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KNOWLEDGE-BASED INSPECTION PLANNING FOR MULTI-SCALED QUALITY TESTING

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Abstract – Inspection planning plays a decisive role in quality assurance. The principal tasks of inspection planning are to decide which measuring instrument is capable for a special inspection feature and how the measurement should be executed. For devices under test with inspection features of different measuring ranges multi-sensor-measuring systems are needed. The aim of this paper is to describe a fundamental concept for multi-scaled quality inspections.

Keywords: inspection planning, multi-scaled measurements

1. INTRODUCTION TO INSPECTION PLANNING

The development and control of more and more complex and extensive technical systems yields to measurement-technology requirements in an increasing degree. These requirements can not be met with the operation mode of a single sensor because, in most instances multifarious and multi-scaled measuring quantities are existing on one device under test.

The aim of this paper is to give essential ideas and concepts to the inspection planning for multi-scaled quality inspections. The main parts of inspection planning are especially the selection of a capable measuring instrument respectively sensor and the design of adequate inspection strategies.

Due to the large number of inspection features on multi-scaled devices under test, the realisation of the sensor selection in a manual way is very costly in terms of time, is based on the inspection planners know-how and can cause rough errors.

The selection and assignment of capable sensors to the different inspection features of a multi-scaled device under test is actually realised manually by the inspection planner. The inspection planner has to be well schooled in the technical characteristics of all available measuring instruments/sensors. It is also the inspection planners task to evaluate the measurement capability of the inspection feature. Furthermore, the bandwidth of possible application areas is not exhaustively investigated yet for some of the newer sensors.

The determination of a potential inspection strategy poses a big challenge for the inspection planner, especially if the sensor selection and the inspection strategy are correlated (fig. 1).

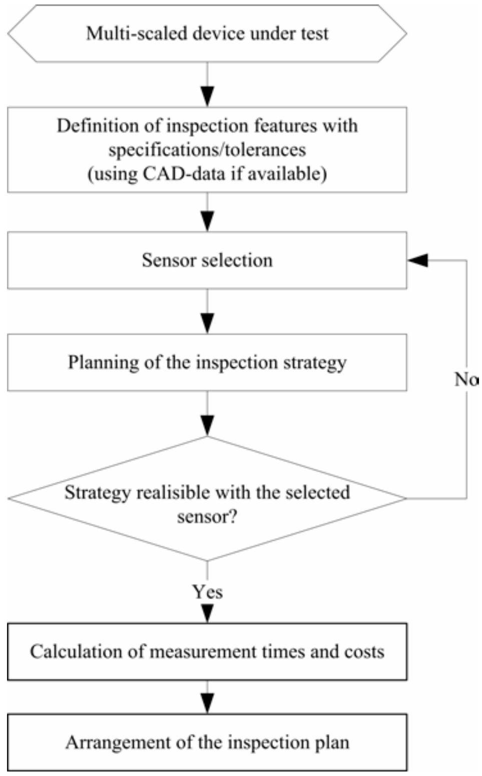

Fig. 1. General course of action for inspection planning

2. PROBLEM DEFINITION

For simplifying the process of inspection planning and to reduce quality cost, it should be worked out if the selection of a capable sensor can be realised automatable. Therefore, extensive interrelations between the sensors and possible inspection features and also detailed information on sensor parameterisation have to be implemented. For general measurements the automated sensor selection would require an immense database with regularities for the assignment of a capable sensor and for the sensor parameterisation. Only for reiterative measurements, as usual in series production, the fully automated inspection planning is efficient and conceivable within custom-made measuring systems.

In a first step an assistance tool for sensor selection should be prepared also to check the users acceptance.

3. ASSISTANCE TOOL FOR SENSOR SELECTION

In a first step the methodology of sensor selection should be broken down to prepare an assistance tool for inspection planning. From these items general rules should be deduced. The previous knowledge of sensors as well as materials and surfaces of devices under test should be provided by the assistance tool. If all information on available sensors is implemented, the sensor selection is a complex decision problem. In [1] an assistant system is presented which is divided into a hardware and a software system. The hardware assistant system uses general rules of thumb and expert knowledge whereby the software assistant system is based on simulations and uses neural networks and generic algorithms for the optimisation of the measurement.

