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Finding Generative Rules in Settlements and Houses by Means of an Ideographic Language

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Abstract

This research revisits an early space syntax method of ideographic representation which was proposed by Hillier and his colleagues in the 1970s. The method provided an effective way of capturing syntactic relations of enclosure in settlements and houses in its compact format but has not gained the attention it deserves in the field of morphological research. Taking advantage of its power of compressed description, we analyse architectural plans of Korean vernacular houses from the fifteenth to the twentieth century. Tracing the 600-years transformation process by means of a series of ideographic formulae, we investigate the changing patterns of their layout and reveal the genotypical elements shared by a wide variety of housing types. By translating spatial relations to simple linguistic descriptions, the ideographic method enables not only an economic way of representing built environment but also a deductive way of finding generative rules in it.

Keywords Generative rules · Ideograph · Space syntax · Korean vernacular houses · Rules of enclosure

Introduction

Interpretation of the built environment has been a subject for many disciplines including architecture, urban planning, geography, archaeology and anthropology. Human settlements in particular have been investigated as material evidence that reveal the lifestyle and worldview of a society. It has been argued that the message encoded by their makers can be decoded by reading their textual meaning embodied in the built structure (Geertz 1973; Bourdieu 1977; Moore 1986; Johnson 1993; Blanton 1994). The encoded message carries the information of behavioural patterns of the society because built environments are basically 'people

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configurations' in their very purpose (Hillier 1996: 20). There exist various types of representational methods to help researchers investigate the social dimension in the built environment. The topological approach of space syntax in particular has been successful in widening its influence over the past decades owing to its quantitative approach to finding meaning. Typical space syntax methods convert a built system into a network of constituent units of spaces and calculate its degree of connectedness. What this paper will focus on, however, is an early space syntax method of ideographic representation developed by Hillier and his colleagues in the 1970s that has not gained the attention it deserves in the mainstream discussion of space syntax theory (Hillier et al. 1976). The reason why we reinstate it in this paper is its power of compressibility in describing morphological logic in space. This can be highlighted by comparing four levels of non-verbal representation of building blocks (Fig. 1).

When constructed in the real world, whether it be a scaled model or a real building, an architectural scheme gains actual presence in the world (Fig. 1a). This representation mode is a true reflection of reality but it may not serve researchers very well because it is overloaded with the maximum level of design information. In comparison, the architectural drawings offer a decreased level of complexity by projecting a single layered image from the scheme. Hence the floor plan in Fig. 1b effectively captures the image of the ground-level configuration by removing all the other layers of information. However, from the perspective of researchers who want to identify shared patterns from multiple cases, architectural drawings still carry too much project-specific information such as shapes and sizes. For them, a more effective analytical tool would be a diagram (Fig. 1c) with its increased level of abstraction in the way they represent reality. By stripping off shapes and sizes, they bring topological relations into our focus. Space syntax and other graph-theoretical methods are indebted to this diagrammatic approach in their attempt to reveal underlying relations of constituent parts. Now, if we decrease the level of information to a minimum and increase the level of abstraction to a maximum, we arrive at the ideographic representation developed by Hillier and his colleagues (Fig. 1d). This format removes the graphic symbols of bubbles and lines in the previous diagram that visualised spatial relations. Instead, it utilises the notational symbol 'X' for a space unit and the relational symbols '()' and 'o' for connectedness

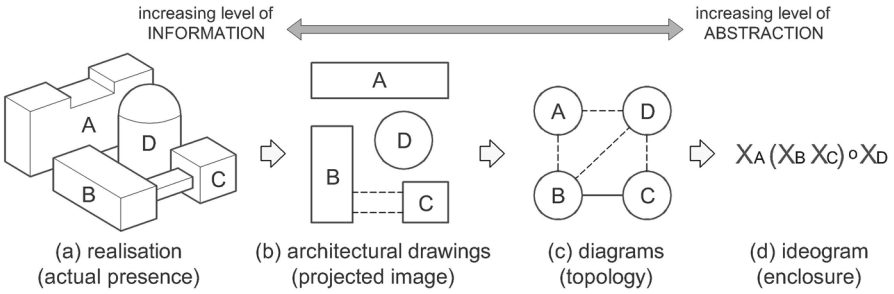

Fig. 1 Four levels of non-verbal representation of built environment. Image: author

and containment respectively. Hence, $X_A(X_BX_C)$ o X_D indicates that three space units, X_A, X_B, and X_C, of which the latter two are connected, contain the space unit X_D on the right side of 'o'. Some topological information is lost in its compact description, but it brings to the fore the relation of enclosure which was not self-evident in the previous diagram.

A higher level of abstraction means a lower level of preserved information, but the power of the ideographic representation above lies in its ability to capture the syntactic rules of enclosure in its short formula which is not possible in other diagrammatic approaches, including the mainstream space syntax methods. According to Hillier, a good theory 'accounts for much variability in morphology' with few principles (Hillier and Hanson 1984: 53), which is in line with the scientific axiom of Ockham's razor. If a small number of rules can explain a wide range of variations in dwelling patterns, it not only achieves the economy of description but also reveals the core value of underlying spatial logic in the makers' minds. We propose that these rules can be more effectively retrieved by means of Hillier's ideograph, which we will call 'syntactic ideograph' in this paper.

This paper takes 55 Korean vernacular houses as a sample and investigates their evolutionary process from the fifteenth century until the early twentieth century. There is a plethora of research on the characteristics of Korean vernacular houses but most of their approaches are descriptive rather than analytical, portraying their observations from material appearances without using an effective theoretical framework. What this research aims is to deduce their morphological logic in a systematic way through a single framework of syntactic ideograph. The design and construction of Korean vernacular houses typically follow the pattern of linear growth since building blocks are mostly single-room deep and rooms are added in a way to make them longer. This growth pattern makes various building block geometries such as L-shapes, U-shapes, and rectangular shapes. In upper-class houses, these linear patterns are configured to fit to the site condition, generating unique relations of enclosure between building blocks and courtyards (Fig. 2).

