"IDO MOVEMENT FOR CULTURE. Journal of Martial Arts Anthropology",
Vol. 22, no. 5 (2022), pp. 62–70
DOI: 10.14589/ido.22.5.8

KINESIOLOGY & COACHING

Michel Calmet [1(ABCDEF)], Jean Sallantin [2(A)], Jean-Louis Monino[3(CD)]
A - Study Design; B - Data Collection; C - Statistical Analysis; D - Data Interpretation;
E - Manuscript Preparation; F - Literature Search; G – Funding Sources.
1 ORCID: 0000-0001-5088-5108
Montoulclip Company, 34190, Montoulieu (France)
Grupo de Estudos e Pesquisas em Lutas, Artes Marciais e Modalidades Esportivas de Combate, da Universidade de Sao Paulo. USP - Universidade de Sao Paulo
Tel. +33 688 475 482, e-mail: michel.calmet@gmail.com
2 Universite de Montpellier, LIRMM UMR 5506, CC477, 161 rue Ada, 34095 Montpellier Cedex 5 (France)
e-mail: jean.sallantin@gmail.com
3 ORCID: 0000-0002-8448-3956
Universite de Montpellier, MRE 7491, Faculte d'Economie, Avenue Raymond Dugrand, CS79606, 34960 Montpellier Cedex 2 (France)
e-mail: jean-louis.monino@umontpellier.fr
Corresponding author: Dr Calmet Michel
Faculte des Sciences, Master Qualite, Av. Escadrille Normandie-Niemen, Marseille (France)
+33 688 475 482, e-mail: michel.calmet@gmail.com

Multicriteria analysis of the force ratio between two judokas in delayed real-time

Submission: 12.11.2022; acceptance: 26.12.2022

Key words: motion analysis, computer science, delayed video, live decision making, to intervene / to annotate, live actors, *judo* combats analysis, force ratio, multicriteria analysis

Abstract
Background. Since 2016, at the University of Montpellier, 3rd-year students (judo specialty) have been analyzing judo combats in a multicriteria way to optimize their coaching, refereeing, teaching, and journalism.
Problem. One of their works consisted in analyzing on a computer a delayed real-time combat (without pause, nor visual or auditory signal) to observe one judoka. The task was to estimate the force ratio between the two judokas to determine if the judoka observed was, by clicking (annotating) next to the video in an orthonormal graph composed of 4 sectors: (dominant-programmed [S1]; programmed-dominated [S2]; dominated-automatic [S3]; automatic-dominant [S4]). The more important the criteria were considered; the more clicks (annotations) were placed on the periphery of the axes.
Aim. To confirm and improve our previous results on this subject: (i) to analyze a recorded video sequence excluding video backtracking (as if they were live, as a coach or a referee), (ii) to identify the reversal of force ratio, (iii) to make repeatable and homogeneous observations.
Method. After 40 min of training, 12 students analyzed 4 times the same combat presenting a reversal of force ratio: the judoka to be observed was first dominant-programmed (many clicks were expected in S1), then was dominated-automatic and lost the fight (many clicks were expected in S3). These students were aged 20.4 ± 1.9 years, brown belt to black belt 2nd dan, practicing 4h to 12h of judo weekly, had followed courses of judo specialty (90h), ICT (18h) and video analysis (10h). Shapiro-Wilk, Kruskal-Wallis and Kolmogorov-Smirnov tests were used to analyze the data collected. A significance level was set at 5%.
Results. The 4 observations were identical and homogeneous. No statistically significant difference in: (i) duration times for the 4 observations (Kruskal-Wallis's test: p=0.919); (ii) number of clicks per observation (Kruskal-Wallis's test: p=0.715); (iii) the distributions of the coordinates X and Y of the clicks per bin in the four observations (Kruskal-Wallis's test: p=0.942 and p=0.968). The percentages of clicks per sector according to time: [S1]=40.2%; [S2]=16.5%; [S3]=32.3%; [S4]=11%) and the evolution of the number of clicks in S1 show the reversal of force ratio. There is a significant difference in the comparison of the distributions of collected and random coordinates (Kruskal-Wallis's test: p=0.699 and p=0.173 respectively for X and Y coordinates).
Conclusions. These results do not appear to be due to chance. The identification of the reversal of force ratio in combat, the homogeneity and repeatability of the analyses confirm our hypotheses and the previous study in 2019. The transferability of these skills to real-life situations must be verified.

1. Introduction

Since the end of the 19th century, research in the analysis of video sequences allow qualitative analyzes (interpretation of the action) and quantitative analyses (distances, velocities, time, power) [Mannoni 1997; Frizot 2001; Adam 2010]. The person or the team is filmed inside a context and the research focuses on the meaning of the person's actions/strategies or the team's actions/strategies in this context [Knoblauch *et al.* 2006]. Usually, it is an a posteriori use to explain or model and simulate these actions/strategies [Calmet *et al.* 2016] or to avoid injuries [Hartigan *et al.* 2019]. In recent years Video Assistant Referee (VAR), CARE system or Hawk-Eye systems are used in different sports: in tennis since 2006, in basketball since 2007, in handball since 2014, in judo since 2014, in soccer since 2018. They are decision aids for referees (did the ball cross the limits of the field), can we validate the goal, the throw, or the try (offside in soccer, score in judo, try in rugby)? We pay attention to the results and live analysis of rugby matches with connected balls and connected players. Topics of research on the analysis of judo combats with "delayed videos" generally relate to technics or penalties (frequency, genre, weight categories, biomechanics, winner, and non-winners), different scientific works in reference were specified in our previous article in 2019. Scientific research must continue to deal with the results (biomechanical, physical, physiological, and strategies) and deal with the training of referees, coaches, and athletes in the use of these new tools. The European Judo Federation proposes a "Referee online test" [EJU 2022], but it is a quiz with written questions without video. However, in judo the CARE system has transformed refereeing. On the tatami, there is one referee, and "in each International Judo Federation (IJF) event there are IJF Supervisors whose function is to ensure that all decisions made by the referee are correct" [IJF 2022]. They are referees and trained in video analysis and in the use of the CARE system.

