found at the upper part of the analysis graph) means the spatial component has greater centrality within an apartment complex's external space, whereas lower integration means lower centrality. A lower PD value for a certain spatial component (found at the lower part of the analysis graph) means higher accessibility from outside of the complex and higher tendency of externalization in the complex, whereas higher PD value means lower accessibility and higher tendency of internalization. This result for the two indices allows interpreting the periodical changes in centrality, accessibility, circulation efficiency, and tendency of externalization or internalization that each spatial component of apartment complexes shows in accordance with the periodical social changes.

Periodical mean integration value for each spatial component is presented in Table 4., Fig.3. Overall, it is possible to sort the spatial components into four ranked groups; complex entry, retail entry/school entry, apartment entry/parks and recreational, and exercise facilities/playground from first to fourth. From a diachronic perspective, such four ranked groups make up the general characteristics of spatial configuration in Korean apartment complexes.

The first period is when these ranked groups are actually formed and revealed in great detail. In the second period however, the degree of centrality for the second group of retail entry/school entry increased significantly in comparison to the third ranked group of apartment entry/parks and recreational, showing great approach to the first group. The third group dropped in the degree of centrality, approaching the level of the fourth ranked group. However, the ranked groups could be clearly specified like the first period.

The third period saw the centrality of the second group dropped drastically, and when parks and recreational experienced this change, that of apartment entry increased, leading to a collapse in the third group. Many design competitions were held during this period, through which the concept of a pedestrian-centered design was expanded and this is explained in increased accessibility for apartment entry. And the decreased centrality of parks and recreational can be explained by its reduction in scale and widespread distribution across apartment complex premises.

In the fourth period, the second group recovered its centrality and the third group collapsed completely. Leaving apartment entry as the sole component of the group, parks and recreational fell to the lowest level even within the fourth group, which showed a steady increase in centrality. This trend explains the increased awareness of spaces for the service facilities compared to the past. A diachronic look into the near future tells us that this trend is likely to continue.

The fifth period saw the centrality of schools fell drastically lower than retails, showing signs of a potential collapse in the second group. This shows a gradual shift from adopting Perry's neighborhood unit concept, where schools become the focus in apartment complexes, to schools moving away to the outskirts or periphery of the complex. Recovering the degree of centrality to that of apartment entry, parks and recreational began to reorganize the third group. Such an increase in centrality of parks and recreational is a reflection of the planning trend that placed its emphasis on a high class, good quality environment in apartment complexes through provision of strolling routes, and open squares.

In the sixth period, the centrality of retails highly increased, nearing the first group and moving away from schools, whose centrality was at a standstill. This represents a collapse in the second group and a possibility for reorganization of the first group. While the centrality of parks and recreational fell once again, moving away from the third group, the fourth group displayed a consistent increase, moving significantly closer to the third group and giving the possibility of combining the two groups. The retail's increased centrality meant its ease in accessibility from within and outside the complex, and the level of centrality for apartment entry, parks and recreational, playground, and exercise facilities showed signs of coming closer to one another. Leveling centrality within these different spaces reveals that the status of these spaces are becoming equal in the planning of apartment complexes, where planning of parks and recreational,
Table 4. Periodical Mean Integration for Each Spatial Component

| Period | Complex Ent | Retail Ent | Apartment Ent | Playground | Exercise Fcl. | Parks/Rec. | School Ent |
|--------|-------------|------------|---------------|------------|---------------|------------|------------|
| 1<sup>st</sup> period | 0.1598990 | 0.0332271 | -0.0316021 | -0.0951297 | -0.0875867 | -0.0412750 | 0.0355074 |
| 2<sup>nd</sup> period | 0.1494527 | 0.0819245 | -0.0421810 | -0.0885911 | -0.0844218 | -0.0557310 | 0.1089473 |
| 3<sup>rd</sup> period | 0.1278205 | 0.0525408 | -0.0319207 | -0.0813073 | -0.0966325 | -0.0738761 | 0.0599287 |
| 4<sup>th</sup> period | 0.1237405 | 0.0623672 | -0.0381951 | -0.0760225 | -0.0799617 | -0.0812690 | 0.0782085 |
| 5<sup>th</sup> period | 0.1220773 | 0.0708461 | -0.0397610 | -0.0709034 | -0.0832818 | -0.0476011 | 0.0351947 |
| 6<sup>th</sup> period | 0.1390161 | 0.0909044 | -0.0411121 | -0.0781182 | -0.0747972 | -0.0575749 | 0.0345061 |