Figure 2 is an old architectural survey drawing of a gentry house drafted in 1764 before it was converted to a royal residence called Sesimgung. It depicts the floor plan where each small box is a room in which its function is written in Chinese characters. This rare existing house plan clearly shows how the linear building blocks can be put together to generate a unique pattern of enclosure in Korean vernacular houses. In this respect, Hillier's syntactic ideograph will be particularly useful in analysing them. While providing a higher level of abstraction to represent a wide variety of real-world variations, it can still carry the essential information of our interest, i.e. rules of enclosure.

Vernacular Houses in Korea

It is rare to find old Korean houses in their original form. Using a post and lintel system made of wood, which is vulnerable to fire and other structural damage, not many old houses have survived to this day. For the analysis of pre-modern design patterns during Choseon dynasty (1392–1909), 22 upper-class houses from the

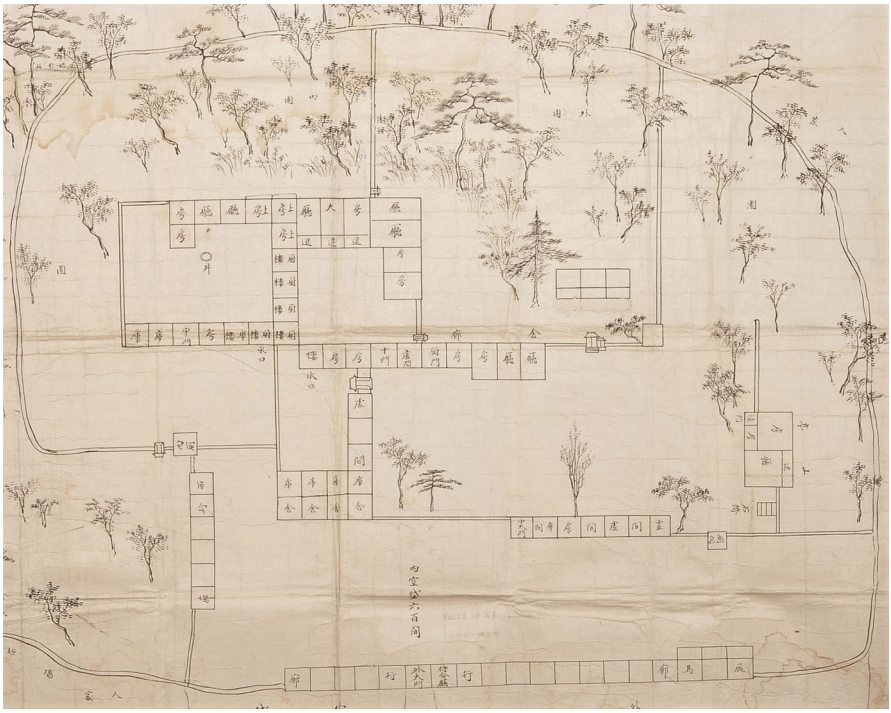

Fig. 2 Survey drawing of a gentry house (Sesimgung-dohyung) in 1764. Image: National Research Institute of Cultural Heritage (2013)

province of Gyeongsangbuk-do were selected. Compared to other eight provinces in South Korea, a dominant percentage of vernacular houses still exists in this province—433 houses (69.3%) out of the total 625 identifiable upper-class houses (Youn 2004). For the analysis in this paper, only those in their original form with clear historic records were chosen from two areas in the province—Andong and Yangdong. The selected 22 houses are all listed as national cultural assets and were constructed between the fifteenth and the nineteenth century, which helps our diachronic analysis. The design pattern of upper-class vernacular houses in Gyeongsangbuk-do is known to have strictly followed Confucian principles than other provinces and influenced those in the capital city of Seoul (Youn and Cho 1998).

For the analysis of modern design patterns in the twentieth century, 33 houses from Gahoe-dong in Seoul, built in the 1930s, were selected. The early twentieth century was the time when urbanised vernacular houses were developed across the city to meet the increasing housing demand. Most of them have by now lost their original shape and many have been demolished, but fortunately there remains a field survey report that recorded architectural details of 33 houses in Gahoe-dong (Moo-Ae Architectural Research Lab 1986). It was assumed that the compact version of urban vernacular houses would reveal how an urban context has exerted its impact on the centuries-long design tradition at the time of radical social change.

Figure 3 shows the site plan of Seobaekdang and its location in Yangdong village. It is the oldest existing house built in 1460 when Neo-Confucianism was expanding its influence as a national philosophy. According to Neo-Confucian philosophy, upper-class houses need to follow patriarchal principles by separating spaces for men, women, and servants, and especially the inner quarters for females (*anchae*) were supposed to be visually separated from the outside world (for details, see Seo and Ryoo 2020). For this, the house placed the rectangular form of the inner quarters behind the gate building for servants (*munganchae*), and the inner room for the mistress (*anbang*) was located in the far corner from the entry point of the quarters (at the end of the arrow in Fig. 3). On the other hand, the outer quarters for males (*sarangchae*) were not emphasised in this early period; it was merely a couple of male rooms accommodated within the inner quarters. In later periods, however, this male domain became increasingly articulated and separated to represent male authority.

When a house is built, it was the norm that the inner quarters are built first to let inhabitants start living and then other buildings are added afterwards. As countryside houses could secure large plots, they generally followed this phased construction by which the inner quarters took the central position and other buildings are added later in the remaining space around it. Wealthy households often built additional buildings such as servant quarters, storage buildings, and mills on this peripheral zone. From the seventeenth century, it was stipulated by the national regulation that the ancestral shrine also had to be built within the compound, especially for the houses of heads of family.

