Comparison of temporal and spatial occluded video karate attacks with regard to predictability

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Abstract—**In sporting activities the early detection of opponent activities often decides about win and defeat. In this paper a research methodology for the analysis of anticipation of attacks in karate sport is developed. Here, methods of spatial and temporal occlusion are used. During the preliminary work, essential hypothesis were put forward with the aim to refute or confirm. Video sequences were occluded spatial, temporal and spatial-temporal. They were presented in life size on a canvas. The two test persons were required to respond verbally and physically. The results are evaluated in detail. The quality criteria are objectivity, reliability and validity. The main result is that at the early occlusion time steps a correct verbal and physical respond to the illustrated attack could be made.**

Keywords - occlusion; anticipation; karate

I. INTRODUCTION

Life today is determined more and more by technology. Instead of a travel plan, there is a navigation device. Even real playmates are no longer a need. They will be replaced by virtual players, for instance by the Xbox-Kinect. So variations of sports, like boxing moves could be mimicked. Virtual reality is applied in high-performance sports. It is used as a training method. The aim is to get usable test results, for example in the field of anticipation. Anticipation is the predicting of future events. For instance, investigations have been carried out in football, handball and tennis [5], [9]. The karate sport still allows much discovery potential. There is one test example in karate in the year 2003 done by the japanese researchers Mori, Ohtani and Imanaka, representatives of the universities in Tokyo and Kyoto [11]. They studied the reaction times and anticipation of expert and novice karate athletes. They are also using the temporal occlusion technique. The test was repeated, when more than 90 percent wrong answers of the target area were given. Experts answered faster but not necessarily accurate. Karate is divided into a lot of different styles. This investigation refers to the subspecies Shotokan. This kind of karate is identified by long deep positions, powerful techniques and its dynamic form [2]. The occlusion technique is divided into temporal and spatial occlusion. By the temporal occlusion the sequence of karate attack is reduced at certain phases of the attack. By the spatial occlusion body parts of the virtual opponent's are concealed by appropriate methods. Objective number 1 of this study is to get statements about the information content of body parts, which were occluded spatial. Objective 2 is to determine the point of time from which a reliable prediction of the attack can be carried out. Objective 2 will be investigated with the temporal occlusion method. From the results of this investigation should emerge, if a continuation of this pilot study is useful.

II. THEORETICAL BASIS

A. Spatial occlusion

In the spatial occlusion method, body parts and areas of the athletes which are shown in the video are concealed. In earlier times there were colored shapes superimposed on the desired areas. Due to the technical progress, this happens today more often by covering with background clippings. You then get the impression of an invisible effect [1].

For the first time the spatial occlusion has been applied by Abernethy and Russel in 1987. They investigated the parameters that are of particular importance for predicting the impact direction in badminton. Five body-bat regions were masked by blackened surfaces.

In a study about the anticipation of tennis strokes it should be investigated which information is of particular importance for the prediction of a stroke. The videos were created with the video program Adobe Premiere (Version 5.1). The videos included 5 different spatial occlusions. The result was that the anticipation ability of players was supported by the information of litter and the arm-racket-region. The body parts were made invisible [10].

The aim is to detect the information content of the hidden part of the body through the change in response of the test person.

B. Temporal occlusion

For the temporal occlusion the video sequences will be cut. It´s divided in the progressive-window-approach and the moving-window-approach. In the first mentioned approach the video length is getting longer by the adding of images at the end of the video. That approach is used in this investigation. In the moving-window-approach the video length remains constant. Video segments are taken away at the end and other segments are added at the beginning [4].

The aim is to predict the output of the sport specific situation as good as possible. It is also investigated how the predictions are changing with increasing video length. The assumption is: with increasing video length the forecast probability increases and the guess probability decreases [8].

For instance, studies were done in football, squash, and hockey [1], [3]. Five occlusion time points were chosen for the investigation in Squash, 2 before, one during and 2 after a bat-ball contact. Experts were able to predict the direction of the blow more accurate than the novices. The error rate of the experts was reducing with increasing video length. [1]

The videos were stopped at important functional phases of the sporting action. Karate is a very complex sport. Therefore, for any technique there are many functional phases described in detail. This is to be shown by the example of the combination attack Gyaku-Zuki/Mawashi Geri. The Gyaku-Zuki is a reversed punch (fist punch with the hand of the other side than the front feet) and the Mawashi-Geri is a reversed semicircle kick.

