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# ADELE: a Blackboard-based Architecture for Ergonomic Simulation

Aline Alauzet<sup>1</sup>

## 1 INTRODUCTION

The design of industrial products such as cars or trucks is a computer-assisted process. Among the different criteria which have to be considered for this type of design, the ergonomic aspect is a key-criterion for designers who want to ensure usability for their products. Following the introduction of the use of computers and CAD tools for the design of industrial products, the need of associated computer based ergonomic tools has emerged. To cover the need of a representation of the human body, graphical mannequins have been designed on the basis of 2D cardboard articulated human figures used previously.

The model to be discussed in this paper is based on one of these tools, a 3D graphical mannequin developed at INRETS-LESCO. This model called MAN3D ([1]) is associated with a CAD tool and allows the user to obtain a good representation of the human body. It has also handling facilities to obtain postures in order to simulate arm or foot reach movements. However, some inadequacies have been detected in the use of this model. To begin with, the user of the model has no means of controlling the realism of his simulation. Often, the user has to decide up on the posture of the mannequin something he is not easily able to do. He wants to simulate the motor behaviour and the activity of the end user of the product he is designing, but he has not the necessary expert knowledge. He also needs a tool that can be used to predict the ergonomic problems that are likely to arise with a particular design or to explore several alternative designs to identify the best one. Therefore he needs help to assess the ergonomic pertinence of his design. The objective of our work is to improve MAN3D. The first result is the ADELE system (Aide au Diagnostic Ergonomique par Liaison avec des bases Expertes) a prototype system which is described in this paper.

## 2 SIMULATION OF MOTOR BEHAVIOUR FOR ERGONOMIC ASSESSMENT: WHAT IS THE PROBLEM?

The graphical simulation of the motor behaviour of a human operator requires two main elements: a structure for the body representation and a way to make this structure move and interact with an environment.

In our context (simulation for human factor analysis for the design of cars or trucks), the ergonomic aspects which are tested by the designer are mainly: - the way the operator is comfortably accommodated or not in the car, - the way it is possible for him to use controls and displays or see the road, - and also the accessibility of the car or truck. There are two types of needs: a need for a good representation in terms of dimensions and shape and a need for good posture simulation.

We focus here on the question of posture and gesture simulation. The realism of simulation depends on the knowledge of

posture determinants. Many parameters can be put forward in order to explain a specific real posture: the aim of the gesture, the duration of the final posture, comfort, and also the weight of the object (for example in the case of manual handling tasks), or the aspect of equilibrium, or the history of the person (the origin of his own postural behavior), as well as more cultural aspects (different ways of making the same gesture in different societies). The problem of the determinants of posture has not yet been solved completely. In fact it has only been partially solved, due to the purely biomechanical and geometrical basis of models such as MAN3D. To improve the realism of these models, two ways can be considered: one can either improve the mathematical methods that are used, or add the use of other methods to complete the model. We have chosen the second solution.

Whatever the method used to predict the posture, the user of the human graphical model must possess a great amount of expert knowledge: in most cases he has to find his own solution and manage its realism.

Another aspect concerning the simulation of postures and gestures for human factor analysis is the question of the output of the simulation. What is the expected information and what is the result of a graphical simulation? The first result is the image itself. If the model is realistic, it answers the question (for example): is this control reachable or not? But other information is whether the obtained posture is comfortable or not. This depends on the duration of the posture, on the position of the hand and on the task to be performed simultaneously. That is to say that the context has to be defined carefully. Therefore, to conclude, obtained postures have to be qualified, in order to answer the initial question: are the different elements of the future car well disposed?, is it acceptable to ensure the usability of the product?

## 3 DATA AND KNOWLEDGE MODELLING

To improve MAN3D, we had to find a way to make it more realistic in terms of posture simulation, to facilitate the mannequin handling, and to add an ergonomic diagnosis module in order to qualify a simulated posture. We also had a constraint: keeping the original version of MAN3D, without changing the model. Facing the limitations of the classical computer science techniques for this case, we have decided to use artificial intelligence techniques, in order to add strategic levels for the simulation, and to implement expert knowledge. We had to analyse three areas of knowledge: - operator model and activity modelling, - mannequin handling, - ergonomic expertise knowledge.

For the first area, we developed a human operator activity model. For this, an object-oriented analysis has been made with the OMT (Object Modelling Technique) method [2]. The model is composed of an environment model, an operator model (a generic model linked with a graphical model, which is a specific qualitative description of MAN3D), and the activity model. In this activity model, we describe the interactions between the operator and the environment, with elementary actions which can be composed in order to create more global actions. The last step is the scenario. We also propose a symbolic postures description.

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For the second area, we analysed movement strategies for reach problems. Heuristics rules have been proposed, from the result of experimental studies.

