

Application of the Augmented Reality in prototyping the educational simulator in sport – the example of judo

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Abstract. The mental training (Galloway, 2011) is one of the measures of the psychological preparation in sport. Especially such as the judo discipline requires the mental training, due to the fact that the judo is a combat sport, the direct, physical confrontation of two opponents. Hence the mental preparation should be an essential element of preparing for the sports fight. In the article are described the basics of the AR systems and presents selected elements of the AR systems: sight glasses Vuzix glasses, Kinect sensor and an interactive floor Multitap. Next, there are proposed the scenarios for using the AR in the mental training which are based on using both Vuzix glasses type head as well as the interactive floor Multitap. All options, except for the last, are provided for using the Kinect sensor. In addition, these variants differ as to the primary user of the system. It can be an competitor, his coach, the competitor and the coach at the same time. In the end of the article are presented methods of exploring, both, the effectiveness and usefulness, and/or the User Experience of the proposed prototypes. There are presented three educational training simulator prototype models in sport (judo) describing their functionality based on the theory of sports training (the cyclical nature of sports training) and the theory of subtle interactions, enabling an explanation of the effects of sports training using the augmented reality technology.

1. Introduction

The mental training (Galloway, 2011) is one of the measures of the psychological preparation in sport. Especially such as the judo discipline requires the mental training, due to the fact that the judo is a combat sport, the direct, physical confrontation of two opponents. Hence the mental preparation should be an essential element of preparing for the sports fight.



1. The aim of the research is to develop three types of models of the prototype simulator dedicated the sports education in these studies for the competitors practicing the combat sports, in particular the judo. It is, however, pointed to the need to develop three models of the educational training simulator in judo, such as:
2. Developing a prototype of the educational training simulator for practicing judo competitors in recruitment groups and youth (the ideal model);
3. Developing a prototype of the educational simulator for the competitors of the championship class (the reference model);
4. Developing a prototype of the educational simulator for all ages and experienced competitors, namely developing a software model, capable of supplying an optimal state of emotional arousal (the concentration) before the sports fight. This model simulator, can be called 'the model simulator of the emotional arousal'. In a word, the simulator used to capture the low-signal and subtle magnetic interactions of the emotional states of the competitor to stimulate optimal psycho-emotional and neuromuscular disorders;

In connection with these objectives, it can be formulated the research questions which are a key aspect defined in the research problems.

It should be considered the following paradigm of the scientific research concerning the defined issues, namely: is the theory of 'low-signal interactions' [Cieśliński, Szczuka, 2015] in the extent to which the theory of 'low-signal interactions' [Perechuda, 2010] can explain the impact of the proposed simulator on the behaviour of the competitors in sports training and combat sports? Proceeding from the above formulated paradigm assumed in this study, it have been indicated that it is possible to formulate the following problems defined in the form of questions. The research problem is as follows:

in what period of the sports preparation is best to use the mental training with the AR?

The hypothesis: the mental training using the AR the can be used as a training in:

- the period of the general preparation in teaching new techniques,
- the period of the special preparation for improving the selected individual techniques,
- in the period of the immediate starting preparation in stimulating the mental structures of movement (the imaginary training),
- during the takeoff and direct sportsmanship to build optimal arousal (concentration) before a fight sport,
- during detraining to 'unlearning' the movement techniques and structures which are not effective in the sports fight.

Summarizing the presuppositions, it is pointed to the need to assume a pattern of conduct leading research (paradigm) associated with the theory of subtle interactions. There is a need to locate a cycle of sports training before using the simulator AR. Finally, it is pointed out that it can be built three models of the prototype of the educational simulator in sport: for beginners, a model for master and the model of the prototype whose function is primarily to optimize the emotional arousal and the ability to concentrate in the field of the low-level impacts of the stimulus training and the incentives related to the sports fight.

In recent times, it has been noticed a significant increase in both the interest in and the applications of the augmented reality systems (called. augmented reality – AR), among others in art, museums, exhibiting, architecture, infrastructure maintenance, exchange of information on human teams, railways, education, editorial work, maintaining security, psychology, supporting browse and searching the information. The augmented reality (AR) can be defined as (Stephanidis, 2015), direct or indirect view of the real world viewed in real time enriched with the virtual elements generated by the

computer. This definition points to the following elements: real and virtual objects embedded in a real environment; their mutual arrangement that allows the observer to view them naturally with different views; It works interactively, in real time and in three dimensions.

