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COMPUTER AIDED ERGONOMIC AND AESTHETIC DESIGN

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1. Introduction

When designing a product for every day use, designer has to consider various influential factors, among them aesthetics and ergonomics are very important. In the group of different products covering the same main function (purpose), those that look more attractive are usually more successful on the market. The ergonomic design is also very important parameter for many products.

Designers are confronted with higher ergonomic demands every day. Despite the existence of the ergonomic data for use in design process, designers have often difficulties when incorporating this data in their designs. The reason for that can be found in poor presentation of ergonomic data to the designers [Vicente et al. 1998]. Such condition led to development of various computer aided techniques for evaluating human performances in a certain workplace. This kind of software usually includes biomechanical data about the potential user of the product, metabolic rate prediction, reach assessment, and time prediction [Karkowski et al. 1990]. To complete the analysis, several different tools have to be used, many of which demand precise models of the working environment.

Among various influential factors that are important for the success on the market the aesthetics is often the decisive one. Unfortunately, the aesthetic is very difficult to describe. Aesthetic concept depends of various influential parameters, for example cultural environment, age, gender, etc. In comparison to classic aesthetic concept, the modern aesthetic concept depends on mathematical lawfulness, which orients modern aesthetics concept towards objective and not only subjective goals. Despite that, determining the aesthetic value of the product is not sufficiently supported with computer software yet.

This paper presents the present state-of-the-art in the field of computer aided ergonomic design and some development directions for computer aided aesthetics design tools. The concept of the intelligent advisory system with expert knowledge to be used for support the ergonomic and aesthetic design is also presented.

2. Ergonomic CAD software

In the field of ergonomic computer aided design (CAD), development process has been focused toward the integrated tools that would enable the use of ergonomic data originating from various sources when performing ergonomic analysis of the product or working process.

The possibility to combine the ergonomic data from multiple sources would enable designer to use a single analysis tool to assess clearances, reach, visual requirements, and postural comfort at the earliest stages of design. It would make possible for designer to incorporate the important features into designs that would minimize the risk of injuries before a person ever physically encounters the product or workplace. These features include:

- three-dimensional modelling of the working place and equipment,
- three-dimensional human form modelling to represent various anthropometries and postures,
- evaluative techniques to assess reach, vision, fit and posture, etc.

Using an interactive interface, designers would be able to manipulate both, the human form and the working place design [Porter et al. 1995].

Two different approaches to development of such software tools have been taken. One approach is oriented into development of so called stand-alone ergonomic CAD software with ergonomic assessment capabilities and built-in tree-dimensional CAD module. The alternative approach is leading to development of the compatible ergonomic software based on the special modules that enable ergonomic analysis within commercially available CAD systems, which are used to provide the three-dimensional modelling and user interface. Some of the best-known representatives of the both groups of software are presented in the Table 1 [Feyen et al. 2000].

Table 1. Representatives of both groups of ergonomic CAD software

Stand-alone ergonomic CAD software	Compatible ergonomic CAD software
SAMMIE	SAFEWORK
APOLIN	MINTAC
TADAPS	ErgoSHAPE
Deneb/ERGO	HUMAN
ERGOMAN	RAMSIS
ErgoSPACE	ANYBODY

2.1 Stand-alone ergonomic CAD software

The stand-alone ergonomic software is functional independently of the other CAD software used in product development process. Thus, for many of these systems, the users must learn terminology, command structures, and modelling techniques that are different from those in the commercially available CAD systems. Fortunately, many of these systems have the ability to import the geometric models modelled in other CAD software, where the complexity of the models can be taken in consideration.

