Human Machine Interface Concept For Virtual Reality Applications

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ABSTRACT

Advanced human machine interfaces, like aircraft cockpits, are difficult and expensive to design. The use of Virtual Reality technologies during the design process of the interface through early ergonomics and layout analysis can help to greatly reduce the time of development and the use of costly physical mock-ups.
Nevertheless, the use of Virtual Reality and the development of the digital mock-up must be done very carefuly.
Via the example of the Virtual Cockpit application for ergonomics studies of aircraft cockpits, this paper presents an approach which consists of a parallel study of the human-machine interface and its image: the "virtual human"-"virtual machine" interface. It introduces a conceptual model of the interface and its image, allowing the preparation of an adapted Virtual Reality application, by studying the application, the human and the machine.

Keywords

Human Machine Interface, Virtual Reality, Virtual Cockpit, Ergonomics Studies.

1. INTRODUCTION

A cockpit is an advanced human-machine interface, i.e. a complex tool of communication between a user and a machine. Its efficiency is linked to its quality, to ergonomics and to its comfort.
During the design process, a cockpit has to be tested with mock-ups. Traditionally, these mock-ups are physical: they need time to be developed and are expensive. The use of virtual mock-ups (VMU),with the help of Virtual Reality tools, instead of physical mock-ups (PMU) is greatly advantageous (easy communications between different disciplines, and saving of time and money).The development of a Virtual Cockpit application without the use of PMU, in order to simulate and provide a model and valuable information (principally for ergonomics), will help to test the interface of the cockpit very early during the design and development process. Such an application can also be used for first learning.
But the construction of the VMU and the application to test it are very complex. The use of the conceptual model of the interface presented in this paper allows a better consideration of all of these aspects, via the example of the Virtual Cockpit.
Virtual Reality tools used in this application are: a Head-Mounted Display; a glove to track the hand and fingers' movements; and a tracking system for the movement of the head, hands, and chest.

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2. CONCEPTUAL MODEL

In the model presented here, the machine corresponds to the final product (e.g. the cockpit) which has to be tested, and not to the Virtual Reality tools or computers (which are only considered as tools).
We can distinguish now two flows between the human and the machine: the first one is going from

the machine to the human and is the observation flow, and the second one, going from the human to the machine is the command flow.

Two cases must be studied in parallel: the interface between the user and the machine when a PMU is used, and when the VMU is used (see Fig.1).

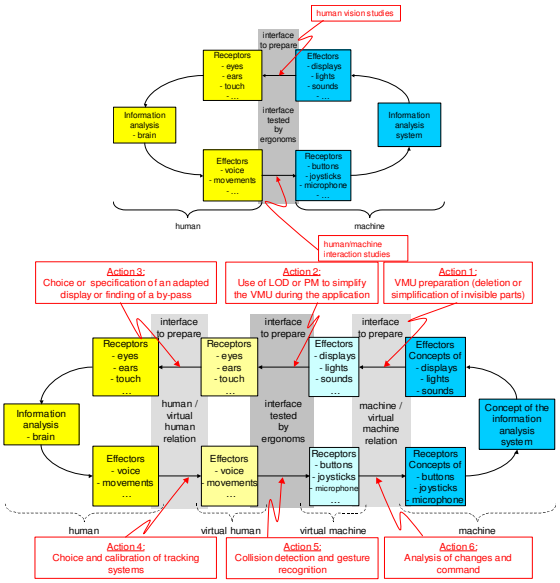

Figure 1. Human Machine interface with a PMU (upper part) or a VMU (lower part)

When using a virtual prototype, there is no physical relation between the user and the machine. The idea is then to study the relation between a "virtual human" and a "virtual machine". This relation will be the center of ergonomics studies of the human/machine interface. It is like an image of the real human/machine relation: the user is in the real world, the machine is in a "CAD/CAM world". The virtual human is the ghost of the user in a virtual world and the virtual machine is the ghost of the machine in the same virtual world. This virtual world is the bridge between two separate worlds, and is the only place where the interface can be studied.

Thus, the interface is broken up into three new ones: the human/virtual human interface (which must allow the user to command the virtual human and to receive feedback from it), the virtual machine/machine interface (which will define a simplified machine even if it doesn't appear as simplified to the user's eyes), and the virtual human/virtual machine interface (which will be used to test the human/machine interface, and then must be similar to the human/ machine interface in the case of the use of a PMU).

3. DEVELOPMENT

In order to realize the Virtual Cockpit application, using this model of human machine interface, we have to study how every link between effectors and receptors of the entities should be realized.

First, the human/machine interface when a PMU is used is studied carefully. For instance, for the observation flow, we studied how and where the user looks at the machine (lines of sight), but although which are the necessary vision characteristics (field of view, visual acuity, temporal resolution...) [Che04a]. These studies will lead the realizations of the links of the interface when a VMU is used.

Hardware and software are only tools, but the application will be dependent on their capacities. That is why they have to be chosen or developed carefully. For instance, the digital mock-up is highly detailed and it is impossible to display it with so many details at a high frame rate. It is then necessary to modify it in order to avoid this issue. With the help of the studies led on the interface when a PMU is used, we delete or simplify automatically a lot of parts of the VMU [Che04a] (see Action 1 in Fig.1). During the application, Level Of Details (LOD) [Lue03a] or Progressive Meshes (PM) [Hop96a] can also be used in order to guaranty a sufficient frame rate, in function of the virtual human line of sight [Red97a] and the vision characteristics found in the studies (see Action 2). Moreover, the immerged human must be able to see the virtual cockpit as the virtual human. Therefore, an adapted display has to be chosen (see Action 3 in Fig.1), once more in function of the human vision. Our work has focused mainly on the observation flow, but will be centered on the command flow in the future (see Fig.1).

4. CONCLUSION

During the design and development process of industrial human/machine interfaces, by studying a model of the interface with a PMU, it is possible to determine criteria that will be used as guidelines during the development of the interface with a VMU, with the help of a model which is centered around the virtual human/virtual machine relation. This model is adapted to the ergonomics studies of advanced interfaces like aircraft cockpits.

5. REFERENCES

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