MANERCOS, a new tool providing ergonomics in a concurrent engineering design life cycle

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ABSTRACT

This paper present MANERCOS, a new tool defined to provide ergonomics in a concurrent engineering design life cycle. This product design life cycle is based on cooperation between all the design actors using mediating objects such as virtual films describing the future using or manufacturing situations. This software has been developed as a 3D Studio MAX Plug-in. MANERCOS is based on an object oriented modeling and simulation approach applied to the global Man-Product-Environment system.

INTRODUCTION

MANERCOS is a new software defined to provide ergonomics in a concurrent engineering design life cycle (GOMES, 1999). MANERCOS is integrated in a 3D Studio Max environment, a commercial animation tool for PC (KINETIX, 1997). In order to analyze user activities on current products during feasibility studies, new features have been developed. These features are based on "paper and pencil" collection or video tape recorded data from real observed using situations. During preliminary studies, MANERCOS is used to create, animate and evaluate virtual models of the future Man-Product-Environment system in different using situations. A modeling and simulation approach is applied during creativity sessions on such virtual models before defining the product's design decisions. Later, it is possible to apply the same methodology to design the future manufacturing process, during detailed studies. MANERCOS is then applied to analyze current working activities and to design the future manufacturing process of the future product. In this paper, after a brief explain of some methodological foundations, we will describe MANERCOS structure and main functionalities.

MANERCOS METHODOLOGICAL FOUNDATIONS

The Computer Aided Design tool MANERCOS has been defined to provide ergonomics in different phases of a spiral product design life cycle based on cooperation between all the design actors (GOMES and al., 1998, SAGOT et al., 1999). This product design life cycle is considered as a concurrent engineering design process (Figure 1).

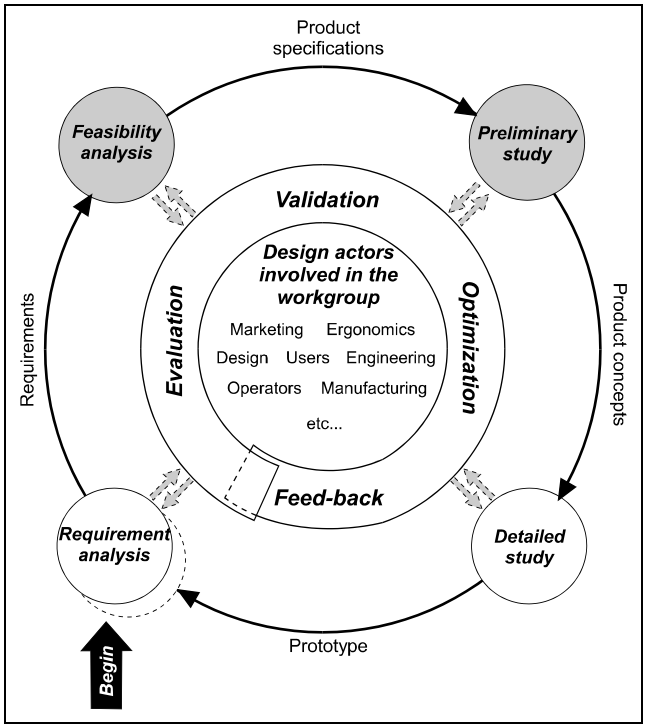

Figure 1 : A part of the spiral design life cycle

MANERCOS can be used during the feasibility

analysis (Figure 2) and the preliminary studies phases (Figure 3).

To illustrate MANERCOS methodological foundations, we will present data extracted from an automotive controls design project.

Working on a number of large-scale product and workplace design projects, we have developed a pragmatic methodology to study ergonomic design problems. This methodology is first based on a user activities analysis approach, applied to evaluate current products usability, during Feasibility analysis (Figure 2).

