Evaluation or Analysis of a Live or a Recorded Video Sequence: An Example in the Analysis of Sports Videos

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Abstract

Background. Since 2006, at the Faculty of Sport Sciences of Montpellier, to train students in the use of sportive video analysis with general and specific software, students must build 4 specific applications. 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. Their learning journey is supported by on line 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 they 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 the video analysis and in judo performance, analyzed (they studied three times the same combat) 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 organization 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 analyze in Masters' students training programs and develop these live analyses for coachs, teachers or referees.

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

1 Introduction

The first analyses of sports sequences date back to the end of the 19th century. Scientist pioneers were Muybrige, Demeny and Marey, [Mannoni 1997; Frizot 2001; Adam 2010]. Their works allowed qualitative analyzes (interpretation of the action) and quantitative analyses (distances, velocities, time, 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 are purchased with a license agreement, these tools allow 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 ministerial National of Education [MEN, 2002, 2010, 2017], and to sportive video analysis. To learn ICT and concepts, students 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). Their 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 appreciations with these applications [Calmet, 2016].

Working on debate analysis requiring to consider several criteria [Luzeaux, Sallantin and Dartnell, 2008], considering the ever-increasing efficiency of new technologies and to go further in sportive video analysis, we have added a step within a 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 will 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, in 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 penalties (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 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 they 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 ± 2.2 years, all judo specialists (brown belt to black belt (1st to 2nd 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 must click with the mouse to specify an observation or annotation when playing the video. This experience would allow:

- To learn how 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 are working professional softwares).

The frequency for annotations was based on the duration of a combat sequence (20 s) [Castanerlas, 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 practices 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[1]/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. A fifth application was built permitting on one hand, the analyze 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.

The example shared below, show 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.

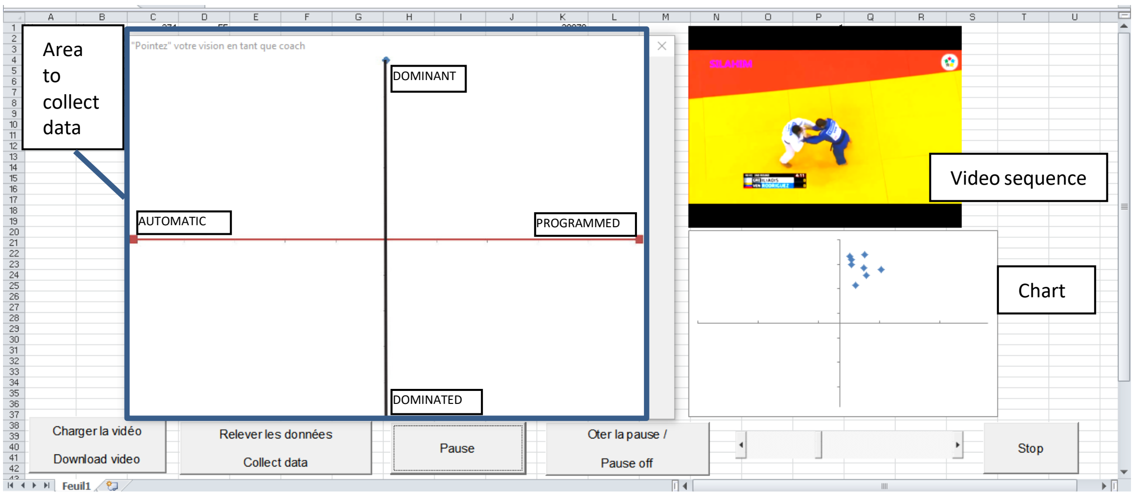

Figure 1. Screenshot of the application to collect data (notational analysis) during the analysis of the combat. Video showing how the application works (hit escape to access the video)

[1] As this concept is not used commonly in judo, video sequence showing it are rare. It is why we present a French video sequence, subtitled, to "see" the expression “attaques programmées” or programmed attacks.

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[2]. Nonparametric Kolmogorov-Smirnov 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 2nd and 3rd analysis of 11 students (Table 1).

