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Modeling of the Objects Search by the Skills- Computational System of Technical Vision

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Abstract

In this paper, the results of the investigation of the influence of noisy images on the reliability of recognition are presented. A technique for modeling a three-dimensional search for an object by a robot with a computer-aided technical vision system is proposed.

Keywords: neighborhood systems, technical vision system, training sample, response, noise, three-dimensional image, recognition, robot.

INTRODUCTION

Technical vision systems are increasingly used in the automation of technological processes. The computer-based visual vision systems, which based on the neighborhood approach [1-4], can be used to analyze the microstructure of a hot-rolled strip [2], to recognize the details and to the robots control [4-7]. The wide application of vision systems is constrained by the influence of various factors on the object recognition reliability: the illumination change, the degree of noisiness, the background change, the location of the object in space, and so on. It is difficult and often impossible to pre-program the influence of various factors that are often random. Such intellectual tasks are based on the neural-like systems that are able to acquire skills through training. One of the tasks of the technical systems improving of technical vision is to increase the reliability of object recognition when the noisiness are changing. For this purpose, studies of the effect of preliminary processing of three-dimensional images were made on the example of a figure with a different degree of noisiness.

Of special interest is the recognition of three-dimensional objects. Three-dimensional objects can be identical or different depending on the angle of view. This problem is solved by searching for two-dimensional images in succession in different planes. The image in each plane is a subspecies. The recognition result in the interconnection of all subspecies gives a general representation of the form (three-dimensional object).

Computer modeling of the recognition process of a three-dimensional object facilitates the task and allows investigating the influence of various factors.

NOISE INFLUENCE ON THE RECOGNITION.

Images may contain errors, photocells of video equipment also have errors that affect recognition. In digital cameras, digital noise is observed when the grain size is larger than the pixels. On color images, noise can have a different intensity. The causes of digital noise are the errors of analog electronics, photo sensors (black, white and other defects). To suppress the sensor noise, larger pixels and more closely fitting micro lenses, color filters that transmit a greater percentage of light, higher quality amplifiers and analog-to-digital converters with a higher resolution, matrix cooling are used. Stochastic digital noise is reduced in post processing by averaging the brightness of a pixel over a certain group of pixels, which the algorithm considers "similar."

To improve the images recognition by the computer-aided technical vision system, we pre-process the images. The noise intensity is reduced by dividing the image into equal segments and sections of the same width and height and assigning to each of them a color equal to the average color value of the pixels in this segment. Thus, we get a kind of mosaic. If we take each segment as a separate pixel and build an image from them, we end up with the original image, but reduced by n times, where n is the width of the segment. Using a neural-like network for recognition, we mean that it consists of a layer of neurons with receptors, for each excitation we take the value of the intensity of the color of the pixel, transferred from the RGB color system to the monochrome form (the colors of the image are in the range [0..255]) by the formula:

$$y = 0.3R + 0.59G + 0.11B,$$

where R, G and B are the values of red, green and blue respectively.

To describe the learning process of the skill-computing system, the mathematical tools of the neighborhood systems was used. The general model of object definition (prediction) includes as input variables (factors) in the simplest case object numbers, as state variables a set of pixel values of rasters corresponding to objects. The solution of the mixed control problem makes it possible to determine the unknown components of the inputs and states by a known part of them.

A linear neighborhood system has the form

$$\sum_{\alpha\in O_x[a]} w_x[a,\alpha]\vec{x}[\alpha] \;=\; \sum_{\beta\in O_v[a]} w_v[a,\beta]\vec{v}[\beta],$$

where $\vec{v}[a]\in\langle R^m\rangle$, $\vec{x}[a]\in\langle R^n\rangle$, $w_x[a,\alpha]\in\langle R^{c\times m}\rangle$, $w_v[a,\beta]\in\langle R^{c\times m}\rangle$, $O_x[a]$, $O_v[a]$ - the neighborhood of the vertex of the carrier by state and input, respectively; $a,\alpha,\beta\in\{A\}$, $A=\{a_1,\ldots,a_N\}$. $\{\mathrm{A}\}$ is the set of values of the discrete argument of a system having power $|\mathrm{A}|=N$

Here N - is the number of objects considered, $x[i]\in R^n$, $1\le i\le N$, state in the *i*-th node, i.e. n -values of the pixels of the raster corresponding to *i*-th object, $v[i]\in R^m$ - the value of the input actions in the *i*-th node, in particular, $v[i]=i$, $m=N$ - the number of situations or options (samples). We consider it in the particular case: $w_v[i,j]=1$, $w_x[i,j]=\omega_i$.

