Study Methods of Image Segmentation for Intelligent Surveillance Systems

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Abstract. The research of the machine-machine interface element is presented for the possibility of dynamic adaptation to improve the perception of the very least environment by developing a technique for adapting the robovision. The study include comparing between different threshold methods of segmentation of images of different categories.

Keywords: image segmentation, thresholds, future robots.

1 Introduction

Computer technologies are so important in the life of a modern society, that is hard to imagine any kind of activity where in one or another way does not use computers.

Persistent tendencies towards attempts to replace people with computers in all business processes where possible are in the world today [3]. The 4th industrial revolution taking place in developed countries stimulates the progress of knowledge, accordingly, the development and implementation of technology is sharply spurred every day, because the creation of some of the latest technologies serves as the foundation for the emergence of new ones. In many industries, science, Internet technologies, etc., developments related to the use of systems of artificial intelligence, as well as various types of robots or robotic systems are effectively used already. Overview of Research and Implementation of Intelligent IT in the EU and the United States: the EU finances the development of sophisticated techniques for understanding audiovisual life-style representations for typical and non-specific groups through the FP7 program [3] and continues to actively fund developments in this area (Horizon 2020). Therefore, the task of research of models and methods of synthesis of methods of perception taking of data of the visual spectrum obtained in real time working out for the machine-machine interface is actual. [2,4].

2 Problem

The perception of the conditions and patterns of the visual spectrum it is technologies with intellectual possibilities: they must feel and understand the real world dynamic [7]. Therefore, the development of computer vision systems with the dynamic perception of the external environment is a critical problem for the next generation tasks. Thus, author looking for best approach to build principles of computer perception of the outside world through the understanding of video data [1-5,11]. The part of this problem it is the problem of image segmentation is considered in work.

3 Purpose

The aim of the work is to improve the perception of the visual input data by developing methods for adapting it to the features of the environment.

4 Experiments

In order to determine the most effective methods of segmentation, we study and take into account some of the most common methods of segmentation of the visual field of real-time knowledge. Author studied different mathematical approaches for processing of information. The approaches are taken from the following categories: (1) Histogram based Entropy computation methods; (2) Iteration based methods; (3) Histogram based modeling methods; (4) Histogram profile based methods; (5) Fuzzy methods.

4.1 Niblak method

The method is based on the brightness of local threshold calculation.

The method idea is to align the threshold of brightness binarization from point to point based on the deviation of the local average brightness value (the value calculated for each pixel based on the brightness values of itself and its neighbors), from the local (calculated for only one pixel) in the given mask [6]:

$$a_{xy}^{new} = \begin{cases} 0, \text{ } if \text{ } B(x,y) \le L \\ 1, \text{ } if \text{ } B(x,y) > L \end{cases}$$

where $B(x,y) \in [0,255] = \frac{r+g+b}{3}(a_{xy})$ is local brightness value of a_{xy} pixel; $L \in [0,255] = m_{w \times w}(x,y) + k \cdot s_{w \times w}(x,y)$ is local brightness value for pixel a_{xy} in the $w \times w$ neighborhood; $m_{w \times w}(x,y) \in [0,255] = \frac{\sum_1^{w \times w} B(x,y)}{w \times w}$ is average brightness value in the neighborhood of pixel $w \times w$; $s_{w \times w}(x,y) = \sqrt{\frac{1}{w \times w} \sum_1^{w \times w} (B(x,y) - m_{w \times w}(x,y))^2}$ is mean square deviation of the sample in the area (neighborhood) of the pixel; k(*const*)=-0,2 for objects if $B(x,y) \le 127$), and k=0,2 for objects if $B(x,y) > 127$); w(*const*) is neighborhood size, for example 16[6].

4.2 Bernsen method

The method is to find the threshold based on the values of the local maximum and the minimum brightness of the pixel

$$B(Avg_l) = \frac{Min(l) + Max(l)}{2} \text{ and } a_{ij} = \begin{cases} 0, if\ \ Avg \le const(l) \\ 1, if\ \ Avg > const(l) \end{cases}$$

where $Avg \in [0,255]$ is average value of brightness; Min_l *and* Max_l is minimum and maximum brightness value in the mask, respectively; a_{ij} ia new pixel brightness value; $l \in [0,255]$ is local level of brightness, the minimum and maximum value vary depending on the brightness that falls into the area.