In countryside villages, these upper-class houses were independently built on selected parcels of land but collectively, intermingled with lower-class houses, they formed a typical organic pattern of rural settlements as in Fig. 3 (right). It may appear that the village layout has no clear pattern with randomly scattered houses,

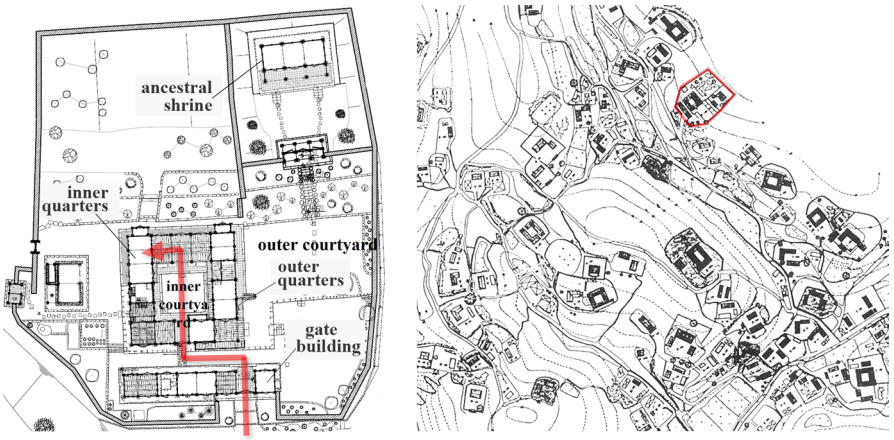

Fig. 3 Seobaekdang, the oldest existing upper-class house built in 1460 (left) and its location in Yangdong village (right)—the arrow shows the transition from the gate to the mistress' inner room. Image: Cultural Heritage Administration database (http://heritage.go.kr), modified by the author

but on a closer look it embeds a subtle spatial order called the 'beady ring' structure (Hillier and Hanson 1984: 56–61). A beady ring is defined by small and large clumps of houses facing towards shared open spaces, or streets, that collectively form global and local rings for people's movement. It is observed from the Yangdong village layout that there are large circular rings in the middle surrounded by smaller rings on the periphery.

From the early twentieth century, due to the explosive growth of the population in Seoul, housing developers purchased a large block of land and built compact versions of vernacular houses in the city. Gahoe-dong is a typical upper-class residential town located on the eastside of the Kyungbok palace in the old city centre. The selected 33 houses are all different in their dimensions and details but Song (1988) found they can be classified into nine distinct layout types. Figure 4 shows two of Song's nine types and their location in the urban context. Gahoe-dong 11–17 in Fig. 4a is a large type sitting on a larger plot, while Gahoe-dong 11–47 in Fig. 4b is the most dominant standard type. Urban vernacular houses were built on plots that had been divided from a large parcel of land into mostly rectangular shapes. Unlike organically grown towns such as Yangdong discussed above, the concept of a grid system was applied at the masterplan phase for the efficiency of plot division and access from the street, as in Fig. 4c. Consequently, the houses in each section of the grid are packed close to each other with no gaps between plot boundaries, and building blocks were built as close as possible to the boundary to secure the central courtyard.

Being on a larger plot, Gahoe-dong 11–17 has relatively generous space for building blocks and yards. It has the L-shaped inner quarters at the top left, the detached outer quarters at the bottom left, and the auxiliary quarters along the right side of the plot boundary. Although structurally separated, the latter two are conjoined by the gate hallway between them, and this makes them appear as another L-shaped block. The house clearly follows the traditional layout pattern of

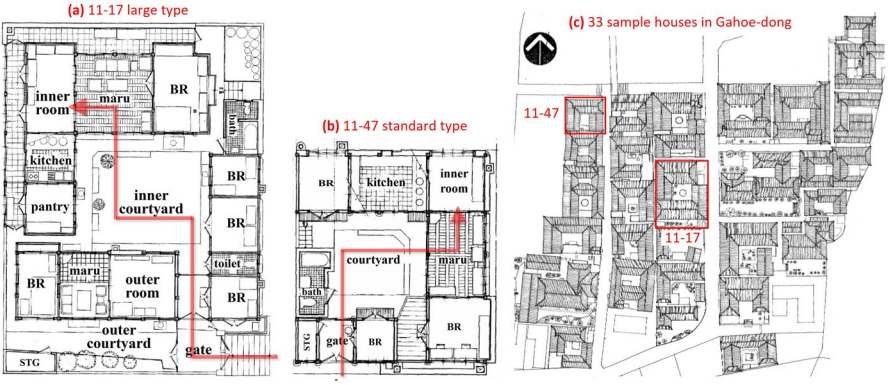

Fig. 4 **a** Gahoe-dong 11–17, larger type; **b** Gahoe-dong 11–47, standard type; **c** locations of 33 sample houses in Gahoe-dong; the arrows show the process of entering from the gate to the inner room (wife's room); BR indicates a bedroom and STG a storage. Image: original drawings from Moo-Ae Architectural Research Lab (1986), modified by the author

separating the female domain from the male domain. It is noteworthy that the outer quarters also have a small outer courtyard at the bottom of the plot. Obviously, there was an effort by the developer to transplant the Confucian logic of separating a male space within the tight urban context.

The Confucian grammar had to be compromised when the plot size was smaller. Gahoe-dong 11–47 has all rooms closely packed together and pushed towards the plot boundary. It has no space for a proper male block and could only add, apart from the inner quarters, a small gate building at the bottom left corner. The small rooms in this kind of gate buildings were normally used to accommodate family members of either gender or tenants. The standard-sized Gahoe-dong 11–17 is the most dominant type; 17 out of 33 houses (51.5%) follow the same plan layout with minor variations in size and detail. It can be said the designated male space was disappearing fast in early twentieth-century Seoul due to rapid urbanisation. Consequently, the inner quarters and the inner room were increasingly used as a gender-neutral space for the whole family.

Ideographic Representation of Settlements and Houses

This research concerns the use of syntactic ideograph to represent built forms in a more compressed way for an efficient processing of data. According to Hillier and Hanson (1984: 52), by means of ideographic representation, one can achieve the following: 1. Finding 'elementary structures' of a human spatial organisation in all its variability; 2. Representing elementary structures in ideography to avoid cumbersome verbal constructs for sets of ideas; 3. Showing how elementary structures are related to each other to make a coherent system; 4. Showing how they may be combined together to form more complex structures.

Their syntactic ideograph uses only three alphabet symbols, Y, X, and o, which generate combinations to describe complex systems ranging from settlements to individual houses. The capital letter Y represents what they termed 'a carrier space', a wider open field, and X a boundary of any finite region of space whether it be walls or buildings. When written in lowercase, x and y represent a smaller open field and a smaller boundary within the realm of Y and X. Finally, 'o' is an operator to indicate that what is on its left contains what is on the right. Figure 5 provides an easy guide on how these can be understood and applied.

