Image Recognition and Interferometry Applied to High Performance Positioning Systems

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Abstract

In broad terms, to achieve high performance and miniaturization of mechatronic systems it is necessary to develop positioning mechanisms with high response and precision. A microtilt stage was developed. It is capable of monitoring the position of a diamond tool relative to a workpiece, in-process, permiting error compensation and the generation of complex forms. The use of artificial neural networks as a tool to help the development of an algorithm for the identification of images is proposed. This algorithm is based on knowledge and employs interferograms as a multi-sensor element representing positions. One desired characteristic of the proposed algorithm is its ability to perform the identification of the position of a surface on the tilt stage and to permit fast processing of the information. This turns the device appropriate to be used in real time applications. This technique was assessed by simulation and presented significant results, encouraging further researches involving interferometric pattern recognition.

1   Introduction

The control and/or measuring the position and shape of a surface are often carried out through measurement systems unidirectional. This work presents a new concept for solving this problem, namely the imaging technology, which allows the analysis of dimensions in space. Creating the concept of measuring multi directional [1]. This concept will be applied to a rotating tilt stage. It consists of a table level to assist in positioning ultraprecision machines or instruments, whose modularity allows its use in various fields such as optics and machining.
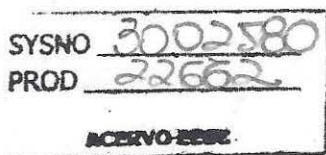
2   Methodology

Figure 1 shows the MAR, which consists basically of a rigid base (bottom) and a flexible base (top) connected by two piezoelectric actuators and a fixed point, placed to 120 degrees at a distance r from the center. The angular micropositioning is defined with the use of piezoelectric actuators.
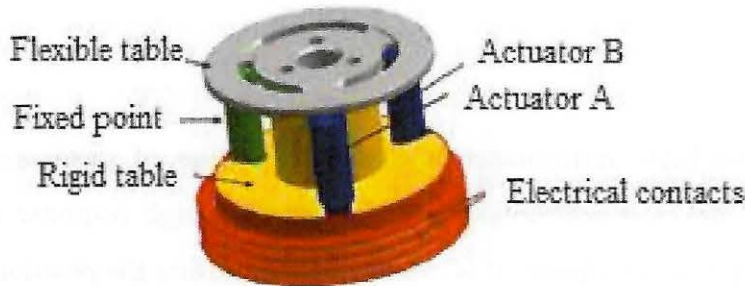

Figure 1. Rotating tilt stage.

The voltages applied to actuators generate different positions on the flexible table. Thus, through mathematical modeling, applying transformation matrices was possible to obtain a homogeneous set of equations (eq. (1), (2) and (3)) that relate the individual displacement of each actuator and the angular variation triggered on the platform [2].

$$dA = -d - r\cos 60^0 \sin\theta_1 \cos\theta_2 + r\sin 60^0 \sin\theta_2 \tag{1}$$

$$dB = -d + r\sin\theta_1 \cos\theta_2 \tag{2}$$

$$dC = -d - r\cos 60^0 \sin\theta_1 \cos\theta_2 - r\sin 60^0 \sin\theta_2 \tag{3}$$

Where:

d – center point translation of the positioner in the Z direction;

r - distance from the actuator to center of flexible table;

θ 1 - turn related to the axis X;

θ 2 - rotation related to the axis Y;

dA, dB, dC - displacement actuators A, B and C, respectively.

Knowing the relation between voltage and angular displacement, it is possible to map the problem by interferometric fringe patterns obtained for each boundary condition. For this purpose it were applied predetermined voltages, namely from 0V to 600V to the actuator A and 0V to 450V for actuator B, with a 50V range. The image after pre-processing was transformed into the input vector of an algorithm based on artificial

neural networks competitive, more precisely, Self-Organizing Maps of Kohonen [3]. Figure 2 shows a proposed system schematic.
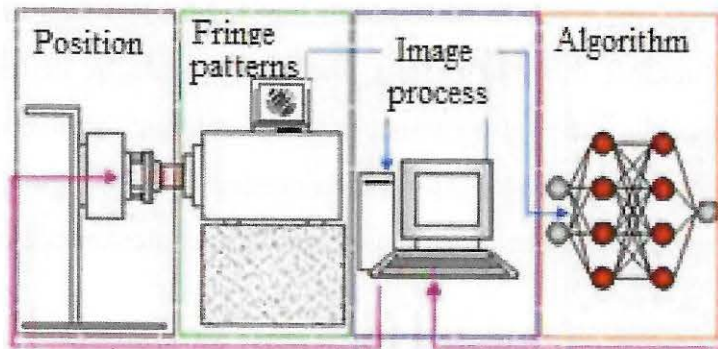

Figure 2 Scheme that characterizes the system

3 Results

The algorithm architecture used is a function hexagonal topology with 20 neurons. These neurons compete according to the Euclidean distance criterion, performing 1000 iterations. As it is a competitive network, each neuron is characterized by a corresponding voltage driven actuator, which corresponds to an interferometric fringe pattern. Table 1 shows the percentage of accuracy for each active tension.

Table 1: Hits of the neural network

Voltage [V]	Percentage of correct answers [%]	
	Actuador A	Actuador B
50	100	100
100	67	67
150	67	100
200	67	100
250	67	100
300	67	100
350	100	100
400	100	100
450	100	
500	67	
550	100	
600	100	

Despite the small percentage of success to be the order of 67 to the actuator A, it is visible that the net effectively recognized which actuator was triggered. The tensions generated by the images too close, there is still some confusion in the identification, probably, if it were a greater number of input vectors, the result would be better. Despite the self-organizing map algorithm is a robust and fault tolerant, as it is a comparison through pixels, there may be loss of information needed in these regions, and even during image capture may have been mechanical and noise interference or acoustic.

4   Acknowledgements

5   Conclusions

In fact, the proposed system has qualities like simplicity, both in the manufacture of opt-mechanical devices, or in obtaining the curve voltage/position, since the positioner calibration is accomplished by mathematical model with a fewer restrictive assumptions, which therefore entail a compact computational model that allows the user for each application, with high reliability, deduce the function that establishes the correspondence between voltage and position of the actuator part to be machined or the inverse function, part position and the actuator voltage. It was found that the use of self-organizing maps for images interferometric identification and image processing are presented as promising techniques in the project area ultraprecision, to identify the surface under study and relate it to pre-established standards.

References:

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[3] Kohonen, T, Self-Organizing Maps, Ed. 4, Springer-Verlag, 501 p. 2001.