

## KINESIOLOGY

MICHEL CALMET<sup>1-2(ABCDEF)</sup>, JEAN SALLANTIN<sup>3(A)</sup>, JEAN-LOUIS MONINO<sup>4(CD)</sup>,  
KEITH LYONS<sup>5(E)</sup>

<sup>1</sup> Université de Montpellier, Faculté des Sciences du Sport, 700 Av du Pic Saint Loup, 34090, Montpellier (France)  
Tél. +33 688 475 482, e-mail : michel.calmet@gmail.com

<sup>2</sup> Université Aix-Marseille, Faculté des Sciences, Master Qualite, Av. Escadrille Normandie-Liemen, Marseille (France)

<sup>3</sup> Université de Montpellier, LIRMM UMR 5506, CC477, 161 rue Ada, 34095 Montpellier Cedex 5 (France)  
e-mail: jean.sallantin@gmail.com

<sup>4</sup> Université de Montpellier, MRE 7491, Faculté d’Economie, Avenue Raymond Dugrand, CS79606, 34960 Montpellier Cedex 2 (France)  
e-mail: jean-louis.monino@umontpellier.fr

<sup>5</sup> University of Canberra, National Institute of Sports Studies, ACT 2601 (Australia)  
e-mail: clydestreet13@gmail.com

Corresponding author: Calmet Michel

UFRSTAPS, 700 Av. du Pic Saint Loup, 34090 MONTPELLIER, France  
+33 688 475 482, michel.calmet@gmail.com

# Evaluation or Analysis of a Live or a Recorded Video Sequence: An Example from an Analysis of Sports Videos

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**Key words:** live decision making, to intervene/to annotate, live actors, judo match analysis

### Abstract

**Background.** Since 2006, the Faculty of Sport Sciences of Montpellier students must build 4 specific applications with general and specific software, in order to train them in the use of sportive video analysis. These ICT skills are part of those defined by the Ministry of Higher Education, and the feature of these applications is the use of “delayed videos” analysis. Students’ learning journey is supported by online tutorials. To consider the ever-increasing efficiency of new technologies and go further in video analysis, we have added a step (a fifth application): the use of “live videos” analysis excluding the backtracking of video. The benefits of this type of work can help decision-making in everyday life and therefore concern the world of sport.

**Problem.** The purpose of this work was to observe students analyzing a recorded video sequence excluding video backtracking, as if it were live, as a coach. The feasibility conditions of such an experiment led us to study a judo combat by appreciating or estimating the interactions between different criteria as a coach.

**Method.** After training, Masters students (n=12), who specialized in video analysis and in judo performance, analyzed (they studied the same bout three times) the balance of power (subjective criterion) between two judokas. The process required the student observers to identify whether a judoka was “dominant, i.e.: in a favorable position to win” or “dominated” whilst managing his/her actions in “programmed/conscious” or “automatic, i.e.: reflex organization” modes. Nonparametric Kolmogorov Smirnov and Wilcoxon tests were used to analyze the data collected by the students.

**Conclusions.** These tests indicated that the analyses were identical and stable at the intra-observer ( $p=[0.095; 0.999]$ ,  $p=[0.219; 1.0]$ ) and group levels ( $p=0.224$ ;  $p=0.406$ ). We propose to include this methodology of analysis in Masters’ students training programs and develop these live analyses for coaches, teachers or referees.

### 1. Introduction

The first analyses of sports sequences date back to the end of the 19<sup>th</sup> century. Scientist pioneers were Muybrige, Demeny and Marey [Mannoni 1997; Frizot 2001; Adam 2010]. Their works allowed qualitative analyses (interpretation of the action) and quantitative analyses (distances, velocities, time and power). Research has been carried out on analyses of video sequences of people at work, in everyday life, and in the field of sports activities. The

person is filmed inside a context and the research focuses on the meaning of the person’s actions in this context [Knoblauch *et al.* 2006]. In sports activities, analysis of video sequences is important to train students, and support coaches and athletes. Many proprietary tools are available for use on a variety of computing platforms. Protected by copyright and purchased with a license agreement, these tools allow to analyze performance in three modalities: in delayed time; in real time with a delay; and in real time with no delay.

Since 2006, Masters students, in the Faculty of Sport Sciences of Montpellier, are trained to ICT, in accordance with the instructions of National Ministry of Education [MEN, 2002, 2010, 2017], and to sportive video analysis. To learn ICT and concepts, students must build four free applications (video analysis; multicriteria analysis; chart video-coupling; decision support system) that use objective criteria (first three applications) or subjective criteria (last one). Students' learning journey is supported by on line tutorials. By building their applications and analyzing videos, students acquire the competences defined in these ministerial instructions.

