

Translating Fengshui into algorithmic design

A digital tool to examine the impact of Fengshui on Siheyuan's layout

Yuyang Wang¹, Asterios Agkathidis², Andrew Crompton³

^{1,2,3}University of Liverpool

^{1,2,3}{y.wang179|a3lab|Crompton}@liverpool.ac.uk

In continuation of our previous work on the design principles of traditional Beijing Siheyuan courtyard housing and their implementation into computational algorithms, this paper investigates the impact of the Fengshui theory on the layout. In particular, we will present the development of a Grasshopper algorithm able to examine Siheyuan houses' fortune status according to their layout. We have verified the algorithm by using Siheyuan precedents from the ancient Beijing map and measured surveys of existing buildings. Our findings highlight that most Siheyuan houses were designed to be auspicious even though other forces were working against it.

Keywords: Siheyuan, digital heritage, algorithmic design, Fengshui, Gongcheng Zuofa Zeli

INTRODUCTION

Courtyard housing was the most common dwelling type in ancient China. The Siheyuan, traditional Chinese courtyard housing type from Beijing, is a typical representative of traditional Chinese vernacular architecture. A typical Siheyuan consists of axially aligned courtyards symmetrically surrounded by individual buildings connected by orthogonally located corridors, walls, and gates, as illustrated in Figure 1.

When Beijing was rebuilt between the Yuan and Qing dynasties, Siheyuan became one of the most potent symbols of imperial rule. As the basic cell of ancient Beijing's urban texture, it embodied the rules of feudal society in its architectural form. Many studies such as by Ma (1999), Zhao (2013), Lu and Wang (2013), have paid attention to its archetypal form in traditional feudal society.

After the rejection of Liang and Chen's proposal by the Beijing government in 1950, many Siheyuan houses were damaged or destroyed up to the present day. One of the consequences of this destruction is that current architects lack knowledge of its principles, thus their Siheyuan design projects are considered as fake. In support of the preservation and popularization of Siheyuan design knowledge, many studies re-introduced its design principles using historical records. For example, Ma (1999), Jia (2012), and Lu and Wang (2013) comprehensively introduced forms of architectural components of traditional Siheyuan based on extant buildings and historical materials. Zhao (2013) studied tectonic methods of Siheyuan's architectural components by the understanding of ancient construction rules and interviews with successors of ancient craftsmen.



On the other hand, computational approaches created by western scholars: shape grammar (Stiny, 2006), space syntax (Hillier and Hanson, 1984), and pattern language (Alexander et al., 1977) have been employed in Chinese courtyard housing studies to explore its design logic. Chiou and Krishnamurti (1995a) developed the grammar of vernacular dwellings in Taiwan, a branch of Chinese courtyard housing, which enhanced the understanding of its design. Huang et al. (2018) analysed the spatial configuration of an ideal archetypal model using DepthX Map in order to continue Siheyuan's cultural connotations in contemporary housing design. Wang and Song (2012) and Liu (2019) respectively studied the composition of walls and rooms in Siheyuan examples recorded on the historical Qianlong capital map (*Jingcheng Qianlong Quantu*, 1750) by categorizing types of courtyards. Their classifications of patterns of courtyards and rooms revealed the design constraints underlying practice.

Moreover, the approach of procedural modelling was applied to create algorithmic tools for the study of the Siheyuan. Liu and Wu (2015) successfully generated traditional Siheyuan models using their algorithmic tool based on the rules mathematically shaping architectural components recorded in the ancient architectural manual *Gongcheng Zuofa Zeli*. However, as Liu and Wu's focus was to reveal rules of the modular system underlying ancient Chinese architecture in construction, they didn't capture the

essence of Siheyuan's traditional design principles. Wang et al. (2019) employed a procedural modelling approach to study the design principles of Siheyuan according to the computational consideration underlying its traditional design principles and produced a digital interactive tool to generate the 3D models. This is the only example of research parametrically generated Siheyuan variations comprehensively based on rules underlying historical sources. Even though there are a great number of studies on Siheyuan design, an important cultural factor, Fengshui (cloud and water, 风水), has rarely been explored for its influence on Siheyuan's architectural form.

In ancient Chinese philosophy, the cosmic aspect of nature is the essence of everything. Therefore, ancient Chinese knowledge about it was applied to many subjects by analogy. For example, a person's body is considered as an individual universe, whose mechanism is believed to be the same as the cosmos. To pursue a healthy body, not only its organs must be well-organized and balanced with each other, but also the person has to be in harmony with the environment where he/she is situated. This idea is called 'tian ren he yi' (unity of the universe and human). Fengshui is geomancy based on this analogy to guide adapting cities and buildings to achieve harmony with nature. There are two branches of Fengshui theory: *Xing Shi* (observing context,) and *Li Qi* (regulating vital energy). The *Xing Shi* helps geomancers to select an auspicious site and the *Li Qi* based on the concept of "cosmic resonance" helps craftsmen and householders predict and select auspicious orientations, qualitative space, and dimensions of rooms in the design process.