In our previous paper concerning "Evaluation or Analysis of a Live or a Recorded Video Sequence: An Example in the Analysis of Sports Videos" [Calmet *et al.* 2019] we have specified the general conditions in which students in the Faculty of Sport Sciences of Montpellier, were trained to ICT in accordance with the instructions of ministerial National of Education [MEN 2002, 2010, 2017].

Since 2016, at the UFRSTAPS of Montpellier, 3rd-year students (judo specialty) analyze in a multicriteria way judo combats to optimize their coaching, refereeing, teaching, and journalism. Their learning path is supported by online tutorials, and one of their evaluated works was to analyze a combat on the computer in real-time (without pause, visual or auditory signals).

Appreciating or estimating the interactions between two judokas as a coach does, live on the court, requires knowing and differentiating several criteria, for example:

— attack and defend at the same time
— acting to create uncertainty in the opponent (suggesting that one is going to attack in one direction, to attack in another direction)
— manage the uncertainties created by the opponent
— reflex counterattack (training helps develop this type of competence) [Potdevin, 2007]
— manage the score

In our previous study we had underlined on the one hand the quality of homogeneity and repeatability of the students' results and on the other hand that in the combat to be analyzed, the observed judoka could always be considered as dominant. Consequently, we had specified in the conclusions that it was necessary to continue this mode of analysis with combats comprising one or more reversals of force ratio (dominant, then dominated for example).

2. Aim of the study

The aim was to observe new students analyzing a recorded video of a judo combat, without replay or pause [Knoblauch *et al.* 2006], as if they were live, as a coach or referee.

In this new study, the analyzed combat includes a reversal of force ratio, and the task for students consisted in assessing or evaluating the interactions of the two judokas to determine if the observed judoka was: 1) "dominant, i.e.: in a favorable organization to win" vs. "dominated" and 2) "programmed/conscious" vs. "automatic" i.e.: for this latter term a reflex organization [Potdevin 2007] (i.e.: the insert on the force ratio).

In the continuity of our previous study in 2019, the observations had to be identical and homogeneous and allow the identification of the reversal of force ratio (i.e.: identify the S1⇔S3 axis, i.e.: Fig.1).

3. Methods

Subjects: Twelve 3rd year students (judo specialty) voluntarily participated in this research project, they were 20.4 ± 1.9 years old, were brown belt to black belt 2nd dan, practiced 4h to 12h of judo per week, had followed courses of judo specialty (90h), ICT (18h) and video analysis (10h). These 12 students had previously worked with video analysis applications under MS-Excel to define the system of attacks of judokas [Calmet *et al.* 2006; Calmet *et al.* 2016].

Protocol to collect data: A demonstration of how to use the application was given to the 12 students for 5min with a specific combat dedicated to learning the application. Then students learned how to use the application with this specific combat for 10min to master the MS-Excel application they would be using. This specific

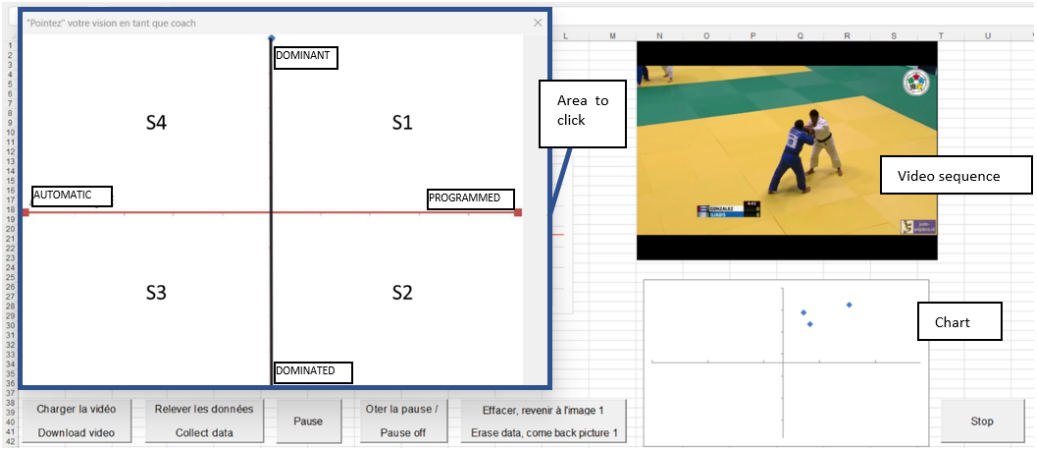


Fig. 1. Screenshot of the application to collect data during the analysis of the combat.

combat was 2 min long, to allow students to have 4 tries [Hopkins 2015]. To find out if students perceived significant changes in the combat, they were asked to click next to the video in an orthonormal graph (Aera to click) consisting of 4 sectors: dominant-programmed (S1); programmed-dominated (S2); dominated-automatic (S3); automatic-dominant (S4). The more important the criteria were considered, the more the clicks were placed at the periphery of the sectors. Each click in the "Area to click" was recorded (time and X and Y coordinates), then a corresponding dot was displayed simultaneously in the chart, and the dot was removed from the "Area to click"; as an example, 3 dots are displayed in the chart (i.e.: Fig. 1). Students' results expected were to sum more clicks in S1 and S3 than in S2 and S4.

The "dominant" vs "dominated" axis (vertical axis or Y axis) was well understood by the students. The "programmed" vs "automatic" axis (horizontal axis or X axis) gave rise to some exchanges about their own practices as judoka or referee. They better understood this X axis when: "automatic" could be related to rebalances, changes in support or reflex counterattacks; and "programmed" (or conscious) [Chambily 2017] could be related to a voluntary triggering of the attack or positioning on the mat: close the combat limit, keep the opponent in a corner of the mat [Potdevin 2007].