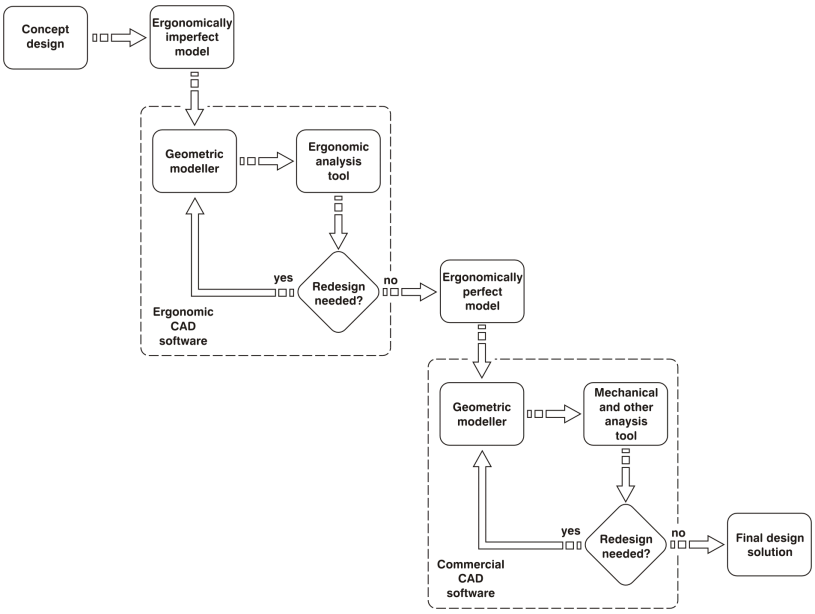

Figure 1. Product development cycle using Stand-alone ergonomic software

Figure 1 shows the product development cycle using the stand-alone ergonomic software. After the concept design phase the concept of the product is usually modelled using a commercial geometric

modeller and imported into ergonomic CAD software, or modelled using ergonomic CAD software geometric modeller. The working environment is created in the next step, followed by the human model that will fulfil the assigned virtual work. After the modelling is finished, the parameters for various ergonomic analyses are set, and the analyses are carried out. The evaluation of the analyses' results is the next step in design process, where the ergonomic satisfaction of the product should be evaluated. The continuation depends on the results of the evaluation process. It could either be remodelling the product or finishing the analysis and proceeding with the detailed modelling phase using one of the commercial CAD software. If the remodelling of the product is needed the first cycle of the process is repeated. From ergonomic point of view, the resulting model of the product is perfect, while some changes may still be necessary in order to improve the other design requirements, as for example the stiffness, the aesthetics, etc.

2.2 Compatible ergonomic CAD software

As distinguished from the stand-alone ergonomic CAD software, the compatible ergonomic software has been designed to be accessed within a CAD system. These systems take the advantage of the designers' familiarity with the terminology, techniques, and command structures of commercially available CAD programs. Moreover, the application of a single geometric model for all phases of the design process is also very important.

Likewise using stand-alone ergonomic CAD software, the development process starts with the concept design and usually ergonomically imperfect concept, which represent the starting point for the compatible ergonomic CAD software (Figure 2). The exact tree-dimensional model of the product is modelled using geometric modeller of the commercial CAD software. When the model is finished, the ergonomic CAD software is run within the commercial CAD system, where the working environment and human model are prepared. The modelling is followed by assigning the proper values to the ergonomic analyses parameters. It the next step, the ergonomic analyses are carried out. Immediately after the results of the ergonomic analyses are evaluated, the product can be redesigned and remodelled in order to correct eventual ergonomic imperfection. Alternatively, the process can be continued towards the other analyses that need to be carried out for the model. The result of this process performed within single software environment is the final design solution of the product that fulfils all ergonomic, mechanical and other demands and conditions.

