Sim-Serv

Sim-Serv Working Group #11
HUCENS
Human-centred Modelling and Simulation

Sim-Serv

Working Group General Information	
Working Group Title	Human-centred Modelling and Simulation
Working Group Short Name	HUCENS
Short Summary of the Working Group Topic	
In spite of all automation efforts, humans still play an important role in manufacturing systems. Correct models therefore must represent the performance of workers in an adequate way. Different approaches are currently used for modelling workers in production oriented simulation models.	
Short Summary of the Working Group Goals	
To review different approaches to modelling humans in production oriented simulation tools, to identify gaps and needs, and provide guidance for further theoretical and development work.	

Short description of the Working Group topic

The ifab-Institute of Human and Industrial Engineering of the University of Karlsruhe (Germany) act as coordinator of the following project. Aim of the project is the recapitulation and description of approaches and further developments of human-centred modelling and simulation.

The activities consist of the following workpackages:

1. Leadership of the Working Group / Arrangement of Workshops
2. Definition of general and strategic goals of Human-centred Modelling and Simulation
3. State of the Art in Human-Centred Modelling and Simulation
4. Pointing out problems and discrepancies between personnel-oriented and material-flow-oriented modelling and simulation
5. Presentation of case study in Human-centred Modelling and Simulation
6. Describing the further development within the field of Human-Centred Modelling and Simulation
7. Summary of the results of workpackages in form of a White Paper Report

For this task, a research assistant will be involved for the whole project. His additionally function will be the installation of the Working Group and preparation of each meeting of them as more as point out the content which has to be discussed within these meetings.

Furthermore he arranges the meetings and has to prepare its moderation.
For examination of the workpackages a term of 6 month of a full-time research assistant will be necessary. The research assistant will be supported by a student assistant and the established Working Group.

Background. Reasons why this Working Group is needed.

The factory of the future will reach various levels of automation dependent on industrial sector, specific applications and socio-technical situation where the factory operates. Thus, it will become more flexible and human-based. Furthermore, the planning of systems is marked to an increasing degree by the development and implementation of computer supported procedures.

Nevertheless, humans will stay the most flexible resource within production system and therefore will play the most important role within operative and decisive functions.

There exist a wide range of techniques to model humans: starting from the - often too simplistic – approach of describing a worker as a special kind of machine with deterministic or randomly distributed process times to the –often too complex – approach of describing each worker by an agent having own goals, motivation and even emotions. A critical assessment of these approaches is needed to guide users in practical applications.

The need of characterising human performance becomes prominent since hardware components are

becoming more and more reliable [Mital et al., 1999]. Human performance depends on individual as well as environmental factors. The former relates to personal attitudes of humans in performing a task within a given time range and a stress level [Bubb, 1992; Furnham, 1992; Parker and Wall, 1996]. Human performance depends on psycho-physical attitude in carrying out operations, on workloads assigned, on physical and mental stress, on learning processes and human skills [Zülch and Schindele, 1996; Buzacott, 2002; Nembhard, 2002]. Environmental factors concern physical and social environments where tasks are performed [Mason, 2001]. Ergonomic or microclimate issues as well as human relationships in the work arena are typical environmental stressors.

Several studies on human performances in production systems are available in the literature since the 30's [Lewin, 1935; Wright, 1936]. However, the characterization of human performances still represents a major issue because of their stochastic dependency by several factors and because of lacking of a general reference framework where both theoretical studies and field investigations can be collocated. Industry and scientific community need of findings which should be specific, more intensely studied, and replicable.

The inability of modelling workers in carrying out operations is a major limitation for modelling production systems. Traditional approaches in evaluating human performances are mainly related to ergonomic concerns which are mostly addressed only after the production system is designed.

Modelling techniques available mainly consist in the Discrete Event Simulation (DES) as well in stochastic and deterministic analytical models. The former allows the description of production systems to evaluate their technical and economic performance. At current, DES models treat people simply as a resource having limited availability for machining and assembly operations. On the other hand, analytical models are based on specific pilot studies which lack in generality. Results are difficult to be replicated and consequently, are of scarce usefulness in system design.

