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# DESIGN INTERFACE: AN ENHANCEMENT OF A FEATURE RECOGNIZER

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***RINGKASAN:*** *Kertas kerja ini menerangkan pengasingan rupamuka pemesinan bahagian-bahagian berprisma dengan menggunakan teknik pengenal rupamuka. Pengenal rupamuka ini dibina diatas 'Hewlett Packard Mechanical Engineering Series 30 Solid Modeller' dan menggunakan teknik lanjutan Sifat Geraf Berdampingan untuk mengenalpasti rupamuka tersebut. Pengenal rupamuka ini menyediakan rekabentuk bagi membina antaramuka untuk mengautomasikan fungsi perancangan proses dan rekabentuk lekapan. Buat masa ini, dengan menggunakan teknik tersebut tiga puluh jenis rupamuka boleh dikenalpasti. Maklumat yang boleh diperolehi termasuklah jenis-jenis rupamuka, permukaan rupamuka dan arah kerja pemesinan. Mutu pengenal rupamuka sedang dipertingkatkan lagi untuk membuat pengasingan ukuran-ukuran dan maklumat teknologi rupamuka serta perkara-perkara yang berkaitan di antara kedua-duanya. Maklumat yang berkaitan dengan pembuatan juga boleh dihubungkaitkan dengan teknik rupamuka ini. Satu ciri yang unik mengenai pengenal rupamuka ini ialah kebolehannya untuk menyediakan syarat-syarat awal stok bagi menghasilkan sesuatu produk.*

**ABSTRACT**: This paper describes a feature recognizer for extracting machining features of prismatic parts. Built on top of the Hewlett Packard Mechanical Engineering Series 30 Solid Modeller, it uses the extended Attributed Adjacency Graph technique to recognize features. This feature recognizer provides the design interface for automating the process planning and fixture design functions. Currently, thirty types of features can be recognized using this approach. The information obtained include feature types, their comprising faces and machining directions. Enhancements have also been implemented to extract the dimensions and technological information of these features and their relationships. Manufacturing related information can be associated with these features. A unique characteristic of this feature recognizer is its ability to provide the conditions of the initial stock from which the part is to be made.

**KEYWORDS**: CAD, design interface, features, tolerance, dimensions, process planning.

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## INTRODUCTION

The task of a design interface is to transform a function oriented drawing into manufacturing related information. It is one of the most important and difficult tasks in the automation of process planning. In any engineering design, a part can be represented in several different ways, such as a two-dimensional engineering drawing or a solid model on a computer-aided design (CAD) system. In order to manufacture the part, a detailed and precise model of the object is crucial. This is to ensure that an accurate specification of the designer's intention can be achieved. In whichever representation, it is hence important to capture and communicate the design and engineering intents of the part. Detailed geometrical information and manufacturing related information should be contained in the representation. Such information greatly influences the way a part is to be processed.

Traditionally, human beings have served as the design interface. The user reasons out the shape of the part in a drawing, based on his experience, and identifies the various essential information. The user thus performs the task of translating a drawing into process planning specific data. This is a highly interactive, subjective and tedious process. It is thus preferable to have an automated design interface.

In recent research in the automation of the design interface, design-with-features and feature recognition are two approaches commonly used (Joshi, 1990; Pratt, 1991). Features (Pratt, 1988) are an efficient tool to provide the function of characterizing and supplying relevant information of the product for all the necessary stages in the product development cycle. The design-with-features approach (Cunningham, 1988; Luby, 1986) involves building a part from feature models defined and maintained in the CAD system. The geometry and topology of a design are maintained by the solid modeller. Feature recognition, (Gadhf, 1991; Henderson, 1988; Kim, 1992; Sakurai, 1990; Wang, 1991b; Wang, 1992) on the other hand, interprets the design internal representation of a part to identify the comprising features of the part. Although the design-with-features approach eliminates the task of feature recognition from low level CAD representations, such an approach may give rise to secondary features, which must subsequently be recognized. Therefore, the task of feature recognition is of fundamental importance in automating the design interface. Several reports on the identification and extraction of features using various approaches exists. Some of the approaches in feature recognition are syntactic pattern recognition, state transition diagrams and automata, decomposition, logic and the graph-based methods (Chang, 1990; Singh, 1992).