For the third area, we considered three different aspects: the ergonomic specifications (which are the constraints the designer has to respect), the postural comfort, and the final ergonomic qualification for the designed product.

## 4 THE ADELE SYSTEM

### 4.1 General principles

Figure 1 gives the general architecture of the ADELE system. The object model has been implemented in an object-oriented DBMS. We have chosen to include the strategic levels and the knowledge bases (for the movement strategies and the ergonomic evaluation) in a blackboard system, developed with the Atome system. This is because we had to face multiple expertise and we needed several agent levels. Furthermore, blackboard architecture is a good tool to realise incremental development. A specific module has been developed for the communication between the MAN3D system and the blackboard system. Another specific point is the link between Atome and the DBMS. We have developed a specific approach, in order to make these tools share the data.

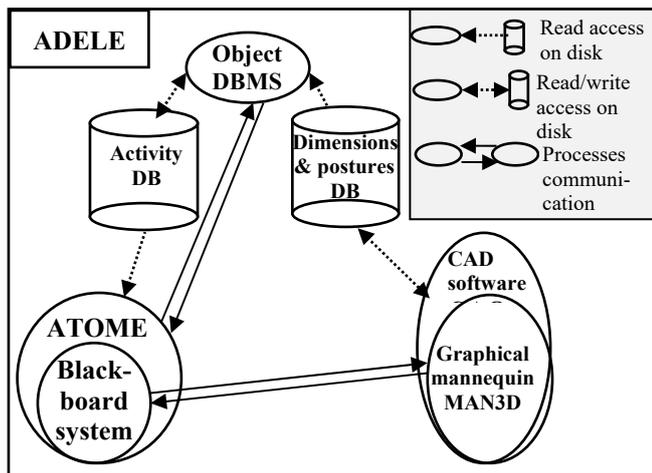


Figure 1. General architecture of the ADELE system

### 4.2 The blackboard system

We used Atome [3], a multi-agent system generator, based on the blackboard architecture paradigm. Atome works with three types of knowledge source, which are hierarchically organised: specialists, tasks and strategy. The specialists are the area knowledge sources. The tasks contain a part of the control knowledge: each task has an events list where changes on the blackboards are signaled. On the basis of this list, the task chooses which specialists have to be activated and the order of these activations. The strategy has to control the global solving process by managing the task activities, on the basis of blackboard summaries. Figure 2 gives the structure of the blackboard system for ADELE.

Before the simulation process, instances of activity classes have to be created. To activate the simulation, the user chooses in the database the action or the scenario to simulate. Then, ADELE makes the mannequin move, by dialoguing with MAN3D and generating the necessary orders. In addition to the visual display, a diagnosis about feasibility and comfort is produced for each action.

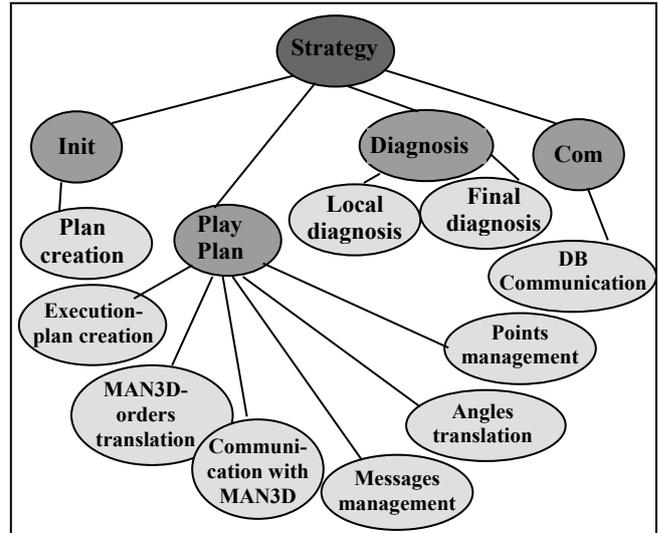


Figure 2. Organisation of the blackboard system for ADELE

## 5 CONCLUSIONS

Knowledge based approaches have already been used to plan specific movements for robotics (see for example [4] for a detailed study of models for the human hand prehension). However, the review of literature (see [5]) shows that using a multi-agent system for man model handling and ergonomic assessment appears to be a new approach. This approach is interesting as it improves the classical man models in this context. It takes into account new determinants of motor behaviour, especially the characteristics of the environment in which the simulated operator acts. With this approach, we can also automate the mannequin manipulation and add a diagnosis module.

The ADELE system, which is an implementation of this approach, exists in a preliminary version. Rules have to be added, in order to improve the simulation. The difficulty is to model the area knowledge and identify the appropriate rules, in a context where knowledge does not really exist today. However, the research of missing rules for the system could constitute a good guide for the experimental tests made to improve biomechanical knowledge. Furthermore, new rules for specific domains (like truck design) have also to be added to the ergonomic assessment module.

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