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Identifying contributing factors to progress in Karate-Do using the Fuzzy Cognitive Mapping approach

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Abstract
Aim. The protection and preservation of *Budo* heritage imposes certain requirements for both traditional karate-do instructors and practitioners. This paper aims at exploring and analysing the critical factors affecting the progress of a traditional *karateka* in the context of Budo.
Method. The Fuzzy Cognitive Mapping (FCM) approach is implemented, which combines the capability of fuzzy logic with dynamic modelling simulations. More specifically, six karate instructors were interviewed in order to construct, first, the individual FCMs and, then, the collective FCM.
Results. According to the overall outcomes "Sensei's knowledge and teaching ability", "Training", "Psychology", "Positive elements of karateka's character", "Sensei's character", and "Dojo climate" are the most mentioned and important factors affecting positively the progress of a traditional karateka.
Conclusion. Although the results provide soft evidence, FCM proves to be a useful tool for understanding complex phenomena, by eliciting and analysing individual and collective knowledge, preferences and beliefs. To this end, this research wishes to help both traditional karate-do instructors and practitioners to identify the most important factors that should pay attention to, in order to maximise the efficiency of Budo practice. Finally, this paper wishes to stimulate further discussions and research on the use of causal knowledge in the context of sport training, in general.

1. Introduction

It is widely acknowledged that traditional karate-do, like other traditional Japan martial arts, aims at completing the Way ("Do") of a well-balanced mind and body through training in fighting techniques ("Bu") [ITKF 2006]. The term "Budo" was used in Japan, in 1911, for the mandatory lessons of kendo and judo in Middle School [*ibid.*]. After World War II and since 1958, Budo was in the school curricula under the term "Kakugi" (combat sports) [Sasaki 2006]. Later, Budo reappeared but it maintained certain elements of Kakugi [*ibid.*].

Although there are many differences between Budo and combat sports, competitions in karate and other Budo systems (e.g. judo has been an Olympic event since 1964) over the last decades have gained increased popularity. More and more karate practitioners are motivated and influenced by such events and, as a result, competition has become a part of Budo training [ITKF 2007]. However, there are concerns that if competitions follow the pattern of regular sports, i.e. to win at any cost, then Budo will be lost. Of course, it is also argued that competitions and Budo may co-exist on condition that competition rules promote Budo fundamentals and respect its spirit.

Related research efforts reveal some worrying evidence about the understanding of traditional karate as a component of Budo culture. For instance, Cynarski [2014] concludes that the institutional development of karate in Europe has resulted in the establishment of new, mostly inauthentic or eclectic, schools, with many experts pointing out that sports rivalry is contrary to the spirit of karate-do. Furthermore, Jakhel and Pieter [2013] found out that karate is being perceived like any other sport and it is becoming less and less restricted to the Japanese regional traditions. These findings are

worrisome. As Sasaki [2006: 13] mentions, based on the "Nenrai Keiko Jyojyo" old textbook, "*budo instruction begins by making budo a fun sport in order to learn until the student is ranked, at which time the training converts to a stricter life training*" because "*budo should be done in a traditional manner*".

Bearing in mind the above-mentioned remarks, it is evident that the protection and preservation of Budo heritage, even in Budo competitions, imposes certain requirements for both traditional karate-do instructors and practitioners. Further, the progress of a traditional karateka in the context of Budo depends on a number of factors both "interior" (e.g. physical condition, talent, persistence, spirit, ego, etc.) and "exterior" (e.g. sensei's teaching ability and knowledge, dojo climate, social environment, etc.). This complex character of Budo may be investigated by means of soft computing methods capable of analysing human perceptions, such as the Fuzzy Cognitive Mapping (FCM) method [Kontogianni *et al.* 2013].

