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AND INTEGRATED MANUFACTURING SYSTEMS

Adrian KAMPA[1*], Grzegorz GOŁDA[1]
[1] Institute of Engineering Processes Automation and Integrated Manufacturing Systems,
The Faculty of Mechanical Engineering, Silesian University of Technology, Gliwice, Poland
*adrian.kampa@polsl.pl

COMPUTER AIDED DESIGN OF HUMAN WORKSPACE AND MANUALLY OPERATED PROCESSES

Abstract: The design of human workspace and manually operated processes can be improved with the use of digital models of human body. An example of design human workspace in CAD software NX 10 and simulation example of work process in Jack software are presented. The use of digital human models allows to improve the ergonomics of human workspace and simulation of work process can be used for calculation of standard work time.

1. Introduction

The design of workspaces and manufacturing processes is a multi-stage process requiring solutions of problems from many fields. It includes both technical problems as well as ergonomics and work safety. Despite the increasing automation and robotization of manufacturing, human labor is still required. This applies in particular to the assembly processes and processes requiring the participation of skilled workers. This is due to the fact that people have innate manipulation skills and easily learn new activities.

An important step is conceptual design which access to detailed design. In traditional design, a two-dimensional drawings and sketches, which do not reflect the full spatial picture of the situation in the workplace, are used. The human body has some limitations and therefore is essential to adapt the workspace for the possibilities of the human body. This includes, inter alia, proper body position, the range of hands, field of view, and distance from dangerous places. Therefore, the use of three-dimensional digital models of the human body for a full visualization of the spatial position in CAD system is preferred [1].

Computer modeling of the human body dates from the 1970s. Initially, these models were very simplified, but they have been improved gradually, so as to fully map the parameters of the human body. Currently there are a number of digital human models available, such as, AnyBody, Delmia Safework, HumanCAD, JACK, ManneQuinPRO, Sammie [2, 4, 6, 10]. They are parameterized and based on anthropometric databases such as ANSUR, NHANES, and can be used in many CAD systems [2].

2. Manually operated processes

The second important type of human behavior modeling, which concentrates on predicting the perceptual-cognitive aspects of human performance. Models of this type have been referred to as human performance process models. The primary motivation for the development of these models has been to understand and predict the time required for different people to perform a task without errors, especially when the task has a high perceptual and/or cognitive load [2].

A contemporary example of this would be when a worker is manually operating a complicated machinery. Accurately predicting under what specific conditions a person would be able to control the machine safely is of immense importance, especially when designing or specifying various types of human-machine interface, such as visual displays, automatic safety systems, and night vision systems.

In industrial engineering, the standard time is the time required by an average skilled operator, working at a normal pace, to perform a specified task using a prescribed method [3]. It includes appropriate allowances to allow the person to recover from fatigue The usage of the standard time are very important and therefore some different method are used for standard time calculation [7].

The one of the most used method in industrial engineering is MTM (Methods-Time Measurement). MTM is a predetermined motion time system that is used primarily in industrial settings to analyze the methods used to perform any manual operation or task and, as a product of that analysis, set the standard time in which a worker should complete that task. The essence of this system is that the individual work activities are spread out into smaller units of movement. In the basic method of MTM-1, these are 17 basic movements. In general there are 5 moves mainly used. These movements include: reaching, grasping, moving, pressing, release. The individual movements are evaluated on the basis of the tables with normative activity time. From these analyses, work standard times are derived. Proper use of the MTM method require very good knowledge about work process in order to obtain correct results.

3. Digital human modelling

Ergonomic work requires sitting or standing body position. Workspace height should be a prime consideration. General work can be done at the normal height of about 900 millimeters. During precision work, the height should be raised to prevent straining of the back, neck, and shoulders. Seating the body in order to bring the workspace closer to the worker is a common solution. Adjustable height workbenches are also available in some cases [8, 9].

An example of digital human model from NX CAD software is presented in the figure 1. The human model with typical body structure was selected with 1750 mm height. It is based on ANSUR anthropometric database. That model is fully scalable and has movable joints. This enables to move each part of body and get different poses.