These four applications are adapted to students' level of computer knowledge. They fall under the generic type of video analysis software [Bloomfield, Polman, O'Donoghue 2004]. The feature of these applications is the use of "delayed videos" analysis, but investigations results concerning the "satisfaction of this course", showed students' great appreciation of these applications [Calmet 2016].

Working on debate analysis requiring to consider several criteria [Luzeaux, Sallantin, Dartnell 2008], considering the ever-increasing efficiency of new technologies and to go further in sportive video analysis, we have added a step within the fifth application: the use of "live videos" analysis with several criteria, excluding the backtracking of video.

## 2. Aim of the study

Starting the process of such an experiment appeared difficult, but it seemed possible to move from: "analyzing a debate" [Knoblauch *et al.* 2006] to "analyzing a combat". In these two situations (debate and combat) till the time out, each of the opponents try to dominate the other to show that his point of view is the best or to win the match. In these two situations, interactions are permanent and high-intensity phases follow less intensity phases.

This led us to study a judo combat by appreciating or estimating the interactions between different criteria as a coach does it, live in the field. It was about analyzing sportive strategies and tactics [Dufour 1989], not concerning the management of a sportive event [Liu *et al.* 2017] and not only collecting the displacements coordinates (x and y) according to the time [Adami, Couturier 1976].

Examples of important interactions in a judo combat:

- attack and defend at the same time
- act to create uncertainty in the opponent (suggest that we will attack in a direction, to attack in another direction)
- manage the uncertainties created by the opponent
- reflex counter attack (training allows to develop this type of skills) [Potdevin 2007]
- manage the score

Topics of research on the analysis of judo combats with "delayed videos" generally relate to technics or pen-

alties (frequency, genre, weight categories, biomechanics, winner and non-winners):

"The techniques used by judoists during the world and Olympic tournaments 1995-1999" [Sterkowicz, Franchini 2000], "A new classification proposal of Judo throwing techniques" [Almansba *et al.* 2015], "Techniques frequently used during London Olympic judo tournaments: A biomechanical approach" [Sterkowicz, Sacripanti, Sterkowicz-Przybycien 2013], "Three-dimensional assessment of the judo throwing techniques frequently used in competition", [Santos *et al.* 2014], "Validation of a video analysis software package for quantifying movement velocity in resistance exercises [Sanudo *et al.* 2016], "Home advantage in judo: analysis by the combat phase, penalties and the type of attack", [Brito *et al.* 2017], "Techniques utilized at 2017 Judo World Championship and their classification" [Martins *et al.* 2018]; "Suggestions for judo training with pacing strategy and decision making by judo championship phases" [Miarka *et al.* 2018], "Video analysis of judo situations to learn physics" [Michelini, Stefanel 2009].

There is little research on the analysis of judo combats with "live videos", their features relate to decision-making for coaches or athletes:

"Is visual search strategy different between level of judo coach when acquiring visual information from the preparation phase of judo contests?". In this paper, participants were instructed to provide verbal coaching instructions to improve a specified judoka's performance at set times during the footage [Robertson *et al.* 2017]. A similar survey with athletes was conducted about fencing, recording gaze direction with NAC eye mark recorder [Papin 1987].

The aim of this work was to observe students analyzing a recorded video of a judo combat, without backtracking [Knoblauch *et al.* 2006], as if it were live, as a coach.

This analysis consisted of appreciating or estimating the interactions of the two judokas according to two criteria: 1) "dominant, i.e.: in a favorable organization to win" vs "dominated" and 2) "programmed/conscious" vs "automatic, i.e.: reflex organization" [Potdevin 2007]. The appreciation or estimation of the interactions, specific to each user, is "subjective".

## 3. Methods

This work is not yet under study with statistical groups, it is a working track to conduct more precise research [Cariou 2019].

Twelve students (n=12), in their third year of study in the Faculty of Sport Sciences participated voluntarily in this research project. They were aged  $20.6 \pm 2.2$ , all judo specialists (brown belt to black belt (1<sup>st</sup> to 2<sup>nd</sup> Dan), practicing from 4h to 12h of judo per week), and having attended judo specialty courses and an ICT course

for three years at university. These 12 students worked previously with video analysis applications under MS-Excel to define the system of attacks of judokas [Calmet, Ahmaidi 2004; Calmet, Trezel, Ahmaidi 2006]. After training, they used the application to analyze the balance of power between two judo players. To analyze the same recorded video sequence, they had to click with the mouse to specify an observation or annotation when playing the video. This experience would allow:

- To learn how to manage a compromise between different criteria, as often in a professional situation.
- To draw a map of students' annotations (scatter plots of the clicked points) to display their decisions graphically and compare the homogeneity and repeatability of their analyses.
- To improve students' competences in two disciplines: video analysis (working with different criteria) and ICT (how professional software is working).

