An adaptive sampling for surface without given geometrical model based on coordinate measuring machine with contact probe

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Abstract: For Coordinate Measuring Machines (CMM), the sampling strategy is very important to ensure the measuring accuracy, efficiency and safety. Up to now there is not an ideal sampling strategy for surfaces without known geometrical models, especially when CMM is equipped with contact probe. Several sampling methods for surfaces without known geometrical models are reviewed. Problems introduced by contact probes during the sampling process are analyzed. A novel adaptive sampling method combining the interpolation and extrapolation techniques is presented. The manually sampled feature points and their interpolation points are utilized to secure the safety of automatic sampling. And the extrapolation technique is adapted to predict the next probing start point, with comparison against the closest interpolation points. A numerical experiment was processed with MATLAB and the results show the sampling method is practical with acceptable accuracy, efficiency and safety level for surfaces without given geometrical models. The sampling method presented could be applied for general measurement and reverse engineering by CMM.

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1. Introduction

The sampling process used to gather the surface data is closely related to the measurement uncertainty for Coordinate Measuring Machines (CMM) with contact probe when the software related issues are handled with enough accuracy[1]. Unfortunately, there are no acceptance standards for determining how many measurements to take during part inspection or where to take them, or for assessing confidence in the evaluation of acceptance based on these measurements[2]. As Weckenmann adviced that a good sampling strategy would meet five requirements, basically three principles should be focused on: accuracy, efficiency and safety. To represent the measurand surface with reasonable accuracy, sufficient data should be sampled, and to ensure the efficiency of the measurement, redundant data should be avoided.

The research on sampling strategy is not satisfied to the CMM application. Zhang conclude that current inspection techniques result in an under-sampling of geometric features on parts with unknown form and measurement errors. For surfaces with given geometrical models, the sampling can be processed according to the nominal information. While for surfaces without given geometrical models, research indicates that a general solution to the sampling problems is not possible with established measurement practices.

3. An adaptive sampling method combining extrapolation and interpolation techniques

An adaptive sampling method combining extrapolation and interpolation techniques (CEIS) is shown as Fig. 2.

The points PI, which is interpolated from the feature points PF_k, is applied to regulate the main trend of the curve to be measured and to avoid the collisions between the probe and the workpiece. The points PE, which is extrapolated from the existing sampled points PS_n, PS_{n+1}, PS_{n+2} based on the curvature extrapolation algorithm, is applied to determine the probing start point (PSP) for the next sample point coordination. Together with PI and PE, sampling efficiency, accuracy and safety are secured.

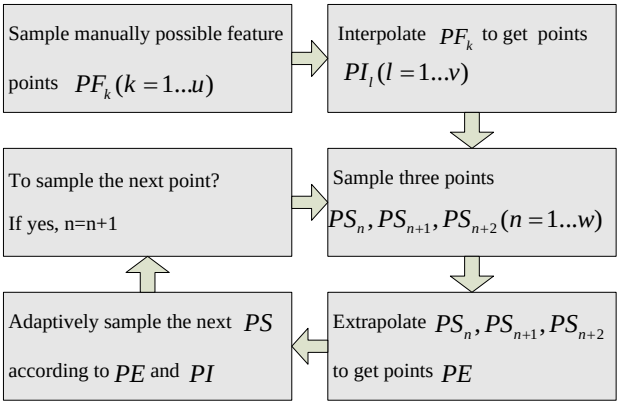

Fig. 2 Main structure of CEIS

4. CEIS main steps

4.3 The combination of interpolation and extrapolation points

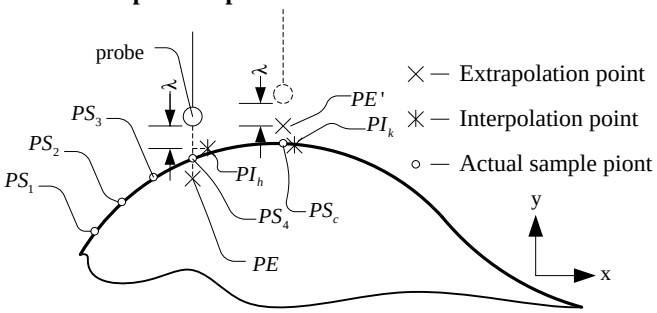

Fig. 6 Determination of PSP

A simulation has been processed to find that the search process for the closest interpolation points $PI_h(x_h, y_h)$ is completed within 0.5 minute for 1000,000 sets of double data. This search time is acceptable for the most of precision measurement.

5. Numerical experiments

The experiments were coded with MATLAB 2009 and run on a 3.4 GHz Pentium PC, with 1 GB of RAM.

7. Conclusion

A novel adaptive sampling strategy based on the combination of interpolation of curve and extrapolation of curvature is presented. The steps such as the interpolation of curve processed by third-order spline function and the curvature extrapolation are introduced. A numerical experiment is processed, which indicates the sampling strategy has different efficiency and accuracy level related with the step-length co-efficiency. This method has obvious efficiency and reliability, and it will avoid the collisions between the probe and the workpiece. It can be used for reverse engineering or general measurement by CMM.

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REFERENCES

1. Choi W., Kurfess T. R. and Cagan J., "Sampling Uncertainty in Coordinate Measurement Data Anlysis," Precision Engineering, Vol. 22, pp. 153-163, 1998.

2. Shilling M., Tran H. D., Huo X., et al, "Determination and Optimization of Spatial Samples for Distributed Measurements," SANDIA REPORT, SAND2010-7333, October 2010.