Applying Ambisonics to Decision-Making Research in Sport Science

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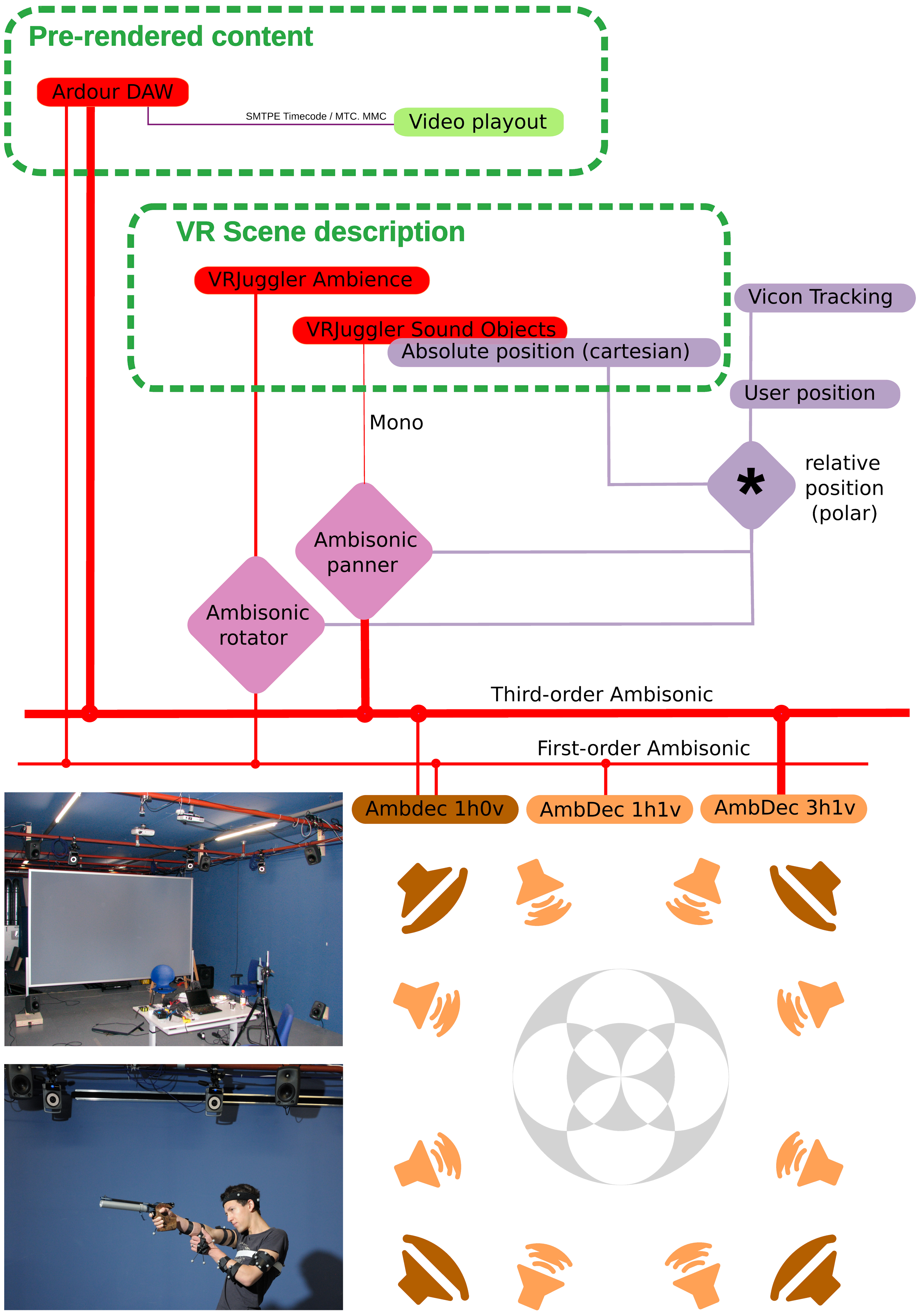
Decision making in sports has been extensively studied over the last two decades, with a particular focus on visual search strategies. However, only a few studies have analysed this process in real world settings due to reliability issues and the large amount of manual data analysis involved.
The question arises whether the inferences drawn from these lab studies provide sufficient validity for generalization, particularly as experts' perceptual advantages increase with higher "in situ"-ness of stimulus and response [1], while most studies heavily restrict both.
Consequently, it seems necessary to extend current research by keeping both stimuli as well as responses, similar to the real-world situation, while maintaining high reliability, i.e. in a virtual reality lab setting. It has been shown that humans fuse information of different sensory modalities in order to excel in deciding [2].
Therefore, in addition to providing accurate real-world visual stimuli, emphasis needs to be put on other relevant modalities, e.g. acoustic information.

