Nat. Volatiles & Essent. Oils, 2021; 8(4): 949-961

NVEO
Natural Volatiles & Essential Oils

An Analysis of Areas Vulnerable to Theft According to the Spatial Structure of Museums

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Abstract

In recent years, with a rising level of cultural awareness among the general public, the demand for museums has been increasing. In addition, the number of museums being built is increasing. This expansion of museum facilities is causing a growing number of museum thefts, highlighting the importance of museum security, and as such, an analysis of the vulnerable areas of a museum is required. However, there has not been much research on museum security. Accordingly, this study aims to build basic data for future museum design by analyzing the spatial structure of a museum in order to understand its vulnerable areas. The conclusions are as follows. 1) This study analyzed areas vulnerable to theft by first deriving the connectivity value of an analysis target. 2) This study derives a convex space which has a low value at the same time for both the connectivity and local integration of a selected museum, and this convex space is identified as the most vulnerable space to theft. 3) This study derives a restriction for a selected museum. The information desks and management facilities that must have high restriction show values that are higher than the average restriction of the entire convex space, but the restriction is analyzed to be inappropriate because the derived areas vulnerable to theft and spatial depths are large. Therefore, in future museum design, the vulnerable areas should be designed to have a high restriction

Keywords: Museum, Spatial Structure, Security, Space Syntax

1. Introduction

1.1. Background and Purpose of Study

Recently, the Korean government has been implementing a policy to expand the facilities of museums and art galleries to improve the cultural level of the general public. In fact, the Ministry of Culture, Sports and Tourism is planning to continuously build new museums and art galleries from 2019 to 2023, and has announced the 'mid-term to long-term plan of promoting museums and art galleries,' which is a plan to increase the number of facilities by 140 from 873 to 1,013. A museum is a social space for the preservation and research of art, history, fine arts, science, and technology-related collections, in addition to materials and specimens with cultural value from botanical gardens, zoos, and aquariums. As an infrastructure for improving the level of culture and education of the public, its value is quite high. [1-9] As such, there have been diverse studies on spatial structure, movement, colors, and exhibition methods of a museum. [10-17] As the number of museums is increasing, the number of museum thefts is also continuously rising. Due to the nature of exhibitions held in a museum, security is emerging as an important element. In fact, museum thefts are frequent. As an example of collection loss due to poor security, a gold coin with a purity of 99.99% (market price of KRW 5.1 billion) was stolen from the Bode Museum in Berlin, Germany in 2019. In addition, a work by Vincent van Gogh was stolen from a Dutch museum when it was closed due to COVID-19 in March 2020. In Korea, there was an attempt to steal national treasures and cultural properties from the Gongju National Museum on May 15, 2003. Yet despite these incidents, there have been few studies on spatial planning considering the risk of theft from museums. As museums are increasingly being designed

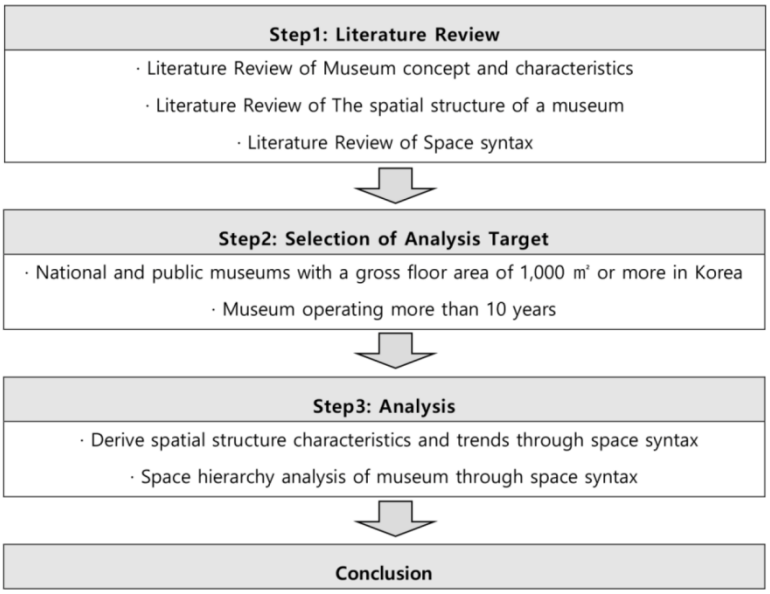
and constructed in an open system as spaces for social communities [18-24], it is expected that security will be an important element of museums in the future.