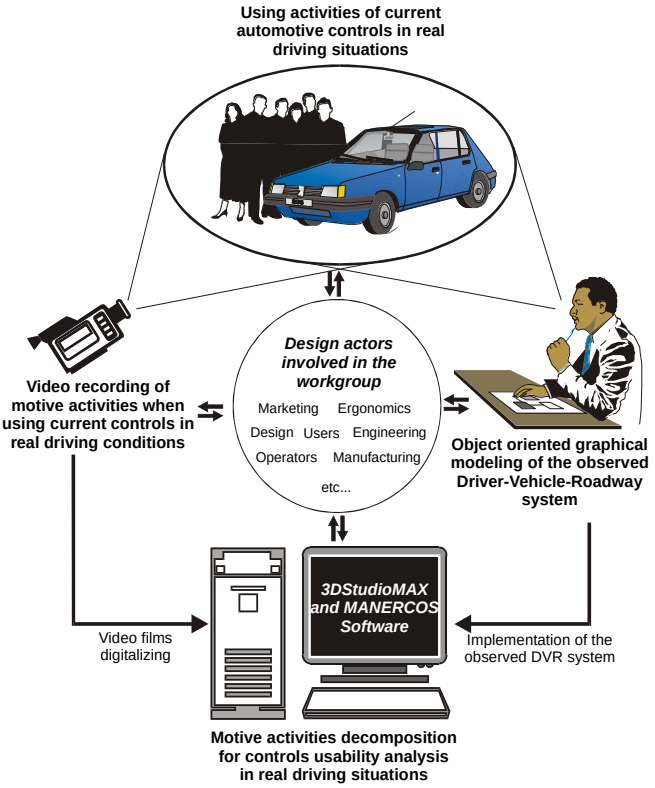

Figure 2 : Driving activity analysis procedure applied in a automotive controls design project focused on the Driver-Vehicle-Environment system (DVR system)

Then, a modeling and simulation approach is engaged, during Preliminary studies, to build new solutions integrated in the future Man-Product-Environment system. In Figure 3, we describe this modeling and simulation approach, applied to the previous automotive controls design project considering the global Driver-Vehicle-Roadway system.

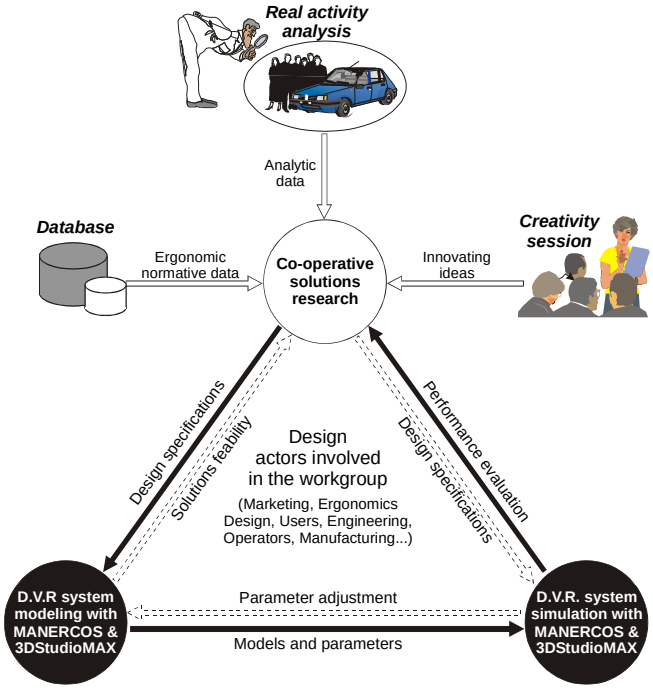

Figure 3 : Modeling and simulation approach in three steps applied in an automotive controls design project in order to build new ergonomic solutions

MANERCOS STRUCTURE AND MAIN FUNCTIONALITIES

MANERCOS is a new plug-in divided into 3 different modules completely integrated in 3D Studio MAX environment : an Anthropometric modeling module, a Motor activity analysis module, an Ergonomic evaluation module.

Anthropometric modeling module

The Anthropometric modeling module has been defined to create parametric mannequins. This module present different functionalities integrated in 3 levels : an anthropometric database manager, a posture manager, a mannequin generator.

The **anthropometric database manager** allows users to create their own population using anthropometric parameters such as stature, sitting height, knee height, etc. (Figure 4).

