DEVELOPMENT AND ANALYSIS OF COMPUTER VISION SYSTEM FOR MICROMECHANICS

Tetyana Baydyk
Corresponding author
Department of Micro and Nanotechnology[1]
t.baydyk@icat.unam.mx

Ernst Kussul
Department of Micro and Nanotechnology[1]

[1]Institute of Applied Sciences and Technology (ICAT)
National Autonomous University of Mexico (UNAM)
Circuito Exterior s/n, Ciudad Universitaria, Mexico, Mexico, 04510

Summary: In micromechanics the best technologies are MicroElectroMechanical Systems (MEMS) and MicroEquipment Technology (MET). The MEMS used the electronic technology to produce mechanical components. Due to the advantages of the MET such as the development of low-cost micro devices, the possibility of using various manufacturing materials, the possibility of producing three-dimensional microcomponents it will be very useful to automatize all processes of mechanics production and develop different technological innovations. The automation and robotics are two closely related technologies since automation can be defined as a technology that is related to the use of mechanical-electrical systems based on computers for the operation and control of production. The field of micromechanics has been involved in different applications that cover almost all areas of science and technology, an example of this is the management of microdevices for the autofocus of digital cameras whose objective is image processing (recognizing and locate objects). The use of computer vision systems can help to automate the work of MEMS and MET systems, so the study of image processing using a computer is very important. The objective was to design a computer vision system that allows the movement of the lens to focus the work area, for the monitoring of the micromachine tool in manufacturing processes and assembly of microcomponents in real time using previously developed image recognition algorithms. The developed algorithms use the criterion of improving the contrast of the input image. We describe our approach and obtained results. This approach can be used not only in micromechanics but in nanomechanics too.

Keywords: computer vision; Micro Equipment Technology (MET); image recognition algorithms; image contrast.

1. Introduction

The MET has been considered as alternative or additional to MEMS for the production of mechanisms with micromechanical technology [1–5]. This technology is based on the application of microequipment, similar to conventional mechanical equipment, but much smaller in size. This allows conventional material treatment technology and automatic assembly of mechanical and electronic devices to be used to manufacture micromechanical and microelectronic devices of millimeter dimensions [1–5]. The first generation has been produced by conventional mechanical equipment. The machine tool of this generation has a total size of 100–200 mm. Using microequipment of this generation, a second generation of much smaller size can be produced. This process can be repeated to produce generations of micromachine tools with millimeter dimensions.

For automation tasks, it is proposed to use image recognition systems. Different algorithms for image recognition have previously been developed. These algorithms are adapted for the automation of micromechanical equipment. With these algorithms and computer vision prototype it is possible to automate production and assembly work in micromechanics. In this article let's present an image focusing system using stepper motors.

2. Methods

The development of the micromechanical systems began formally in the mid-1980s and since then has had a high impact in the scientific and industrial field [1–5]. For automation tasks, it is proposed to use image recognition systems. Different algorithms for image recognition have previously been developed [6–9].

The algorithms for the automation of micromechanical equipment are adapted. With these algorithms and computer vision prototype it is possible to automate production and assembly work in micromechanics. The vision system prototypes have been developed that have a video camera, four lamps, microequipment and a PC, for image recognition for this microassembly task [10]. These prototypes were used to obtain image databases. With these image databases, new image recognition algorithms were approved.

A vision system using a webcam is being developed. The design of the computer vision system is focused on image capture in microassembly and manufacturing tasks of microparts. With this computer vision system, it is possible to use image recognition algorithms that have already been developed and tested offline. The elements of the computer vision system are shown in **Fig. 1**.

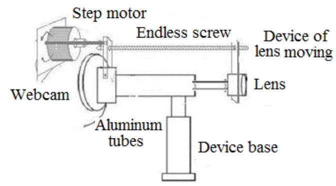

Fig. 1. Elements of the computer vision system

3. Results

A device was developed that allows the webcam to be mounted on one end and the lens used on the other end. This device (armed tubes) has the possibility of moving the lens closer or further away to focus on the object under study. It also has a light source, in the form of a ring of bulbs to achieve a diffused light form.

To manage the computer vision system (**Fig. 1**), a stepper motor was developed, which will allow automatic focus movement, to have a more precise movement [11, 12]. The proposed stepper motor is a bipolar permanent magnet motor; this design is 4 coils. The operation is very simple. The rotor is fixed in the middle of the stator, when the polarity of one of the stator poles changes, then the magnet aligns itself according to the polarity.

