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COMPUTER-BASED INTEGRATED ASSISTANCE SYSTEM FOR COORDINATE MEASURING MACHINES

KOMPJUTERSKI INTEGRIRANI POMOĆNI SISTEM ZA KOORDINATNE MJERNE MAŠINE

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Abstract

The constant increase in application areas of coordinate metrology is due to the universality and flexibility of coordinate measurement machines (CMMs). Their varied applications require of the CMM operator and measurement planner a high degree of basic and action knowledge. In coordinate metrology, uncertainties are mainly caused by the operator. The aim is to achieve small uncertainties, so that reliable and predominantly operator-independent measurement results can be obtained. To reduce the effects of the operator it is necessary to support the CMM operator in his processing of measuring tasks. The presentation deals with a support system for CMM operators. It is integrated into the workplace so that CMM operators can receive advice during their planning and measuring activities. It describes how an assistance system can be set up and how the computer-based knowledge required by the operator can be presented.

1. INITIAL SITUATION

The constant increase in use of coordinate metrology is due to its universality and flexibility. In addition to measurement of lengths in three dimensions, CMMs are also used to execute form tests and to digitise unknown surfaces. Their varied applications require of the CMM operator and measurement planner a high degree of basic and action knowledge, so as to achieve measurement results with the smallest possible measurement uncertainty.
Measurement deviations in coordinate metrology are caused by the operator, environment, workpiece, and measuring machine. The influencing factors operator – environment – machine have a relative importance of approx. 100:10:1 [1] respectively in causing deviations.
The technology of the hardware today is such that uncertainties of 1 to 2 µm, in some cases, even smaller, are state of the art. Monitoring of inspection, measuring, and test equipment with calibrated test pieces ensure long-term stability of the test results and traceability to national and international standards. Uncertainties caused by environmental influences can be minimized by using specified materials and establishing of defined constant conditions. It is to some extent possible to compensate the influence of the environment computationally.

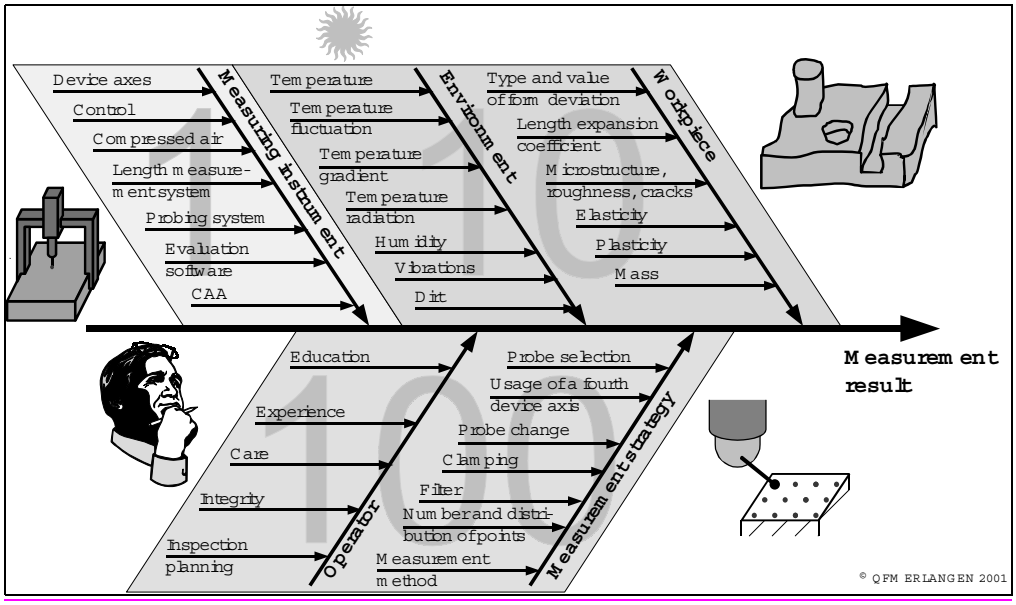

FIGURE 1: INFLUENCES ON RESULT VALUE AND UNCERTAINTY USING FLEXIBLE MEASURING INSTRUMENTS.