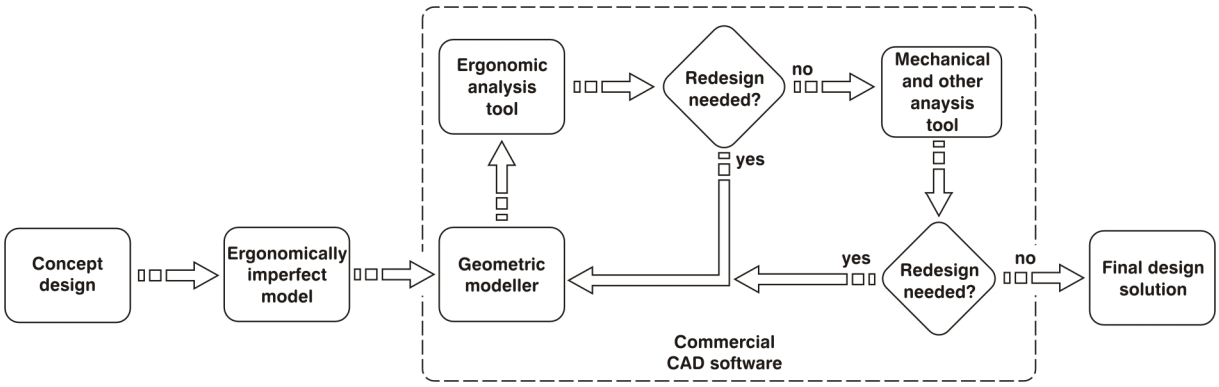

Figure 2. Product development cycle using Compatible ergonomic CAD software

3. Computer aided aesthetic design

While the use of computer-aided technologies in the area of mechanical and ergonomic design is quite well established, the gap in the computer-aided process chain due to the aesthetic design phase still represents a serious problem. Since the computer aided aesthetic design tools do not exist, designer have to trust to his or her aesthetic abilities and feeling in order to perform product design of complex-shaped products like car hoods, consumer appliances, toys, packaging, etc.

It is very hard to define a procedure that would assure acceptable results of the aesthetic design process. Currently, two European projects: FIORES and FIORES-II (FIORES - Formalization and Integration of an Optimized Reverse Engineering Styling Workflow) aim at building innovative CAD tools that adhere to the creative user mentality and at improving the cooperation between the main players involved in the product development process, by identifying shape properties directly affecting the aesthetic character, and by providing modelling tools for their evaluation and modification [Giannini & Monti 2002].

4. Intelligent advisory system with expert knowledge

In order to deliver suitable design solutions, designer has to consider a wide range of influential factors. Ergonomics and aesthetics certainly belong to the most complex ones. Less experienced designer could meet several problems in this design stage. Although ergonomic CAD software described in this paper can assure better ergonomic condition of the product, the designer has to have quite a lot of experience and knowledge in field of ergonomics to chose and carry out the appropriate redesign actions to improve the ergonomic value of the product in reasonable time. Moreover, the aesthetic design phase still depends mostly on the designers' skill and experience and is not supported by any computer tool at all.

It is obvious, the expert advice is often needed and the application of the intelligent advisory system with expert knowledge could be very useful in the field of aesthetic and ergonomic design [Dolšak et al. 1997]. The system should be able to offer expert help – advice to the designer during the ergonomic and aesthetic design phase of a product. Since the aesthetic and ergonomic properties of the product are established at the early phases of the product development, the intelligent advisory system should be able to support this process with minimum data requirements.

Our vision for the intelligent support to the aesthetic and ergonomic design phase is presented in Figure 3. It is anticipated the product development cycle using intelligent advisory system would be very similar to the present conventional development cycle. The first main difference can be noticed in the concept design phase, where the intelligent advisory system should be used to improve the aesthetic and ergonomic value of the concept design solution. The ergonomic analysis and aesthetic evaluation should be performed on the CAD model with more precise geometry definition. After that, the intelligent system could be used again to advice the user which redesign changes are possible to improve the ergonomic and/or aesthetic value of the product if applicable.