Ultimately, it has been presented the idea to develop and test a prototype of the simulator dedicated to education for the sport. Preliminary studies indicate that the prototype of a dedicated simulator will include two models. The first relates to the development program enabling exploration model of a perfect execution of the individual techniques. It is a prototype dedicated the coaches involved in coaching recruited groups. Proper performance of throws in judo at the beginning of science is the basis for learning the normal motor structures. However, for the experienced competitors, it cannot be designed the ideal model of a particular throw, because every competitor, especially the champion acquires the specific structure of the movement, reference to the type of personality, physique and mentality of the competitor. Thus, in this study, it is pointed to the construction of an expanded real-life technology in two models; the ideal model dedicated to an opponent's quick recruited groups and the reference model, dedicated individually different for each competitor.

In the article, besides the basics of the augmented reality systems, the selected devices that enable the implementation of the AR systems, will be presented the idea of using the AR in the training mental of the judo and an outline of the method of examining the implemented prototype of the AR system supporting the judo training for increasing the effectiveness of training and/or the prototype of the User Experience.

This article was prepared on the basis of the results of the earlier stages of the grant NCN called 'Application of the augmented reality in perfecting the judo techniques Tachi Waza (the technique in the high position)', and in particular, the implementation of the project 'Development of the idea of using the augmented reality in teaching the judo techniques' (Cieśliński, Witkowski, Maslinski, Kalina, 2015). The project has been hypothesized that the use of the AR enables to: increase the attractiveness of teaching, deepen the effect of the mental and imaginary training; and it is applicable in practice without an opponent, with the opponent, the imaginary combat the and combats in the competition.

2. The augmented reality systems

The augmented reality is a technology that allows to simulate and improve the technique of the throw using what and how it is performed by the competitor in the reality. It allows also to the imposition of a given physical structure of the computer-generated sequences of movements. The imposition of these two images on each other (overlapping in the image of the real and computer image), is called 'imaging' of reality. The consequence of imaging in this technology is the ability to conduct the mental training using the so-called sighted glasses which indicate the examined competitors considered how they should do the throw in the best way.

For many years one of the most technologically advanced forms of human interaction with the computer system is the Virtual Reality (Virtual Reality - VR) which was originally used to describe the sensory immersive experiences with the artificially generated worlds (N. & J. Chapman, 2004). The VR is defined as a measure of visualization, manipulation and human-computer interaction and complex data. The VR utilizes a set of technologies, such as the helmet HMD (Head Mounted Display), the gloves or overalls entire interactive devices that generate sound. Even today the AR is defined as a variant of the VR (Kipper, Rampolla, 2012) in which the digital information, in the form of images, audio, video or haptics experience, is applied to the real world surrounding the recipient. Although the AR can be used to impact all five senses, usually the AR allows users to see the real world overlaid by virtual graphical objects. One of the first applications of the AR is to use a special

head-up displays (HUD heads-up display) for the presentation of information on the state of avionics and weapons systems for fighter pilots. For the most popular hardware platforms used by the AR systems are considered to be the tablets and the mobile phones where on the screen of these devices is screened an image from a camera mounted in the device (usually, the rear camera) enriched with some virtual graphics elements. In the LSOA-HCI lab of the Wrocław University of Technology, to implement a judo training simulator currently are used:

- the sighted glasses Vuzix Star 1200 XLD are the AR system that supports audio and 2D and 3D video for most devices with HDMI output (eg. desktops, laptops, tablets, smartphones or DVD or 3D Blu-ray players). The glasses are also equipped with the HD camera with 1080p mounted between displays. The camera uses a separate USB connector through which it can be connected to the control computer as a standard web camera in MS Windows,
- the Kinect sensor enables the implementation of the new ways of human interaction with the computer systems (Miles, 2012). It's a combination camera, microphone and directional sensor in the integrated product. It enables the software developers to create the interactive systems of all forms of kinetic interactions, for example the complex gestures made with hands. Currently, the following versions are used: Kinect for Xbox 360, Kinect for Windows and Kinect for Xbox One,
- the interactive MultiTap floor is an integrated device combining a PC and a high power video projector in a single chassis. The mirror surface is used by the projector to display the image on a substrate and a Kinect sensor (on the extended arm). The system allows creating the modern multimedia systems that displaying the image on the floor. It also allows the natural interaction of the user with the system using body movements or its individual parts, for example the feet and/or the hands (Multitap, 2015). The AR is used in implementing the information systems currently applicable in many areas already mentioned in the introduction, and such as advertising, industry, games, entertainment and translations.

It is worth to notice that the research is free of conflict of interest.

3. The theory of subtle interactions, the sports training efficiency and using the identified models of the educational training simulator AR

The theory suggests the subtle interactions in the context of the theory of sports training and 'the cyclical sports training' that there is a need for accumulation of effects which consist of the direct and prolonged effects. To obtain the cumulative effect (the increased state of the readiness to exercise – fitness, achieving the effect of improving strength, speed, stamina and/or what in the object of the study is essential, the effective execution of kata with and without a partner) each of direct and prolonged effects has to have a synergistic impact to another. Therefore, it is important what measures and in what point of the training cycle have to be used [Cieśliński, 2008].

