Development of Automatic Measurement System for Surface Profiles

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論　文　要　旨

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論文題名　Development of Automatic Measurement System for Surface Profiles
（表面形状自動測定システムの開発に関する研究）

論　文　内　容　の　要　旨

This thesis presents the research findings of measuring surface profiles automatically in manufacturing components where a traditional measurement system is not applicable. In Part I of this study, the laser guided deep-hole measurement system is applied to holes with normal millimeter-level diameters and lengths up to several hundred millimeters. A measurement system that can measure a small size hole with diameter range of 17-21 mm and length range between 0-800 mm is fabricated, and the performance has been evaluated in measuring deep-holes. In Part II of this thesis, the gear circumference measurement system has been described with the improvement of the overall system incorporating vision. During gear profile measurement, synchronized movement control of both radial and spindle axes is the key issue to achieve the constant line speed scanning in whole measurement without detaching a stylus. To realize the proposed measuring strategy, the new gear measuring machine (GMM) was developed with direct axis-driving and 3D probe implementation. A standard cylindrical gear was measured as an example using the developed GMM and the whole shape of the gear outline was successfully obtained with the maximum scanning speed of 7mm/s. The developed system can measure root and bottom profiles of the teeth and the tip edges successfully by adjusting the nominal data as well as working tooth flanks. Finally, a camera and software system has been integrated with the gear measurement system in order to make tracking of a stylus during measurement and to avoid sudden crashing of the stylus.

The thesis consists of two parts. Part I describes about an automatic deep-hole measurement system whereas Part II describes about a new gear profile measurement system.

In Part I, Chapter 1 describes briefly about deep-hole, problem statement of the thesis, research objectives, methodology and research scope. Chapter 2 introduces several systems that has been applied and implemented for measuring surface profiles of various mechanical components. Mainly, it discusses the implemented methods applying laser and optical instruments in surface measurement. Chapter 3 elaborates the experimental components and its application in measuring deep-holes having a range of diameters between 17-21 mm. The system consists of various optical components such as pentaprism, corner cube prism, PSD sensor, CCD cameras and also laser interferometer as well as laser diode for the purpose of measuring roundness and detecting rear probe attitude. Chapter 4 explains experimental methods of roundness measurement for deep-holes. Here, it shows the fundamental working principle of pentaprim, PSD sensor and other components with the simplified flow charts. The experimental steps are shown in this section. Finally, the result of this research could be found in Chapter 5. This Chapter presents experimental results of the developed system for a hole diameter of about 18 mm. It analyzes results that are acquired under various experimental conditions. It plotted three types of resulted figures. One figure for roundness measurement of the hole, another one is the 3D inner shape of the 18 mm deep hole and finally CCD camera resulted graphs are plotted to find the rear deviation of the measurement probe. From the results we can easily find the optimum condition in order to acquire best experimental results from this automatic developed system. Chapter 6 concludes by summarizing the main achievements of the developed small measurement probe.

The contents of this dissertation in Part II are organized as follows: Chapter 1 comprises of introduction. It introduces several measurement systems for gear shapes and its accuracy. Beside this, problem statement, research objectives and research methodology are shortly described. Chapter 2 describes the drawbacks of conventional gear measurement and proposes measurement strategy to overcome the problems. In addition, it is found that the existing techniques do not integrate camera for stylus tracking and control in precision engineering such as gear circumference measurement. Chapter 3 presents gear profile measurement system for a test case with detail explanation. The newly developed system can measure a whole gear circumference without detaching a stylus at the maximum scanning speed of 7mm/s. Applying the developed measuring strategy, the measuring time reduced up to 95%; thus the developed system is 20 times shorter than the conventional one. Chapter 4 demonstrates camera based gear measurement system. This chapter discussed technical issues of the developed software system as well as elaborates its features and working principles. Chapter 5 discusses the applications of the camera system for gear measurement. This chapter has briefly shown some tracking results of the proposed color base stylus tracking and saving tracking data in x and y coordinate values. The performance has been analyzed of the developed system in order to test the feasibility of the existing system. This chapter also highlights the key achievements of the developed system and analyzes the performance of the system. Chapter 6 concludes by mentioning concrete achievements and proposed new ideas for future works. Further applications of machine vision will surely make the system more autonomous.