Human factors consideration in the interaction process with virtual environment

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1 Introduction

New requirements are needed by industry for computer aided design (CAD) data. Some techniques of CAD data management and the computer power unit capabilities enable an extraction of a virtual mock-up for an interactive use. CAD data may also be distributed and shared by different designers in various parts of the world (in the same company and with subcontractors). The use of digital mock-up is not limited to the mechanical design of the product but is dedicated to a maximum number of trades in industry. One of the main issues is to enable the evaluation of the product without any physical representation of the product but based on its virtual representation.

In that objective, most of main actors in industry domain use virtual reality technologies. These technologies consist basically in enabling the designer to perceive the product in design process. This perception has to be rendered to guarantee that the evaluation process is done as in a real condition. The perception is the fruit of alchemy between the user and the VR technologies. Thus, in the experiment design, the whole system human-VR technology has to be considered.

2 Product evaluation in virtual environment

Evaluation of the product is the final stage done before the decision making and the production launching. Of course, this stage is complex because several decision makers act at this level. So, the process is often done in an iterative way with several loops occurring on the definition of the product [1-5]. If major industries develop a virtual representation of their product, it subsists nevertheless a final step where several physical prototypes are performed for the evaluation process required to take a decision on the design. The use of virtual mock-up facilitates the diffusion of technologies to compare different possible solutions faster than with the physical representations. The use of VR technology implies a perception process depending on the coupling between the user and the interaction process. This interaction process is done through the relation between the virtual mock-up and the virtual representation of the user.

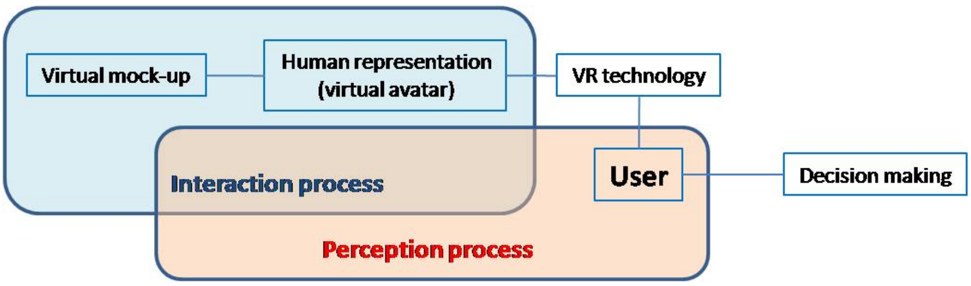

Figure 1. Relation between the user and the virtual mock-up.

With the use of very large screens, the user is surrounded by images of the virtual world, facilitating his immersion in that virtual world. With the technologies of stereoscopic rendering (using polarized glasses for example), the user can perceive the 3D model with the stereoscopy. The real time 3D tracking system enables the virtual world reference to correspond to the real world reference. Then, the user could move around the virtual prototype as he would do with a real one [6-12]. In conjunction with large screens, the virtual prototype could be rendered at human scale [13]. The sense of vision is one of the most important to perceive the world but is not unique. 3D sound technologies could render the sound effect with a localization of the sound in the space. Haptic devices (force feedback and tactile feedback) give the user the perception of the touching on virtual object. All these different technologies contribute to the perception of this new virtual environment. Of course, cognitive factors play an important role in the perception process [14-15].

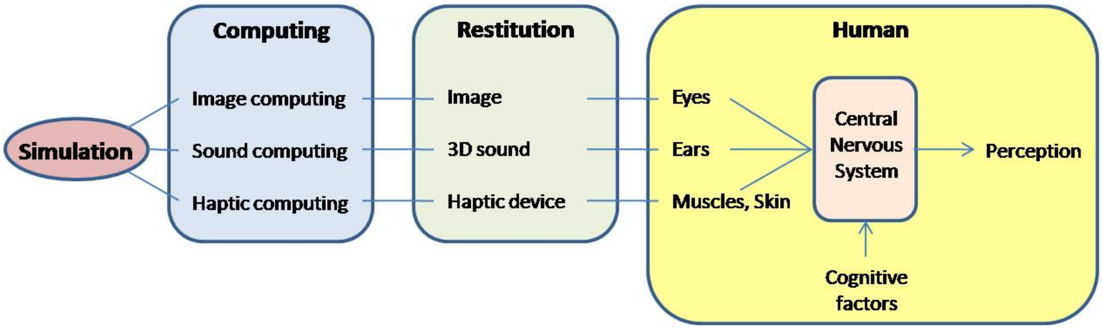

Figure 2. VR technology to perceive virtual world.