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

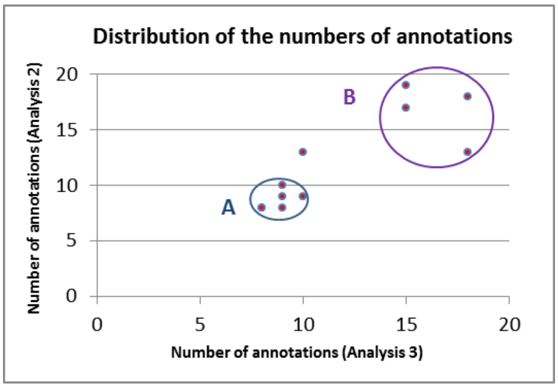

Figure 2.: distribution of the numbers of annotations

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

- A normal distribution: Kolmogorov-Smirnov nonparametric test resulted in p=0.186 and p=0.510, respectively.
- The same distribution: Sign test resulted in p=1 and Wilcoxon nonparametric signed-rank test resulted in p=0.670

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

Two groups (Figure 2) appear with mean ± SD (A: 8.6 ± 0.8: B: 15.6 ± 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 ± SD) were 11.7 ± 4 and 12 ± 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 (Xmin=4, Ymin=10, XMax=309 and YMax=494), i.e. 12.3% of the total area to collect data.
- 83% of the coordinates of the annotations (108 for X2-Y2 and 108 for X3-Y3) were in the same area (yellow) of coordinates (Xmin=4, Ymin=205, XMax=196 and YMax=494), i.e. 4.6% of the total area to collect data (Figure 3).

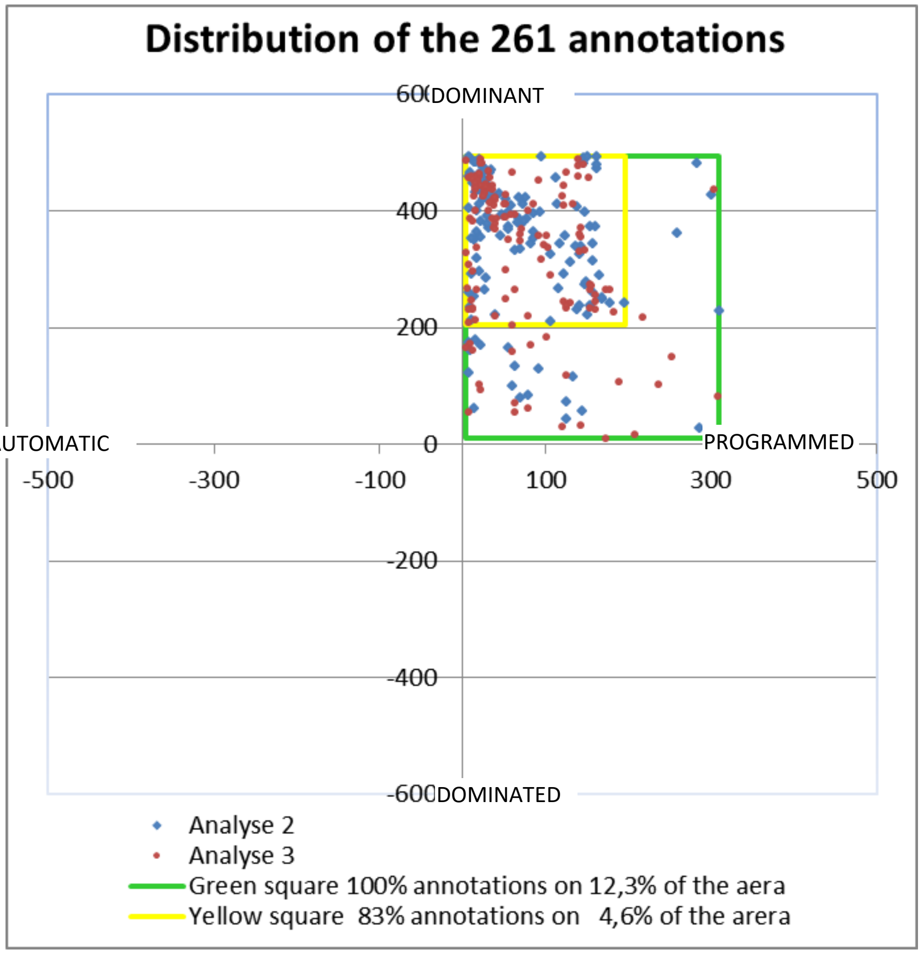

Figure 3. coordinates of the annotations (clicked points)

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^{nd} and 3^{rd} 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^{nd} and 3^{rd} analysis is negligible) seems reproductible 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 ($k=2.5 \times \sqrt[4]{data}$): 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.