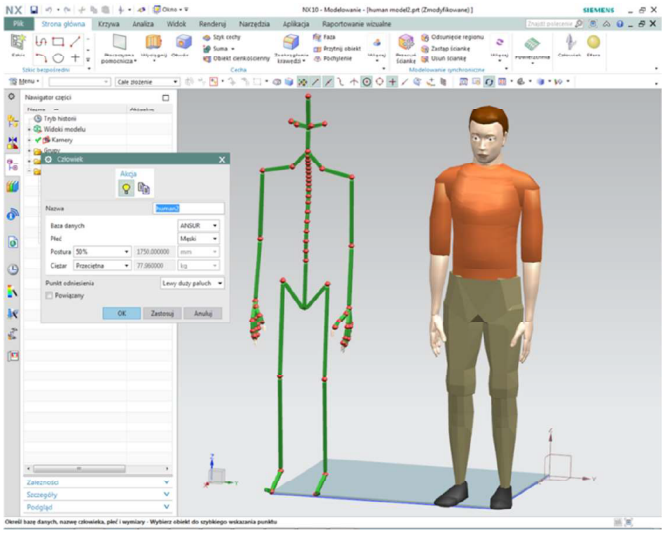

Fig. 1. Digital model of human body and skeleton in NX 10 software

The digital human model was then used for workspace design. The example of human worker operating a machine is presented in the figure 2. We can see that this machine is too low for ergonomic work. That situation can result in work-related musculoskeletal disorders (WRMDs) connected with persistent pain, loss of functional capacity and work disability [8].

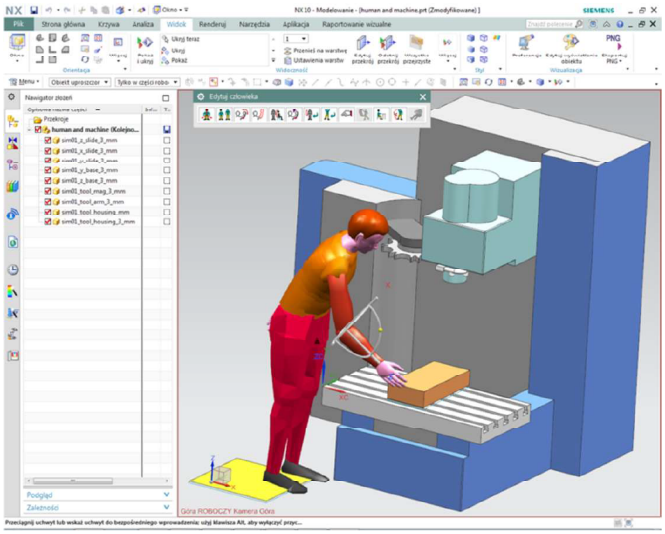

Fig. 2. 3D workspace view of human operating the machine

However detailed analysis of human work process was made with another software tool.

4. Simulation of human work process

Human work requires many movement activities. Jack software, which is a human modeling and simulation tool, was used for modeling and simulation of human work. Jack human model is made up

of 71 segments, 69 joints and 135 degrees of freedom [5]. An example of human model creation is shown in the figure 3.

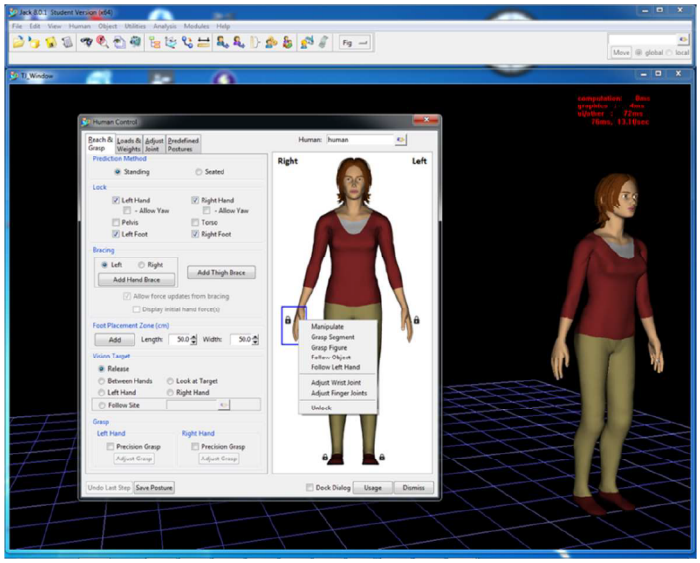

Fig. 3. Example of human model in Jack software

Jack enables improvement of the ergonomics of your designs and to refine industrial tasks. Also provides human-centered design tools for performing ergonomic analysis of virtual products and virtual work environments. Jack enables you to size your human models to match worker populations, as well as test your designs for multiple factors, including injury risk, user comfort, reachability, line of sight, energy expenditure, fatigue limits and other important human parameters [6].

