PHYSICAL ACTIVITY IN VIRTUAL REALITY

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The purpose of this conference is to discuss about research on human physical activity based on Virtual Reality (VR). VR 1) offers a unique compromise between control and ecological property of the studied situation, 2) enables to enrich/modify the physical environment, 3) provides control on the multisensory feedback given to the user, 4) and has the potential to enhance motivation and increase the number of repetition in motor skills training. Recent democratisation of immersive technologies, with the development of cheap interactive devices for videogames, has encouraged research in this domain. In this conference, we will address examples of perception-action coupling analysis based on VR, will analyse how technical choices could affect the behaviour of the studied subjects, and will expose perspectives in motor skills training based on VR.

KEY WORDS: virtual reality, interactions, motor skills training, experiments in VR.

INTRODUCTION: Virtual Reality is now widely used in many domains, for entertainment, but also in serious applications, such as analyzing the behaviors of subjects, or training skills in highly controlled environment. VR is based on interactions between a user and numerical simulation through interfaces. This paradigm is a unique chance to control multi-sensory feedback and analyze the perception-action loop in complex and almost ecological situations. The talk will be organized in three parts. The first part will focus on experiments that have been carried-out to analyze such a perception-action loop in sports duels, such as thrower-goalkeeper interactions in handball, deceptive motions in rugby and free-kick in soccer. The goal was to identify the kinematic and kinetic variables used by a subject in order to anticipate the final goal of the opponent. In such highly constrained situations, unrealistic behavior of the simulation would compromise the experiments and make impossible to transfer knowledge acquired in VR to real practice.
Thus, in the second part of the talk, we will discuss about the influence of technological choices in such type of experience. Visual feedback are computed by the computer thanks to an approximation of the real world. Is this approximation a problem in such perception-action loop? In addition to vision, other multisensory feedbacks may be difficult to manage, such as feeling the mass and contact with a ball. Thus, we are currently exploring original methods to compensate the weakness of current physical interfaces to make users feel the forces in the virtual environment.
The last part of the talk is dedicated to training motor skills in such type of environment, which raises the problem of transferring skills from virtual environments to real situations. This training process requires to design a virtual coach that would be able to automatically detect errors or possible improvements in the users' performance, which is still a challenge. Once such errors are identified, what type of feedback is the most convenient one to make users adapt accordingly and improve their performance?

PERCEPTION-ACTION COUPLING ANALYSIS WITH VR: The goal is to study how perception influences choices about which action to perform and how the choice of action influences subsequent perception. We have proposed to use interactive immersive VR as a mean of studying the perception/action loop in athletes. First of all we can use this type of VR to simply study perception by asking players to make judgments about what will/could happen next (for example where will the ball go when the end part of the ball's trajectory is cut-off). Then having studied what perceptual information is important, the action component can then be introduced to complete the loop. In previous works, we have proposed a framework that handles these two kinds of experiments. It was based on videogames technology, with a dedicated computer animation engine. To demonstrate the two kinds of experiments, we present two case studies: the goal of the first one, which is a perception only task, is to evaluate skilled and novice rugby players' ability to detect deceptive movement (Brault et al., 2010). The second one concerns a perception-action task whereby handball goalkeepers' responses (action) when faced with different throwing actions/ball trajectories (perception) (Bideau et al., 2004; 2010) are analyzed. In this last case, it is imperative to standardize the throw and to provide a real time interaction between the goalkeeper's movements and the ball trajectory in order to evaluate successful interception. As the movement of the thrower in both instances has to be performed by a real human the resulting actions will be inherently variable, and hence the throwing action and resulting ball trajectory cannot be exactly reproduced and are not standardized in real-world experiments. Likewise using a video system which would allow for the same action to be presented repeatedly, collision detection between the ball and the goalkeeper limbs cannot be attained and the point of view of the subject is not changed accordingly with his head movement, leading to decouple perception and action.

Using virtual reality therefore allows us to overcome these limitations by providing an environment with standardized throws and a real time interaction between the handball goalkeeper and the ball trajectory, as shown in Figure 1. We have shown that large scale immersive systems (named CAVEs) with simulated throws performed by virtual opponents could lead to natural behavior of the goalkeeper. We also have shown that performance of goalkeepers in such an immersive environment was more similar to real performance than when using video, as generally performed in previous works (Vignais et al., 2015).