In the context of Taiwanese vernacular dwellings, Chiou and Krishnamurti (1995b) investigated the method from *Li Qi* to determine the fortunate dimension of a building using the ancient measuring ruler *Lu Ban Chi* and interpreted it in an algorithmic format. Later, they (1997) also introduced applications of *Li Qi* in finding fortunate orientations of a site and auspicious dates to start building construction and

Figure 1
Beijing Siheyuan,
after Ma, 1999.

implemented it in computers. Meanwhile, Wang et al. (2019) created an interactive tool to assess the fortune of site environment of Beijing Siheyuan according to principles from *Xing Shi*, which gave guidance to design a Siheyuan house following Fengshui. Although this research made passing reference to the principles of Fengshui on architectural design, the implementation of Fengshui in the Siheyuan's form in practice has rarely been investigated. Chan and Xiong (2007) have pointed out the cultural perpetuating forces defining Beijing Siheyuan are multiple, such as feudalism, Confucianism, Taoism, and the clans. We note that there are conflicts between them and Fengshui once they are reflected in the Siheyuan's design. This study aims to explore how principles from Fengshui constrain Siheyuan design as well as investigate how Fengshui harmonizes with other cultural forces to influence Siheyuan's form in practice, through the development of an algorithmic tool. In particular, our main aim addresses the three research questions:

1. How can these principles be implemented into algorithmic design and be applied as an interactive tool for examining the fortune of a Siheyuan house?
2. How do Fengshui principles influence Siheyuan design?
3. Were these principles being applied in traditional Siheyuan design practice?

To answer these questions, we have first studied the Fengshui theory based on historical material and interviews with Fengshui geomancers to clarify the original principles relating to Siheyuan design. We have then analyzed the mathematical logic underlying its principles to produce an algorithm using the *Grasshopper* visual scripting platform. Finally, we have employed this algorithm as a tool to examine the fortune of historical Siheyuan cases, whose corpus has derived from measuring surveys of extant Siheyuan examples and documented historical examples.

MATERIALS AND METHODS

Source of rules

As stated above, *Xing Shi* is used to finding proper sites for building construction while *Li Qi* is to find fortunate orientation, size ratio, and the dimension of buildings. *Li Qi* dominantly shapes the form of Siheyuan. Principles in Fengshui constraining orientation, size ratio, and dimensions of buildings were selected to study, which were originally recorded in historical books such as *Dili Huitu Wu Jue (Five Tips For Geographic Mapping, Zhao, 2011)*, *Bai Zhai Ming Jing (Eight Mansions Bright Mirror, Yang, 2010)*, *Yang Zhai San Yao (Three Essences of Positive Houses, Zhao, 2011)*.

Methods

Many previous architectural Fengshui studies, as noted, centred on its metaphysical and anthropological aspects but neglected to examine its influence on its building form. However, Chiou and Krishnamurti (1997) illustrated the potential to solve this problem by using an algorithm to interpret the application method of Fengshui. Taking this idea further we uncover Fengshui's influence with a digital interactive tool developed in *Rhino/Grasshopper*. Since Fengshui influences buildings in orientation, size ratio, and dimension, we were able to test our algorithm by entering data of historical Siheyuan examples into the tool to generate results shaped by Fengshui principles and then compare them with corresponding historical ones.

ANALYSIS OF FENGSHUI PRINCIPLES

Fengshui geomancers supposed a kind of mysterious energy called *Qi* flows in the air in the form of invisible gas. This gas brings good fortune to people. *Li Qi* is the method to steer this energy. In the case of Siheyuan, the proper size ratios and function of rooms can store this energy in the housing space.

