The Variation of Visibility in Izena's Vernacular Houses in Relation to Occupants' Living Activities

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1. Introduction

Vernacular architecture can be viewed to embody culture norms that are understood among designers, builders and users[1]. The houses in Izena Village manifest this vernacular feature, for the formation of the houses' configurations are not only from how they are built originally, but also from occupants' social and spatial practices onto the houses. Therefore, this study aims to explore not only the physical spatial configurations of Izena's vernacular houses, but also how these spatial configurations interplay with the occupants' social living patterns. In specific, this study focuses on two perspectives, i.e., the visibility related to the configuration and the visibility related to the occupants' daily living activities such as meeting friends, chatting, eating, etc. In order to analyse the visibility properties for each house, Visibility Graph Analysis (VGA) based on Space Syntax theory is applied in this research. By identifying the variation of the visibility properties with the occupants' living activities, this research intends to discuss how vernacular architecture flows and interacts with the Izena's occupants' social living patterns that learned and experienced through literature studies and on-site fieldworks.

2. Previous Studies

Uyar et al.[2] pointed out vernacular buildings are considered to be "timeless" meaning that their forms as well as styles rarely change in conventional studies. In Space Syntax field, vernacular architecture is studied in the perspective of configuration. For example, by studying the configuration properties, Hanson[3] revealed how British vernacular houses provide frameworks for everyday lives. While Uyar et al. studied how the vernacular domestic buildings from three countries, Turkey, Japan and Britain, evolve through the times. By identifying the variation of syntactic configuration properties of these houses, Uyar et al. proposed the "vernacular" as a fluid, rather than a fixed description of national traditions of domestic architecture. However, how the configuration of each domestic building flows through the mutual interaction with occupants has not attracted many scholars. The case for the configurations of Izena's vernacular houses shows a much complex situation, from which the fluid "vernacular" conception interplaying with the social activities of the users could be expected.

The configurations of Izena's vernacular houses share common features and are related to the occupants' living activities to a great extent. According to a survey about the vernacular houses in Kyushu area by Sakamoto[4], as Fig.1 shows, a typical vernacular Izena's vernacular house can be viewed to be divided into two parts and each room corresponds to a series of expected living activities or social routines. The front part called OMOTEZA is composed of ICHIBAN-ZA, NIBAN-ZA and SANBAN-ZA. ICHIBAN-ZA facing the east as well as the south, viewed as the most sacred room, is used by the occupants to have formal meetings with the guests of honour. NIBAN-ZA is the room where a mortuary tablet is kept. SANBAN-ZA is used for young or female occupants' drinking tea, resting or chatting.

The back part called URAZA is composed of ICHIBAN-URAZA, NIBAN-URAZA and SANBAN-URAZA. ICHIBAN-URAZA is used for young couple or male children's resting and sleeping. NIBAN-URAZA is used for the owner's sleeping or female children's resting.

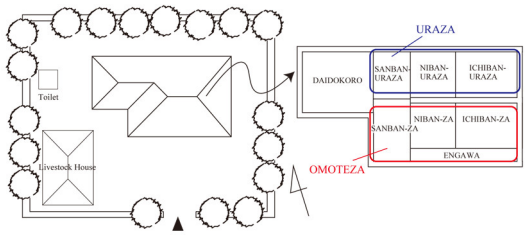

Fig.1 A Typical Configuration for Izena's Vernacular House in 1980s (Referring to The Figure Made by Sakamoto[4])

3. Methodology

3.1 The Calculation of Visual Integration Value in VGA

In order to analyse the visibility in relation to the spatial configuration for each house, VGA developed by Turner et al.[5] was applied. For each House, the Visibility Graph was made by representing a plan as a grid of mutually visible vertices with edges (see Fig.2). An edge is made if any two vertices are directly visible from each other and viewed as one depth in calculation. Then, the Mean Depth (MD) for each vertex was calculated. For a certain vertex $v_i \in V$, MD ($\bar{L}_i$) is the average of all the depth d_{ij} from this vertex v_i to every other vertex $v_j \in V$ in the graph.

$$\bar{L}_i = \frac{1}{|V|-1}\sum_{j}^{v_j \in V} d_{ij}$$

In order to make the indicator comparable in different configurations, the Mean Depth for each vertex was normalised to be Visual Integration Value for that vertex ($int.V_i$) by the Formula below:

$$int.V_i = \frac{|V|\left\{log_2\left(\frac{|V|+2}{3}\right)-1\right\}+1}{(\bar{L}_i-1)(|V|-1)}$$

Detailed explanation can be found in Turner et al.'s work about VGA[5].

