Title:
A Methodology for Filtering Point Cloud generated by CMM to apply NURBS

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Keywords:
NURBS, BLISK, point cloud, 5-axis CMM

DOI: 10.14733/cadconfP.2017.474-477

Introduction:
Nowadays, as aeronautical technology develops, an output of turbine is increasing. A turbine is necessary a BLISK for generating driving force. As shown in Fig. 1, a BLISK is a single engine component consisting of a rotor disk and blades, which may be either integrally cast, machined from a solid piece of material, or made by welding individual blades to the rotor disk. Due to the complex shape of BLISK, most researches related to BLISK are studies on the processing methods. Although there have been many previous researches, they didn't study related to measurement. A BLISK must be measured since it is critical components related to safety.

Recently, As shown in Fig 2, a 5-axis CMM(Coordinate Measurement Machine) is used in product measurement system. The 5-axis CMM is suitable for measuring complex shapes because the surface is measured using a probe in contact with the object. It uses two rotary axes. For rotation and positioning, one is on a vertical plane and the other is on a horizontal plane. 5-axis CMM moves the probe in contact with the surface of the workpiece, leaving a trace of points continuously. However, it is difficult to obtain the desired mesh with the existing algorithm using the data. So this paper proposes that a methodology for filtering point cloud generated by 5-axis CMM to apply NURBS.

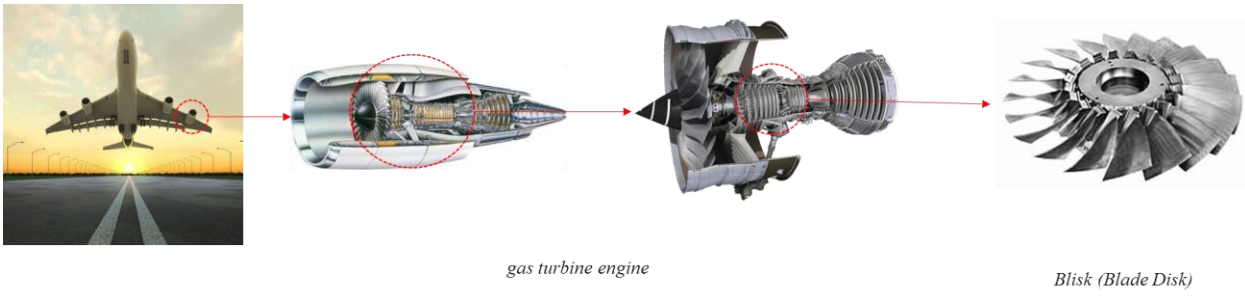

Fig. 1: BLISK.

Main Idea:
In computer graphics, there are two ways to express curvature: wireframe and curvature. In the wireframe method, the curved surface is represented by a set of line segments, and both vertices of each line segment can be represented in the three-dimensional coordinate system of X, Y, and Z. In this representation method, the curves are represented by a set of short segments, so the expression of the curved surface differs depending on how the curve is segmented. Another way is to use a Bezier

curve or a B-spline curve as a way to more accurately calculate the curvature. The Bezier curve is a method of obtaining various free curves by starting points and end points and control points located there between.

Fig. 2 shows that the 5-axis CMM measures the blade. The measurement was divided into six zones (two on the blade front, two on the blade back, and two on both corners) and created six point clouds.

Control points filtering methodology from a point cloud

- Pt: a raw point cloud array.
- newPt: a 1/5 point cloud array of Pt.
- CompVec(p1, p2, p3): compare the p1-p2 vector with the p2-p3 vector.
- EdgeIdx: index array to indicate the beginning and ending position in u.

```
//create newPt
For( i=0; j=0; i < Pt.count; i++ ){
        If( i % 5 == 0)     {
                newPt[j] = Pt[i];
                j++;
        }
}
//find a edge point index in u-axis
For(i=0; j=0; i<newPt.count - 2; i++){
        If(CompVec(newPt[i], newPt[i+1], newPt[i+2]) > 0.6){
                EdgeIdx[j] = i;
                j++;
        }
}
```

The above pseudo code shows how to filter the raw point cloud for NURBS. The first step in the filtering process is to filter out the point clouds in the 1 / 5th point by reading the raw point clouds in order. After that, we use newPT to compare the edge points by using the direction vector between points. First, the reason for filtering at 1/5 is that if the direction vector is compared without filtering as shown in Fig. 3 This can happen because the raw point cloud is a number that accepts the mechanical error as it is. The value of 1/5 for filtering and 0.6 for the direction vector comparison value are values obtained empirically.

There are a total of 6 point clouds on the blade, and one surface must be created. However, the position and number of edge points of each point cloud are different. To apply to NURBS, the number of edge points of each point cloud must be the same, so points outside the region of interest are ignored, as shown in Fig. 4.The number of edge points in the point cloud of interest is the same, and the closest edge point in the adjacent point cloud can be connected. Finally, it is possible to distinguish points that can be placed in the B-spline. Than the number of different control points can be applied by filtering with resolution.

