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# A feature-based inspection process planning system for co-ordinate measuring machine (CMM)

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**Abstract**

This paper outlined a feature-based inspection process planning system for co-ordinate measuring machines (CMMs). The inspection process planning system is designed to produce an inspection process planning directly from CAD model. The prototype inspection process planning system includes five functional modules: the tolerance feature analysis, accessibility analysis, clustering algorithm, path generation and inspection process simulation. The tolerance feature analysis module is used to input tolerance information and establish the relationship between the tolerance information and surface feature. The accessibility analysis module evaluate all the accessible probe orientations for every surface feature. The clustering algorithm module groups the inspection probe and surface features into inspection group so that time for inspection probe exchange and calibration can be reduced to minimum. The path generation module determines the number of measurement points, their distribution and their inspection sequences. The inspection process simulation module animated display the inspection probe path and check whether a collision occurs between the part and the inspection probe. The methodology and theory for corresponding five functional modules are outlined. An example demonstrate the general process for the application of the inspection process planning system. The prototype inspection process planing system shown that the proposed theory and methods can be used in industry to generate an inspection process planning for a CMM. 

*Keywords:* Inspection process planning; Co-ordinate measuring machines; Accessibility analysis; Clustering algorithm; Path generation

## 1. Introduction

Recently, researches in inspection process planning have been increased [1]. Some prototypes inspection process planning systems have been developed. These systems include the task-decomposition inspection process planning system [2–5,11], the knowledge-based inspection process planning system [6,10] and some hybrid inspection process planning systems [7–9]. However, these systems are not satisfied by the industry.

This paper outlined a prototype inspection process planning system. The inspection process planning system can be used to generate an inspection process planning for a CMM. It can be used as an integrated system starting from solid model and finishing at production of inspection process planning file. However, it can also be used as five stand alone function modules for the tolerance feature decomposition, accessibility analysis, clustering algorithm, path generation and the inspection process simulation, respectively.

The inspection process planning system can be linked to a CAD system so that an inspection process planning can be produced directly once a part design has been finished. It is expected that the laborious and error-prone manual programming currently used for a CMM can be replaced with the developed inspection process planning system. The lead-time for the CMM programming can be reduced significantly.

## 2. System framework

The prototype inspection process planning system includes the tolerance feature analysis, accessibility analysis, clustering algorithm, path generation and inspection process simulation as shown in Fig. 1.

The tolerance feature analysis module is used to input the tolerance information and then to decompose the tolerance features into individual surface inspection features. The accessibility analysis module evaluates all the possible probe orientations for a surface feature and represents these probe orientations with an accessibility cone. The probe orientation from the accessibility cone can guar-

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Fig. 1. Flow chart of integrated applications of the developed system.

antee a no collision between the probe stylus and the part during the inspection process. The clustering algorithm module arranges both the inspection probes into probe cells and the surface features into feature families so that the time for probe exchange and calibration can be reduced. As a result, the number of the inspection groups is reduced to a minimum. A knowledge-based clustering algorithm is used in the module so that a partial separated block diagonal matrix can be obtained if it is not possible to obtain a complete separated block diagonal matrix. The path generation module determines the number of sampling points, their distributions, and the sequences. Then, the inspection process simulation module is used to simulate the inspection process on a computer video display unit intuitively. The collision check is also implemented in the inspection process simulation module so that a no collision occurs during a real inspection process. Finally, an inspection process file is produced, which is a similar file as DMIS command codes. The generated inspection process planning can be used both for automated and manual inspections. On an automated inspection system, it generates the inspection instruction codes directly according to the format of the CMM instruction codes. On a manual inspection system, it guides the CMM operator for the part installation, selection of probe orientations, and determination of the distribution of the measurement points. Fig. 2 shows main menu for the prototype inspection process planning system.

## 3. Tolerance feature analysis

The tolerance information representation in CAD model has been a bottleneck for manufacturing industry. The size of the tolerance value is too small to be presented in CAD model with its real dimension. It has been judged that it is very difficult to represent this information with a CSG solid model. Some CAD system, such as the AutoCAD system, uses a facility of DIMENSION to represent the tolerance information in a CAD drawing. However, this tolerance information is for displaying on the computer screen or for printing as a hard copy only. The tolerance information and its relationships to the surface features are not included in the database of the AutoCAD system. It is not possible to apply the tolerance information in the subsequent operations such as manufacturing and inspection process.

Fig. 3 shows a 3D solid model that is used as a test component for the inspection process planning system. Surface features *F10*, *F11*, *F14*, *F17*, and *F24* apply the dimensional or geometrical tolerances and will be inspected with a CMM. Other surface features will not be inspected with a CMM because those surface features either have the general tolerances that can be guaranteed by general manufacturing method or those tolerances are not suitable to inspect with a CMM.

Therefore, it is necessary to develop a methodology to represent the tolerance information and its relationship to the surface features. In the project, tolerance information and its

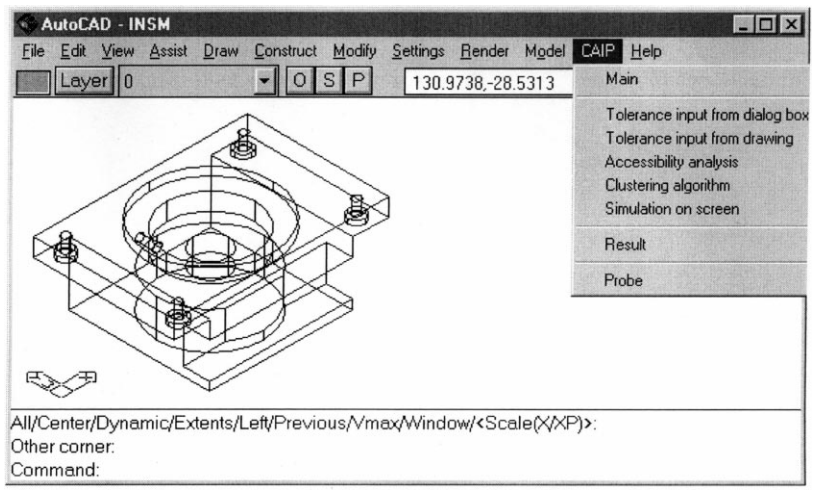


Fig. 2. The main menu of the automated inspection process planning system.