The frequency for clicks (annotations) was based on the duration of a combat sequence (20s) [Castanerlas & Planas 1997; Franchini *et al.* 2013; Miarka *et al.* 2012; Miarka *et al.* 2013] and/or the time assigned to the referee to give a non-combativity penalty (about 30s) [IJF 2016]. For a 5min long combat, the order of magnitude of the number of annotations for a student was from 10 annotations (2 per min) to 15 annotations (3 per min). Because of their judo specialty, the students were aware of these temporal phases (20s to 30s), and they only had the clock time of the combat (embedded in the video) as a reference.

Data collection and statistical analysis: After the training, students analyzed 4 times a combat opposing in 2013 Gonzalez (from Cuba) and Iliadis (from Greece) in the category -90kg in semi-final during the world championship in Rio de Janeiro. The video of the combat lasts 8min 39s, this combat contains a reversal of force ratio and ends at 7min 40s. The difference is due to the ceremony. The judoka to be observed was first dominant-programmed (many clicks were expected in S1), then the judoka to be observed was dominated-automatic (many clicks were expected in S3), and finally the judoka observed lost the combat. The time allocated to do these 4 analyses was 40 min.

Data were then input and run in MS-Excel 365 and statistically processed with XLSTAT 2019.4.1 Addinsoft, 2020. A significance level was set at 5%. Shapiro-Wilk, Kruskal-Wallis, and Kolmogorov-Smirnov tests were used to analyze the data collected.

4. Results

The application was useful, and data collected enabled the analyses.

4.1) Comparison of the observation times (duration between first click and last click of the observation) per student

Tab. 1. durations means and SD of the 4 observations

	Obs.1	Obs.2	Obs.3	Obs.4		
Mean	0:07:37	0:07:36	0:07:31	0:07:32	General mean	00:07:34
SD	0:00:15	0:00:14	0:00:29	0:00:27	General SD	00:00:18

Our investigations focused on the first 11 students, as observations 2 and 3 of Stud.12 were too short (respectively 0:05:34 and 0:04:56; these values were less than: (overall average - 3 * overall SD).

Regarding these 11 students, the observations times 1, 2, 3 and 4 did not have a normal distribution (respectively Shapiro-Wilk's tests: p=0.14; p= 0.44; p= 0.58; p= 0.03) but no significant difference was found for the

observation times in the 4 observations (Kruskal-Wallis's test: p=0.919).

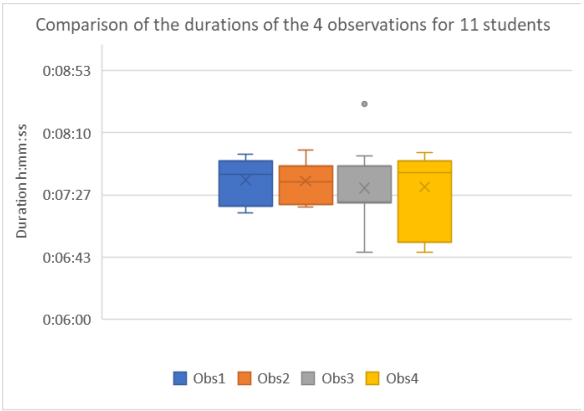


Fig. 2. Comparison of the 4 durations of the 4 observations

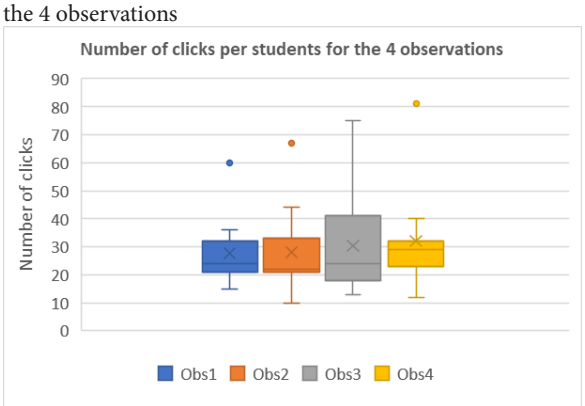
4.2) Comparison of the number of clicks per observation per student

Tab. 2. Number of clicks per student for the 4 observations

	Obs.1	Obs.2	Obs.3	Obs.4		
Mean	27.6	28.1	30.5	32.09	General mean	29.6
SD	11.9	15.2	17.9	17.78	General SD	15.4
Min	15	10	13	12		
Max	60	67	75	81		

The number of clicks regarding observations 1, 2, 3, and 4 did not have a normal distribution (Shapiro-Wilk's tests: p=0.004; p= 0.013; p= 0.02; p= 0.001 respectively) but no significant difference was found for the number of clicks in the four observations (Kruskal-Wallis's test: p=0.715).

Fig. 3. Comparison of the number of clicks per student for the 4 observations



Regarding the number of clicks, as in our previous study, each of the students made their 4 observations with a similar number of clicks (annotations). In Fig. 4, after sorting, 3 groups appear regarding the number of clicks and the gap between the min and the MAX of clicks:

As the duration and the number of clicks for the 4 analyses were comparable, it was possible to study the distribution of the coordinates of these clicks.

