VIRTUAL REALITY RESEARCH - FROM TECHNOLOGY TO KINESIOLOGY

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Abstract:

Most recent generations of computers allow for designing qualitatively quite different, new versatile systems for data acquisition and analysis in many scientific fields, kinesiology as well. These systems are created by means of new simulation technologies which generate signals for visualisation of the computer generated environment. This technology is known under the names of virtual reality (VR) or virtual environment (VE). Even today its research and scientific application potential has not been comprehended entirely, but it seems to be almost infinite. The purpose of this review paper is to excite the interest of kinesiologists, especially the Croatian ones, in the application of virtual reality technology. Therefore, several examples from the fields cognate and adjacent to kinesiology and singular efforts from sports practice already in usage, as well as a comprehensive list of reference literature dealing with the subject are presented here. The opportunities to explore human movement in simulated environment(s) are numerous and versatile due to the specific nature of kinesiology and the abundant kinesiological practice.

***Key words**: virtual reality, computer technology, kinesiology*

INTRODUCTION

The study of human movement and exercise programmes' effects on humans is strongly affected by the technology applied (Haggerty, 1997; Powers, Ward, Shanely, 1997). Rapid advances in information technologies are neither additive nor subtractive to the state of art in teaching, research and professional activity, so it is timely to consider the implications of their application for kinesiology and physical education, as well. Although the history of virtual reality, which is the core issue of the presented article, dates back to the late 1950s and early 1960s (Yi Xiao, 2000; Sutherland, 1965), only the last two decades can be denoted as the period of intensive promising applications of virtual reality (VR), or virtual environment (VE), or artificial reality (AR) in various research studies and areas, such as education and training, medicine, design, architecture, astronomy, data handling, teleoperation and many others. Vehement advances of electronic, computer controlled instruments/systems stand, before anything else, in the background of such a development.

Such a course of technological progress, shaped by an array of various forces, including tradition, politics, economic interests, history, philosophy, and competition between technologies, has already substantially changed the dynamics and the approach to various research issues (Haggerty, 1997). Recent computer technology generations allow for creating quite new and strong systems for data acquisition and analysis (and feedback) almost in real time. Further, they provide opportunities to produce various simulations by generating signals for creating images (visual presentations) of the computer generated environment that tends to achieve the actual reality level of "our" reality. These systems or technologies are known as virtual reality (VR), or virtual environment (VE), or artificial reality (AR).

The early stages of development of any new technology or theory are often confounded by disagreement over what it actually involves, means, and implies.

Definitions of VR are still numerous and versatile. Some explain virtual reality as a set of technologies/devices, such as Head Mounted Display (HMD)[1] , Data Glove[2] and 3-D stereo sound, which compose the specific architecture of VR (Figure 1), whereas others expand the meaning of the term up to and including the literature and movies which are compred of some elements of VR. Nevertheless, any serious approach limits the definition of virtual reality to the computer controlled systems characterised by a complex technology of multimedial visualisation that enables a user to get in touch with or to interact with the parallel, computer generated world as if he/she is a part of it (immersive sense of presence).

