

# A data format providing side wall orientation and adaptive slicing for use in stepless rapid prototyping

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## Abstract

Current Rapid Prototyping systems mainly use 2D layers building techniques that result in the 'staircase' effect on slanted surface. A new method has been developed to eliminate the 'staircase' effect and to improve the surface quality by extending the 2D layers to 3D layers building. In this approach, a new data format, Layer Transfer Interface (LTI), is introduced to generate layers having slanted side wall. It provides a faster slicing algorithm and accurate reconstruction of 3D objects. This format is independent of any particular RP machines. Furthermore, adaptive slicing has been achieved using this format and implemented on a five-axis milling RP system.

## 1. Introduction

Research in rapid prototyping places a constant emphasis on the need for improvement of accuracy and surface smoothness. From the CAD model point of view, the three main ways of slicing are:

- Fixed slicing where peaks or flat areas (areas parallel to the slicing planes) are ignored [1,2,3,4].
- Adaptive slicing where the slice thickness varies in response to the surface curvature [2,3,4].
- Direct slicing from CAD original models as opposed to tessellated models [5,6].

Presently, Common Layer Interface (CLI) [7] and 3D system's format SLC [8] are the universal slice formats that are simple, efficient and unambiguous. However, the staircase effect cannot be totally eliminated using these formats. Also, there are redundant data between slices due to 2D slice contours in these formats, which result large data file being produced.

The use of slanted and ruled slices can remove the staircase effect. Slanted slices can be generated using these approaches [9]. However, it requires a minimum of 4-axis control to make the slanted edges of the RP part. In order to have a slanted slice, a data format must be able to be read by the RP machines.

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## 2. Layer Transfer Interface (LTI) Format

A new data format is proposed to use in new RP machines with at least 4-axis control. Figure 1 shows the slope information of a point of a slice. These additional information of the roll and pitch angles enable slanted slices to be represented.

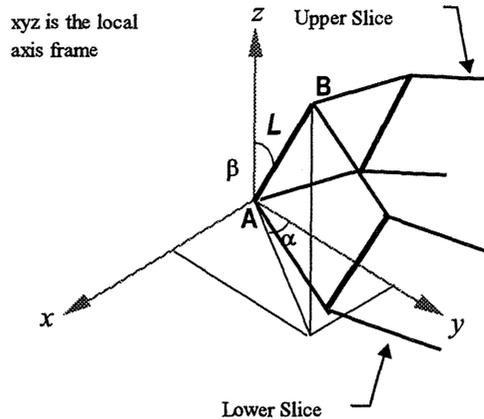


Figure 1 – Slope information of a point

The LTI data format consists of a collection of segments as shown below.

```
// LTI format
Parts_Begin
  Head
    Number_of_Layer: [number]
    Part_size: [x1, y1, z1, x2, y2, z2]
    units: [mm or inch]
  End Head
  Layer_Begin
    Index: [number]
    Thickness: [z]
    Number_of_Contour: [number]
    Contour_Begin:
      Number_of_Hole: [number]
      Begin_Tool:
        Number_of_Point: [number]
        x, y, z, α, β,
        .....
      End_Tool
      Hole_Contour_Begin:
        Begin_Tool:
          Number_of_Point: [number]
          x, y, z, α, β,
          .....
      End_Tool
      Hole_Contour_End
    Contour_End
  Layer_End
Part_End
```

The first segment is the header segment that contains the global information of solid model such as layer number, size etc. The second segment contains the layer contour data. Inside this segment, the layer structure is sectioned into many parts that consists of contour, hole and hatching data for each slice.

With the slope information of the LTI, data transfer to other slice data format can be done readily. In the generation of the sliced contour data for a user defined layer thickness, the interpolation from the upper and lower contours can be carried out. This technique is fast and easy and also adaptive slicing can be implemented.

### 3. Method

A new slicing method is developed to provide the roll and pitch angle information. Currently, only faceted model is used. The slicing starts with the determination of the topological information of the input model. This topological information consists of the vertex and face lists. The vertex and face lists are linked using a circular link list. The vertex list is later sorted along the direction of build direction. Using the vertex information, the flat areas are determined.

Next, an advanced marching algorithm is carried out using two parallel planes to obtain the slope information. With this information, the Layer Transfer Interface (LTI) data file is then generated. This data format is independent of any RP machines. A five-axis milling machine has been developed to use this data format to build parts using layering techniques. This data format is further preprocessed to create each layer with variable layer thickness. The system parameters that affect the slice thickness are the tool diameter and tool length. Figure 2 shows the faceted .STL model. The slicing algorithm is developed using C++ with OpenGL working in Windows NT platform. Figure 3 shows the sliced part with slope information for slanted side wall using LTI data format.

