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MEASURING INFORMATION INTEGRATION MODEL FOR CAD/CMM*

Abstract: A CAD/CMM workpiece modeling system based on IGES file is proposed. The modeling system is implemented by using a new method for labelling the tolerance items of 3D workpiece. The concept—"feature face" is used in the method. First the CAD data of workpiece are extracted and recognized automatically. Then a workpiece model is generated, which is the integration of pure 3D geometry form with its corresponding inspection items. The principle of workpiece modeling is also presented. At last, the experiment results are shown and correctness of the model is certified.

Key words: CMM   Character recognition   3D reconstruction   Feature face   Inspection item

0   INTRODUCTION

Modern factory automation —flexible automation pushes the development of inspection technology to the direction of high efficiency and intelligence. As a kind of modern inspection instrument, the coordinate measuring machine (CMM) has the potential of adapting modern factory automation. One of the important things is to improve its efficiency and to make it commonly adaptable. In traditional CMM inspection technology, inspection items are recognized manually, and most of its programs are also programmed manually. All these result in its low efficiency. The quickly developing CAD system provides the condition and possibility for integrating CAD with CMM. In CAD/CMM system, the data integration between CAD and CMM is one of the important problems. After analyzing different kinds of CAD software and their function of integration, considering the existing DMIS format, the authors decide to use AutoCAD as the design tool and adopt IGES file as a medium for the data communication between AutoCAD and CMM.

The first step to integrate CAD and CMM is to extract the primitive geometry information and inspection information[1~3]. Then 3D part reconstruction is proceeded[4], and inspection items are recognized[5]. The objects processed in Refs.[4,5] are limited to pure geometry or text respectively. In this paper, a method to deal with both geometry and inspection items is proposed, further more a way to match these two as a whole is presented. This provides the complete information for down stream processes.

1   STRUCTURE OF THE SYSTEM AND FUNCTION OF EACH MODULE

The module structure of CAD parts deals with the transmission of information between CAD and CMM. It contains the extraction, exchange and share of the CAD information of parts. So that transmission and exchange of data between CAD and CMM should be kept unobstructed. However, CAD and CMM belong to two different application areas, and each needs different data module structure of its own. There are some difficulties in the direct communication between them.

A kind of method is needed to solve the problem mentioned above so that the information stream could be formed and the product could be dealt automatically by computer, and the information transmission could be realized.

1.1   Structure of the system

Based on above analyses, a workpiece modeling system which integrates CMM with CAD system via IGES is developed. The system has a module structure consisting of three modules: CAD 2D data processing module; 3D reconstruction module; inspection item recognition module. Fig.1 shows the general frame chart.
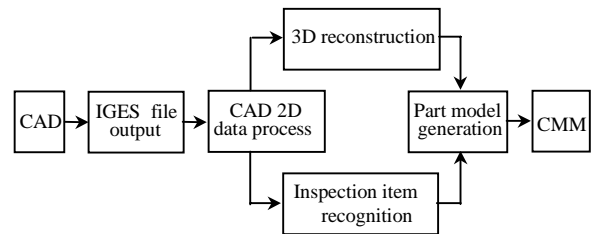

Fig.1   Principle of CAD/CMM

After finishing mechanical drawing with AutoCAD, an IGES file is output. The IGES file is read by the modeling system. First, the system analyzes the IGES format automatically and extracts all the geometry entities and annotation entities. Then on the base of geometry entities extracted, intersecting points between lines or curves are calculated. Geometry entities are classified based on their three views. 2D loop patterns are constructed by following the turn-to-the-most-left rule. 3D form features are matched by following the engineering drawing rules. A new data structure is proposed to describe 3D form features and their topological structure. At last, inspection items of the workpiece are recognized. New 3D form features are generated, which are integration of pure geometry 3D form and corresponding inspection items.

1.2   CAD 2D data processing module

In IGES file, a product is described as a colletion of geometric and nongeometric entities. The geometric entities represent the definition of physical shape, i.e. points, lines, circles, parametric splines, etc. The nongeometric entities are divided into annotation entities (e.g. dimensions and text) and structure entities (e.g. view and associativity). Two different formats are used to represent IGES data: binary and ASCⅡ. The ASCⅡ format in turn, has two types, a fixed 80 character line length format and a compressed format.

The nominal size of the feature can be derived directly from the geometric IGES entities representing the feature. But the dimensional information conveyed by a dimension entity is stored in the corresponding general annotation entity (IGES entity type number 212) as one or more text strings of ASCⅡ characters. This process is described in Ref.[3].

1.3   3D reconstruction module

When the whole 2D entities of 3-view drawings are extracted, the information about position, orientation and relation of these entities are obtained. First, 2D loops are constructed. Starting from one end point of an edge, the turn-to-the-most-left rule is followed to get the next edge. If more edges are encountered, the edge that has the smallest angle in the anticlockwise direction is chosen as the next edge of the loop pattern. Other edges are stacked

for later processing. When all 2D loop patterns are obtained, as a reversal process of the 3D forms projecting to a 3-view drawing, the 3D forms of the workpiece are reconstructed. A kind of data structure is defined to describe the 3D forms.

```
3D form entity
{
    Number;   // The serial number of 3D forms
    Type;     // Belonging to which geometric
                    form, e.g. cuboid, cylinder etc.
    Attribute;       // Positive or negative
    Coordinates of reference point;
    Normal vector of main section;
    Parameters;      // To define the size of a 3D
                          form
    Parent entity;
    Child entities;
}
```

The volume attribute of a 3D form feature can be positive or negative. If the 3D form is a solid, its volume attribute is defined as positive; If the 3D form is an empty, its volume attribute is defined as negative. Table shows four types of intersection relation among the 3D forms.