Cognitive maps were introduced by Axelrod [1976] to represent social scientific knowledge and model decision making in social and political systems. Fuzzy Cognitive Maps (FCMs) constitute an extension of cognitive maps by embedding to them the use of Fuzzy Logic and were proposed by Kosko [1986]. FCMs are interconnected, signed directed graphs consisting of nodes and edges/connections that represent causal relationships among concepts which stand for the states and variables of a system [Kosko 1986; Kontogianni *et al.* 2013]. Thus, FCMs could be regarded as a combination of Fuzzy Logic and Neural Networks [Kosko 1992]. More explicitly, FCMs consist of nodes, i.e. concepts/variables, C_i, i = 1…N, where N is the total number of concepts. Each interconnection between two concepts C_i and C_j has a weight, a directed edge W_{ij}, which is similar to the strength of the causal links between C_i and C_j. Each FCM can be expressed as a fuzzy comparison *adjacency matrix* [E], where each concept is compared with one another according to causal relationships. According to Papageorgiou, Kontogianni [2012] there are three types of weights:

$W_{ij} > 0$ indicates a positive causality between concepts C_i and C_j; the increase (decrease) in the value of C_i leads to the increase (decrease) on the value of C_j.

$W_{ij} < 0$ indicates an inverse (negative) causality between concepts C_i and C_j; the increase (decrease) in the value of C_i leads to the decrease (increase) on the value of C_j.

$W_{ij} = 0$ indicates no causality between C_i and C_j.

The first step of the process is to define the concepts comprising the FCM system, as determined by the participant (e.g. a domain expert). Then, the participant describes each interconnection either with an if-then rule or with a direct fuzzy linguistic weight, which associates the relationship between the two concepts and determines the grade of causality between the two concepts [Papageorgiou, Kontogianni 2012].

According to the authors' best knowledge, this is the first attempt to apply the FCM framework for exploring the factors behind the progress in Budo. The main objective of this research is to identify and analyse the factors and the causal links between them that influence karateka's progress in Budo using FCM and, to this end, to help traditional karate instructors and practitioners to focus on the most critical parameters so as to maximize the efficiency of Budo practice. Finally, it wishes to stimulate further discussions and research on the use of causal knowledge in the context of sport training, in general.

2. Methods

The study involved 6 different traditional karate instructors the main characteristics of whom are outlined in the following Table 1. All of the participants were fully informed of the goals and the methodology and provided signed consent. At the beginning, participants were explained what is and how to draw a FCM and were shown related FCMs as examples. Once the interviewees understood the process of constructing a FCM, they were asked to draw their own map of the issue under investigation, i.e. the factors affecting the progress of a traditional karateka.

In this particular application, the participants were asked to assign the strength of influence of concept C_i on concept C_j using the following form: "The strength of influence of concept C_i on concept C_j is T{*influence*}", where the variable T{influence} declares the causal inter-relationships by means of a fuzzy linguistic variable. More explicitly, thirteen linguistic variables were used in order to describe the influence of one concept on another, following Papageorgiou, Kontogianni [2012]: "*negative very very strong influence, negative very strong*

Table 1. Main characteristics of survey participants

Participant no.1	28	5	38
Participant no.2	15	3	28
Participant no.3	23	4	46
Participant no.4	21	4	49
Participant no.5	30	5	48
Participant no.6	37	7	52

influence, negative strong influence, negative medium influence, negative weak influence, negative very weak influence, zero influence, positive very weak influence, positive weak influence, positive medium influence, positive strong influence, positive very strong influence, positive very very strong influence".

The fuzzy numbers of the linguistic weight are transformed to a crisp value within the range [-1, 1] after defuzzification using fuzzy sets and integration theory [e.g. Liu, Liu 2002; Bojadziev, Bojadziev 2007].

This process refers to the construction of individual FCMs for each participant. The transformation of individual maps into "collective" or "social" maps is realized by additively superimposing and, hence, augmenting the individual maps [Eden *et al.* 1992; Kosko 1987, 1992; Özesmi, Özesmi 2004]. Papageorgiou and Kontogianni [2012: 436] note that in order to achieve this transformation "*it is essential that the original concepts-variables […] be clustered in more generic or more specific concepts, because most of them present the same meaning with a different word*". The process of condensation is a means of qualitatively/quantitatively aggregating the variables of the individual FCMs into higher-level concepts [Özesmi, Özesmi, 2004]. This encompasses the formation of new (clustered) concepts, and the establishment of new connections. The aggregation methods are based on fuzzy preference relations and the individual fuzzy sets are aggregated point by point to determine the expert group judgement [e.g. Kacprzyk *et al.* 1992; Hsu, Tsen 1996; Lu *et al.* 2006].