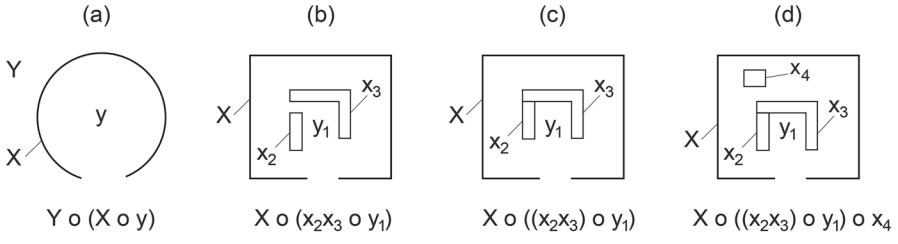

Fig. 5 Basic examples of ideographic operation. Image: author

Figure 5a is a basic diagram adapted from Hillier and Hanson (1984: 73) where an open carrier space Y contains a boundary X which surrounds a smaller open space y. Since the letter o denotes the relation of containing, the diagram can be converted to an ideographic representation of Y o (X o y), meaning Y contains the boundary X, which itself contains a small space y in it. The second arrangement in Fig. 5b has more complicated relations but defined by the same principles. Here, the open continuous space Y is excluded to make the ideograph simpler, since it is something taken for granted for any possible arrangement. The small letter x has been numbered by subscripts to distinguish multiple objects from each other. The outer boundary X encloses two internal objects, x_2 and x_3 that together make a boundary to surround a small courtyard y_1; hence the formula of X o (x_2x_3 o y_1). If the two objects are in direct contact as in Fig. 5c, a pair of brackets is added to surround them to indicate their physical connection: X o ((x_2x_3) o y_1). In Fig. 5d, an object x_4 is inserted between the two boundaries of X and (x_2x_3), so we need to add its relation at the end of the formula: X o ((x_2x_3) o y_1) o x_4.

The layout patterns in Fig. 5 were intended to imitate Korean vernacular houses with a surrounding wall and building blocks inside. This type of spatial system is defined as 'non-distributed' since its transformation occurs within a given boundary of X. In contrast, there is a different type of system defined as 'distributed' where transformation occurs by recursively adding more units of X to build up a wider network between them. Settlements are a typical example of a distributed system. Borrowing the same principles of ideograph shown in Fig. 5, two settlement patterns in Figs. 3 and 4 can be expressed in a simple ideographic language.

The organic structure of Yandong village in Fig. 3 can be described by a generic formula, Y o $X_1X_2X_3…X_k$ o X_{k+1} o $X_{k+2}…$o X_{k+n} in which Y indicates the boundary of the village and X indicates each house boundary. In the first phase of the village development, it can be assumed that a group of houses were built in appropriate locations without having to be contiguous to each other. In the formula, the first set of containment $X_1X_2X_3…X_k$ includes those first houses strewn across the village territory. In the following phases, more houses were added incrementally in a way to fit into the remaining parcels of land. This process can be expressed as 'o X_{k+1} o $X_{k+2}…$o X_{k+n}' since each new house added will be contained within the existing fabric of the village, between the wider boundary of Y and all the pre-established smaller boundaries of X. During this process of recursive filling in, when there are not many plots available, some houses would have to put their boundaries against others. Consequently, along with the growth in house numbers, housing clusters would naturally emerge.

Unlike this process of natural growth in Yangdong, the planned town of Gahoe-dong in Fig. 4 has a completely different formula. The ordered pattern of house clustering and its repetition on a grid system can be represented by a generic formula: Y o ($X_{1a}X_{1b}X_{1c}…$)($X_{2a}X_{2b}X_{2c}…$)…(X_{ka} $X_{kb}X_{kc}…$). Each pair of brackets includes a cluster of houses whose individual plot boundaries are closely packed together. Externally each cluster is surrounded by streets. Thus, the number of brackets and the number of houses in them are determined by the scale of the development. This formula has no relation of containment since the town was conceived as a whole

from the beginning with all plots divided by a grid system, without the concept of enclosure.

For the analysis of an individual house layout, each X in the above formulae needs to be expanded further in its description to represent internal layouts. For the precise translation of each house, it will be convenient to use definitive labels for subscripts instead of ordinal numbers. These labels can be abbreviations of the names for each built structure: X_b for the house boundary; x_i for the inner quarters for females; y_i for the inner courtyard; x_o for the outer quarters for males; y_o for the outer courtyard; x_g for the gate building; and x_a for other auxiliary buildings including servants' quarters. In this way, Seobaekdang in Fig. 1 can be translated as: X_b o $(x_i$ o $y_i)$ o $x_g y_o(x_{b2}$ o $x_{sh})$. As mentioned before, Korean vernacular houses are not built all at once but in an incremental manner. The inner quarters were the first phase construction for Seobaekdang, sot it can be put down as X_b o $(x_i$ o $y_i)$. The gate building x_g and the outer courtyard y_o have been added in the following phase on the periphery of the inner quarters, and the ancestral shrine x_{sh} was added in the final phase. Following Confucian layout principles, the shrine is bounded by a separate fence x_{b2}, yet is within the perimeter zone around the inner quarters. Thus, the last part of the formula $x_g y_o(x_{b2}$ o $x_{sh})$ includes all the later-phase additions that are between X_b and $(x_i$ o $y_i)$.

Analysis

The 22 houses from Gyeongsangbuk-do built between the fifteenth and nineteenth century and 33 houses from Gahoe-dong, Seoul built in the early twentieth century were analysed using syntactic ideograph. To facilitate the conversion from architectural plans to ideographic representation, all site plans were first translated into a simpler format of site plans as in Fig. 6 to highlight the building block arrangement around the inner quarters. For the economy of analysis those minor additions at later phases that have no meaningful relation to the inner quarters or the outer quarters were not included. By focusing on key blocks, i.e., the inner quarters, the outer quarters, and adjacent auxiliary buildings, it was possible to distinguish major changes in the six-century long process of housing transformation.