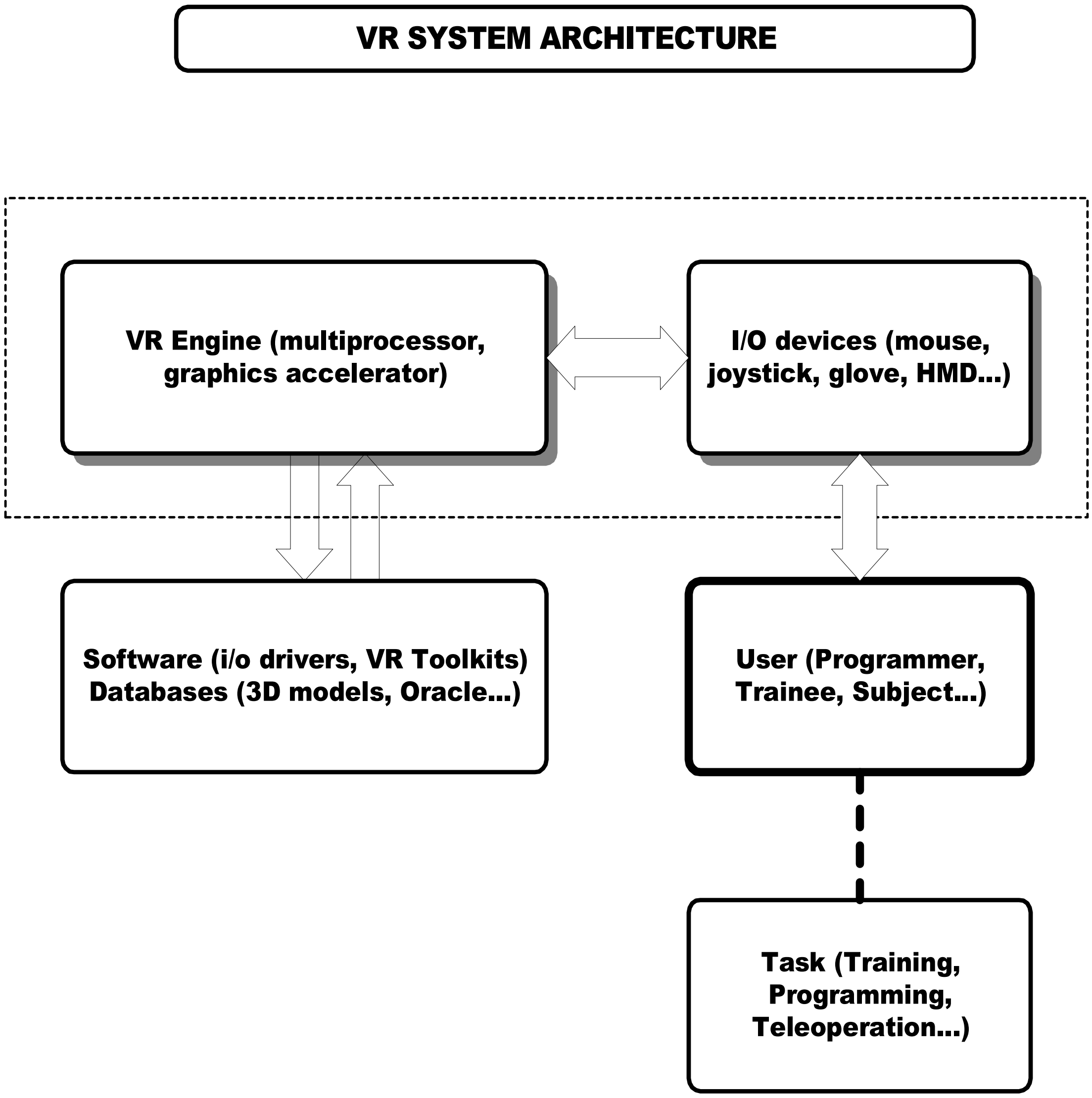

Figure 1. *Virtual reality system architecture*

Maybe one of the best VR definitions can be found in the book *The Silicon Mirage* by Aukstakalnis and Blatner (1992): "Virtual reality is the way for humans to visualise, manipulate and interact with computers and extremely complex data." (p.7).

Virtual reality literature reveals numerous approaches. For example, Newquist (1992) explains that VR is a technology which combines computers and sensory mechanisms to create simulated, interactive, computer-controlled environments and experiences. Hamit (1993) defines VR as an idea of human presence in a computer generated environment, whereas Pantelidis (1993) writes about a specific, highly interactive, computer multimedial environment in which a user becomes a participant in seemingly real surroundings.

The present advances in the computer industry, together with the accessory devices and technologies, enables VR or its components to be effectively used in sports, leisure time, entertainment, education, research, training, medicine, psychology, travel, shopping, design, communications, military sciences, robotics, employment, and the last, but by no means the least important one as an aid to people with disabilities (Haggerty, 1997; Foreman, Wilson and Stanton, 1999; Osberg, 1992).

Virtual reality stands for both the generated environment and the tool, the interface, which might sometimes cause ambiguity (Figures 2 and 3). By means of simulations a quite new quality might be attained - the interaction of humans with a computer system becomes more natural, similar to the human way of thinking and acting, mostly because all the senses become more agitated and stimulated.

Nowadays researchers use VR-technology so as to apply simultaneously different kinds of stimuli, all kinds of perceptive, auditory and tactile stimuli, in various modes of intensities, power, or quality to an examinee (or a group of examinees) in order to better analyse certain bio-psychological dimensions involved in human interaction with virtual environment.

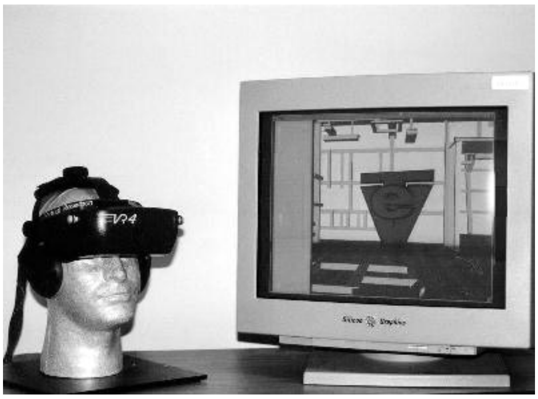

__Figure 2.__ Head Mounted Display –a device and presentation.

__Figure 3.__ Data Glove – a device and presentation.

However, the technology manifests certain shortcomings that interfere with more extensive and intensive usage of VR, like the negative correlation between the amount of time spent in the simulated surroundings and in actual reality, resulting in decreased levels of socialisation. The other objection (Steuer, 1992) regards health and safety issues connected with the duration of the contact a person has with the simulated environment and with the amount of stimuli he/she receives during that contact. Namely, a long contact and complex interactions with a virtual environment are considered to induce states of discomfort, headache, dizziness, disorientation and nausea in users. But, the adaptation of subjects to the specific demands and features of the virtual reality technology can be improved and the discomforts can be averted by repeated application and improvements of visualisation. The discomfort is known as cybersickness, the term being derived from the analogous terms carsickness, or travelsickness, or seasickness (Kolasinski, 1995).

If VR systems are to receive widespread use, researchers in their systematic research need to focus on still numerous technology and human factor issues, including: human functioning and effective performance in a technical environment and virtual worlds, the characteristics of the users, human sensory and motor physiology, multi-modal interaction, health and safety issues, and the social impact of the technology.

VIRTUAL REALITY IN RESEARCH

Researchers have generally shown a growing interest in virtual reality lately. Two possible crucial reasons must be emphasised here. The first one is the multifacet nature and versatility of the media which manifests itself in the transmission of spatial information, and the second is the possibility of applying an integral, flexible methodology to the spatial cognition of problem solving. Many experimental designs that are impracticable in actual reality due to their complexity (resulting in lack of control over too many environmental and behavioural factors) and/or ethical reasons, become conductible in a simulated environment which provides opportunities for manipulation and interaction with the controllable computer-generated objects and immersive environments.