The frequency for annotations was based on the duration of a combat sequence (20 s) [Castaneras, Planas 1997; Franchini, Artioli, Brito 2013] and/or the duration assigned to the referee to give a non-combativity penalty (about 30 s) [IJF 2016]. For a 5min-long combat, the order of magnitude of the annotation number for a student was 10 annotations (2 per min) to 15 annotations (3 per min). The students were aware of these temporal phases (20 s to 30 s), and they had only the stopwatch of the combat clock (embedded in the video) as reference. The "dominant" vs "dominated" (y axis) was well understood by the students. The "programmed/conscious" vs "automatic" (x axis) gave rise to some exchanges about their own practice as judoka or referee. They better understood this x axis when: "automatic" could be related to rebalances, changes in support or reflex counter-attacks; and "programmed<sup>1</sup>/conscious" [Chambily 2017] could be connected to a voluntary attack trigger or positioning on the mat: near the combat limit, keep the opponent in a corner of the mat [Potdevin 2007].

A demonstration of the use of the application with a combat was made to the 12 students for 5min. Then students learned to use the application with this combat for 10min. This combat was 2min long, to allow students to have 4 trials [Hopkins 2015].

#### 4. Tools

MS-Excel allows the creation of applications adapted to the users' needs, and in that case, facilitates the sharing of concepts involved in video analysis. The fifth application was built permitting on the one hand, the analysis of a recorded video sequence excluding video backtracking and on another hand, the appreciation or estimation or the interactions between two criteria. When the user clicks, his action is recorded. Each student's click corresponds to an observation or annotation.

<sup>1</sup> As this concept is not used commonly in judo, video sequence showing it is rare. That is why we present a French video sequence, subtitled, to "see" the expression "attaques programmees" or programmed attacks.

The example shared below, shows the work of a student to assess the balance of power between two judo opponents. While observing the real-time video of a judo combat, student coded (clicked) in the "area to collect data" whenever and how he thought that the winner was acting in a "dominant" or "dominated" mode (y axis) whilst managing his/her actions in "programmed/conscious" or "automatic" mode (x axis) [Potdevin 2007]. The two axes delimited 4 sectors to collect observations or annotations.

Each click in the "area to collect data" was recorded, a dot appeared immediately in the chart, and the dot was erased in the "area to collect data" (Figure 1).

To test the functionalities of this fifth application became a sub-goal.

#### 4.1. Data collection and statistical analysis

Students worked for 20 min on the analysis of the same combat (a second round from the 2014 world championships between Iliadis and Rodriguez, in the 90kg weight category). This combat was chosen specifically because the initial time was 5min, the winner was often dominant, made few attacks, scored twice and scored the decisive point (ippon) just after 3min of combat.

Students had to view this judo combat 3 times and click in the area to collect data (Figure 1) containing the two axes to indicate how was acting the winner. Each student's annotation (i.e., each dot) was referred to the x and y coordinates.

Data were analyzed using the XLSTATS 19.03.45137 pack<sup>2</sup>. Nonparametric KolmogorovSmirnov and Wilcoxon tests were used to analyze data. A significance level was set at 5%.

### 5. Results

The application was useful and data collected allowed the analysis of performance.