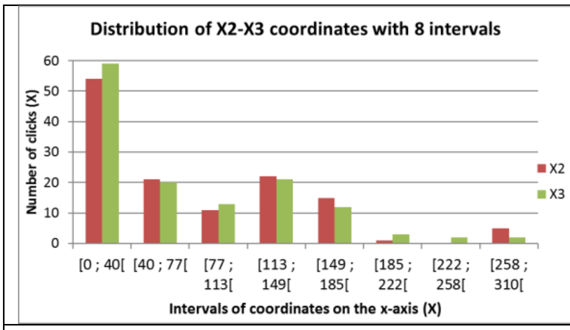

Figure 4. distribution of X2 and X3 for 11 students with 8 intervals

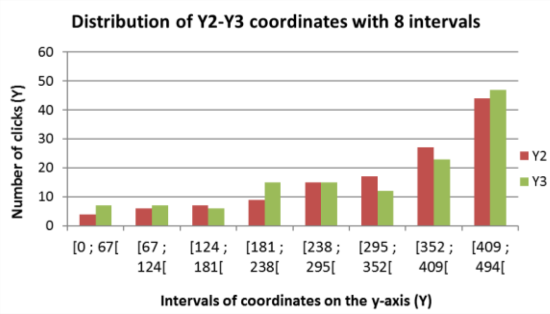

Figure 5. distributions of Y2 and Y3 for 11 students with 8 intervals

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.

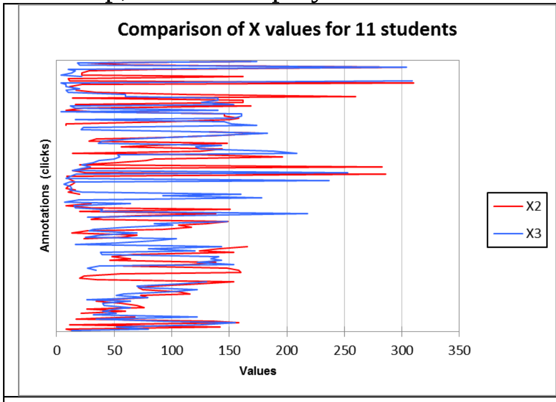

Figure 6. coordinates of X2 and X3 as curves for 11 students

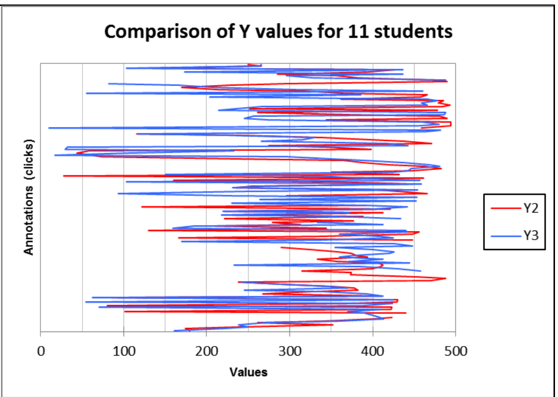

Figure 7. coordinates of Y2 and Y3 as curves for 11 students

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?

