Martina Jakob and Martin Geyer, Potsdam

Measuring Individual Performance to Design the Man-machine-interface

Time studies subjectively estimate individual performance and this is called the performance index. The normal performance index and the duration of the task result in the normal performance rate. The ability to successfully estimate the normal performance rate only comes from a wide range of experience. To optimise work processes and the design of man-machine-interfaces, motion analysis was applied, which describe individual achievement potential and objectively compare the performance of various workers.

Dipl.-Ing. Martina Jakob and Dr. Martin Geyer are members of the scientific staff of Leibniz-Institute Agricultural Engineering Potsdam-Bornim e.V., Max Eyth-Allee 100, 14469 Potsdam (Head: Prof. Dr. R. Brunsch); e-mail: *mjakob@atb-potsdam.de*

Keywords

Work-place design, motion analysis, level of performance, time study

Modern agriculture is in a flux, characterised by technical progress, a large choice of products, stronger awareness for quality, but also an increasing interest for the workers themselves. The methods of work place design have to adapt to these changes.

Nevertheless, work design in the manufacturing environment is traditionally technology-driven, focussing on machine capacities, but neglecting the role of people in production processes [2]. A lack in the understanding of man-machine-interactions can result in bottlenecks and outputs below the potential maximum.

The performance rate is characterised by the ratio of input to the achieved result. Related to the work force this means the worker's commitment to yield a result. The individual work performance is influenced by different factors, like the individual capability and willingness, the knowledge or skills.

The work related capability of a person determines the suitability to do a job. Individual performance rates often show large variations. For a quantification of the influence of factual conditions, the output is commonly straightened out by a qualitative correction factor representing the standard human performance. This standard work rate (REFA, 1984) describes the ratio of expected to the observed performance and is determined by the observer. Reliable estimation demands a wide range of practical experience.

In horticulture as well as in agriculture time studies have been conducted [4, 5, 6] over the years to be able to schedule the work processes or increase efficiency. On the other hand, a just and reasonable evaluation of skill and performance has become important for the whole sector of wage-work, once employees' rights have been taken into consideration. As a result, payment based on output demands the determination of standards.

Nevertheless the determination of the standard work rate was not always part of the cited time studies. Reasons for this may be the large variety of tasks, the short cycle times or a lack of experience in reliable estimation. If the individual performance is not straightened out, the measured process times cannot necessarily be transferred to other situations. In consequence an objective assessment criterion is demanded to reduce the influence of individual human performance.

Method

Motions are the basics elements of work processes. An online motografic system was used to track the human motions (Extrac, Wente/Thiedig, Braunschweig, Germany). It contained two CCD cameras, recording the positions of the infrared light-emissive diodes, which track the human motions. The course of motion is described by 3-D-room coordinates, which allowed calculation of significant indicators [1].

The determination of the standard work rate is based on the visual evaluation of the worker's efficiency and intensity. The intensity is mainly influenced by the speed of movement, whereas the efficiency is described by many factors like target precision, harmony, task control or a rhythmic work flow [3].

The evaluation of the work speed was realised by comparison with MTM data. For this the process was subdivided into motion elements.

The efficiency was checked on harmony, target precision and rhythmic work flow.

For the investigations a simple re-enacted process, the placing of delicate products like asparagus on conveying units, was set up. By the means of significant indicators the individual performance rate shall be rated.

Results

In order to rate the intensity of the work process, the motion elements moving and reaching were separated. The time spent for these elements is mainly influenced by the speed of motion and the distance. If the measured data is compared with MTM data, representing a standard work rate of 100%, one can determine the achieved performance (*Fig. 1 and 2*). The different graphs represent the varying times spent, due to different influential factors. Figure 1 and 2 display the measured average durations and the distances for

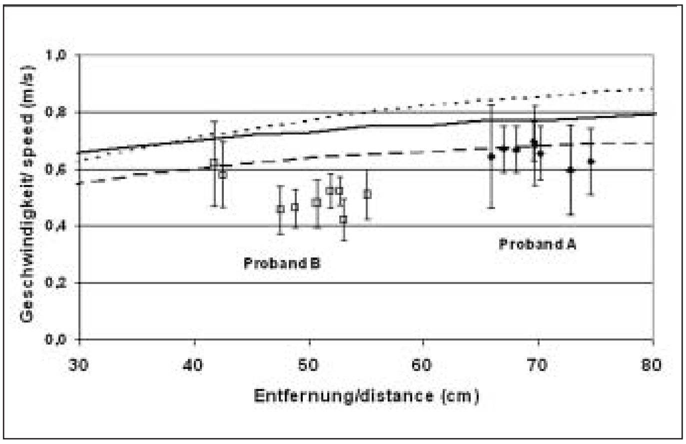


Fig. 1: Measured average speed of the right hand of subject A and B for bringing products in comparison to MTM data for different degrees of difficulty (A solid line, B broken line short, C broken line long)

