

Recording, storing and querying judo match data using an Android tool and Cloud computing

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Abstract

Judo is a martial art that was created as a physical, intellectual and moral education method in Japan. In competition matches, Judo is a combat sport where two athletes fight against each other. Judo matches are ruled by different scores, penalties and durations, which change regarding the age and gender of the competitors. There is a need to record the actions in favour of or against a judoka during a match in order to create an efficient training programme as well as technical and tactical development strategies for each competitor. In this work, a technological solution is presented; it records each athlete's matches and scores, penalties, pauses during the match and its actual length of time. These aspects can help to create charts reflecting efforts made by the judoka. The research is focused on the support of the technical–tactical analysis of judo matches, taking into account recent information technology and communications trends: (1) the solution is developed for mobile devices which use the Android operating system, (2) the solution takes advantage of Cloud computing to allow ubiquitous access to the data and (3) the desktop component of the solution is portable to many computer systems because it has been developed using the Java programming language. The initial results show how the technological solution can be used for improving the performance of the athlete by providing feedback of the behaviour of the judoka during each match.

Keywords

Judo, technological software solution, Cloud computing, Android operating system, technical–tactical analysis, judo match data

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Introduction

Judo is a martial art that was created as a physical, intellectual and moral education method¹ in Japan. In competition matches, Judo is a combat sport where two athletes fight against each other. Judo matches are ruled by different scores, penalties and durations, which change regarding the age and gender of the competitors.¹ During the match, many actions may take place including first and second intention attacks, counter-attacks, combinations of throwing and on-ground techniques and so on. Therefore, the following are key elements for a judoka to possess: technical knowledge of the discipline, techniques and tactics and an optimal physical condition for enduring the exhaustion produced during every match.²

Judo is a strategical and tactical sport, so a contestant must think about the overall match plan before the fight starts. Unlike other sports, such as basketball, the coach cannot call a timeout to offer advice to the

judoka. The judoka has to have a match plan which may change during the fight according to the current points scored against or in favour of him or her. During the match, the coach can only influence the judoka's decisions by providing him or her commands or advice from a distance.¹

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In order to be a judo coach and in order to improve the performance of an elite athlete, it is necessary to have patience, empathy, communication skills and, above all, a deep knowledge of the sport and the ability to create an efficient training programme, as well as technical and tactical development strategies for each competitor.³ Due to the aforementioned reasons, there is a need to record the actions in favour of or against a judoka during a match. Generally, this information is written in a previously structured sheet, called the Match Control Sheet, for the future study of aspects such as the frequency of attacks (FA) performed by the judoka, the most efficient techniques of the athlete, the recorded period of time the judoka has his or her best performance, the effect of an opponent's right- or left-handedness, the ability of the athlete to win the match either within the established time or during the Golden Score period and whether the judoka wins the match or not.⁴

The Match Control Sheet is a highly valuable tool because the recorded actions give an idea of what the judoka needs to improve. Nevertheless, since there is no better method for studying the match than watching it and that the coach himself records the information, some small inconveniences often take place, for example, having to look away from the match in order to record something or having to write fast in order not to lose details from the match, which may cause illegible writing.

Over the years, sports have become an activity that have benefited from auxiliary sciences (biomechanics, physiology, nutrition, psychology, informatics, etc.) by increasing athletes' performances. This has helped to break records that previously seemed unbreakable and to develop highly complex motor actions. Judo is a sport whose rules are designed to contribute with 'fair play'. For the past 2 years, changes have been introduced into the sport that have forced judoka to improve their technical and tactical levels in order to achieve first place in world competitions. Technical levels have been favoured as Asians, Europeans and the rest of the world have had to adapt to these changes. The emergence of mobile phones and smartphones, which are widely designed with Android operating systems, has assisted the birth of an increasing number of applications in all areas, including sports.

In this work, a technological solution, which includes an application for mobile devices running Android operating systems, is presented. This application records each athlete's matches and scores, penalties, pauses during the match and its actual length of time. These data, which are automatically stored by synchronisation in a Cloud system, are used to generate charts using the tool for reflecting efforts made by the judoka. The solution solves many of the described inconveniences and allows the user (usually the coach) to register important details, make a meticulous evaluation of each competitor in a later analysis and study charts that will be used to make the necessary modifications during

the competition or for future competitions. This solution is a powerful tool that will define the analysis of every action that took place during the match, as well as the competitor's profile during one or many competitions, which will have a positive impact on the organisation and planning of the training.