With these technologies, one important goal for industrials is to take a decision in a similar way in virtual environment than in real environment. The challenge is to evaluate the product in virtual immersion as in the real condition.

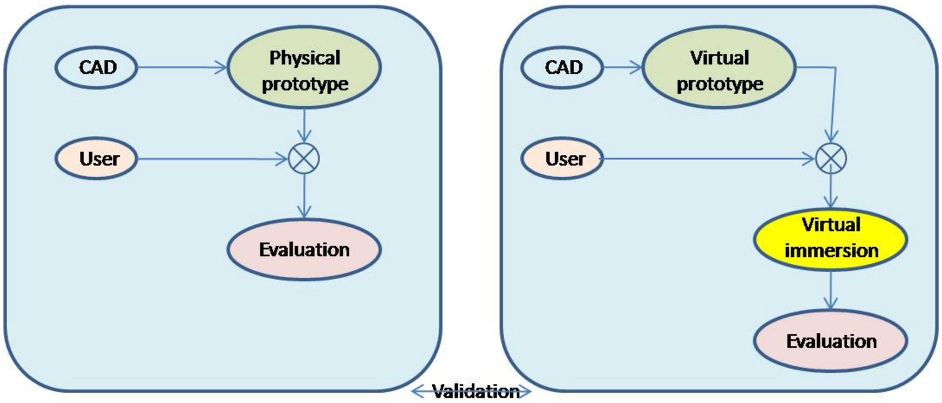

Figure 3. Virtual immersion for process of product evaluation.

3 Scientific issues

To attain these goals, different scientific issues have to be addressed. Because virtual immersion consists in surrounding a user with technology, scientific issues are linked to technology and human factors consideration. Thus, from CAD technology to human factors consideration, scientific issues can be grouped in the VR technology and perception items.

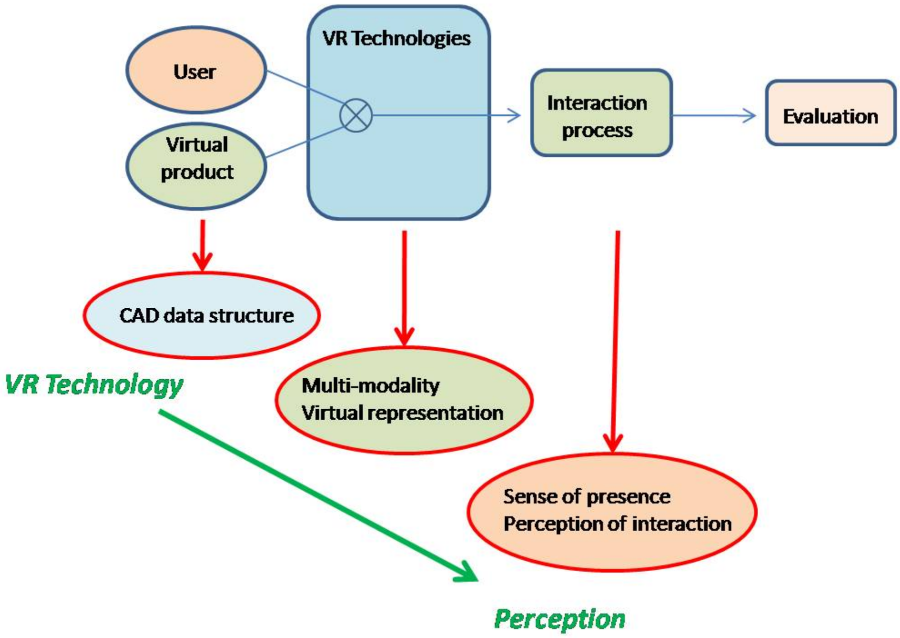

Figure 4. Scientific issues on virtual immersion.