In order to automate the task of the design interface, an automatic feature recognizer has been developed and enhanced. This feature recognizer is built on top of the Hewlett Packard Mechanical Engineering Series 30 Solid Modeller (HP ME30). It is capable of recognizing thirty types of features from the three-dimensional model of a part created using the HP ME30, following an extended Attributed Adjacency Graph approach (AAG). However, this current feature recognizer is only capable of recognizing the features of a part, identifying the comprising faces of these features and their machining directions. The dimensional and other manufacturing related information, such as tolerancing and referencing, are lacking in the existing system. Also of paramount importance is the initial stock characteristics. These information will have a direct influence on the set-up and operation planning for the manufacture of the part. Enhancements have been carried out on the feature recognizer in order to obtain these information.

This paper describes the work that has been carried out to extend the scope of the feature recognizer. The approach, capabilities and restrictions of the original feature recognizer will be described. The enhancements implemented and the procedures used will be elaborated. An example is used to show the various information that can be extracted.

## FEATURE RECOGNIZER

Recently, an automatic feature recognizer has been developed and enhanced (Chan, 1992; Tung, 1990). This feature recognizer essentially uses the AAG concept originally developed by Joshi (1987), where thirty types of features can be recognized, as shown in Appendix A. The basic information that can be obtained by this recognizer from a solid model includes the name of the feature, its feature type, its comprising faces and the machining direction of this feature. However, this recognizer cannot identify the geometrical relationship between neighbouring features. Manufacturing related information such as tolerancing, referencing and surface conditions cannot be extracted from a solid model either.

This section presents and discusses the approach, methodology and the procedures used by this feature recognizer.

### Attributed Adjacency Graph (AAG)

A graph-based method, the Attributed Adjacency Graph, is adopted in the feature recognizer for feature recognition. The AAG method uses a B-Rep internal representation scheme to capture the topological relations of faces of a solid model and embeds these relations into an AAG. An algorithm is then applied to recognize these machining features. In this way, the low level B-Rep is transformed into features which form higher level structural entities, which primitives are the elements of a B-Rep. An AAG is a graph with attributes assigned to each of the arcs connecting the nodes. It can be defined by the following notation:

$$G = (N,A,T)$$

where;
N = set of nodes
A = set of arcs
T = set of attributes assigned to arcs in A

A node in an AAG denotes a face on the part. The arc between two nodes represent the adjacency of the two faces denoted by the nodes. In Joshi's original implementation (Joshi, 1987), wherever two adjacent faces form a convex angle, the arc is labelled 1 and concave adjacency is labelled 0.

In the current automatic feature recognizer, the concept of AAG is extended to handle more general planar features and features with curved surfaces. New attribute values are incorporated so that the relationship between faces can be clearly defined. Table 1 shows the attribute values assigned to the arcs of the different pairs of face types. The complete set of attribute values assigned to the various face types combinations is shown in Figure 1.

**Table 1.** Attribute values for different types of arc adjacency

| Types of faces | Types of arcs | Atrribute value |
|---|---|---|
| Planar & Planar | 270 degrees convex | 7 |
| Planar & Planar | 90 degrees concave | 4 |
| Planar & Curved | 270 degrees convex | 2 |
| Planar & Curved | 90 degrees concave | 1 |
| Planar & Planar | non 270 degrees convex | 6 |
| Planar & Conic | 270 degrees convex | 1 |
| Planar & Conic | 90 degrees concave | 1 |
| Any other combination | Nil | 0 |

These improvements, which include the differentiation of convex and concave adjacency between planar and curved faces and the provision for non 270 degrees convex adjacency between two planar faces, greatly increase the number of features that can be identified. Features such as chamfers and counterbore can also be recognized.

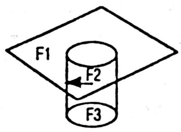
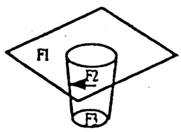
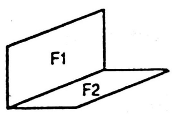
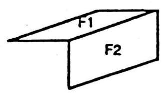
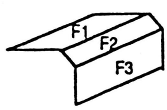
| Types of faces | Types of arcs | | Attribute value |
|---|---|---|---|
| Planar & Curved | 90 degrees concave |  | (F2) —1— (F3) |
| Planar & Curved | 270 degrees convex | | (F1) —2— (F2) |
| Planar & Conic | 90 degrees concave or 270 degrees convex |  | (F1) —1— (F2)<br>(F2) —1— (F3) |
| Planar & Planar | 90 degrees concave |  | (F1) —4— (F2) |
| Planar & Planar | 270 degrees convex |  | (F1) —7— (F2) |
| Planar & Planar | non-270 degrees convex |  | (F1) —6— (F2) —6— (F3) |