After completing the procedure for identifying parameters ω_i, we solve the problem of mixed control: we determine from the values obtained in the experiment $x[i]$ and estimated values ω_i the calculated values $v_p[i]$. We find the differences

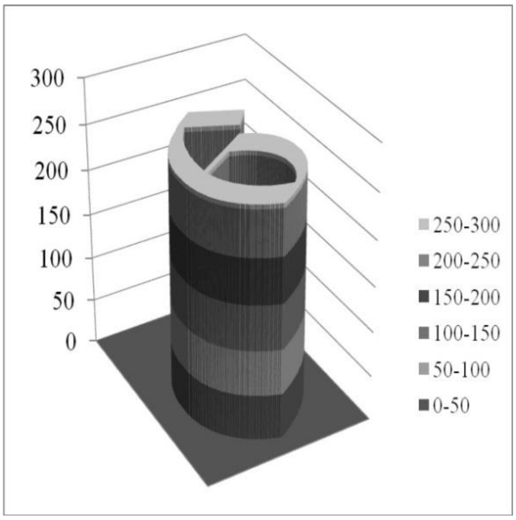
$$\Delta v_i=\frac{(v[i]-v_p[i])x[i,j]}{\sum_{j=1}^{n}x^2[i,j]}$$

and calculated values $v_p[i]$ using mixed control and Δv_i. Next, we organize the iteration cycle until the condition is fulfilled $\Delta v_i\le\varepsilon$, where ε - is the specified accuracy. For a given state $x[i,j]$ in the i-th node, we determine the values $v_p[i]$ and the corresponding object number. The calculated values of the image codes are determined by the formula:

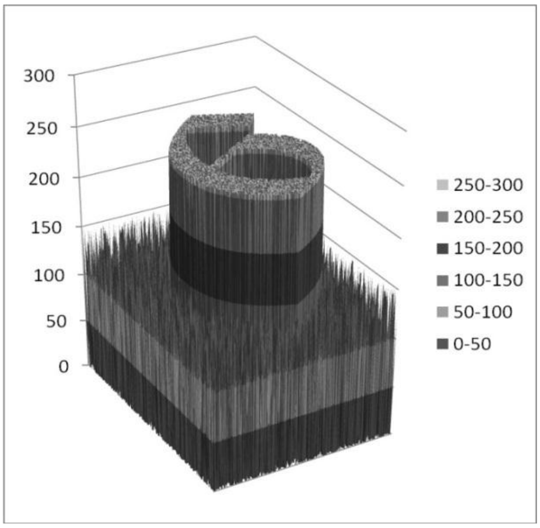
$$v_p[i]=\sum_{i=1}^{m}\sum_{j=1}^{n}x[i,j]c[j],$$

where $c[j]$ are weight coefficients.

As the initial image for the training sample, a volumetric image of the digit “6” was selected on a white background (Fig. 1a), the initial response was assumed equal to Y = 1, the preliminary recognition error Δ = 5%. The image size is 320x240 pixels. The figure is based on the color values of the pixels imported into the Microsoft Office Excel spreadsheet. The value of the color intensity in the range [0..255] is plotted along the vertical coordinate axis. The image is added noise - a set of pixels randomly located throughout the area of the image and having an arbitrary color. The volume image of the figure 6 with a noise intensity of 30% (Fig. 1b) worsened the perception, blurred outline. A noisy image is processed by segmentation. As a result, the noise value decreased, and the sharpness of the circuit deteriorated (Fig. 2a). Recognition by the computer system of technical sight deteriorates. Therefore, it is not advisable to perform segmentation of a noisy image before recognition. In addition, this increases the total processing time, reducing the ability to use this method when operating the system in "real time".