Only very little information is available about the influence of the operator although it can be the cause of the greatest result deviations. To achieve low deviations, that are reliable and largely operator-independent measurement results, it is necessary to place the emphasis of development on the operator. In addition to solid training of the measuring machine operators, another way of reducing the operator influence on the measurement result is to provide the operator with direct support during processing his measuring tasks.

2. REQUIREMENT FOR NEW ASSISTANCE SYSTEMS

Training courses for operators of CMMs are usually held by the manufacturers of the machines. Their focus is on hardware and software details. Far too little time is given to teaching basic metrology and imparting knowledge of standards. Even if efforts are being made to rectify this deficiency with a manufacturer-independent training concept for coordinate metrology Š2Ć, there is still the disadvantage of the lack of practical reference. The problems then occur after the training during practical application of the knowledge learnt while performing measurement tasks. In the training course, usually lasting 3 to 5 days, it is difficult to impart the necessary metrological know-how. The whole range of ever more complex functionality of CMMs is only dealt with in a fragmentary way in these courses.
For companies, conventional training courses are a significant cost factor because of training costs, possible travel and accommodation costs of the participants, and the cost of absences from the company [3]. Moreover, training courses are bound to fixed dates and localities and are not available to the user "just in time". An integrated assistance system, on the other hand, can be called up by the user at any time and at any workplace. The user no longer has to leave his place of work to obtain knowledge, thus eliminating additional costs. That is a point in favour of using workstation-integrated assistance.

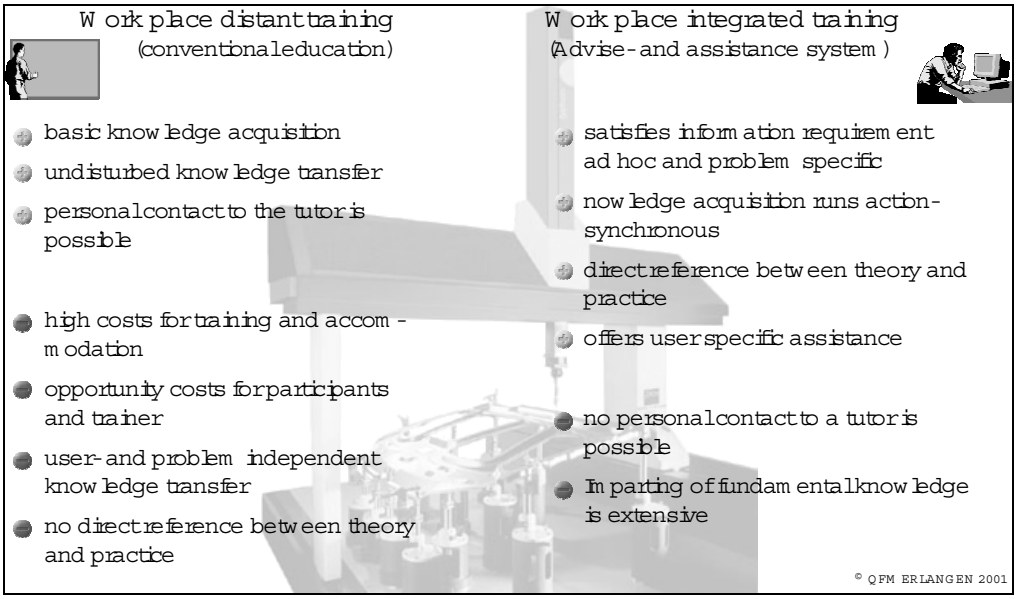

FIGURE 2: COMPARISON OF WORK PLACE DISTANT AND WORK PLACE INTEGRATED TRAINING.