The developed prototype is demonstrated in **Fig. 2**. There were two aluminum tubes, a webcam, a PVC mount for the webcam, a thin lens with a focal length of 8.4 cm for which a PVC mount was also developed. A diaphragm was developed to limit light rays from external sources, a base for the device and a light source, formed by a ring of 12 V bulbs to obtain a diffused light.

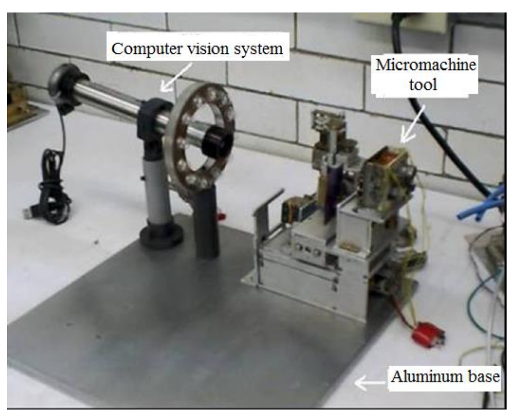

Fig. 2. Complete system of computer vision

Autofocus by contrast evaluation is based on the principle that an out-of-focus image has lower contrast, while a focused image has higher contrast, especially in the contours or reliefs of figures [13]. As it was said to move the elements of the system let's use stepper motors [14]. The lens shifts can focus the image of our objective.

Finally, in **Fig. 3**, the interconnection of the motor, the controller circuit as well as the power source, known as the computer vision system, has been made.

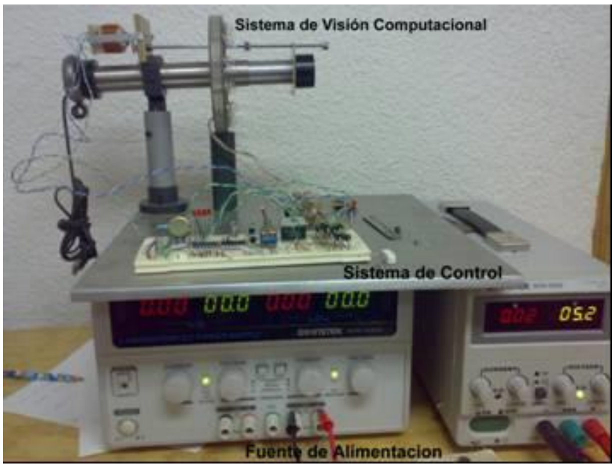

Fig. 3. Computer vision system

4. Discussion and scope of application

There are various tasks for which this computer vision system can be used by applying image recognition algorithms in manufacturing tasks of microcomponents. As an example of a task it is possible to select the images captured with this device of 3 mm diameter screws of four different classes that are depending on the position of the cutter in which they were generated [10, 15]. **Fig. 4** shows the vision system in the process of capturing images of 3 mm diameter screws, displayed on the computer.

Fig. 4. Capturing images of screws with vision system

A device was developed that will be used to capture images in manufacturing or assembly tasks of microdevices in real time, applying image recognition algorithms that have already been developed previously.

Images were obtained with this vision system of 3mm diameter screws (**Fig. 5**), obtaining an acceptable image quality for the image recognition algorithms. Images of screws are captured with the computer vision system with different focal lengths and, as a result, with different contrast levels (**Fig. 5**).

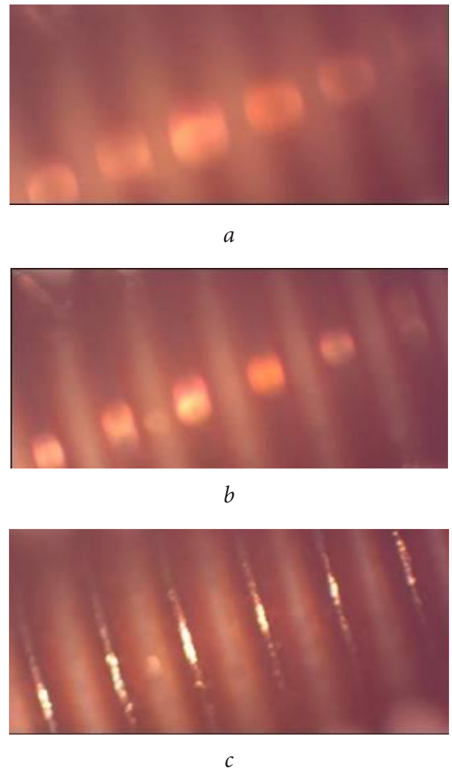

Fig. 5. Examples of screws with different focal lengths:
a – blurred image; *b* – better quality image; *c* – focused image

For the computer vision system, the algorithms are developed to define best approach. The calculation of the contrasts in the images was chosen as a first approach. The program for calculating the contrasts of the images was written in C++ Borland 6. Let's divide the range of brightness contrast in the image by 16 intervals. For each image let's calculate the contrast histogram. Example of program work (screw image with contrast histogram) is shown in **Fig. 6**. For each histogram let's calculate sum of all histogram values. This sum characterizes the image presented to the system.