The **posture manager** is used to define different postures such as sitting posture using comfort angles (Figure 5). These comfort angles are defined for low muscular and articular constraints between different limbs : upper-arm, arm, chest, wrist, etc. (VERRIEST, 1986)

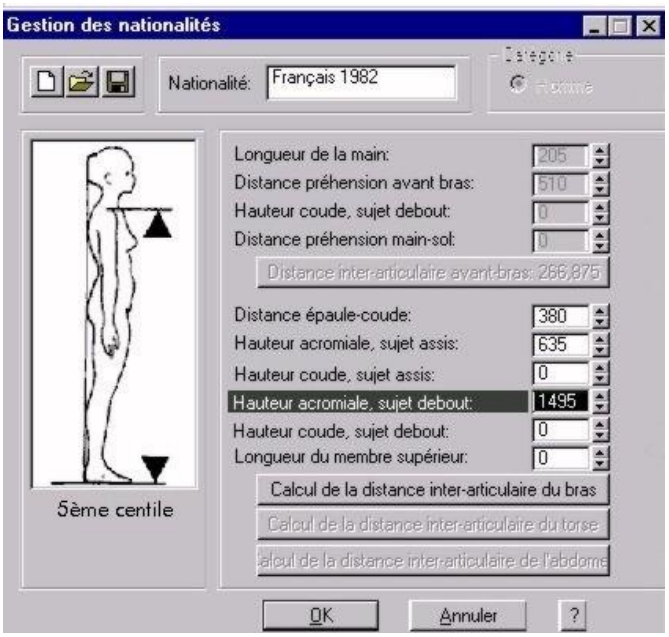

Figure 4 : Anthropometric database manager screen

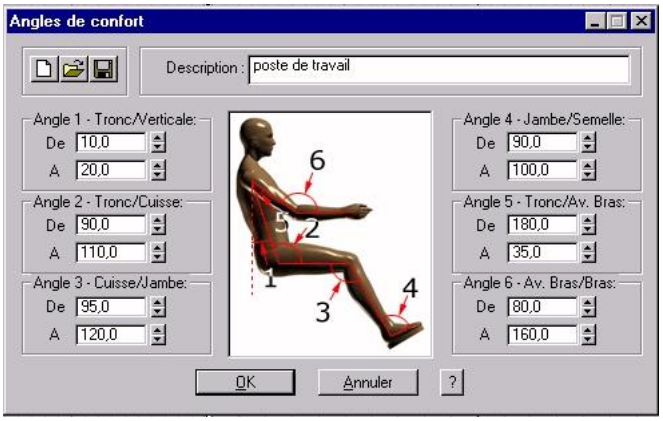

Figure 5 : Posture manager screen and 3D male and female mannequin generation

Then, it is possible to create 3D mannequins in the 3D Studio MAX environment with the **mannequins generator**.

Figure 6 : 3D Mannequins created by the mannequin generator

Mannequin creation is based on previously defined population and posture choices. It is also possible to call on different evaluation tools such as field of vision or maximum reaching volume.

Motor activity analysis module

The motor activity analysis module has been defined to manage the dynamic behaviour of the Man-Product-Environment system. This MANERCOS module can be applied by using a specific methodology described in Figure 7.