Existing advice and assistance systems, inasmuch as there are any, are usually no more than online help systems and assistants that provide support with writing measurement procedure programs. They explain the syntax of the device's own programming language or automate working steps, whose effect, however, often remains unclear. In some cases, help systems are no more than digital manuals. None of the current systems supports the user with expert performance of his measurement tasks in a holistic way, from analysis, through planning and execution of measurement, to assessment and evaluation of the results. Current help systems do not make use of the full range of knowledge teaching that multimedia assistance modules offer. In the way they impart information, these systems have little specification of users, providing every user with the same help regardless of his level of knowledge and his tasks.

3. REQUIREMENT OF ASSISTANCE SYSTEMS

An advice and assistance system that supports the user actively in correct processing of his measurement tasks must meet higher demands than are met by the systems currently implemented. Such a system must not limit the support it offers to help with programming. It must support the machine operator and measurement planner with all steps: analysis of measurement tasks, planning and execution of measurements, evaluation and representation of the results. The provided information must be accessible on the measuring machine and understandable to every user at any time and in a simple way. That requires that such an advice and assistance system be capable of user-sensitive adaptation to individual requirements for information and support. The user must be provided with a way of intervening in the assistance system so as to control interactively the breadth and depth of the information offered. It must also be possible for the user to add information to the existing assistance system.
We can also expect, that the assistance offers itself to the user according to situation and context, that is only to provide information and support which is required for the measuring task in hand.
Individual requirements are fulfilled by current help systems but none meets all the requirements of a complete advice and assistance system.

4. WAYS OF PROVIDING INFORMATION

Provision of information at a workstation can be implemented in different ways. For example, the assistance system can be integrated into the system of the CMM.

Or, knowledge can be provided through a Web-based assistance system. Both ways have their advantages and disadvantages.
With an assistance system integrated into the machine it is easier to provide information specific to the machine because it is possible to create an individual assistance system for each type of machine, which, for example, can deal with the special features of processing measuring tasks on that particular measuring machine. The breadth of such assistance solutions is restricted by the programming effort required for each machine type. Because they are integrated, such assistance solutions can only be developed in close collaboration with the CMM- and measuring software manufacturers.
Web-based provision of information has the advantage that it can be implemented simply and without any restrictions imposed by the machine system. This way of providing information is also independent from the platform of the CMM software. In particular, multimedia assistance modules can be implemented web-based. The disadvantage is that provision of machine-specific knowledge can be very broad because of the variety of types of CMM. On the other hand, it is an efficient way of providing and updating machine-independent basic knowledge for performing measuring tasks on the Web.
An assistance system with comprehensive functionality can only be implemented with a combination of these and other concepts.

5. OFFERING ASSISTANCE

We can expect a user-sensitive assistance system to present the required information depending on the profile of the user. A simple machine operator requires extensive assistance, including learning options close to the workstation, for example, to be able to decide reliably between scanning or discret-pointprobing. When using the scanning method, an experienced and trained measurement engineer requires only information about parameter optimisation or estimation of the measurement uncertainty.