Vernacular Houses in Choseon Dynasty

Figure 6 shows site plans of the 10 houses in Yangdong in a simple format. Each plan shows the compositional relation between building blocks centered around the inner courtyard. The first house is Seobaekdang from Fig. 3. The thick-lined block is the inner quarters, where the hatched part indicates the inner room for a mistress. The solid-hatched space is the outer quarters or male rooms. The thin-lined blocks are auxiliary buildings that include spaces for servants, storage, and other supporting functions. The red arrow indicates the sequence of a visitor's movement from the main entrance to the inner room. By tracing the movement from the public to the private domain, a similar layout pattern shared by these

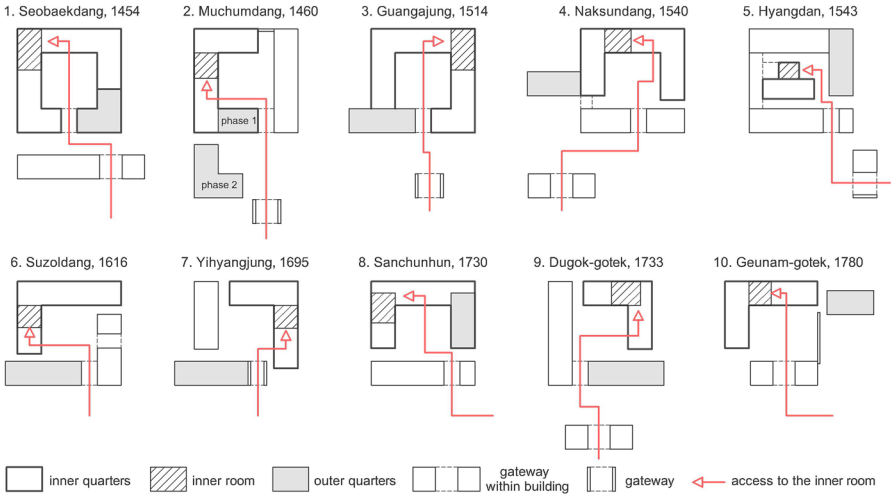

Fig. 6 Simplified site plans of ten upper-class houses in Yangdong. Image: author

houses can be found. Accessing the house, a visitor encounters the outer quarters or male spaces first, and then goes through the inner courtyard before getting into the inner room, which tends to be in the far corner.

It has been argued that the status of the outer quarters gradually changed during the period of Choseon dynasty. In Fig. 6, it is embedded inside the inner quarters in the first and second houses built in the fifteenth century but in the third and fourth houses built in the sixteenth century, they became articulated, albeit still attached to the inner quarters. From the sixth house, Suzoldang built in the seventeenth century, there emerges a detached block of outer quarters as an independent male space. Finally in the tenth house, the outer quarters are de-clustered from the inner quarters and stand as a completely separate building. This change coincided with the increasing influence of Confucian principles by which male dominance in the social system is more legitimised.

Now, it is possible to further scrutinise whether the same spatial patterns and their change in time can be found in a larger sample. Table 1 lists 22 sample houses in Gyeongsangbuk-do, including the 10 houses in Fig. 6. They are ordered according to their construction years in the third column; in addition to the initial construction year, the column shows the years of the later renovation or addition of the outer quarters in the bracket. Most importantly, the table has each house converted to a simple ideograph, highlighting the relations of enclosure. For example, the first house, Seobaekdang, is represented as X_b o (x_i o y_i) o $x_g y_o$. As pointed out before, the formula itself follows the process of housing construction. First, the house boundary X_b is set; then the inner quarters are built to surround the inner courtyard as in (x_i o y_i); and the last-phase construction of $x_g y_o$ takes place between X_b and (x_i o y_i). Reading from left to right, this linear structure of ideograph actually inscribes the incremental process of house construction. As the same logic is found from all formulae, it can be said that syntactic ideograph

Table 1 Vernacular houses in Yang-dong represented by ideograph and their changing traits

	House name	Construction year	Confucian influence	Ideographic representation	Position of outer quarters (x_o)	Type
1	Seobaekdang	1454	Early adoption	X_b o (x_i o y_i) o $x_g y_o$	Within x_i	1
2	Muchumdang	1460 (1550)		X_b o ($x_i x_a$ o y_i) o y_o	Within x_i	1→4
3	Guangajung	1514	Established	X_b o (($x_i x_o$) o y_i) o y_o	Articulated within x_i	2
4	Naksundang	1540		X_b o (($x_i x_o$)x_a o y_i) o $x_g y_o$	Articulated within x_i	2
5	Hyangdan	1543		X_b o ($x_a x_v$ o $x_i y_i$) o $x_g y_o$	Within x_a (atypical)	3
6	Yeanyisigotaek	1551 (?)		X_b o (x_i o y_i) o $x_o y_o$	Within x_i (2nd x_o added later)	1→4
7	Sangbyukdang	1566 (?)		X_b o (($x_i x_o$) o y_i) o $x_g x_o y_o$	Articulated within x_i (2nd x_o added later)	2→4
8	Yangjindang	Late C16th		X_b o (x_i o y_i) o ($x_g x_o$ o y_o)	Within x_i & separate x_o	1 & 4
9	Euisungkimsijongtaek	Late C16th		X_b o (x_i o y_i) o ($x_g x_o$)y_o	Separated from x_i	4
10	Yecheonkwonsijongtaek	1598 (?)		X_b o (($x_i x_o$) o y_i) o $x_g x_o y_o$	Articulated within x_i (2nd x_o added later)	2→4
11	Chunghyodang	Early C17th	Constitutionalized by law	X_b o ($x_i x_o$ o y_i) o $x_g y_o$	detached from x_i (x_o extended later)	3
12	Gyeseodang	1613		X_b o ($x_i x_o$ o y_i) o $x_g y_o$	detached from x_i (x_o extended later)	3
13	Suzoldang	1616 (1744)		X_b o ($x_i x_a x_o$ o y_i) o y_o	Within x_i (detached x_o built later)	1→3
14	Yulijongtaek	1630		X_b o (($x_i x_o$) o y_i) o y_o	articulated Within x_i	2
15	Yuiljae	Late C17th		X_b o ($x_i x_o$ o y_i) o y_o	Detached from x_i	3
16	Yihyangjung	1695		X_b o ($x_i x_a x_o$ o y_i) o y_o	Detached from x_i	3
17	Sangchunhun	1730		X_b o ($x_i x_a$ o y_i) o y_o	Within x_i	1
18	Dugokgotek	1733		X_b o ($x_i x_a x_o$ o y_i) o $x_g y_o$	Detached from x_i	3
19	Geunamgotek	1780 (?)		X_b o ($x_i x_a$ o y_i) o $x_o y_o$	Separated from xi	3→4
20	Sugokjongtaek	1792 (?)		X_b o ($x_i x_o$ o y_i) o $x_o y_o$	Detached from x_i (2nd x_o added later)	3→4
21	Hadonggotaek	1836	Undermined	X_b o ($x_i x_o$ o y_i) o $x_g y_o$	Detached from x_i	3
22	Bukchondaek	1862		X_b o ($x_i x_o$ o y_i) o $x_o y_o$	Detached from x_i & separate x_o	3 & 4