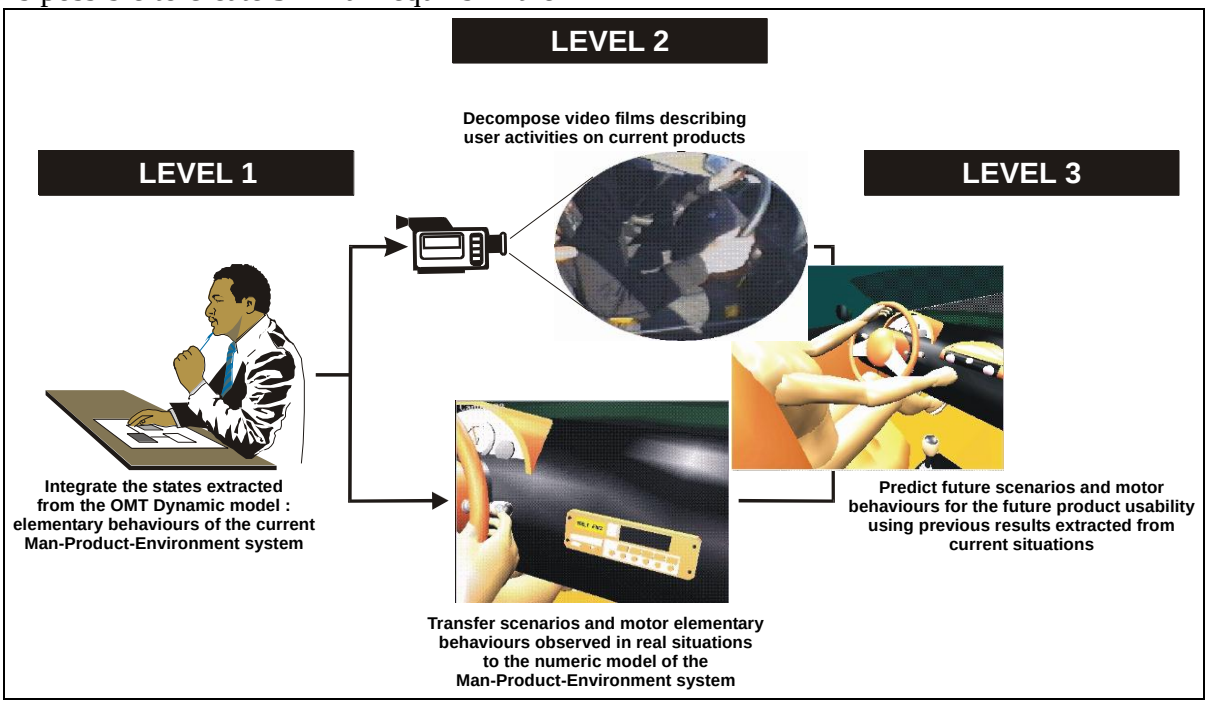

Figure 7 : Methodology applied when using MANERCOS motor activity analysis module

The motor activity analysis module integrates several levels such as an elementary behaviours manager, a user (or manufacturing) activity analyzer, a scenario manager and a virtual animated picture generator.

The **elementary behaviours manager** allows a MANERCOS user to implement the different states describing the dynamic model of the Man-Product-Environment system. These states have been previously defined through the dynamic OMT graphical model. This feature allows us to create a database of motor elementary behaviours.

The **user (or manufacturing) activity analyzer** allows video recorded data decomposition based on the previous stored elementary behaviours (Figure 8). This feature generates a scenario describing the action chronology in the observed situation.

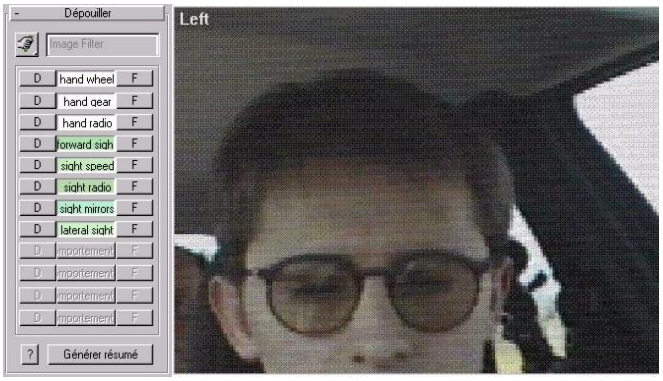

Figure 8 : MANERCOS user activity analyzer applied to a driving activity analysis

Then, it is possible, through a **scenario manager**, to define statistic data of real observed activities when using or manufacturing current products (statistics on elementary behaviours duration or frequencies). Later, it will be possible to design a new product and to build scenario of future activities when using the future product (Figure 9).

Finally, virtual films can be created with the previous elementary behaviours database and the various defined scenarios (real and future scenario). These virtual films are created with the **virtual animated pictures generator** and other 3D Studio MAX features.

