A PHOTOGRAMMETRY AND PERCEPTION STUDY OF CHERNIKHOV FANTASY NO. 32 AND 38

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Abstract. This research investigated the object composition in Chernikhov's 101 Architectural Fantasies through computer-aided visualization, for the purpose of interpreting the relationships between architectural components. In contrast to traditional simulation analysis, this research applied photogrammetry to investigate the orthogonal and parallel ambiguity of 3D objects in 2D drawings by calculating the position of matching geometries. This test took Fantasy no. 38 and 32 as examples to confirm their spatial relationship. 60 architectural students were asked to conduct 3 tests. The algorithmic approach (photogrammetry calculation) was referenced by a cognitive approach (the perception survey) as a comparison base. Photogrammetry test proved that the relation between objects was usually oriented by personal spatial experiences that did control the deduction process of an observer. Perception survey showed that orthogonal assumption existed in the interpretation process of an object's position. It turned out that a testee would still consider two linear objects intersected in orthogonal angle within a tolerance of 15 degree or parallel position between 4 and –16 degree. The finding showed that the interpretation of paper architecture drawings not only was given by the author, but tended to be re-interpreted by an observer. The interpretation process, just like modeling and rendering process, should be a two-way process that facilitates a study oriented either from 2D images or 3D models.

1. Introduction

Paper architecture refers to buildings that have never been constructed in the real world(Borsi, 1997; Cooke, 1984; Klotz, 1990). Original creators of paper architecture could not possibly reproduce the artifacts using today's applications; as a result, it's difficult for scholars and students in these days to interpret the concepts behind the perspective drawings with such limited spatial information.

Many cases of paper architecture can be found in the study of architectural history. Among those creators or architects, the drawings of Chernikhov have been collected and systematically categorized. Accordingly, this study was conducted as a Chernikhov-based paper architecture study.

This study tried to clarify two questions faced in previous studies:

- Problem identification: Which factors affect an observer's judgement?
- To what extent the factors might influence configurations of various objects.

2. Research Purposes

This research used photogrammetry methods to re-construct objects and their spatial relationships from several drawings presented in the "Fantasy 101" series (Chernikhov, 1933; Sasaki, 1981) of Chenikhov's paper architecture. The research tried to reproduce paper architecture in 3D form to facilitate comprehension of the original creator's intention. Design concepts subject to traditional manners of representation were also studied in order to explore possible combinations of building components behind a normal scene, to foster a thorough understanding of historical teaching materials. In the following study, architectural students tested the difference between the orthogonal and parallel visual perceptions of objects and their relations in the real world.

This paper consists of three parts:

- Human experiential / perception evidence, in additional to algorithmic evidence;
- The algorithmic evidence / proof of non-orthogonal relationships in spaces;
- The varieties of non-orthogonal results based on different assumptions.

3. Related Studies

This study started by reviewing two examples of paper architecture modeling the "Trinity" and earlier Chernikhov's drawings. Their problem-solving strategies are introduced, and also questions were raised.

3.1. "TRINITY"

Perspectives have been considered as one of the best methods to deliver design concepts by traditional architects. Although it's common sense to create perspectives by assigning vanishing points and lines, it's considered a special technique to visually enhance the depth of space in two-dimensional drawings. One of the most famous examples was Masaccio's "Trinity" made during the Italian Renaissance(Gombrich, 1995). In order to enhance the solemn and honorable characteristics of Jesus, Masaccio created a three-dimensional illusion by guiding edges from a 2D elevation to a vanishing point. Masaccio proposed a manner of relating space and time through a creative description that was seldom applied in those days. This 2.5D concept revealed a new definition and technique in perspective construction(Finke, 1989). His point of "field" was made by the special relation of the viewing point and way human eyes focus. His theory was criticized by the majority of the contemporary artists a drafting skill of perspectives. When we look back, perspectives were used to describe paper architecture (or visionary architecture) as early as the Italian Renaissance.

The 2.5D analysis of the "Trinity" showed that:

- The heads of the column array formed "virtual lines" that were similar to vanishing lines in perspectives;
- Jesus' hands reaching out proposed a "foreshortening" emphasis of his body that was further visually enhanced by vanishing lines.

The 3D computer models made by a previous study (Gombrich , 1995; Marchese, 1995) showed that viewers' eyes had a lower viewing point, so that only the front façade of the base could be seen. The suggested spatial relation did not clearly specify the locations of figures. As a result, the feasibility of the evaluation based on computer models remained to be seen.