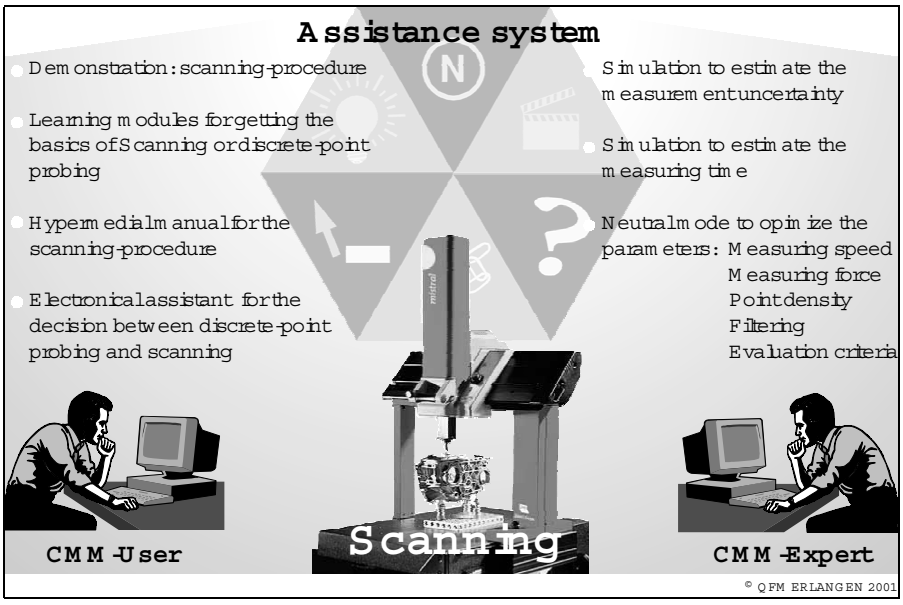

FIGURE 3: VARIABLE ASSISTANCE FOR DIFFERENT USER PROFILES.

Therefore such an advice and assistance system must be able to decide according to different user profiles that depend on the level of knowledge, the field of functions and practical experience of the user. In practice, a distinction between at least three user profiles has become standard. For example, a distinction is made between the CMM-Operator, who runs completed measurement programs, the

CMM-User, who can modify measurement programs and perform simple measuring tasks himself, and the CMM-Expert, who performs complex measuring tasks and makes decisions [2].
It is also necessary to make a distinction between the types of information to be imparted. The didactic presentation of action knowledge is different from that of structural knowledge or knowledge of standards. Action knowledge, such as use of the "right-hand rule" to find the coordinate direction, is most easily imparted using illustrations. Structural knowledge on the other hand, such as orientation of the coordinate systems in space is easily described verbally or mathematically. But it is not enough just to divide the information to be presented in to action knowledge and structural knowledge. It is also necessary to distinguish between background knowledge that is essential for processing measuring tasks and additional information that contributes to a better general understanding.
An advice and assistance system must therefore present its support in various ways to assist the user during his measuring tasks in a context-sensitive way.

6. COMPONENTS AND INTEGRATION OF ADVICE AND ASSISTANCE SYSTEMS

Using various, also multimedia assistance modules, it is possible to provide an assistance system that offer users with different profiles individual task-related support and gives them the necessary knowledge. Each of the modules shown in Fig. 4 is especially suitable for imparting structural knowledge, action knowledge, additional information, or background knowledge, such as metrological background knowledge and knowledge of standards. Each addresses the various user profiles differently.

