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CATA SHOTOKAN KARATE-DO ANALYSIS BYMETHODS OF APPLIED STATISTICS

The analysis of the karate-do kata shokotan by the methods of applied statistics is carried out. The scheduling of the kata numbering is offered. The analysis of the main components with use of the object-sign matrix is made and dependences between signs are revealed. The cluster analysis of kata in the six main components space is carried out.

Keywords: Shotokan kata, karate-do, applied statistics, cluster analysis

Digitization of kata

Karate-do is a martial arts, in which there are different styles and trends. For example, Shotokan, kekushin, Shito-ru, etc. These styles are sometimes substantial differences in the rules of the competition and training techniques. However, almost all of them are practiced as a part of learning kata - formal complexes protective and attacking movements. These complexes (kata) allow to develop the technique of karate, even doing it alone. The performance of kata looks like the «fight with the invisible one». There are more than two dozen of kata in Shotokan. In karate, all the names of kata, forms, and counters are not translated, the Japanese words used. It is possible to learn the terminology in paper [3]. The object of the study were eight kata Shotokan Karate-do: Taykoku Shodan (TA1), Heyan Shodan (X1), Heyan Nidan (X2), Heyan Sandai (X3), Heyan Yondan (x4), Heyan Year (X5), Tekki Shodan (TE1), Bassan Dai (B1). Typically, these kata are taught in schools of Shotokan Karate-do in the above sequence. Since the Taykoku Shodan and Nidan Taykoku are practically identical, the latter is not involved in the analysis. Higher kata , such as: Dziin, Dzion, Dzite and others - are not considered. The restriction on the number of the analyzed kata (eight) is due to labor intensity of the analysis. Subject of research - qualitative and quantitative structure of the eight kata. The research allowed to answer the following questions:

1. What techniques (blocks, strikes, stands, bends) are emphasized in kata?
2. Is there a relationship between the techniques?
3. Which kata are maximum «similar» with each other, and which are maximum «different»?

The first step to formal analysis has become a «digitization» kata, in which each movement was seen in the context of shapes, bends and racks. As a result, for each of the eight kata there was built a table that looks like follows.

All major forms are in full compliance with the performance of classical Shotokan kata. However, during the «digitization» of kata it became clear that the developed mathematical model does not take into account several important factors:

Table 1

A fragment of kata Heyan Shodan structure

№	Form		Turn °	Stance
1	Block	gedan-barai	90	zenkutsu
2	hand strike	oi-tsuki	0	zenkutsu
...	...	...	...	...
21	Block	shutouke	45	kokutsu

Turn Form number, Stance

The use of so-called «hidden techniques», i.e. the possibility of different interpretations of the forms;

- dynamic performance;
- consideration of block as the strikes;

– a breakdown of individual elements of kata on additional components, etc.

Since karate learning is based primarily on multiple repetition of kata, it is interesting to trace the entire amount of movements and techniques which are necessary to learn in training.

Table 2

Summary statistics on eight kata

№	Indicator	Total number	Various
1.	Movement	197	55
2.	Blocks	117	33
3.	Impacts of all	80	22
4.	Strikes hands	63	15
5.	Kicking	17	7
6.	Turns	11250°	6
7.	Recurrence	66%	
8.	Stances		9

Feature «recurrence» was calculated separately for each kata and totally according to the following formula: $100\% - (\text{number of different movements}) / (\text{total number of movements}) * 100$.

Feature «recurrence» indicates the relative complexity of kata, therefore we conduct the corresponding comparative analysis of kata.

As can be seen from the sequence of learning, the complexity increases (recurrence decreases) beginning with Heyan Shodan to Heyan Godan. The first kata is based on repetition of a smaller number of forms, the last kata are more variable. The kata, taught as the eighth one, Bassaj Dai appeared to be the average on, considering the recurrence feature.

In the eight of kata there are 55 unique forms, which are executed in total 197 times. That is, the average recurrence frequency of the form is 3.5 times. The blocks in kata are more emphasized than the strikes (60% vs. 40%). One third of movements are strikes with hands. And only the tenth - kicking.