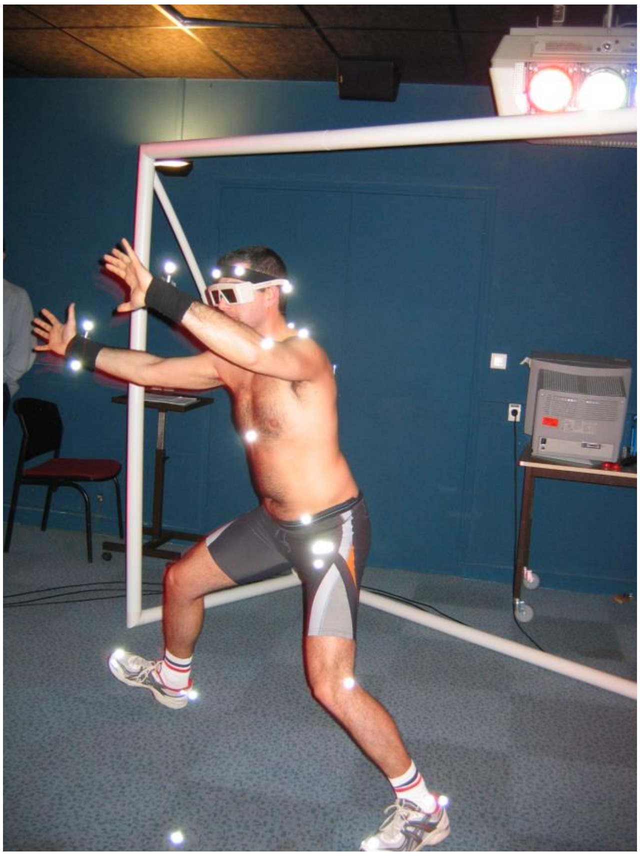

Figure 1: handball goalkeeper trying to intercept virtual ball thrown by a simulated opponent in order to study the perception-action coupling in this simulated situation.

We extended this work to evaluate skilled and novice rugby players' ability to detect deceptive movement in the attacker-defender interaction. A potential variable that could allow players to accurately detect a reorientation in body alignment in a deceptive movement (and as a result a change in running direction) could be a spatio-temporal variable that encapsulates not only the magnitude of a motion-gap (distance, angle or force) but its current rate of closure. In collaboration with Queen's University Belfast, we used VR to evaluate if this variable was relevant for such duel situation (Brault et al., 2012). We concluded that this was a relevant variable taken considered by the defender to distinguish deceptive and non-deceptive motions.

DOES TECHNOLOGY INFLUENCE MOTOR PERFORMANCE IN VR:

VR is based on an user interaction loop with a simulated environment thanks to devices. These devices enable the system to capture the current state of the user, to compute a relevant simulation accordingly, and to provide him with coherent multisensory feedback. During this interaction loop, series of inaccuracies and delays could occur, which could lead to a different situation compared to real world. We have carried-out series of experiments to better understand the impact of various technological choices on the way subjects perform a motor task in VR, compared to real world. For example, we have shown that handball goalkeepers adapt their motor performance when intercepting ball thrown by virtual throwers displayed with various levels of details (from point clouds to fully rendered 3D models) (Vignais et al., 2009). We also concluded that third person view leaded to more realistic basketball free throws in VR than first person view, supporting the assumption that the latter visual condition leads to larger distance underestimation in VR compared to third person view (see Figure 2) (Covaci et al., 2015). We also proposed metaphors to enhance the experience of navigation in large virtual environments and to provide illusion of force feedback in lifting tasks (Jauregui et al., 2014).

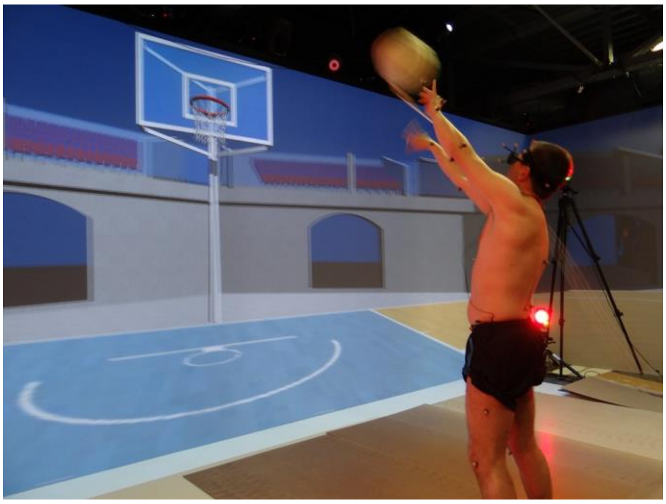

Figure 2: First and third viewpoint conditions in virtual basketball free throw.

TOWARDS VIRTUAL COACHES TO SUPPORT MOTOR SKILLS TRAINING:

VR is commonly used to train complex procedures in many application domains, such as maintenance of costly or dangerous systems, emergency procedures or interviews. However training motor skills is still a complex problem especially if we aim at transferring the skills learned in VR to real world. Indeed, training in Nintendo Wii tennis does not enhance real tennis skills. We have evaluated the impact of using (or not) real-time avatars in karate VR-training, assuming that real-time feedback of the subject's performance could help to adjust motion. The results do not completely support this hypothesis (Burns et al., 2010). Although we has shown that VR leaded to similar performance enhancement than video or real training did, we did not notice significant advantage of using real-time avatars to help the subject. Training motor skills using VR is consequently a still open problem that require multidisciplinary approach.

CONCLUSION: With the wide use of cheap immersive systems in the public audience, many impressive training systems have been proposed using this technology. Although VR offers promising advantages to understand and train motor skills, many questions are still unsolved. For example, being able to select the most appropriate technological solution and type of feedback rises many fundamental and practical questions. Research in sports biomechanics should help researchers in VR to better understand the relevant variables to train and to evaluate. It would also provide them with useful information to search for new technological solutions. Reversely, this technology should be useful in sports biomechanics to address new challenges with a better compromise between experimental standardisation and naturalness.

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