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Exploring assisted scene understanding in virtual reality: Task-based and human behaviour-based approaches

Système d'aide en réalité virtuelle pour la compréhension de scène de crime : design centré humain VS design centré tâches

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ABSTRACT

We aim to extend the design space of help systems in virtual reality for data exploration by putting an emphasis on real time human behaviour analysis. We presented and evaluated a help system model using a task-based and a human behaviour-based approaches.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**.

KEYWORDS

Interaction technique; virtual reality; adaptive computing; cognition; models.

RÉSUMÉ

Nous souhaitons étendre l'espace de conception des systèmes d'aide en réalité virtuelle pour l'exploration des données en mettant l'accent sur l'analyse du comportement humain en temps réel. Nous présentons et

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évaluons un modèle de système d'aide utilisant une approche basée sur les tâches et une approche basée sur le comportement humain.

MOTS CLÉS

Techniques d'interaction; réalité virtuelle; adaptation automatique; cognition; modèles.

CONTEXT

Key challenges have been raised by *Immersive analytics'* community, and of these, we focus on two in particular: 1) the changing of analysis process using immersion; and 2) the idea of combining human and computer intelligence [3, 7]. Boger *et al.*[1] highlighted that people do not see what they are not focused on and thus miss the obvious elements of their environment. So relying only on environment structure and tools is not perfect to perform analysis, in particular during exploration of data, when you are unsure what your searching for [4]. In this paper we want to build an informed environment that includes a help system for exploration.

Literature also raised the question of user empowerment in visualization research and noticed the relevance of designing systems, especially immersive ones, as superpowers providers [6, 8]. Willett *et al.*[8] built a framework to understand cognitive mechanisms behind super-powers description in fantasy and science fiction. With our helping system, we focused on enhancing 3 specific cognitive mechanisms, attention, recall and comparison, described to induce super-deduction power. Our approach here is to provide an adaptive help according to the human-behaviour. To do so, our help system will tackle real time recognition and exploitation of humans affective and cognitive states (described deeply by Luong *et al.* in [5]), in order to enhance aimed cognitive mechanisms. In summary, helping systems in VR present mainly a task-based approach. In data exploration context, a human behaviour-based approach can be more relevant now that physiological data is widely use for cognitive state estimation in VR. This work is at the frontier of adaptive VR systems and cognitive science usage in VR.

HYPOTHESES

Hypotheses formulation

Data analysis can be biased by task designers [2] and there are different interesting level of details during exploration. Data exploration efficiency can either be based on the main points of interest discovery, either on small or edgy points of interest discovery. We considered the helping system model described in Figure 1. Which helping system approach gives the best trade-off between efficiency and unbiased exploration ? To tackle that question, we consider 3 variations of our system: [V.1] There is no helping system. [V.2] Our helper decision model has access to data-based & TASKS_BASED knowledge,

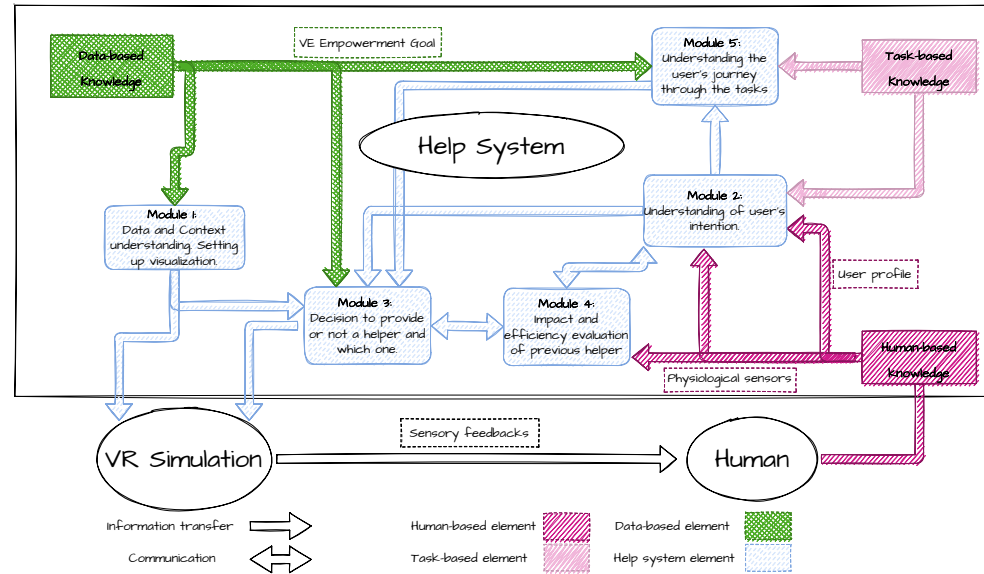


Figure 1: Adaptive virtual environment model for data analysis helping system. Each blue element is a unit of the model. They communicate to evaluate which helper is needed for the user. In dark pink and light pink are shown where the two approaches (TASKS_BASED and BEHAVIOUR_BASED in that order) impact help system logic.