Applied sports technology has enormously helped Judo training. Physical ability is measured and assessed by a variety of sophisticated equipment⁵ such as heart rate monitors; dynamometers for measuring the isometric strength of the hands, back or legs; jump platforms for measuring the strength of the legs; and so on. The Android application, designed to be used with a mobile device such as a tablet with a rear camera, can ease the job of the coach, allow the athlete to have a better understanding of himself (the attack and defence system) and his opponents (strengths, weaknesses, preferred techniques, combinations and feints) and guide the training in order to improve the athlete's physical performance (technique and tactics).

Being able to understand each action (offensive and defensive) that takes place during a fight and to look at a detailed analysis of those actions will allow the coach to correct the grappling as well as to efficiently understand offensive techniques, FA and their results, the part of the fight the victory or the loss is produced (and if this could be an effect of the athlete's activation level) and the physical condition or the right-handed/left-handed nature of the adversary. In addition, it will allow the coach to identify those techniques that when applied by the adversary will result in a score in favour of the adversary or which may produce a counter-attack that will result in a score against him.

The recording, storage and subsequent analysis of these data help to convince the athlete of the need to redesign his strategies or strengthen his performance. In order to do so, specific tasks aiming to achieve the desired objective may be set for the training. These elements replace and improve the process of collecting data with a sheet: a process that often required one to look away from the fight in order to take notes of an action, and whose notes may be difficult to read because they had to be taken quickly so as not to miss any details of the fight.

This is a solution that will help the user to record each action, to obtain the subsequent analysis of those actions and to substantially improve the athlete's performance.

In order to reach the proposed objectives, this article has been structured as follows. The literature review revealed that similar tools have been developed, so in section 'Related software tools', those tools are compared to the solution presented in this article. Section 'Judo rules and scoring' describes judo rules and scoring, and in section 'Method', the research method including the proposed technological solution for the technical-tactical analysis of judo matches is detailed. Some experiments were performed in order to validate the technological solution, so the experimental set-up,

generation of the statistical information and analysis of the results are presented in section ‘Experiment’. Finally, section ‘Conclusion’ provides the final remarks of the article including the future works.

Related software tools

In recent years, there has been exponential growth in the number of judo research papers; however, the scientific productivity in this area is still low.⁶ According to a study carried out by Peset Mancebo et al.,⁶ most of these articles are related to sport science and sport medicine. Although it is well known that the use of technology and computer science can improve the athlete’s performance,⁷ the development of computer tools for supporting judo is in an early stage. Many of the software have been developed for judo tournament management, such as JudoShiai and Judo Tournament Manager.⁸ On the other hand, although judo match analyses have been performed in the last four decades, few automated tracking systems capable of collecting, analysing and quantifying judoka’s behaviour during a match exist. For example, Kulasa and Kalina⁹ propose a general method for registering, processing and analysing data from a judo fight using computer technology. Although the authors present the need for technology for judo match data analysis, they do not show how the method could be implemented using a tool.

In another paper, a tool called FRAMI software¹⁰ is presented, which is used for the technical–tactical analysis of judo matches recorded previously. The tool considers the following variables: match time frame, attack techniques, defence methods, scores and penalties, gripping types, walking patterns and methods of use for the match area. The software was developed using the Delphi programming language and runs on devices which use Windows and Linux operating systems. Calmet et al.¹¹ developed a tool that works on an Excel spreadsheet using the Visual Basic for Applications (VBA) programming language to analyse the judoka’s positions and behaviours during a match. In another related work, Marcon et al.¹² describe a computer programme to identify the judoka’s actions during a match. The programme estimates the time of several activities to be examined at a later time: break, preparation, grip, technique, and fall and groundwork.

Like related works, the research presented in this article is also focused on the support of the technical–tactical analysis of judo matches. However, a solution which takes into account recent information technology and communications trends is proposed:

- The solution is developed for mobile devices which use the Android operating system;
- The solution takes advantage of Cloud computing to allow ubiquitous access of the data;

- The desktop component of the solution is portable to many computer systems because it has been developed using the Java programming language.

