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A Virtual Reality Handball Goalkeeper Analysis System

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Abstract

Understanding how professional handball goalkeepers acquire skills to combine decision-making and complex motor tasks is a multidisciplinary challenge. In order to improve a goalkeeper's training by allowing insights into their complex perception, learning and action processes, virtual reality (VR) technologies provide a way to standardize experimental sport situations.
In this poster we describe a VR-based handball system, which supports the evaluation of perceptual-motor skills of handball goalkeepers during shots. In order to allow reliable analyses it is essential that goalkeepers can move naturally like they would do in a real game situation, which is often inhibited by wires or markers that are usually used in VR systems. To address this challenge, we developed a camera-based goalkeeper analysis system, which allows to detect and measure motions of goalkeepers in real-time.

Categories and Subject Descriptors (according to ACM CCS): Computer Graphics [I.3.7]: Three-Dimensional Graphics and Realism—Virtual reality Information Interfaces and Presentation [H.5.1]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1. Introduction

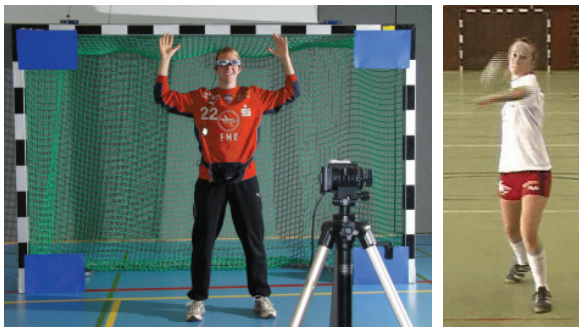
World class handball goalkeepers need to anticipate ball trajectories, rapid visual cue processing and efficient motor control, since handball is one of the fastest indoor sports. Choosing an appropriate reaction to protect the goal is based on the perception of the shooter's motions [BMK*04]. Sophisticated strategies and motions which are essential to save balls thrown with more than 120km/h must be trained over many years. But, the question which cues the goalkeepers exploit to succeed at making a save often remains unanswered.

Virtual reality (VR) systems can help researchers to gain an understanding of how humans acquire skills to perform complex motor tasks. Sports like handball require a set of cognitive skills of players, such as anticipation, techniques, decision-making and also social behavior. For them, improving these skills is mandatory, due to the competition of skilled performers [SB09]. Therefore, in sport sciences as in others, controlled conditions for experiments are needed to gain reproducible and reliable measurements of the performance of players. Virtual reality technologies provide a way to standardize experimental situations and are already used by researchers around the world [BKV*10]. But still, research in the domain of sports rarely employs VR technologies [Ric09]. One major reason for this is the often inconvenient instrumentation required to track user motions, which restricts and limits natural motion. The ability to allow players to move naturally is particularly important for the training of professional players. Another reason are the expenses for VR systems, which hinder a broader range of goalkeepers to apply them for home training. To address this challenge, we developed a camera-based goalkeeper training and analysis system, which consists of consumer equipment and is used for professional analysis of players' motions and performance of handball goalkeepers in the youth national teams of the German Handball Federation and their talent identification.

2. Handball Goalkeeper Analysis System

2.1. Hardware Setup

Our approach allows to perform goalkeeper reaction analysis both in gymnasiums and arbitrary rooms with reasonable dimensions (e. g., $7m \times 3m$) and preferably uniform lighting.



(a) (b)

Figure 1: (a) Handball goalkeeper analysis system in use with light-weight head-mounted display. (b) A pre-recorded video snapshot of a shooter aiming at one of the corners of the goal. The videos are recorded with a visual angle of average goalkeepers' height.

We either instrument goalkeepers with a light-weight Carl Zeiss Cinemizer Plus head-mounted display (HMD) or use a projection screen for the visual stimulus presentation, i. e., no additional hardware equipment restricts the goalkeepers' freedom of movement. A low-cost Philips SPC1030 USB webcam with 60 frames per second (FPS) is used for markerless computer vision based detection of the goalkeeper's reactions and motions. Therefore, we capture the goalkeeper's body in front of uniformly colored patches of rectangular shape, which are attached to a goal-sized wall or goalposts (see Figure 1(a)). Due to the low computational power requirements of the goalkeeper analysis system, an Intel computer with Core2 Duo processor, 4GB of main memory and *n*Vidia GeForce G210M graphics card suffices for both the visual stimulus presentation and the goalkeeper analysis system.

2.2. Goalkeeper Reaction Analysis

We divided the goalkeeper reaction analysis process into a calibration, visual stimulus and a detection phase.

In the *calibration phase* the detection areas are determined. Therefore, an interior point of one of the aforementioned uniformly colored patches is selected using the mouse in a webcam stream visualization. The color of the selected point is taken as the initial detection *color threshold* in HSV color space. A flood fill algorithm with a kernel of size 3 (i. e., a 7×7 pixel area) is used to overcome gaps in the webcam images. From the range of pixels with color values in the interval defined by the color threshold and a maximum tolerance value, we iteratively update the axis aligned bounding rectangle and the color threshold of the detection areas.

In the *visual stimulus phase* pre-recorded videos of a shooter aiming at one of the corners of the goal (illustrated in Figure 1(b)) is presented to the goalkeeper either on a HMD or on a projection wall.

The *detection phase* begins after the visual stimulus ends. In case the number of pixels with color values between the determined color thresholds falls below a given tolerance for one of the detection areas, a goalkeeper reaction is detected and logged. If the goalkeeper moves her hand or foot into one of these areas, she occludes parts of the uniform background. As a result, we are able to determine if the goalkeeper reached into the correct corner of the goal, as well as measure the time difference between the visual stimulus and the detected reaction. At the end, the results are analyzed to score the performance of each goalkeeper.

3. Conclusions and Future Work

In this poster we presented a goalkeeper training and analysis system that allows to track reactions of goalkeepers without restricting or limiting their natural movements. The system can be used for training purposes without the danger of goalkeepers internalizing unnatural movements. The system is currently in use for performance analysis of goalkeepers for the youth national teams of the German Handball Federation and their talent identification. In the future we will adapt the system according to the results of the currently running field test. In particular we plan to replace the low-cost camera with a high-speed camera for more accurate reaction time measurement, and extend the presented system for full-body silhouette analysis.

Acknowledgments

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