Original Article

Features of hexagonal pattern on metal wire network structure made by experts and non-experts with different lengths of work experience

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Abstract

"Kana-ami" is one of the traditional craft products of Kyoto. It was made all by hand and, for this reason, there was no industrial pollution produced during the manufacturing process. The product's quality was judged by the standard structure of "Kana-ami", which was established and developed in the long course of history and culture. That aesthetical standard has already been deeply and consistently rooted into Japanese peoples' hearts. However, production has decreased dramatically year by year due to mechanization difficulty and a lack of heritage consciousness of craft techniques. Therefore, there is an urgency time to pay attention to do something to keep this traditional wealth of culture and skill for the next generation. In this research, expert-A and expert-B were employed from "Kana-ami Tsuji" workshop, which is one of the most outstanding workshops in Kyoto. The best three products were chosen by expert-A and expert-B respectively from 38 products made by 38 different students to be compared as non-experts with the excellent products of experts. So, the average hexagon angles by experts were treated as the standard in this study. All hexagon angles of the experts and non-experts final products were investigated and measured, at the same time, angle degrees at corresponded label location were calculated and compared between experts and non-experts in order to explain the structure distribution. Their mean and standard deviation values of corresponding vertex angles for 48 hexagons were calculated and analysed. In this current study, the characteristics of metal wire network structure made by different people were discussed and analyzed through mathematical measurement. Based on this structure evaluation system, the hexagon angles of experts' products showed complete uniformity and consistence. Further more, Kana-amis' hexagon structure evaluation standard of expert-A, with 45 years experience, was considered to be achieved better aesthetic requirements and appreciation.

Key words

kana-ami, expert, non-expert, traditional handicraft, metal wire network

1. Introduction

Kyoto was the capital city of Japan for one thousand years. This long ancient culture brings about a series of traditional craft products, which have already been studied and reported in previous literature. Such as, the earthen wall, bow, tile for a roof, sharpening a Japanese kitchen knife and so on (Asada et al., 2011a; 2011b; Kawasaki et al., 2009; Kuroda et al., 2010; Miyamoto et al., 2008; Odawara et al., 2009; Shiono et al., 2010). "Kana-ami" (Figure 1), a kind of metal wire network, which was employed as a kitchen utensil (tofu scooping or fence knitting for cultural relics), date back to around 50 years ago. There were about 50 Japanese "Kana-ami" handicraft workshops in Kyoto. However, it has already decreased dramatically year by year due to mechanization production's difficulty and a lack of heritage consciousness of handicraft technique until now only seven workshops remain. Therefore, it is the urgent time to pay attention to this severe reality and try to do something to keep this culture and continue the technique and skill for the next generation.

"Kana-ami" was made all by hand, so processing motion/technique and working experience have a big effect on the final products' quality (Goto et al., 2007; Tsuji et al., 2007; Zelong et al., 2013). The product's quality was judged mainly by the final customer's perceptual assessment. With the development of Japanese history and culture, the aesthetic criteria for Japanese Kana-ami has already been established and rooted into Japanese peoples' hearts deeply.

In this study, cooperating with "Kanaami Tsuji" workshop, Mr. K. Tsuji and Mr. T. Tsuji were employed as experts and were called Expert-A and Expert-B, which have parent-child and master-apprentice relationships. Mr. K. Tsuji was the most excellent metal wire net designer of Kyoto in 2009 and 2010 with 45 years experience. Mr. T. Tsuji is determined to continue the Japanese traditional handicraft technique, and he has 9 years weaving experience.

Referring to a previous study, one of the classic "Kana-ami" was chosen as the object shown in Figure 1 with the simplest structure. The average vertex angle at the corresponded posi-

Figure 1: Yutofu kana-ami

tion from the eight hexagons has already been given attention, and in this research was applied to evaluate the "Kana-ami" structure of metal wire network (Tanaka et al., 2007; Tsuji et al., 2012). Continuing with former research, all the angles of hexagons of the products were measured and recorded for Kana-ami structure evaluation. The investigated experts were required to make five Kana-ami products continuously, which was defined as an average standard system. There were 38 metal wire network products were made as a sample set of non-experts by 38 different students without experience. The best three metal wire net products were chosen by Expert-A and Expert-B respectively as the investigation subjects of non-experts to be compared with the experts' standard.