Fig.3 shows the visualisation for Visual Integration Value, the VGA result in this research. In Fig.3, the areas with high Visual Integration Value are highlighted as red, which means they are visually integrated. While the areas with low Visual Integration Values are highlighted as blue, which means they are visually segregated. All the VGA results for the houses shown below are flowing the same colour gradient.

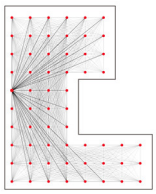

Fig.2 The Construction of a Visibility Graph

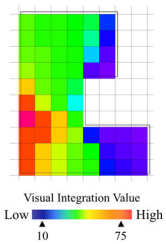

Fig.3 Visualisation of Visual Integration Value (VGA Result)

3.2. Fieldwork in Izena Village

To investigate the occupants' activities and their houses, fieldworks were conducted June, 2017 in Izena. In the fieldwork, the researchers observed the environment of each house, recorded how the sliding doors were positioned and interviewed with the occupants for their use of space and daily activities. Also, researches experienced these houses in person by walking around them, operating the sliding doors and doing activities like the occupants.

3.3 The Application of VGA in This Study

During the fieldwork, the occupants' operation on the sliding doors, i.e. SHOJI or FUSUMA, is found to be an important spatial practice to control the visibility in the house. Therefore, in this research the Izena's vernacular houses are analysed in three conditions (Frame, Reconfiguration and Manipulation) marked as "w/o", "w/" and "m" which represent three levels of the interaction between the occupants and the vernacular houses through the control of sliding doors. In the condition "w/o", each plain plan was analysed regardless of all the sliding doors and furniture items that block the view. In the condition "w/", the doors that were kept closed constantly as well as the fixed furniture items investigated during the fieldwork were treated as visual obstacles during the analysis. In the condition "m", besides the fixed sliding doors and furniture items, the manipulation (open, close and remove) for daily living activities on the movable doors was overserved and the variation of the configurations brought by that was taken into analysis. In this study, plans for houses are represented as grids with 150mm×150mm cell size of mutually visible vertices for constructing the Visibility Graph.

The plans for the vernacular houses in this study were made through observation and field survey from 2014 to 2018.

4. Findings

Through studies, it is found that Izena's vernacular houses provide the occupants with great flexibility to adjust the configurations. In the light of this fact, the visibility of the houses varies to a great extent with the three conditions mentioned above.

4.1 "Frame" - Condition w/o

In this section, plans of 19 houses from House A to House S were analysed regardless of all the sliding doors and furniture items. It is the situation in which all the sliding doors are assumed to be movable so that they will not be treated as visual obstacles in the VGA analysis.

Through the analysing of the visibility for 19 houses, several features about configuration are identified (see Tab.1). Each feature means whether over half of the area of the corresponding room is shown as red in the VGA result, i.e., visually integrated in the house. In this paper, the VGA results of 12 houses from the 19 houses are listed and classified according to the features they have into four types in Tab.2 and Fig.4.

Houses F, K, L belonging to "Type 1" share the common point that the OMOTEZA and DAIDOKORO are significantly visually integrated than any other spaces in the house. Houses A, D, I