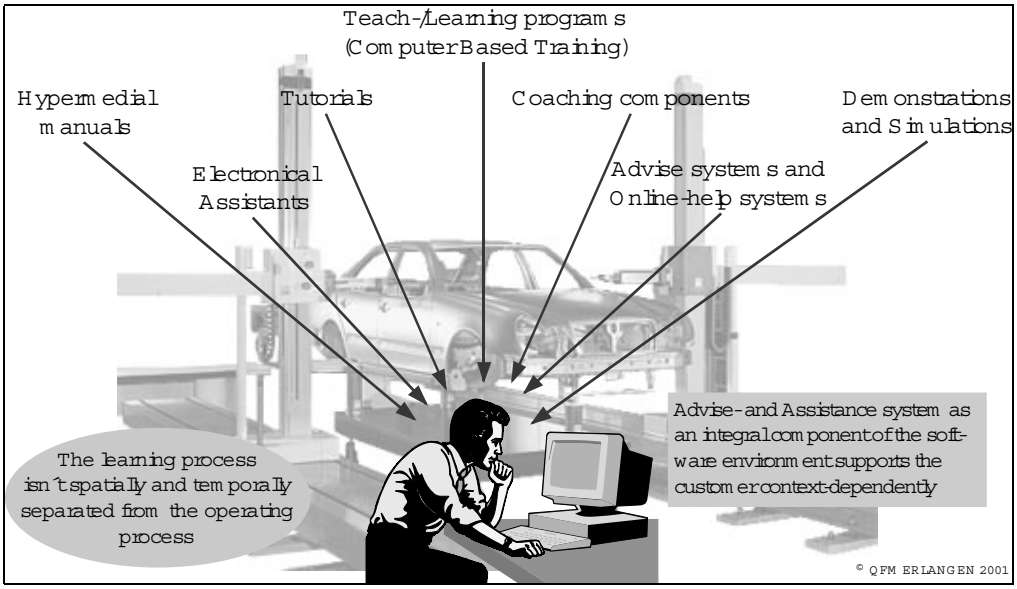

FIGURE 4: COMPONENTS OF AN INTEGRATED ASSISTANCE SYSTEM.

For example, electronic assistants are used for work processes where the only aim is to solve the task without the necessity of informing the user of the background and technical details. They are mainly used to catch incorrect or missing input or parameters and to ensure sequential execution. Starting a coordinate measuring machine is one example of that. It is usually necessary to perform numerous actions that must be performed in a certain sequence. An assistant for the starting procedure monitors observance of the sequence and ensures that the inputs are complete. At the same time, on the basis of a user log-in, it can assign a user profile to the user or load his personal profile, containing information about his level of knowledge, his field of functions or his practical experience. To start the measuring machine, the

user does not have to be informed about the background of the sequence of operations, it is only necessary to ensure that the sequence is kept to.
Tutorials are especially suitable for providing introductory knowledge of standards, basic knowledge, and action knowledge about extensive topics. They provide the user with an initial introduction to the problem in hand, for example, about selecting the correct evaluation criterion for determining the form deviations. After that, the user selects the necessary information, such as extracts of standards with an explanation or learning units about evaluation criteria and form testing that teach him the minimum zone method as the standard-compliant evaluation criterion for form testing. The information is presented to him interactively in small steps. Afterwards he can check his level of knowledge and obtain a course certificate. The initial extra work time spent using the tutorial quickly leads to time savings due to faster processing times and reliable operation of the CMM. Tutorials are especially suitable for user profiles CMM-Operator and CMM-User. For the CMM-Expert, who no longer requires an introduction to the topic, they are too time-consuming to obtain the required information quickly.
If the technical subject matter to be explained is very complicated, demonstrations often provide an excellent illustration. They are especially suitable for representing self-contained action sequences, for example, a video description of a scanning procedure at the CMM. Photos and movies create a link with practical work. The user can recognize the real environment at the CMM. Demonstrations are above all suitable for imparting action knowledge, but they do not permit the user any interaction.
These examples show that individual modules are especially suitable for presenting some of the types of information described, depending on their characteristics. The most suitable module can therefore be selected and implemented to provide the information required.

7. SUMMARY

The interest exhibited by industry indicates that there is a requirement for workstation-integrated computer-based advice and assistance systems for executing measuring tasks on CMM. Conventional training course are a considerable cost factor for companies. They also have the disadvantage of not being available on the CMM at the moment the problem is posed. Existing assistance systems in the current work environments on CMMs are only implemented in an unsatisfactory and fragmentary way. There is therefore a need for a new generation of advice and assistance systems whose requirements are defined here.
If the objective of supporting the user consistently in performing his measurement tasks is achieved, the influences on the measurement result of the measurement strategy and the operator can be reduced. Finally, this leads to reliable statements about the measurement result.
The research project at the Chair for Quality Management and Manufacturing Metrology at the University of Erlangen/Nuremberg is elaborating fundamental knowledge for the creation of advice and assistance systems. The resulting method for creating the assistance systems for coordinate measurements will be applicable to other procedures, in particular to numerically controlled measuring instruments, because of the multi-faceted nature of the metrological method and the applications of coordinate metrology.

8. REFERENCES

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