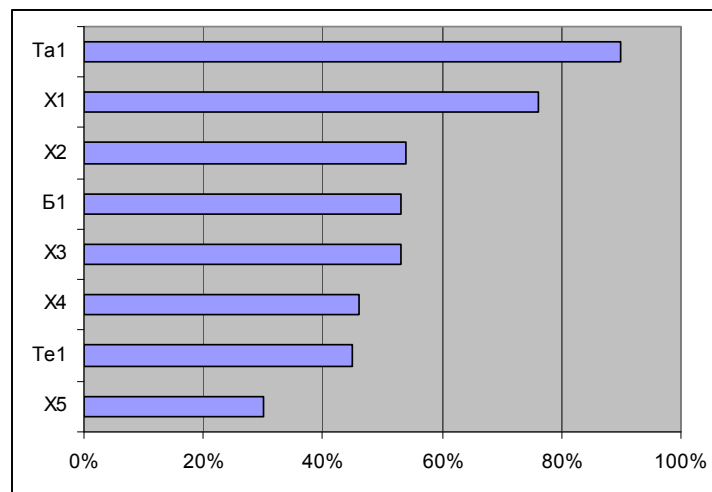


Fig. 1. Comparative analysis of the frequency of movements of kata

Fragment of a detailed analysis of the use of forms is presented below.

Table 3

The use of forms in eight kata

№	Form		Total	%	Total, %	Recurrence in kata
1	hand strike	tsuki	23	11,7	11,7	5
2	block	shuto ucke	21	10,7	22,4	4
3	block	gedan barai	18	9,1	31,5	4
4	block	uchi-ude uke	12	6,1	37,6	4
5	block	morote uchi-ude uk e	10	5,1	42,7	5
6	hand strike	gyaku -tsuki	8	4,1	46,8	4
7	hand strike	empi	6	3	49,8	4
...	...	...	...	...	...	...
55	kick	hiza - Gary	1	0,5	100	1

Half of all movements of kata represent the execution of the 7-th form, which occur simultaneously in 4 or 5 kata. These are the three hand strikes (oi-tsuki, gyaku-tsuki, empi) and four blocks (morote uchi-ude-uke, shuto ucke, gedan barai, uchi-ude uke). Moreover, a third part of all the movements are divided between the three forms (oi-tsuki, shuto ucke and gedan- barai): each of these forms is executed approximately 20 times.

90% of movements in kata are executed with three main are the three main Stances. The stance zenkutsu-dachi is executed most often in kata (45%). Kiba- dachi and kokutsu dachi are made the same number of times.

Very often during movements there occur the turns of 90 and 180. Perhaps the other types of turns (45, 135, 270, 360) are included in order to dilute the basic ones and to perfect any arbitrary angles of movement.

Analysis of principal components

For applications of applied statistic analysis it is necessary to provide data in tabular form of table: peculiarity- object (or object - peculiarity) [2]. The columns of the table correspond to the analyzed objects (in our case - kata). Lines of the table - peculiarities. There are 4 groups of characters, which are singled out here.

Table 4

Matrix peculiarity – object

№	Title	Kata							
		Ta1	X1	X2	X3	X4	X5	Te1	B1
1.1	movements	20	21	26	19	26	23	22	40
1.2	blocks	8	13	18	7	12	12	12	29
1.3	hand strikes	12	8	5	9	8	9	10	8
1.4	kicks	0	0	3	3	6	2	0	3
2.1	zenkutsu	20	16	12	3	12	7	0	16
2.2	kokutsu	0	4	14	3	13	7	0	9
2.3	kiba	0	0	0	9	0	3	22	7
3.1	45°	0	2	5	0	1	0	2	1
3.2	90°	3	3	2	3	5	7	5	4
3.3	135°	0	1	2	0	0	0	2	0
3.4	180°	3	2	2	3	3	4	2	7
3.5	270°	2	2	2	1	1	0	2	1
3.6	turns	1350	1395	1575	1440	1305	1350	1170	1665
4.1	recurrence	90%	76%	54%	53%	46%	30%	45%	53%