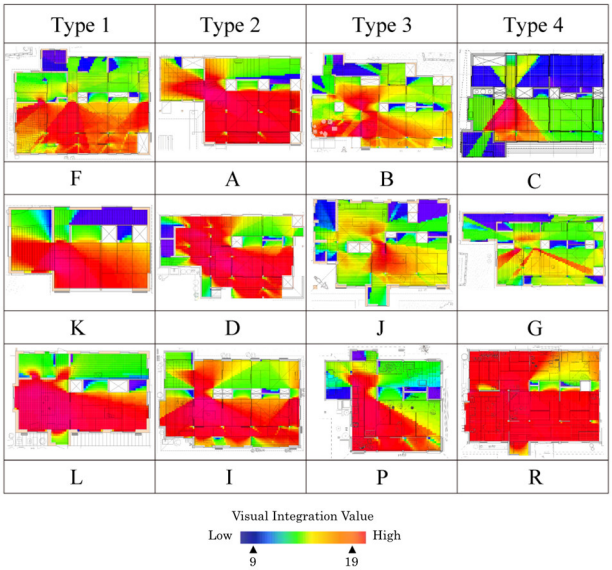

Fig.4 Classification of VGA Results for 19 Vernacular Houses

Tab.1 Features Identified by VGA

Feature I: ICHIBAN-ZA	Feature II: NIBAN-ZA
Feature III: SANBAN-ZA	Feature IV: ICHIBAN-URAZA
Feature V: NIBAN-URAZA	Feature VI: SANBAN-URAZA
Feature VII: DAIDOKORO	

Tab.2 Classification of Features for 19 Izana's Vernacular Houses

	House \ Feature	I	II	III	IV	V	VI	VII
Type 1	F	yes	yes	yes	no	no	no	yes
	K	yes	yes	/	/	/	/	yes
	L	yes	yes	/	/	/	/	yes
Type 2	A	yes	yes	yes	no	no	yes	yes
	D	yes	yes	yes	no	no	yes	yes
	I	yes	yes	yes	no	no	yes	yes
Type 3	B	no	yes	yes	no	no	yes	yes
	J	no	yes	/	no	no	/	no
	P	no	yes	yes	no	no	yes	yes
Type 4	C	no	no	yes	no	no	no	no
	G	no	no	no	no	no	no	no
	R	yes	yes	yes	yes	yes	yes	yes

"yes" means the VGA result of a house is with the corresponding feature; "no" means the VGA result of a house isn't with the corresponding feature;
"/" means the corresponding room to a certain feature doesn't exist in the house so that this feature is not applicable.

belonging to "Type 2" share the common point that not only the OMOTEZA and DAIDOKORO, but also the part of URAZA that connects to the OMOTEZA are visually integrated in the house. Houses B, J, P belonging to "Type 3" share the common point that only a part of OMOTEZA instead of the entire one is visually integrated. The rest of the houses show unique features from each other and are classified in "Type 4".

However, for a general picture, the common characteristic through the four types can be found that the OMOTEZA and the DAIDOKORO in most houses are significant visually integrated than other spaces. While the URAZA is usually the visually segregated space in the houses.

The commons of the visibility properties proved that there can be found cases of the reproduction of typical syntactic configuration features through different vernacular houses in Izena Village, i.e., the visually integrated OMOTEZA and DAIDOKORO as well as the visually segregated URAZA.

Since the room arrangement of the Izena's vernacular houses corresponds to the expected living activities[4], the syntactic configuration features in common that are mentioned above indicate a correlation between the visibility properties in the houses and the expected occupants' living activities. For instance, considering the VGA results with the literature about the Izena's vernacular houses, it can be found that the formal meeting with guest and informal chatting among family members takes place in highly visible spaces (OMOTEZA) in expectation. However, sleeping and studying takes place in spaces that is hardly seen (URAZA) in expectation. As the house configuration in condition "w/o" could be argued to represent the expected situation that how the house could be occupied. The correlation between visibility and the occupants' living activities indicate a designed spatial practice concerning the interplay between the visibility properties and the occupants' living activities.

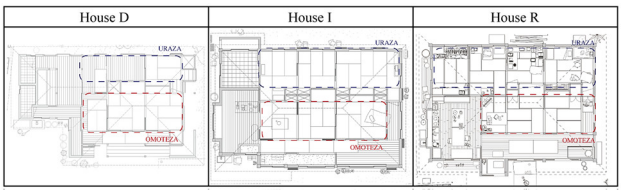

Fig.5 Plain Plan of House D, I and R

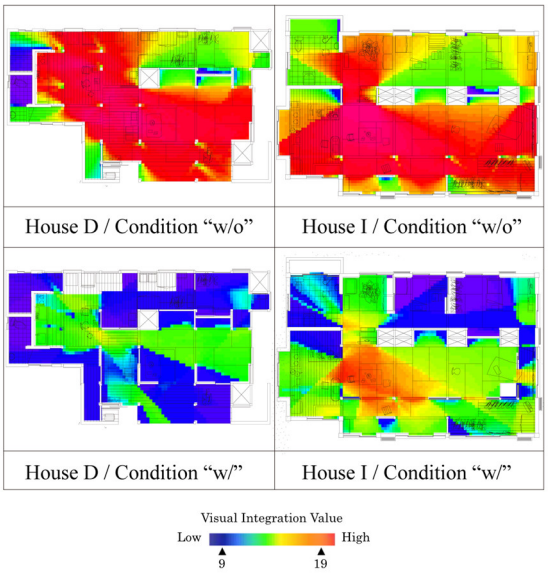

Fig.6 Comparison of the VGA Results for House D and House I in Condition "w/o" and Condition "w/"