In this survey, the weight w_i of the participant E_i (i= 1, 2,..., n) was estimated by her/his experience in traditional karate, as expressed by the years of training and her/his rank, according to the following equation:

$$w_i = \beta^* YW_i + (1 - \beta)^* RW_i$$

where w_i is the weighting factor of participant i, YW_i are the years of training weighting factor of participant i, RW_i is the Dan-ranked weighting factor of participant i and $0 \leq \beta \leq 1$ is defined by the analyst (in this case 0.4).

The collective FCM was finally calculated using the following equation [Taber *et al.* 2007; Amer *et al.* 2011]:

$$CFCM = \sum_{i=1}^{n} FCM_i * w_i$$

where, n represents no. of participants, w_i is the weight of participant i, and FCM_i is the FCM matrix of participant i.

The analysis of the structural properties of cognitive maps is based on Graph Theory [Ozesmi, Ozesmi 2004]. The maps are analysed in relation to the number of concepts, connections, connection-to-concept ratio, and density. To allow for identification of key criteria within the process of cognitive mapping, an analysis of domain and centrality is also conducted. The complexity level of each individual concept is revealed through a number of structural measures of cognitive maps, e.g. the centrality index borrowed from social networks analysis [Papageorgiou, Kontogianni 2012]. The main indices used are: density, indegree, outdegree, centrality, hierarchy and complexity [for further details readers are referred to Ozesmi, Ozesmi 2004].

Collective FCMs are commonly used to model the dynamic evolution of the concepts' interplay and analyse both static and dynamic scenarios [Carley 1997; Amer *et al.* 2011]. In this sense, FCMs can dynamically reflect and simulate the perceptions and beliefs of experts with time. Through this type of analysis, "what-if" scenarios are investigated by performing simulations of a given model from different initial state vectors. The initial stimulus is an input vector, the "activation level" – taking values in the unit interval [0,1], which excites the FCM adjacency matrix E by applying a multiplication of the input vector with the adjacency matrix [Papageorgiou, Kontogianni 2012]. Zero values are attributed to concepts not present in the system, while value(s) of 1 indicate that the concept(s) is (are) present to its (their) maximum extent; all the other values refer to intermediate levels of activation [Papageorgiou, Kontogianni 2012].

The value A_i of each concept C_i in a moment $t+1$ is calculated by the sum of the previous value of A_i in a precedent moment t with the product of the value A_j of the cause node C_j in precedent moment t and the value of the cause-effect link w_{ij}, as follows [Papageorgiou *et al.* 2009]:

$$A_i^{(k+1)} = f(A_j^{(k)} + \sum_{\substack{j \neq i \\ j=1}}^{N} A_j^{(k)} * w_{ji})$$

where is the value of concept C_i at simulation step $k+1$, is the value of concept C_j at step k, w_{ji} is the weight of the interconnection between concept C_j and concept C_i and f is the threshold (activation) function. The threshold function reduces the result of multiplication in the interval of [0, 1]. In this study, the sigmoid threshold function is used, which hinders quantitative analysis, but allows for qualitative comparisons between concepts [Bueno, Salmeron 2008].

The algorithmic procedure of the simulation process used in this research consists of five steps and is described in Papageorgiou, Kontogianni [2012] and the simulations were carried out using the FCM Tool, a software that works in Matlab environment (http://www.cs.ucy.ac.cy/fcmdss/index.php?option=com_content&view=article&id=61&Itemid=68).

3. Results

A total of 34 different factors were obtained from the individual FCMs. The total number of factors and

connections and the graph theory indices obtained for the individual FCMs are shown in Table 2.

On average, there are 14.4 variables affecting traditional karate progress, ranging from 13 to 17. The average number of transmitter variables, which affect the system independently, was found equal to 3.3 (ranging between 0 and 6) and the average number of receiver variables, which indicate the expectations from the system was 1 (from 0 to 2). Maps with a large number of receiver variables are seen to be complex because they consider many outcomes and implications that are a result of the system [Eden *et al.* 1992]. However a large number of transmitter variables indicate thinking with 'top down' influences, where causal arguments are not well elaborated [Eden *et al.* 1992]. The average ratio between connections number per variable numbers, which is an indicator of the density between the described variables and the casual relations, was 3.9 (from 1.7 to 6.7). The average density, which expresses how connected or sparse the maps are, was equal to 0.2595. Furthermore, the average hierarchy index was calculated at 0.3019, ranging significantly between 0.0081 and 0.7362. The closer to zero the hierarchy index of a FCM, the more "democratic" the FCM is, which indicates a system that is open to change. On the contrary, the closer to 1 the hierarchy index of a FCM, the more hierarchical the FCM is. As shown in Table 2, the most hierarchical FCM is that of Participant no.6, i.e. the highest ranked instructor.