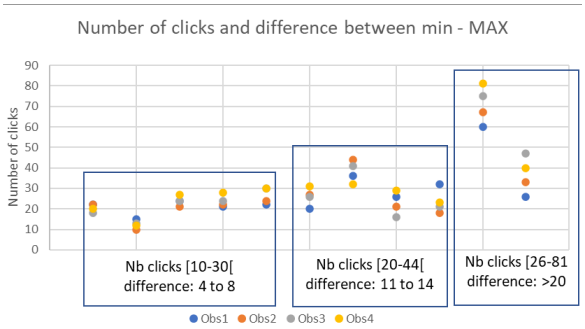


Fig. 4. Number of clicks per student regarding the number of clicks and difference between min - MAX of clicks per student for the 4 observations

1) 5 students made clicks from 10 to 30 with a gap between min (4) and MAX (8)

2) 4 students made clicks from 20 to 44 with a gap between min (11) and MAX (14)

3) 2 students made clicks from 26 to 81 with a gap between min and MAX greater than 20

4.3) Normality of the distribution of the coordinates of the observations

All the 8 coordinates did not all follow a normal distribution, (Shapiro-Wilk's tests: X1→p=0.005; X2→p=0.0002; X3→p=0.001; X4→p=0.002; Y1→p=0.0002; Y2→0.0004; Y3→p=0.072; Y4→p=0.149), but no significant difference was found for the X1, X2, X3, X4 coordinates and the Y1, Y2, Y3, Y4 coordinates in the four observations (Kruskal-Wallis's test: p=0.376 and p= 0.952 respectively).

4.4) Distribution of the coordinates of the clicks (annotations)

The total of the annotations was 1301 (304 + 309 + 335 + 353, for analysis 1, 2, 3 and 4, respectively): 40.2% were in the sector 1; 16.5% were in the sector 2; 32.3% were in the sector 3; 11.0% were in the sector 4.

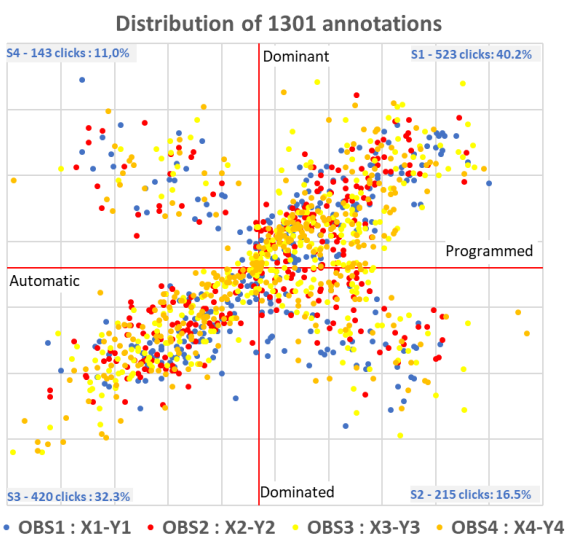


Fig. 5. Mapping of all the clicks (annotations)

4.5) Mapping of the clicks (annotations) per observation per sector

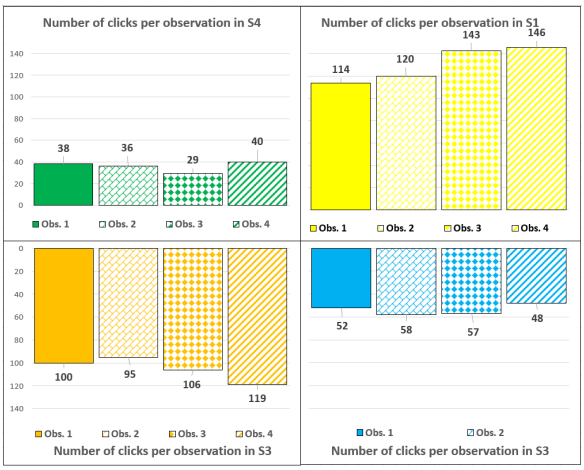


Fig. 6. Mapping of number of 1301 clicks (annotations) per observation per sector

How to read Fig. 6: during 1st Observation (Obs. 1), 114 clicks were collected in S1

4.6) Number of clicks in S1 and reversal of force ratio: In this combat, the observed judoka is dominant until the last minute of the combat before the golden score (i.e., 4min because the duration of a combat was 5min in 2013). By analyzing the students' data from 2min before the reversal to 40s after the reversal, it is possible to check whether they correctly determined the reversal (i.e., if the observed judoka is dominant-programmed, then the number of clicks in S1 will increase, whereas if the judoka is dominant-automatic, the number of clicks in S1 will remain unchanged or increase more slowly). The interval analyzed is from 00:02:11 to 00:04:39 (combat time).

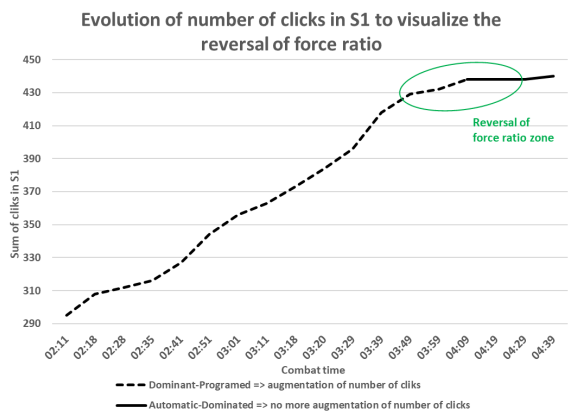


Fig. 7. Evolution of the number of clicks for all the students in S1 according to time

Reversal of force ratio for the students

Tab. 4. Time when the reversal of force ratio appears for the students

00:03:29	00:03:39	00:03:49	00:03:59	00:04:09
1	3	1	1	5

How to read Tab. 4: 5 students have determined the reversal of force ratio at 00:04:09

4.7) Students who found the axis S1⇔S3 (i.e.: § Protocol to collect data)
To determine if the S1⇔S3 axis was found comparing the other sectors, for each student, we counted whether the cells in S1 and S3 were strictly greater than those in S2 or S4.

Tab. 5. Determination if the S1⇔S3 axis was found

	Obs.1		Obs.2		Obs.3		Obs.4	
Stud.05	6	9	2	10	2	12	9	12
	4	5	6	5	5	5	6	3
Stud.09	6	9	5	6	3	5	7	10
	7	4	7	3	4	2	8	3

Legend
S4
S3

How to read Tab. 5: For Stud.05, in Obs.1 and Obs4, the S1⇔S3 axis did not associate the greatest values. For study.09, all axes S1⇔S3 associated the largest values.