Considering this, the goal of this study is to build data that can be used in future museum design by predicting and analyzing the spaces within museums that are vulnerable to theft, for museums recently built and in operation.

1.2 Method and scope of study

As a study to build basic data for museum space planning, we proceeded as shown in Fig. 1 below. First, as a literature review to derive an analysis method, the concept of a museum was examined and spatial structure analysis and museum theft examples were investigated. In addition, this study investigated the indicators and analysis methods of space syntax used as a quantitative analysis method for spatial hierarchical analysis. Second, based on the literature review, four domestic museums were selected for analysis and the spatial structure characteristics and connection relationships were analyzed. Since museums that are larger and older are more vulnerable to security, this study selected only museums operating more than for 10 years with a gross floor area of 1,000㎡ or more. Third, analysis and evaluation were conducted using space syntax based on the research analysis conducted above. Space syntax is an analysis method that can be used to quantitatively derive the accessibility and cognition of an indoor space, and is suitable for this study. In addition, of the various space syntax analysis methods the convex space map was applied to a space, and the S3 convex developed by the Urban Architecture Space Analysis Laboratory at Seoul National University was used to apply the methodology.

Figure 1. Flow Chart of Research



2. Concept and Structure of Museum

2.1 Concept and Structure of Museum

Although the concept of a museum may differ depending on the institution that defines it, it generally refers to a cultural facility that stores and displays academic materials in addition to archaeological materials, artworks, and historical relics for the audience. [25-29] The International Council of Museums

defines a museum as a non-profit permanent facility that collects, preserves, and studies material evidence of the human environment and discloses it to the public so that it can serve the development of society through exhibitions, thus contributing to research, education, and science. In addition, in the Charter of the International Council of Museums, a museum is defined as a permanent public facility constructed to hold exhibitions for the education and entertainment of the general public by preserving and studying museum collections of art, history, fine arts, science, technology, and culturally valuable materials from botanical gardens, zoos, aquariums, etc. through various methods. In a broader sense, museums include not only art museums and science halls but also technology halls, public archives, and private preservation areas. As shown in Table 1, these types of museums can be categorized into national museums, public museums, and private museums depending on how they are founded, and can also be divided into general museums and specialized museums according to the contents of their exhibitions. As the name suggests, a general museum has a collection of various types of exhibits, while specialized museums exist in different categories such as archeology, history, art history, anthropology, folklore, natural history, industry, communication, transportation, medicine, calligraphy, and diverse other areas [9].

The space of a museum is subdivided into exhibition space, storage space, work space, and public space according to its nature. [30] The exhibition space is largely divided into an exhibition facility and an exhibition subsidiary facility. It occupies the widest area as a single function among the unit spaces. It is the space most frequently used by visitors, so it should be planned by closely considering the exhibition program. The storage space is for the safe storage of collections, and a sufficient space should be provided for storage in consideration of the fact that the size of the collection will likely increase over time. In addition, the storage space must be accompanied by a facility for unloading, packing, and dismantling artifacts, as well as other management and auxiliary facilities. The work space is for the museum staff to perform various tasks, and as much as possible is in a location that does not interfere with the viewing flow of visitors. The public space induces the participation of visitors through various programs, and such space is increasing as the functions of a museum transform into a complex cultural space. [31, 32]

Table 1. Types of Museums

Type	**Details**	
Founder	National museum, Private museum	
Exhibition Contents	General Museum	Museum that collects, stores, and exhibits materials on two or more fields, such as nature and humanities
	Specialized Museum	Exhibits in a limited area such as archeology, history, art history, anthropology, folklore, natural history, industry, communication, transportation, medicine, calligraphy, etc.

2.2 Previous Studies on Museums

As shown in Table 2, prior studies on museums have mainly focused on research on the spatial structure, exhibition method, hierarchy, and movement, but as of yet there has been no research on security, which is the area this study aims to analyze, and as such, this study offers a meaningful contribution to museum-related research.