Unlike other tools, the software allows real-time recording through voice, video and manual commands. In this version of the application, a more limited number of variables than the FRAMI solution have been considered, so the tool only takes into account the following: scores and penalties, attacks and match duration.

Judo rules and scoring

Judo is a combat sport which has rules and a scoring system that must be followed during a match. The two judokas fight in a match area – the area should be 10 m × 10 m and 4 m minimum for the safety area¹³ – for the maximum duration of the match, which is usually around 4 min for women, junior and cadet contestants and 5 min for senior men contestants.¹ Three referees conduct the match with the aid of the scoreboard keepers, timekeepers and contest sheet writers. Only one referee is in the match area; the others (the judges) are sitting at the table at the side of the mat. The referees communicate with each other via earphones. During the fight, the judokas must wear either a blue or white judogi (the traditional uniform for judo practice or competition); the judoka wearing the white uniform is to the right of the referee (see Figure 1).

During a fight, the judokas apply many techniques which are categorised as throwing techniques (‘Nage-waza’) and grappling techniques (‘Katame-waza’). A judoka may attempt the following actions against the other player: to throw him, to force a submission by either strangling him (‘Shime-waza’) or applying an armbar to him (‘Kansetsu-waza’), or to hold him on his back on the tatami (mat used in judo practice or competition) (‘Osaekomi-waza’) (see Figure 2). The referee should administer the decisions based on the



Figure 1. A judo match between two judokas wearing the official uniforms during the Youth Olympic Games, Olympic Games 2014, Nanjing, China. The referee is in the middle of the match area.

Source: IJF Media.¹⁴



Figure 2. A throwing technique or 'Nage-waza' (left) and a holding technique or 'Osaekomi-waza' (right).

Source: IJF Media.¹⁴

actions performed by the judokas and following the International Judo Federation Refereeing Rules¹ by awarding them the value of an action or a penalty.

Technical scores

The following are the technical scores which may be administered by the referees:¹

1. 'Ippon' is scored in the following situations: a judoka throws the other contestant on his back with real impetus and considerable speed and force, a judoka holds the other contestant on his back on the mat for 20 s and a judoka forces submission – the opponent must tap two or more times with his hand or foot – through a grappling technique.
2. 'Waza-ari' is scored in the following situations: a judoka throws the opponent, but the technique does not have one of the three elements required for the 'Ippon' (real impact, force and speed), or a judoka holds the other contestant on his back on the mat for 15 s or more but less than 20 s. After a contestant obtains a second 'Waza-ari' during the match, the referee will announce an 'Ippon' ('Waza-ari-awasete-Ippon').
3. 'Yuko' is scored in the following situations: a judoka throws the opponent, but the technique does not have two of the three elements required for the 'Ippon', or a judoka holds the opponent for 10 s or more but less than 15 s.

In addition, the referee will announce an Osaekomi when one of the contestants controls the opponent who must have at least one shoulder on the tatami.

Prohibited acts and penalties

The penalties are divided into slight violations ('Shido') and grave violations ('Hansoku-make'). A referee can

award a slight violation to a judoka who commits, for example, one of the following infringements: taking an excessively defensive posture, performing a false attack – when the judoka makes an action without intention of throwing the opponent – and untying the belt intentionally without authorisation of the referee (other infringements can be found in Article 25 – Prohibited Acts and Penalties of the Refereeing Rules of the International Judo Federation¹). A referee can award a grave violation to a contestant who commits, for instance, one of the following penalties: applying an armbar anyplace other than elbow joint, disobeying the referee's instructions and performing an action against the spirit of judo (other infringements can be found in Article 25 – Prohibited Acts and Penalties of the Refereeing Rules of the International Judo Federation¹). The referee will award a 'Hansoku-make' when the judoka obtains the fourth 'Shido'. After receiving a 'Hansoku-make', the contestant can continue in the competition, except in those cases of grave infringements for acts against the spirit of judo.

The penalties do not provide points to the other fighter; only technical scores add points to the contestants. Thus, the winner is decided based on the following conditions: the fighter who scores an 'Ippon' or equivalent; the fighter who has a 'Waza-ari'; if both contestants have one 'Waza-ari', the fighter who has scored more Yukos; and if the fighters have not scored, the fighter who has scored less 'Shidos'.