The model for stimulating by the training measures with respect to the training cycles is presented in the table 1. The training cycles should produce results in the form of fitness and / or improving the elements of technical, tactical, motor and psychological preparation. As it can be seen, an important element of the application of a specific model of simulator is:

- to which the training effect it refers: current, prolonged cumulative.
- in which phase of the preparing cycle it occurs:
 - the general preparation (it refers to recruited groups in general and master level as part of the overall preparing mesocycle),
 - the targeted preparation (for recruited groups it is the core of the curriculum where the main objective is the efficiency in carrying throws in the form of the kata and during the imaginary combat and in the relation to the championship level it should be noted to increase the efficiency and effectiveness of the throws in the qualifying events)

- the special preparation (it relates only to the champions and it points to the need to obtain the exercise capacity whose function is to earn the highest championship degrees during the sports events).

Table 1. The model of the relations between the sports efficiency, the training cycle and the selected model of using the AR. Source: own study.

| Type of cycle / effects of training | General preparation | Targeted preparation | Special preparation | Overtraining |
|-------------------------------------|---------------------|--------------------------------|---|---|
| Current | Primary education | Improving individual technique | Preparing for combat | Indicating other techniques |
| prolonged | | Improving individual technique | Improving technique before the imaginary combat | Changing the pattern of movement |
| cumulative | | Effectiveness of own throws | Optimal level of concentration | Unlearning the structure of movement |
| Model of simulator | ideal | referral | To the mental training | Maintaining fitness at a level slightly below the previous cycle |

Initially, to define and identify major research problems related to the application of the various models of simulator and in general, functionality of the judo educational simulator, it should built the scenarios of the development which are possible, in order to answer the question: how to program the model to meet the expectations for the performance of his particular function? Recalling, these include:

- the educational model (ideal) – its feature is the quest for the perfect physical structure enabling the coach for effective teaching throws among the recruited groups.
- The model for the championship level (reference) - the feature is the search for perfectly chosen the structure of movement for the individual competitor for a particular throwing technique under the static conditions and during the imaginary combats, and especially and above all during the sports fight.
- The model of the simulator used for mental training which allows among the recruited groups the mental playing (imaging) of the correctly throwing technique and for the master, the function of the AR simulator will be optimizing the psycho-emotional states (the concentration) before the sports fight.

4. Using the AR in the mental training of the judo

This section of the article will present the selected scenarios for the implementation of the prototype of the judo simulator. The study assumed that the sensor tracking the movement of the competitor performing the throws will be the Kinect sensor for the Xbox One, but for the purpose of presenting the information is used a tablet/smartphone running on Android, the sighted glasses Vuzix Star 1200 XLD or interactive floor. Each of these displays enables to visualize the virtual models applied to real

image of an athlete performing a throw. They show the reference (suited to the learner, the weight, the height, the level of adjustment to the technique and others) motor activity. At the same time it may be presented the adequate for on-going throws, the feedback of the coach, the psychologist, the biomechanics or the teacher, discussing the proper performance of the individual sequences of movements.

4.1. The option 1 – learning and improving the kata by the competitor

In this scenario, they are used the desktop computer, the Kinect sensor for the Xbox One, the glasses Vuzix Star 1200 XLD or alternatively the interactive floor MultiTap. The scenario is as follows:

1. With the Kinect sensor, to which is set frontally the athlete which is located in the field of view of the sensor (0,4-4,5 m), is recorded the standard judo kata;
2. On the basis of the position information for the highlighted joints calculated for each frame of the video recording the kata, there is created a mathematical model of the standard judo kata. This model takes into account the position of each joint in certain quanta of time (1/30 second). In addition, this model can be created not on the basis of one of the standard execution of the kata but rather on the basis of the selected performances of the kata;
3. Exercising the kata by an athlete in a field of view of the Kinect sensor with the additional use of the glasses Vuzix Star 1200 XLD or the MultiTap interactive floor that allows the presentation of the feedback. During executing the kata it can be optionally used the displayed icon (the eyeglasses) or the background color of the ground (the floor) to display the information whether in the moment of executing the kata the athlete performs it properly (good – the green colour) or incorrectly (wrong – the red colour), or other intermediate colour (between the green and red), depending on the deviation from the ideal;
4. After executing the kata the athlete receives depending on the used device (at glasses or floor) the following feedback:
 - the video of the executed kata,
 - the video of the executed kata with the imposed competitor's image as a skeleton;
 - the information whether the kata was performed correctly,
 - in the case of deviations are displayed differences from ideal (eg. an animated perfect skeleton and the skeleton of the practitioner)
 - in addition, the deviations from the standard are explained by the 'voice of the coach' or using the display on a suitable text,
 - in the same way are given the advices on how to improve executing the kata (in the version for less advanced athletes can be presented the detailed instructions for performing the kata with the accuracy to display on the floor the places of putting feet and taking a specific position in particular highlighted the key elements of executing the kata). Using the proper position on the one hand can be presented in the form of picture and in the form of an interactive manner that is verified by the skeleton read by the Kinect.
5. After the sequence of the throw the athlete receives the following feedback:
 - the information that all the kata in the sequence are made correctly,
 - the indication using the video or the animated skeleton of these parts of kata in which the athlete committed the highest number of errors (deviations from the standard).
 were committed the most errors (deviations from standard) - is presented in the proper execution along with the information that in some parts the kata should be improved.