All the hexagon angles of experts and non-experts final products were investigated and measured, and at the same time, average angle degrees at corresponded label location from 5 investigated products by experts were calculated as a systemic structural standard. All internal angles from 48 hexagons were compared of experts and non-experts were compared in order to explain the structure distribution. Their mean and standard deviation values of vertex angles at the corresponded position from 48 hexagons were calculated and analyzed.

The purpose of this paper was, through the evaluation and analysis of the metal network structure of "Kana-ami", to explain the differences between experts and non-experts, and also to discover the expert key point of structure system and to provide a reference for new scholars.

2. Method

2.1 Subjects and weaving procedure

The subjects were two males who had experienced wire netting techniques for 44 years and 8 years respectively, who were called Expert-A and Expert-B in this study.

Firstly, the three best products from 38 metal wire net products made by 38 different students without experience were chosen as the investigation subjects to be compared with the excellent products of Expert-A, which was called Group-A.

Secondly, the experts were required to knit wire and make a wire net of 5 tofu scoops continuously. 5 tofu scoops were made by stainless wire. The hexagonal pattern was knitted from the first line and twisted from upper to right lower, the wires were crossed twice to make one side of a hexagonal pattern to the end and a new wire was inserted to conduct the same process as shown in Figure 2.

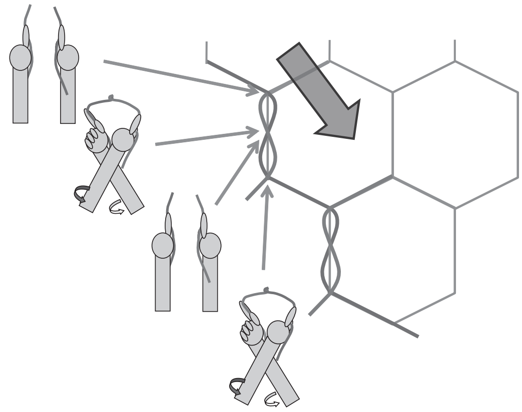


Figure 2: The making process of a hexagonal pattern

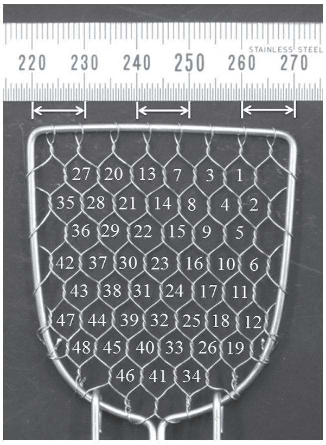
2.2 Measurement setting and recording method

A 30-centimeter-long steel rule was placed on top of the sample as a reference as shown in Figure 3(a). Then a comparatively larger sheet of black paper was laid on the bottom side for better contrast with metallic silver. A Nikon P300 camera was placed perpendicular to the sample with a distance of 50 centimeters. All samples (16 products) were recorded under the former predetermined conditions as shown in Figure 3(b).

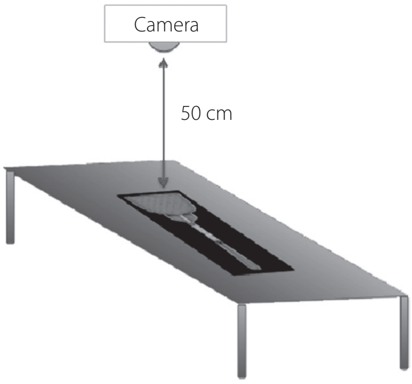
In this study, 48 hexagons, as shown in white numbers on Figure 3(a), were paid attention to. The inside vertexes and angles of each hexagon were measured and named according to the order on Figure 4. In total, 288 vertexes' angles were recorded in each finished product respectively.

3. Experiment result and discussions

Average angle degrees at corresponded given location were derived and calculated from the expert groups (Expert A & B).Group A and Group B's angle values the corresponded specific label location were plotted in the same way. A wire net is one hexagon with six angles. The total number of measured groups of hexagons for each sample was 48, additionally, 48 lines for each subject corresponding to weaving order have been successively drawn by the A. H. Munsell color solid as shown in Figure 5.