3.2. FORMER CHERNIKHOV STUDY

Previous studies of Chernikhov's drawings used perspective deconstruction that modeled objects and then adjusted the location of the viewing point and the focus length in order to match the rendered image with transformed objects in a drawing(Seebohom, 1990). In order to deliver relatively correct adjustment, the locations of objects were also moved to match what the original drawing had described. The movement of the viewpoint uncovered unreasonable composition (like a building floating on the air) that violated common sense in building layout.

Perspective de-construction basically consists of three steps(Seebohom, 1990):

- Unique check (plan): Draw left and right vanishing points by following the concept of two-point perspectives. Use these two points as the ends of a diameter to draw a circle. Select several nearby viewing points, which are located on the circle, until a match is found with a particular perspective.
- Consistency check:
  - elevation and plan: Choose a plan and move viewing point backward to inspect the similarity between elevation and plan.
  - elevations and original image: Choose a viewing point and rotate plan to inspect the relationship between elevations and original images.

The perspective deconstruction method, as a geometry modeling approach, assumes the objects in a drawing to be normal i.e. adjacent polygons intersecting with each other perpendicularly. This assumption may need further study to find if other possible solutions exist.

3.3. CONCERN FROM COGNITIVE INTERPRETATION

Previous studies showed that the visual cognition of observers was influenced by visual experience. The way humans “see” includes retinal and mental image processing. Anderson considered a mental image could be different from the details and reality that we perceive in the real world(Anderson, 1990). Finke thought images could be categorized into retinal, iconic, and mental images(Finke, 1989). Reber also classified images into optical and mental images(Reber, 1985). When the world is perceived, the adjustable “mental image” can be different from the “pictures” regenerated from optical perception.

The perception of the real world includes heuristic experiencing, i.e., a person can deduce rules from common phenomena as a response to the world. Since humans “see” the world in different manners, illusions can also occur. Based on Handee’s study, illusions can be ambiguities, distortions, paradoxes, and fictions(Hendee, 1997). The distortion misleads an observer’s perception of size, length, curvature, etc.

4. The Test I

The previous research showed that Chernikhov might apply drafting skill to distort spatial relationship in order to deliver intentions. What about if an observer also read it wrong? The deliver process from Chernikhov to an observer might not exactly be a reversed process from an observer’s interpretation to Chernikhov’s drawing. The previous study used a normal 3D modeling tool. But each modeling tool bears certain restrictions. Two questions are raised: the first, is a normal 3D modeling application the only tool in studying architecture history? the second, what are the disadvantages of a modeling tool? Since the cognition interpretation of an observer could lead to different “pictures” of what optical perception might receive, the basic assumption in interpreting the paper architecture drawings needs to be investigated at a more detailed level.

The clarification of the relationships between the space described in a Fantasy and the interpretation of an observer can be conducted in two parts:

- Identification of the problem: Which factors affect an observer’s judgement? Is it the relationships between objects?
- To what extent the factors might influence configurations of various objects: the configurations of objects or their geometries

4.1. TEST SETUP

The most difficult part of this re-construction came from limited spatial information(Rogers and Adams, 1990). Usually only one drawing was provided. Normal photogrammetry methods need at least two images merely to calculate the shared geometries (points, lines) (Debevec, Taylor, Malik, 1996). In other words, in order to find the correct location of the four vertexes of a polygon, the vertexes have to appear on both images taken from different angles. Another photogrammetry method would be to assume the relationship between geometries (like adjacent edges of a polygon) in order to assign x-, y- or z-axis. Both methods were tested, but the latter method was used. A “3D Builder” application on a PC platform was used (see Fig. 1).

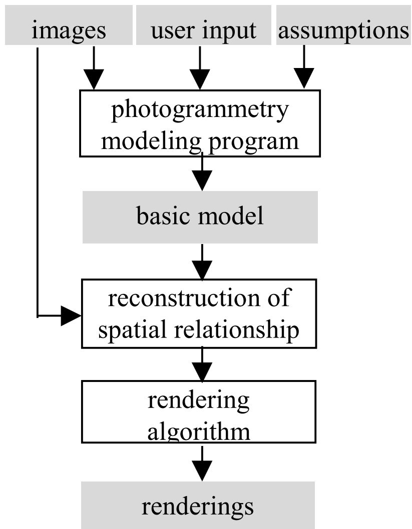


Figure 1. Photogrammetry method

This test included three parts:

- Select a picture showing orthogonal (90 degree) intersection
- Select a picture showing parallel relation
- Check the spatial relationship of two objects overlaid with Chernikhov’s perspectives

This test took Fantasies no. 32 and 38 for examples (see Fig. 2) to apply photogrammetry to quantify the spatial relationship depicted in the two perspectives.