To that end, the Sensorimotor Lab at ISPW has been augmented with a **16-loudspeaker Ambisonic system**, in addition to the existing 3D projection, eye tracking, and high-speed motion capturing facilities.
In its initial stage, the audio system is to provide soundscapes captured with a Soundfield ST450, such as playing field or gymnasium atmo. Later, directional auditory cues will become part of the experimental designs.



Above left: Overview of the speaker installation, taken during calibration work.
Below: Research in competetive marksmanship, showing two speakers of the upper ring and two of ten tracking cameras.

A typical experimental setup: determining decision accuracy and movement initiation time of expert beach volleyball players for different attack variations presented on a 3D projection screen. The participant is instrumented with Vicon infra-red reflective marks and an eye tracker.

Due to the constraints of room height and the demands of the video projection, a dual-octagon layout with an elevation range of (on average) -22° to +20° was chosen, with the understanding that height reconstruction will be limited. The main speakers (Genelec 8030A active near-field monitors) are complemented with four subwoofers (Genelec 7060B) in the corners of the room. The subwoofers are driven in first-order horizontal and run up to 85Hz. Hence, the decoder is tailored for max r_V mode.
On the main speakers, two decoders are running in parallel: a 3h1v matrix for panned directional cues, and a 1h1v matrix for the surround atmo. Both are operating dual-band (max r_V at LF,max r_E at HF), with a crossover frequency of 300 Hz.

The audio system is controlled by a Linux server running JACK and three instances of AmbDec [3]. Ardour2 [4] is used for playout and signal routing. For playback of external A/V media or pre-produced atmo, stereo and 5.1 inputs are available, which are then reproduced as virtual sources in third-order Ambisonics. The audio server is equipped with an RME HDSPe MADI interface connected to a DirectOut Andiamo 32-channel AD/DA converter. An RME QuadMic provides four microphone preamps for measurement microphones and other low-level sources.

Three-D visuals are provided by an interference filter rear projection. It can be driven interactively by VR Juggler [5], a virtual environment framework that can integrate a number of different tracking and visualisation systems. Such environments are described using OpenSceneGraph [6]. Alternatively, pre-rendered multichannel A/V content for experimental setups can be played back by Ardour in combination with any SMTPE or MTC/MMC capable stereoscopic video player.

The localisation performance of the audio system is currently being evaluated. The greatest challenge lies in the fact that for optimal visual immersion, the test subject should operate very close to the screen. While the "virtual sweet spot" of the speaker system can be moved accordingly using appropriate delays and matrix modifications, the effective speaker density in the most critical frontal range is lowered dramatically. The boxy room acoustic is another limiting factor, particularly if a large gymnasium or even open-air situtation is desired, as is customary for most sport scenarios. The next implementation of the Sensorimotor Lab (which is scheduled to move to bigger premises) may try to address these problems with modifications to the speaker layout and acoustic treatment of the room, depending on the lessons learned in ongoing experiments and the desired qualitity of auditory immersion and localisation accuracy.

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