As far as the collective FCM is concerned, the 34 variables were combined into 19 clustered factors (Fig. 1), namely dojo climate (i.e. relationships between the dojo members); dojo level (e.g. number of high-ranked karateka); practitioner's economic situation (i.e. ability to participate in competitions, to attend karate seminars, etc.); education level; experiences (e.g. competitions, seminars, etc.); family climate (i.e. family problems); physical health; lifetime training activity; progress; psychology; sensei's character; sensei's knowledge and teaching ability; acceptance of martial arts by social circle; talent; targets set by the practitioner; training load; practitioner's negative elements of character; practitioner's positive elements of character; and workload.

The number of transmitter variables is 1 and the number of receiver variables is 0, while there are 18 ordinary variables. The ratio between connections number per variable numbers is 8.7. The density is equal to 0.4598 and the hierarchy index is calculated at 0.0431, indicating system that is open to change.

In order to explore the dynamic interactions between the concepts involved in the collective map, a number of simulations were conducted. The simulation

Table 2. Graph theory indices for the individual FCMs

	Part. no.1	Part. no.2	Part. no.3	Part. no.4	Part. no.5	Part. no.6	Average
Density	0.1302	0.1531	0.4796	0.1644	0.2800	0.3495	0.2595
Hierarchy Index	0.0081	0.0421	0.5042	0.0860	0.4347	0.7362	0.3019
Total Nr. Factors	13	14	14	15	15	17	14.7
Total Nr. Connections	22	30	94	37	63	101	57.8
Nr. Transmitter	6	6	0	6	1	1	3.3
Nr. Receiver	0	1	1	2	1	1	1.0
Nr. Ordinary	7	7	13	7	13	15	10.3
Connection/Factor	1.7	2.1	6.7	2.5	4.2	5.9	3.9

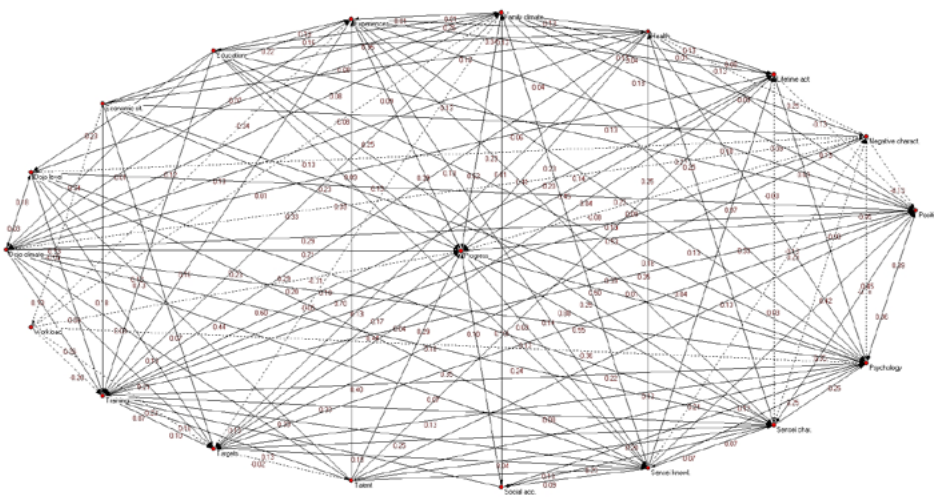

Figure 1. The collective FCM

Table 3. The most central factors in the collective FCM

Concepts	Outdegree	Indegree	Centrality
Dojo climate	2.95	2.74	5.70
Dojo level	0.57	1.23	1.80
Economic situation	1.67	0.00	1.67
Education	1.84	0.29	2.12
Experiences	1.01	1.64	2.65
Family climate	1.91	1.50	3.41
Health	2.18	1.05	3.23
Lifetime activity	0.81	0.78	1.59
Negative characteristics	1.38	1.03	2.41
Positive characteristics	3.02	3.06	6.07
Progress	0.09	6.96	7.05
Psychology	1.69	4.02	5.71
Sensei's character	3.71	1.35	5.06
Sensei's knowledge and teaching ability	3.55	0.58	4.12
Social acceptance	0.36	0.48	0.84
Talent	1.54	0.13	1.67
Targets	0.59	2.15	2.74
Training	2.42	3.79	6.22
Workload	1.56	0.09	1.65