Tab. 6. Percentage of students who have found the S1⇔S3 axis

S1⇔S3 axis		Sum and %
Nb Times	Nb students	
0/4	2	3 students below the mean: 27,3%
1/4	1	
2/4	1	8 students have the mean or above: 72,7%
3/4	4	
4/4	3	

How to read Tab. 6: 4 students have found 3 times out of 4 the axis S1⇔S3.

4.8) Distribution of X and Y coordinates of the clicks by bins
To compare coordinates X and Y we determined 11 bins using Yule's rule: (k=), with N=325.25 as average observation.

The measurement method, used by the same operators, with measurement conditions that have remained identical (the time interval between the analysis is negligible) seems reproductible or repeatable [Desquilbet 2015]. No significant difference was found for the distributions of clicks per bin in the four observations (Kruskal-Wallis's test: p=0.942 and p=0.968 respectively for X and Y coordinates.).

Tab. 3. Evolution of the sum of clicks for all students in S1 according to time

Combat times	02:11	02:18	02:28	02:35	02:41	02:51	03:01	03:11	03:18	03:20	03:29	03:39	03:49	03:59	04:09	04:19	04:29	04:39
Sum of all clicks	295	308	312	316	327	344	356	363	376	384	396	418	429	432	438	438	438	440

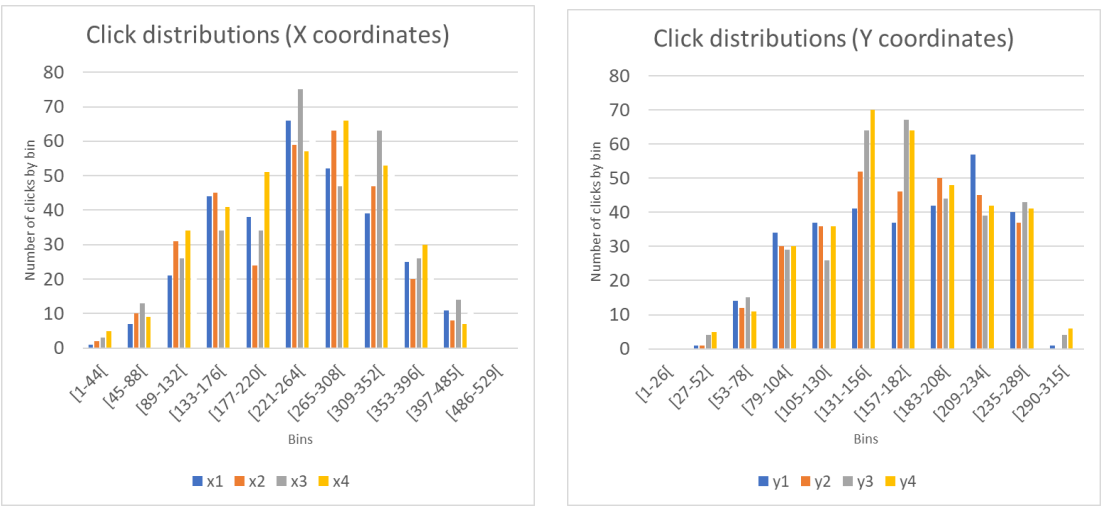


Fig. 8. Click distributions (X and Y coordinates)

How to read Fig. 8: Concerning the X coordinates bin [89-132] values are: 21; 31; 26; 34.

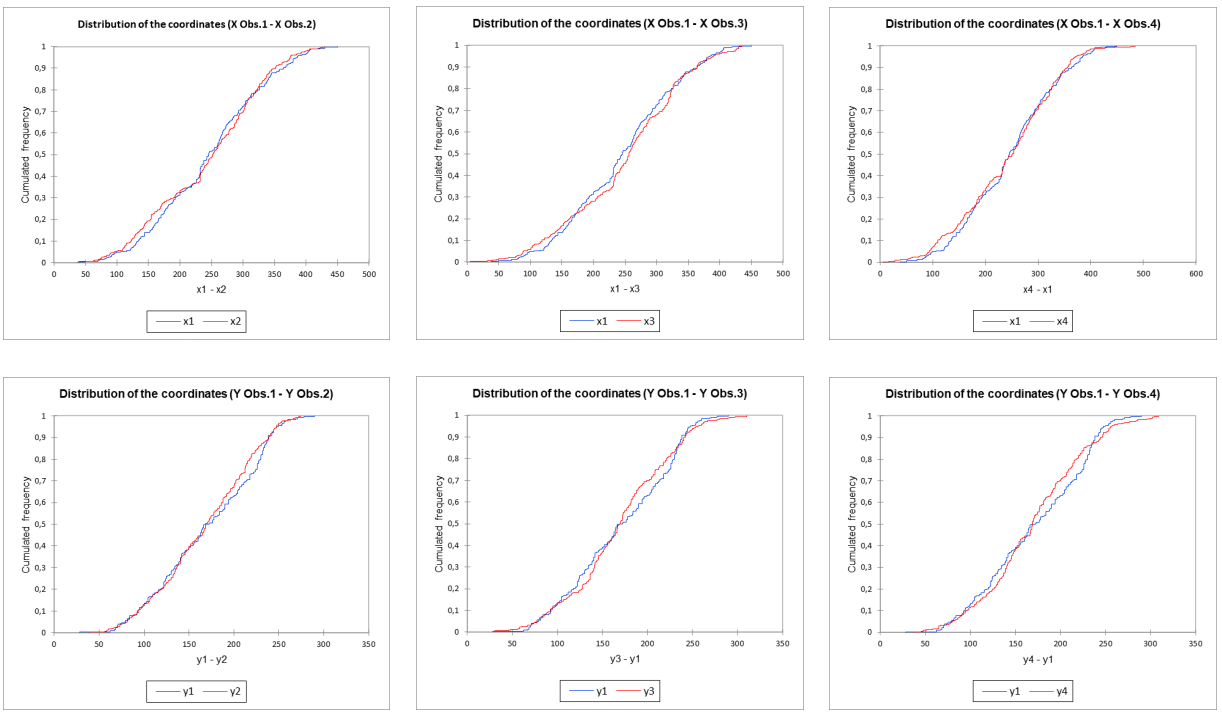


Fig. 9. Graph of the distributions two by two

4.9) Two-by-two comparisons of the distributions of the X-Y coordinates for each observation

