Simulation Fidelity Metrics for Virtual Environments based on Memory Semantics

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A photorealistic, computer-generated interactive *environment* strives to achieve the same sense of *space* as in the real world. Subjective measures based on human spatial perception supplementary to accurate geometry, illumination and task performance, reveal the actual cognitive mechanisms in the perception of a VE that is not otherwise apparent. In this sketch, we present a methodology for the assessment of simulation fidelity of VEs, centred on a validated theory of memory awareness states. It is challenging to identify whether VE simulations, displayed on Head Mounted Displays (HMDs) and related interaction interfaces have an effect on the actual mental processes participants employ in order to achieve a spatial memory task in a VE, in relation to reality and more traditional displays.

105 participants were involved in a study which investigates participants' accurate memory recall and awareness states of elements and objects in a VE replica of a real-world room displayed on a typical desktop monitor or on a Head Mounted Display (mono, stereo, head-tracked or non-head tracked). Each memory recall question included a choice between four awareness states for each object recall. Traditional memory research has established that *'Remember'* and *'Know'* are two subjective states of awareness linked with memory recollections. Some elements of a visual space may be 'remembered' linked to a specific mental image or could just pop-out, thus, could be just 'known'. Remembering refers to experiences of the past that are recreated with the awareness of re-living them mentally. Knowing refers to those in which there is no awareness of re-living any experiences. What has been encountered or experienced recently, although this recent occurrence can't be recalled, could feel *'familiar'*. Also, elements of a space could be reported as a *'guess'*.

The radiosity rendering was based on photometry data acquired in the real space. The resultant space memory recall and cognitive states as well as participants sense of presence is compared with that obtained from an analogous experiment in the actual physical space. The extent to which judgements of memory recall, memory awareness states and presence in the physical and VE are similar provides a measure for the fidelity of the simulation in question.

Overall, the level of presence was higher for the real condition compared to the HMD and desktop conditions. Across the technological conditions, presence and memory recall, due to the high quality of the rendering, were similar. Results show that the navigation method (head movements vs mouse) has an effect on the cognitive strategy adopted and therefore on the type of memory representation of the scene. In particular, the proportion of accurate responses under the 'remember' state was significantly higher for the HMD-monocular-mouse condition compared with the HMD, mono/stereo head-tacked conditions and also the real world and the desktop conditions. These responses showed a weaker mnemonics' strategy for this particular condition, expressed by the lower proportion of correct responses under the 'know' awareness state.

A VE system is likely to involve navigation in a synthetic space and rarely, in this process will the participant employ mnemonics. Does the higher proportion of correct 'remember' responses for the HMD-mono-mouse make this condition more "realistic"? Even if it gives more correct "remember" responses han the real world condition. The cognitive strategy is affected by the degree of realism of the motor response. Therefore, participants transformed the real-room task into something artificial. The utilisation of a unreal viewing method (HMD) plus a unreal motor response, such as the mouse stopped them using this mnemonic - "unreal"- strategy and resulted in a more natural distribution of remember/know responses than even the real scene. By decreasing the degree of reality both of the viewing system and of the motor response, participants -paradoxically- adopt a more natural strategy. Something less "real", but more

demanding because of its novelty, may restore a more naturalistic cognitive strategy. By employing methodologies that have been examined and validated through decades of experimentation, as the memory awareness states methodology, computer graphics research and VE technologies get closer to actually exploiting the human perceptual mechanisms towards successful applications.

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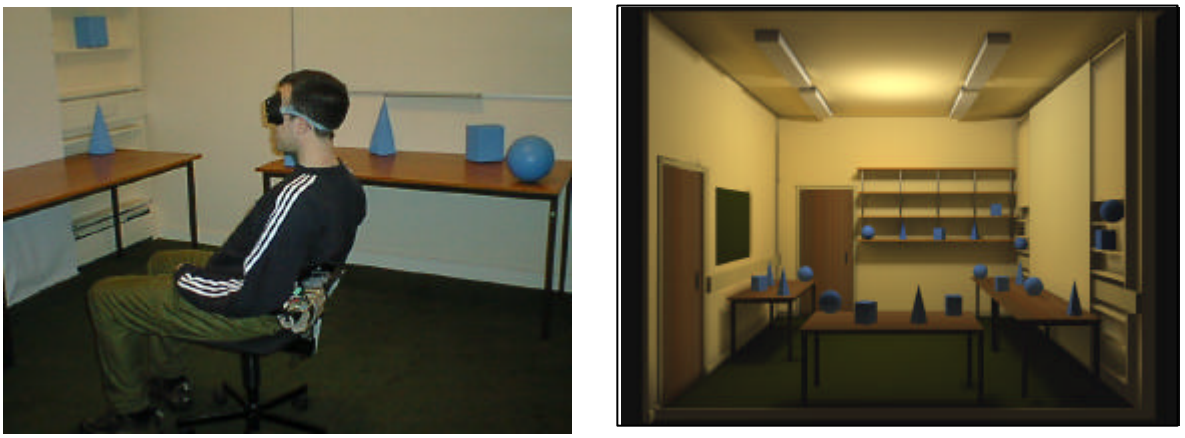

Figure 1. Real and VE.

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