Table 2. Previous Museum-Related Studies

Title of study	**Author**	**Study Details**	**Museum Security Considered**
Analysis of Museum Exhibition Space using Spatial Syntax [33]	Kim	Perform quantitative analysis for a museum space and compare the results to present basic data for museum design	×
The Structure of Museum's Exhibition Space and the Diversity of Visitors' Movements [34]	Cui and Kong	Identify visitors' pattern according to the structure of a museum and establish basic data for museum design	×
A Study on the Influence of Exhibition Environment Perception on Museum OFbservation Behavior [35]	Lee and Choi	Verify the correlation between museum exhibition environment and observation behavior and establish basic design data for the museum exhibition space	×
A study on How To Leverage Space Design in Museum Planned Exhibitions [36]	Ko and Choi	Review the spatial design utilization plan for a planned exhibition in a museum and present basic data for exhibition planning	×
Correlation between Museum Exhibition Space Structure and Visitor Movement (Ⅰ): Exhibition Space Structure and Observation Frequency [37]	Kim	Construct the basic design data of a museum exhibition space by understanding visitors' movement according to the structure of an exhibition space	×
A Comparative Study of Space Programs between Korean Museums and Art Galleries by Considering Exhibition Programs [38]	Byun	Compare and analyze the spatial program of exhibition and storage spaces for efficient museum and space planning	×
A Comparative Study on the Architectural Characteristics of National Museum and Public Museum in Korea [39]	Suk	Compare and analyze the architectural spatial characteristics of museums, and present the design direction for a museum exhibition hall based on the analysis	×

2.3 Review of Space Syntax

This study used space syntax to analyze areas vulnerable to theft according to the spatial structure of a museum. Space syntax is suitable for this study as a method of dividing an inner space into convex spaces, i.e. unit spaces, and quantitatively analyzing the spatial hierarchy between the unit spaces. In this study, the convex spaces that divide a space mean the unit spaces of an open space that can recognize all spaces in an indoor space as a point of view. It is possible to analyze the connectivity between unit spaces by dividing an indoor space to be analyzed into convex spaces. [40-43] In particular, space syntax can derive the vulnerable areas of a museum by deriving the outer areas of spaces with low space utilization and

spaces with low cognition through spatial analysis. The following is an explanation of the quantitative indicators of space syntax.

First, connectivity refers to the number of connections from a specific convex space to an adjacent convex space; here, connectivity means that there is a moving line through which visitors can move. Accordingly, a convex space with high connectivity may be congested due to its increased utilization, and at the same time there is a disadvantage that congestion may occur during observation. However, a convex space with high connectivity means that there is less risk of theft due to the high utilization rate, and it is located at an important part of the observation moving line at the same time. [44-49] Second, a restriction shows the influence of a specific convex space and adjacent convex spaces as a quantified value. A convex space has high restriction when it is easy to move to an adjacent convex space. In a museum, a convex space with high restriction should be an information desk or waiting space for staff, and the problem of theft can be directly or indirectly resolved in these spaces. Third, integration refers to the number of convex spaces to go through when moving from one convex space to an adjacent convex space; high integration means that access to other spaces is convenient. However, integration is a numerical value that represents the relationship between the convex space of an entire space and a specific convex space. On the other hand, local integration is a numerical value representing the accessibility to a specific unit convex space based on the fact that a convex space with a spatial depth of 3 is recognized when following a moving line. That is, if the accessibility to a specific unit convex space compared to the convex space of an entire space is an integration, the accessibility to a specific unit space in consideration of human cognitive ability is classified as a local integration. In this respect, an area with high integration has a high spatial cognition, resulting in a lower risk of theft. On the other hand, an area with a low indicator for integration may have a high possibility of theft. Fourth, spatial structure intelligibility refers to the correlation between integration and local integration. In other words, as the correlation between the two indicators is high, space cognition tends to be high. [50-56]

3. Analysis of Vulnerable Areas according to the Spatial Structure of a Museum

3.1 Selection of Analysis Targets

As shown in Table 3, this study selected four museums: Gwangju National Museum, Iksan National Museum, Buyeo National Museum, and Ulsan Onggi Museum. These museums were selected because they have been in operation since they opened and have a total floor area of 1,000 m^2 or more. In addition, they are located in an area other than Seoul Metropolitan Area, and are specialized museums limited to a specific subject.