Conclusion:

This study is focused on Blade which is one of the parts of the jet airplane turbine. The blades serve to compress the air for the engine to gain momentum and are an important part of human safety.
However, the research on evaluating the finished product is in short supply and the research from the 5-axis CMM to the 3D model generation has been carried out to solve this problem.

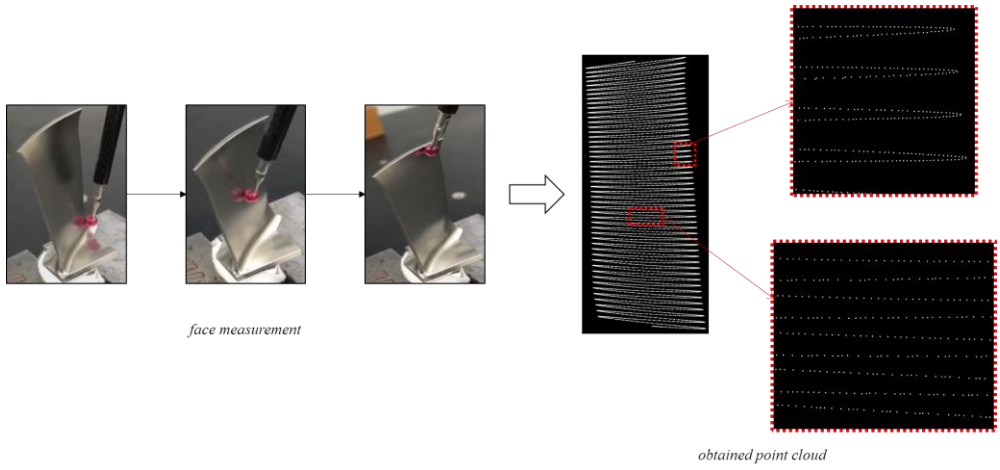

Fig. 2 BLISK measurement method and obtained point cloud.

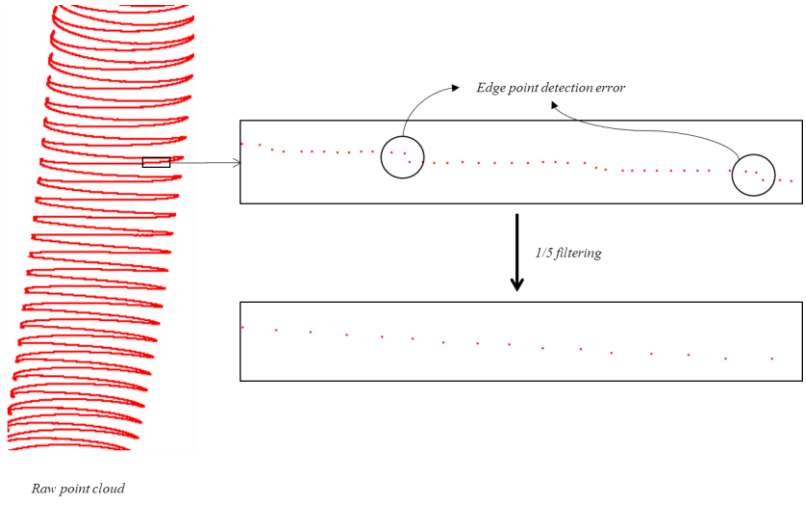

Fig. 3: Result of 1/5 filtering.

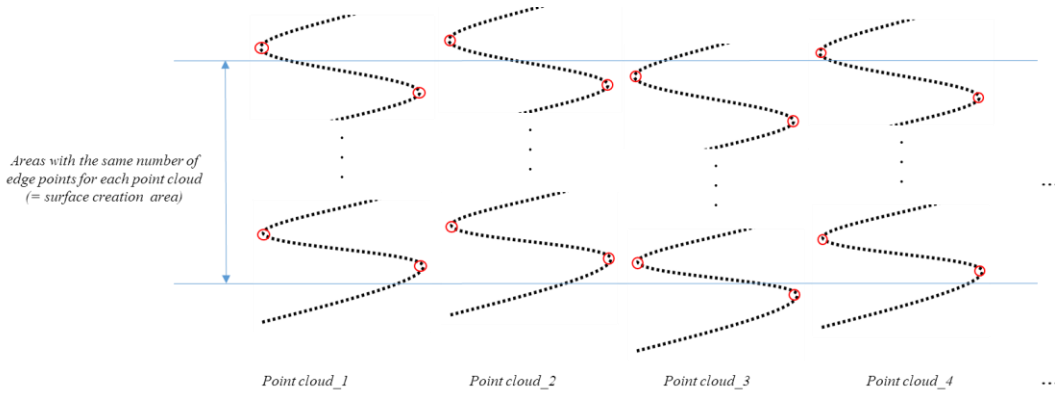

Fig. 4: Interest area of point cloud.

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