2581-4575
International Journal For Recent Developments in Science & Technology
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AN END-USER ADAPTED TO SLANT IO ENTERPRISE MAN-MACHINE INTERFACES FOR CAD/CAM

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ABSTRACT

This paper describes the design, the specification and the implementation of a new type of graphical system in order to design a dialog architecture : SACADO. This system is an Adaptative System for Computer Aided Design and Development. Thus, it can be considered as :

- a CAD/CAM tool.
- a basis of CAD/CAM systems development (this point of view is generic; in such P manner, any SACADO systems itre constructed with the sitme methodology and the same tools).

Features of the system include a hierarchical structure of the dialog with special effects of menus and a capability to allow immediate modification of the dialog specifications. This original approach, based on different kinds of menus and a single interaction, permits an end-user to design interfaces for CAD/CAM systems without any knowledge in computer science. Moreover, an overview is included on the technique used in the implementation of the dialog interpreter, which involves an intensive use of syntactic grammars.

INTRODUCTION

User interfaces of expert systems are mainly based on a standard technique of so-called knowledge-base browsers of the kind proposed. They are domain-independent tools aimed mostly at an expert system designer and allow for a textual (and limited graphical) access to the contents of the knowledge-base dictionary network, an actual state of the inference graph, etc. An end-user interface should, however, communicate information in a form compatible with Fphical symbology and conventions used in the particular application domain. To easily create such an interface for every domain of a given expert-system shell application, the shell should include appropriate graphical interface design tools. Systems capable of graphical presentation of various data stored in knowledge bases were proposed quite long ago, though with a limited success, mostly due to the lack of powerful enough graphic synthesis paradigms and tools. These ideas and potential possibilities can be fully put

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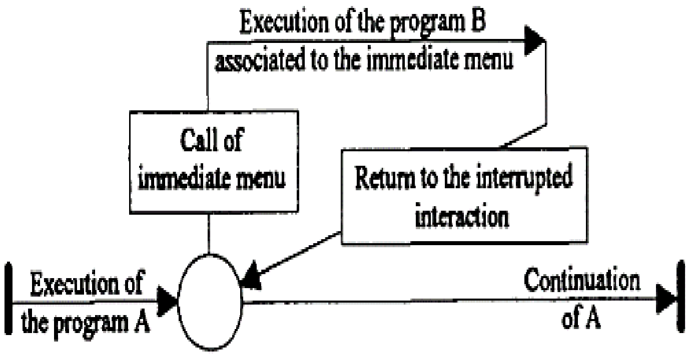
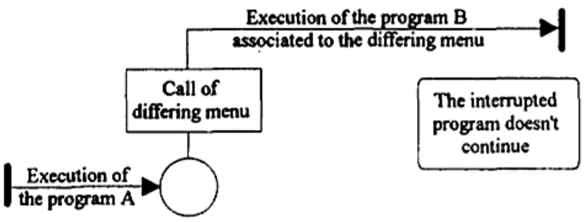
into practice as a result of the development of novel techniques of object-oriented and constraint-oriented programming, visual languages and visual programming, improved user interface design principles, and hypermedia approach to information presentation. The incorporation of all these developments in CAD systems will revolutionize this domain, making it possible to fully integrate machines and human experts in all the design and manufacturing cycle, from conceptual design to automatic manufacture and assembly. One of the crucial problems here is, inevitably, the effective man-machine communication. In this paper, we present the general structure of a graphical interface based on these ideas and integrated with the object-oriented knowledge-based engineering environment built as an extension of EXPERTALK and DICEtalk sytems.

One of the crucial problems in integrating machines and human experts in new-generation engineering design and manufacture systems is the effective man-machine communication. The object-oriented knowledge-based environment requires an appropriate graphical user interface built on the modern principles of object- and constraint-oriented programming, visual languages and hypermedia. The interface should provide semantic-rich graphical presentation of diverse domain-dependent data as well as a direct-manipulation interface easily adaptable to graphical symbology and conventions used in the particular application domain(s). To achieve these goals, the interface incorporates knowledge-base techniques both at the interface design stage and as a part of the interface manager. The interface will serve both the system designer (providing easy access to all the relevant mechanisms of the knowledge base and tools to create an appropriate domain-dependent end-user interface) and the end user (providing data acquisition from the user, system state presentation and control, and presentation of final results). The end-user interface design toolkit includes an extensive data and knowledge visualization subsystem, consisting of parametric, constraint-based image library, qualitative, quantitative (numeric) and structural data visualization modules, and interface-control specification module.