Another example include work process from industrial practice that require manipulation with rectangular box and transport it from machine to conveyor (fig. 4).

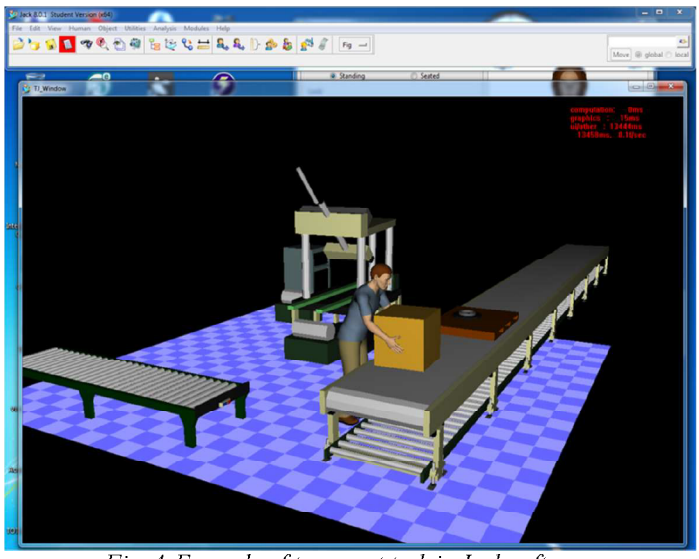

Fig. 4. Example of transport task in Jack software

Next simulation of worker movement activities was conducted. One of the simulation step is presented in the figure 5.

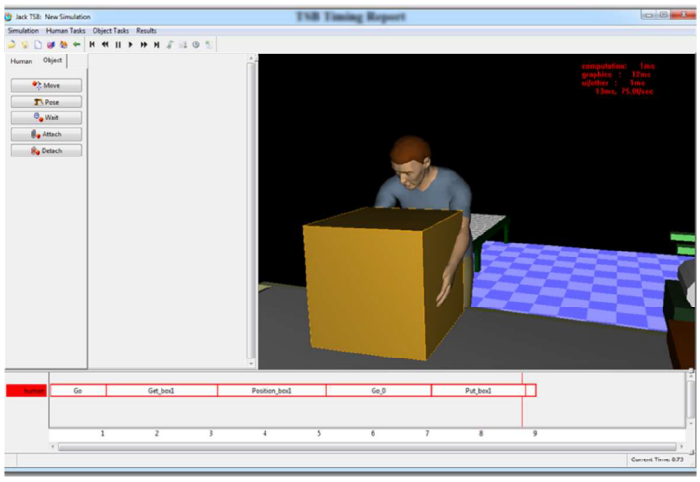

Fig. 5. Simulation of transport task in Jack software

As a result from simulation a human task summary was acquired (Tab. 1), which contain the same action description as is in the MTM method.

Table 1. Simulation report of human activity

Task Summary human			
Task	*Action*	*Duration*	*Code*
Go		**1.04**	
	Walk	1.04	W3FT
Get_box1		**2.06**	
	Bend_And_Reach	1.99	B + R20.704A(b)
	Grasp	0.07	G1A(b)
Position_box1		**2.01**	
	Arise_And_Reach	2.01	AB + R18.356A(b)
Go_0		**1.95**	
	Walk	1.95	W5FT
Put_box1		**1.75**	
	Bend_And_Reach	1.67	B + R11.727A(b)
	Release	0.07	RL1(b)
Go_1		**0.19**	
	Walk	0.19	W0FT

The simulation allows to verify the results obtained from MTM method and more precise calculation of standard work time.

5. Conclusion

Ergonomic workspace design is very important for human health. The technology of digital human modelling has the potential to drastically change and improve the process by which most designers decide on the appropriate human physical attributes to consider in a workspace when attempting to meet ergonomics and production goals. In addition digital simulation of human work process enables prediction of time required for different people to perform a task. Using digital human models facilitates significant cost and time savings by enabling product quality improvement and process feasibility, early in the product lifecycle.

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