Room Orientation

As shown in Figure 2, *Xing Shi* gives an ideal environmental context in Fengshui for a building's or a

city's site. The site should be surrounded by hills and mountains (the highest and largest mountains at its north side), located on the smooth ground with its main elevation facing south and a river crossing its front area. However, as Beijing's urban area had been subdivided into an urban grid system, it is almost impossible to find this ideal context. Referring to the original considerations of Fengshui and regarding the urban planning of ancient Beijing, we simplified the principles into two main constraints: 'being within the auspicious degree ranges of orientation' or 'facing an adjacent street or alley'. The simplest way to find the auspicious degree is to use a Fengshui compass, which averagely divides a 2D plane into 24 sections (called '24 mountains') by 15 degrees and additionally divides each section into 5 subsections by 3 degrees, as shown in Figure 3. Degrees located within each second and fourth subsection are defined as auspicious orientation. The first constraint requires the elevation of the primary room of each courtyard in Siheyuan orientated within the range of auspicious degrees. The second requires it facing an adjacent street or alley, but there are two exceptions. If the adjacent street or alley exists on the north, primary rooms face the opposite direction. If adjacent streets or alleys exist on multiple sides, there is a priority sequence of determination of primary rooms orientation: south> east> west> north.

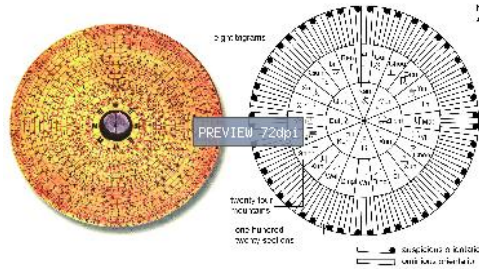


Figure 3
a Fengshui compass
and fortunate
orientation.

Room Size Ratios

Size ratios of rooms in a courtyard are various. In Fengshui, there are many methods to identify room size ratios., such as *Da You Nian* (big tour calendar), *Chuan Gong Jiu Xing* (crossing courtyard nine stars), *Fen Fang Jie Lu* (dividing rooms and intercepting paths), whose logics are the same but the determination of parameters or the applicable types of Siheyuan vary. Siheyuan is classified into three types: one-courtyard Siheyuan, Siheyuan with multiple courtyards aligned in the depth direction, Siheyuan with multiple courtyards aligned orthogonally. Here we propose the method of one courtyard Siheyuan and then supplement the differences between it and the method of the other two Siheyuan types.

For one-courtyard Siheyuan:

1. Divide the courtyard of the Siheyuan into nine areas with a three-by-three grid, and then allocate the eight trigrams (*Bagua*) to the eight boundary areas (the central area is left as empty) according to its orientation. The allocation of each trigram corresponding to the eight boundary areas are: east-*zhen*, southeast-*xun*, south-*li*, southwest-*kun*, west-*dui*, northwest-*qian*, north-*kan*, northeast-*gen*. The principle to allocate the eight trigrams to the eight boundary areas comes from the identification of attribute of each area recorded in *Luo Shu* (*Decussation Rivers Book*). The attribute of an area includes one of eight trigrams, one of the five elements (*Wuxing*), a number between one and

Figure 2
the ideal
environmental
context from Xing
Shi.

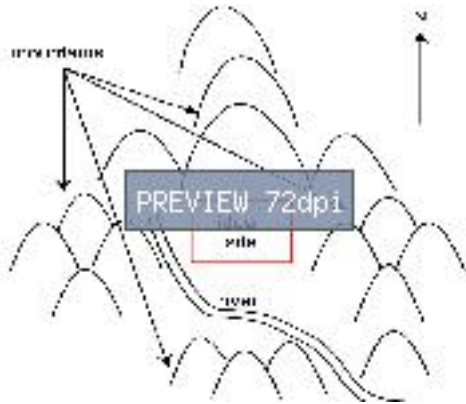


Figure 4

Each area's attribute: one of eight trigrams, one of five elements, one of seven colors.

2. Identify the area of fortune origin. The area of fortune origin is where the centre point of the key-space locates. Either the entry gate or the primary room could be the key-space. It is important to state to the selection of the type of the key-space (the entry gate or the primary room).
3. Assign the 'nine stars (*Jiu Xing*)' to eight trigrams according to the location of the area of fortune origin. In Fengshui, the seven stars of the Great Bear constellation and two nearby stars, called 'nine stars', were analogized with meanings of fortune. Each of the nine stars is assigned with fortune, as shown in Table 1. Each of the eight boundary areas is associated with one of the nine stars. Once the area of fortune origin is identified, each area's associating star(s) is(are) determined. Geomancers created a pithy formula to represent the eight results corresponding to the eight each of the eight areas as being the area of fortune origin. The eight results are shown in Figure 5.
4. Calculate the fortune of each area by the principles 'five elements produce and destroy'. The concept of 'five elements' comes from *Luo Shu*, in which each of the eight trigrams attributes an element within the five: metal, wood, water, fire, and earth. The correspondence between trigrams and elements are shown in Figure 4. Each star of the nine stars is assigned with fortune and also one of the five elements as an attribute, shown in Table 1. Between every two elements, there is a 'destructive' or 'productive' relation as shown in Figure 6. A simple way of identifying the fortune of an area is using the element of the trigram of this area to compute with the element of the trigram of the area of fortune origin. If the two elements are in 'destructive' relation, the area is ominous, and If the two elements are in 'productive' relation or the same, the area is auspicious.