not only represents the relation of enclosure but also replicates the actual process of realisation in time.

Looking at all 22 ideographic representations, we can start to see some recurring patterns and their change over time. Based on the finding from Fig. 6 that the outer quarters become independent over the hundreds of years of Confucian rule, we can identify four different types of formulae. Following the order of their appearance, we can label them from Type 1 to Type 4 as in the last column in Table 1. Type 1 is defined by a subset of (x_i o y_i) with no x_o appearing in the formula; it is the earliest type where the outer quarters are still within the inner quarters. Type 2 has a subset of (($x_i x_o$) o y_i); it is the second phase when the outer quarters were articulated while still being a part of the inner quarters. Type 3 contains ($x_i x_o$ o y_i) which is similar to Type 2 but the inner quarters and the outer quarters now lose their connection, although they are still adjacent to each other around the inner courtyard. Finally, Type 4 is the formula that has the ideographic structure of (x_i o y_i) o x_o, in which the outer quarters are decoupled from the inner quarters' cluster to become a fully separate unit. If a subsequent construction transforms the existing layout pattern and thus the type is changed, it is indicated by an arrow connecting two types in the last column of the table—the subsequent construction year is in the brackets in the third column. For instance, 2→4 means that the house was classified as Type 2 at its initial construction but converted to Type 4 when the outer quarters were added later. Browsing the 'Type' column, from top to bottom, it is recognised that they show no clear pattern of transition from Type 1 towards Type 4. Plotting their types against construction years, we begin to see some patterns emerging (Fig. 7).

Obviously, Type 1 started earlier than others and rarely appears after the early seventeenth century; House 17 seems to be an exception. Type 2 started from the early sixteenth century and built until the early seventeenth century. Type 3 was first built in the mid-sixteenth century and consistently built until the nineteenth century; it is the most persistent type. Type 4 is the latest addition started a bit later than Type 3 in the mid-sixteenth century and concentrated around 1600 and the later part of the nineteenth century. Some researchers claimed that this architectural change of the male domain becoming pronounced exactly follows the direction of social change where Confucian principles were gradually strengthened, as indicated at

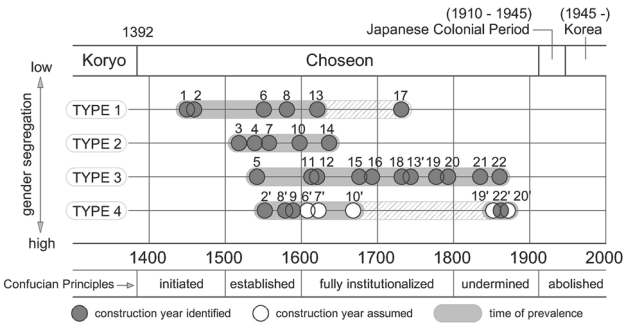

Fig. 7 Types and construction years of 22 vernacular houses in Gyeongsangbuk-do. Image: author

the bottom row in Fig. 7 (Kim and Joo 1996; Lee 1991, 1988; Deuchler 1992; Yun 2012). In our sample, the architectural change exhibits no clear and sharp division of periods by types as the researchers claimed; rather it shows considerable overlap and some irregularities while gradually shifting towards right as we go down from Type 1 to Type 4.

This less clear pattern may have been caused by the small sample size but it can be accepted as a realistic phenomenon in cultural studies. In doing research on material culture, it should be understood that it is not 'material manifestations' but the 'ideas' in culture that change (Glassie 1975). Once becoming a part of design ideas, an architectural type will remain in the vocabulary, but its realisation may not be immediate and consistent. Comparing the plots of Type 3 and Type 4, the former seems to prevail in a consistent manner, while the latter is less frequent and has a long dormancy in the middle. This proves the discrepancy between manifestations and ideas. Although the social value has shifted towards Type 4 to advocate a more prominent and independent male domain, many houses still seem to rely on Type 3, of which the construction is simpler and more affordable. This tendency seems align well with the existing study which confirmed that houses with separate outer quarters are relatively rare and they were selectively built by those with a higher level of wealth and scholastic achievement (Youn 2004: 99).