3.1 Acquisition of sensor-specific properties

In dependence on the functional principle of the used sensors all for the inspection task relevant sensor-specific information should be determined and systematically classified. Therefore the inspection task based measurement uncertainty should be analysed for the determination of operation area limits. Operation areas of several sensors should be confined in relation to their application. Assets and drawbacks of several sensors should be experimentally analysed by means of selected samples of inspection features.

The technological prerequisites of measurements on micro- and nanoscaled quality features have to be defined. Therefore material properties of the surface, technological manufacturing processes and the geometry of the inspection feature have to be taken into account. Additional intrinsic properties of the sensor have to be determined for the selection of an adequate inspection equipment respectively sensor. Within a database criteria for possible inspection features should be assigned to available sensors considering the specifications of the inspection feature. This database is the foundation of the automated sensor selection of micro- and nanoscaled inspection features. Often a main part of necessary information on the inspection feature can be taken from the CAD-data. The sensor selection can be realised using an inference method based on the information about the measuring spectrum of each sensor stored in the database. Compulsory selection criteria are in addition to the technical feasibility, the measurement range of the available sensors and the maximum permissible measurement uncertainty corresponding to the specification of the quality feature. The sensor selection should be realised comprehensible and reproducible according to logical defined rules

3.2 Knowledge-based method

Knowledge-based principles of decision theory are used for assigning inspection features and capable sensors. Thereby constructive algorithms should be used for the concentration of information and for the realisation of automation. It is the aim to reduce the influence of the inspection planner insofar as equal measuring tasks yield to the same sensor selection.

At the moment inspection planning is effected in dependence on the state of the planners knowledge. For this reason it is not enough to upgrade the accuracy of the sensors.

A multitude of measurement-specific parameters has to be determined for predefining the measuring strategy, which is an essential part of inspection planning. The parameter setting has an considerable effect on the measuring result. On that account it is needed to develop approaches to inspection planning in which the preparation of the inspection plan is less depended on the individual measurement technicians state of knowledge.

The sensor selection takes up an essential position within the knowledge-based inspection planning. The automation of sensor selection would reduce the measurement times, the measurement uncertainty and would advance the usability as well as reduce the planning effort.

Experiments to the measurability of different multi-scaled inspection features are realised as a first step to the central aim. In the following the stepwise procedural method of automated sensor selection using measurability experiments is itemised:

a) definition, characterisation and classification of the inspection feature
b) experiments to measurability on the available sensors/sensor systems
c) evaluation of experimental results:
   - feasibility of the measuring task
   - documentation of capable parameter settings and inspection strategies
   - measuring condition requirements
   - expression of the measurement uncertainty
   - measuring time
d) transfer of results in the database

Based on the measurement experiments a systematic structure has been developed for automated sensor selection, which is depended on possible criteria e. g. physical measuring principle, dimensionality of the inspection structure (direction sensitivity) and surface properties.

Figure 3 demonstrates one of the experiments, especially the measurement of a micro lens. The multi-scaled approach becomes apparent. Some inspection features especially the surface structure (fig. 2 d)) are measurable only with high-resolution sensors. The external dimensions of the lens are measurable with standard image sensors. Whereas special properties for example the edge (fig. 2 b), c)) are analysable trusted only with high-resolution 3D-sensors.

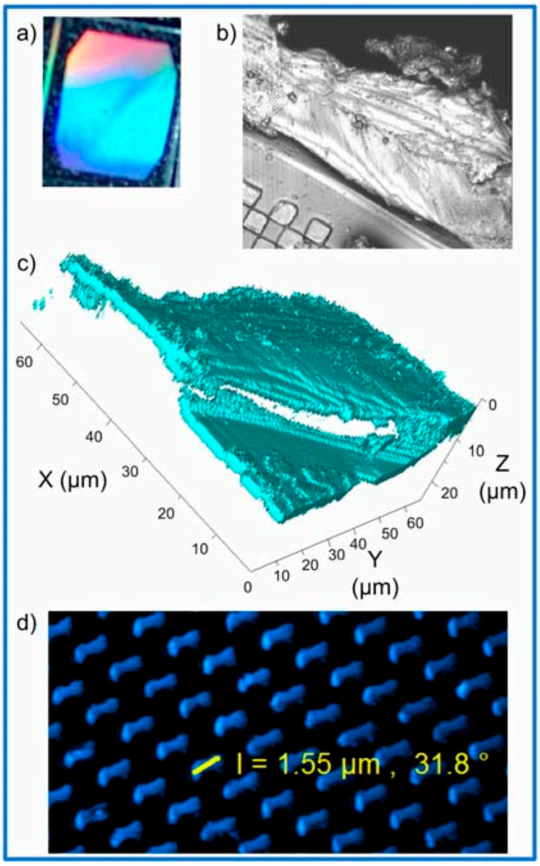

Fig. 2. Examples of measurements on a micro lens; a) illustration of the lens (length = 9 mm); b) topography view of an edge on the lens; c) 3D-view of the same edge; d) surface measurement with laser scanning microscope