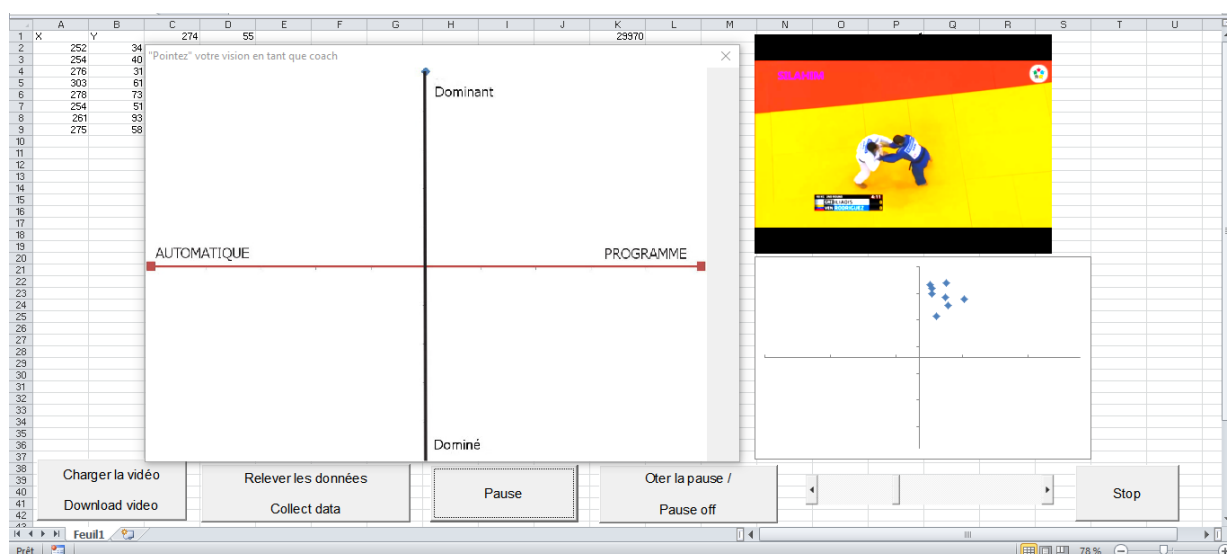
#### 5.1. Study of the number of annotations recorded during the analyses

The analysis of the 3 viewing of the combat indicate that the first analysis included for 5 students very different number of annotations (-12 to +4) between the first analysis and the other two. In addition, one student made 53 and 26 annotations for analyzes 2 and 3 respectively. Our results therefore relate to the 2<sup>nd</sup> and 3<sup>rd</sup> analysis of 11 students (Table 1).

Concerning analyses 2 and 3, the numbers of annotation for these 11 students followed:

- A normal distribution: Kolmogorov-Smirnov non-parametric test resulted in  $p=0.186$  and  $p=0.510$ , respectively.

<sup>2</sup> Addinsoft (2019). XLSTAT statistical and data analysis solution. Long Island, NY, USA. <https://www.xlstat.com>



**Figure 1.** Screenshot of the application to collect data (notational analysis) during the analysis of the combat. Video showing how the application works (hit escape to access the video)

**Table 1.** Number of annotations concerning analysis 2 and analysis 3 for 11 students

Students	NB annotations analysis 2	NB annotations analysis 3
Stud-01	10	9
Stud-02	9	9
Stud-03	15	17
Stud-04	18	18
Stud-05	15	19
Stud-06	9	8
Stud-07	10	13
Stud-08	18	13
Stud-09	8	8
Stud-10	9	10
Stud-11	8	8
Average	11.7	12
Stand. Dev.	4	4.1

— The same distribution: Sign test resulted in  $p=1$  and Wilcoxon nonparametric signed-rank test resulted in  $p=0.670$

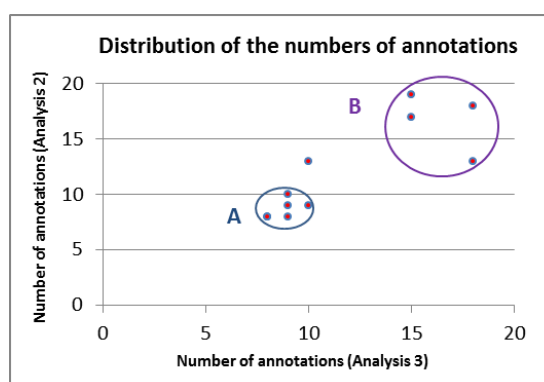
Two groups (Figure 2) appear with mean  $\pm$  SD (A:  $8.6 \pm 0.8$ ; B:  $15.6 \pm 2.9$ ). Furthermore, students did more annotations than expected: for a 3min-long combat, we could expect 6 to 9 annotations, and students' annotations (mean  $\pm$  SD) were  $11.7 \pm 4$  and  $12 \pm 4.3$ .

As the two numbers of annotation for analyses 2 and 3 were comparable, it was possible to study the distribution of the coordinates of these annotations.

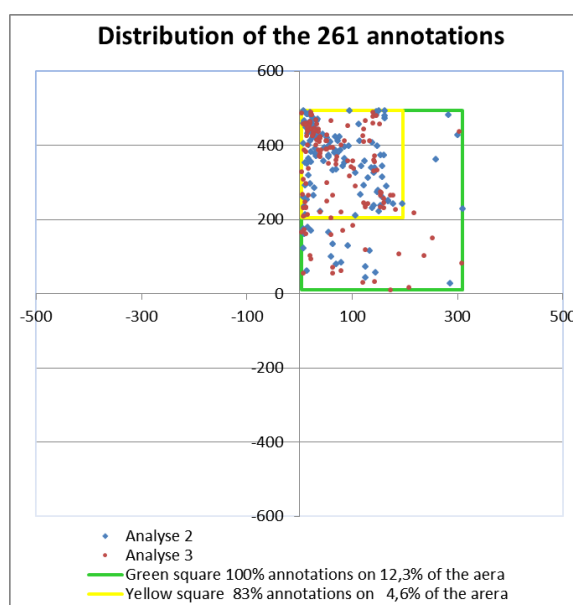
### 5.2. Survey of the distribution of the coordinates of the 261 annotations