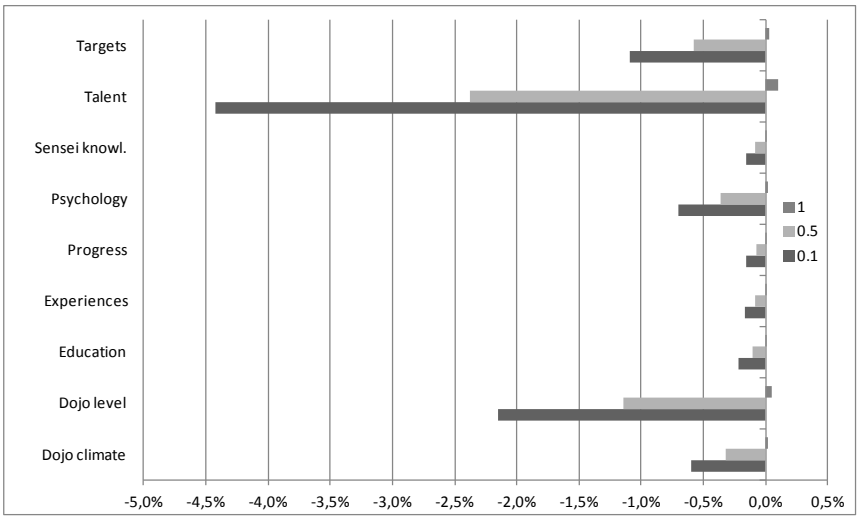

Figure 2. Effect of "Training" on the other concepts of the collective FCM

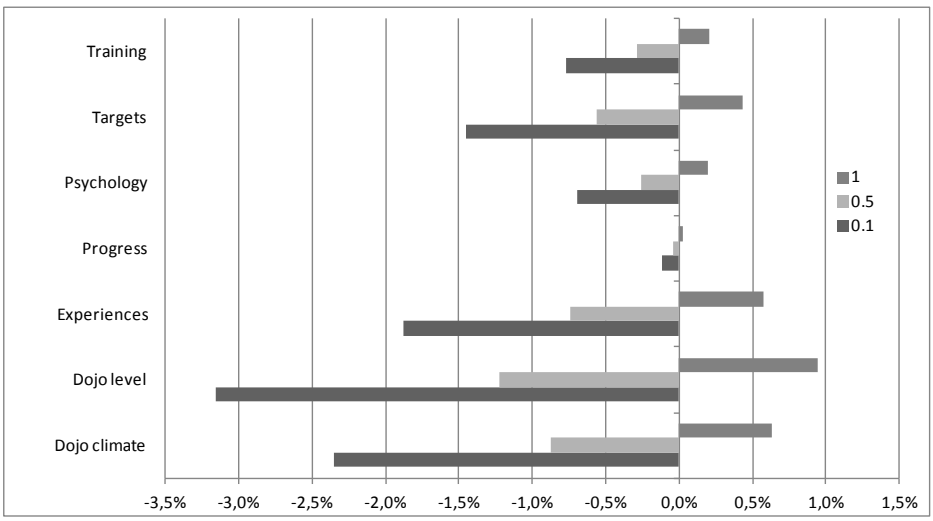

Figure 3. Effect of "Sensei's knowledge and teaching ability" on the other concepts of the collective FCM

is not intended to produce exact quantitative values, but rather aims at identifying the general pattern of system's behaviour via the achieved values of the FCM's concepts. More explicitly, key variables were increased or decreased continually, a process known as "clamping" by Kosko [1986], and the values of the final vector were compared to the steady state vector [Vasslides, Jensen 2016], so as to study the relative changes to the conceptual system. The initial values used for the concept under investigation were sequentially set to 0.1, 0.5, and 1.0, representing three possible situations, i.e. from almost "non-existence" to the highest possible level. In all simulations, the system reached after six iterations an equilibrium state.

For conciseness reasons, only the results for a subset of the most important concepts, namely "Training" and "Sensei's knowledge and ability" are presented in Fig. 2 and 3 and are briefly discussed in the next section.