Table 3. Outline of Analysis Target

Museum Name	City	Exhibition Theme	Opening Date	Total Building Area (m^2)
 Gwangju Museum	Gwangju	Relics	1994.10	14,227

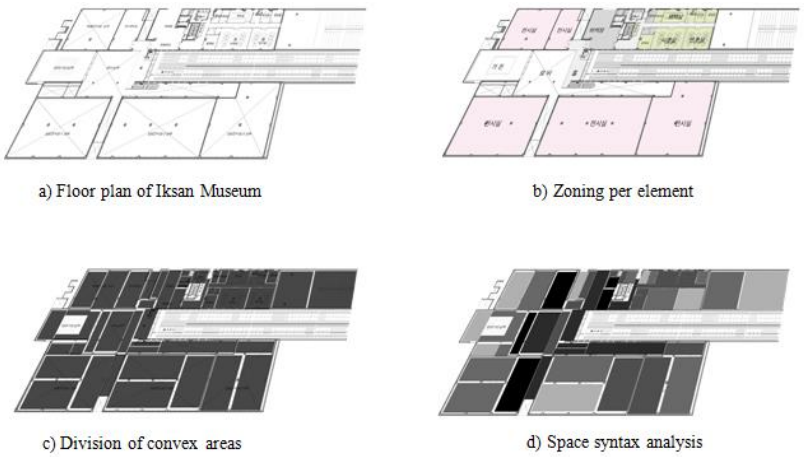
 Iksan Museum	Iksan, Jeollabuk-do	Relics	1945.10	7,499
 Buyeo Museum	Buyeo, Chungcheongnam-do	Relics	1994.12	13,924
 Ulsan Onggi Museum	Ulsan	Onggi	2009.11	1,755

3.2 Analysis Method

This study analyzes areas vulnerable to theft according to the spatial structure of a museum. It proceeded according to the method shown in Fig. 2.

First, this study grouped the spaces, including the museum's exhibition space, storage space, work space, and other public spaces. Second, the floor plan of a museum was divided into convex space units. If multiple spaces are homogeneous (excluding corridors), they are regarded as a single convex space, despite there being a visual blocking. Third, connectivity and local integration were derived for the divided convex spaces using the space syntax, and spaces with both low connectivity and local integration can be described as spaces with low utilization and cognition by the visitors. Therefore, it is possible to predict the vulnerable areas of a museum by deriving convex spaces with both low connectivity and local integration. Fourth, restriction values were derived for the analysis targets, and the information desks and management facilities that should have high restriction values were reviewed to confirm that their values were appropriate.

Figure 2. Analytical Method



3.3 Analysis Results and Discussion

This study analyzes the areas vulnerable to theft according to the spatial structure of a museum and predicts and analyzes the places vulnerable to theft in museums under operation using space syntax. The results are as follows.

First, Convex spaces, which have low connectivity within a museum, are predicted to show a low utilization rate, which can make them vulnerable to theft. Therefore, as shown in Table 4, this study derives the minimum and maximum mean and lower values of the connectivity of an analysis target. Local integration can predict a place with low cognition in an indoor space, and spaces with low cognition are expected to be vulnerable to theft. Therefore, as shown in Table 5, this study derives the minimum and maximum mean and lower values of the connectivity of an analysis target.

Second, as shown in Table 6, when a space shows a low value for both connectivity and local integration at the same time, the space becomes the most vulnerable space. Spaces with both low utilization and cognition are usually convex spaces at the edge of a museum's observation path, or are storage spaces. CCTVs and motion detectors should be installed for such areas that are vulnerable to theft.

Table 4. Connectivity Analysis

Museum Name	Connectivity			
	Minimum	Maximum	Average	Five convex spaces with lower connectivity values
Gwangju Museum	1	19	5.8	Balcony (2F upper side), left side of exhibition hall 1 (1F), storage (2F lower right side), upper side of exhibition hall 3 (2F), upper right side of top of planned exhibition hall (2F)
Iksan Museum	1	13	3.2	Office (1F), archive room 2 (1F), upper side of lobby (B1), left side of office (1F), laboratory (1F)
Buyeo Museum	1	13	3.7	Upper right side of planning & operation team, right side of planning & operation team, upper corridor of meeting room, upper side of planning & operation team, left side of exhibition hall 3
Ulsan Onggi Museum	1	7	2.5	Upper side of storage space (1F left side), right side corridor of front space (2F lower side), upper side of permanent exhibition hall (2F left side), entrance of storage space (1F left side), arrangement space (1F left side)

