The Intelligent Coaching Space: A Demonstration

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Abstract. Here we demonstrate our Intelligent Coaching Space, an immersive virtual environment in which users learn a motor action (e.g. a squat) under the supervision of a virtual coach. We detail how we assess the ability of the coachee in executing the motor action, how the intelligent coaching space and its features are realized and how the virtual coach leads the coachee through a coaching session.

Keywords: Coaching, Virtual Reality, Motor Skill Learning

1 Introduction

This demonstration presents the current state of the ICSPACE (Intelligent Coaching Space) project. In this project we are building an immersive virtual environment in which users are learning a motor action (e.g. a squat) under the supervision of a virtual coach. The project combines expertise from several disciplines such as sport psychology, computer graphics, human computer interaction and computational linguistics.

This short demonstration paper describes how we assess the ability of the coachee to execute the motor action (Section 2), how the intelligent coaching space and its features are realized (Section 3), the virtual coach (Section 4) and finally the demonstration version of the system (Section 5).

2 Coachee Assessment

We have two ways to assess the ability of the coachee to execute the motor action being taught. In the first, we look how the motor action is represented in the coachee's long-term memory (see Section 2.1). In the second, we analyze their performance of the motor action using motion tracking and analysis (see Section 2.2).

2.1 Cognitive representation and neurocognitive diagnostics

As a perceptual-cognitive source for subsequent intelligent virtual coaching based on multilevel analysis of motor action [2], the coachee's memory structure of

Fig. 1. The Intelligent Coaching System with virtual mirror and virtual coach.

the motor action to be learned is assessed and analyzed using the structural-dimensional analysis of mental representations (SDA-M) [4]. This splitting method provides psychometric data regarding the coachee's memory structure, revealing the relations and groupings of basic action concepts (BACs) of a complex action in long-term memory. By comparing the coachee's structure to an expert structure, errors are identified and appropriate instructions are chosen based on these errors. This serves as a perceptual-cognitive source for the virtual, intelligent coach to support motor learning and structure formation [1].

2.2 Motion Tracking and Analysis

To track the movement of our coachee we use a 10-camera Prime 13W OptiTrack motion capture system. The Motion Tracker uses information obtained from passive markers attached to a motion capture suit to calculate 20 joint angles / positions of the user.

To segment this data stream of joint angles and positions, recognizing the motor action we are interested in, we use a state machine approach. Each segment of a motor action is defined by a movement primitive. We search our data stream for a posture similar enough to the first key position of the first movement primitive of a given motor action. It will remain in this segment state until a posture is detected that is similar enough to the first key position of the next movement primitive.

Given segmented motor actions, we analyze the execution of the motor action looking for Prototypical Style Patterns (PSPs). These PSPs describe typical errors made during the execution of the motor action. The coaching system is informed of the presence and severity of these PSPs and can use these to make decisions on what feedback to give to the user. This process is explained in more detail in [2].

3 Virtual Coaching Space

The virtual coaching space is located inside a two-sided CAVE (L-Shape, $3\,m \times 2.3\,m$ for each side) with a resolution of 2100 x 1600 pixels per side. Our render engine runs on a single computer equipped with two NVIDIA Quadro K5000 graphics cards. Rendering runs at approximately 60 fps supporting high quality character rendering, shadows, and post-processing and fulfills our low latency requirements [5].

In the virtual coaching space the user, equipped with passive 3D goggles, is located inside a virtual fitness room and stands in front of a *virtual mirror* (see Figure 1). The system maps the user's motion in real time onto an avatar to effect a virtual reflection.

The virtual world is capable of providing visual feedback on motor skill performance in several ways: users are able to observe their own movements inside the virtual mirror; the tint of the mirror adapts depending on the observed performance; and/or the problem area of the movement is highlighted on the mirror character. In our initial setup, feedback was also provided by a summary of the performance as text overlay inside the virtual world.

4 The Virtual Coach

Besides the virtual mirror we also have a virtual coach in the fitness room (see Figure 1). The virtual coach leads the coachee through a coaching session and is there to provide verbal feedback.

Realistic Character Rendering - The coach character and the character in the mirror can be rendered with photo-realistic textures. These characters are created by mapping a texture obtained using photogrammetry techniques onto a model character. Users are placed in a room and surrounded by synchronized cameras. Pictures from these camera are stitched together to form the texture that is then mapped on a model character.

Dialogue and Decision Making - The coaching session follows the dialogue structure of coaching sessions found in human-human coaching interactions [3]. The most important part of the coaching session are the coaching cycles. At the start of each coaching cycle the virtual coach selects the next *Skill-Under-Discussion* (SkUD) based on the assessment of the coachee (see Section 2). SkUD represents the part of the motor action that is currently put in focus to be improved and correspond to BACs and PSPs from the assessment modules. Given this SkUD, the coach selects the coaching act - such as instruction, demonstration or explanation - that is expected to give the most performance gain and does so until the performance on this aspect of the motor action is satisfactory.

The multimodal behavior of the virtual coach is driven by AsapRealizer [6].

5 Demonstration System

In the demonstration people will be able to experience our virtual coaching system. In the interaction with our system people will experience a short coaching interaction where the virtual coach will teach the user how to do a perfect squat.

For the demonstration we will bring a downscaled version of our virtual coaching system. The CAVE will be replaced by a HTC Vive head mounted display, while the motion tracking system will be replaced by a Kinect.

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