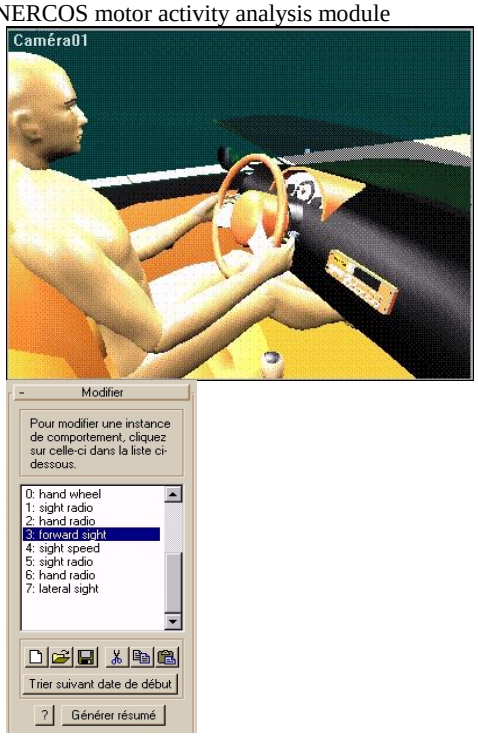

Figure 9 : MANERCOS scenario manager applied to simulated future user activities on a new radio concept

Ergonomic evaluation module

The ergonomic evaluation module has been defined to analyze "human lifting" activities and to estimate energetic metabolism when performing different tasks. This module integrates also 2 levels : a human lifting task analyzer (Figure 10) and an energetic metabolism analyzer.

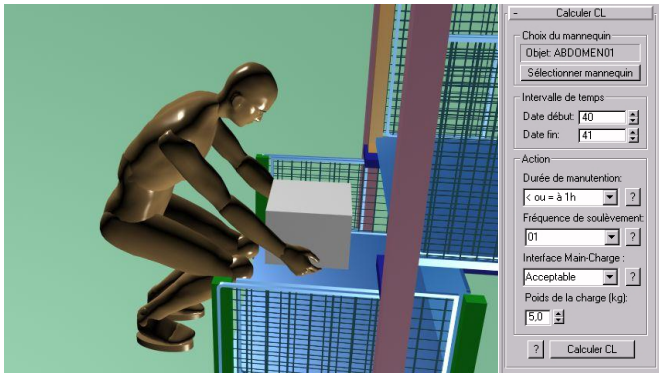

Figure 10 : Description of an available interface to analyse human lifting tasks with the ergonomic evaluation module

The **human lifting task analyzer** is based on a revised NIOSH lifting equation (WATERS et al., 1993). The NIOSH lifting equation is a tool for assessing the physical stress of two-handed manual lifting tasks. It is designed to assist in the identification of ergonomic coalitions for reducing the biomechanic stresses associated with manual

lifting tasks. It is specifically related to the prevention of lower back pain

The MANERCOS **energetic metabolism analyzer** proposes an evaluation of physical stresses associated with working activities, by an energetic metabolism evaluation. This parameter constitutes a quantitative index of an activity physical stress. The energetic metabolism analysis, running in MANERCOS, is based on the SPITZER and HETTINGER model (ISO 8996).

CONCLUSION

Situated in the industrial systems engineering field, this paper present MANERCOS, a software tool that can be applied for better designing new products adapted to future users. Different commercial tools using anthropometric 3D mannequins for ergonomic evaluations are available (DAS and SENGUPTA, 1995). The specificity of MANERCOS is to combine 2 approaches integrated in a product design methodology. MANERCOS software is first dedicated to perform motor activity analysis in real user situations, based on video recordings. Thereafter, the same software is used for modeling and simulating desired future using activities. In accordance with concurrent engineering techniques, the same methods and tools are proposed to evaluate and to design production means and working activities. MANERCOS is actually applied in different design projects

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BIOGRAPHIES

Samuel Gomes is an associate Professor at Université de Technologie de Belfort-Montbéliard. Graduated in Industrial Systems Engineering, his research areas are products design methodologies and ergonomics. His current work is focused on defining methodologies and tools to provide ergonomics in concurrent engineering design process.

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