For the inspection planning support a software tool with the implemented systematic structure for sensor selection has been developed (fig. 3). Based on test measurements the systematic of the software tool was verified.

The software tool distinguishes between typical devices under test and non-established inspection features. For typical or rather established mechanical components e. g. silicon wafers, ball-grid arrays or injectors varied experiences for capable measuring strategies are available. For this, current literature researches into new measuring methods and measuring results were executed and experts consulted.

After selecting of an established device under test in the most cases there are offered further properties in combo-boxes for selection.

For non-established inspection features a systematic goal-oriented questioning-system is implemented, which is based on the principle of the decision-tree and yields to capable sensor selection.

Furthermore, the software tool includes an interactive help function, which illustrates the operation instruction of the tool and describes the principles of all available sensors and gives definitions of used technical terms.

Basically, both ways should yield to the same result in the proposal of capable sensors for the respective measuring tasks.

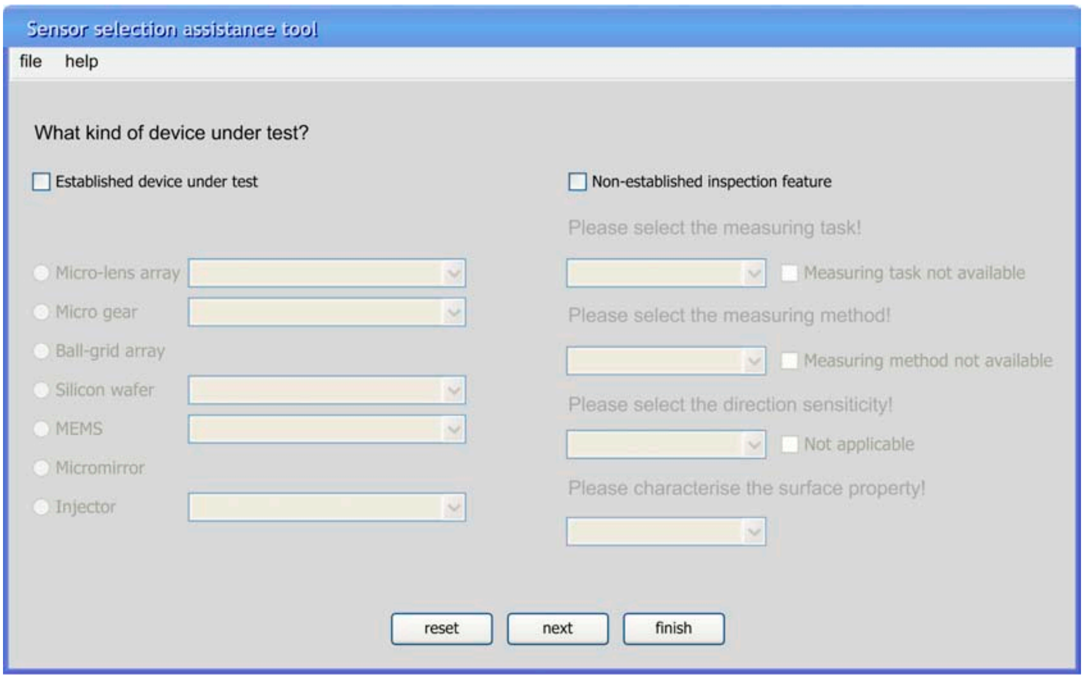

Fig. 3. User interface of the sensor selection assistance tool [4]

3. CONCLUSION

An essential contribution to the improvement in efficiency and usability can be fulfilled by the preparation of knowledge and rules for assigning of capable sensors to current inspection tasks.

The topic of further research are methodologies for optimising the measurement strategy and the sensor parameter setting using simulations. Thereby the expression of the measurement uncertainty is essential for the inspection planning especially the sensor selection.

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