A comprehensive overview of recent research studies on virtual reality can be found in Sakurai's article (1995) in which the focus is on: the terminology used in the research areas surveyed, descriptions of the technological approaches implemented to setting up the different components of VR, objects of measurement, interaction and presence capacities, and the present applications of VR to different fields of science. The authors have concluded that the intermodality conflict and the sense of presence measurement were crucial and most often present perceptual and cognitive topics in virtual reality research studies.

The present paper is a survey of selected research studies from scientific fields cognate and adjacent to kinesiology, that are based on the VR-technology implemented in the following fields of application: *VR and learning, computer games in the cognitive dimensions research, and VR in other research fields.* Elements pertaining to the kinesiology scope of interest, and consequently, kinesiological issues can be recognised in each of the listed fields. The authors suppose it is feasible to design same completely new equipment, viable measurement instruments and systems aimed at exploring the issues appertaining to the realm of kinesiology, such as the influence and assessment of anthropological dimensions, for instance. From the present point of view, it seems that VR-technology allows for almost everything, from playing games to serious scientific explorations. Its potential and capacities, combined with the variety of research issues inherent to kinesiology, might be an inexhaustible source of new research ideas.

VIRTUAL REALITY AND LEARNING

The high flexibility of the graphic interface and an abundance of visual presentations have undoubtedly contributed to an enhanced comprehension and intuition the users manifest when using computers, while they simultaneously evaluate a certain portion of their intellectual abilities and potential. Research studies indicate progress even in the simple, 2D-graphical working surroundings. Certain features of virtual reality, especially the three-dimension principle in creating virtual or artificial environment for the activities that the users are engaged in, the feeling of presence that the users are able to experience, the control over and interaction with virtual objects in virtual surroundings, as well as the communication with other users within the same simulated environment, make VR an almost ideal medium for learning.

Wann and Williams (1996) discussed the criteria of usage of the term virtual reality and emphasised that the applied learning design must focus on perceptual-motor capacities of the users, on the one hand, and on the equipment used on the other hand, in order to enhance the complexity of the set tasks, whereas control in interactive 3D environment should simultaneously be facilitated. The latter habilitates and supports the user-simulated environment interaction.

Siegler (1978) presented the examples of interaction between children and a computer and underlined the problems related to children's perception of computer controls. The authors have identified the aspects of object-based reasoning and decision-making processes as important factors of problem solving/object manipulation skills, which are a basis for other forms of cognition.

Lawler (1985) has also investigated children perception of computer tasks, wheres McClurg (1992) assessed application effects of the computer-based training of spatial cognition. The research used third and fourth-grade students. Their spatial visualisation skills were measured by the *Black & Black Figural Classification Test (1984)* and the *Shepard & Metzler Mental Rotations Test* (Zarevski, 2000). The results indicated that the spatial visualisation skill level in the children who had worked with the problem-solving software was significantly enhanced.

Investigation of Regian and associates (1992) suggests that virtual reality is a superior environment for enhancing spatial skills, especially because it allows a total preservation of visuo-spatial characteristics of the simulated real environments, simultaneously enabling the linkage between them and the motor activities of users. The research also indicates that the task performance of spatial processing is quantitatively and qualitatively better in the 3-D simulated world.

Middleton (1992) lists and describes elements or attributes that make virtual reality an ideal learning environment: great flexibility in the creation of virtual or artificial surroundings and in the creation of feelings of presence, users' control over and interaction with objects, as well as a good performance that enables communication with other users within the simulated world, and provides feedback from the touch stimuli (palpation).

Lanier (1992) worked with a population of students in developing a learning environment by means of VR-technology. A distinctive attribute of such an environment is that it creates conditions that foster memorising, retention and recall of the data stored in the students' memory.

Steuer (1992) stated that the vividness and interactivity of VR were in positive relation with the sense of presence in natural surroundings. Yet, these attributes can induce "sensory overload" for the participants, therefore they must be carefully applied.

Bricken (1991) describes the potential of the computer generated virtual world application to educational theory and pedagogical practice in order to enhance the teaching and learning processes.

Osberg (1992) performed an exploratory study to evaluate the effect of designing and experiencing a virtual world as a method of the spatial processing skill improvement, that represents an aid to cognitive development. The group of participants consisted of 10 children, 12-14 years of age, with neurological impairments, who took part in an intensive, week-long class in which the virtual reality technology was applied. Intensive training in such a generated 3D-environment, which offers an opportunity for a participant to directly manipulate objects and navigate through it, significantly contributed to the improved test results. It was concluded that the intensive teaching within the virtually generated envinronment can enhance spatial processing skills in neurologically impaired children.

Ghahramani and Wolpert (1997) investigated the influence of the complex tasks decomposition into simpler tasks on the learning strategy, that is, the way in which the human motor system uses the strategy of decomposing complex tasks in order to learn visuo-motor maps. In the research the system of VR was used in which virtual environment examinees were subjected to visuo-motor re-mapping. The results obtained showed how the human brain can apply the strategy of modular decomposition during the process of learning.

COMPUTER GAMES IN COGNITIVE DIMENSIONS EXPLORATIONS

Traditional computer games and the games using VR-technology are nowadays the most common mode in which users come in contact with the interactive 3D-surroundings. Their spatial compounds may serve as a starting pattern for the new application development aimed exclusively at various assessments or examinee testing, or the finished products can be used, after more or less excessive modifications, for the same purpose.

