Experience-based User Support System for the Measurement of Micro-mechanical Parts

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Abstract

The selection of a suitable measurement strategy for micro-dimensional quality features is a task which requires considerable expertise and experience. To aid technicians with the appropriate selection of a sensor and its parameter settings for a given measurement task, this article presents an experience-based user support system. The structure of the system's backbone, a relational database, as well as the interaction of the technician with the system is described. The support system can lead to improved measurement results while also decreasing the necessary time and effort for the inspection planning process.

1 Inspection planning for micro-dimensional quality characteristics

In order to guarantee the successful operation of micro-systems, the functionally relevant features must be inspected to verify that they meet the defined specifications. As a general rule, the measurement uncertainty should not exceed one tenth of the width of the tolerance of the feature to be examined [1]. As the size of quality characteristics decreases, this requirement becomes more difficult to fulfill. The measurement process itself thus becomes an ever more vital process for the successful manufacturing of micro-dimensional components.

The measurement of geometrical characteristics of micro-structured workpieces places high demands not only on the utilized measuring device but also on the user, who has to choose among a large number of possibilities to define a measurement strategy [2]. For example, specialized measuring devices for the characterization of parts with dimensional features in the micron range often employ multiple sensors. The appropriate selection of a sensor and its parameter settings for a given measurement task requires considerable expertise and experience from the technician.

2 Vision: fully automatic determination of an inspection plan

In the future, an intelligent user support system, which suggests a measurement strategy for a certain measurement task could aid technicians in this decision process. The system relies on information about past measurements as well as on theoretical models to evaluate the influence of the measurement strategy on the measurement result, e.g. the measurement uncertainty. Therefore, the technician must provide the system with a precise definition of the measurement task. If a CAD-Model of the part is available, the type, the nominal size and the tolerance of the feature could be provided by highlighting the feature in the model. Further information about the material of the part (optical properties, coefficient of thermal expansion, etc.) needs to be defined.

Ideally, after the technician fully describes the measurement task, the support system would recommend the best measurement strategy based on the available measurement devices and sensors. The best measurement strategy can be found by evaluating the time, cost and measurement uncertainty of the measurement. Figure 1 illustrates the interaction between the technician and the support system.

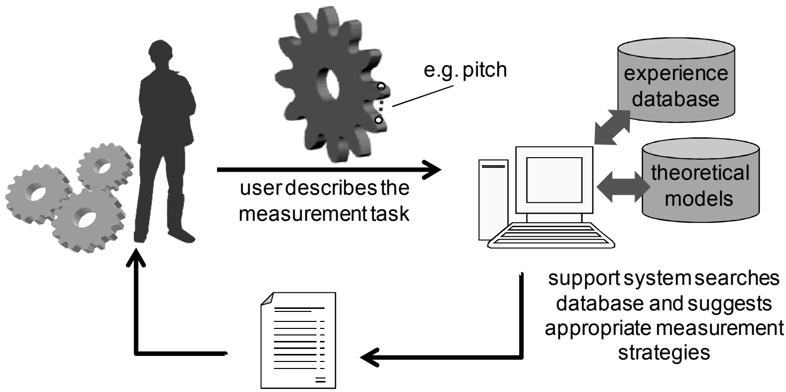

Figure 1: Intelligent user support system

3 Experience-based user support

In this section the experience-based component of the described user-support system is presented. This component bases its recommendation on past experiences. The sensor and sensor parameter combinations for a new measurement task for example can be found by reviewing past selections for similar measurement tasks. The system thus learns over time with increasing experience how to best complete a given task. To enable this learning process, adequate systems for data storage and for the classification of measurement tasks were developed.

3.1 Database structure for the support system

The backbone of the support system is a relational database, which was developed to store information about past measurements. The database not only includes measurement results but also details about the measured workpiece, the used instrument and its sensors, clamping and parameter settings as well as the evaluation and sampling strategies. To be able to apply the database to a wide field of different measurement tasks and methods, the database structure needs to be constructed in a flexible manner. For example, possible parameter settings for a large range of available sensors must be assignable.

Figure 2 gives an overview of the structure of the developed database with a simplified Entity-Relationship diagram [3]. Only the main tables and the cardinality of their relationships are shown.

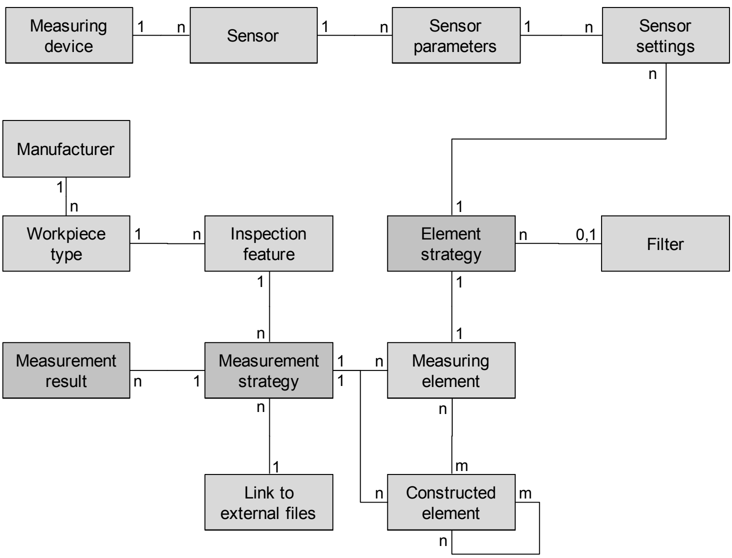

Figure 2: Database structure

As can be seen, for each inspection feature multiple measurement strategies can be defined, and every measurement result is assigned a measurement strategy. Thus, the user can review the details of the measurement for every result in the database.

Each measurement strategy defines different measuring features, for whose measurement a certain element strategy is described. This includes information for example about the used sensor and its parameter settings, the sampling strategy and the use of filters in the evaluation process.

3.2 Database search

The user, who has to develop a measurement strategy for a specific micro-structured workpiece, uses a search function to find similar measurement tasks in the database.

The initial point of the search is the measurement result table, where all information in the database about past measurements converges.

The search criteria are based on a classification scheme, which allows similar measurement tasks to be identified. Multiple criteria, such as the material of the workpiece or the size of the structure to be measured, can be defined to find datasets, which correspond to the measurement task at hand. Based on the search results the user can then determine with which measurement strategy similar workpieces have been successfully characterized before.

4 Summary and conclusion

The experience-based user support system described in this article can aid technicians in the selection of the appropriate measurement strategy for a given measurement task, leading to improved measurement results while also decreasing the necessary time and effort for the inspection planning process.

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