The grouping of these functional phases was performed in this investigation by a karate expert, see Table I. Main operating phases are connected to the attainment of the objective movement. Auxiliary function phases serve as preparation for the attainment of the objective movement. The classification of these phases has been made frame by frame. Also, there are detailed descriptions about the motion at any phase. Each phase provides information on significant and important characteristics of the motion. This gives karateka approaches to anticipate the attack of the opponent. No function phase was assigned to the first occlusion time point because the real attack does not begin at that time point (only step motions). Thus an anticipation cannot be done. Especially the preparatory and supporting auxiliary function phases of attacks are of relevance for the test persons. The phases prepare the execution of the sporting action. The test persons take relevant information from the phases to anticipate the attack. The results show that many of the shown attacks were predicted correctly starting from occlusion time point t_2 (see IV. Results and discussion). Table II shows an excerpt of the phase descriptions Gyaku-Zuki/Mawashi-Geri.

TABLE I. FUNCTION PHASES GYAKU-ZUKI/MAWASHI-GERI

occlusion time point	frames (Δt)	Function phase (inclusive)
t_0	0 - 98	-
t_1	0 - 104	support help function phase ,1GZ
t_2	0 - 105	preparatory help function phase 1, MG (half)
t_3	0 - 106	preparatory help function phase 1,GZ main function phase ,1GZ
t_4	0 - 111	support help function phase 2, MG
t_5	0 - 113	main function phase 2, MG

Description of the used abbreviations:

- t_0 - t_5: first to last occlusion time point
- GZ: Gyaku-Zuki
- MG: Mawashi-Geri

TABLE II. A PART OF THE DESCRIPTION OF THE FUNCTION PHASES GYAKU-ZUKI/MAWASHI-GERI

phase	content/motion feature
preparatory help function phase 1	• big step forward, place the front leg that can take the weight, Increment is much greater • reduction of the centre of pressure • place the front leg with external rotation • the beginning of the longitudinal axis of rotation - simultaneous start of the hip and shoulder
support help function phase	• dropping of the right arm • drawing the arms to the body • lift of the thrust arm while the upper body rotation
preparatory help function phase 1 Mawashi-Geri	• back leg is moved to the front (Leg-torso angle almost 180° and flexion of the knee)
main function phase 1 Gyaku-Zuki	• arm extension up to stop the stretching motion

C. Hypothesis

- At the first occlusion time point (t_0) of the shown attack techniques correct physical and verbal reactions are not possible.
- The spatial occlusion technique is better suited for anticipation in karate, because information for predicting attack techniques can be drawn from even smallest body movements of the opponent.

III. EXPERIMENTAL SETUP

A. Preparatory work

To occlude videos of karate attacks, it was necessary to record videos of various karate techniques. Each attack has an average length of 10 seconds. The Videos were recorded with 25 Frames per second. The attack videos were occluded temporally and spatially with the program Adobe Premiere Pro CS 4. It should be avoided to put simple forms, like circles or bars over the desired area in the sequences. In a suitable method, a still image is placed over the sequence. Each frame had to be edited individually so that the desired area was obscured over the full video length. Thus the effect of invisibility was achieved. The disadvantage of this method is that the method is very time consuming.

The following figure 1 shows some examples of the results of the treated video material. The spatial occlusion technique was applied.

Figure 1. Possibilities of spatial occlusion, from left to right: make invisible the hip, make invisible the left shoulder/arm, make invisible the right leg, make invisible the right shoulder/arm

B. Test design

This investigation is a pilot study. Because of that fact the investigations were initially carried out with two male subjects. Test person 1 is at age of 20 (he possesses the first Dan) and test person 2 at the age of 24 years (he possesses the second Dan) and they have more than 10 years of competition experience.