In the study regarding the relationship between spatial ability and performance, conducted by McClurg and Chaille' (1987), two computer games were employed to test whether the spatial nature of the games would enhance the spatial abilities of the examined students, measured by the Shepard and Metzler (Zarevski, 2000) Mental Rotations Test (measuring the ability to turn something over in one's mind).The spatial ability elements presented in the games included visual perception and discrimination, differentiation of opposite obliques, visualisation of transformations in a series, the use of referent systems, as well as the development and constant updating of cognitive maps. The results indicated that all the students, regardless of age and sex, benefited from playing the games.

Viskić – Štalec and Horga (1991) assessed cognitive functioning by selecting tasks that included several different aspects of intelligence, trying at the same time to avoid certain unfavourable features of the classical cognitive ability measuring procedure. The authors used the computer game called *Block Out*, three cognitive and six conative tests. The results obtained showed that the efficiency in the game was mostly determined by the quality of the parallel information processor, that is, by spatial visualisation.

Kokdemir (1996) carried out an investigation including 20 young men and 20 young women (20-22 years of age) using the Amiga 500 computer and the computer game *Escape from Colditz* (© Gibson Games). The author was interested in investigating the concept of cognitive mapping, the concept of which is generally used to describe mental representations (images) of spatial environments.

COGNITIVE ABILITIES RESEARCH USING VR

Almost in the entire body of research studies regarding or using VR-technology, the concepts of **perception** and **visualisation** are predominant issues. **Perception** is an active mental process of organising, integrating, and interpreting sensory information data oncoming from the sense organs. The process allows for a person to get acquainted with and to recognise, identify the meaning of persons, objects, occurrences or phenomena, and events occupying or taking place in one's surroundings. Although all the senses are included in the process, the relative contribution of particular sensory fields varies significantly. Literature on perception unanimously underline its two most important functions: recognition – recall, recollection of structures, and localisation – arrangements of structures in space. Visualisation is a complex mental process of representing vividly mental images which are the results of the imagination or of "recall", retrieval from one's memory. It has a capacity to generate physiological and emotional responses in a person similar to those caused by and during "real-time" perception.

Samuels and Samuels (1975) described visualisation as the "inner landscapes" of human perception, that is as an internal perception of the meaning, essence of objects, persons, concepts, or processes. They stated that visualisation is a highly personal, individual manifestation of the mind, whereas Kosslyn (1983) said that it can be used, in a strictly intellectual sense, to develop focus, establish connections and relationships, and for creative problem solving, concept enhancement, and memory enrichment.

Visualisation is of particular importance to spatial learning. Pelligrino and associates (1984) focused in their exploratory study on the psychometric measurement of speed, power, and complexity of spatial manipulation, splitting spatial ability into two components – spatial visualisation and spatial relations.

At Queen's University, in its Visual and Auditory Neurosciences Laboratory Barrie Frost directs the research project called VAPER (Virtual and Artificial Perceptual Environment Research), the purpose of which is to bring knowledge of multisensory perceptual mechanisms to technical advancements (VAPER, 1999). The research team explores the perceptual consequences of various types of stimuli and body motion constraints in humans and animals. Much of their work is focused on the distinction between self motion and object motion, as well as on the segregation of objects using motion cues. The research is conducted on several VR-platforms, basically consisting of cyber bicycles and treadmills (Figure 4).

Figure 4. *VAPER Cyber bicycle*

Since 1998 Viskić-Štalec and Katović have been devising a VR instrument for assessing cognitive abilities, particularly the spatial processing of skydivers (Viskić-Štalec and Katović, 1999; 2001). The authors, from the Zagreb Faculty of Kinesiology, are convinced that the VR technology based measurement instruments permit the avoidance of the shortcomings of the paper-pencil instruments, even that they expand the interpretable portion of variance. The instrument is focused on spatial processing, being vital for skydivers participating in the Free Fall Formation 4-WAY or in any other modern discipline of style jumps in skydiving. Abundant research experiences have been obtained from the VR-testing applied to the students of kinesiology and skydivers. These experiences differ from the experiences obtained from the traditionally constructed paper-pencil, motor, or other tests. Namely, VR-technology is extremely sensitive, which implies an intensively cautious approach to the construction of a measurement instrument and its application. It is time consuming since the measurement characteristics control of the instrument is indispensable always after certain, no matter how small, alterations have been made. Till now the authors have produced eight versions of the instrument and checked the relations between the newly constructed instrument and traditional cognitive measurement instruments.

OTHER RESEARCH STUDIES USING ELEMENTS OF VR-TECHNOLOGY

VR-technology, due to its vehement development and the flexibility of its structure and compounds, is a medium adjustable to versatile aspects of scientific research, especially to those types of investigations that normally, in the actual, real world, could not be realised.

Its contribution to the creation of new approaches to the various scientific issues is growing, becoming more obvious each day. The results obtained reveal not only the abilities and/or achievements of the examinees, but more often they witness either the successful or unsuccessful integration of and transfer between the virtual (digital) and actual (real) environments.

Gentilucci, Jeannerod, Tadary i Decety (1994), utilising VR devices (Head Mounted Display and Data Glove), created and explored the situation where the visual system was dissociated from the kinaesthetic coordinates system while aiming at targets.