Tab. 7. p-values of the distributions (bilateral Kolmogorov-Smirnov test)

Comparisons	p-value, X coordinates	p-value, Y coordinates
Obs.1 by Obs.2	0.407	0.101
Obs.1 by Obs.3	0.390	0.141
Obs.1 by Obs.4	0.372	0.103

Distribution with the cumulated frequency of the coordinates:

The coordinates did not all follow a normal distribution but followed the same distribution (i.e.: Fig. 9 and Tab. 7 below), the p-values of the bilateral Kolmogorov-Smirnov tests are in Tab. 7.

The overall analysis of the results shows that students appear to have repeated the same analysis 4 times.

4.10) Two by two comparisons of the distributions of the X-Y coordinates for each student

No student has a significant difference for both X and Y coordinates at the same time.

4.11) Comparisons with randomized data

With 1301 randomly drawn coordinates, we obtain with 11 intervals the graphs below. The differences are signif-

icant when comparing the coordinates by intervals two by two, i.e.: Tab. 9.

Tab. 8. Two-by-two comparisons for each student

	Significant differences comparing for each student all his X then Y coordinates (Kruskal-Wallis's test)		Significant differences bilateral two by two comparisons Kolmogorov-Smirnov test
Coordin. Students	X coordinates	Y coordinates	X
Stud.01	**0.017**	0.716	X1-X4
Stud.02	0.892	0.944	
Stud.03	0.264	0.996	
Stud.04	0.486	0.849	
Stud.05	0.051	0.704	
Stud.06	0.871	0.660	
Stud.07	**0,028**	0.431	X1-X2 ; X1-X3 ; X1-X4
Stud.08	0.209	0.658	
Stud.09	0.809	0.514	
Stud.10	0.862	0.889	
Stud.11	0.711	0.984	

How to read Tab. 7: There is a significant difference in the X coordinates for Stud.01. This difference is between the X-coordinates of observation 1 and those of observation 4.

There is a significant difference in the comparison of the distributions of collected and random coordinates (Kruskal-Wallis's test: p=0.699 and p=0.173 respectively for X and Y coordinates). The randomized values put in evidence that students made their 4 observations carefully and not by clicking randomly.

Discussions

The video lasted 00:08:39 and the average observation is 00:07:26 because of the ceremonial and the cumulative *mate-hajime* (stop the combat-start the combat) pauses.

Regarding the observation times, as in our previous study, each of the students made their observations with a similar duration (i.e.: Fig. 2).

Tab. 10. Comparisons of collected observations with randomized observations

X1 – X1 rand : p >0.0001	Y1 – Y1 rand : p >0.0001
X2 – X2 rand : p >0.0001	Y2 – Y2 rand : p >0.0001
X3 – X3 rand : p >0.0001	Y3 – Y3 rand : p >0.0001
X4 – X4 rand : p >0.0001	Y4 – Y4 rand : p >0.0001

The number of clicks obtained is above of what was expected: a combat lasting 5min 48s (5min + 48s golden score) with 2 clicks per min would yield 12 clicks and with 3 clicks per min it would yield 18 clicks. The results yielded 29.6 ± 4.9 clicks, but whatever the number of clicks (low or high) each student repeats her/his observations with the same number of clicks (i.e.: Fig. 4), this confirms our observations in our previous study.

Students have identified the reversal of force ratio:

1. the high concentration of clicks in the sector S1 with 40.2 % and in the sector S3 with 32.3% (i.e.: Fig. 5 and Fig. 6)
2. the change in the slope of the curve (reversal of the force ratio zone) in Fig.7
3. 8 students (i.e.: Tab. 6) were successful in finding the S1⇔S3 axis from 2 times (average) to 4 times (full success) on 4 trials

Although these students are judo specialists, understanding this type of observation and meaning of the 4 sectors seems an important goal for the analysis.

Concerning the repeatability and the homogeneity of the observations, no significant difference was found for the distributions of clicks per bin and all the X and Y coordinates follow the same distribution two by two (i.e.: Fig. 8, Fig. 9, and Tab. 7).

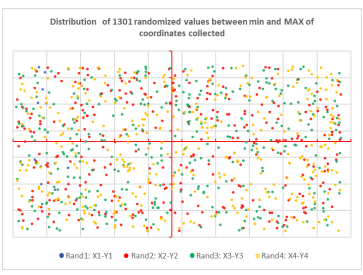
With the significant differences in the comparison of the distributions of collected and random coordinates (i.e.: Tab. 10), we can say that these results were not obtained by pure chance.

5. Conclusions and perspectives

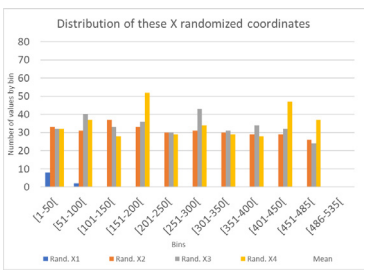
This application seems functional and easy to use. As in our previous studies on institutional surveys of course satisfaction, students said they liked this kind of work and had a better understanding of how professional software work.