When none of the judokas has scored points or the scores are the same, the match is decided by the Golden Score match, which finishes as soon as a fighter is penalised or obtains a technical score.

Method

The proposed tool was designed based on the requirements provided by several judo coaches of the Venezuela judo team. A software development method called Agile¹⁵ was used. It is an incremental and

interactive method that reduces the time between software deliveries to the client, while increasing the interaction with the client and the customer collaboration in order to respond to change over the initial planning. During the development of the research, there was a lot of interaction with the coaches through interviews and observation, and scenarios and prototypes were used to help the coaches understand the proposed system.¹⁵ The software was validated against the defined requirements and tested in a Judo Club Tournament celebrated in the Dojo ‘Victor Urbina’ in Caracas, Venezuela. The project was developed following the stages shown in Figure 3. A list of tasks to be completed during the project is specified in the backlog. The software was developed and some deliverables (in the form of prototypes) were generated for the coaches, who provided the software developers with some feedback.

Software architecture

Figure 4 shows the software architecture of the solution, which includes a mobile application for recording

judo match information (judo fights videos, actions occurring during the match registered through voice command, scoring and penalties), an application for judo match data processing that runs on a desktop computer and that includes statistical information generation and data synchronisation, an external Cloud service for multimedia data storage and processing and a web server for data storage. All the solution components communicate with each other using an Internet connection.

The technological solution can be used to support athletes’ activities before, during and after a competition. The coaches can use previous multimedia judo match data and statistical information recorded by the tool to make some changes in the judoka’s training programme. The coach can utilise the tool during the match to record significant information which can be used to provide advice to the judoka for future matches in the same competition. After the tournament, the coach can analyse the recorded data in order to prepare or update the judoka’s fight strategy.

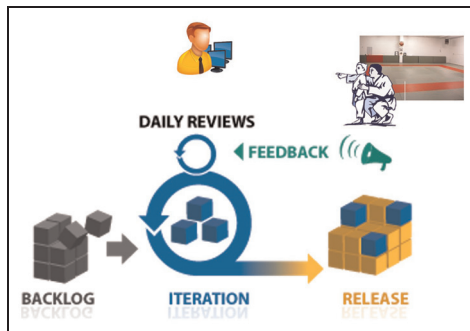


Figure 3. Project management process.

Mobile application for judo match data recording

The mobile application was created for the Android operating system and includes the following functionalities: match recording, display of the video recorded, data synchronisation, scoring, penalties and attacks registration (using voice and commands) and fighters and tournament information management. As mentioned above, the judo coach should be able to register the different events that are occurring in the fight while he or she is watching it. Therefore, a touchscreen application was developed that allows the user to record the different fight actions through the use of buttons while

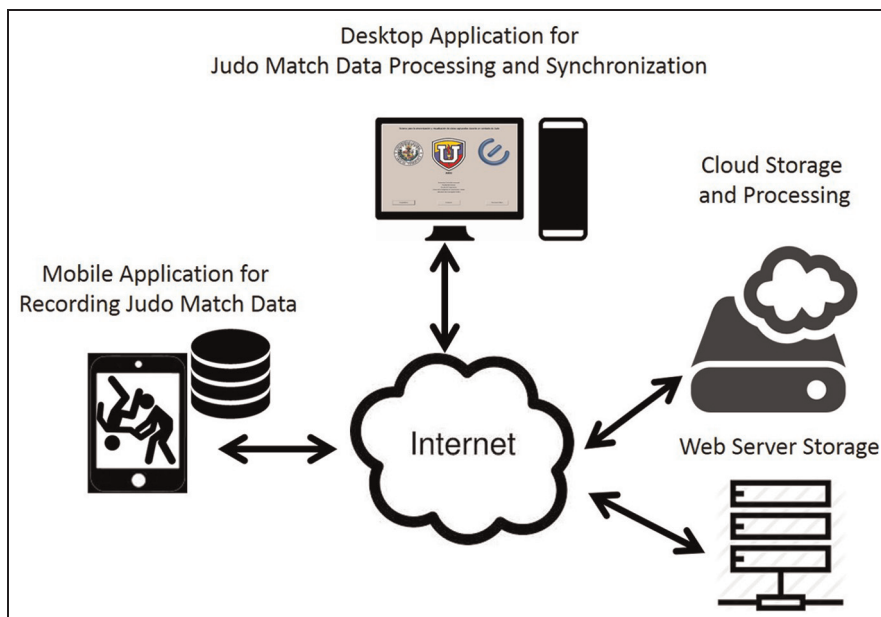


Figure 4. Proposed technological solution architecture.

