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Position precision improvement throughout controlled led paths by artificial vision in micromachining processes

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Abstract

Vision control systems applied to manufacturing processes have become an important research area in recent years. In this proceeding a robust and innovative artificial vision algorithm (AVA) has been developed in order to control the positioning system of a micro-machine tool mounted with a camera-LCD screen system. This study differs from previous research by using an enhanced AVA, which processes the capture image of pattern of LEDs, where the gap between illuminated LEDs is of one single LED, thus gaining in resolution. A new camera lens has been mounted on the micro-machine tool, which jointly moves with the *XY* platform with better resolution that that applied in previous research. The camera captures the optimized image of the tool path represented in the form of a series of lighted LEDs on a 326ppi smartphone screen. Moreover, the implementation of two new processes, such as the auto-alignment and autofocus along with a robust grid window of 5×5 lighted LEDs, let the AVA be more robust and accurate. As a result, a significant positioning error decrease is achieved for the controlling system, thus obtaining and important precision and repeatability improvement in the position system of the micro-machine tool.

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Keywords: Machine tool; Precision; Positioning; Accuracy; Micromachining; Artificial Vision.

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1. Introduction

Recent studies have proven the benefits of using computer vision for automatic machine tool controlling. Thus, Ahmand et al. [1] carried out image-processing algorithms in order to optimize the tool path in a CNC machine. Zhang et al. [2] reconstructed a 3D image by using a single camera so as to estimate the cutting tool position. Further, Karabagli et al. [3] developed a vision system for automatic verification of machining fixtures in high speed machining, thus protecting machines against the collision of the tool with the clamping elements. In the field of micromachining, Chen et al. [4] proposed an on-machine method to measure and compensate the error cause by the inaccuracy of the mechanical system when moving the workpiece and objective, and the optical system when delivering and focusing a laser beam. Following similar approach, the use of a closed-loop positioning systems plays a very important role for achieving the required accuracy. In recent years different methods based on the development of positioning algorithms analyze a pattern shown in a photo image LCD screen [5]. In a previous research [6,7] a vision algorithm for controlling the position in micromachining was implemented in a low cost micro-machine tool based on the detection of the color intensity transition thus showing uncertainty associated to the precision measurement procedure of 0,26 μm. However, it has been detected that, due to the low-cost approach, more improvement should be implemented in order to reach more stability and precision in the micromachining system. In this communication, the artificial vision control system of a demonstrator used in previous studies has been improved in order to achieve better results of precision and repeatability by integrating additional modules within the vision control algorithm, such as auto-alignment and autofocus, along with the implementation of a more robust grid window of 5×5 lighted LEDs. The positioning control system is based on a tool path, which is drawn by a pattern of illuminated LEDs on the black background of a phone screen.

This study differs from previous work in reducing the space between on LEDs (illuminated) to a sole off LED (unlit), and implementing a mask correction of 5×5 LEDs mesh. Moreover, both auto-alignment and autofocus processes have been integrated into the LABVIEW software, so that a significant improvement in the stability of the system is achieved. Having estimated the position of the LED within the limits of the image captured by the camera, the closed-loop system has been checked by a series of laboratory tests in order to evaluate the accuracy and repeatability of the micro-machine tool (MMT).

2. Artificial Vision Methodology

The Artificial Vision Algorithm (AVA) is based on taking a photo of 32-bit color type BMP image drawn on a smartphone screen by a camera placed opposite the image, which jointly moves with the XY platforms of a MMT. After obtaining the red color plane of the image, the AVA builds a mask from a Region of Interest (ROI), as seen in Fig. 1, where only the lighted LEDs which could construct a tool path are included on the study, so obtaining a computational cost improvement with respect previous research [6,7]. It is noted that a single unlit LED separation between two illuminated positions is used in the study.

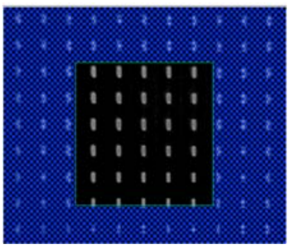

Fig. 1. Mask image, region of interest and image processed of a 2×2 illuminated LED matrix.

After the mask extraction process the newly implemented AVA modules can be summarized as follows:

1. Threshold module. This option applies a threshold to an image based on an image analysis technique called entropy. Entropy-based methods result in algorithms that use the entropy of the foreground and background regions and the