Tab. 9. Randomized coordinates

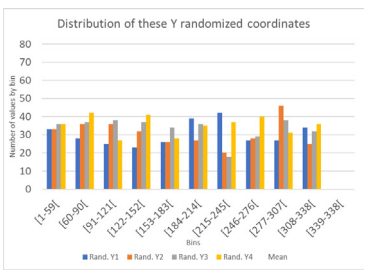
Distribution of 1301 randomized values



Randomized X coordinates



Randomized Y coordinates



— For students, the programmed / automatic axis was difficult to perceive at the beginning of the study, contrary to the dominant / dominated axis.
— The identification of the reversal of force ratio in the combat, the homogeneity and the repeatability of the analyses verify our hypotheses and confirm the previous study of 2019. It should be noted that 2 students did not pass this task at all (identify the reversal of force ratio), whereas in our previous study, 100% of the students correctly analyzed the force ratio. This confirms the importance of this training, especially for coaching, teaching, and refereeing.
— The transferability of these skills to real-life situations must be verified.
— In the paper, we have often used the term "clicks (annotations)". The click is the action that the students performed on the graph, and we have collected the coordinates of the click, but we can emphasize that this type of application could be used to analyze verbal exchanges between two people debating on any type of topic. The person in charge of the analysis will have to annotate their debates having defined the criteria beforehand.
— A future survey could consist in a better understanding of the organization of the groups of observations (few annotations and small differences between the number of annotations vs. more annotations and larger differences between the number of annotations, i.e. Fig. 4).

This training could be integrated into the learning methods. On the theoretical level, this training is based on the learning systems used in robotics and particularly the "PDDA" loop:
Perceive; Diagnose; Decide; Act
Perceive: follow and analyze the video
Diagnose: identify a critical situation in the video and establish a diagnosis
Decide: select an appropriate response
Act: put into action the adapted response
This training required the students to focus on the first two points (Perceive and Diagnose).
The last two points (Decide and Act) are those that will allow students to be operational in the court.

Acknowledgements

Thanks to students: Orens Breton, Lisa Cordesse, Fabrice Fenelon, Hugo Gros, Yoann Guillaume, Elodie Lachevre, Antoine Lory, Lea Refrege, Lucas Reiffer, Melina Tijeras, Dimitri Froideval, Elisa Feuerhuber.

References

1. Adam H.C. (2010), *Eadweard Muybridge: The Complete Locomotion Photographs*, Taschen, Koln.
2. Calmet M., Arelanno R., Lyons K. (2016), *Video analysis and MS-Excel*, https://www.researchgate.net/project/Video-analysis-and-MS-Excel (access: Aug. 2022).
3. Calmet M., Pouliquen I. (2022), *Little cascades of innovation to deep changes: contribution of digital and artificial intelligence to the active pedagogies*, "Journee de la pedagogie", Mar. 2022, Marseille, France ⟨hal-03618245⟩. https://hal.archives-ouvertes.fr/hal-03618245/file/contribution%20to%20the%20pedagogical%20workshop%2017-03-2022_v6_1_en.mp4
4. Calmet M., Gouriot M. (1987), *Didactique judo*, CDDP Beauvais, France [in French].
5. Calmet M., Sallantin J., Monino J.L., Lyons K. (2019), *Evaluation or Analysis of a Live or a Recorded Video Sequence: An Example from an Analysis of Sports Videos*, "Ido Movement for Culture. Journal of Martial Arts Anthropology", vol. 19, pp. 36–44; doi: 10.14589/ido.19.4.5.
6. Calmet M., Trezel N., Ahmaidi S. (2006), *Survey of the system of attacks of regional - interregional level's judoka*, "Perceptual and Motor Skills", vol. 103, pp. 835-840; doi: 10.2466/PMS.103.7.835-840.
7. Calmet M., Miarka B., Franchini E. (2010), *Modeling of grasps in judo competition contests*, "International Journal of Performance Analysis in Sports", vol. 10, pp. 229-240; doi: 10.1080/24748668.2010.11868518.
8. Castanerlas J.P., Planas A. (1997), *Estudio de la estructura temporal del combate de judo*, "Apunts: Educacion Fisica y Deportes", vol. 47, pp. 32-39 [in Spanish].
9. Chambily F. (2017), *Teddy est tres prudent*, "l'equipe.tv"; https://www.dailymotion.com/video/x5z6g51 (access: Jul. 2022) [in French].
10. Desquilbet L. (2015), Repetabilite, reproductibilite, et concordance de methodes de mesure, V9, https://docplayer.fr/51455779-Repetabilite-reproductibilite-et-concordance-de-methodes-de-mesure.html, (access: Aug. 2022) [in French].
11. EJU (2022), Referee online test, https://www.eju.net/activity/referee-online-test/ (access: December 2022).
12. Hartigan E., Col Eman K., Brooks J., Frisbee A., Lawrence M., Hawke K., Breslen G. (2019), *Self-assessment during Jump Shot Drills Translates to Decreased Vertical Ground Reaction Forces during Single Limb Drop Jump Landing*, "International journal of sports physical therapy", vol. 14, no. 3, pp. 403-414; ISSN 2159-2896; doi: 10.26603/ijspt20190403.
13. Franchini E., Artioli G.G., Brito C.J. (2013), *Judo combat: time-motion analysis and physiology*, "International Journal of Performance Analysis in Sport", vol. 13, pp. 624-641; doi: 10.1080/24748668.2013.11868676.
14. Frizot M. (2001), *Etienne-Jules Marey: Chronophotographe*, "Nathan", Paris [in French].
15. Hopkins W.G. (2015), *Spreadsheets for Analysis of Validity and Reliability*, "Sportscience", vol. 19, pp. 36-42; https://sportsci.org/2015/ValidRely.htm (access: Aug. 2022).
16. IJF (2016), *Referring rules of the international judo federation – Edition 2014-2016,* "IJF".