Immediate effect

when such a menu is chosen, the current action is stopped (usually it failed but it must be terminated in good conditions) and the actions or sub-menus associated to the chosen menu are activated.



Differing effect

Now, we define the term "compatibilities" by the set of effects

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defined for a menu or an interaction (local, immediate and differing). The interface programmer can define the compatibilities between menus, the compatibilitics inheriting from the father to his sons by respecting the following rules :

- Except opposite indications, a son menu inherits his father's compatibilities.
- Except opposite indications, the interactions inherit the compatibilities of the associated terminal menu.

But he can also define these compatibilities directly for the interactions. Of course, these two methods can be mised; in this case, we tell about refinement: the interface programnicr specifies compatibilities obtained by inheritancc.

As seen at the beginning, the end-user may only influence the execution of the system when he interferes; thus, let's enumerate the different behaviours that a enduser may have when an interaction is required:

- To respond directly by a valid object (this is the standard behaviour).
- To execute a new action leaving the current action.
- To execute a new action without leaving the current action (by this way the current action is only suspended while the new action is executed; the zoom is an example of such an action).
- To execute a new action to respond to the interaction; in this case, the new action constructs the object required by the interaction (for example, the construction of a forbidden object).

Knowledge-based system architecture

Most knowledge-based systems have been developed for programmers. Their specialized knowledge description languages (frames, semantic networks) associated with programming languages (LISP, C) are often too difficult for use by engineers. The consequences of these relatively complex systems are long system development times with concomitant negative impacts on product cost, quality and supportability. A key idea behind our system (based on EXPERTALK and DlCEtalk knowledge-based systems) is the concept of objectorientation (high-level structured programming) providing procedural knowledge-based programming integrated with simplified English as declarative knowledge-based programming. The integration of both declarative and procedural knowledge bases is supported by the graphical user interface with direct access to the Smalltalk environment, and through Smalltalk to other conventional languages, for example the C language, by user defined primitives. This integration (with the older version of the system, using conventional Smalltalk graphical interface) has been successfully verified in the two knowledge-based applications: the Printed Wiring Board Manufacturability Advisor and the Turbine Blade Fabrication Cost Advisor [CERC, in preparation].

The low-level architecture of the system is described by special kinds of objects that are implemented in the system as more than fifty Smalltalk classes. The high-level architecture includes a problem-

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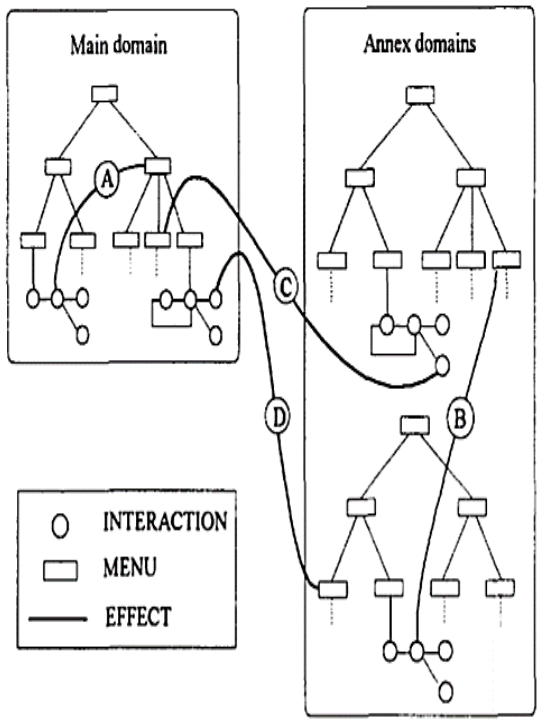
solving engine, a graphical and application knowledge bases, and graphical user interface. The problem-solving engine consists of an inference engine, knowledge base compiler, task dispatchers, task mangers, explanation manager, object-oriented knowledge server, and Smalltalk compiler. The inference engine implements rule-based and knowledge-source-based deduction with procedural attachment mechanism, metaknowledge control and a broad interface to Smalltalk. The user interface is generally divided into two parts, each serving a different purpose. The first part creates the model of the knowledge-based problem-solving environment that users interact with.



Mends complete structure

METHODOLOGY

Man-modeling CAD systems

A wide variety of such systems have been developed. Their functionality, flexibility and success have also varied considerably. Kinematic modeling enables the spatial evaluation of workplaces where either the human operator or parts of the physical environment are placed in different positions over time - the type of modeling which is the focus of this chapter. In order to represent these spatial relationships the man model needs to be suitably 'enfleshed', preferably using solid modeling as this allows evaluative features such as hidden lines or interference checking between two solids in three-dimensional space. Kinetic, or dynamic, modeling is usually associated with assessing the body's response to large external forces such as those experienced in car crash simulations. In this type of modeling more consideration may be given to body segment parameters such as mass, center of gravity and moments of inertia.