Usually material-oriented simulation methods (as well as logistics and business process oriented tools) are not suitable since they regard employees in the same way as they do machines, buffers and conveyors. In extreme cases of material-oriented simulation, the personnel does not represent a bottleneck in the production process. For planning modern production systems with the choice of machinery and conveyor systems, personnel-oriented simulation proves as a very useful tool in order to evaluate the dynamical process of interaction between personnel and machinery equipment [Zülch, Heitz and Schindele, 1995].

Personnel-oriented simulation tools require additional information about the workload and the characteristics of modelled persons for handling them a specific model-element, separated from the modelled technical resources [Zülch and Vollstedt, 2000]. So the main aspects are the modelling of personnel qualifications, learning and unlearning effects and aspects of occupational psychology and physiology. The main elements are work functions, work forces and organisational units, which are related to each other by feasibility, competence and ability.

In personnel-oriented simulation approaches the employees are regarded as independent elements of the simulation model, separate from machines, buffers and conveyors. The results of these developments are personnel-integrated and personnel-oriented simulation tools [cf. German guideline VDI 3633, part 6, 2001]. Personnel-integrated simulation models allow for a distinction between the capacities of the personnel and the machines, individual modelling of the working times of the personnel and the operation times of the machines, the modelling of various abilities and the modelling of co-operation and group work. Compared with personnel-integrated simulation tools, personnel-oriented simulation tools possess an even higher degree of detail for answering special human related questions. For example, emphasis may be put upon the analysis of the work situation, the work load and stress on humans, the over- or under-utilization of employees, learning and unlearning effects, special aspects of modelling human abilities, human effects caused by different forms of work organisation, psychological aspects, special aspects of group work or even the human reliability. Further applications are the control of the assignment of employees to tasks and examinations of the effects resulting from different kinds of working time models [cf. Zülch and Schindele, 1996; Zülch, Bogus, and Krüger, 1999; Zülch and Vollstedt, 2001; Zülch, Vollstedt and Müller, 2002; Zülch, Bogus and Fischer, 2002].

Working Group goals.

The WG will review the existing approaches and assess their adequacy and range of applicability. A survey will be produced describing these approaches, their strong and weak points, and recommendations as to how and when they should be used will be derived. Knowledge gaps and directions for further research will also be identified.

The goals of the Working Group have to be reached based on preliminary 3 Workshops. Further input should be provided through case studies.

First step for the Working Group is going to be a discussion about the basics of "human-centred" modelling and simulation in general. In this section basically definitions are carefully worded to gain a common groundwork. Furthermore in this step consists of a discussion about the state of the art of "human –centred simulation". Therefore generally and strategic goals have to be defined.

A second Workshop concentrates on the comparison of personnel-oriented with material-flow or logistic-oriented modelling and simulation. Advantages of each type of modelling and simulation have to be analysed.

The third Workshop of the Working Group discusses the further development within the field of human-centred modelling and simulation. Furthermore, a first version of a white paper state will be discussed.

Participants of the Working Group will be experts in personnel- and material-flow-oriented modelling and simulation.

Preliminary content of meetings of the Working Group:

a) Basics of "human-centred" or "personnel-oriented" modelling and simulation
b) General and strategic goals of "human –centred modelling and simulation".
c) Problems and discrepancies between human-oriented and material-flow-oriented modelling and simulation procedures
d) Discussion of case studies
e) Further development within the fields of "human-centred modelling and simulation"

The expected impact of the Working Group.

The Working Group is expected to produce a guideline for practitioners as well as orientation for research and development.

Expertise already possessed by the proposed members.

The Management of the Working Group will be taken over by a research assistant guided by Prof. Dr.-Ing. Dipl.-Wirtsch.-Ing. Gert Zülch from the ifab-Institute of Human and Industrial Engineering of the University of Karlsruhe Germany.

Since 1985 Prof. Zülch is head of the ifab-Institute. Previously, he served as Managing Engineer at the Research Institute for Rationalisation (FIR) at the University of Technology in Aachen and as Head of the Department for Work Structuring within the Central Department for Research and Technology of Siemens Munich, Germany. He hold a Dr.-Ing. degree from the University of Technology in Aachen.
His research activities include ergonomics of communication in industrial applications, computer-aided design of manual workplaces, computer applications in time studies, simulation of organisational studies and qualification of personnel in industrial workshops, structuring of the departmental organisation of industrial enterprises as well as strategies of production planning and control. He conducted various national and international projects concerning the ergonomic and economical improvement of workshops and departments in industrial enterprises of mechanics, electronics, plastics and others, and supported a number of companies in the re-engineering of their production systems. Furthermore, he acted as an expert for various German research programmes and for the French President in the evaluation of research activities. Beyond national activities, he served as an expert for Finish, Swedish and French Universities.