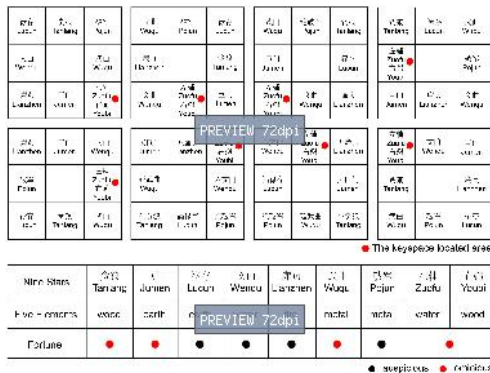
☰ Qian	☷ Kun	☱ Dui	☴ Xun	☵ Kan	☶ Gen	☳ Zhen	☹ Xun	☺ Kun	8	1	9	metal	water	earth	white	white	white
☰ Qian	☷ Kun	☱ Dui	☴ Xun	☵ Kan	☶ Gen	☳ Zhen	☹ Xun	☺ Kun	7	5	4	wood	wood	wood	red	yellow	dark green
☰ Qian	☷ Kun	☱ Dui	☴ Xun	☵ Kan	☶ Gen	☳ Zhen	☹ Xun	☺ Kun	2	2	4	earth	fire	wood	black	purple	green
eight trigrams			numbers			five elements			colors								

However, this way only indicates which area is auspicious or ominous. Another detailed way can illustrate the level of each area's fortune using stars' fortune, elements of stars, and elements of trigrams, whose principles are:

- For the area assigned with an auspicious star, a) if the element of the star is in 'destructive' relation with the element of the trigram, the area is lesser auspicious, and b) if the element of the star is in 'productive' relation with the element of the trigram or they are the same, the area is greater auspicious.
- For the area assigned with an ominous star, a) if the element of the star is in 'destructive' relation with the element of the trigram, the area is lesser ominous, and b) if the element of the star is in 'productive' relation with the element of the trigram or they are the same, the area is greater ominous.
- For the area assigned with *Zuofu* star and *Youbi* star, it is always least auspicious.

For Siheyuan with multiple courtyards aligned in the depth direction, there are four differences:

- Step 1 is applied to each courtyard of the Siheyuan separately,
- Only the entry gate could be the key-space.
- The trigram and the star of each of eight boundary areas in the first courtyard are identified in the way the same as it is for one-courtyard Siheyuan, and this pattern is applied to all courtyards except the mid back area.
- Assign the corresponding star of the mid-front area of the first courtyard and then assign the star of the mid-back area of each courtyard sequentially according to the order of production of the 'Na-tone five elements', as illustrated in Figure 7.



The fortune of area forces size ratios and functions of rooms constructed in each area. Normally, rooms in auspicious areas are large, whose functions are bedroom, living room, hall, kitchen, or entry gate while in ominous areas are small, whose functions are toilet or storage. Two examples of the process for a one-courtyard Siheyuan and a Siheyuan with five courtyards aligned in the depth direction are illustrated in Figure 8.

Figure 5
Eight results of assigning the nine stars to eight trigrams.

For Siheyuan types with multiple courtyards aligned orthogonally: each courtyard could be seen as an individual Siheyuan to compute.

Room Dimensions

According to the ancient rulebook *Gongcheng Zuofa Zeli*, there is a modular system underlying the determination of dimensions of individual rooms in a Siheyuan house by constraining its components' dimensions and positions, whose basic module is the diameter of an eave column (Wang et al., 2019). Besides following this modular system, the 'Pressing White Ruler Method' from Fengshui identifies the fortune of dimension, which filters the ranges of dimensions by Lu Ban rulers. In this method, there are two principles, the *Chi Bai* (feet white) and the *Cun Bai* (inch white) constraining the dimensions in parallel. Since only the *Chi Bai* are applied to dwellings normally and most Siheyuans are dwellings, we analysed the *Chi Bai* principle, which consists of five steps:

Table 1
correspondence between the nine stars, five elements, and their fortune.