Urban Vernacular Houses (1930s)

The 33 surveyed urban vernacular houses in Gahoe-dong, Seoul, were classified into nine types (Fig. 8). They are simplified versions of actual survey plans. Their relations with the original surveyed plans can be seen by comparing house 1 and 7 with the plans in Fig. 4. The house code above each plan came from the postal addresses where the type is found, and the number inside brackets indicates the number of its cases within the 33 surveyed houses. We did not draw a plot boundary for the houses in Yangdong because it is much bigger than building footprint areas, but it is drawn here since it directly influences the way buildings are composed in the tight urban plot. Three different plot sizes exist. Houses 1–5 have larger plots; houses 6–8 have standard plots; and house 9 has a small plot. Thick-outlined

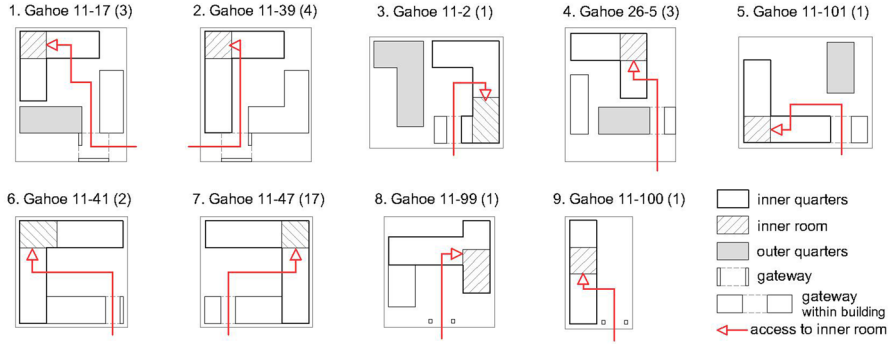

Fig. 8 Nine types of urban vernacular houses in Gahoe-dong. Image: author

buildings are the inner quarters; solid-hatched ones the outer quarters; and thin-outlined ones auxiliary buildings. The arrows show the user's transition from the entrance, through the inner courtyard, then into the inner room.

It appears that the outer quarters are mostly found in larger plots (except house 2) while it never appears in standard and small plots. Also, it is noticeable that the small plot had no choice but took the unusual straight shape of the inner quarters, losing the typical way of enclosing the inner courtyard with the L-shape. These diagrams are converted to syntactic ideograph in Table 2.

Comparing the case numbers in the third column, it is found that House 7, Gahoe-dong 11–47 is the most dominant type—17 cases out of 33, which is 51.5%. Two other types fall into this category of standard plots, and by adding 3 cases from them, it turns out that an overwhelming 20 cases (60.6%) use the standard-sized plot. It is noteworthy that all three types on standard plots have the same ideographic representation of X_b o $((x_i x_a)$ o $y_i)$. It is a simple formula where the 'L' shaped inner quarters x_i and an auxiliary building x_a are connected to form a U-shape to contain the inner courtyard y_i. Due to the tight plot boundary, no additional buildings or yards are added outside this cluster.

Compared to this, larger plots (House 1–5) clearly have more complex formulae. Having more generous plot sizes, the building blocks could be all detached, hence there are no nested brackets in their formulae as in the standard plot formula. Of the five types, four have outer quarters x_o, except House 2 (Gahoe-dong 11–39). Also, the outer yard appears in four houses except House 5 (Gahoe-dong 11–101). At least until the 1930s, it seems that the custom of separating outer quarters in upper-class houses was still practiced where possible even in urban plots, but when the plot size became more restricted, it had to be compromised.

Synthesis: Transformation of Korean Vernacular Houses

The formal change of Korean vernacular houses has been discussed by means of ideographic representation. Two comparable design approaches have been identified by two major periods: the pre-modern period of Choseon dynasty from the fifteenth

Table 2 Nine types of urban vernacular houses in Gahoe-dong and their ideographic representation

	House name	Cases	Plot size	Ideographic representation	Outer quarters
1	Gahoe-dong 11–17	3	Large	X_b o $(x_i x_o x_a$ o $y_i)$ o y_o	Detached from x_i
2	Gahoe-dong 11–39	4		X_b o $(x_i x_a$ o $y_i)$ o y_o	None but has an outer yard
3	Gahoe-dong 11–2	1		X_b o $(x_i x_o$ o $y_i)$ o y_o	Detached from x_i
4	Gahoe-dong 26–5	3		X_b o $(x_i x_o x_a$ o $y_i)$ o y_o	Detached from x_i
5	Gahoe-dong 11–101	1		X_b o $(x_i x_o x_a$ o $y_i)$	Detached from x_i; no outer yard
6	Gahoe-dong 11–41	2	Standard	X_b o $((x_i x_a)$ o $y_i)$	None
7	Gahoe-dong 11–47	17		X_b o $((x_i x_a)$ o $y_i)$	None
8	Gahoe-dong 11–99	1		X_b o $((x_i x_a)$ o $y_i)$	None
9	Gahoe-dong 11–100	1	Small	X_b o x_i	None (no inner courtyard)

to ninteenth century and the modern period in the early twentieth century. The former has seen upper-class houses built in many countryside villages in large plots, accommodating many building blocks and yards, while the latter is built in a compact format in tight urban plots. Whether it be an influence from Confucian principles or urbanisation, the whole process of housing transformation between the fifteenth and twentieth centuries can be explained by six distinct types:

- **Type 1** (15th–16th c.): X_b o $(x_i x_a$ o $y_i)$ o y_o when x_o is embedded within x_i
- **Type 2** (16th–17th c.): X_b o $((x_i x_o)$ o $y_i)$ o y_o when x_o is articulated but still connected to x_i
- **Type 3** (16th–19th c.): X_b o $(x_i x_o$ o $y_i)$ o y_o when x_o is detached from x_i
- **Type 4** (16th–19th c.): X_b o $(x_i$ o $y_i)$ o $x_o y_o$ when x_o is de-coupled from x_i
- **Type 5** (1930s): X_b o $(x_i x_o$ o $y_i)$ o y_o when x_o is detached from x_i in large urban plots
- **Type 6** (1930s): X_b o $((x_i x_a)$ o $y_i)$ when x_o disappears or is replaced by x_a in standard urban plots

Type 1 to Type 4 represent pre-modern vernacular houses in Choseon dynasty that have been defined in Table 1. Type 5 and Type 6 are urban vernacular houses in the 1930s that have been defined in Table 2. It should be noted that the periods of their occurrence are not clearly separated; they overlap and sometimes co-exist at the same time. However, they still give us a clue as to how the housing form has gradually changed following the social evolution. Looking at these six types through 600 years' time, it can be said that the single most influencing factor in shaping Korean vernacular houses is the outer quarters. Until the fifteenth century these were a couple of male rooms within the inner quarters, as defined by Type 1, but became articulated in the sixteenth century, forming $(x_i x_o)$ as in Type 2. In the mid-sixteenth century, the outer quarters began to be detached from the inner quarters, forming $x_i x_o$ as in Type 3, and eventually gained their independence in Type 4.