4.2 "Reconfiguration" - Condition w/

4.2.1 A comparison of the configurations of the houses in two conditions with First Person Experience

In this section, all the fixed sliding doors as well as the furniture items in vernacular houses observed during the on-site fieldwork are treated as visual obstacles during VGA analysing. Two vernacular houses, House D and House I (plans of them are listed in Fig.5), from the 19 houses were picked here for two reasons. One is that their VGA results in condition "w/" show significant difference from those in condition "w/o". The other is that their VGA results in condition "w/o" belong to the same type, while their VGA results in condition "w/" show different patterns from each other.

Concerning the condition "w/o", the VGA results of House D and House I belong to the same category, "Type 2" (see Fig.4). It is indicated that the OMOTEZA including the ENGAWA as well as a part of URAZA connecting to OMOTEZA in both houses are very red, which means these spaces tend to be significant visually integrated in both houses (see Fig.6). In addition, even though the position of the DAIDOKORO is different in the two houses, both of them are very red in the VGA result, meaning that they can be seen easily in the entire house as well.

Concerning the condition "w/", the VGA results indicate significant difference from those in condition "w/o". Meanwhile, the VGA results in condition "w/" for both houses are very different from each other as well. In House D, instead of a large

area with high integration degree as shown to be red in the result in condition "w/o", there forms a green linear pattern in condition "w/", which means the integrated area becomes a linear pattern here. In House I, the original large red area of OMOTEZA that is highly integrated in condition "w/o" becomes a concentrated spot in SANBAN-ZA in condition "w/". The spaces other than SANBAN-ZA becomes much green and blue, which means these spaces tend to be less visually integrated in this house in comparison with the condition "w/o".

Through our fieldwork in Izena in June, 2018, it is found that occupants in House D tend to rest and chat with their friends in ENGAWA in front of SANBAN-ZA (see Fig.7). By sitting on ENGAWA in person, it is found that OMOTEZA and DAIDOKORO were rather visible and the ENGAWA felt like an open space. This observation corresponds to the VGA result for House D in condition "w/" where the part of ENGAWA in front of the SANBAN-ZA is easier to be seen compared with the OMOTEZA.

In House I, occupants were watching TV, eating, relaxing, etc. in SANBAN-ZA, which is the centre for living activities. As a result of VGA, SANBAN-ZA is the space with the highest visual integration degree, which means it is particularly easy to be seen in the entire house (see Fig.8).

By comparing the VGA results for both houses with first person experience, A common feature can be found that the centre for living activities is always the place that is easily seen in the entire house. On the other hand, in terms of how SANBAN-ZA is used, the cases of two houses show significant difference. In House D, instead of a space for living activities, SANBAN-ZA tends to be mainly used for storing living stuffs. Occupants were passing through SANBAN-ZA as a passage rather than staying. In contrast, In House I, SANBAN-ZA is treated as the centre of daily living activities.

Fig.7 ENGAWA Facing towards South in House D, Occupants Were Chatting.

Fig.8 SANBAN-ZA in House I, Occupants Were Chatting, and Watching TV.

4.2.2 Analysis of Occupants' Living Activities with VGA Measures

In order to have a closer look at how the specific actual activities are related to the house configurations, behaviour maps for House D and House I were made during the fieldwork in June, 2018 (see Fig.9). In each behaviour map, different locations are recorded through on-site observation and interview for occupant's living activities are mapped in different colours.

It is proposed that activities of chatting, meeting friends, etc. mainly take place in OMOTEZA[4], and it is revealed in the analysis in condition "w/o" that the OMOTEZA is always the space that is visually integrated in expectation.