(a)



(b)

Figure 1: The 3D model of the image: a) the original image; b) the same with a noise intensity of 30%

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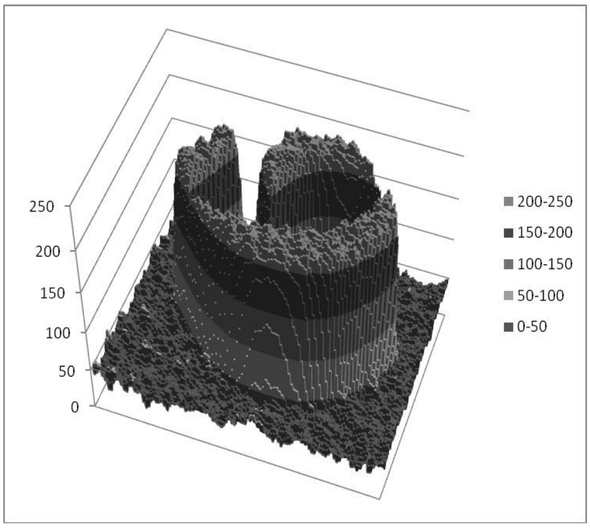


(a)

(b)

Figure 2: The image obtained after processing: a) volumetric interpretation, b) reconstructed two-dimensional image

However, the inclusion of noisy images after their processing in the training sample improves recognition (Fig. 3). The dependence (practically straight) between the increase in the width of the segment in which the pixel color is averaged, and the response of the system is traced: the more pixels we include in such a segment, the more accurately the image is recognized. The increase in the size of a group of pixels is limited. For the maximum size of the segment, the smallest size (in pixels) of the significant element of the object under study in the image should be taken. If you combine a specially selected training sample and image processing, you can get a high enough accuracy (accuracy) of recognizing noisy images. In Fig. 3 is a graph (line 1) that shows how the recognition accuracy is improved while using a special sample (three images included: 0%, 80%, and 90% noise intensity) and image segmentation. This approach can significantly reduce the effect of noisiness on the reliability of recognition. Using only a special sample of this effect does not give (line 2) - the response of the system decreases with increasing noisiness.

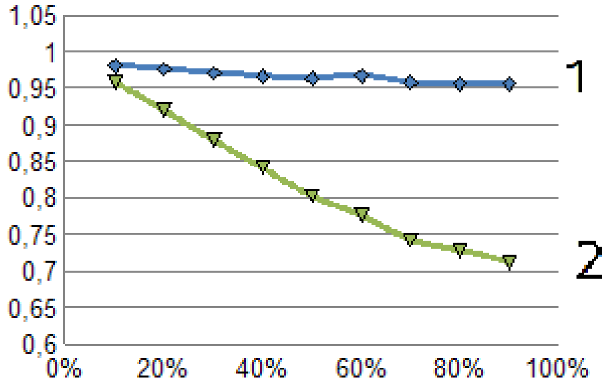
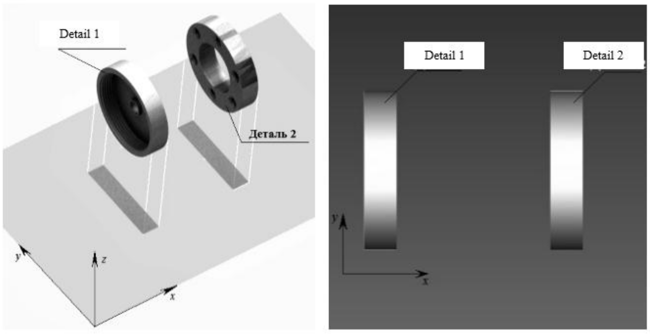


Figure 3: Changing the response of the technical vision system depending on the noisiness: 1 - with image processing; 2 - without treatment