The ifab-Institute (abbreviated from its German name Institut für Arbeitswissenschaft und Betriebsorganisation) provides expertise in the fields of simulation-based evaluation of designed production systems, systematic analysis for redesigning organisational structures, object-oriented modelling of business processes and production systems and user interface design, testing, and evaluation.

Sim-Serv

For the analysis of production systems with respect to their dynamic behaviour, the simulation tool FEMOS has been developed at the ifab-Institute since 1988. It has been successfully applied to the solution of various types of problems in real production systems. Other simulation tools are the ESPE- and the OSim-Software, both of them being described in the literature and applicated in numerous transfer projects.
The ifab-Institute has acted as partner and coordinator in European projects within the COMETT, LEONARDO, TEMPUS, and ESPRIT Programmes (for example within the REALMS re-engineering project from 1996 to 1999).

Literature

Bubb, H. (edt.) (1992), Menschliche Zuverlässigkeit. Landsberg: ecomed-Fachverlag.

Buzacott, J. A. (2002), The impact of worker difference on production system output, Int. J. of Production Economics, vol. 78, pp. 37-44.

Furnham, A.(1992), Personality at work: the role of individual differences in the workplace, Routledge, London.

Lewin, K. (1935), A dynamic theory of personality, McGraw-Hill, NY.

Mason, S., and Baines, T.S. (2001), Micromodelling of human performance, Operational Research Society, Annual Conference, 4-6 September, University of Bath.

Mital, A., et al. (1995), The need for workers training in advanced manufacturing technology (AMT) environments: a white paper, Int. J. of Industrial Ergonomics, vol. 24, pp. 173-184.

Nembhard, A. D., and Osothsilp, N.(2002), Task complexity effects on between-individual learning/forgetting variability, Int. J. of Industrial Ergononmics, vol. 29, pp. 297-306.

Parker, S. K., and Wall, T. D.(1995), Job design in modern manufacturing, in: Psychology at work, Penguin Books, Harmonsworth.

VDI - Verein Deutscher Ingenieure (edt.) (2001), Abbildung des Personals in Simulationsmodellen, VDI-Richtline 3633, Blatt 6, Beuth-Verlag, Berlin.

Wright, T. P. (1936), Factors affecting the cost of airplanes, J. of Aeronautical Sciences, vol. 3, no. 4, pp. 122-128.

Zülch, G., Bogus, T., and Fischer, J. (2002), Integrated Simulation and Workforce Assignment for the Evaluation of Flexible Working Time Models, in: Chen, Z. et al., System Simulation and Scientific Computing, International Academic Publishers, Beijing, vol. I, pp. 353-357.

Zülch, G., Bogus, T., and Krüger, J. (1999), Decision Theory Based Approach for Modeling and Simulating the Activity Preferences of Workers, in: Axelsson, J. et al., TQM and Human Factors - towards a successful integration, vol. 2, pp. 211-216.

Zülch, G., Heitz, M.-J., and Schindele, H. (1995): Use of simulation for planning of work organization in highly automated production systems - Two case studies. In: International Journal of Production Economics, Amsterdam, 41(1995), pp. 429-436.

Zülch, G., and Schindele, H., (1996), Dynamic model of human reliability for quality-oriented planning of production systems, in: Özok, A. F., and Salvendy, G., Advances in Applied Ergonomics, Istanbul, USA Publishing, West Lafayette IN, pp. 51-54.

Zülch, G., and Vollstedt, T. (2000): Personnel-integrated and Personnel-orientated Simulation – A New Guideline of the German Association of Engineers in: Information and Communication Technology (ICT) in Logistics and Production Management. Edts.: Strandhagen, J. O, and Alfnes, E. Tromsø, 2000, pp. 185-192.

Zülch, G., Vollstedt, T., and Müller, R. (2002), Balancing of Hybrid Assembly Systems Using a Simulation Approach in: Jagdev, H., Wortmann, H., Pels, H.-J., and Hirnschall, A., Collaborative Systems for Production Management, Technische Universiteit Eindhoven, pp. 411-418.