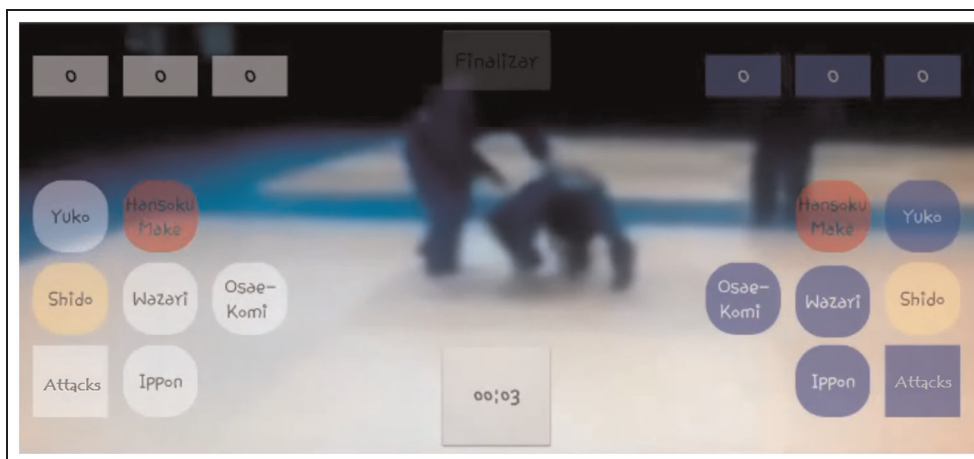


Figure 5. Judo match data recording application for an Android mobile device.

he or she is watching the match through the display of the mobile device. The actions are registered either using the different buttons designed based on the judo scoring or penalties system described in section ‘Judo rules and scoring’ or through voice recording. Additionally, the video is stored for later analysis.

Figure 5 shows the application interface and most of the buttons which are in accordance with the explanations given in section ‘Judo rules and scoring’. The coach can use the buttons ‘Ataque’ (right bottom corner and left bottom corner) to register a judo technique applied by the judoka either wearing the white judogi or the one wearing the blue judogi, and he or she can use the top middle button to end the registration of the current match. The scores and penalties for each judoka are displayed on the right and left top. The current duration of the match is shown on the middle bottom.

Desktop application

The desktop application was developed using the Java programming language and includes the following functionalities: displaying the recorded videos, registering judo players, inspecting or updating the recorded match actions, displaying statistical information and data synchronisation. The coach can utilise the application to add or to update the fighter information, to display fighters’ statistics, to display recorded match videos, to inspect match actions, to update judo match events, to display match statistics, to synchronise the data with the Cloud, to update tournaments and to inspect tournament statistics.

Cloud storage and processing

The videos generated during a judo match are stored in the Cloud (in this work Google Drive¹⁶ is utilised) using synchronisation. In order to upload and download the multimedia data to the Cloud, the following Google Drive application programming interfaces

(APIs) were used: Drive API for Android¹⁷ and Drive API Client Library for Java.¹⁸ In addition, the charts displayed by the desktop application are created using a Java API called charts4j,¹⁹ which facilitates the communication with the Google Chart API¹⁶ in order to generate nearly all the graphs available in Google Chart Tools.²⁰

Web server storage

For simplicity, the judo match data are stored in a public web server. A communication programme developed using the PHP programming language²¹ is used to transfer, store and process the data.

Synchronisation process

An important part of the solution is the Cloud data synchronisation, which allows the data to be backed up and accessible by the users (the coaches) ubiquitously. Data upload and download occur as shown in Figure 6. The judo match data registered by the Android application are synchronised with the data, either in the Cloud or in the web server, as follows: the videos are synchronised with the Cloud, and the other data are synchronised with the data in the Web storage server. The user of the desktop application can synchronise the data stored in both the Cloud and the Web storage server.