THE SIMULATION METHOD OF THREE-DIMENSIONAL OBJECT SEARCH

Recognition of three-dimensional volume objects has its own characteristics, in contrast to flat two-dimensional ones. Such objects can have the same projections under one and different projections from a different angle. The task of recognizing three-dimensional objects is reduced to recognizing two-dimensional objects, if it is possible to view an object from different angles of view. This is possible when using several video cameras or an industrial robot with a video camera. An android robot with a video camera [4] is able to find three-dimensional objects, projections of which differ from different angles of view. Natural studies do not allow you to easily change the properties of objects and the environment. It is advisable to develop a virtual environment that would help in the study of skill-computing systems of technical vision, studying the behavior of the system when recognizing moving objects, recognizing details under different lighting, background, from different materials, and a number of other phenomena and processes.
Computer modeling allows creating a virtual environment for the process of recognizing three-dimensional objects from different angles of view of different design and different environmental properties. The program is written in a high-level Delphi programming language using OpenGL application libraries to enhance visual effects and ease of operation in a three-dimensional environment. Suppose that we need to find a certain detail, let's call it "Detail 1", among several similar details on it. After iterative-recurrent learning, we begin the search for an object. The motion is carried out in one plane XY. During motion of the video camera, which is fixed on the robot's arm, it fixes two different parts in turn (Fig. 4.1), but with the same views from the camera side to the XY plane (Fig.4.2). The subject of search is one of the details. The system will accept for the desired part the one that will fall into the lens of the video camera. And since the first account in the path of the camera may turn out to be an

unnecessary detail, in this case it is "Detail 2 ", it is not enough to use only one plane of motion. To complete the representation of the object under study, it is necessary to increase the number of planes along which the camcorder can move. It is necessary to examine the object from Search different sides.



4.1 4.2

Figure 4: The image of the parts when working in three-dimensional (Figure 4.1) and in a flat environment (Figure 4.2.)

Therefore, in the training sample we include several images of the object of interest from different positions. The image of the detail in each plane is in fact a subspecies of the whole kind of detail. Recognition of the three-dimensional view is carried out on the basis of analysis in the relationship of the three subspecies of the image. This circumstance is the main one in comparison with the system working with flat images.

The 3D model of the part is not modeled directly in this program, but imported from the Autodesk Inventor program, followed by processing in Autodesk 3D Max. In the program, you can change the scene illumination; the nature of the light reflection (varies depending on the light source). It is also possible to change the texture of the part (Fig. 5), which corresponds to the material change in the virtual environment.

Such the approach reduces the economic costs of manufacturing the samples under study when used together with laboratory equipment.

Figure 5: Detail "Shaft" with different texture

Movement can be reproducible or built on the basis of skills obtained through iterative recurrent training, an integral part of which is the compilation of a training sample. It is a set of images of the parts under study and a table in which the system responses used to calculate the system weights are set to compare them with the actual response values for the part recognition. For each of the images in the training sample, individual response values are assigned so that there are no conflict situations when learning and recognizing objects. To teach the system to move in the direction we need in the training sample, it is also necessary to include images whose purpose is limited only to determining the direction of motion.

Moving a virtual video camera is possible in three coordinate directions with the simultaneous implementation of necessary rotations. Moves and turns can be done both in manual mode and in automatic mode, when the camera moves depending on the result of the response in each direction.

CONCLUSION

In this paper we present the mathematical tools of the neighborhood systems for describing the learning process of the skill-computing system. As a result of the research, it has been established that the segmentation of a noisy image before recognition is impractical, but the learning of the skill-computing system on such transformed images improves recognition, unlike the learning of the system on images without conversion. The highest validity of recognition is achieved by including images with different noises in the training sample.

The developed program refers to emulator programs, whose task is to simulate the operation of systems under conditions close to the natural ones for their operation. Therefore, special attention, while developing the program, was given to visualization, which helps to give a more natural image of detail, texture elements, as well as glare and shadows.

To increase the reliability of recognition of the skill-computing system of technical vision, it is necessary to include in the training sample noisy images of the object and its projection images in three planes. The system is able to learn to search for objects of complex shape with a minimum number of images in the training sample, and also to track the object. It is necessary to examine three-dimensional objects from different sides for recognition. The decision-making process should be based on an analysis of the relationship of the three subspecies of the image.

It is advisable to use three-dimensional modeling to study the learning process and recognize the skill-computing system of technical vision. Since it allows to relatively easily change the size, shape and properties of three-dimensional images.

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