4. Discussion

Looking at the most mentioned factors in the individual FCMs, some similarities and differences are noticed among the participants. "Sensei's role", "Dojo climate" and "Training hours" are the most mentioned factors, followed by "Psychology", "Family climate" and "Talent". All these factors seem to affect positively the progress of a traditional karateka. In addition, by looking at the most central variables, it can be understood which variables are most important in a FCM, while the outdegree and indegree indices, show how much these central factors affect and are affected by other variables [Ozesmi, Ozesmi 2004]. Besides "Progress", the most central factors are: "Psychology", "Training", "Sensei's role", "Dojo climate", "Health" and "Positive (or Negative) elements of karateka's character". The factors that affect more other variables (i.e. high outdegree index) are: "Psychology", "Sensei's role" and "Dojo climate". For some interviewees "Economic situation" and "Health" are also of high importance as outdegree variables.

According to the collective FCM (Table 3), "Training" is the most central variable, followed by "Positive elements of karateka's character", "Dojo climate", "Psychology", "Sensei's character" and "Sensei's knowledge and teaching ability". "Sensei's character" and "Sensei's knowledge and teaching ability" have the biggest effect on other variables (outdegree index: 3.71 and 3.55, respectively), followed by the "Positive elements of karateka's character" and the "Dojo climate". Besides "Progress", "Psychology" and "Training" are more affected by other variables (indegree index: 4.02 and 3.79, respectively).

The simulations reveal some interesting information, as well. As shown in Fig. 2, clamping "Training" from a low up to a high level has a positive, though not important, effect on "Progress". This is attributed to the fact that "Progress" is affected by almost all the concepts. However, "Training" has significant effects on "Talent", "Dojo level", and even the "Psychology" of the karate practitioner. The effect of "Sensei's knowledge and ability" on the "Progress" is not very significant, for the same reasons (i.e. "Progress" is influenced by all the concepts) (Fig. 3). Yet, it seems that there exists an important influence on practitioners "Psychology", "Training", "Targets" and "Experiences". Moreover, it affects "Dojo climate" and "Dojo level". The difference observed in the behaviour of this concept is driven by the direct and indirect linkages determined by the karate instructors. For instance, the increase of "Sensei's knowledge and ability" leads to a direct increase mainly in "Dojo climate", "Dojo level", "Experiences.", "Progress", "Psychology", "Targets" and "Training". Nevertheless, there are also indirect influences between the "Dojo level" and the other concepts, e.g. an increase in "Dojo climate" and "Training", increases "Dojo level", as well.

From a general perspective, the research illustrates that both 'endogenous' (i.e. 'in-Dojo') and 'exogenous' (i.e. 'out-of-the-Dojo') factors play an important role in shaping the progress and development of a traditional karateka. It is evident, however, that only endogenous factors can be controlled by karate instructors. Thus, from an instructor's viewpoint, cultivating good relationships between the dojo members, attracting high-ranked karateka in the dojo, and encouraging karate trainees to gain experiences (e.g. attending traditional karate seminars) are the most critical elements towards supporting students' progress in Budo. Yet, it should not be forgotten that the integrity of sensei's character, and her/his knowledge and teaching abilities hold the key to success, since these factors, as detailed above, have an important effect on a number of other elements of the system. Finally, this research should be seen as a complement to existing empirical research regarding the attitudes and motivations of people practicing karate [e.g. Cynarski, Niewczas 2017], the changes in the understanding of karate [e.g. Jakhel, Pieter 2013] and even the directional changes and the institutional development of karate [e.g. Cynarski 2014].

Conclusions

This paper aimed at exploring and analysing critical factors affecting the progress of a traditional karateka in the context of Budo, using the FCM approach. FCMs can serve as a basis for exploring the interactions between the concepts involved into the system studied, even though they are not substitutes for statistical techniques, nor they provide real-value parameter estimations [Özesmi, Özesmi 2004].