Using the technological solution for recording, storing and querying judo match data

To benefit from the technological solution, the following steps can be followed:

- During the match, the coach can use the mobile application to record the fight as well as the penalties and scores in favour of or against the judoka. If the coach has to assist the judoka during the fight, he or she may choose to delegate the task to either

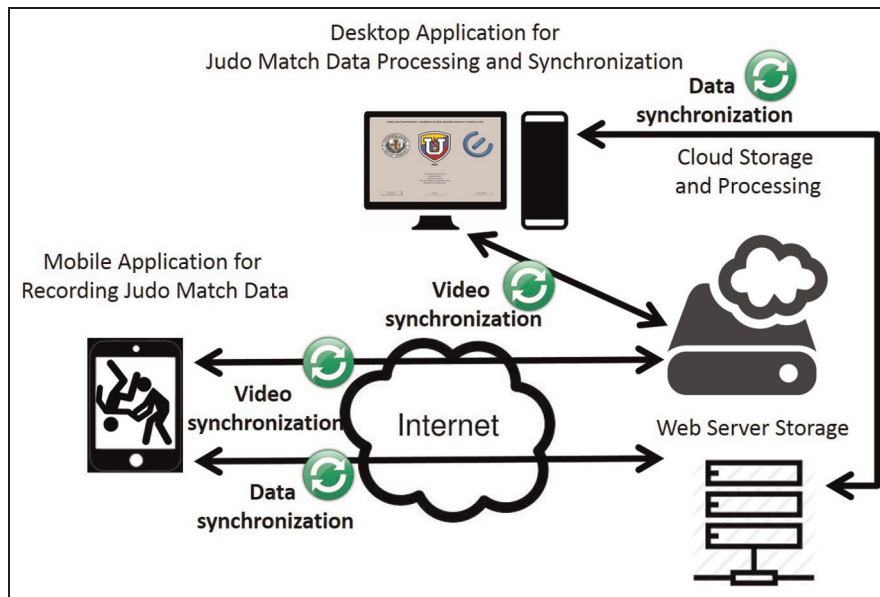


Figure 6. Judo match data synchronisation process.

his or her assistant or any member of the judo team with enough knowledge about the judo rules.

- If the mobile device is connected to the Internet, the user can synchronise match data as described in section ‘Synchronisation process’ using the synchronisation facility in the mobile application.
- The coach can use the desktop application after the Tournament is finished to perform technical–tactical analyses of the matches as described in section ‘Desktop application’.

Experiment

The aim of the experiment was to show the functionality of the tool as described in the following sections.

Experimental set-up

The solution was validated against the functionalities described above. Also, some usability tests were conducted²²—*usability* is defined as ‘the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use’.²³ The results showed that the solution has a high usability level.²² Then the solution was used during a Judo Club Tournament where the information about the matches was recorded for later analysis. A total of four matches were recorded. The contestants in each of the matches were Miguel and Joel. Miguel won one match and lost three matches during the regular match period and during the Golden Score period, respectively.

Statistical information generation

The desktop application generates and displays a wide variety of statistical information proposed by Copello²⁴

and related to the recorded judo matches. It is described as follows:

1. Scoring/penalties graph shows statistical information about the scoring or penalties of a judoka during a match.
2. Win/loss records graph presents historical statistics related to the number of wins and losses of a judoka.
3. FA graph shows either statistical information about the number of attacks applied by a judoka during a match or historical statistics about the number of attacks applied in all the recorded matches.
4. General profile graph displays three variables: average FA during a match, number of attacks scoring points from the total number of attacks during a match and the relationship between the number of applied throws and the number of scoring attacks received.
5. Scoring style graph presents statistical information about the way the judoka has obtained scores: in the border of the match area, ‘Ne-waza’, ‘Osakomi-waza’ and others during a match.

The variables have been selected because they allow one to track several important aspects related to the performance of an athlete during a match, such as his or her efficiency during a fight, as mentioned by Copello:

the high frequency of attacks and their poor effectiveness shown, among others aspects, bad technical-tactical preparation.²⁴

Using this information, the coach can identify each judoka’s behaviour and make some changes to the training programme in order to improve the performance of the judoka in futures matches.