***Figure 1.*** *Attribute values and their representations*

## Feature Recognition

When an AAG is formed for a particular part, a heuristic algorithm is used to reduce the AAG for the part into several subgraphs. The method is based on the observation that faces adjacent to all their neighbouring faces with a 270 degree convex angle, do not form part of a feature. Using this method, the part's AAG can be split into several subgraphs. Each subgraph corresponds to a single feature or a set of intersecting features. For a set of intersecting features, node splitting procedures are used to split these features. With the node splitting procedure, various subgraphs are separated from sets of intersecting features. All the features can subsequently be recognized. When a set of intersecting features cannot be further split, this set of intersecting features is collectively termed as virtual pocket.

The recognition process is a graph isomorphism problem. A rule is developed for each feature type. These feature recognition rules are based on the properties of the AAG unique to each feature. Figure 2 shows some of the features together with their AAGs. The algorithm to recognize the feature is outlined in Figure 3. The recognizer incorporates all the feature recognition rules. Each subgraph formed is analysed to determine the feature type it corresponds to.

## Determination of Machining Direction

In metal cutting processes, the cutting action is effected by the relative motion between the workpiece and a cutting edge with a specified geometry. In order to plan the machining sequence for a part, a feasible and practical tool approach direction for each feature must be determined. The tool approach should be such that the tool will not interfere with parts of the workpiece that it is not supposed to cut. In addition, it should be such that the tool is able to form the correct geometry of the feature. These criteria are essential for determining set-ups and cutter paths. The approach direction of a feature is an unobstructed path that a tool can take to access the feature in the workpiece. The tool approach direction greatly influences the selection of the locating and fixturing faces and the machining sequence for the part. It forms part of the geometrical constraints that must be conformed to, in the process planning function.

The current feature recognizer, besides providing the feature type and their comprising faces, also gives the feasible machining direction of these features. Each feasible machining direction of a feature is represented by the face which vector points outwards from the workpiece. For features which do not have any feature face vector that points outwards, a non-machined face which vector coincides with the machining direction is selected.

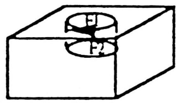
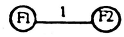
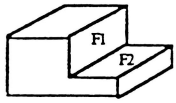
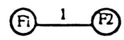
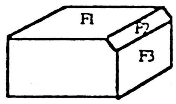
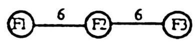
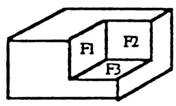
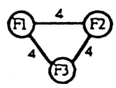
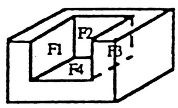
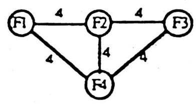
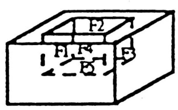
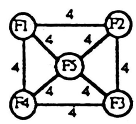
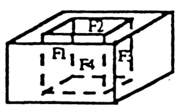
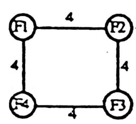
| Feature | | AAG |
|---|---|---|
| Blind Hole |   |   |
| Step |   |   |
| Chamfer |   |   |
| Blind Step |   |   |
| Blind Slot |   |   |
| Pocket |   |   |
| Multi-Facet Hole |   |   |

***Figure 2.*** *AAG's of some features*

```
Procedure RECOGNIZE_FEATURE

    create AAG
    delete nodes (and the incident arcs at the nodes) that have all incident arcs
    having attribute '2' and/or '7'
    form subgraphs

    for each subgraph

        CALL RECOGNISER
        if recognised then
            return (feature_type, machining_direction, comprising_faces)
        else
            CALL SPLIT_NODES[1]
            form subgraphs
            for each subgraph

                CALL RECOGNISER
                if recognised then
                    return (feature_type, machining_direction, comprising_faces)
                else
                    printf " Feature can't be recognised"
                endif
            next subgraph
        endif
    next subgraph
END
```

***Figure 3.*** *Algorithm to recognize features*

## ENHANCEMENTS TO THE FEATURE RECOGNIZER

Generally, a feature has its specific geometry and must be associated with some feature attributes. The attributes can be dimensions, dimensional tolerances, manufacturing related information and others. An understanding of the shape together with the non-geometrical information are essential in planning the fixture layout and selecting the operations for a part. On top of these information which can be collectively called feature parameters, information such as feature relationships and interactions are crucial in determining the machining sequences of the features and the formation of set-ups. The characteristics of the initial stock from which the part is to be made is of vital importance in the process planning and fixture-design functions. These characteristics greatly influence the number and sequence of set-ups and machining operations required to manufacture the part. It is thus of first priority to expand the scope of the current feature recognizer to include the extraction of geometrical and manufacturing related information of the designed part, and to identify the characteristics of the initial stock.

