

The computer as an aid in the analysis of ergonomic and safety features of maintenance

Description of two graphic applications

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Computer-aided design (CAD) systems are widely used for the modeling and design of various kinds of environments and products. Suitable additional programs, used together with a common CAD system, make it also possible to check and develop the features of man-machine interface. When various kinds of ergonomic aspects are studied with the aid of a computer, the procedure can be characterized by the concept "ergoCAD". Nowadays these programs are generally anthropometric modeling programs (5).

Several ergonomic CAD programs have been developed in various countries during the 1970s and 1980s (5, 7, 12, 21). The first of them were planned to aid cockpit design in the vehicle and airplane industry. In addition to the man-model facility, they generally also contain various routines for analyzing and visualizing the man-machine interface.

Both of the programs developed in Finland deal especially with work postures. Often the worker cannot freely adopt his or her work posture. The spaces in which tasks are performed cause numerous mechanical restrictions. Therefore postures are naturally one of the first and most suitable factors to be analyzed with ergoCAD systems.

Strenuous work postures strain the musculoskeletal system, increase energy consumption, cause other physiological reactions, and may be linked to accident occurrence (2, 3, 4, 8, 14, 15). For example, in Finland in 1985, 34.5 % of the disability pensions granted workers employed in forestry, agriculture, construction work, and dock work were due to the diseases of the musculoskeletal system (13). As far as all occupational accidents in Finland in 1986 are concerned, overexertion (20.2 %) was often the type of accident to occur and physical effort (17.1 %) was often the cause of the accident (18). In addition, workers commonly experience musculoskeletal strain and discomfort in the neck, shoulders, and back.

Description of developed applications

The first program, named MINTAC, creates a three-dimensional graphic man-model (figure 1) which can be modified and placed in a three-dimensional model of the work environment. The anthropometric data are derived from studies by Dreyfus (6). The man-model is expected to wear winter clothes. It contains six links. The man-machine interaction can be evaluated by several parameters, eg, visual contact with the work object, the height and depth of a given object, need for climbing (figure 2), the distance between the model's extended arm and the object to be reached, and the strenuousness of the work posture.

As far as maintenance activities are concerned, forced postures are caused by limitations of accessibility. The difficulty of maintenance work is traditionally thought to depend on accessibility to the objects (parts) to be maintained, ie, serviced or repaired (1). Accessibility has been shown to be an important factor affecting work conditions, eg, in power plant maintenance (17). Effects of accessibility on postures in forest machinery maintenance have been studied in Finland (19, 20). The first ergoCAD application followed this study. Both in the study and in the application of its results, the work postures were analyzed and rated according to the Finnish method called the Ovako working posture analyzing system (OWAS) (9, 10, 16). OWAS has been briefly described also, eg, by

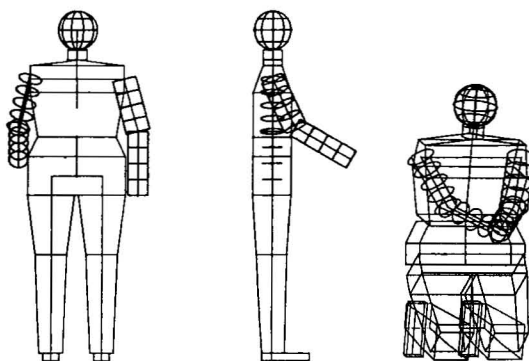


Figure 1. The Finnish anthropometric, three-dimensional man-model wearing winter clothes (MINTAC). The standing height of the model can be defined (percentiles between 5 and 95).

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Chaffin & Andersson (3), Corlett et al (4), and Keyserling & Budnick (11).

The OWAS method is designed to suit especially "moving" manual tasks in which all parts of the body are needed. In addition to anthropometric aspects it is also related to some biomechanical ones, ie, force and movement. The program can determine the OWAS-classified work posture (positions of the back, upper limbs, and lower limbs) of the man-model and the OWAS action category, which ranks the strenuousness of the posture combination on an ordinal scale. This program was applied in an analysis of safety and ergonomic variables in the maintenance of forest tractors. The physical configuration of the tractor was entered into the computer. Thereafter an interactive analysis of the "fit" of the man-model into the given workspace (maintenance objects of the tractor) was

possible (figure 2). The program was developed for a special, large CAD computer (Computervision system).