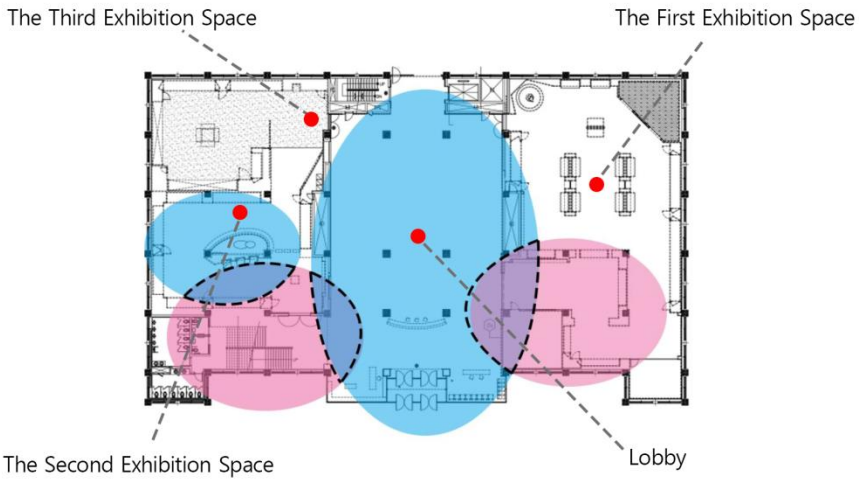
Table 5. Analysis of Local Integration

Museum Name	Local Integration			
	Minimum	Maximum	Average	Five convex spaces with lower local integration values
Gwangju Museum	0.3	0.9	0.71	Storage (2F lower right side), lower right side of planned exhibition hall (2F), Lower side of planned exhibition hall (2F), right side of planned exhibition hall (2F), lower left side of planned exhibition hall (2F)
Iksan Museum	0.4	1.3	0.8	Museum director's office (1F upper side), left side of meeting room (1F upper side), sunken garden (1F left side), left side of office (1F), auxiliary entrance (1F right

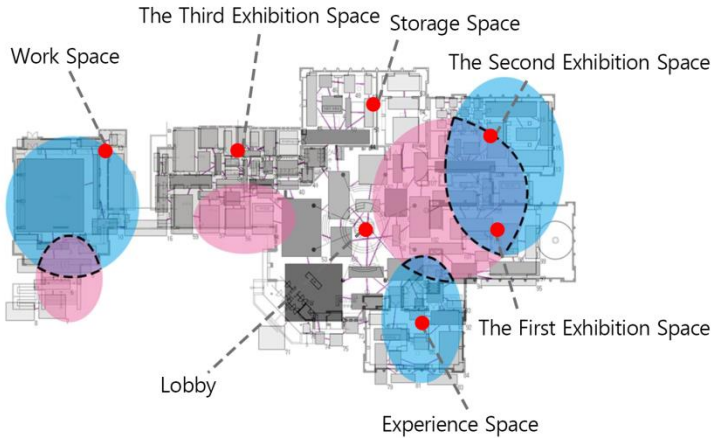
				side)
Buyeo Museum	0.3	1	0.6	Upper side of left side exhibition hall entrance, entrance of left side exhibition hall, entrance lobby of left side exhibition hall, right side of left side exhibition hall, upper side of exhibition hall 3
Ulsan Onggi Museum	0.3	1	0.64	Lower side of entrance yard (1F left side), lower right side of lobby (1F), upper side of storage space (1F left side), arrangement space (1F left side), lower side of permanent exhibition hall (1F right side)

Table6. Analysis of Areas Vulnerable to theft based on Connectivity and Local Integration

