The Japan Society for Precision Engineering

Introduction of JSPE Best Paper Awards 2009

1. Euclidean Symmetry Detection from Scanned Meshes of Mechanical Objects based on a Combination of ICP and Region Growing Algorithms

Tomohiro MIZOGUCHI and Satoshi KANAI

Recently scanned meshes from mechanical objects can be easily acquired using high-energy industrial X-ray CT scanning technologies, and these meshes are widely used in various fields of product developments. Mechanical objects often exhibit symmetries for their functionality. They are originally defined by creating a copy of the solid and then by placing it with a certain transformation including an arbitrary set of translations, rotations, and reflections. Therefore it is desired to detect such symmetries from the scanned meshes for their effective use in mesh applications, such as reconstruction of CAD models with compact data representations or CAE mesh enhancement using the symmetries. In this paper, we propose a method that can detects multiple Euclidean symmetries from scanned meshes of mechanical objects based on a combination of ICP and region growing algorithms. We define Euclidean symmetries detection as to detect both pairs of regions that match under certain transformations and their transformations including arbitrary sets of translations, rotations, and reflections. We also propose a method that derives all possible sequences for reconstructing an entire model from the original mesh using planar-reflective symmetries among all the detected symmetries, and represents them in an AND/OR graph in order to compactly represent the mesh. Our proposed method contains several advantages. It can robustly detect symmetries from noisy scanned meshes that include many planar regions. Our method also can detect both global and local Euclidean symmetries from meshes. Moreover it can detect maximally large pairs of regions under user specified tolerances. We demonstrate the effectiveness of the proposed method from various experiments using X-ray CT scanned meshes of mechanical objects.

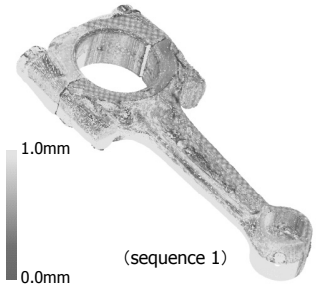

Fig. 1 Accuracy evaluation of the reconstructed models

2. A Precision Instrument for 3D Edge Profile Measurement of Single Point Diamond Micro-Cutting Tools

Takemi ASAI, Yoshikazu ARAI and Wei GAO

This paper describes an instrument for 3D edge profile measurement of diamond micro-cutting tools used for ultra-precision fabrication of micro-structures. The measurement targets of this instrument are round-nose tools with nose radii of less than 100 μm. The core elements of the instrument are an atomic force microscope (AFM) for profile measurement of the tool edge and an optical sensor for alignment of the AFM cantilever tip with the tool edge. A three-axis closed-loop controlled PZT scanner is employed in the AFM for high-accuracy profile measurement and DC-servo-motor-driven stages are employed in the alignment mechanism for automatic alignment. Measurement experiments of micro-tools with nose radii of 30 μm and 8 μm are carried out, respectively. Cutting edge radii, nose local radii and edge contour roundness are evaluated based on the 3D edge profile measurement data.

3. Fundamental investigation of subsurface damage in single crystalline silicon caused by diamond machining

Jiwang YAN, Tooru ASAMI, Hirofumi HARADA, Tsunemoto KURIYAGAWA

Single crystalline silicon was plunge-cut using diamond tools at a low speed. Cross-sectional transmission electron microscopy and laser micro-Raman spectroscopy were used to examine the subsurface structure of the machined sample. The results showed that the thickness of the

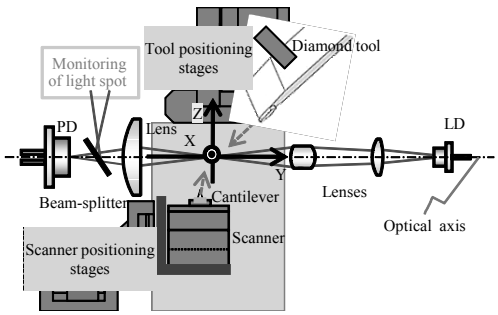

Fig. 2 Design outline of the instrument

Kudan Seiwa Building, 1-5-9 Kudan-kita, Chiyoda-ku, Tokyo 102-0073, Japan
Phone: 81 3 5226 5191, Fax: 81 3 5226 5192, http://www.jspe.or.jp

machining-induced amorphous layer strongly depends on the tool rake angle and depth of cut, and fluctuates synchronously with surface waviness. Dislocation activity was observed below the amorphous layers in all instances, where the dislocation density depended on the cutting conditions. The machining pressure was estimated from the micro-cutting forces, and a subsurface damage model was proposed by considering the phase transformation and dislocation behavior of silicon under high-pressure conditions.