McCormick and associates (1998) investigated the performance of examinees in solving four visualisation tasks: searching, travelling, a local and a global assessment. These tasks were compared through three frames of reference. The subjects were instructed to locate a pathway and to follow it through 15 tasks set in the virtual environment. The outcomes of the simulated movement through the generated surroundings were better in the subjects who were positioned in the centre of the simulated world (i.e. the simulated objects surrounded them) than in those subjects who were on the periphery (the simulated space did not embrace all the objects). When all the objects were included in the visible space, frames of references allowed for better accomplishments in the tasks of searching and local and global judging.

In their study Werkhoven and Groen (1998) explored manipulation with objects performed by means of the two types of computer-controlled devices: the virtual hand and the 3D-mouse. The manipulation methods were tested under both the monoscopy and stereoscopy conditions. The examinees were asked to manipulate virtual objects along the x, y and z axes. The speed and accuracy of the manipulations were measured. The virtual arm manipulation appeared to be much faster than the mouse manipulation. Further, the examinees made more head movements while manipulating with the virtual hand (glove). Improvements in speed and accuracy were recorded in the conditions of the stereoscopy view.

Slater, Steed, McCarthy and Maringelli (1998) explored the influence of the through-space simulated body which was moving, on the sense of presence in the virtual environment. Twenty examinees, moving through a virtual field with trees, had to count the diseased trees. The field characterised by a greater variation in the height of the trees required more head movements (the head had to be lifted and lowered more often). More complex tasks required from the subjects to remember the number and arrangement of the diseased trees in the space. The results showed a significant positive association between the reported sense of presence and the amount of body movements. A strong interaction between the task complexity and gender was also registered. Women reported a substantially lower, fainter sense of personal presence in the virtual environment in the more complex tasks than in the simpler ones. For the applications in which the immersive sense of presence is important, the investigators suggest that such tasks should be designed whereby the user – VR-interaction will require movements of the entire body.

SPORTS SIMULATIONS, GAMES AND ENTERTAINMENT

Virtual reality technology, as has been the case with other types of electronic technology, has been primarily implemented on a large scale in the field of entertainment (TV, films, games and other). Since then it has also been implemented in simulations regarding various sports. The high level of reality achieved by the simulated sports games and their resemblance to the actual sports games is the crucial issue here. Very realistic sensations have been accomplished by the senses of physical and visual immersion, as well as by the tactile/force feedback in a contest with an opponent or sport object, resulting in enthusiasm very similar to the one a user can feel in a real sports competition.

Special attention should be focused here on the persons whose interaction with the real world is limited in some way, that is, on the needs of persons with various disabilities and impairments. To them a VR-sport competition may be the only experience of sporting competition they ever experience (Vanderheiden and Mendenhall, 1993).

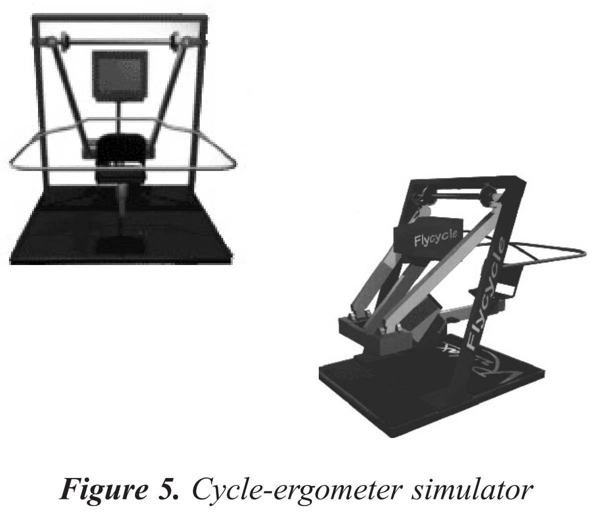

Figure 5. *Cycle-ergometer simulator*

Virtual technology simulations have entered the world of training with the aim of improving sport specific abilities and performance of athletes from different sport events. Simple examples are the VR applications and simulations already in use in fitness centres, like the complement physical-fitness related devices attached to cycle-ergometers (Figure 5), treadmills, ski-running simulators, step-machines (step climbing simulators), or rowing simulators. The VR visualisation system enhances the users' sense of immersion into the VR surroundings and events. At the same time, performers receive tactile feedback which is a result of the interactively caused changes in resistance, speed, inclination and others. The responses of the human body (most often, the heart rate) to exercise are also recorded on the dynamic parts of exercise machines along with either the wanted or programmed resistance adjustments that correspond to the chosen track or terrain (Pimentel, 1993).

Autodesk cycle-ergometer riders might get bored. In order to prevent such a nuisance, the firm has provided a helmet, a HMD in fact, on the display of which a virtual presentation of hilly landscape is offered as if the user is riding through the countryside. Steering angle, pedal resistance, and translation velocity are modified by the computor according to the track or terrain inclination. Sensors simultaneously monitor rider's heart rate. Almost as it in the real world, the users can freely choose a bicycle route (Dohm and Withrow, 1993).

The same firm has developed a racquetball simulation system (Pimentel and Teixeira, 1994). The participant in this case uses a special racquet and HMD. He/she is free to exercise and improve his/her strokes to the desired performance level as long as he/she wishes. Johnstone (1990) describes a similar squash game simulation.