These enhancements are implemented through the development of C language routines and the ME30 Application Interface (ME30 AI). The ME30 AI is a library of subroutines written in the C programming language that provides the programming interface to the 3-D modelling capabilities of ME30. The following enhancements are made:

(i) Extraction of dimensional information.
(ii) Attachment of manufacturing related information.
(iii) Determination of features relationships.
(iv) Identification of characteristics of the initial stock.

### Extraction of Dimensional Information

Dimensional information has a distinct influence on the processes and tools selected for the manufacture of a part. One main area of concern is the dictation of the range of possible sizes of tools that can be selected for generating a feature. Dimensions are implicitly embedded within the geometry and topology of the model. Hence, it is possible to extract these dimensions for the various identifiable features.

The determination of these dimensional information is accomplished by a set of feature parameter extraction functions in this first module. These functions retrieve parameters such as position, orientations and dimensions of the various features. There are two sets of parameter extraction functions, namely:

(i) Primary feature parameter extraction functions.
(ii) Secondary feature parameter extraction functions.

*Primary Feature Parameter Extraction Functions*

These functions extract real/floating dimensional values from the product model. These information are extracted for all the primary features of the product. The primary features of a part refer to the basic building entities of a part. These include the faces, edges and vertices. Some of the parameters extracted are the area of a face, the length of an edge, and the radius of a circular edge.

*Secondary Feature Parameter Extraction Functions*

These functions are used to determine the various attributes of features. They act on pointers to the comprising faces, edges and vertices of a feature to identify its dimensions and position. A set of dimensional parameters is identified for each of the thirty types of features. This module currently contains functions for the extraction of parameters for twenty-seven of the thirty identifiable features. These features are referred to as secondary features in this implementation. Figure 4 shows a parameter extraction description for a slot. Figure 5 shows some of the features and their dimensional parameters.

```
for each face of slot
    if base face then
        for each edge of base face
            if common edge then
                slot:length = edge:length
            endif
            if not common edge then
                slot:width = edge:length
            endif
        next edge
    endif
next face

for each face of slot
    if not base face then
        for each edge of face
            if not common edge then
                if edge:length != slot:length then
                    slot:height = edge:length
                endif
            endif
        next edge
    endif
next face
```

***Figure 4.*** *Parameter extraction description for feature slot*

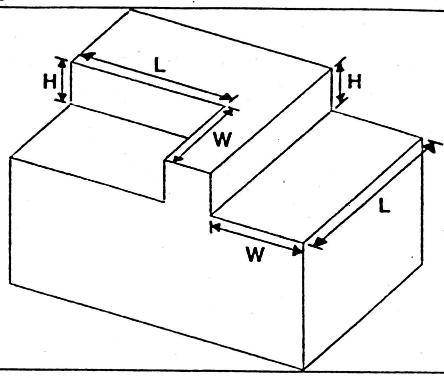
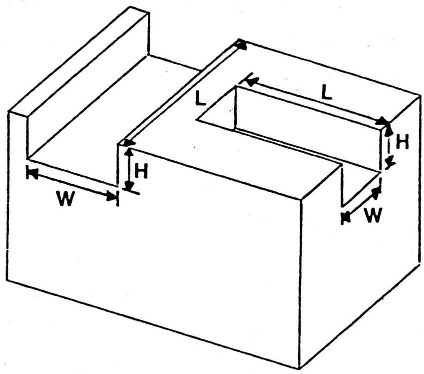
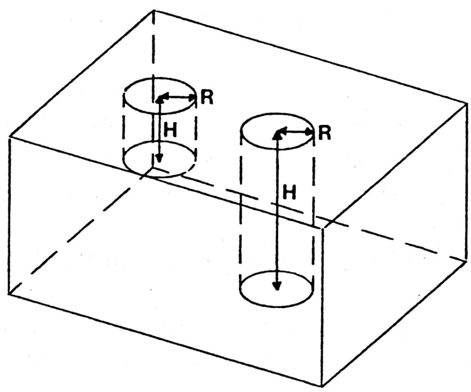
| Feature | Parameters | Diagram |
|---|---|---|
| Step | L : length<br>W : width<br>H : height |  |
| Blind Step | | |
| Slot | L : length<br>W : width<br>H : height |  |
| Blind Slot | | |
| Hole | R : radius<br>H : height |  |
| Blind Hole | | |