The video footage consists of 8 main videos, 24 spatial, 42 temporal and 129 spatial-temporal occluded videos. Every video starts with a countdown of 3 seconds, followed by an attack of 6 seconds. The countdown is for the test persons to prepare for the following attack. The videos were presented randomly. For instance, sequences that ended at early occlusion time points were presented in the first parts of the investigation. Spatial occluded videos were presented sorted by occluded body parts. A habituation based on the types of videos should be avoided.

Used equipment: beamer (Samsung SP-D400S DLP Projektor), laptop (Hewlett-Packard hp G62 - b80SG/Processor), camera (Casio Exilim EX-F1), spotlight, semi-translucent rear projection screen, 6 judo mats. Figure 2 shows the study environment with the used equipment.

Figure 2. semi-translucent rear projection screen from the perspective of the test person

C. Test execution

Before the investigation began, the test persons had to do an individual heating and got a clear instruction in the investigation process. At first the physical (active reaction to the shown attack) was to be examined than the verbal reaction (name the shown technique). Caused by the large number of videos, both types of investigation were on two days. So we had 4 investigation days. Between these 4 days there was a pause of 5 to 7 days. The reason for this was to minimize the learning and memory process to the videos. The verbal responses were recorded. The video playlist was randomized. After the end of the investigation the test persons were asked 8 feedback-questions. They were asked to look critical at the investigation. For instance: Did you feel that you could deal with the karate attacks shown in the later stages of the investigation (adaptation, system recognized in playlist)?

With test person 1 a short test run with the randomized order of videos was implemented. His physical reaction was investigated and filmed. After that, there were changes in the investigation. The last frame of each video had been extended to a second, so that the attack canceled not immediately and that the test person does not directly lose the attacker out of sight. The order of the shown videos was changed in consultation with a psychologist. Only the temporal and spatial occluded videos of the male and female karate were presented and that separately. Each video appeared in the playlist up to five times. The total number of videos is thus 330. They were presented in video blocks. In each video block, there were ten videos. Between the video sequences there was a pause of eight seconds, so that the test person could adjust to the following attack. The length of a block was about two minutes, and approximately corresponded to the length of a real karate fight by the old rules of the World Karate Federation German Karate Federation e.V.. Between each block, the test person had the possibility of taking a break. Per study day the test persons were presented 17 blocks. It was required maximum of 4 hours for each investigation. Due to the lack of time, the verbal tests were carried out for all techniques and the physical only in one exemplary test. It also applies for the physical investigation: Only the temporal and spatial-temporal occluded sequences were shown in order to be able to compare these kinds of occlusion. The spatial-temporal occur in the playlist up to three times. The first occlusion time point was saved because according to the classification of the phasing functions a physical reaction is not possible. The evaluation was carried out in collaboration with the project managers. The spatial occluded videos were not presented. Reason: The verbal investigation has shown, that the test persons were unaffected in their reactions up to nearly 100 percent, only by masking of parts of the body.

For evaluation a point system was used: The body's responses were evaluated with regard to temporal correctness of -1 to +3. -1 indicates a much too late and +3 an optimal time response. For the correct physical response 0 to 2 points were awarded. 0 points for a reckless or not implemented defense, 1 point for evasive maneuvers without counterattack and 2 points for counterattacks with or without evasive

maneuver that would lead to a point win in the contest. The verbal response is rated from -1 to +1. Where -1 indicates an incorrect prediction, 0 for no statement and +1 indicates the correct prediction.

D. main quality cirteria

Main quality criteria are objectivity, reliability and validity. Objectivity means that the implementation, evaluation and interpretation remain unaffected of examiners. It is divided into the implementation and interpretation objectivity. Implementing objectivity is maintained very well. The test person has to respond exclusively to the video material. There is no compelling argument with the investigators. The interpretation objectivity is difficult to maintain. It is used in the evaluation of the physical reactions that's why the estimation of several experts may be necessary.

Reliability provides information about the results of the measurement method. It increases when retest methods come to the same results under the same conditions. Disorders, poor sleep or previous physical stress of the test persons have to be recorded.

