CoDiS Lab

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Master Theses

Visualization Techniques and Haptic Feedback in Virtual Reality Learning Environments

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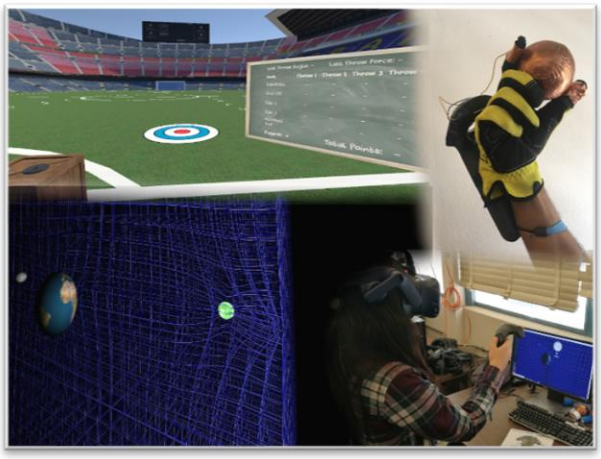
Virtual Reality Learning Environments (VRLEs) have proven to prevail in certain applications over conventional learning methods by drastically improving immersion, interactivity and especially interactive visualization. While being already adopted in various mainly educational institutions, Virtual Learning Environments (VLEs) remain a topic of an open debate whether its influence is exclusively positive. Till this day on there is active research happening trying to shed more light on this question.

Among all the aspects that require such an investigation, two of them were selected and looked into in this thesis, becoming objectives of two separate projects. The adopted approaches concentrate on the effect of visualization techniques chosen for complex theories and formulas in an immersive, interactive way and the other one on the influence of haptic feedback on intuitive learning and performance improvements. The positive effect of haptic feedback in such applications as medical simulations appears to be doubtless; however, in other implementations this influence may appear not beneficial enough for the potentially expensive hardware or cumbersome implementation. The second objective was to further inspect the qualities of dynamic visual representations of complex formulae, which have already often shown higher long-term results in understanding and memorization. Both studies together involved close to 100 study participants.

The first VRLE involving haptic feedback in virtual reality has shown certain trends that are supporting the initial assumption of the importance of an additional haptics channel. The system included conventional virtual reality controllers with custom modifications - a simple but effective method of introducing haptic feedback elements. Under the restrictions and limitations of the setup a general statement of the effectiveness of mixed reality systems could not be derived, but certain important insights were obtained nevertheless. Furthermore, notable influence of the quality of such a low-budget setup on the haptics implementation could be identified - therefore, future work on the matter is required to make use of a more reliable hardware implementation.



The second project examines a visualization technique for gravitational waves and their effects, a recent discovery in astrophysics. An immersive and interactive VRLE experience was implemented where participants could explore the influence of gravitational waves freely with an understandable visual channel and several interaction methods. The user study conducted within this project has shown a striking improvement in understanding among the testing respondents.
Additionally, strong indications of high engagement and positive influence of the application could be identified within an immersion analysis via the Game Experience Questionnaire in both studies.