In early twentieth-century Seoul, when the upper-class houses were built in tight urban plots, it seems that developers still wanted to separate the male quarters from the female quarters following the old convention. This is evident from those houses built in larger plots where they tried to build the detached outer quarters with a designated outer yard, as in Type 5. Thus, Type 5 has the identical formula with Type 3 despite its urban context. However, when it comes to a standard-sized plot, this convention had to be compromised due to the reduced buildable area. This entailed the disappearance of the outer quarters as well as their yard for the majority of urban vernacular houses, as in Type 6. Since the standard plot size was most dominant in the market, it is presumable that it was socially acceptable to do without a separate male space at the time. This can be confirmed by the fact that after the end of the nineteenth century, the old patriarchal order was losing its predominance together with the diminishing power of Choseon dynasty which upheld it. It has been reported that from the early twentieth century the spatial segregation by gender became less rigid. Thus the inner quarters were increasingly shared by both males and females while the outer quarters became more frequently used to accommodate tenants and servants (Jongro-Gu 2014; Shin 2013). In this vein, the demise of the

outer quarters can be understood as a result of two forces: the compactness of urban dwellings and the gender-neutral use of domestic spaces.

While the six types make evident a process of transformation, there exists a distinguishable common denominator in all six formulae, that is X_b o (x_i o y_i). Once a house defines its plot boundary X_b, it is a norm that the inner quarters x_i are shaped in a way to enclose the inner courtyard y_i, regardless of socio-political contexts and plot sizes. It is a configurational sub-set embedded in all types of housing arrangement. In a simple syntax, it defines a genotypical characteristic of Korean vernacular houses that is universal and timeless. All the vernacular houses we have seen are simply the variations of this abstract rule of enclosure.

Arguments have been made that the modern Korean apartment house can be characterized by its peculiar spatial arrangement where the open public zone made of a dining-kitchen and a living room is surrounded by bedrooms; this can be traced back to the configuration of the vernacular house with its inner quarters surrounding the inner courtyard (Kang et al. 1999: 333). This has been typically explained by comparing the old and new house plans, and therefore asking readers to use their imagination to see the hidden similarities. By using the ideographic language, this can be more logically deduced. From the vernacular genotype formula X_b o (x_i o y_i), if the inner quarters x_i are replaced by three modern bedrooms and the inner courtyard by the open public spaces of a dining-kitchen and a living room, we get X_b o (($x_1x_2x_3$) o ($y_{dk}y_l$)) which represents the most popular unit plans in the late twentieth century (Fig. 9).

The modern apartment plans have the same permutational design approach by which rooms are arranged within a given boundary of the unit. It is difficult to prove why this particular configuration prevails over others in the market, and it is even more difficult to prove it has its origin in the Korean vernacular house. The power of ideograph lies in its succinct abstraction in representing the relation of enclosure. As the debate on the continuity of generic Korean spatial properties is centered around this relation of enclosure, the ideograph can be the most reliable tool for the analysis and interpretation.

Fig. 9 The most dominant apartment plans in the 1970–80s (left) and 1990–2000s (right). Image: author

Conclusion

When Hillier and his colleagues first attempted to find spatial logic in built forms under the name of space syntax in the 1970s, they defined their ideographic method as a form of morphic languages (Hillier et al. 1976). According to them, morphic languages fall between mathematical and natural languages, borrowing certain properties from each. Like mathematical languages, they have very small lexicons, i.e., few primary morphic units, but what is generated from them is manifested in the experiential world like natural languages. They argued that the peculiarity of this middle-ground approach empowers morphic languages to explain rule-governed creativity. What we have investigated in this paper exactly proves what they wanted to explain. We have observed that a basic rule of enclosure, X_b o (x_i o y_i), can create a wide variety of real-world embodiment of built forms. Then this formula can be called a genotypical property in Korean vernacular houses.

The construction of Korean vernacular houses starts by defining plot boundaries. The next step is positioning the inner quarters. Collectively or independently, the inner quarters take the inclusive form of L-shape, U-shape or rectangular shape to surround the inner courtyard. This configuration and its construction process are succinctly represented by X_b o (x_i o y_i). This simple ideographic representation explains the initial process of forming an internal boundary nested within the plot boundary by using two 'o's as multiple operations of containing. If the plot size allows, more spaces can be added on the periphery of the inner quarters' cluster. This will make the formula grow linearly to the right after adding a third 'o'. Hence X_b o (x_i o y_i) o $x_1x_2…x_n$ $y_1y_2…y_n$. As we have seen, it is the interplay between plot sizes and socio-cultural contexts that influences the final arrangement of the housing. While this generates a wide range of variations, the existence of a genotypical formula attests the collective intention of folk architects to provide stability to the changing socio-cultural environment. Their work is continuous across place and time with minimum adjustments added to the existing grammar (see Glassie 1975: 112; Alexander 1964: 55–59).

There clearly exist limitations in our ideographic analysis in that the sample size was not large enough to achieve statistical reliability. In addition, the approach of 'gross architecture' in this research took no account of lower-level details in explaining built forms (Glassie 1975: 38). This might be seen as a weakness, although it served us to see the higher-level order in design. To borrow Hillier's terms, however, the purpose of this research was to 'work towards mathematisation from intuitive formal principles, rather than to adopt a branch of mathematics' (Hillier et al. 1976: 149), and to show how complex real-world patterns can be made knowable through basic concepts and operations. Clearly, the power of abstraction and compressibility in syntactic ideograph helps us simplify the complex real-world manifestations and organise them into a manageable set of categories. This can benefit researchers to amplify their computing power, especially when dealing with a large quantity of artefactual

data. In particular, the small number of lexicons in syntactic ideograph has been proven to provide effective conversion between it and a computer language (Fernandes 2022). In this respect, it is hoped that the way we applied the syntactic ideograph can be replicated in various other research fields dealing with syntactic relations of enclosure, such as social archaeology, human geography, urban planning, social ecology, and so on.

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