4.2. The option 2 – assisting the coach's work

In this scenario, they are used the desktop computer, the Kinect sensor for the Xbox One, the tablet/smartphone or the sighted glasses Vuzix Star. This scenario is executed in the initial portion as described in section 4.1 as follows:

1. As in Option 1;

2. As in Option 1;

3. The athlete performs the certain kata in the field of view of the Kinect, practicing kata is observed by the coach or biomechanic which uses a tablet/smartphone or Vuzix glasses. At the time, the coach is observing the kata by a suitable device on which he obtains (an option) the following information: displays the skeleton against the real picture of the competitor (this requires the recognition of the competitor's position and to overlay the skeleton at a certain angle), the display of the parallel the animation model of the executing kata in the form of a skeleton, the display of the information about errors during executing the kata (live) displayed eg. by changing the color of the skeleton;

4. After executing the kata or its sequence the coach receives the following information:

- the video of the kata executed by the competitor;
- the video of the executed kata with the imposed competitor's image as a skeleton;
- the information whether the kata was properly executed;
- in the case of deviations are displayed the differences from the ideal (eg. an animated perfect skeleton and the skeleton of the practitioner);
- in addition, there is presented the text list of deviations from the pattern;
- in the same way they are given suggestions on how to improve the executed of kata;
- in the case of the sequences, the kata are presented in the form of the video or the animation of the skeleton of these parts of the kata in which the athlete committed the highest number of errors (deviations from the standard).

4.3. The option 3 – collaborative, assisting the competitor and the coach's work with the AR

This option is a connection of the options 1 i 2.

4.4. The option 4 – the motivational training

Using the sight glasses Vuzix (with dimming) the competitor have presented before the fight the multimedia content that result reaching by the competitor the optimum level of motivation before the fight, for example :

- the video of the competitor's won fights;
- the video awards for his victory;
- the customized multimedia content affecting the respectively agitation, calm or motivate of a competitor.

5. Conclusion

The effectiveness of supporting through the mental training of the judo by the techniques using the AR systems can only be determined experimentally. Therefore, it has to be implemented the certain options and then they have to be subjected to verification with the athletes and, possibly, their coaches and biomechanics. Some difficulty in this task is the fact that the applications executing each scenario will be the prototypes which in many ways will not be fully functional and free of at least some disadvantages associated with the utility. It may, in more or less, influence the perception of the suitability of the proposed solution. The proposed procedure for testing the effectiveness of the mental training support using the AR may, on the one hand, consist of examining the usefulness and/or the User Experience of the proposed solution, on the other, consists of verifying whether using of such solutions in some way on how they influence the improvement achieved by a competitor's results. The idea of the usability is defined in many ways. According to the PN-EN ISO 9241-11 the usability is defined as 'the level to which the product can be used by the specified users to achieve the specified objectives to obtain: the effectiveness, the efficiency and the satisfaction in a specified context of use'. And the ISO / IEC 9126-1 defines the usability as a model for the external and internal quality and is defined as 'the ability of the software product to be affordable, operational and attractive when it is used in the certain conditions.' In the literature are currently more than 100 different methods

providing or otherwise testing the usability. In the case of testing the usability of the prototypes of the systems supporting the mental training of the judo using the AR, it can be proposed the following methods:

- the focus survey which involves performing the discussion moderated by an expert, in a group of users – the result of that session are the observations, the comments and the evaluation related to the investigated product;
- the tests of the individual users which are based on the observation of the user during the implementation of the tasks set by the experimenter when using the system under test – they allow users to see how they deal with their performance but also their intentions and interpretation of the encountered problems;
- the eye-tracking, a technique for registration of the user's eyesight focal point while working with the product which is usually used during testing of individual users – it allows for a better understanding of the process of the implementation of the tasks and establishing the design errors in the graphical interfaces;
- the satisfaction survey, is carried out usually through the use of the specially developed survey questionnaires that are filled both before the use and after controlled using the system – they enable to determine the level of user's satisfaction with using the system.

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