However, difference from expectation can be found in condition "w/". In the case of House D, as the Fig.8 shows, the activity of chatting among family members take place in the corner of NIBAN-ZA as expected. While, the NIBAN-ZA becomes rather blue in the VGA result in condition "w/" (see Fig.6). This means the activity of chatting takes place in space that is much less visually integrated than expected. Moreover, the activity of sleeping may take place in ICHIBAN-ZA which is supposed to be place for informal meeting. Considering the movement with activities, the visually integrated area in House D forms a liner circulation path correlated with the occupants' movement through DAIDOKORO and OMOTEZA. In House I, the activity of sleeping takes place in ICHIBAN-ZA as in House D and the activity of studying takes place in ENGAWA instead of URAZA in condition "w" (see Fig.9).

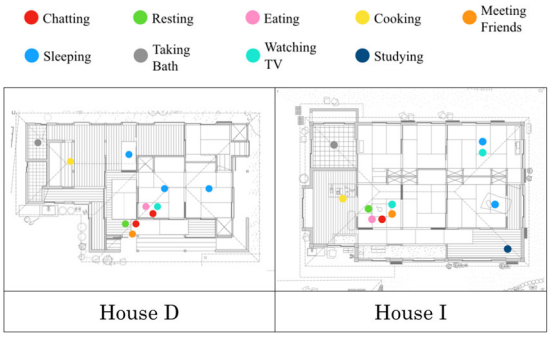

Fig.9 Behaviour Map in House D and House I for Occupants' Living Activities

To sum up, the results of the condition "w/" show a significant difference from those in condition "w/o". It can be argued that this difference is generated from the occupants' adjustment of designed expected situation to reach to the actual situation. The reformed configuration manifested the process of occupants' understanding about their living situation and interacting with their domestic physical environment based on their own experience and living patterns.

4.3 "Manipulation" - Condition "m"

During the fieldwork, it is found that the occupants in Izena Village manipulate the sliding doors not only through opening and closing them but also through removing them, which leads to profound variation of the configuration of the houses. In this section, two cases, House I and House R (plans of them are listed in Fig.5) were picked to analyse.

4.3.1 Case 1 - House I

In House I, through the interview with the occupants, it is found that the sliding doors around OMOTEZA will be removed

so that ICHIBAN-ZA, NIBAN-ZA and SANBAN-ZA can be treated as one entire large room in the occasion that relatives gather for family routines.

In this situation, OMOTEZA becomes redder in condition “m” than in condition “w” as shown in the VGA result (see Fig.10), which means it becomes much visible from the other spaces in the house.

In addition, this manipulation affects the visibility of ENGAWA in the south side of OMOTEZA as well. In condition “w/”, the space for ENGAWA in VGA result is greener, which means it is visually segregated from other spaces. While in condition “m”, the space for ENGAWA becomes much redder, which means it becomes more visible.

On the other hand, ICHIBAN-URAZA and NIBAN-URAZA are not changed greatly. Hence, the difference of visibility between OMOTEZA and URAZA becomes more significant in condition “m”.

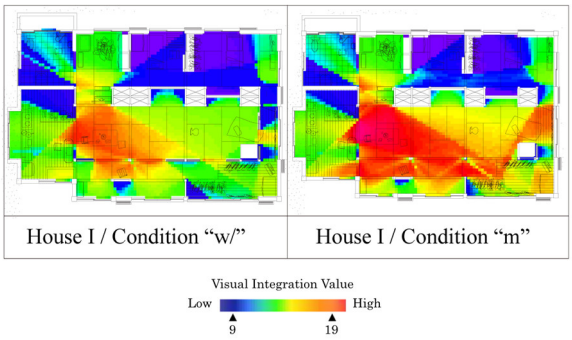

Fig.10 Comparison of the VGA Results for House I in Condition “w/” and Condition “m”

4.3.2 Case 2 - House R

Meanwhile, House R is sometimes used for private home rental. According to the occupants, if guests come to House R, sliding doors on the south side and the west side of ICHIBAN-ZA will be closed to let the guests stay there. As Fig.11 shows, in condition “m”, Visual Integration Value for ICHIBAN-ZA slumps so that the visibility of ICHIBAN-ZA is as low as that of ICHIBAN-URAZA. In this way, the guests in ICHIBAN-ZA and occupants in ICHIBAN-URAZA can keep privacy from each other. Moreover, ENGAWA in the south side of NIBAN-ZA becomes the most visible space in the entire house. According to the interview, if guests come to House R, they will eat, chat, rest, etc. in ENGAWA which becomes the centre of living activities for them.