As regards the specific FCM application, six experienced and high-ranked traditional karate instructors were interviewed in order to construct, first, the individual FCMs and, then, the collective FCM with 19 factors, in total. "Training" was the most central variable, fol-

lowed by "Positive elements of karateka's character", "Dojo climate", "Psychology", "Sensei's character", and "Sensei's knowledge and teaching ability". Furthermore, "Sensei's character", and "Sensei's knowledge and teaching ability" have the biggest effect on other variables, followed by the "Positive elements of karateka's character" and the "Dojo climate". Finally, using the adjacency matrix of the collective FCM, simulations were performed in order to observe whether the system converges toward a steady state. According to the results of the FCM simulations, the system converges in 6 simulation time steps and the most critical factors influencing the progress of a traditional karateka are "Sensei's knowledge and ability", "Training", "Positive elements of karateka's character", and "Dojo climate", followed by "Sensei's character" and "Dojo level". Although the results provide soft evidence, the FCM framework proved to be helpful in identifying the factors influencing Budo, i.e. the way of seeking "The Path" towards a better way of life [Sasaki 2006].

To the authors' best knowledge this is the first attempt to apply the FCM framework for exploring the factors behind the progress in Budo. In this sense, it can be helpful for those teaching and practicing traditional karate. Nevertheless, much work has still to be done in order to improve the conceptual model. For instance, future research efforts could and should expand the number of instructors recruited and could also elicit the view of novice and expert practitioners.

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References

1. Amer M., Jetter A., Daim T. (2011), *Development of fuzzy cognitive map (FCM)-based scenarios for wind energy*, "International Journal of Energy Sector Management", vol. 5, no. 4, pp. 564-584.
2. Axelrod R. (1976), *Structure of Decision, the Cognitive Maps of Political Elites*, University Press, NJ Princeton.
3. Bojadziev G., Bojadziev M. (2007), *Fuzzy Logic for Business, Finance, and Management, 2nd ed.*, World Scientific Publishing, Singapore.
4. Bueno S., Salmeron J.L. (2008), *Fuzzy modeling Enterprise Resource Planning tool selection*, "Computer Standards & Interfaces", vol. 30, pp. 137–147.
5. Carley K. (1997), *Extracting Team Mental Models Through Textual Analysis*, "Journal of Organizational Behavior", vol. 18, pp. 533-558.
6. Cynarski W.J. (2014), *The European karate today: The opinion of experts*, "Ido Movement for Culture. Journal of Martial Arts Anthropology", vol. 14, no. 3, pp. 10-21.
7. Cynarski W.J., Niewczas M. (2017), *Perception and attitude towards Karate among the members of the Polish Junior representation squad: diagnostic survey*, "Arrancada", vol. 17, no. 31, pp. 58-65.
8. Eden C., Ackerman F., Cropper S. (1992), *The analysis of cause maps*, "Journal of Management Studies", vol. 29, pp. 309–323.
9. Hsu H.M., Chen C.T. (1996), *Aggregation of fuzzy opinions under group decision making*, "Fuzzy Sets and Systems", vol. 79, pp. 279–285.
10. International Traditional Karate Federation – ITKF (2006), *Understanding Budo – Definition and Fundamental Ideas*. Retrieved from http://www.itkf.org/images/Understanding__Budo.pdf (access: July 2017).
11. International Traditional Karate Federation – ITKF (2007), Budo – Fundamentals and competitions. Retrieved from: International Traditional Karate Federation – ITKF (2006). Understanding Budo – Definition and Fundamental Ideas. Retrieved from http://www.itkf.org/images/Budo_The_First_Budo_Congress.pdf (access: July 2017).
12. Jakhel R., Pieter W. (2013), *Changes in primary motives of karate beginners between 1970–1999*, "Ido Movement for Culture. Journal of Martial Arts Anthropology", vol. 13, no. 1, pp. 48-57.
13. Kacprzyk J., Fedrizzi M., Nurmi H. (1992), *Group decision making and consensus under fuzzy preferences and fuzzy majority*, "Fuzzy Sets and Systems", vol. 49, pp. 21–31.
14. Kontogianni A., Tourkolias C., Papageorgiou E.I. (2013), *Revealing market adaptation to a low carbon transport economy: tales of hydrogen futures as perceived by fuzzy cognitive mapping*, "International Journal of Hydrogen Energy", vol. 38, no. 2, pp. 709-722.
15. Kosko B. (1986), *Fuzzy cognitive maps*, "International Journal of Man-Machine Studies", vol. 24, no. 1, pp. 65-75.
16. Kosko B. (1987), *Adaptive inference in fuzzy knowledge networks* [in]: *Proceedings of the First IEEE International Conference on Neural Networks (ICNN-86)*, San Diego, CA, pp. 261–268.
17. Kosko B. (1992), *Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence*, Prentice-Hall, Englewood Cliffs, NJ.
18. Liu Y., Liu B. (2002), *Expected Value of Fuzzy Variable and Fuzzy Expected Value Models*, "IEEE Transactions", vol. 10, no. 4, pp. 445-450.
19. Lu C., Lan J., Wang Z. (2006), *Aggregation of fuzzy opinions under group decision-making based on similarity and distance*, "Journal of Systems Science and Complexity", vol. 19, pp. 63-71.
20. Ozesmi U., Ozesmi L. (2004), *Ecological Models Based on People's Knowledge: A Multi-Step Fuzzy Cognitive Mapping Approach*, "Ecological Modelling", vol. 176, no. 1, pp. 43-64.
21. Papageorgiou E., Kontogianni A. (2012), *Using Fuzzy Cognitive Mapping in Environmental Decision Mak-*