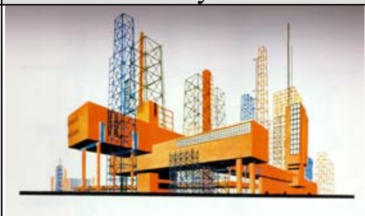
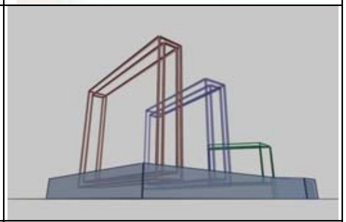
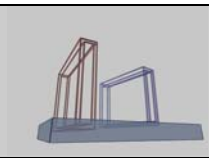
	Fantasy 38	Fantasy 32
original drawings		
photogrammetry made models		
spatial relationship	85 degree	-3 degree
test images		

Figure 2. Spatial relationship of Fantasy no. 38 and 32

The calculated angles were cross-referenced and analyzed with testees' visual perceptions of orthogonal and parallel relationships. After photogrammetric calculation, we found that Fantasy no. 38 had an intersection angle of 85 degree and Fantasy no. 32 had an angle -3 degree off parallel position.

The tested objects were oriented at 27 different angles and testees chose what they thought wee parallel or orthogonal intersections. The modeled objects later were overlaid on two Fantasy drawings to test human orthogonal and parallel perception. 60 tests were analyzed. Fig. 3 shows that most testees considered 75 degree as an orthogonal intersection, from 30, 45, and 60 degrees of viewing angle, which were previous as minor adjustments of viewing angle in perceiving spatial information. The percentage accepting 75 degrees as orthogonal reduces as the viewing angle increases.

4.2. PART I: ORTHOGONAL TEST

From the distribution in the orthogonal test (Fig. 3), we can discover that testees were intended to consider an acute angle (75 degree) as an orthogonal intersection angle while the viewing angle in Chernikhov's perspective was upward.

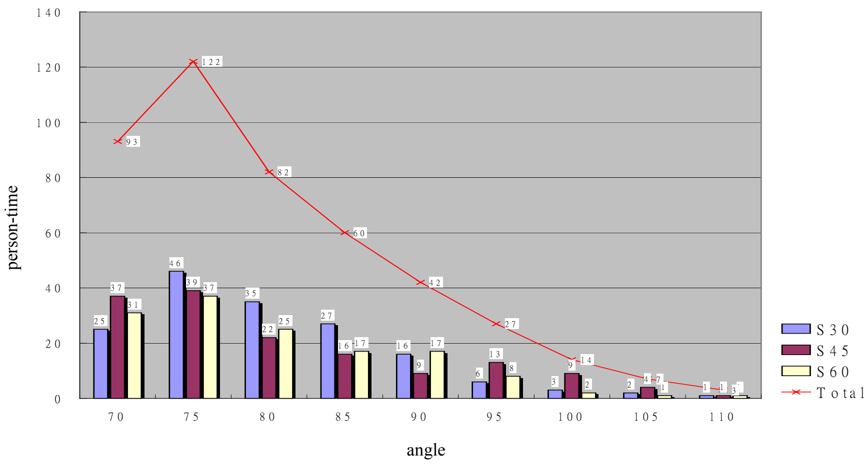


Figure 3. Orthogonal test diagram of person-time and angle

Clearly the testees were more likely to be aware of a non-orthogonal intersection if the angle was more than 90 degrees. The average and standard deviation of the angles selected by each testee shows that only 3 out of 60 testees selected an angle larger than 90. 60 tests were analyzed.

Statistics shows that the "orthogonal perception" had an average between 72.5 and 100 degrees. Obvious differences existed between testees. The standard deviation varied from 2.88 (minimum) to 13.87 (maximum). This variation also showed each testee had a different perception of spatial orthogonal relationship.

4.3. PART II: PARALLEL TEST

Most of the testees considered that object B was rotated 8 degrees clockwise from a parallel position (see Fig. 4) from 30 and 60 degree viewing points.