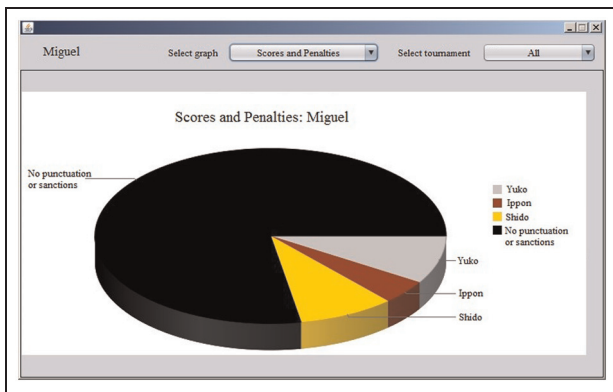


Figure 7. Graph showing the scores and penalties of the judoka 'Miguel'.

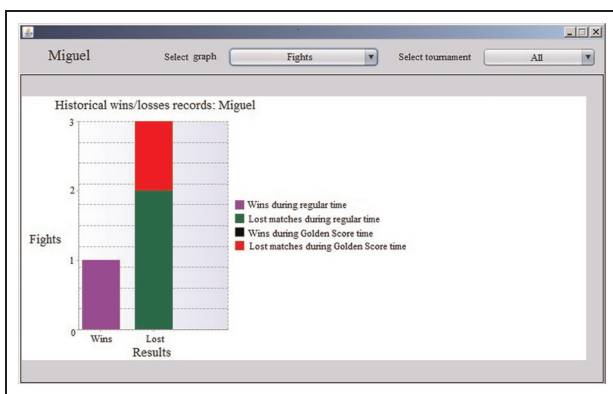


Figure 8. Graph showing historical wins/losses records for the judoka 'Miguel'.

Results

The statistical information is presented utilising several types of charts provided by Google Chart Tool, and in this section, some examples of statistical information generated from the Tournament judo matches are presented. Figure 7 shows the scores and penalties of a judoka during a match. For example, Miguel has scored an 'Ippon' during the match, so he is the winner.

Figure 8 shows the results of the matches (i.e. wins and losses) versus the number of fights during all the matches registered for the judoka. For example, the results show that Miguel has won a fight, while he has lost three fights – two of them during the regular duration of the match and one during the Golden Score time.

The attack frequency graph shows how many attacks each fighter has performed during the match. Figure 9 exhibits the number of attacks of the judokas 'Miguel' and 'Joel' during the first minute of the match. The results show that Joel applied four throwing actions during the first minute, while 'Miguel' applied two.

The general profile graph is a radar chart of three or more variables represented on axes starting from the same point. The further away the point is from the

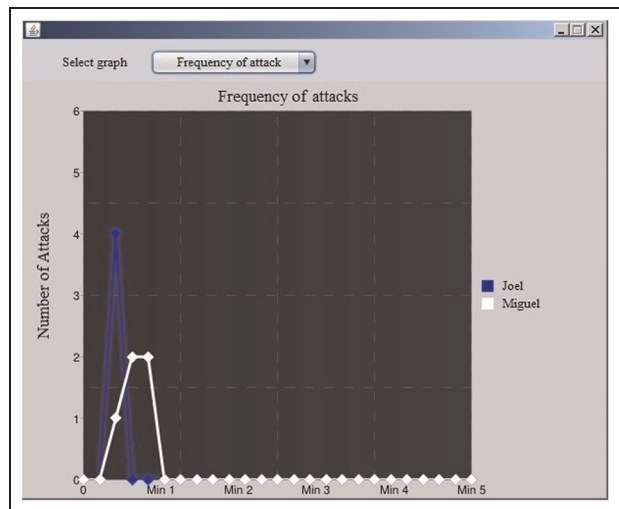


Figure 9. Graph of frequency of attacks during a match.