The total of the annotations was 261 (129 + 132, for analysis 2 and 3, respectively):

— 100% of the coordinates of the annotations were in the same area (green) of coordinates ( $X_{min}=4$ ,  $Y_{min}=10$ ,



**Figure 2.** Distribution of the numbers of annotations



**Figure 3.** coordinates of the annotations (clicked points)

$X_{Max}=309$  and  $Y_{Max}=494$ , i.e. 12.3% of the total area to collect data.

— 83% of the coordinates of the annotations (108 for  $X_2-Y_2$  and 108 for  $X_3-Y_3$ ) were in the same area (yel-

low) of coordinates (Xmin=4, Ymin=205, XMax=196 and YMax=494), i.e. 4.6% of the total area to collect data (Figure 3).

Figure 3 shows a high concentration of clicks in the same area for analyses 2 and 3.

Students seem to have repeated the same analysis on their 2<sup>nd</sup> and 3<sup>rd</sup> tests.

### 5.3. Survey of the repeatability of the analyses

The measurement method, used by the same operators, with measurement conditions that have remained identical (the time interval between the 2<sup>nd</sup> and 3<sup>rd</sup> analysis is negligible) seems reproducible or repeatable [Desquilbet 2015]. X values and Y values concerning 11 students (i.e. where they clicked in the area to collect data cf. Figure 1) can be compared.

Using Kolmogorov-Smirnov nonparametric test, bilateral test, the samples X2, X3, Y2, Y3 do not follow a normal distribution, respectively:  $p=0.004$ ;  $p=0.002$ ;  $p=0.047$ ,  $p=0.018$ .

#### *Distribution as histograms of the coordinates of the 261 annotations*

A way to display students' annotations and repeatability, is to count how often values occur within a range of intervals. As X2, X3, Y2, Y3 do not follow a normal distribution, we used Yule's rule. It is a Sturges rules alternative [Sturges 1926] to calculate the number of intervals ( $k=$ ):  $k$  is the number of intervals and here, data is the average of annotations  $(129+132)/2=130.5$ . In that case  $k=8.44$  means 8 intervals.

In each interval, numbers of annotations are close. From trendlines,  $R^2$  for each coordinate samples X2, X3, Y2, Y3 are respectively:  $R^2=0.66$ ;  $R^2=0.67$ ;  $R^2=0.82$ ;  $R^2=0.66$

#### *Comparisons as curves of the coordinates of the 261 annotations*

First step, we can display as curves the X2-X3 and Y2-Y3 coordinates of the 261 annotations.

Fig 6 and Fig 7 represent the variations of the clicks for 11 students concerning the x-axis (fig 6) and the y-axis (Fig 7).

Second step let us analyze an example (student Stud-10) to after, better analyze all the data. If Stud-10's coordinates X2 and X3 are close (Figure 8), were they comparable? The low accuracy of the mouse and the absence of audio-time references allow us to better understand the differences between the values of the coordinates. The most important difference for clicks in Figure 8 is "Object1":  $79-40=39$ , or  $39/1000$  (1000 is the length of x axis), i.e. 3.9% of the X axis in Figure 1.

Stud-10's coordinates X2/X3 follow the same distribution (Figure 9), the Kolmogorov-Smirnov nonparametric test resulted in  $p=0.916$ , and Stud-10's

samples X2/X3 are comparable, the Wilcoxon nonparametric test resulted in  $p=0.953$ .

In Stud-10's example, only the X values have been processed, for all the comparisons, both for the group and for each student the X2/X3 coordinates and the Y2/Y3 coordinates will be analyzed in the same way as Figure 9.

#### *Distribution with cumulated frequency of the coordinates of the 261 annotations*

The X2/X3 samples and the Y2/Y3 samples follow the same distribution, the Kolmogorov-Smirnov nonparametric test resulted in  $p = 0.951$  (Figure 10) and  $p = 0.533$  (Figure 11), respectively.

Comparison of two samples. The X2/X3 samples and the Y2/Y3 samples of the 11 students are comparable, the Wilcoxon nonparametric test resulted in  $p=0.224$  and  $p=0.406$ , respectively.