***Figure 5.*** *Features' dimensional parameters*

## Attachment of Manufacturing Related Information

The manufacturing related information refers to tolerancing specifications, datums referencing specifications and surface condition requirements of the features and/or of a part. These information are essential for automatically planning the manufacturing, inspection and robotic assembly of mechanical components. They specify the allowable inaccuracies or variations from the nominal geometry of parts. The datums referencing specifications will control the sequence in which processes are carried out to produce a part.

Although it is possible to extract the dimensional information of a part from the present CAD data model, it is not possible to do likewise for the manufacturing related information. This is due to the fact that currently it is not possible to represent tolerancing information or other technological information (such as surface roughness and accuracy data, feature information, etc.) using the presently available CAD data models. Various schemes have been developed to associate these information with features, either by interfacing with the solid modeller or by graph methods (He, 1992; Requicha, 1986; Roy, 1988; Wang, 1991a).

The approach used in this feature recognizer is to associate these information with the features through an interactive attachment scheme. A non-geometrical information attachment module is currently under development. This module will be integrated with the feature recognizer. It is capable of handling size, position, form and orientation tolerances. Information such as datum information, material properties, surface conditions, and others can also be obtained interactively.

In this module, functions are written in the C programming language and the ME30 Application Interface. Geometric tolerancing, conforming to the ANSI Y14.5M standard (ANSI, 1982), can be performed interactively using these functions. Besides, the information on the datum referencing and surface condition of a part can also be obtained.

## Identification of Features Relationships

The relationships between features are important for determining the process sequences and sometimes the processes themselves. Features can be related to one another through geometry or tolerances. The relationships can involve more than two features at a time. The relationships due to tolerances are captured in the tolerance specifications. The relationships dealt here are the geometrical relationships between neighbouring features.

The two factors constituting to the geometrical constraints are the geometrical relationships between features and the features' machining directions. The determination of the features' machining directions has already been dealt with. This module ascertains the geometrical relationship between features.

The geometrical relationships between neighbouring features are inherent in the design of a part and the physical attributes of the machined surfaces. Based on these relationships, the geometrical constraints can be found. These constraints due to the shape, size and location of the features, cannot be violated as they physically limit the machining of surfaces or shape elements.

This module finds the starting-from-face and the opening-to-face of a feature. These geometrical relationships between neighbouring features can be used as geometric constraints imposed on feature precedence determination. The opening-to-face is the face to which the first cut ends. The determination of the opening-to-face is implemented by finding a face which vector is equal to the machining direction of the feature but reversed, and which either belongs to the face or has edge(s) which belongs to the feature.

The starting-from-face of a feature is defined as the surface from which the first cut to generate that feature starts. There could be more than one starting-from-faces for a feature. The starting-from-face is found by the following procedure. First, a face which does not belong to the feature and has common edge(s) with the faces of the feature is found. Next the normal vector of this face is checked to determine if it coincides with the machining direction of the feature. If the normal direction coincides with the machining direction of the feature, then it is a starting-from-face for this feature.

### Identification of Stock's Characteristics

In the machining of a workpiece, an essential and main starting point is to ensure that there are three orthogonal sides present in the stock. These three sides could serve as reference planes for the squaring up of the remaining three sides and for the machining of features on the stock. The number of set-ups and the sequence to achieve a minimum of three orthogonal sides or a fully orthogonal six-sided, cube-like block into which features can be machined depend on the initial conditions of the stock (Hayes, 1986; Wright, 1988).

The initial condition of the stock can be in various forms; a flat plate, a cube or a block. There could be already some smooth sides on the stock, which are cold rolled as in as-supplied conditions. In other cases, the stock may be completely rough-sawn on all sides. In the former case, these smooth sides could be used as initial referencing for the stock while in the latter, all the sides must be machined. These conditions have an effect on the number of set-ups required for the machining of a workpiece, and hence the fixturing plans.