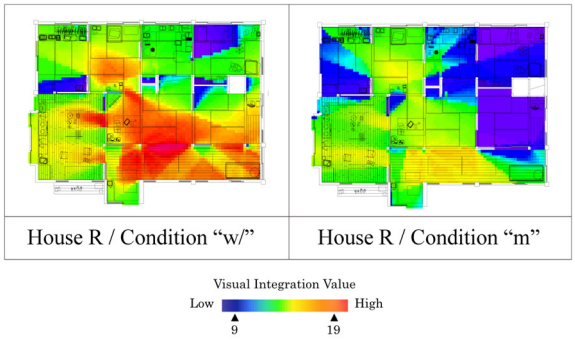

Fig.11 Comparison of the VGA Results for House R in Condition “w/” and Condition “m”

To sum up, the manipulation of sliding doors by occupants could be viewed as an important practice to control visibility in the house. Through this way, the spatial configuration is changed by the occupants to fit various activities and special events in daily life.

5. Discussion and Conclusion

This research compares the visibility in relation to the house configuration in Izena Village. The analysis was conducted in three conditions, “w/o”, “w/”, “m”. The three conditions represent three levels of interaction between occupants and houses, i.e., Frame, Reconfiguration and Manipulation. The findings indicate that the reproduction of the configuration features can be identified in condition “w/o”, which correlates with the expected occupants’ living activities. While the variation of the configuration in condition “w/” manifests the occupants’ own understanding and interaction with their houses. Also, the variation in condition “m” indicates the adaptation of the configuration for occupants’ special life scenarios. Vernacular buildings are considered as architectural practices that embed certain information and innovation inside[2]. The variation of the Izena’s houses proves cases of the vernacular tradition that embeds occupants’ understanding and innovation of the built environment flows with the occupants’ living patterns. The application of VGA makes it possible to manifest the visibility properties of house configuration objectively. While in this research other variations such as the climate, the condition of houses and the different cognition for each individual occupant were neglected, which makes the results biased. Therefore, more detailed observation with first person experience is needed for future work.

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伝統的な伊是名民家における居住者の行動に関連した見られやすさの変化に関する研究

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キーワード：スペース・シンタックス, VGA, 伝統的民家, 伊是名

本研究では、沖縄県伊是名集落の伝統的な特徴を継承する民家を対象として、居住者の生活上の行動と空間構成の変化の関係を求めることを目的としている。民家の空間構成は、居住者が建具を操作することで元々の構成から居住者の生活に即した構成に変化すると考えられる。そこで民家の状態を、建具を全て外した状態、現在の日常生活での建具の使われ方を反映した状態、そして居住者の特定の行動の際の建具の使われ方を反映した状態の 3 つに分けて、それぞれの状態を分析することにより居住者の行動が建具の操作を通して、どのように民家内部の空間構成に影響を与えているのかを考察する。考察の方法については、スペース・シンタックス理論に基づく Visibility Graph Analysis（VGA）という評価手法を用いており、民家内のある空間が他の空間からどの程度見られやすいのかをもとに民家内部の空間構成の特徴を考察している。

建具を全て外した状態における VGA の結果について、民家南側の表座が全体的に見られやすい場所となっている型、表座に加えて表座と裏座を接続している場所も見られやすくなっている型、表座の一部のみが見られやすい場所となっている型の 3 つの型と、それらに当てはまらない独自の特徴を持った民家に分けられた。これらの型は民家がつくられた際に想定された使われ方が反映されたものであると考えられる。

また、日常生活での実際の建具の使われ方を反映した民家の空間構成を、建具を全て外した状態と比較し、居住者の各行動がどこで行われているかをヒアリングした結果と照らし合わせて、建具を全て外した状態と比較して現在の建具の使われ方が反映された空間構成が居住者の生活に合わせたものとなっていることを確認した。

さらに、居住者の特定の行動における建具の使われ方での空間構成の変化について、2 軒の民家の具体例を元に考察している。それぞれの民家では目的に合わせて居住者が建具を操作して空間構成を変えていること、その操作の目的である各空間の使われ方と見られやすさの間に関係性があることが考えられた。

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