Validity questions whether a feature can be studied reliably. Which is true for this study? In the spatial occlusion only a body part has been processed. The focus is thus only on this. The same applies for the temporal occlusion. The focus is thus on a certain functional phase.

IV. RESULTS AND DISCCUSION

A. Feedback questions

The feedback questions contributed positively to the investigation. Following there are the responses of both test persons to the example question in point III. Experimental Setup:

Test person 1:

- Adaptation: Test person 1 could adjust to the time of the movements of the karate technique and the body movements.
- System recognized in playlist: A system or the type of video assembly was not detected in the playlist.

Test person 2:

- Adaptation: Test person 2 could also adjust to the time of the movements of the karate technique and the body movements. Especially the initial step movements in the videos of the male and female karateka contributed to the adaptation.
- System recognized in playlist: A system or the type of video assembly was not detected in the playlist.

B. Verbal investigation

The verbal study provided many correct answers. The spatial occluded videos were answered correctly close to 100 per cent. In temporal occluded videos there were small differences between the test persons. The following Table III shows the statistic of correct and wrong answers of each test person.

TABLE III. SCOREBOARD OF TEST PERSON 1 AND 2

	test person 1	**test person 2**
Correct statements	311 points	283 points
Incorrect statements	5 points	37 points
Total number of points	306 points	246 points
Total number of points in %	92,7 %	74,5 %

Large differences between the test persons in their responses were observed at the temporal occluded Kizami-Zuki/Gyaku-Zuki of the male karateka. The differences between test persons 1 and test person 2 are shown graphically in Figure 3. The Kizami-Zuki/Gyaku-Zuki composed of a jab and reverse punch:

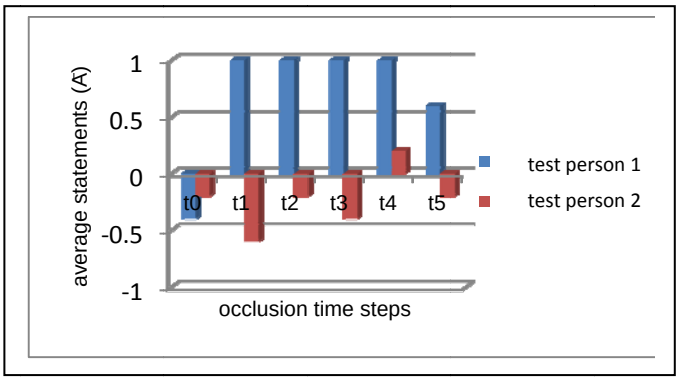

Figure 3. response diagram of the accuracy from the verbal response of test person 1 and 2 of temporal occluded Kizami-Zuki/Gyaku-Zuki of the male karateka

From occlusion time point 2 (t1) test person 1 got 0,92 points and test person 2 only -0,24. The average total variance (standard deviation calculation) of test person 1 is very low. It amounts to 0,1788 points. Test person 2 shows an uncertainty in his answers. This was confirmed in his feedback. So his average total variance is very high and amounts 1,0146 points. The Kizami-Zuki was not perceived as an attack of test person 2.

The given points for the Kizami-Zuki/Gyaku-Zuki of both test persons are shown in Table IV and Table V. S stands for the standard deviation calculation and for the average of the answers A1 to A5.

TABLE IV. TEST PERSON 1, VERBAL REACTION TO TEMPORAL OCCLUDED KIZAMI-ZUKI/GYAKI-ZUKI OF A MALE KARATEKA, -1 ≙ WRONG PREDICTION, 0 ≙ NO ANSWER, 1 ≙ CORRECT PREDICTION

time point	Investigation scope	A1	A2	A3	A4	A5	A	S
t_0	verbal reaction	-1	0	1	-1	-1	-0,4	0,89
t_1	verbal reaction	1	1	1	1	1	1	0
t_2	verbal reaction	1	1	1	1	1	1	0
t_3	verbal reaction	1	1	1	1	1	1	0
t_4	verbal reaction	1	1	1	1	1	1	0
t_5	verbal reaction	1	-1	1	1	1	0,6	0,89