(a) Measured wire net



(b) Measurement method

Figure 3: Measurement setting

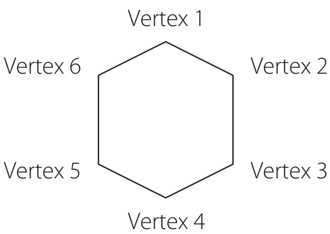


Figure 4: The name of six vertexes in one hexagon

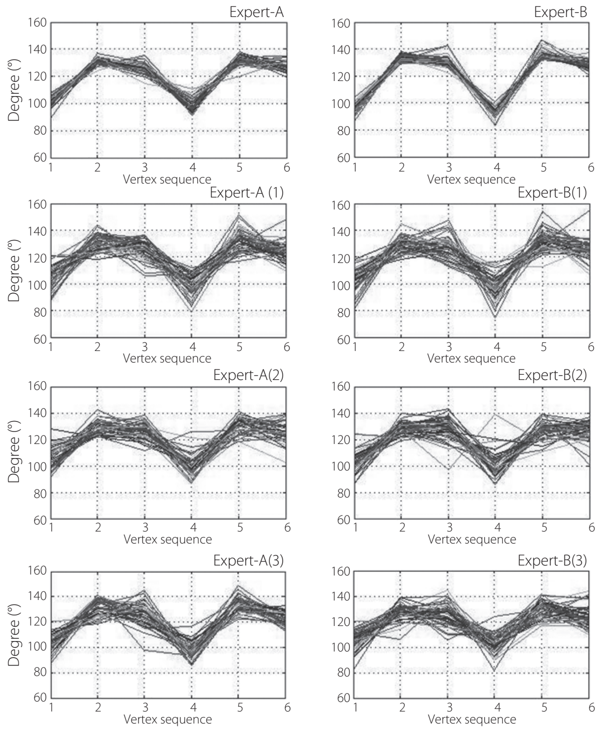


Figure 5: Distribution diagram of hexagonal angles accompanied with weaving order

According to the values of 6 internal angles' degree distribution graphs of 8 subjects as shown in Figure 5, it is easy to see that the majority of angle lines showed concentrated distribution. However, the non-expert's angle lines performed more dispersed distribution. It can be explained that the products of the experts showed a more stable hexagonal structure. The stability of the hexagon structure can make people feel it is neat and beautiful, which was one of most important standards of quality evaluation. Meanwhile, it was also a important factor that distinguished between the expert and non-expert.

The average vertex angle at the corresponded position from 48 hexagons corresponded to 5 knitted "Kana-ami" samples made by expert A and B which were calculated and plotted in Figure 5, which is named as "standard A" and "standard B" respectively. At the same time, the following discussion and evaluation system are also based on these two standards. As shown in Figure 5, 48 plotting lines were gathered and painted following the specific color system of 48 divisions originated from default hue cycle sequence from yellow, pink, dark blue, red, green and cyan, which also corresponded to predetermined Kana-ami knitting sequence simultaneously.

It is easy to note that the averaged vertex angle value for 48 hexagons among 5 knitted samples showed a concentrated distribution in both expert A and B' Kana-ami products. On the contrary, performance of non-experts from groups A and B displayed a comparatively dispersed trend. In other words, 48 hexagons knitted by experts in the same Kana-ami product showed a structure consistence, which can be attributed to the long-term practice and experience performance.

A large number of people appreciate and prefer the orderliness of the Kana-ami product. That perceptual understanding can be transferred to a quantitative parameter of stability to evaluate the product's structure, which can also be employed as an important index to distinguish between expert and non-expert.

Few plotting angle lines deviated from the center average value were circled in Figure 5, which were painted by a latter hue cycle system sequence. Those hexagons originated from deviated angle lines and finally confirmed the location in the

8th and 9th oblique knitting row.

Compared with the expert's hexagon angle plotting distribution, all the non-experts' performances showed a rather bigger deviation for each hue cycle's divisions. Therefore, in order to keep the consistence of all the hexagons in one knitted net, the expert's concept was to give the priority to knitting orderliness of hexagons until the 7th oblique rows. For this reason, the hexagons' shape and structure change will concentrate in the last two knitting rows. That is to say, the experts' knitting concept can eliminate the irregular effect of visual evaluation of the overall structure of the Kana-ami as much as possible.