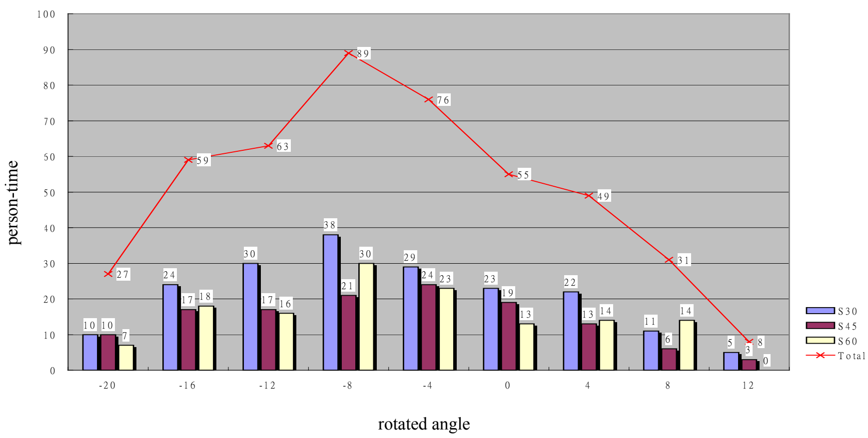


Figure 4. Parallel test diagram of person-time and angle

The number of person-time reduced when the degree increased. We can discover that testees were intended to consider a parallel position in Chernikhov's perspective (viewing upward) as from 4 degrees counter-clockwise to 16 degrees clockwise. Clearly the testees were more likely to be aware of a non-parallel position if the angle was larger than that range. The average and standard deviation of the angle selected by each testee shows that only 7 out of 60 testees selected an angle larger than 0 (average, counter-clockwise).

Statistics shows that the "parallel perception" had an average between 16 degrees clockwise and 4 degrees counter-clockwise. Obvious differences existed between testees. The standard deviation varied from ±2.3 degrees to 12.1 degrees (maximum). This variation also showed each testee had a different perception of spatial parallel relationships.

4.4. PART III: REAL SAMPLE TEST

The orthogonal test (test I) and parallel test (test II) were overlaid with the image of no. 38 and 32 to check if the sub-conscious assumption process was influenced by the super-imposed clue (test III). The orthogonal-related distribution shows that the visual perception of most testees considered the relationship in Fantasy no. 38 ranged between 80 and 90 degree, which is close to the results of 85 degree found from photogrammetry calculations. The number of person-time increases to 20 which seems to be influenced by the orthogonal visual experience.

The parallel-related distribution shows that the visual perception of most testees considered the relationship of the two front objects in Fantasy no. 32 ranged between +5 and -5 degrees, which is close to the result of –3 degree found from photogrammetry calculations. The number of person-time increases to 26 which seems to be influenced by the parallel visual experience.

5. Discussion

Several issues are raised:

- The rationality of perspectives: From the photogrammetry-concluded 3D modeling analysis, we found that the creator usually ignored the reality or feasibility of perspectives in order to fulfill personal intentions or for the purpose of representation. The spatial relationship between the observers and the observed objects seems to determine the human visual perception. This tendency is similar to the examples found in architectural history like the "visual correction" of column space at ends in Greek temples or the upward curved roof at four corners in Chinese southern temples. The similarity echoes the rationality the Fantasy perspectives did not reach or purposely avoided in order to achieve or to represent specific intentions.

- Reconstruction of space and objects: The photogrammetry reconstruction of spatial relationships could assign different types of faces as referencing polygons in 2D images. The following modeling of components can be considered as a reversed verification process of the spatial frames and in-fills. The computer simulation actually assists the students, also observers, in re-thinking the spatial relationship of objects with this new media. The re-thinking and verification processes significantly contribute to the decoding of created artifacts and strongly hold creators and observers together.
- The facts in the construction of non-orthogonal intersected spaces: One of the assumptions used by traditional perspective deconstruction refers to the locations of the vertexes and edges on an orthogonal rectangle. Nevertheless, the objects used in architecture are not all rectangles. This study assumed that adjacent polygons do not have to be 90 degree and this assumption was verified by photogrammetry calculations. In Chernikhov’s perspectives, non-orthogonal spaces did exist. The original creator, who was subjected to personal spatial experience, made orthogonal look alike drawings in order to generate similar visual experience.
- Two-way construction relation between 2D images and 3D objects: The two-way generation direction was made possible by applying a photogrammetry method. The flexibility greatly facilitates the study of the subjects that had limited spatial information. The communication between creators and observers can come from either side. Although errors exist in finding exact shapes and observers can be misled, the errors can be quantitatively described to facilitate a thorough comprehension in architectural historical education.

6. Conclusion

A not-so-accurate presentation was corrected by human spatial experience. Readers finish up the other part of the story. The tolerance of human perception can be large. In fact, the interpretation of paper architecture should not be exclusive. Instead, the possibilities or alternatives provide the potential that a reader or a student can explore. Whether a balance exists between the algorithmic reality and the imagination drawn from it remains to be seen. Whether the balance can be considered as a complementary operation in enlightening architectural learning is also a pedagogical issue. This study hopes to provide students, who need to be discreet readers as well, an inspection of what appeared to be ordinary, but was, in truth, complicated.

Acknowledgments

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