Fig. 3. Periodical Trends in Integration for Each Spatial Component

Table 5. Periodical Mean PD for Each Spatial Component

| Period | Complex Ent | Retail Ent | Apartment Ent | Playground | Exercise Fcl. | Parks/Rec. | School Ent |
|--------|-------------|------------|---------------|------------|---------------|------------|------------|
| 1<sup>st</sup> period | -0.2170861 | -0.0121335 | 0.0338059 | 0.1043941 | 0.1128519 | 0.0657203 | -0.0167206 |
| 2<sup>nd</sup> period | -0.1953557 | -0.1063144 | 0.0555387 | 0.1233001 | 0.1075423 | 0.0803959 | -0.1575412 |
| 3<sup>rd</sup> period | -0.1744966 | -0.0679186 | 0.0403220 | 0.1090043 | 0.1149960 | 0.1071789 | -0.1356444 |
| 4<sup>th</sup> period | -0.1871298 | -0.1123896 | 0.0596437 | 0.1323011 | 0.1245839 | 0.1376130 | -0.1534366 |
| 5<sup>th</sup> period | -0.1833969 | -0.0864262 | 0.0604203 | 0.1168789 | 0.1475578 | 0.0791652 | -0.1334317 |
| 6<sup>th</sup> period | -0.2018160 | -0.1515590 | 0.0616042 | 0.1190685 | 0.1209885 | 0.0944565 | -0.0116647 |

Fig. 4. Periodical Trends in PD for Each Spatial Component
playground, and exercise facilities are becoming just as important as that of apartment buildings.

Periodical PD value for each spatial component is as shown in Table 5, Fig.4. As shown in integration, it is possible to generally sort them from first to fourth. The first period revealed little PD deviation between the second and the third group, while PD value for the first group was extremely low. This shows that retails and schools were built to serve its complex only.

In the second period, the depth of the third group became deeper, whilst the second group was much shallower. However, the fourth group did not show much difference to that of the first period. It can be interpreted that apartment entry, parks and recreational are showing more tendency towards internalization, whilst retails are showing more tendency towards externalization.

The third period shows that retails have become deeper whilst apartment entry became somewhat shallower. The depth of parks and recreational has become substantially deeper, joining from the third group to the fourth. It can thus be said that this particular period involved various attempts at planning the complex and the tendencies shown in the first and second period have been partially mixed. It is also important to note the widespread distribution of parks and recreational, as well as its tendency to be internalized at the same time.

The fourth period shows the depth of retail becoming shallower once again, narrowing the difference with the first group. The depth of parks and recreational was revealed to be the deepest out of all the spatial components. Major change in external space during this period can be seen in the apartment entry, whose tendency to be more internalized has been settled; retail's tendency to be more externalized and internalized and internalized parks and recreational intensified. Explanation for the change in parks and recreational can be made as done through integration; that increase in securing green space and focus on landscape planning was the eventual cause.

The fifth period showed the depth of parks and recreational recovering to the level it reached in the second period, forming the third group along with apartment entry, whereas the depth of retail became slightly deeper again. This indicates that the tendency for retails to be more externalized has been settled, and apartment entry's tendency to be more internalized has been weakened.

The sixth period showed the depth of retails becoming shallow to a great extent, and parks and recreational becoming deeper by a small margin once again. This is a noteworthy point as retail's tendency to be externalized is maximized, moving closer to the level of complex boundary. It can thus be said that the target group for retails was broadened from the complex residents to those living outside the complex. Other spatial components maintained the same level they did in the past.

When we examine these analysis results diachronically, it is noticeable that retails and schools, composing the second group, display a similar degree of both centrality and accessibility in the early periods, and the accessibility of schools is highly increased over time compared to retails. This may be explained by Perry's neighborhood unit concept, where schools become the focus. However, after the fifth period, this trend is reversed as school's centrality and accessibility drop and those of retail show a consistent increase, indicating a persistent focus on retails securing commercial supremacy.

As for the apartment entry and parks and recreational that make up the third group, apartment entry did not show too much change with respect to centrality and accessibility, whereas parks and recreational displayed a sharp drop in the initial and middle period to fourth group, only to regain interest and join apartment entry as third place after the fourth period. While the initial and middle period witnessed parks and recreational's gradual decrease in size and its tendency to be widespread, the post-middle period revealed its increased accessibility and centrality reflecting the emphasis on landscape planning with subsequent securing of maximum green space.