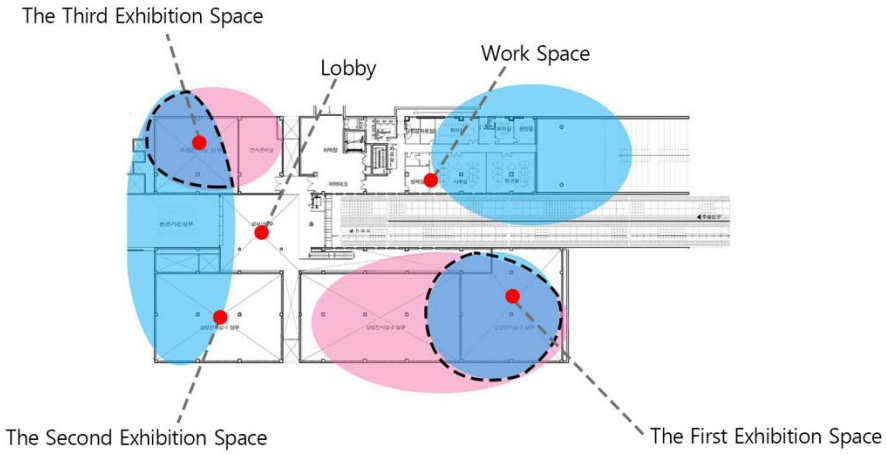
Gwangju Museum



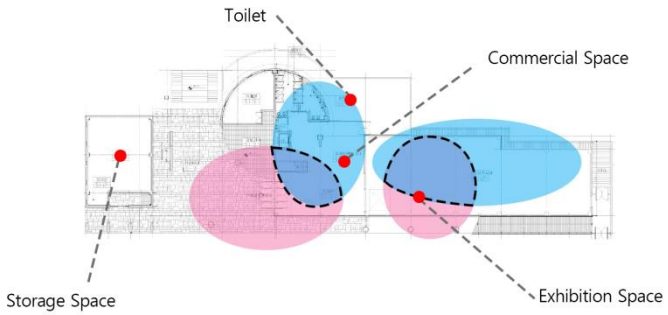
Buyeo Museum



Iksan Museum



Ulsan Onggi Museum



Third, as shown in Table 7, this study derives the minimum and maximum average restriction values for the selected museums. The restriction values of information desks and management facilities are higher than the average, which is appropriate, but it is analyzed that they are not sufficient because the areas determined as vulnerable to theft and spatial depths are large. Therefore, in future museum design, a space with high restriction needs to be designed to increase restriction over vulnerable areas.

Table7. Restriction Analysis

Museum Name	**Restriction**					
	Min.	**Max.**	**Avg.**	**Information Desk**	**Management Facility**	**Number of spatial depths related to areas vulnerable to theft**
Gwangju Museum	0.09	3.2	1	1.5	1.4	17
Iksan Museum	0.07	5.9	1	1.4	1.1	20
Buyeo Museum	0.07	3.1	1	3.1	1.8	22
Ulsan Onggi Museum	0.1	3.8	1	1.14	0.94	9

4. Conclusion

This study is an analysis of areas vulnerable to theft based on the spatial structure of a museum, and analyzes building area, spatial structure ratio, and change of moving lines for larger museums. The conclusions are as follows.

First, this study derives the minimum, maximum average and lower values of the connectivity of an analysis target; a place with a low rate of utilization by visitors may become a space that is vulnerable to theft if the connectivity is low. In addition, this study predicted places with low cognition in an indoor space through deriving local integration. Second, this study derives a convex space showing a low value at the same time for both connectivity and local integration in a selected museum, and this convex space is identified as the space that is most vulnerable to theft. The derived spaces with low utilization and cognition are usually convex spaces at the edge of a museum moving line or convex spaces at a storage space. CCTVs and detectors should be installed for the vulnerable spaces to resolve this problem. Third, this study derives restriction for the selected museums. Information desks and management facilities that must have high restriction show values that are higher than the average restriction of the entire convex, but they are insufficient because the derived areas vulnerable to theft and spatial depths are large. As such, for future museums a space with a high restriction needs to be designed in order to increase restriction over vulnerable areas.

This study has its significance in that it builds basic data for museum design by analyzing the areas that are vulnerable according to the spatial structure of a museum. However, this study has a limitation of relying on the space syntax methodology based on the spatial structure and hierarchy to derive the areas vulnerable to theft. In future research, more diverse methods should be applied.

ACKNOWLEDGMENTS

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF- 2020S1A5A8040240).

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