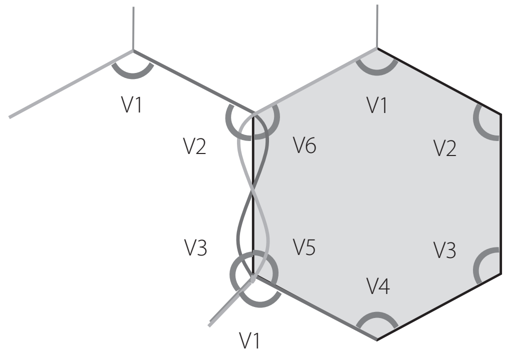


Figure 7: Hexagon pattern of kana-ami product

The standard deviation (SD) of 6 vertexes among 48 hexagons for the experts and non-experts was calculated respectively and is illustrated in Figure 6. It can be seen that there is a big difference between the experts and non-experts vertex angle SD value. According to Figure 6, both expert A and B showed a very small SD value, below 2, and comparatively uniformed SD value among 6 vertex angles. However, the SD parameter of the non-experts product dropped into the region of between 4.5 and 9.5, accompanied with apparent disperse distribution. The result of the vertex angle's SD value comparison between the expert and non-expert indicated and proved the expert's performance of one knitted net's structure stability.

Except for non-expert GA3, the SD value of vertex 1 for all the other non-experts showed a higher value (over 7) than the other five vertexes. However, in the case of expert A, vertex 1's SD value was only 1.38, which was the lowest among the 6 vertexes in one hexagon. Even if expert B's performance showed very low vertex angle SD (below 2), it was the biggest of the other five vertexes. Compared with expert B and all the non-experts, expert A's lowest angle SD of vertex 1 can be considered to show expert A's stability of the knitting process and technique. As vertex 1 was the first angle to be knit during processing, it will be affected by the upside second cross and downside two symmetric cross-one (showed in Figure 7). Therefore, vertex 1's knitting was deemed to be the most difficult to control and to keep consistence.

The same as vertex 1's condition, the SD value of vertex 4's average value also showed a higher value than the other vertex. During the knitting process, vertex 4 in one hexagon was the last vertex to be knitted. Therefore, vertex 4 was inevitably affected by vertex 1's angles determination for both sides' of the hexagons. That is to say, the knitted angle of vertex 4 is allowed to be dropped in a floating band in evaluation system and activity.

Referring to the vertex 2's SD value, it was nearly the smallest value of all knitted vertex in a hexagon for both non-experts and experts' performance. Based on knitting rules and procedure, it is well known that the current vertex 2's knitting makes an effect on the right side of hexagon's vertex 6's angle structure directly. At the same time, in order to keep vertex 1's angle consistence for better visual evaluation of the overall hexagon structure, vertex 3 in the current hexagon and vertex 5 of the right side hexagon will also be affected. It is inferred that vertex 2's angle control was a very important technique and procedure during the whole knitting process due to vertex 2's function and effect.

All the measured vertex angles of the subject's hexagons were calculated respectively and gathered to illustrate in Figure 8. In the overall view, both vertex 1 and 4's average angle value of all the subjects' work showed nearly 100°. Also, the