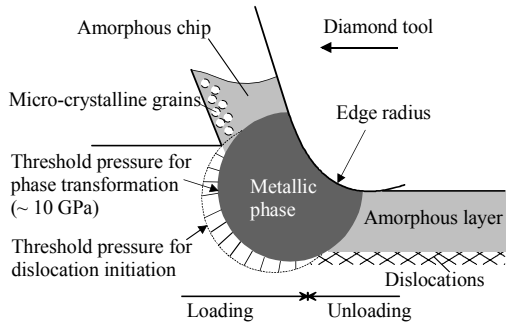

Fig. 3 Schematic model for subsurface damage mechanism in silicon during ductile machining

Introduction of JSPE Takagi Awards 2009

1. A Study on Control Structure for Slide Screw Stages - Mechanical Nonlinearity and Control Optimization

Susumu MAKINOUCHI, Hideaki SAKAMOTO and Shinji WAKUI (NIKON CORPORATION)

A slide screw drive is a kind of old technology. However it is usable and important technology even in high-tech fields such as semiconductor manufacturing. This paper intends to improve the slide screw controllability which has strong non-linearity due to grease characteristics. We measured the grease non-linear viscosity using a special tool. This grease property explains the shot dislocation phenomenon which occurs in slide screw stages particularly. Since we understood the phenomenon, we found one non-linear gain control method which embedded the grease property reversely. It not only fixed the dislocation problem but also enhanced the slid screw stage performance and maintainability.

2. Observations on the Behavior of Bubbles Generated by Laser Focusing in a Piezo-Driven Inkjet Head

Tsuyoshi SATO and Toshiro HIGUCHI

(TOSHIBA CORPORATION)

In recent years inkjet technology has a wide range of application such as Flat Panel Display and

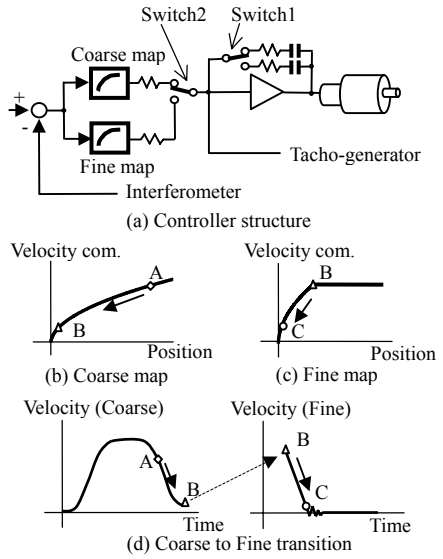

Fig. 4 Non- linear control

Semiconductors. The stability of jetting is a major requirement for industrial inkjet heads. However, air bubbles can cause jetting failures in piezo-driven inkjet heads. The piezo actuators can be used as sensors to detect the acoustic influence caused by air bubbles. In order to analyze the relationship between the air bubbles and the voltage signal from the piezo actuator, a controllable bubble generation method inside the inkjet head is strongly required.

In this paper, we propose a bubble generation method by focused THG Nd:YVO_4 laser and the secondary Bjerknes forces and obtain bubbles from about 5 micron to 150 micron in radius inside the inkjet head. Using the observation technique with a glass nozzle plate, some interesting bubble migration patterns in the applied pressure field are observed. We consider that the primary Bjerknes forces drive the displacement of air bubbles against buoyancy.

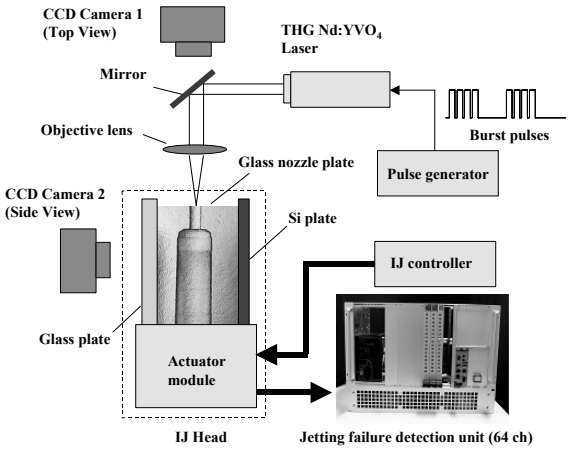

Fig. 5 Experimental setup for bubbles generation inside an inkjet head