The results obtained for each class of images (the results are average values) are presented in **Table 1**.

Table 1
Sum of histogram values

Class	Contrast
Blurred	76661
Best Quality	87805
Focused	160525

From **Table 1** it is possible to see that for the focused image there is maximum contrast. This feature can be used in the computer vision system to correct the position of the lens. So let's obtain the best image quality when there is the maximum contrast.

The objective of the designed program is to define the image quality using the contrast histogram calculations algorithm. Depending on image quality (maximum contrast) the system can define stepper motor movement to change the focal length of the lens.

Development of the algorithms of computer vision systems can be found in publications [15].

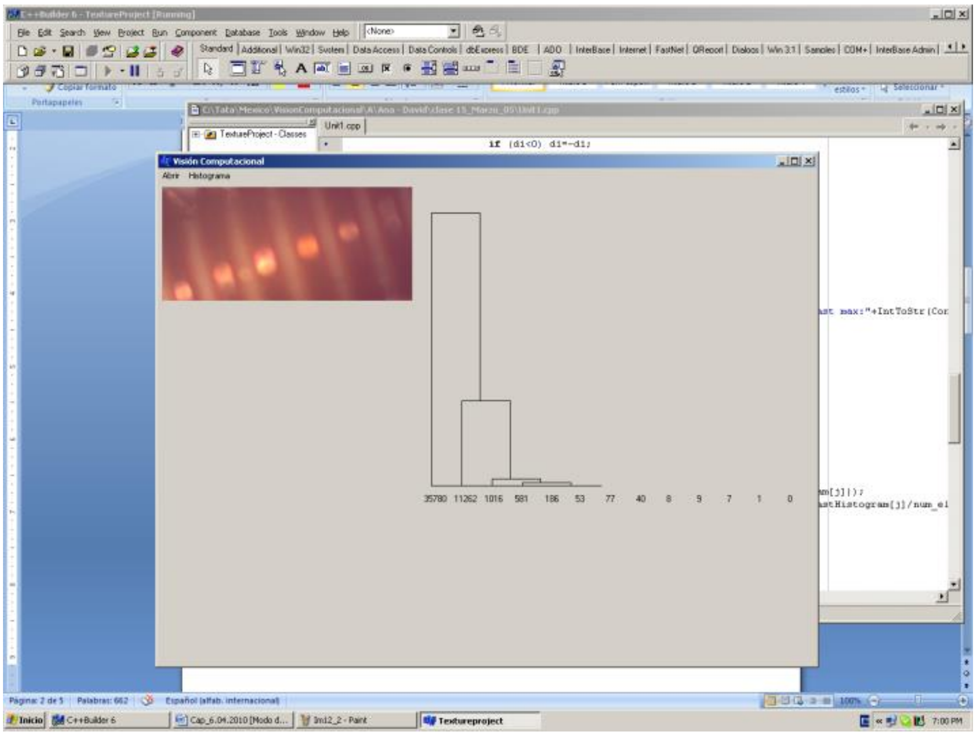

Fig. 6. Example of program work

The prototype of a computer vision system has the simplicity of its design and low cost. It is necessary to develop fully automated microfactories in future.

5. Conclusions

All the elements described above as well as the stepper motor were developed and machined using machine tools (milling machine, lathe, drill, etc.). The control of the stepper motor is based on a set of integrated circuits. Consequently, the computer vision system has contrast calculation algorithms. The algorithms are carried out with the help of C++ Borland 6. The focus adjustment has very smooth system movements. The system could be automated using a microcontrollers and other algorithms for image recognition, such as contrast histogram, contour recognition, etc.

Conflict of interest

The authors declare that there is no conflict of interest in relation to this paper, as well as the published research results, including the financial aspects of conducting the research, obtaining and using its results, as well as any non-financial personal relationships.

Financing

The study was performed without financial support.

Data availability

Manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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