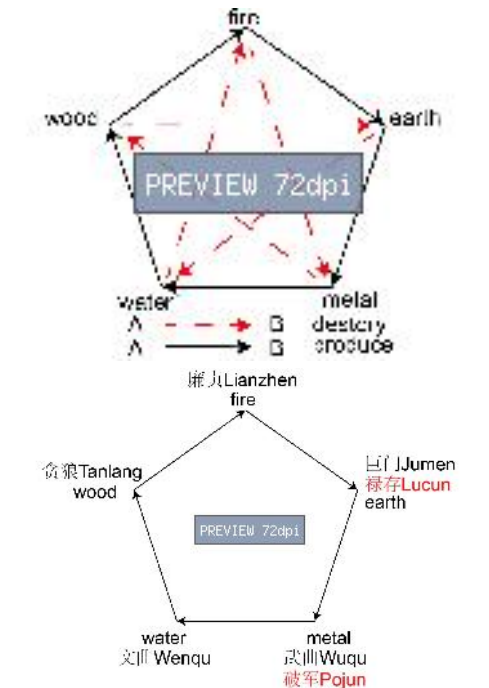


Figure 6
Five elements produce and destroy principles

1. Identify the orientation of the room's door within the 24 mountains of a compass (figure 3) and then find its opposite section on the compass.
2. Use the 'earth mother selecting first' (*Di Mu Na Jia*) principle to identify the trigram of the opposite section in the eight trigrams. The correspondence between the twenty-four mountains and the eight trigrams are shown in table 2.
3. Find the corresponding colour and number of the trigram in Luo Shu and then use it as the first range on a Lu Ban ruler. The correspondence between trigrams and numbers is shown in table 3. This correspondence has two variations: the heaven trigram and the earth trigram. The heaven trigram is to determine fortune dimensions in the vertical direction- the

Figure 7
Order of Na-tone five elements. (the stars Pojun and Lucun only exist in the mid area of the first courtyard.)

As a consequence, five levels of fortune are classified.

Table 2
The
correspondence
first number of each
trigram in the eight
trigrams.

height of the building, and the earth trigram is to determine fortune dimensions in horizontal direction- width and depth of the building.

4. Identify the sequence of numbers. Based on the first number to assign each range's number repeatedly on the Lu Ban ruler in numerical order from Luo Shu, as illustrated in Figure 4. In the assignment, the heaven trigram excludes number 1 and the earth trigram excludes number 9. 1 range= 3.2 centimetres. Each number indicates its fortune.
5. Use each auspicious colour's corresponding element in the five elements to compute with the element identified in 24 mountains by the building's orientation (Figure 3) according to the principles "five elements produce and destroy". If the two elements are the same or in 'productive' relation, the colour's corresponding range is identified as auspicious, otherwise, as ominous.

number	1	2	3	4	5	6	7	8	9
the heaven trigram	☰Qian	☷Kan	☳Xun	☱Dui	☵Gen	☶Zhen	☴Li	☲Dui	☱Dui
the earth trigram	☷Qian	☱Li	☶Zhen	☴Dui	☳Kan	☵Kun	☲Xun	☱Gen	☴Dui

DEVELOPING THE ALGORITHM

Based on the analysis explained above, we identified four key input parameters for *Grasshopper* to determine Siheyuan houses' fortune. They are: for the orientation of the Siheyuan house, a) the location of the adjacent street or alley, for the rooms size ratios in a courtyard, b) the selection of the type of the key space and c) the location of the key space, and for the dimension of each room, d) the orientation of the room. Accordingly, we produced an interactive *Grasshopper* script for the implementation of the algorithm to identify the fortune of the house's orientation, room size ratios, and room dimensions. The workflow is illustrated in Figure 9.

To implement the algorithm in *Grasshopper*, the plan of a Siheyuan and site context is imported. In our *Grasshopper* script, streets or alleys of the Si-

Figure 8
Two examples of
the process of
computing room
size ratios of areas.