#### *Survey of the distribution of the annotation coordinates for each student*

**Table 2.** Tests of distributions and comparisons of X2/X3 and Y2/Y3 coordinates for each student

Student	Comparison of distributions Kolmogorov-Smirnov nonparametric test		Comparison of samples: Wilcoxon nonparametric test		
	Distribution X2/X3 comparable	Distribution Y2/Y3 comparable	Sign test / Bilateral test X2/X3	Wilcoxon's signed test / Bilateral test X2/X3	Sign test / Bilateral test Y2/Y3
Stud-01	0.095	0.889	0.180	<b>0.024<sup>a</sup></b>	1.000
Stud-02	0.124	0.336	0.180	0.138	1.000
Stud-03	0.958	0.219	1.000	0.443	<b>0.007<sup>a</sup></b>
Stud-04	0.964	0.964	0.815	0.8275	0.815
Stud-05	0.914	0.865	0.791	0.975	0.607
Stud-06	0.999	0.899	0.727	0.529	0.727
Stud-07	0.597	0.627	0.344	0.476	0.754
Stud-08	0.866	0.780	0.267	0.402	0.267
Stud-09	0.627	1.000	0.289	0.183	0.727
Stud-10	0.916	0.587	0.727	0.834	0.508
Stud-11	0.627	1.000	0.727	0.624	0.727

Distributions of the coordinates are comparable.

Two students among 11 (18%), Stud-01<sup>a</sup> and Stud-03<sup>a</sup> had samples of different coordinates, X2/X3 and Y2/Y3, respectively.

## Conclusions

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 works.

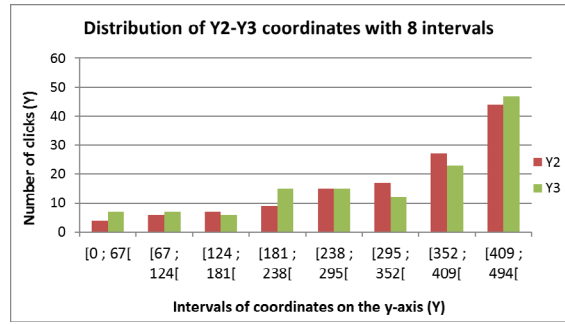
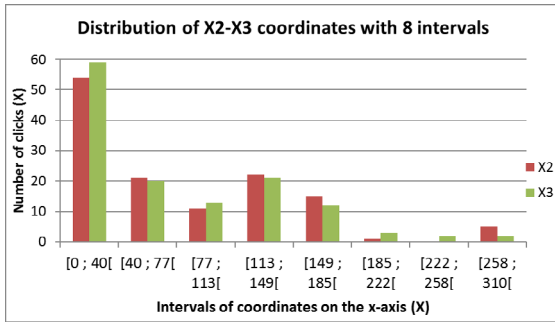


Figure 4. Distribution of X2 and X3 for 11 students with 8 intervals

Figure 5. Distributions of Y2 and Y3 for 11 students with 8 intervals

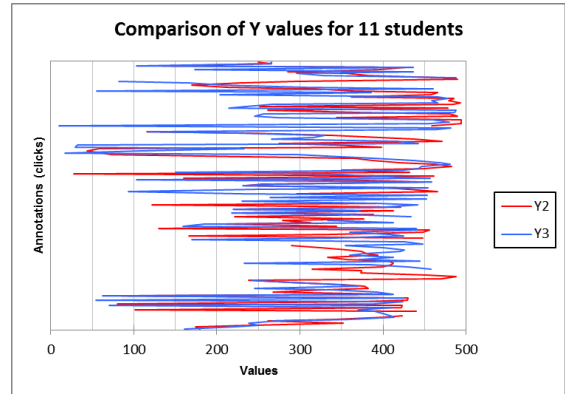
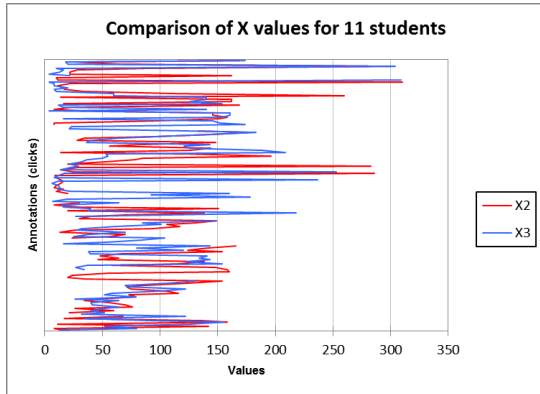