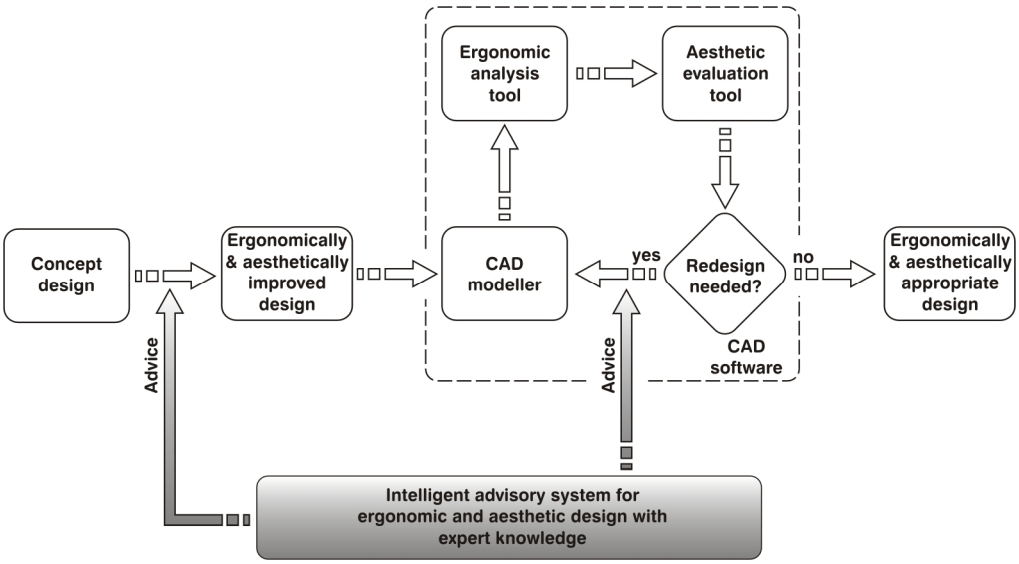

Figure 3. Aesthetic and ergonomic design cycle using intelligent advisory system

Figure 4 shows the general architecture of the proposed intelligent advisory system [Luger & Stubblefield 1989]. The development of the proposed intelligent advisory system needs to be implemented in several steps.

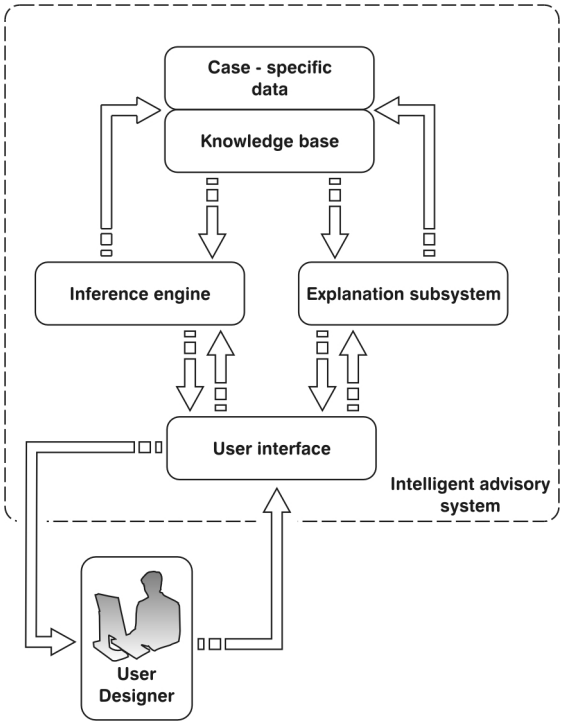

Figure 4. General architecture of an intelligent advisory system

First of all, the theoretical and practical knowledge about the design and redesign actions should be investigated and collected. After that, the appropriate formalism for the acquired knowledge representation should be defined. The commonly used formalisms for encoding knowledge are production rules, which are quite similar to the actual rules used in the design process. The collected rules will construct the knowledge base of the system. Our next step will be encoding the rules, most likely in Prolog syntax, and building the prototype of the system. The shell of the system should enable user-friendly input of data about the problem itself. The redesign recommendations should be proposed to the user by using the expert knowledge collected in the knowledge base and the case-specific data given by the user.

5. Conclusions

The ergonomics and aesthetics of the products are more and more important, especially when designing the utility goods for every day use. The paper briefly presents the state-of-the-art in the field of computer aided ergonomic and aesthetic design and the possibilities to apply artificial intelligence techniques to make this part of design process more intelligent. The general architecture of the intelligent system for computer aided ergonomic and aesthetic design is proposed as well as the basic idea for its integration into the product development cycle.

In general, computer tools for ergonomic CAD do not provide possibility for simultaneous exact geometric modelling and ergonomic analysis and the designer is not assisted with higher level advice when performing ergonomic design. Designers meet similar problem when setting and evaluating the aesthetic value of the product. Moreover, for this task they do not have any supporting computer tool at their disposal at all. They have to relay on their own aesthetic abilities and experiences.

Thus, we believe a development of an intelligent advisory system that would offer expert help and advice to the designer during the ergonomic and aesthetic design phase of a product has a great potential. The aim of our future research work is to develop an intelligent system, which will be able to support the user through design process, especially at the concept design and redesign phase in

fields of ergonomics and aesthetics. The system should help and guide the user through concept design phase and suggest the appropriate ergonomic and aesthetic design solutions for certain demands. In redesign phase the user should be assisted with advice, by the intelligent system, regarding the possible redesign steps to improve the ergonomic and aesthetic design.

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