In a diachronic perspective, playground and exercise facilities that make up the fourth group display continuous increase in accessibility and centrality. This is the result of extended perception on the importance playground has in the complex and how these spaces should be easily accessible and observable by the parents. However, such change of perception does not reverse its status as the fourth group, indicating strong tendency to be internalized.

4.2 Interpretation of the Results

In this section, the result of the analysis mentioned is comparatively analyzed along with the relevant social, economic climate of its period. The first period was the time when large scale apartment complexes were starting to be developed, particularly in the Seoul metropolitan area. Planning the complex at the time was based on Perry's neighborhood unit concept, where retails, parks and recreational, and other service facilities were mostly provided for its residents. This led to placing schools, retails, and parks and recreational in the center of the complex, surrounded by apartment blocks. The analysis conducted above with resulting four ranked groups from the spatial components can be explained in this context. That is, formation of these ranked groups speaks on behalf of Korea's early stage planning of apartment complexes.

The second period was the time of the 'apartment boom', when the private sector started to build large-scale apartment complexes. While succeeding its previous planning trends, there was increased interest in securing commercial supremacy for retails. This is reflected in the increased centrality of schools and
retails, and the retail's increasing tendency to be more externalized as shown in the previous section.

The third period represents formation of a large scale, new residential section in the city such as that of the Mokdong complex, as well as expanded design competition for apartments. Breaking away from the previous planning trends, there was much attention to applying and testing various new methods focusing on pedestrian circulation and community spaces. This is reflected in the increased centrality of the apartment entry and internalization tendency of community spaces such as parks and recreational as shown above.

The fourth period included development of new cities in the metropolitan area such as Bundang, Iksan, Pyeongchon, and under the banner of two million housing construction, there was a widespread supply of apartments as the main form of housing across the country. As the period of succeeding and enhancing the previous planning methods, the analysis results indicate decreased centrality and internalization in parks and recreational, and increased internalization in playground and exercise facilities.

The fifth period saw the financial crisis of 1997 (IMF) shrinking the housing development market, deregulating apartment prices, and expanding reconstruction of buildings. This was also the period of increased interest in securing green spaces and landscape planning that followed. Priority in planning was placed on parks and recreational, and as shown above, their centrality and internalization recovered to a level similar to that of the apartment entry.

The sixth period saw the introduction of apartments with brand names, and expanded gentrification. Securing green spaces within a complex was greatly expanded in this period, playing a large part of the gentrification trends by promoting a sustainable, well-being lifestyle. Through the introduction of programs such as strolling routes, squares, and other various design elements, the importance of parks and recreational, playground, and exercise facilities was enhanced. As shown in the previous section, increased accessibility and centrality for parks and recreational, playground, and exercise facilities, close to the level of apartment entry, is a positive reflection of the planning method adopted in this period.

5. Conclusion

In order to comprehend the needs of the times inherent in the configuration of the apartments that represent contemporary Korea, this study analyzed apartment complexes with a minimum ten blocks built from the 1960s until now. As part of the spatial analysis methodology, the axial map was applied in order to analyze the properties in spatial configuration according to each period, its resulting change, and the meaning it has from a social and economic perspective. Results revealed that differing planning initiatives for each period were not only reflected in the spatial configuration of the apartments in its entirety, but it was also possible to extract key elements in planning which made up the apartments in that particular period. This research is significance from the fact that the results were deduced through a quantitative spatial analysis methodology, giving this study more credibility through its objective nature than the existing researches with qualitative and subjective approaches. The validity of an improved analysis model through proposing a new index of standardized point depth on the existing spatial analysis methodology in analyzing and interpreting apartment complexes also holds valuable significance.

Though this research originally aimed for a complete enumeration survey of all apartment complexes in the Seoul metropolitan area, complexes with less than 10 apartment blocks were effectively discarded in the analysis. With the emphasis on spatial configuration, it may be deduced that a certain degree of scale is required, but the real issue lies in setting the scope of research. There is a need to include complexes of smaller scale in order to carry out a more comprehensive study. Future studies will also need deeper and more concrete examinations of several actual apartment complexes through case studies. It is expected that succeeding research will be able to overcome these limitations.

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