Traditional methods used by ergonomists/human factors engineers for the specification of dimensional information for equipment and workstation design include the use of published or in-house recommendations and guidelines, anthropometry, two-dimensional plastic manikins (full size or scaled to be used in conjunction with engineering drawings), mock-ups, user questionnaires and user trials. Man-modeling CAD systems do offer significant advantages to the designer with respect to issues such as fit, reach, vision and task related posture; these issues are discussed below.

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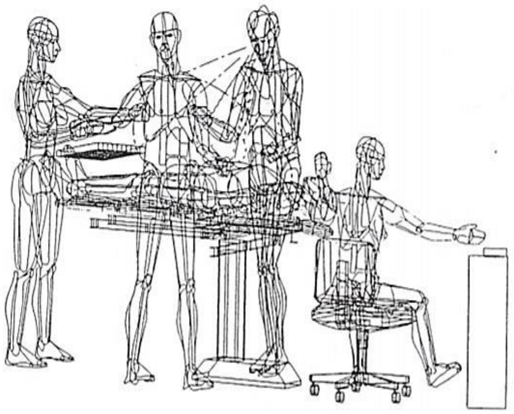


Time

While recommendations can provide information rapidly they are rarely sufficiently user and task specific to be used unreservedly. Detailed information of current designs from user questionnaires and user trials, or of new designs using mock-ups with selected subjects, can take weeks or, more usually months, to acquire.Man-modeling CAD systems provide a means of simulating the user and task specification using computer graphics and anthropometry instead of users/subjects of an existing/new design. This results in a tremendous saving in time, in some cases a reduction from a few months to a few days.

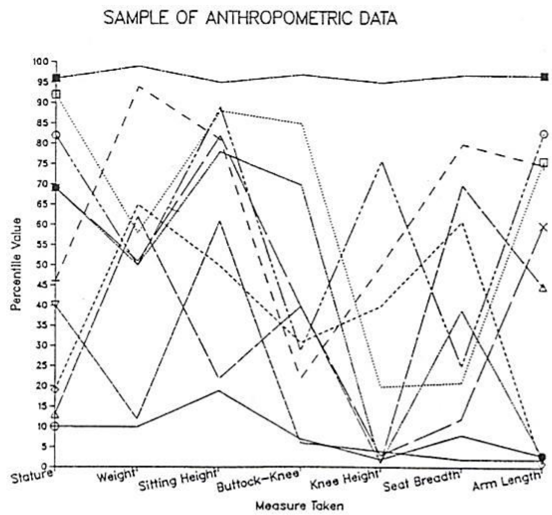
Cost

'Time is money', so any reduction in development times should be advantageous from the financial point of view. In addition, the production of mockups is an expensive process, even for simple models constructed from wood, plastic, etc.The cost of a man-modeling system such as SAMMIE can be less than the cost of making just one full size mock-up. Fitting trials or similar studies also incur extra costs for space rental, staff costs, subject payment and so on. As CAD systems enable the ergonomics input to be provided much earlier in the design process, this reduces the likelihood of expensive or unfeasible modifications being necessary at later stages.

Accuracy

Ergonomics CAD systems are not intended to be used in isolation during the design process. They should be regarded as useful tools which can be used to predict the ergonomics problems that are likely to arise with a particular design or to explore several alternative designs to identify the superior one(s). Recommendations and results from marketing surveys and product evaluations can still be consulted. The greatest validity will usually be provided when real people are asked to perform real tasks with a real product for realistic durations in a real environment.

RESULTS



CONCLUSION

An end-user oriented method to design interfaces for CAD/CAM system has been described. It is based on an original approach with different kinds of menus and a single interaction. Its principal interest is to permit an application oriented definition of the dialog and of the architecture of the software. The dialog can be interactively modified by the end-user to be in accordance with its view of the application and its degree of knowledge.

This approach has been soon proved to be interesting through a prototype of SACADO. This paper has described a more formalized version using NADRAG. The NADRAG language is invisible for the end-user, but is necessary in order to model the dialog. An interactive graphic interface (based on X) is offered to model the menus and the architecture of the interaction.

The NADRAG language is completely defined (although not described in this paper) and the interactive tool to describe the menus is operational. The last tool (description of the architecture of the interaction) is currently developed.

Future work will focuse on the integration of these tools in a coherent system and its use to implement a complete application oriented CAD/CAM system.

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