Figure 6. Coordinates of X2 and X3 as curves for 11 students

Figure 7. Coordinates of Y2 and Y3 as curves for 11 students

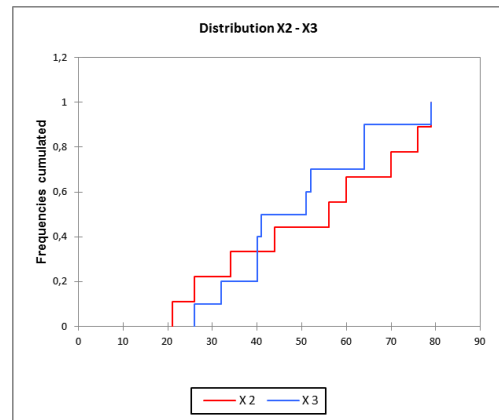
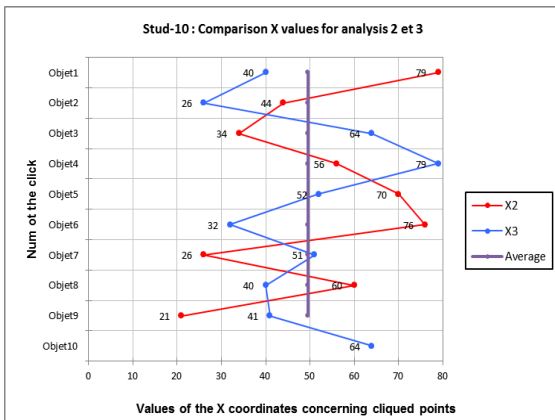


Figure 8. Coordinates of X2 and X3 and average for student Stud-10

Figure 9. Distribution of X2 and X3 for student Stud-10

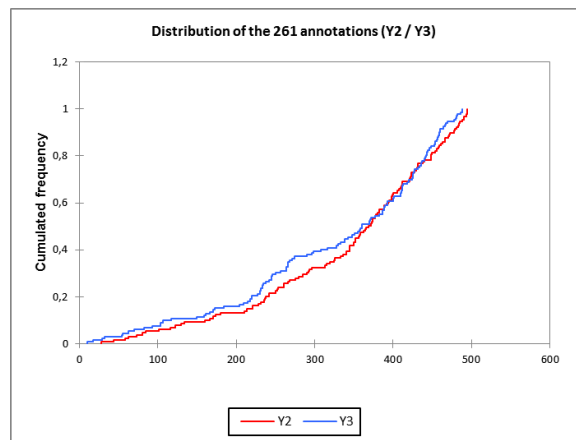
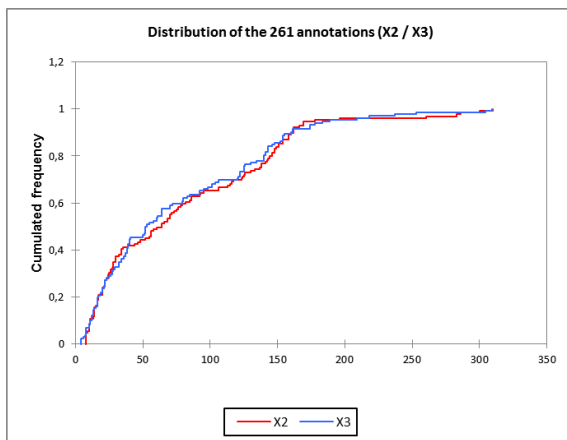


Figure 10. Distribution of X2/X3 coordinates for 11 students

Figure 11. Distribution of Y2/Y3 coordinates for 11 students

In MS-Excel, a user form is necessary to collect the data and VBA commands are of the same level as in the four applications. We can consider a new tutorial to help students to build this fifth application.

For students, the PROGRAMMED/CONSCIOUS vs AUTOMATIC axis was difficult to perceive at the beginning of the study, contrary to the DOMINANT vs DOMINATED axis. Eventually, they did understand the work to be done even if the first analysis should have been considered to learn the application. We will increase learning time in our upcoming courses.

The repeatability concerning students' analysis is strong, although they worked without visual/audio/time reference. For the 11 students, the X2/X3 and Y2/Y3 coordinates distributions were comparable and the X2/X3 and Y2/Y3 samples were comparable. We can underline the quality of homogeneity of their results without audio signal or metronome to click quite in the same way. There was no significant difference between the numbers of annotations (Table 1), but we can differentiate 2 groups who clicked (A less and B more) but in the same way and with the same number of annotations for each group during the 2 analyses (Table 1 and Figure 2).