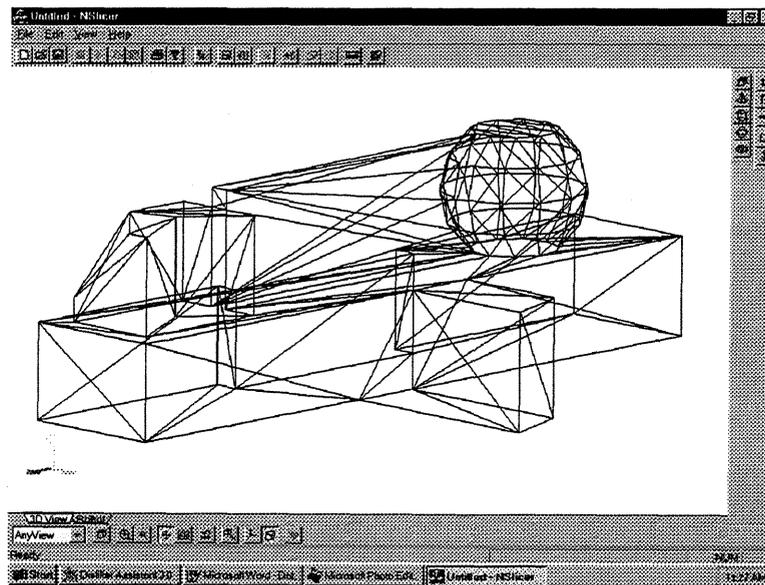


Figure 2 - A .STL facet model

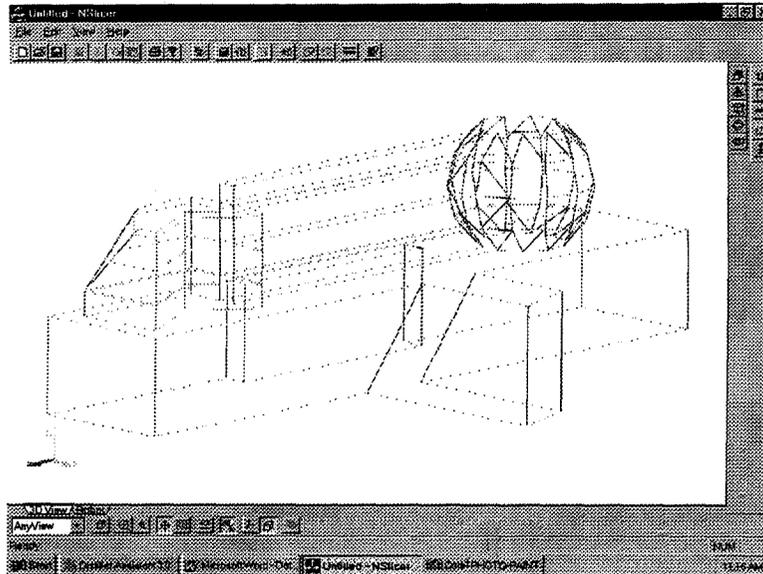


Figure 3 – A sliced part with slope information for slanted side wall using LTI format

#### 4. Implementation

A five-axis milling machine was developed to build layers with slanted side wall. Figure 4 shows a part built using this machine. The slope information obtained from the LTI format was used to machine the slanted side wall. With this slanted building technique, part accuracy and speed are greatly improved. The offset and tool path calculation are performed using this new LTI format.

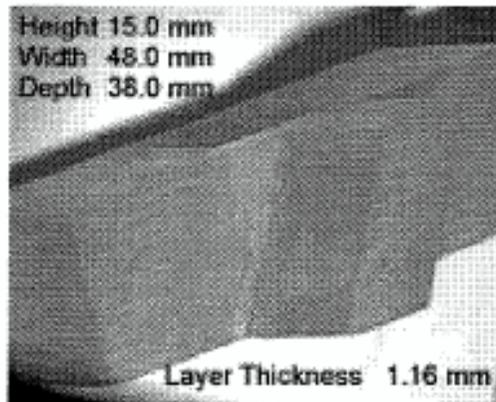


Figure 4 – A part with layer having slanted side wall fabricated using a five-axis milling machine

## 5. Conclusion

The new data format (LTI) was proposed for producing stepless RP parts. This format increases the part accuracy and it is easy to perform adaptive slicing. With the capability of the RP machines keeps on improving, the use of more than 3-axis control to built layers will be seen in the near future.

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