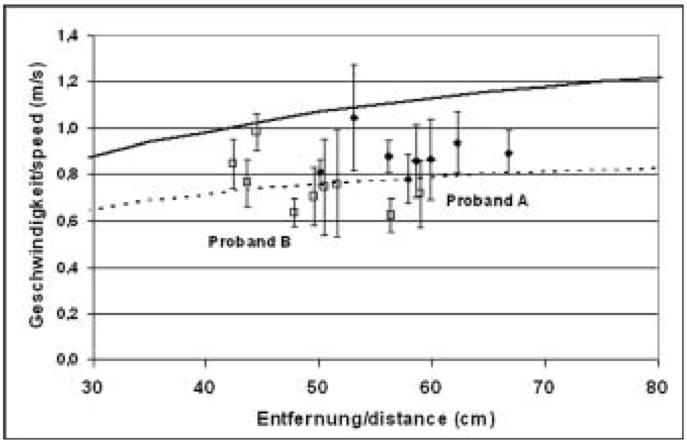


Fig. 2: Measured average speed of the right hand of subject A and B for reaching to products in comparison to MTM data for different degrees of difficulty (A solid line, B broken line)

the right hand of two test persons. For the motion element moving person B mainly achieved values lower than the MTM data, which means that its performance was below a normal performance rate. The performance of A was slightly higher, but at the same time, larger distances for moving the material were measured. For the motion element reaching the measured values did not show noteworthy interpersonal differences and were situated along a normal performance rate.

The path that a person's hand travels to move an object from one place to another is, as known, curved. The maximum distance from the work surface was defined as the summit point. It was measured with 17.14 cm (0,68 stdv) for person B and 19.51 cm (0,76 stdv) for person A.

To evaluate the target precision of both test persons, the working width and the summit points of the motion elements moving and reaching were examined (Fig. 1 and 2). The movement of test person A was fast but unnecessarily far, whereas B minimised the distances for material transport, but showed a higher maximum deflexion upwards.

The harmony and rhythm of uniform and recurring motions is for example characterised by the degree of conformance of the motion tracks. At the same time body posture was checked and described by representative and recurring positions. If these positions are drawn in a graph, one can see a characteristic shape for the duration of one cycle (*Fig. 3*). A large congruence of these shapes proves a rhythmic and harmonic work style. Random testing of this parameter is possible. Fatigue can also be detected that way.

Discussion

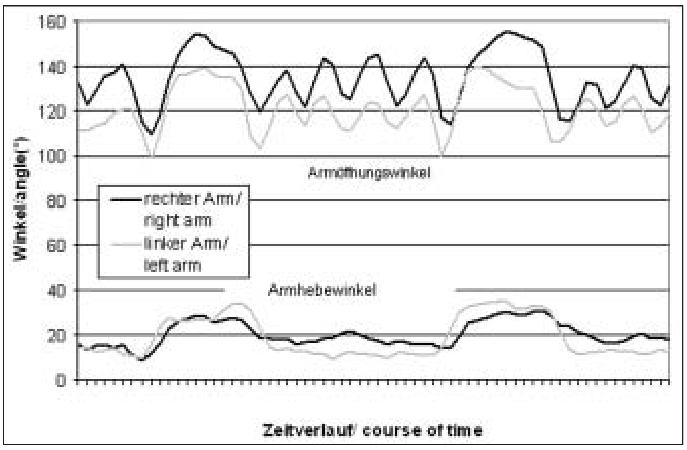
Following the definition of the standard work rate, four of its descriptive parameters were measured, the speed of motion, target precision, harmony and rhythm. These indicators allowed an objective evaluation of the motion tracks as well as an interpersonal comparison.

The rating of the speed of motion mainly depends on the reference data. Figure 1 and 2 point out that solely looking at the speed of motion is not enough. Test person A shows explicitly faster but also further movements, reducing the positive effect of the higher speed. This fact should be cleared by the time study engineer, estimating the standard work rate.

If the work process is divided in phases the quantitative parameters can be checked according to the sections. A high conformance of data indicates a harmonic work style. To finally calculate the standard work rate, the measured parameters need to be weighted. The interdependence could be determined by regression models.

Finally it can be stated that the motion analysis is an appropriate tool to objectively measure individual performance. The sum of motion and the speed of motion are the most influential factors on the amount of time spent.

Fig. 3: Arm position over the course of two cycles described by the opening angle (top graphs) and the elevation of the upper arm (bottom graphs)



Literature

Books are identified by •

[1] • *Jakob, M.:* Bewertung von Arbeitsprozessen im Gartenbau mit Hilfe der dreidimensionalen Bewegungsanalyse. Dissertation, HU Berlin, 2005, http://edoc.hu-berlin.de/dissertationen/jakob-martina-2005-02-03/HTML/

[2] *Paquet, V., and L. Lin:* An integrated methodology for manufacturing systems design using manual and computer simulation. Human Factors and Ergonomics in Manufacturing, 13, (2003), no.1, pp. 9-40

[3] • Refa: Verband für Arbeitsstudien und Betriebsorganisation, Methodenlehre des Arbeitsstudiums, Teil 1. 7. Auflage, Carl Hanser Verlag, München, 1984

[4] *Schick, M.:* The work budget as an aid to work organisation and time planning. Proceedings of the XXXI CIOSTA-CIGR V Congress, Hohenheim, 2005, S. 52-57

[6] *Stoffert, G., und H.-R. Rohlfing:* Von der Planzeit bis zum Produktionsverfahren. GbGw, Heft 35, 1980, S. 770-773

[7] *Stoffert, G., und H.-R. Rohlfing:* Arbeitszeitbedarf zur Erzeugung von Topf-Chrysanthemen. GbGw, Heft 35, 1980, S. 773-776