The technology of VR is also important to the analysis of human movement, especially due to the 3D-visualization applications, on the one hand, and to the interactive treatment of the data gathered, on the other. A new level of interaction has been achieved by making motor behaviour of virtual people/players in virtual settings more natural and similar to humans moving. For example, Microsoft is keeping records of athletes performing in actual situations (real movements and motions) by means of the technique called "motion capture". The firm has established a large data base, a library of real movements, real faces and expressions to enable computer re-creation to be so real that no one can tell it is an animation (Katz, 1995). Greenleaf Medical System (according to Hamilton, 1992) has analysed the pitching techniques of four Red Sox's pitchers and the baseball ball trajectories, using a data glove. This analysis and the VR-pitching training have enabled the participants to improve their pitching technique (Figure 6).

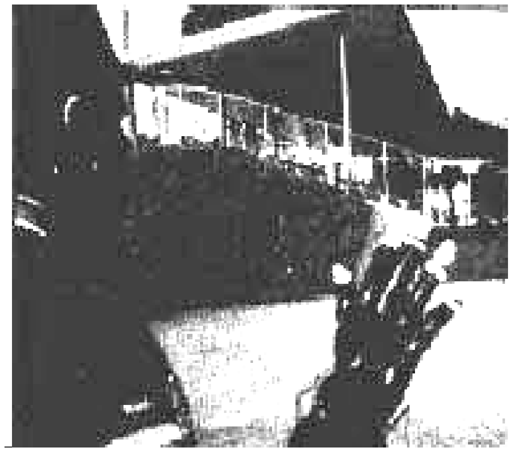

Figure 6. *Analysing pitching technique using Data Glove*

Todorov and associates (1997) investigated the effects of computer simulation on the complex stroke acquisition in table tennis. They explored the differences between the effects of training performed in the real and in the virtual environment. The trainees who had been working in virtual surroundings, performed much better.

Brian Shimmer, a member of the American Olympic AmE bobsleigh Bo.E team, participated in the virtual reality training prior to the Albertville Winter Olympic Games. The VR training sites (the Albertville bobsled track was digitally modelled) were built up by Silicon Graphics Inc. on a blue screen in front of the fixed sled. Shimmer was able to "drive" his bobsled down the Olympic bobsled run by commands connected with mechanical sensors, and therefore he was able to influence the virtual bobsled moving down the track. Thus he could see and experience the course in a very realistic setting. In another "white" sport the Japanese are using a virtual skiing simulator, developed by NEC (Figure 7), to teach and master downhill skiing (Li, 1993).

Various simulators and VR-technology make it possible to play golf on one of the world most famous golf courses and greens, while actually being in a commercial venue or in a hotel, because the simulations are very realistic, says Puttre (1993). The Virtual Ventures' Golf simulator is a sophisticated system, based on a patented infrared ball tracking system, which can trace the trajectory of the real ball that has been hit by a real golf club.

Figure 7. *Virtual ski - simulator*

The system extracts data to calculate the ball's velocity, spin and direction vectors in real physical time. As soon as the real ball hits the display, the system transfers the captured features of the ball's flight and the graphical part of the system takes over by simulating the virtual reality of the ball's flight over the visual images of a golf course. The same system (both the hardware and software) is configurable to simulate the interactive experiences of baseball pitching to a virtual batter, a soccer player kicking the ball at the goal, American football player kicking ball through a virtual goal post, dart throwing (using a golf ball), or any other baseball attractions, such as Virtual Baseball Home Run Derby Arcade Game and Officially Licenced Major League (Power Pitcher – Pitching Video Simulator and Power Alley – Video Simulator Batting Cage).

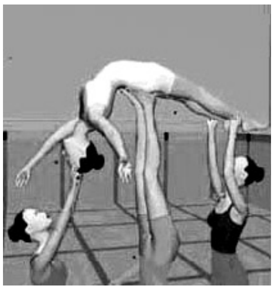

Figure 8. *Syseca's synchronised swimming simulation*

An interesting soccer game simulation system has been designed by SYSECA specially to the 1998 World Cup broadcasters' conveniences (Syseca, 2000). Its performances incorporate recordings of positions, attitudes and the motions of the players performed in real time. These recordings are utilised to re-create the game by simulating it in VR-surroundings. The system enables a wide range of VR possibilities such as: instant playback, frame freezing, changing viewing angles at will, especially the view of particular players, and their attitudes. The same firm has responded to the French national teams needs and developed a synchronised swimming simulation system to facilitate the ballet choreography elements acquisition and perfection during the preparations for the Olympic Games (Figure 8).

For training purposes the corporation System Technology has designed a parachute simulator which allows for free fall simulations (Heid, 1999). A user wears a Head Mounted Display which is connected with the computer. The computer-generated simulations (the parachute opening during free fall in a rich virtual environment) are directed by the operator. A parachuter can appear to be overhead and react to simulated parachute malfunctions, and he/she can scan in any direction to avoid collisions and conduct operations with other recorded or networked parachutists.

VIRTUAL REALITY IN KINESIOLOGY - STATE OF THE ART

Kinesiology is itself in a relatively early stage of development and recognition In the Croatian circle of kinesiologists it is understood as the science primarily focused on the explorations of all the aspects of human movement and on the bio-psycho-social responses to the influences of the process of physical exercise. From the kinesiological perspective, all the aforementioned research studies are extremely interesting. The opportunities presented of VR might become a real discovery: immersive simulated environments can significantly improve, even alter traditional investigations of anthropological dimensions, training processes, motor learning, game analyses and many other issues of kinesiology. Such an optimism is undoubtedly corroborated by the aforementioned already existent VR-projects, especially from the domain of sports. Yet, only a few strictly kinesiological research studies based on VR-technology have been conducted till now. The statement is confirmed with only a superficial look at the contents of the Proceedings Book comprising reports of the 3rd International Symposium of Computer Science in Sport and the 5th World Congress of Performance Analysis of Sport, held in Cardiff, 26th – 29th June, 2001. From all the presented contributions, only one was based on VR-technology (Viskić-Štalec and Katović, 2001). However, several speakers have mentioned its rich application potential. Almost naturally, the question arises: what are kinesiologists waiting for?