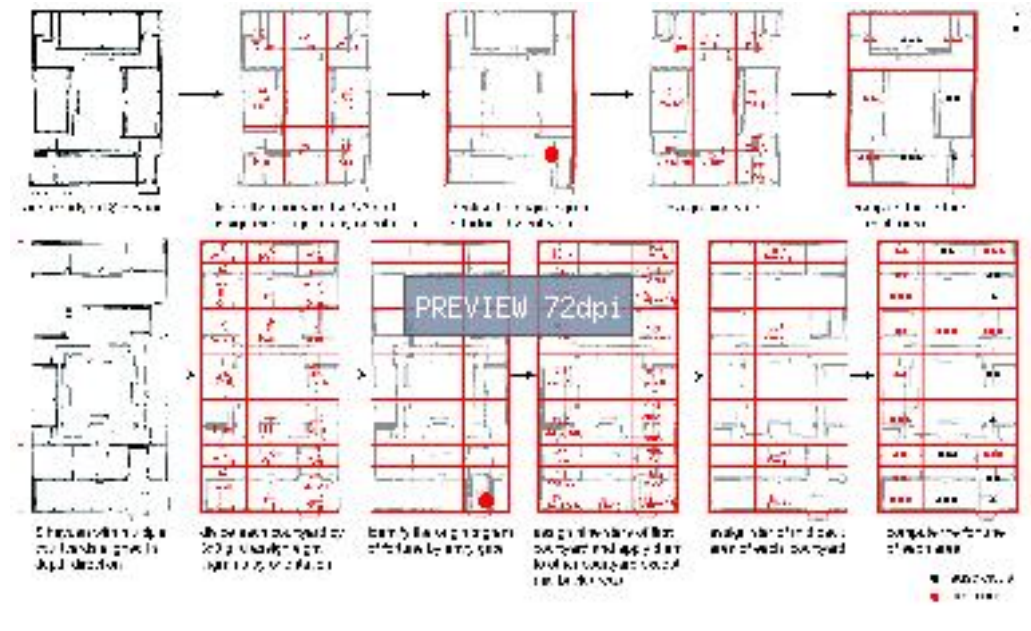




Figure 9
The workflow of Fengshui principles translated into a Grasshopper script

heyuan are identified by being collected by *Curve* components. The surrounding area of a Siheyuan site is identified and divided into four parts (north, south, east, and west) and collected by *Curve* components to find adjacent streets or alleys. The selection of the type of the key space is indicated by a 'slider' component, whose values are to be inputted. The plan of the key space is identified by a 'curve' component to find their central positions and then identify their locations within the 3x3 grid. The orientation of each room is identified by a *Vector 2Pt* component, whose orientation is from the central point of the room to the central point of the line indicating as the room's front elevation on the plan.

eight trigrams	☰Qian	☷Kun	☳Gen	☵Dui	☶Xun	☴Zhen	☱Kan	☲Li
twenty-four mountains	☰Qian	☷Kun	☳Gen	☵Dui	☶Xun	☴Zhen	☱Kan	☲Li
	☰Qian	☷Kun	☳Gen	☵Dui	☶Xun	☴Zhen	☱Kan	☲Li
	☰Qian	☷Kun	☳Gen	☵Dui	☶Xun	☴Zhen	☱Kan	☲Li
	☰Qian	☷Kun	☳Gen	☵Dui	☶Xun	☴Zhen	☱Kan	☲Li

Table 3
The correspondence between the twenty-four mountains and the eight trigrams in the "earth mother selecting first" method.

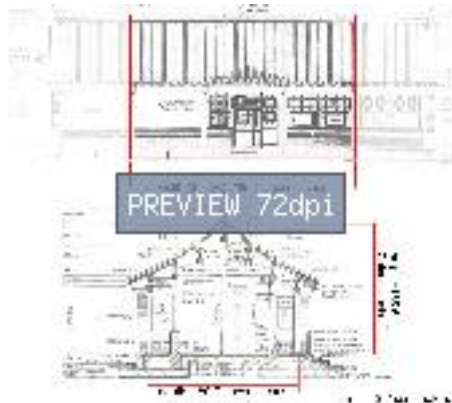
VERIFICATION

To verify whether Fengshui was used in Siheyuan design to obtain auspicious patterns, we used our tool to identify the fortune of Siheyuan examples by deriving the value of parameters from the precedents and then examining whether they are auspicious or not. The corpus comes from historical Siheyuan examples recorded on the Qianlong capital map, historical individual building examples recorded in *Gongcheng Zuofa Zeli*, and measuring surveys by

Duan (2016).

The Qianlong capital map (1750) presents all the buildings of Beijing at a scale of 1: 650, including thousands of Siheyuan houses. Duan (2016) organized measured surveys on existing Siheyuan examples. We selected two examples(left two in Figure 10) from the map and another two from Duan's surveys(right two in Figure 10), which are the most common types according to Ma (1999), Zhao (2013), Lu and Wang (2013), and Wang and Song (2012). However, the map and the measuring surveys cannot be used for verifying rooms' dimensions as well as we would like. Alternatively, examples of individual buildings recorded in *Gongcheng Zuofa Zeli* were used to replace rooms in the selected examples since they are described with detailed dimensions. The individual buildings in this manual have been drawn by Liang (2006), who translated texts in the manual into architectural drawings with detailed dimensions noted. We assumed the dimensions of the primary rooms of our selected examples are the same as in Liang's drawings. To be consistent with the Siheyuan rooms, a building given by Liang (2006) was modified by reducing the number of bays in the front view from five to three (in Figure 11) and then used as a primary room for verification. Figure 10 shows how our models assessed the fortune of our examples.