There are 8 objects (kata) and 14 peculiarities. The method of principal components can not be applied in quantities of less than the number of peculiarities. This is our case (8 objects < 13 peculiarities). Therefore, a principal component analysis is applied to each of the three groups of peculiarities separately [1, 42 - 56]. The results were interpreted in the space of the first two principal components for each group of characters. There had been revealed the strong correlation between the peculiarities. With further transition to a new system of six uncorrelated peculiarities on the basis of which the cluster of kata had been made.

Cluster analysis

As the tool has been selected the hierarchical cluster analysis and the Euclidean metric. For the presentation of the proximity graph we use the projection of kata in the first two principal components (for six new peculiarities). We will not include to the graph the long edges, such as Taykoku Shodan - Tekki Shodan.

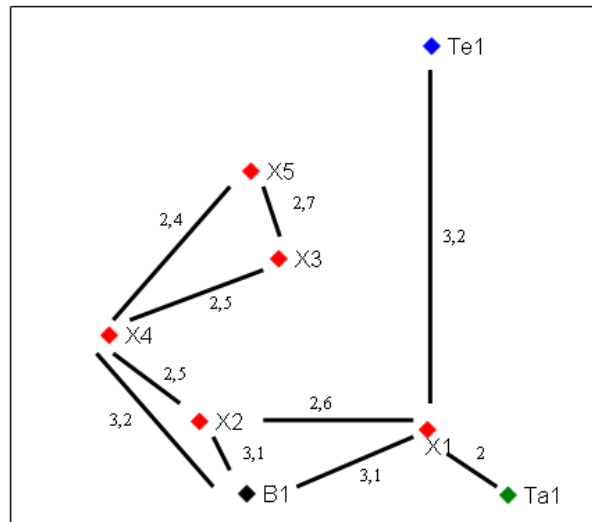


Fig. 2 - the distance between kata

The lengths of edges approximately correspond with the actual distance. The essence of the visualization - to show a rough lay-out. Above each edge there are the true distance in the space of six main components.

Joint analysis of similarity shows the extreme contrast of kata Tekki and Bassaj from other kata. Heyan 1 is closest to Tekki, Heyany 1, 2 and 4 are closest to Bassaj. It turned out that the clear cluster structure has not been observed: all the kata are separated. Heyan 1 and Taykoku 1 are very similar. Heyan 1 acts as a bridge connecting Taykoku 1 with Heyan 2. Starnges as it is, Heyan 2 is much closer to Heyan 4, than to Heyan 3. Heyany 3 - 5 form a fairly tight group.

Conclusions

The numerical results of the analysis of kata have to be treated carefully. The model, suggested in this work is based only on 14 peculiarities. Impact and protective technique were grouped into one peculiarity, without taking into account the different variants of techniques and hidden technology. In some cases, there had been obtained the unexpected results. Thus, the most powerful as for the execution kata Bassan-Dai is formally the most defensive (72% of techniques - blocks). And formally the most attacking kata - Heyan Sandal (37% of blocks), and it's as if it were composed of two parts. The first part - 7 blocks in succession, the second part - 12 attacks in succession. The three forms are actively trained in kata, which account for one third of all movements. There is no single form that would be found in all 8 kata. Ratio of blocks and strikes is 60 to 40 (there are more blocks nominally). The stance zenkutsu-dachi is worked through most actively (nearly half of all stances). The turns by 90 or 180 degrees are worked through most

frequently. It was not possible to reveal the clear cluster structure of kata. Perhaps this shows that each kata has its own meaning, and two identical directories do not exist. A promising area of research is the inclusion in the analysis of all the Shotokan kata. Apart from that, the interesting thing is the use of individual peculiarities at the level of techniques (eg, number of strikes «oi-tsuki»), but not the aggregated peculiarities (block, strike).

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