One of the most important reasons is undoubtedly the high complexity of the tool implementation, on the one hand, and complexity of the virtual reality creation/ designing, on the other.

Both reasons make VR-technology an expensive enterprise, and that crucial reason may discourage researchers even from taking the first step. The Internet data about VR- prices confirm it is a high cost project. That statement applies equally to the hardware and software products. However, the prospects are not entirely gloomy - an encouraging fact is that, due to its quick development, computer technology prices are falling quickly. Even the Croatian researchers can nowadays find decent, affordable products. No financial problem should, the authors believe, overshadow a more important issue in the whole story – the ideas and enthusiasm of researchers.

Therefore, they advocate for the implementation of VR-technology in kinesiology despite all the difficulties. More than ever before the multidisciplinary nature of kinesiology may become visible in the future investigations based on this intriguing technology that is able to create a parallel, virtual world in which a user can be immersed and "live" there. Many research designs, that have been unaccesible to kinesiologists or researchers from adjacent scientific domains, due to financial, material, ethical, or safety reasons, could be madeavailable by means of new technology.

This overview of the published papers on virtual reality has been written in order to incite interest in kinesiologists, scholars and practitioners, Croatian ones in particular, to test the new medium. The presented studies offer more than enough versatile ideas to design VR-based kinesiological fundamental and applied research studies to address the various issues of exercise, physical education, growth, maturation, ageing, health enhancement and preservation, sport, sports recreation activities and kinesitherapy. It is worth trying, the authors sincerely hope.

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[1] *Head Mounted Display* – a helmet necessary for the VR production; it projects a computer generated image on to the user's eye cornea and tracks motions of his/her head by sensors.
[2] *Data glove* – a glove with integrated sensors for tracking motions of the user's hand.

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ISTRAŽIVANJA PRIVIDNE STVARNOSTI: OD TEHNOLOGIJE DO KINEZIOLOGIJE

SAŽETAK

UVOD

Proučavanje ljudskoga pokreta uvelike ovisi o primijenjenoj tehnologiji. Razvoj računalne tehnologije, odnosno računalno upravljanih sustava, nazvanih tehnologija prividne stvarnosti, posljednja dva desetljeća omogućuje stvaranje kvalitativno različitih sustava za odašiljanje, prikupljanje i analizu podataka gotovo u realnom vremenu, na čemu se temelji mogućnost simulacije i generiranja signala za vizualno predočavanje računalno generirane okoline.

Još se uvijek pod terminom prividna stvarnost (Virtual reality - VR) razumiju razne stvari, no ozbiljan pristup ograničava definiciju na računalno upravljane sustave sa složenom tehnikom multimedijalne vizualizacije koja omogućuje interakciju korisnika s paralelnim računalno generiranim svijetom ili: *Prividna stvarnost je način na koji ljudi mogu vizualizirati, manipulirati i biti u interakciji s računalom i ekstremno kompleksnim podacima* (Aukstakalnis i Blatner, 1992:7). Danas se tehnologija prividne stvarnosti koristi u edukaciji, znanstvenim istraživanjima, osposobljavanju, treningu, medicini, psihologiji, vojnoj znanosti, astronomiji, astronautici, obradi podataka, daljinskom upravljanju, robotici, dizajnu, arhitekturi, komunikacijama, prometu, sportu, zabavi i drugim područjima.

VR U ZNANSTVENIM ISTRAŽIVANJIMA

Dva su bitna razloga za primjenu VR-tehnologije: svestranost medija pri prijenosu spacijalnih informacija te mogućnost primjene jedinstvene fleksibilne metodologije u rješavanju problema vezanih uz spacijalnu kogniciju. Mnoge eksperimentalne situacije, koje zbog svoje kompleksnosti (nemogućnost kontrole brojnih faktora), etičkih ili sigurnosnih razloga ne mogu biti izvedene u stvarnosti, prihvatljive su u formi manipulativnih i interaktivnih simulacija u koje korisnik “može uroniti”. U Sakurai (1995) mogu se naći podaci o istraživanjima koja koriste VR-sustave s opisima tehnoloških pristupa, objektima mjerenja, aplikacijama u različitim znanstvenim disciplinama, o sveprisutnom konfliktu između različitih modaliteta rada i osjećaja prisutnosti (uronjenosti) te o najčešćoj temi tih radova - percepciji i kognitivnom prostoru.

Ovaj rad selektivan je pregled uporabe VR – tehnologije u istraživanjima, prije svega, procesa poučavanja i učenja, ispitivanja kognitivnih dimenzija (i primjenom računalnih igara), u drugim istraživanjima, kao i u igrama, zabavi i raznim simulacijama. U svakom području primjene VR moguće je prepoznati elemente i probleme svojstvene kineziologiji i kineziološkoj praksi. Danas je moguće kreirati potpuno novi instrumentarij i sustave za procjenu antropoloških dimenzija u kineziološkom prostoru.