The analysis (Table 2) shows for 82% of students:

- The X2/X3 coordinates distributions and Y2/Y3 coordinates distributions were comparable.
- The X2/X3 samples and the Y2/Y3 samples of these students were comparable.

Students have had homogeneous analysis level, as shown by the similarity of analyses 2 and 3 concerning the same combat (Figure 3, Figure 4, Figure 5, Figure 10, Figure 11).

Green square in Figure 3 is a kind of static map, the locations of the coordinates Figure 6 and Figure 7, are a kind of dynamic map, the shifts of the 11 mice to click.

The chosen combat was a good example for a first step.

Students well considered that the winner was acting as Programmed-Dominant:

- As dominant he imposed his actions
- As programmed he imposed his intentions of actions.

However, the high concentration (geographically) of the coordinates shows that students understood the work to be done and differentiated the two axes of analysis (Programmed/Conscious vs Automatic and Dominant vs Dominated). Their great interest and concentration (intellectually) during this work could come from: their knowledge/skills, the application and an innovative analysis with the 2 proposed axes. This example of innovative work leads them to examine both their knowledge in judo and their use (and built) of different tools.

Our future work in this area will:

- Continue this way of analysis with combat involving one or more status reversals (“judoka 1” dominating for 1/3 of the time, then “judoka 1” dominated for 1/3 of time, then “judoka 1” winner by decisive point in the last part of the combat).

- Organize an analysis with two students (one student analyzing a judoka and the second student analyzing the second judoka) to study how the two analyses are complementary.
- Introduce a hidden time frame to the users to locate their annotations from a qualitative point of view. This time frame could contain annotations from experts.
- Simplify the MS-Excel application to make students more autonomous in their constructions and advanced uses of office tools.
- To verify the contribution of this type of tools in the formation for the “live actors”.

The use of “live videos” to analyze behaviors or train users of system of video analysis seems in development, data mining and artificial intelligence are giving us new possibilities to explore. “Visual Video Analytics for Interactive Video Content Analysis” could be an example of reflection [Schoning and Heideman, 2018], in this experiment, the user (the analyst), helps the computer in close cooperation to translate the pixels of videos to meaningful content.

## Disclosure statement

The authors declare that there is no conflict of interest.

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### **Ocena lub analiza sekwencji obrazu na żywo lub nagranych: Przykład analizy filmów dotyczących sportu**

**Słowa kluczowe:** podejmowanie decyzji na żywo, interweniowanie/anotowanie, gracze na żywo, analiza dopasowania judo

#### **Streszczenie**

Tłó. Od 2006 roku, studenci Wydziału Nauk o Sporcie Uniwersytetu w Montpellier muszą stworzyć 4 konkretne aplikacje z oprogramowaniem ogólnym i specjalistycznym, w celu

przeszkolenia się w wykorzystaniu sportowej analizy wideo. Umiejętności teleinformatyczne są częścią umiejętności zdefiniowanych przez Ministerstwo Szkolnictwa Wyższego, a cechą tych aplikacji jest wykorzystanie analizy „filmów wideo z opóźnieniem”. Studencka ścieżka naukowa wspierana jest przez materiały szkoleniowe online. Aby uwzględnić stale rosnącą efektywność nowych technologii i pójść dalej w analizie wideo, autorzy dodali jeden krok (piąta aplikacja): wykorzystanie analizy „wideo na żywo” z wyłączeniem cofania wideo. Korzyści płynące z tego typu pracy mogą pomóc w podejmowaniu decyzji w życiu codziennym, a tym samym dotyczą świata sportu.

Problem. Celem tej pracy było obserwowanie studentów w roli trenerów analizujących nagraną sekwencję wideo, z wyłączeniem cofania wideo, jakby walka odbywała się na żywo. Warunki realności takiego eksperymentu skłoniły autorów do przeanalizowania walki judo poprzez ocenę interakcji według różnych kryteriów będąc w roli trenera. Metoda. Po szkoleniu, studenci studiów magisterskich (n=12), którzy specjalizowali się w analizie wideo i wydatności judo, analizowali (studiowali tę samą walkę trzy razy) równowagę sił (kryterium subiektywne) pomiędzy dwoma judokami. Proces wymagał od studentów-obszerników określenia, czy zawodnik judo był „dominujący, tzn.: w korzystnej pozycji, aby wygrać” czy „zdominowany” podczas zarządzania swoimi działaniami w trybach „zaprogramowanym/świadomym” lub „automatycznym, tzn. organizacji refleksyjnej”.

Do analizy danych zebranych przez studentów wykorzystano nieparametryczne testy Kolmogorova Smirnova i Wilcoxon.