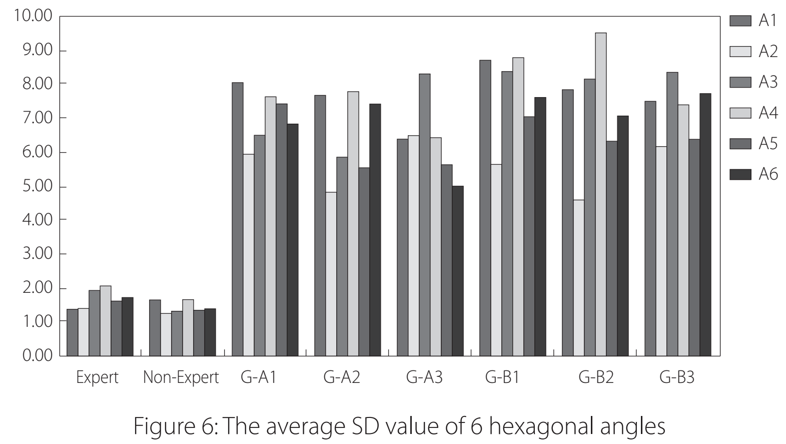


Figure 6: The average SD value of 6 hexagonal angles

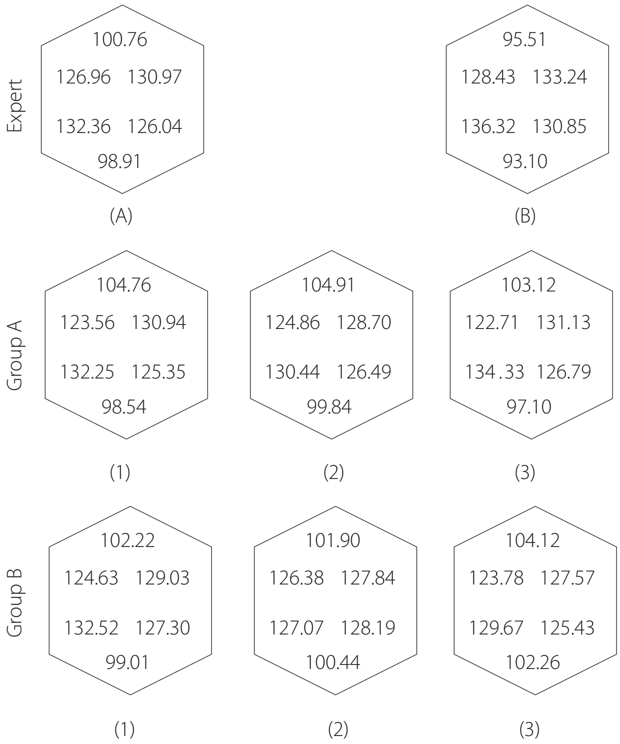


Figure 8: The average value from all hexagons

angle of vertex 2 and 5 were almost higher than vertex 3 and 6. Referring to the comparison between expert A and B, it was found that expert A's vertex angle of 1 and 4 were bigger than expert B at around 5°. However, compared with expert B, expert A's vertex 2 and 6 were smaller at around 2°, and vertex 3 and 5 were smaller at around 4°. As mentioned earlier, both expert A and B's vertex angle showed a very small SD value. Therefore, expert A and B's stable hexagon structures can be regarded as a net knitting system for further comparison and a referenced system.

Based on previous research, differentiate value calculation between non-expert and expert at the corresponded label location was regarded as an effective method for Kana-ami evaluation. Averaged vertex angle at the corresponded label location among all members of group A and B were calculated separately and were followed by comparison with expert A and B's structure system (Figure 8), and the calculated differentiate value results are shown in Figure 9.

According to Figure 9, both group A (selected by expert A's evaluation system) and group B (selected by expert B's evaluation system) differentiate value, which compared with expert A's reference system, showed a more similar trend with expert A's structure evaluation standard than compared with expert B's evaluation system. It is clear to demonstrate that the average vertex angle value of those 6 members' excellent work selected by expert A and B from 38 students were close to expert A's structure standard system.

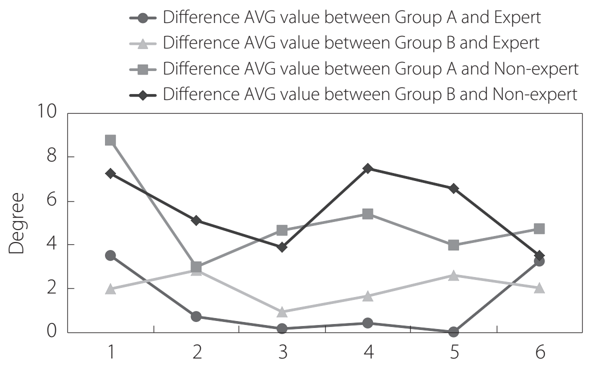


Figure 9: DV against with standard A and B

4. Conclusions

The hexagon structure of the Kana-ami product made by experts was more stable than the non-expert's work. Therefore, knitted net's structure stability affected final product's quality greatly. Two cross-knitting was a very important procedure during the Kana-ami process as it can affect the hexagons' angle and consistence in the Kana-ami product. Giving priority to keeping the hexagon's consistency positioned in the central region of the sketch of the "Yodofu" Kana-ami can bring about a better perception evaluation effect. Therefore, Kana-ami' hexagon structure evaluation standard of expert A with 45 years' experience can meet with Japanese aesthetic requirements and appreciation better.

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