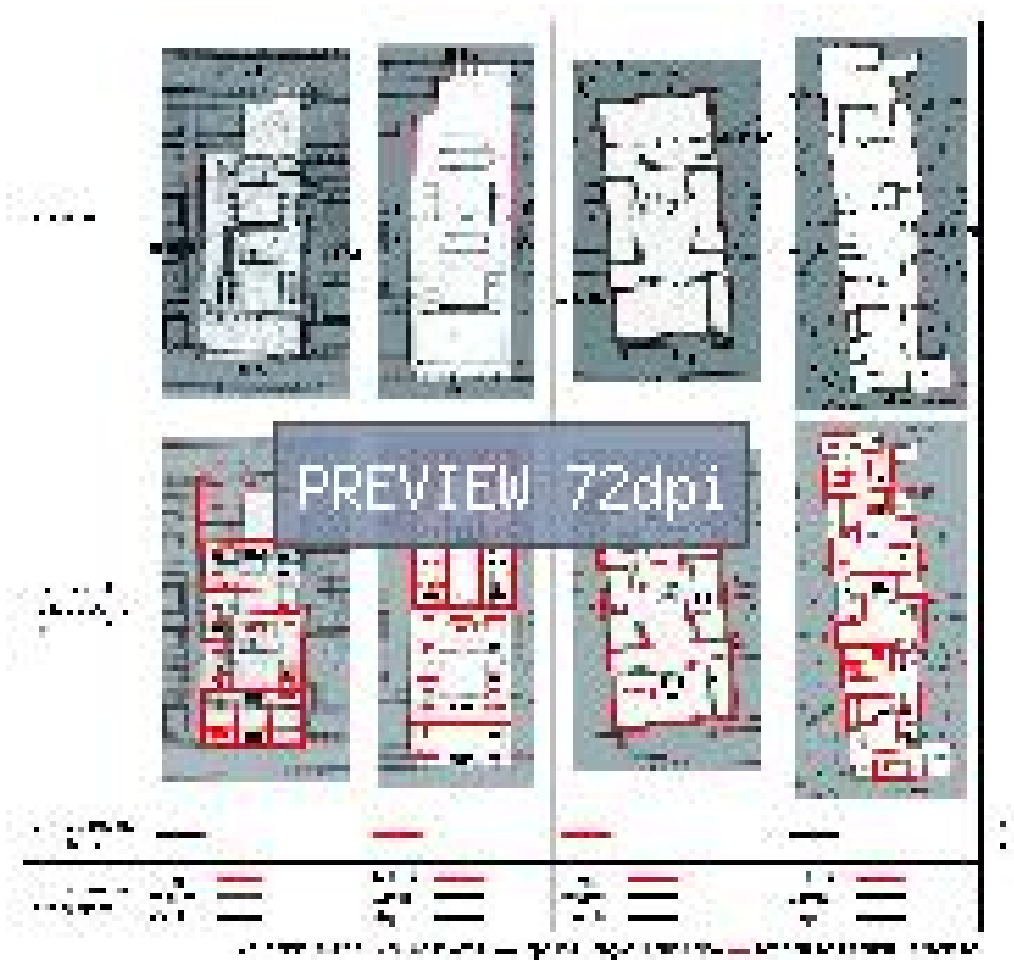
Figure 11
The dimensions of a building example applied in Siheyuan as primary rooms. After Liang, 2006.



DISCUSSION AND CONCLUSION

The results of the verification of four selected examples confirmed the Fengshui principles since they are mostly auspicious. We noted that other influence, more important than Fengshui, are also at work. For this reason, even the most common types, which are the closest to Siheyuan's ideal prototype, did not completely follow Fengshui to create auspicious patterns. For example, Confucianism and Taoism constrain rooms in a courtyard to be axial, and feudalism and clan constrain the size ratios of rooms in a courtyard in the sequence: primary room > east secondary room = west secondary > primary east wing room = primary west wing room > secondary east wing room = secondary west room. This constraint of room size ratio is more dominant than the one from Fengshui, so it can be easily observed that most Siheyuan houses follow this pattern. Meanwhile, to make Siheyuan conform to Fengshui, craftsmen would slightly change the room sizes to ensure size ratios of rooms are in auspicious patterns, which is hard to prove without conducting a measuring survey. This is the reason why, in many Siheyuan examples, the east wing room is slightly larger than the west wing room within a courtyard. Another example is the simplification of the *Cun Bai* method. The rules in *Gongcheng Zuofa Zeli* and consideration of material consumption constrained the available dimensions of a room in limited ranges. The constraint deriving from Fengshui dictates additionally limited ranges for room dimensions, but the ranges of each room may vary because it is a variable parameter for each room of a Siheyuan. This variability of room dimensions results in difficulty in building construction. However, in many cases, the limited ranges of room dimensions constrained by Fengshui are unified by simplification of the *Cun Bai* method. As a result of the simplification, instead of using the orientation of a room as the parameter to conduct the complex calculation, the *Lu Ban* ruler, which consists of 9 units marked by their fortune type, is directly used to find auspicious dimensions of a building in practice. We infer this simplification is to solve the difficulty in

Figure 10
Verification of four
examples



building construction since it unified limited ranges of room dimensions constrained by Fengshui.