VR I UČENJE

Već je dvodimenzionalno grafičko korisničko okruženje nesumnjivo je pridonijelo većem razumijevanju i intuitivnosti korisnika računala, a istodobno je razvilo neke njihove intelektualne sposobnosti, osobito spacijalne kognicije i vizualizacije te memorije. Trodimenzionalnost prividne ili umjetne okoline, stvaranje osjećaja prisutnosti ili uronjenosti u računalno stvorenu stvarnost, kontrola i interakcija s objektima i ukupnim okruženjem te komunikacija s drugim korisnicima u simuliranoj okolini, prividnu stvarnost čine gotovo idealnim medijem za učenje (Wann i Williams, 1996; Siegler, 1978; Lawler, 1985; McClurg, 1992; Regian i ostali, 1992; Middleton, 1992; Lanier, 1992; Steuer, 1992; Bricken, 1991; Osberg, 1992; Ghahramani i Wolpert, 1997).

RAČUNALNE IGRE U ISPITIVANJU KOGNITIVNIH DIMENZIJA

Klasične računalne igre i igre razvijene primjenom VR-tehnologije danas su najčešći oblik dodira korisnika s interaktivnim trodimenzionalnim okruženjem. Svojim spacijalni elementima one mogu poslužiti kao predložak za razvoj novih aplikacija za testiranje subjekata, ili se već gotovi proizvodi ovog tipa mogu, uz veće ili manje modifikacije, koristiti za testiranje i procjenu antropoloških dimenzija (McClurg i Chaille’ , 1987; Viskić – Štalec i Horga, 1991; Kokdemir, 1996).

ISPITIVANJA KOGNITIVNIH DIMENZIJA UPORABOM PRIVIDNE STVARNOSTI

Gotovo u svim istraživanjima utemeljenima na tehnologiji prividne stvarnosti dominiraju problemi percepcije i vizualizacije. Percepcija je aktivan proces organiziranja, integriranja i interpretiranja osjetnih informacija, koji omogućuje upoznavanje i prepoznavanje značenja predmeta, pojava i događaja u okolini. Vizualizacija je kompleksan proces reprezentacije mentalnih slika koje nastaju kao rezultat imaginacije ili *pozivanja* slika iz memorije (Samuels i Samuels, 1975; Kosslyn, 1983; Pelligrino i ostali, 1984). Na zagrebačkom studiju kineziologije Viskić-Štalec i Katović od 1998. god. razvijaju instrumentarij za procjenu spacijalnoga procesiranja padobranaca (4–WAY figurativni skokovi). Autori navode izuzetnu 'senzibilnost' VR-tehnologije, koja se reflektira na metrijske karakteristike instrumenta. Provjerene su i relacije s kognitivnim mjernim instrumentima (Viskić-Štalec i Katović, 2001).

OSTALA ISTRAŽIVANJA UPORABOM ELEMENATA TEHNOLOGIJE PRIVIDNE STVARNOSTI

Fleksibilnost elemenata čine prividnu stvarnost medijem prilagodljivim različitim vidovima istraživanja. Rezultati takvih istraživanja ne govore isključivo o sposobnostima ili postignućima ispitanika, nego, često i više, o uspješnoj ili neuspješnoj integraciji prividne i stvarne okoline te o komunikaciji čovjek-stroj (Gentilucci, Jeannerod, Tadary i Decety, 1994; McCormick i ostali,1998; Werkhoven i Groen, 1998; Slater, Steed, McCarthy i Maringelli, 1998).

SPORTSKE SIMULACIJE, IGRE I ZABAVA

Tehnologija prividne stvarnosti u prvom je koraku, kako je to uobičajeno s informatičkom tehnologijom, našla masovnu primjenu u zabavi (TV, film, igre i sl.), a tek potom u simulacijama usmjerenim prema zahtjevima sporta. Na to je utjecala velika realističnost simuliranih sportskih igara (osjet fizičke i vizualne uronjenosti, kao i povratne informacije o taktilnom podražaju u kontaktu s protivnikom ili sportskim objektom). Posebna pažnja usmjerena je hendikepiranim osobama, osobama sa smetnjama u razvoju i dr. VR simulacije se koriste i u trenažnom procesu u fitnes centrima, *racquetball*-u, *squash*-u, bejzbolu, golfu, stolnom tenisu, bobu, skijaškom spustu, nogometu, sinkroniziranom plivanju, padobranskim skokovima (Pimentel,1993; Johnstone, 1990; Hamilton, 1992; Todorov i suradnici, 1997; Li, 1993; Puttre, 1993; i drugo).

KINEZIOLOGIJA – STANJE STVARI

Za kineziologiju, usmjerenu prije svega istraživanju različitih vidova pokreta i posljedica procesa vježbanja, tehnologija prividne stvarnosti mogla bi biti pravo otkriće: istraživanje antropoloških dimenzija, trenažni procesi, nepregledne mogućnosti simuliranja okoline u koju se uranja sportaš itd., samo su neke od mogućnosti primjena. Interdisciplinarnost kineziologije više nego ikada mogla bi doći do izražaja. Mnoga istraživanja koja su zbog materijalnih ili humanih razloga nedostupna kineziologu ili stručnjacima dodirnih znanosti, novom tehnologijom postaju moguća. Ovaj pregled radova s tim je ciljem i prezentiran čitatelju: probuditi interes u istraživača koji rade u kineziološkoj praksi, kao i onih u kineziologijskoj znanosti.

Ključne riječi: *prividna stvarnost, kompjutorska tehnologija, kineziologija*