TABLE V. TEST PERSON 2, VERBAL REACTION TO TEMPORAL OCCLUDED KIZAMI-ZUKI/GYAKI-ZUKI OF A MALE KARATEKA, -1 ≙ WRONG PREDICTION, 0 ≙ NO ANSWER, 1 ≙ CORRECT PREDICTION

time point	Investigation scope	A1	A2	A3	A4	A5	A	S
t_0	verbal reaction	0	-1	0	-1	1	-0,2	0,95
t_1	verbal reaction	1	-1	-1	-1	-1	-0,6	0,89
t_2	verbal reaction	-1	-1	1	-1	1	-0,2	1,09
t_3	verbal reaction	0	-1	-1	-1	1	-0,4	0,89
t_4	verbal reaction	1	1	-1	1	-1	-0,2	1,09
t_5	verbal reaction	-1	-1	1	-1	1	-0,2	1,09

Test person 1 gave wrong statements only at occlusion time point 1 and occlusion time point 6. According to the phasing functions it is not possible to draw conclusions at the first occlusion time point. The false and no-answers can be justified with this fact. The false statement at occlusion time point 6 can be regarded as a slip by loss of concentration, caused by the plurality of the videos being shown during the investigation. Test person 2 gave wrong and correct answers at each occlusion time points. The wrong answers outweigh what can be seen in the average of his answers. His response spectrum reflects uncertainty in the detection of the shown attack. This is also reflected in the high standard deviation. With increasing video length an improvement of his anticipation cannot be recognized.

C. Physical investigation

The evaluated example was the Gyaku-Zuki of the male karateka when test person 1 has to react. This technique is a shock, and was evaluated for temporal correctness and proper response. The test person always reacted to the temporal occluded sequences. To later occlusion time points an improvement of his reaction cannot be recognized. Also, inappropriate reactions to the shown attack happened.

Table VI and Table VII illustrate the given points in terms of temporal accuracy and correct response as an example of the spatial-temporal occluded videos (hip was occluded): k R stands for the average of the given points to his physical reaction of the 3 physical reactions kR1 to kR3.

The complete range is covered. A more positive development of his reactions is not visible with increasing length of the sequences. It happened that the test person responded to early. This can be explained with a habituation to the attack. Even his physical reaction was rated almost entirely with 2 points. It can be said, that the test person detected the attack in time. So he could react also temporal appropriately to the shown attack. The assessment of a correct temporal reaction needs many gradations, because karate is a very fast sport. Other independent assessments of the attacks by several karate experts would be advisable to be able to draw more comparisons and conclusions. It would be advisable to cut the physical reaction videos of the test persons so that all have the same starting point. So a frame-

TABLE VI. TEST PERSON 1, PHYSICAL REACTION TO SPATIAL-TEMPORAL OCCLUDED GYAKI-ZUKI (HIP OCCLUDED) OF A MALE KARATEKA WITH REGARD TO TEMPORAL CORRECTNESS, -1≙ NO TEMPORAL REACTION, 0 ≙ DELAYED REACTION, 1 ≙ SLIGHTLY DELAYED REACTION, 2 ≙ JUST IN TIME REACTION; 3 ≙ OPTIMAL REACTION, * TO EARLY

time point	Investigation scope	kR1	kR2	kR3	k R
t_1	physical reaction	-1	2	2	1
t_2	Physical reaction	3	3*	3*	3
t_3	physical reaction	0	1	2	1
t4	physical reaction	0	2	1	1

TABLE VII. TEST PERSON 1, PHYSICAL REACTION TO SPATIAL-TEMPORAL OCCLUDED GYAKI-ZUKI (HIP OCCLUDED) OF A MALE KARATEKA WITH REGARD TO A CORRECT DEFENSE AND COUNTERATTACK, 0 ≙ INEXPEDIENT COUNTERATTACK; 1 ≙ EVASIVE MOVEMENT WITHOUT COUNTERATTACK; 2 ≙ COUNTERATTACK WITH/WITHOUT EVASIVE MOVEMENT

time point	Investigation scope	kR1	kR2	kR3	k R
t_1	physical reaction	0	2	2	1,33
t_2	physical reaction	2	2	2	2
t_3	physical reaction	1	2	2	1,66
t4	physical reaction	2	2	2	2

wise comparison of the videos could be performed and the quality of the evaluation could be increased.