17. IJF (2022), *Sport and Organisation Rules – Version: 9 March 2022*, "IJF".
18. Knoblauch H., Schnettler B., Raab J., Soeffner H.G. (2006), *Video-analysis methodology and methods- Qualitative Audiovisual Data Analysis in Sociology*, "Peter Lang Offprint"; doi: 10.17877/DE290R-9443.
19. Mannoni L. (1997), *Georges Demeny, pionnier du cinema*, "Pagine", Douai [in French].
20. MEN ENSEIGNEMENT SUPERIEUR RECHERCHE ET TECHNOLOGIE (2002), *NOUVELLES TECHNOLOGIES, Certificat informatique et internet (C2i)* ®, "NOR: MENT0201078C, RLR : 434-5d, circulaire N°2002-106", [in French].
21. MEN ENSEIGNEMENT SUPERIEUR RECHERCHE ET TECHNOLOGIE (2010), *Généralisation du C2i® niveau 2 métiers de l'ingénieur*, "NOR: ESRT1001033C, RLR : 434-5d, circulaire n° 2010-0003 du 3-2-2010", [in French].
22. MEN (2017), PIX: Evaluez et developpez les competences numeriques des etudiants, (access: Jan. 2019), https://pix.fr/enseignement-superieur, [in French].
23. Miarka B., Hayashida C., Ferreira Julio F., Calmet M., Franchini E. (2013), *Judo combat: time-motion analysis and physiology*, "International Journal of Performance Analysis in Sports", vol. 11-2, pp. 255-267; doi: 10.1080/24748668.2013.11868676.
24. Miarka B., Julio U.F., Fabricio B. Del Vecchio, Calmet M., Franchini E. (2012), *Technique and tactic in Judo: A review*, "Revista de Artes Marciales Asiaticas", vol. 5, pp. 91-112; doi: 10.18002/rama.v5i1.139.
25. Potdevin F. (2007), *Les différents types de mouvement*, https://studylibfr.com/doc/2242207/les-diff%C3%A9rents-types-de-mouvements (access: Aug. 2022), [in French].

Wielokryterialna analiza stosunku sił pomiędzy dwoma judokami w opóźnionym czasie rzeczywistym

Słowa kluczowe: analiza ruchu, informatyka, opóźnione wideo, podejmowanie decyzji na żywo, interweniować/anotować, żywi aktorzy, analiza walk judo, stosunek sił, analiza wielokryterialna

Streszczenie

Wprowadzenie. Od 2016 roku na Uniwersytecie w Montpellier studenci III roku (specjalność judo) analizują walki judo w sposób wielokryterialny, aby zoptymalizować swoją pracę trenerską, sędziowską, dydaktyczną i dziennikarską. Problem. Jedno z ich zadań opierało się na analizie komputerowej opóźnionej walki w czasie rzeczywistym (bez pauzy, ani sygnału wizualnego czy dźwiękowego) w celu obserwacji jednego judoki. Zadanie polegało na oszacowaniu stosunku sił pomiędzy dwoma judokami i określeniu, jakie był obserwowany judoka. Studenci mieli kliknąć (skomentować/adnotować) w graf ortonormalny, znajdujący się obok filmu, złożony z 4 sektorów: (dominujący-programowany [S1]; programowany-dominujący [S2]; dominowany-automatyczny [S3]; automatyczny-dominujący [S4]). Im ważniejsze kryteria zostały uznane; tym więcej kliknięć (adnotacji) umieszczono na obrzeżach osi.

Cel. Potwierdzenie i poprawa wcześniejszych wyników dotyczących tematu: (i) analiza nagranej sekwencji wideo z wyłączeniem możliwości cofania się wideo (tak jakby były na żywo, obserwowane przez trenera lub sędziego), (ii) zidentyfikowanie odwrócenia stosunku sił, (iii) dokonanie powtarzalnych i jednorodnych obserwacji.

Metoda. Po 40 minutach treningu, 12 studentów analizowało 4 razy tę samą walkę prezentującą odwrócenie stosunku sił: obserwowany judoka był najpierw dominujący-programowany (oczekiwano wielu kliknięć w S1), następnie był zdominowany-automatyczny i przegrał walkę (oczekiwano wielu kliknięć w S3). Studenci mieli 20,4 ± 1,9 lat, od brązowego pasa do czarnego pasa 2. dan, trenowali judo 4h-12h tygodniowo, odbyli kursy specjalizacji judo (90h), ICT (18h) i analizy wideo (10h). Do analizy zebranych danych wykorzystano testy Shapiro-Wilka, Kruskala-Wallisa oraz Kołmogorowa-Smirnowa. Poziom istotności został ustalony na poziomie 5%.

Wyniki. 4 obserwacje były identyczne i jednorodne. Nie stwierdzono istotnych statystycznie różnic w : (i) czasach trwania dla 4 obserwacji (test Kruskala-Wallisa: p=0,919); (ii) liczbie kliknięć na obserwację (test Kruskala-Wallisa: p=0,715); (iii) rozkładach współrzędnych X i Y kliknięć na bin w czterech obserwacjach (test Kruskala-Wallisa: p=0,942 i p=0,968). Procentowy udział kliknięć na sektor w zależności od czasu: [S1]=40,2%; [S2]=16,5%; [S3]=32,3%; [S4]=11%) oraz ewolucja liczby kliknięć w S1 pokazują odwrócenie stosunku sił. Istnieje istotna różnica w porównaniu rozkładów współrzędnych zebranych i losowych (test Kruskala-Wallisa: p=0,699 i p=0,173 odpowiednio dla współrzędnych X i Y).

Wnioski. Wydaje się, że powyższe wyniki nie wynikają z przypadku. Identyfikacja odwrócenia stosunku sił w walce, jednorodność i powtarzalność analiz potwierdzają hipotezy i poprzednie badania autorów z 2019 roku. Należy zweryfikować możliwość przeniesienia tych umiejętności na sytuacje rzeczywiste.