Table   Intersection relation among the 3D forms

Types	Meanings
PP	Positive volume in positive volume
PN	Positive volume in negative volume
NP	Negative volume in positive volume
NN	Negative volume in negative volume

The coordinate of reference point and the normal vector of main section determine the position and orientation of a 3D form. Fig.2 shows the reference points and normal vectors of main sections of some typical 3D forms.
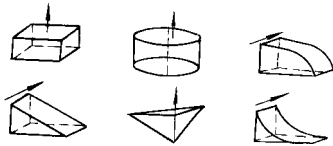

Fig.2   Reference points and normal vectors of main
sections of typical 3D forms

1.4   Inspection item matching with 3D form

The reconstructed 3D forms are pure geometry forms. They should match with their tolerances. In this module the recognized inspection items and reconstructed 3D forms are matched together via "feature face" and 3D geometry forms with their corresponding inspection items are generated.

Tolerance describes the relation between feature faces of a 3D form. Feature face is a geometry characteristic of a 3D form. The 3D geometry form is built with its corresponding inspection items by using "feature faces". Each tolerance has its base face and acting face. Fig.3 shows "feature faces" of typical 3D forms.
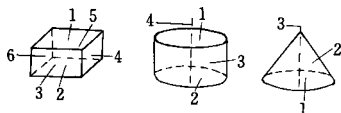

Fig.3   Feature faces of typical 3D forms

The data structure for describing the inspection item that matches with a 3D form can be defined as follows.

```
Inspection Item
{
   Number;
   Type;
   Attribute; // To which tolerance: dimension, position or shape;
   Orientation; // Cosine value of the angle that is formed by
                      dimension line and coordinate axis
   Nominal value;
   Acting face;
```

```
   Base face;
}
```

By using the data structure, the geometry information and inspection information are matched as a whole. This model can be used for CAPP and in automatic measuring systems.

2   EXPERIMENT

2.1   CAD drawing of the experiment

For experimental purpose a workpiece with several typical 3D forms such as cuboid, cylinder and cone is designed. Fig.4 is its 3-view drawing. Its elemental 3D forms are shown in Fig.5. For example, the base face and acting face of the tolerance item "5.00±0.02" are the 2nd feature face (bottom face as shown in Fig.3) of 3# 3D form and the 1st feature face (top face) of 0# 3D form, respectively.
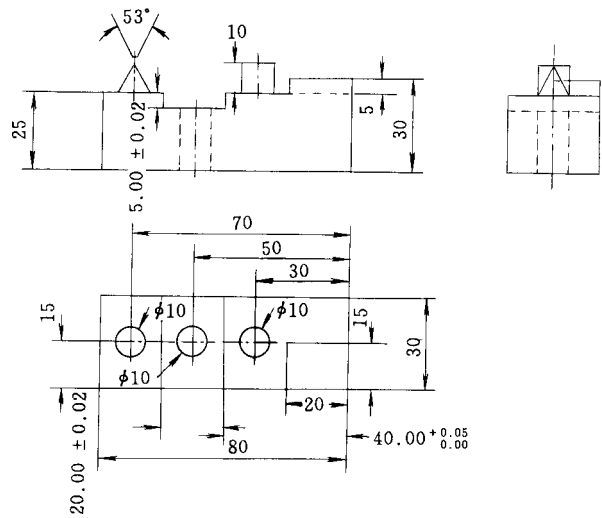

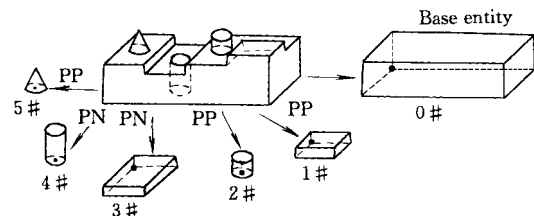Fig.4   3-view drawing of the experiment workpiece

Fig.5   Result of 3D reconstruction

2.2   Experiment data output

When the IGES file of Fig.4 is input to the CAD/CMM workpiece modeling system, the system outputs reconstructed 3D form data are as follows.

```
Workpiece Name: model amount=6
Number: 0#
Type: cuboid
Attribute: base
Position: x=0.000, y=0.000, z=0.000
Orientation: l=0.000, m=0.000, n=1.000
Parameters: l=80.000, b=30.000, h=25.000
Parents: NULL
Children: 1#, 2#, 3#, 4#, 5#
…
```

Fig.5 shows the result of 3D reconstruction. The dark points describe the reference positions of the 3D forms.

The output inspection items matched with 3D forms are listed as follows.

```
Inspection items amount=5
```

Number: 1#
Type: distance
Attribute: P
Orientation: 0, –1, 0
Tolerance: nominal=40.000, lowtol=0.000, toptol=0.050
Act_face: 3#, 4   //Acting face: 4th face of 3# entity //
Base_face: 0#, 4   //Base face: 4th face of 0# entity //
    …

2.3   Analysis of experiment result

In the experiment result, all the inspection information and geometry information are recognized. The 3D form of the work-piece is reconstructed correctly. The inspection items are matched with the 3D form. Its result reaches anticipated demand.

3   CONCLUSIONS

This system builds a bridge between CAD and automatic measuring system. When the IGES file is input to the system, all the geometry information and inspection information of the work-piece are analyzed. Typical 3D forms can be reconstructed and be fit together with inspection items. This has broad applications, such as intelligent CMM, process planning and tolerance analysis in assembly. The next step is to dispose more complex work-pieces.

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