i.e. only light pink elements in Figure 1. [V.3] Our helper decision model has access to data-based & BEHAVIOUR_BASED knowledge, i.e. only dark pink elements in Figure 1 Based on these variations, our hypotheses about our model are the following: [H.1]: Overall performance during a data exploration phase is better using V.3 than V.1, which means that using a BEHAVIOUR_BASED only approach is valid. [H.2]: Main performance during a data exploration phase is better using V.2 than V.3, which means that a TASKS_BASED approach is more efficient for the focus on main points of interest. [H.3]: Even if the help system may reduce user experience comparing to V.1, using V.3 will provide a better user experience than V.2. [H.4]: Performance on edgy points of interest during a data exploration phase is better using V.3 than V.2, which means that a BEHAVIOUR_BASED approach is more efficient for unbiased exploration.

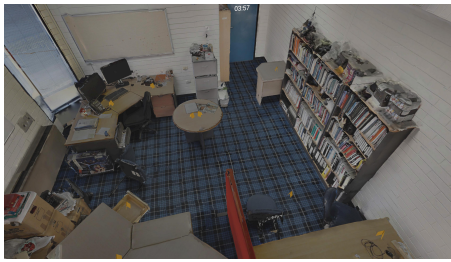


Figure 2: The reconstructed office to explore in VR. It shows the room where the robbery occurred. In the scene, 12 orange crime scene markers have been placed. 8 are showing the correct location of stolen objects, 4 are decoys

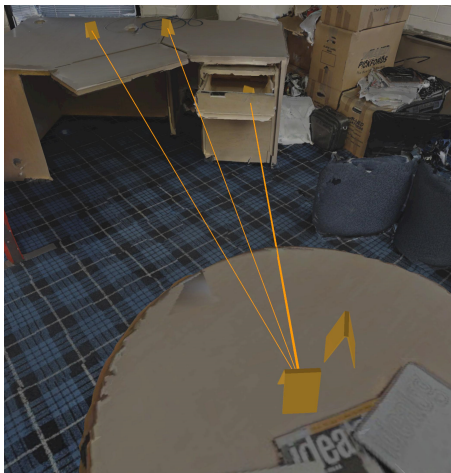


Figure 3: Example of visual helping system used for TASKS_BASED and BEHAVIOUR_BASED.

Hypotheses evaluations

In order to conduct a user study validating the model's hypotheses described above, we defined the study hypotheses and users tasks to carry on. The experiment uses a between-subjects design, where each of the 66 participants experienced one of 3 helping system. We selected a crime scene understanding use-case (see Figure 2) where our model would display predefined helpers. Figure 3 shows a helper example. Here, stolen objects positioning and scenario understanding are the main points of interest guiding the exploration. However, spatial understanding of the room and attention to details are also evaluated, even if they are may not directly linked to the main interests points. User experience was also assessed. Therefore, our 4 main categories of evaluation are : Narrative recall, Spatial understanding, User experience, and Attention to scene's details.

RESULTS

Results show that [H.1] seems validated, [H.2] et [H.4] seems inconclusive and [H.3] seems partially validated. Moreover, two different strategies arose: On the one hand it seems that a task based approach makes users more focus on exploration's main elements. Their confidence in the acquired knowledge is increased and tend to be very careful on non explored elements. On the other hand, a human behaviour based approach makes users more aware of non-main elements. The strategy used is more exploratory and tackle all information available even if it may not be relevant in the end.

FUTURE WORK

During my Phd, I am seeking to develop recognition and usage of cognitive mechanisms in VR. With this work I tried to validate that helping system can be used to impact cognitive mechanisms, with a focus on attention, recall and comparison mechanisms. My next step is developing cognitive illusions concept in VR, in order to design useful interaction technique based on biases usage.

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