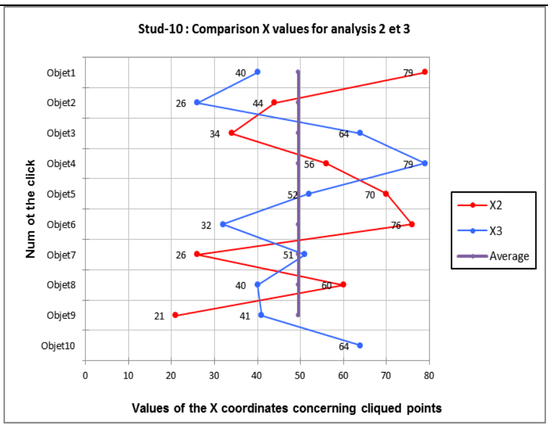

Figure 8. coordinates of X2 and X3 and average for student Stud-10

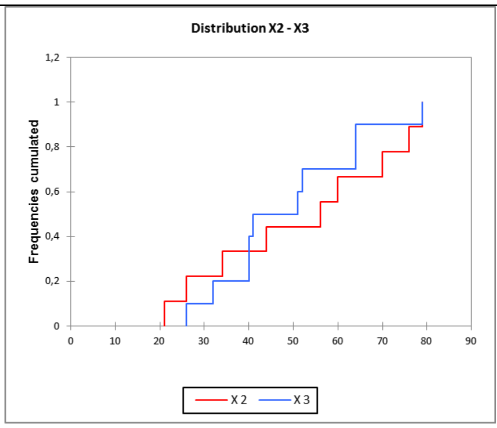

Figure 9. distribution of X2 and X3 for student Stud-10

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 "Objet1": 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.

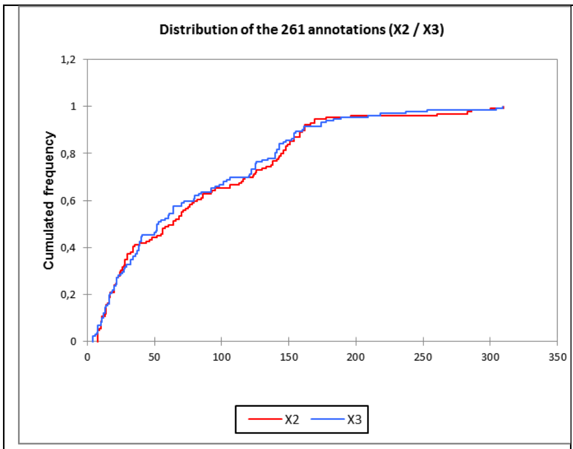

Figure 10. distribution of X2/X3 coordinates for 11 students

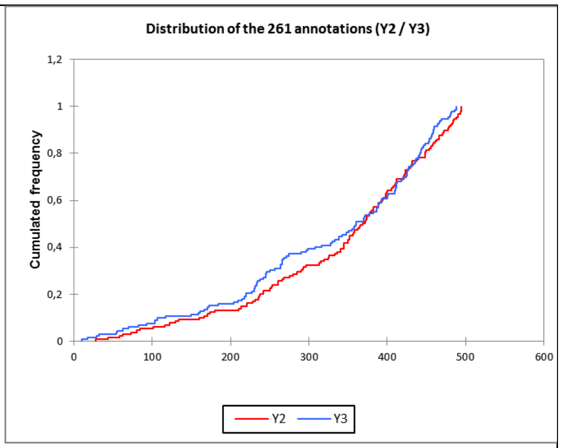

Figure 11. distribution of Y2/Y3 coordinates for 11 students

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

	Comparison of distributions Kolmogorov-Smirnov nonparametric test		Comparison of samples: Wilcoxon nonparametric test			
Student	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	Wilcoxon's signed test / Bilateral test Y2/Y3
Stud-01	0.095	0.889	0.180	**0.024**[a]	1.000	0.553
Stud-02	0.124	0.336	0.180	0.138	1.000	0.477
Stud-03	0.958	0.219	1.000	0.443	**0.007**[a]	**0.029**[a]
Stud-04	0.964	0.964	0.815	0.8275	0.815	0.8276
Stud-05	0.914	0.865	0.791	0.975	0.607	0.514
Stud-06	0.999	0.899	0.727	0.529	0.727	0.889
Stud-07	0.597	0.627	0.344	0.476	0.754	0.683
Stud-08	0.866	0.780	0.267	0.402	0.267	0.108
Stud-09	0.627	1.000	0.289	0.183	0.727	1.000
Stud-10	0.916	0.587	0.727	0.834	0.508	0.636
Stud-11	0.627	1.000	0.727	0.624	0.727	1.000

Distributions of the coordinates are comparable.
Two students among 11 (18%), Stud-01[a] and Stud-03[a] 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.

In MS-Excel, a userform is necessary to collect the data and VBA commands are of the same level than 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 analyzes 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 knowledges/skills, the application and an innovative analysis with the 2 proposed axes. This example of innovative work leads them to interrogate both their knowledge in judo and their use (and build) 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 analyze with two students (one student analyzing a judoka and the second student analyzing the second judoka) to study how the two analyzes 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 [Schöning 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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