D. Wrap-up

Test person 1 was not influenced by the spatial occlusions in the verbal investigation. He always answered correctly. Test person 2 gave 3 incorrect answers, respectively at the fourth time of the showing Gyaku-Zuki/Mawashi Geri (hip, rear right leg, front left leg occluded). It can be said that both test persons were not influenced by the spatial occlusion in their verbal responses. Further studies in karate with spatial occlusions are not recommended. The combination of spatial and temporal occlusion is preferable. Due the lack of time, the method could only be performed at a selected example. Information can be acquired when an anticipation can happen and where (body part) relevant information for the anticipation come from. This can be done in a comparison of the temporal occluded videos with the associated spatial – temporal occluded videos.

Comparisons between the physical and verbal response can hardly be drawn. The physical reaction was only assessed on one example. The temporal occluded Gyaku-Zuki of test person 1 is the only comparison possibility. The test person responded always appropriate to the shown attack in the physical examination with few exceptions (temporal correctness and a correct defense and counterattack). This is also reflected in the verbal investigation of the temporal occluded Gyaku-Zuki, when the test person answered correctly in all cases. The results of the physical investigation also show that the test person had marginally more difficulties to anticipate the spatial - temporal occluded attacks than the temporal occluded attacks. Further studies are recommended to draw more comparisons between the test persons and occlusion methods (temporal and spatial-temporal).

E. Conclusions

Hypothesis 1:

- It was partially confirmed. The test persons also gave correct answers at early time points. The physical reaction could only be examined by one example. It has to be investigated if verbal and physical statements are really not possible at the first occlusion time points.

Hypothesis 2:

- It was not confirmed. The most correct answers were given to the spatial occluded videos. It is not the best way to investigate the anticipation of karate athletes. They get enough information about other physical features.

The selected randomization has to be criticized. A mixture of all existing videos would be more advantageous, to avoid adaptation of the test persons to one occlusion technique. Later occlusion time points should be also shown later, so that the test persons do not get all information about the shown attack at the beginning of the investigation. Learning and memory processes could be better avoided. Spatial-temporal occluded videos are preferred to the spatial, because the test persons have responded to this almost entirely correct. To allow further comparisons between the occlusion methods it is worth considering to use more occlusion time points and attack techniques.

In the evaluation, there were problems. The shown attacks must really be recognizable as such. By the Kizami-Zuki/Gyaku-Zuki the Kizami-Zuki was not perceived as such from test person 2. Even with the combination attack Gyaku-Zuki/Mawashi-Geri the Gyaku-Zuki was not perceived as such by both test persons. This is a punch-kick combination.

The feedback questions are also maintained for future investigations. Suggestions for improvement emerged from them:

- other occlusion areas
- respond only to karateka of the same sex
- different videos of the same attack → for instance to avoid adaptation to the step movements before the attack begins

The idea came up that the test persons can stop the shown sequence by pressing a button. The verbal responses could be better temporal classified and compared with each other [9].

The investigation revealed that both experienced test persons could anticipate the occluded attacks very well, as well under application of the spatial as the temporal occlusion technique. Karate is a sport that consists of many sub-movements. Experienced test persons can choose from small movements close to the respective technique. This statement is reflected in the results. Furthermore, the investigations have shown that a combination of the spatial and temporal occlusion technique can expect more precise statements about forecasts. It is a method that has a great potential for research. This is to be exploited.

V. OUTLOOK

The investigation is a topic with great research potential. The results can be seen as positive. It has created a basis for further studies. There were suggestions arising.

Still planned is to investigate the anticipation of the test persons in the Cave (Cave Automatic Virtual Environment), see Figure 4, at the Fraunhofer Institute Magdeburg [6], [8]. It has the following features: stereoscopic display, tracking system, side walls can be unfolded.

Figure 4. Cave with the folded side walls (see: http://www.iff.fraunhofer.de/de/geschaeftsbereiche/virtuell-interaktives-training/labore/cave.html)

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