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Neural classifier for micro work piece recognition

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Abstract

The aim of this article, is to describe a technical vision system for automation of micromanufacturing and microassembly processes. One of the principal problems is connected with the recognition of work pieces and detection of their positions. For this purpose we use neural classifier named limited receptive area (LIRA) grey scale. This classifier was developed for wide range of image recognition tasks. A special software was designed. We describe some experiments and results of application of LIRA in the recognition of micro work pieces and their positions for automated handling system. The best recognition rate obtained was 94%.

Keywords: Neural network; Neural classifier; Technical vision; Object recognition; Position recognition; Microassembly

1. Introduction

The miniaturization of products coupled with development of new technologies [1,2] has enabled us to develop equipment and instruments of small dimensions [3,4]. Our aim is to create fully automated desktop microfactory. With help of this microfactory it is possible to create smaller and smaller microfactories. We consider different generations of microfactories, each of then corresponds to a microfactory of certain dimensions. The proposed technology is MicroEquipment Technology (MET) [3]. In development of each generation new problems will appear, but a lot of useful products can be produced. We are developing this technology at the Micromechanics and Mechatronics Laboratory, Centre of Applied Science and Technological Development (CCADET) of National Autonomous University of Mexico (UNAM) [3,4].

The most important areas of microtechnology applications are: automotive industry, medical engineering, electronics, security systems, vision systems, environmental control, traffic control, communication networks and aerospace technology. The potential market for microproducts was estimated in more than 30 billions euros in 2002 [5].

Micromanufacturing and microassembly processes automation is fundamental goal to achieve good performance of corresponding equipment [6,7]. It is important to apply computer vision methods in automation. One essential part of an automated microfactory is a system for work pieces handling. We are working out a fully automated work pieces handling system. The goal of this system is to recognize one random-located work piece in work area, to define its coordinates, to take it with manipulator and to transport it to another place. This system has to be flexible. This means, the system must be able to handle work pieces of different dimensions and shapes. The scheme of the proposed system is presented in Fig. 1.

This system is composed of two cameras, one manipulator and three subsystems: manipulator control subsystem (MCS), technical vision subsystem (TVS) and intelligent manipulation subsystem (IMS). The manipulator has special characteristics for mini–micro handling abilities. It will have six degrees of freedom. We use general purpose, low cost, commercial CCD cameras. They serve as an input to the TVS. The main purpose of this system is to process the data from the cameras for recognize work pieces and their positions. This is the main topic of this article. The IMS controls the whole system. This means it gives the instructions to manipulator, processes the data from the TVS, communicates between both and with the user. The user can be a person or another system.

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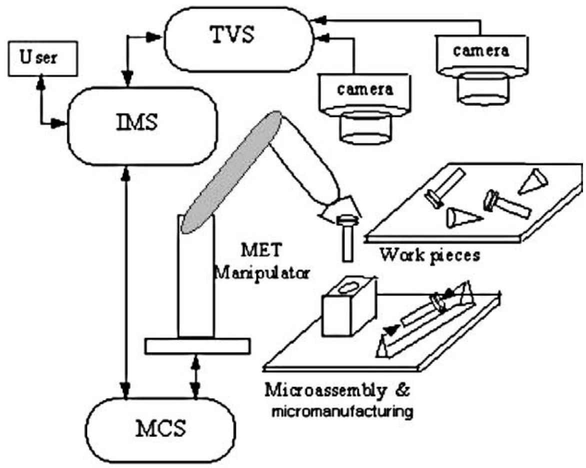

Fig. 1. The scheme of automatic work piece handling system.

We begin to work with the system that contains one camera and the TVS. TVS is based on the method of micro work piece recognition and their position detection. For this purpose we adapted the neural classifier LIRA grey scale [8]. In work piece recognition task we obtained the recognition rate of more than 90%. In position detection task we obtained coordinates of recognized work pieces.

The paper is organized as follows. The Section 2 is devoted to the state of the art in the object recognition and the automatic handling systems. In the Section 3 we describe our TVS. In the Section 4 we describe the neural classifier LIRA grey scale, the training and recognition processes. In the Section 5 we describe the developed software and the databases used in the experiments. The experiments and results are presented in the Section 6. Discussions we give in the Section 7 and the conclusion in the Section 8.

2. State of the art and related works

Object recognition problem and different methods to solve this task are presented in [9,10]. There are many approaches and methods to resolve the object recognition problem. Very often the first step of these methods is to extract contours from the image. We want to analyse four methods based on contour images applied to objects of 2D, these methods are: pattern matching, principal component analysis, graph matching and generalised Hough transform [11].

2.1. Pattern matching method

The square differences between an image I and a template image T are summed pixelwise:

$$r(x,y) = \sum_{i\in T}\sum_{j\in T}(I(x+i,y+j)-T(i,j))^2 \tag{1}$$

If the resulting sum is larger than experimentally obtained threshold, the object template T is found in I. This method is time and memory consuming and it does not handle brightness changes or scaling on image.

2.2. Principal components analysis method

This is a correlation based technique. The application of this technique has the learning phase and the application phase. The image is stored in a vector. To reduce the computation time this vector is transformed to a smaller dimension vector with a vector transformation T. This vector is chosen to maximize the variation of the transformed image vectors. In the application phase, an image to be processed is transformed with vector T and after that the correlation with the database images is found [12]. This method has detection stability and detection correctness but it is time consuming and it works only if the object can be differentiated from the background.

2.3. Graph matching method

This method works on an object contour model of the image. The idea is to analyse orthogonal line segments that cross certain points of the object contour. The search of image features is permorfed along these lines. The similar features are used to compare a model with a given image for object recognition. Any feature can be implemented in this method (colour, brightness, texture or others). This method demands memory, but time is reduced. Under specific conditions this method can work with partially hidden, scaled or rotated objects. This method does not work with images that have several objects. It is hard to recognize small objects too.

2.4. Generalised Hough transform (GHT)

The contours are approximated by a set of points taken in the object contour. Every point of the object contour is described in terms of some reference point inside the contour. The contour image can be obtained by the application of a Laplacian-of-Gauss filter. Partially hidden, scaled or rotated objects can be recognized. This method is not memory consuming but it is time consuming and it does not work with small objects on images.

The superquadrics technique is used for object recognition and modelling. The superquadrics consist of a parametric descriptive family of shapes. In the 2D case it is defined as:

$$\vec{X}(\theta) = \begin{pmatrix} a_1\cos\theta^{\varepsilon} \\ a_2\sin\theta^{\varepsilon} \end{pmatrix} \tag{2}$$

where $\vec{X}$ is a 2D vector that describes an image object contour; θ is the orientation angle; ε is the shape parameter; a_1 and a_2 are the size parameters [13]. This function describes a large set of simple geometrical figures like circles, rectangles, etc and more complicated ones like ellipses. Combining these basic shapes, superquadrics can be used for modelling of a lot of objects. Superquadrics object recognition is used in 3D recognition [14]. Superquadrics are invariant to object size and orientation. Superquadrics technique has a lot of problems in complex shape object recognition, i.e. in the recognition of the natural objects.