The second of the applications, OWASCA (Ovako working posture analyzing system, computer-aided), is intended to demonstrate and rank work postures used in any heavy mobile manual tasks. It is a cheap two-dimensional graphic program for personal microcomputers (IBM PC XT/AT or compatibles, Apple Macintosh). OWASCA is easy to learn. It includes only man-model facilities according to the OWAS system (figure 3). Potential users, in addition to designers, are occupational safety and health personnel. The training of OWAS specialists is one of the main possibilities. The OWASCA software, together with an expected increase in microcomputer use by safety and health professionals, makes possible the redesign of work spaces and work methods for decreasing postural load. Developed further, OWASCA can be integrated into CAD packages for real ergoCAD purposes. Now OWASCA is mainly a computer-aided, graphic interactive, personal training system which can be delivered on a single application disk.

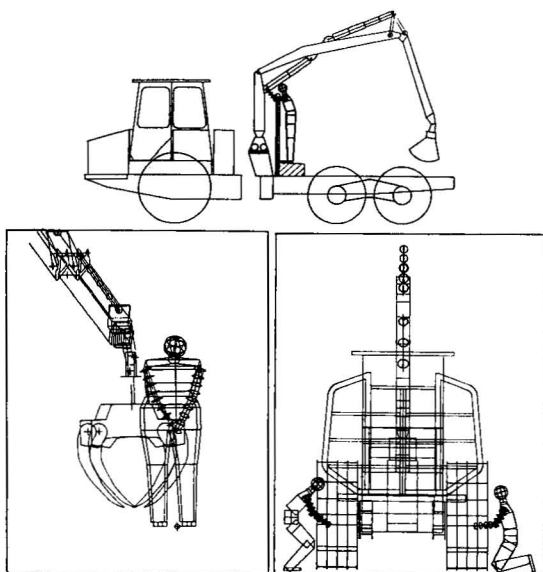


Figure 2. Man-model placed in a work environment modeled by a computer-aided design system, work postures, and reaching to objects (upper figure) being simulated and evaluated.

Concluding remarks

To summarize, design for better safety and ergonomics can be simplified and speeded up by computers, computers can explore and visualize on screen large numbers of concepts and variations in a short time, and ergoCAD provides a designer with qualitative and quantitative answers to a host of questions to which he could previously have applied only his intuition and experience. Actually, in the conventional design process the ergonomic aspects are often totally ignored because their evaluation has been too strenuous or even impossible. But, in all fairness, it ought to be said that applying ergoCAD naturally has limitations of its own. The potential possibilities, including task animation, are in any case very promising.

Much development is still needed, especially when computer-aided simulation applications involved more with physiology, biomechanics, and accidents rather than pure engineering anthropometry are to be developed. Checking and improving accessibility in maintenance are suitable activities for ergoCAD. Many other features of manual maintenance are not so easily analyzed with a computer. The reliability and validity of ergoCAD has not yet been evaluated sufficiently. As far as posture analysis is concerned, the standard posture categories used in the OWAS system may be too broad for some purposes. (See reference 11.)

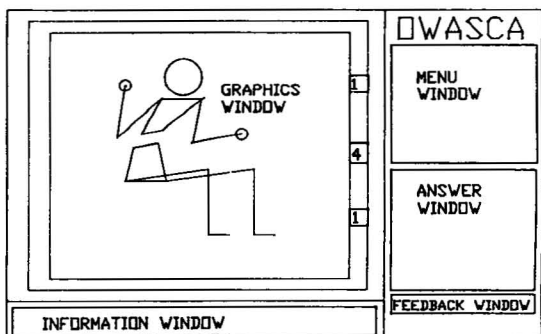


Figure 3. Microcomputer software including man-model facilities according to the Ovako working posture analyzing system (OWAS).

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