There are two limitations to our study. First, for the verification of room dimensions, we have used ideal examples of buildings with constant values of dimensions according to *Gongcheng Zuofa Zeli*, but an individual building's dimensions could vary in

practice, which may lead to errors of verification of room dimensions. Second, in this study, we only verified the most common Siheyuan types rather than all variations, whose Fengshui assessment results might possibly be different. Further research is needed to verify if Fengshui applies to these variants.

REFERENCES

- Alexander, C, Ishikawa, S and Silverstein, M 1977, *A pattern language: Towns, buildings, construction*, Oxford University Press, New York
- Anon, Anon 1734, *Gongcheng Zuofa Zeli (Structural Regulations)*, Qing Engineering Department, Beijing
- Choiu, S and Krishnamurti, R 1995a, 'The grammar of Taiwanese traditional vernacular dwellings', *Environment and Planning B: Planning and Design*, 2(6), pp. 689-720
- Choiu, S and Krishnamurti, R 1995b, 'The fortunate dimensions of Taiwanese traditional architecture', *Environment and Planning B: Planning and Design*, 22(5), p. 547 – 562
- Choiu, S and Krishnamurti, R 1997, 'Unraveling fēngshu', *Environment and Planning B: Planning and Design*, 24(4), pp. 549-592
- Duan, B (eds) 2016, *Beijing Siheyuan Zhi (Beijing Siheyuan Chronicle)*, Beijing Press, Beijing
- Hillier, B and Hanson, J 1984, *The Social Logic of Space.*, Cambridge University Press, Cambridge
- Huang, B, Chiou, S and Li, W 2019, 'Study on courtyard residence and cultural sustainability: Reading Chinese traditional Siheyuan through Space Syntax', *Sustainability*, 11(6), p. 1582
- Jia, J 2012, *Beijing Courtyards*, Tsinghua University Press., Beijing
- Liang, S 2006, *Diagrams of Qing Gongbu Gongcheng Zuofa Zeli (Building Regulation by Qing Work Ministry)*, Tsinghua University Press, Beijing
- Liu, D 2019, 'An Intensive Analysis of the Typical Urban Micro-Fabrics of Beijing in Middle Qing Dynasty: Taking the Area in Northeast of the East Four Archways in Qianlong Jingcheng Quanguo for Example', *History of Architecture*, 2(1), pp. 130-152
- Liu, J and Wu, Z 2015, 'Rule-based generation of ancient Chinese architecture from the Song dynasty', *Journal on Computing and Cultural Heritage.*, 9(2), p. 22
- Lu, X and Wang, Q 2013, *Beijing Siheyuan Renju Huanjing (Beijing Siheyuan Human Settlements Environment)*, China building industry press., Beijing
- Ma, B 1999, *Beijing Siheyuan Jianzhu (Buildings of Siheyuan in Beijing)*, Tianjin University Press, Tianjin
- Stiny, G 2006, *Shape: talking about seeing and doing*, The MIT Press, Cambridge
- Wang, Y, Agkathidis, A and Crompton, A 2019 'Parametric Beijing Siheyuan: An algorithmic approach for parametric generation of Siheyuan housing variants based on its traditional design principles', *Proceedings of the 37th eCAADe/XXIII SIGraDi*
- Wang, L and Song, M 2012, 'The Application, Spread and Distribution of the Courtyard-dwelling: A Hypothesis based on the Analysis of the Complete Map of Peking in the Qianlong Period', *South Architecture.*, 1, pp. 80-84
- Yang, J 2010, *Eight Mansions Bright Mirror.*, World Knowledge Press., Beijing
- Zhao, J 2011a, *Dili Huitu Wu Jue (Five Tips For Geographic Mapping)*, Hualing Press., Beijing
- Zhao, J 2011b, *Yang Zhai San Yao (Three Essence of Positive Houses)*, Hualing Press., Beijing
- Zhao, Y 2013, *Beijing siheyuan traditional constructional technique.*, Anhui Science and Technology Press, Hefei