The module implemented is able to extract all the dimensions of the initial stock and its characteristics. This module essentially uses the same approach as modules 1 and 2 in extracting the dimensions and characteristics of the initial stock. The dimensions of the stock are extracted from the B-Rep internal representation using the primary feature parameter extraction functions followed by the stock's parameter extraction functions. The stock's parameters extraction functions pick out the three main dimensional parameters of the prismatic stock from the information of the primary features which make up the stock. The information of the primary features are found using the primary feature parameter extraction functions.

The characteristics of the stock's faces and edges are interactively attached to these primary features through the use of C language functions. The methodology used is the same as in module 2.

**Example**

An example is used to illustrate the results that can be obtained using this current feature recognizer. The initial stock from which the part is to be machined and its characteristics are shown in Figure 6. The final part with its feature information is shown in Figure 7.

## CONCLUSIONS

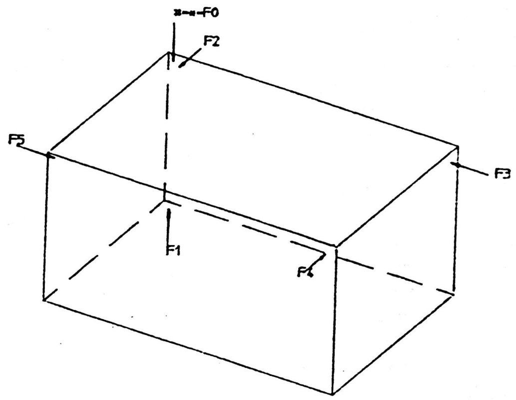
The task of automating the design interface is of increasing concern to the manufacturing industries. This can be attributed to the fact that a major obstacle in developing a fully automated computer-integrated manufacturing system is the lack of complete information transfer between the design, process planning and manufacturing phases.

An automatic feature recognizer has been developed and enhanced. The approach used in this research has been that of feature recognition using an extended AAG method.

The first implementation of this feature recognizer has the capabilities to identify thirty types of features and their comprising faces and machining directions. Improvements made to the feature recognizer include the extraction of dimensional information and the attachment of manufacturing related information to these features. The starting-from-faces and opening-to-faces of features have also been identified for all the features.

A distinctive character of this feature recognizer is its capability to provide the conditions of the initial stock from which the workpiece is generated. Most feature recognizers

Length : 100 mm
Width : 70 mm
Height : 50 mm

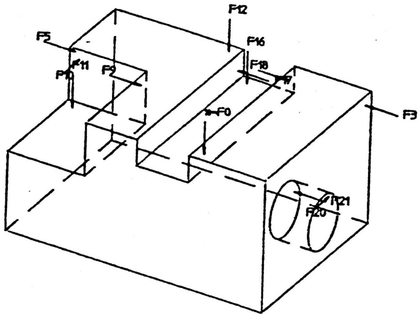



| | Face 1 | Face 3 | Face 5 |
|---|---|---|---|
| Name | : F0 | : F2 | : F4 |
| Type | : Planar | : Planar | : Planar |
| Length | : 100 mm | : 100 mm | : 100 mm |
| Width | : 70 mm | : 50 mm | : 50 mm |
| Area | : 7000 sq. mm | : 5000 sq. mm | : 5000 sq. mm |
| Surface finish | : 25 microns | : 3.2 microns | : 3.2 microns |
| Straightness | : 0.04 mm | : - | : - |
| Flatness | : 0.25 mm | : - | : - |

| | Face 2 | Face 4 | Face 6 |
|---|---|---|---|
| Name | : F1 | : F3 | : F5 |
| Type | : Planar | : Planar | : Planar |
| Length | : 100 mm | : 70 mm | : 70 mm |
| Width | : 70 mm | : 50 mm | : 50 mm |
| Area | : 7000 sq. mm | : 3500 sq. mm | : 3500 sq. mm |
| Surface finish | : 25 microns | : 3.2 microns | : 3.2 microns |
| Straightness | : 0.04 mm | : 0.04 mm | : 0.04 mm |
| Flatness | : 0.25 mm | : 0.25 mm | : 0.25 mm |