ing and Management: A Methodological Primer and an Application [in:] Stephen S. Young and Steven E. Silvern (eds.), *International Perspectives on Global Environmental Change*, InTech, pp. 427-450. Retrieved from http://www.intechopen.com/books/international-perspectives-on-global-environmental-change/using-fuzzy-cognitive-mapping-in-environmental-decision-making-and-management-a-methodological-prime (access: July 2017).

22. Papageorgiou E.I., Markinas A., Gemptos T. (2009), *Application of fuzzy cognitive maps for cotton yield management in precision farming*, "Expert Systems with Applications", vol. 36, pp. 12399–12413.
23. Sasaki T. (2006), *The meaning and role of budo (the martial arts) in school education in* Japan, "Archives of Budo", vol. 2, pp. 11-14.
24. Taber R., Yager R.R., Helgason C.M. (2007), *Quantization effects on the equilibrium behavior of combined fuzzy cognitive maps*, "International Journal of Intelligent Systems", vol. 22, no. 2, pp. 181-202.
25. Vasslides J.M., Jensen O.P. (2016), *Fuzzy cognitive mapping in support of integrated ecosystem assessments: Developing a shared conceptual model among stakeholders*, "Journal of Environmental Management", vol. 166, pp. 348-356.

Identyfikacja czynników przyczyniających się do postępów w Karate-Do przy użyciu metody Rozmytych Map Kognitywnych (Fuzzy Cognitive Mapping)

Słowa kluczowe: rozmyte mapy kognitywne, *budo, karate-do*, symulacje rozmytych map kognitywnych

Abstrakt

Cel. Ochrona i zachowanie dziedzictwa Budo nakłada pewne wymagania zarówno na instruktorów jak i adeptów tradycyjnego *karate*. Niniejszy artykuł ma na celu zbadanie i analizę najważniejszych czynników wpływających na postępy tradycyjnych karateków w praktykach *Budo*.

Metoda. Wprowadzono metodę rozmytych map kognitywnych Fuzzy Cognitive Mapping (FCM), która łączy w sobie zdolność logiki rozmytej z symulacjami modelowania dynamicznego. Mówiąc dokładniej, przeprowadzono wywiady z sześcioma instruktorami karate w celu skonstruowania, po pierwsze, indywidualnych a następnie zbiorowych map kognitywnych.

Wyniki. Ogólne wyniki wskazują, że najczęściej wymienianymi i ważnymi czynnikami wpływającymi pozytywnie na postępy adeptów tradycyjnego karate są: „wiedza i umiejętności Senseia", „trening", „psychologia", „pozytywne elementy charakteru karateki", „charakter Senseia" i „klimat *dojo*".

Wnioski. Chociaż wyniki dostarczają pewnych dowodów, metoda rozmytych map kognitywnych okazuje się być użytecznym narzędziem do zrozumienia złożonych zjawisk, poprzez uzyskiwanie i analizowanie indywidualnej i zbiorowej wiedzy, preferencji i przekonań. W tym celu niniejsze badanie pragnie pomóc zarówno instruktorom, jak i adeptom tradycyjnego karate w zidentyfikowaniu najważniejszych czynników, na które należy zwrócić uwagę, aby zmaksymalizować efektywność praktyki *Budo*. Niniejszy dokument ma także na celu stymulowanie dalszej dyskusji i badania dotyczącego ogólnego wykorzystania wiedzy nieformalnej w kontekście szkolenia sportowego.