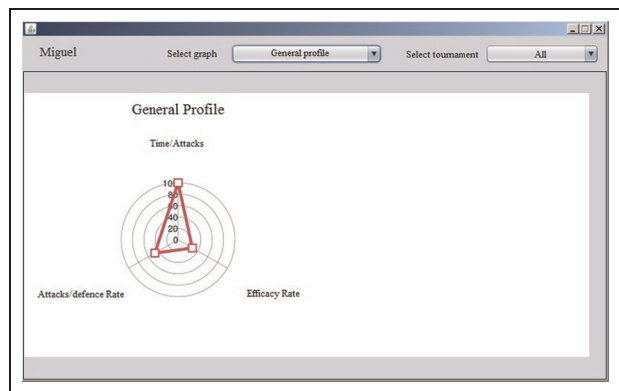


Figure 10. General profile of a judoka.

starting point, the better the result. Figure 10 shows a radar chart which represents three variables: the first is the average FA during a fight (i.e. 'times/attacks') (see equation (1)); the second is the number of attacks scoring points from the total number of attacks during a match, called 'efficacy rate (ER)'²² (see equation (2)); and the third expresses the relationship between the number of applied throws and the number of scoring attacks received (i.e. 'attack versus defence rate (A/D)') (see equation (3)). The following are the equations used to calculate the average FA, ER and A/D, respectively

$$FA = \frac{N_{attacks} \times 5}{M_{duration_time}} \quad (1)$$

$$ER = \frac{N_{scoring_attacks}}{N_{attacks}} \times 100 \quad (2)$$

$$\frac{A}{D} = \frac{N_{scoring_attacks}}{N_{scoring_attacks_received}} \quad (3)$$

where $N_{attacks}$ is the total number of attacks for a fighter, $M_{duration_time}$ is the duration of the match (in

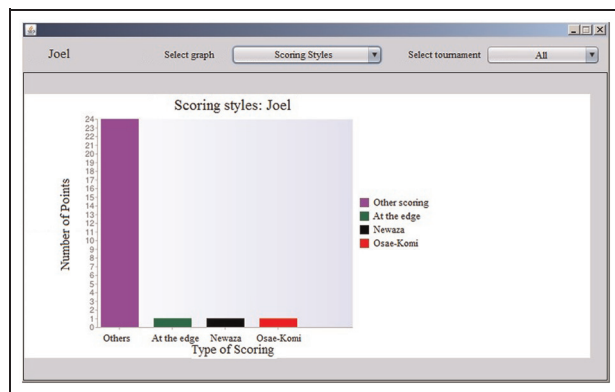


Figure 11. Graph of scoring styles.

seconds), $N_{scoring_attacks}$ is the attacks scoring some points for a judoka and $N_{scoring_attacks_received}$ is the total scoring points a judoka received. The figure shows that Miguel has an average of one attack every 5 s, an ER of approximately 43% and a rate of attacks versus defence of about 20%.

The scoring style graph shows the way a judoka has obtained points: at the edge of the match area, using 'Ne-waza', using 'Osaekomi-waza' and others. Figure 11 shows that 'Joel' has scored 24 points using other scoring styles.

Conclusion

The development of computer tools for supporting judo is in an early stage. This work details a technological solution for recording, storing and querying multimedia judo match data which involves, for the first time, the use of new information and communication technologies (ICT) trends, such as Cloud and mobile computing, which have not been used before in the software development of solutions for supporting this discipline. The initial results show that the solution can be useful for the technical-tactical analysis of judoka actions during several contests using the recorded multimedia judo match data and the statistical information displayed by the software. Another advantage of the solution is that the match can be recorded in real time, and the information registered can be updated by the coach after watching the recorded videos (e.g. incorporate any omitted attack performed by the judoka during the match).

Although the solution shows a high usability level, the potential users must be trained in the proper use of the tools. This guarantees that the information is recorded correctly, and the data are retrieved adequately for their analyses. On the other hand, although no Internet connection is needed in order to record the matches, the data recorded using the mobile device and the data in the Cloud must be synchronised before performing any match analysis. Data synchronisation needs an Internet connection to be set up.

The current solution has some limitations: the maximum duration of a video has been restricted to 15 min because of storage limitation, and only the data from one mobile device can be synchronised at a time. Also, the solution considers a limited number of judo match variables in order to increase software usability, so future updates of the solution should consider other variables, such as walking patterns and methods and judo techniques.

Finally, this research unfolds new opportunities for the development of other software tools that may be used to improve the performance of a judoka using the new ICT trends such as the ones utilised in this work.

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