***Figure 6.*** *Initial stock and its characteristics*

| Feature 1 | |
|---|---|
| Type | : B-step |
| Machining face | : F9 |
| Starting-from-face | : F5 |
| Opening-to-face | : F9 |
| Comprising faces | : F9, F10, F11 |
| Position | : (0,0,30) |
| Length | : 40 mm |
| Width | : 30 mm |
| Height | : 20 mm |




| Face 1 | |
|---|---|
| Name | : F9 |
| Type | : Planar |
| Length | : 40 mm |
| Width | : 20 mm |
| Area | : 800 sq. mm |
| Surface finish | : 2.5 microns |
| Straightness | : 0.04 mm |
| Flatness | : 0.25 mm |

| Face 2 | |
|---|---|
| Name | : F10 |
| Type | : Planar |
| Length | : 30 mm |
| Width | : 20 mm |
| Area | : 600 sq. mm |
| Surface finish | : 2.5 microns |
| Straightness | : 0.04 mm |
| Flatness | : 0.25 mm |

| Face 3 | |
|---|---|
| Name | : F11 |
| Type | : Planar |
| Length | : 40 mm |
| Width | : 30 mm |
| Area | : 1200 sq. mm |
| Surface finish | : 2.5 microns |
| Straightness | : 0.04 mm |
| Flatness | : 0.25 mm |

| Feature 2 | |
|---|---|
| Type | : Slot |
| Machining face | : F16 |
| Starting-from-face | : F0, F12 |
| Opening-to-face | : F16 |
| Comprising faces | : F16, F17, F18 |
| Position | : (50,0,40) |
| Length | : 70 mm |
| Width | : 20 mm |
| Height | : 10 mm |

| Face 4 | |
|---|---|
| Name | : F16 |
| Type | : Planar |
| Length | : 70 mm |
| Width | : 20 mm |
| Area | : 1400 sq. mm |
| Surface finish | : 1.6 microns |
| Straightness | : - |
| Flatness | : - |

| Face 5 | |
|---|---|
| Name | : F17 |
| Type | : Planar |
| Length | : 70 mm |
| Width | : 10 mm |
| Area | : 700 sq. mm |
| Surface finish | : 1.6 microns |
| Straightness | : - |
| Flatness | : - |

| Face 6 | |
|---|---|
| Name | : F18 |
| Type | : Planar |
| Length | : 70 mm |
| Width | : 10 mm |
| Area | : 700 sq. mm |
| Surface finish | : 1.6 microns |
| Straightness | : - |
| Flatness | : - |

| Feature 3 | |
|---|---|
| Type | : B-hole |
| Machining face | : F21 |
| Starting-from-face | : F3 |
| Opening-to-face | : F21 |
| Comprising faces | : F20, F21 |
| Position | : (100,40,15) |
| Height | : 15 mm |
| Radius | : 10 mm |

| Face 7 | |
|---|---|
| Name | : F20 |
| Type | : Cylindrical |
| Height | : 15 mm |
| Radius | : 10 mm |
| Area | : 942.478 sq. mm |
| Surface finish | : 2.0 microns |
| Circularity | : 0.25 mm |
| Cylindricity | : 0.25 mm |

| Face 8 | |
|---|---|
| Name | : F21 |
| Type | : Planar |
| Radius | : 10 mm |
| Area | : 314.159 sq. mm |
| Surface finish | : 2.0 microns |
| Circularity | : 0.2 mm |
| Flatness | : 0.25 mm |

***Figure 7.*** *A simple part and its representation*

reported only recognize features that are present on the workpiece and their associated dimensional and manufacturing related information. The initial stock characteristic extraction is often neglected. In this feature recognizer, the dimensional parameters as well as the initial surface conditions of the stock can be obtained.

Though the feature recognizer is able to recognize and extract the dimensional and manufacturing information for twenty-seven of the thirty identifiable features, the one main restriction of the system is the fact that it cannot handle fillets. It is also assumed that the features dealt here are axi-symmetrical.

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# Appendix A

## List of recognizable features

1. Through hole
2. Blind hole
3. Tapered hole
4. Blind tapered hole
5. Triangular hole
6. Multi-facet hole
7. Slot
8. Blind slot
9. T-slot
10. Blind T-slot
11. V-slot
12. Blind V-slot
13. Curved slot
14. Blind curved slot
15. Step
16. Blind step
17. Slant step
18. Dovetail
19. Blind dovetail
20. Inverted dovetail
21. Blind inverted dovetail
22. Pocket
23. Virtual pocket
24. Island
25. Boss
26. Chamfer
27. Obtuse chamfer
28. Countersunk
29. Blind countersunk
30. Counterbore