3.1 VR technology issue – From technology point of view, strong scientific issues occur at different levels. The following topics could be noted:

- *CAD data structure:* one important problem is to enable the design process of product with the use of VR technology. But, due to real time constraints, the CAD data has to be simplified on a virtual mock-up (which can be managed in real time). The challenge is to propose a data structure to make possible the reverse process from modified virtual mock-up to CAD data description.
- *Multi-modality:* to improve the immersion of user in the virtual scene and his interaction with the virtual mock-up, several senses could be excited (vision, ear, haptic...). The way each modality is managed is very different from one to another (for example in term of frequency). This constraint implies the use of a specific virtual mock-up for the corresponding sense as well as a coherent real time management (problem of lag).
- *Virtual representation of the body and its relation to the virtual product:* the interaction process between the virtual product and the user is managed through a representation of

the user's body [16]. This representation could be virtual (it means without concrete representation) or used to propose to the user a representation of his own body in the scene (enabling an external point of view which could be useful for decision helping).

3.2 Perception issue – Interaction process requires taking into account the user's perception of his own body interacting in the scene. Two main issues could be reported:

- *Action-perception coupling*: one important characteristic of virtual reality experience is the sense of presence in the virtual environment. To improve this sense of presence, technologies have to propose to the user to freely move around the virtual product: the sense of presence is linked to the sense of movement. Neuro-science community develops the concept of coupling between action and perception [17-22]. This concept implies that an action is simulated by the brain before being executed and the perception of an action implies a simulation of this action by the brain with the same mechanism in the central nervous system as if the action is executed. This theory validates the engagement of the whole body in an interactive process with a virtual product for a better immersion and then the use of VR technology.
- *Virtual human:* for a better understanding of interaction process and an optimization of interfaces, a virtual human has to be developed. This virtual human could include a cognitive and motor control model to anticipate the interaction process [23-25].

A challenging work is to develop VR technologies for interaction process with the virtual mock-up in taking into account human factors. Then, a fine balance has to be found between VR technology, the application and human factors. With a better understanding of the coupling between these components, human factors would be used as a guide to VR technology design.

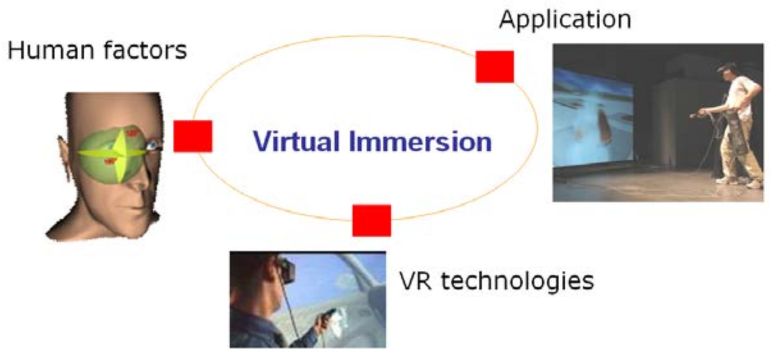

Figure 5. Key factors in virtual immersion experience.

Research works on virtual human could also be useful to enable a virtual experience of the virtual human interacting with the virtual product. Then, a simulation process for evaluating the virtual product could be performed. Lots of works need to be done yet to develop such virtual human and particularly on the domain of cognitive and motor control model.

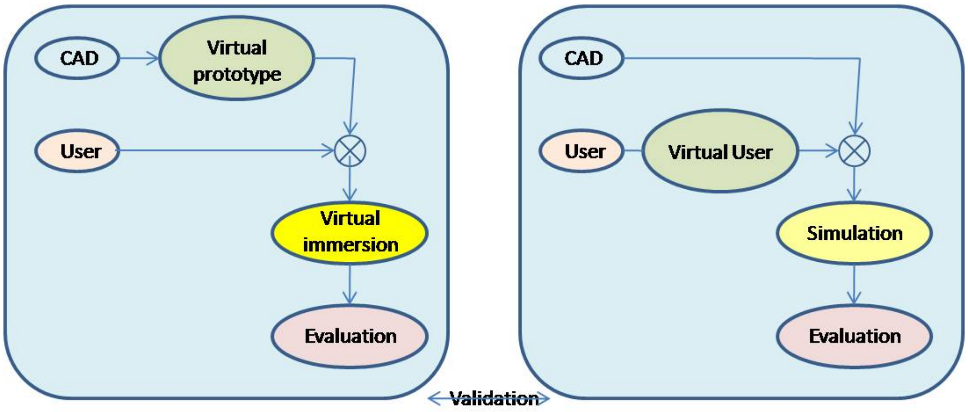

Figure 6. Toward a virtual user to optimize the evaluation process.

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