4.3 Yen method

This method refers to methods that use the entropy of the distribution of the brightness of colors in the image. Yen's method looks at the object on the images and the background on which this object is located, as two different sources of visual information. The value of brightness, in which the sum of these two entropies reaches its maximum, is considered as optimum threshold for image segmentation [8].

At first step histogram of $p(l)$ image and incidence rate $N(l)$ of every level of image brightness is calculated. Next, we need sum brightness N_T of image pixels: $N_T = \sum_{i=0}^{\max(G)} p(i)$. Build helping histogram: $p_{norm}(i) = \frac{p(i)}{N_T}$,

$$p_{normC}(i) = p_{normC}(i-1) + p_{norm}(i),\ p'_{norm}(i) = p'_{norm}(i-1) + p_{norm}(i+1)^2,$$

$$p''_{norm}(i) = p''_{norm}(i+1) + p_{norm}(i+1)^2.$$

Find entropy of objects and background:

$C_{ob}(T) = -\log\{p_{normC}(i) \times (1 - p_{normC}(i))\}$, $C_b(T) = -\log\{p'_{norm}(i) \times p''_{norm}(i)\}$,

value i is calculated: $L = ar\,ma\,x_i\{C_b(T) + C_f(T)\}$.

L is used as threshold: $a_{xy}^{new} = \begin{cases} 0, if\ \ B(x,y) \le L \\ 1, if\ \ B(x,y) > L \end{cases}$

4.4 Minimal value method

The method of setting the threshold based on the minimum between two maxima. Maxims are the maximum values of the distribution of the brightness of the background image and the object itself on the histogram t=min($h[b_{ij}]$), where t is threshold value; b_{ij} is pixel brightness; $h[b_{ij}]$ is brightness distribution value on the histogram; min($h[b_{ij}]$) is minimal brightness distribution value on the histogram between two maxima.

4.5 Average value method

The method find average value based on image histogram: $t = \frac{\sum_{i=1}^{n} h[b_{ij}]}{n}$, where t is threshold value; n is quantity of histogram elements; $h[b_{ij}]$ is brightness distribution value on the histogram.

4.6 Triangle method

According to the method [9]: threshold – is element with maximal distance to line s from minimal b_{min} to maximal brightness value b_{max} on the histogram: t=max(d), where t is threshold value; d is distance from brightness value on the histogram $h[b_{ij}]$ to line value on the histogram (fig. 1).

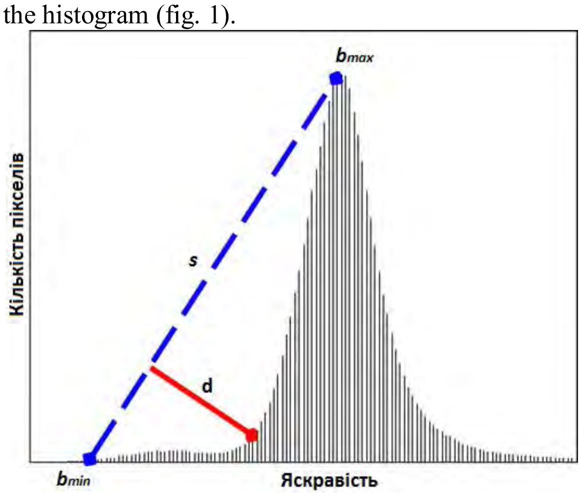

Fig. 1. Triangle method

$$L = \arg\max_{b(i)} d \, ,$$

where L is threshold value; d is distance from pixel brightness value $b(i)$ to the s.
Next, binary procedure by standard formula is realized:

$$a_{xy}^{new} = \begin{cases} 0, if \;\; B(x,y) \le L \\ 1, if \;\; B(x,y) > L \end{cases}$$

4.7 Otsu method

Method use histogram distribution of pixel brightness value of image. Histogram with value $p_i = \frac{n_i}{N}$ is built: $\omega_0(k) = \sum_{i=0}^{k} p_i$, $\omega_1(k) = \sum_{i=k+1}^{L} p_i = 1 - \omega_0(k)$, $\mu_0(k) = \sum_{i=0}^{k} \frac{ip_i}{\omega_0}$,

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$\mu_1(k) = \sum_{i=k+1}^{L} \frac{ip_i}{\omega_1}$, $\eta(k) = max_{k=1}^{L-1}\left(\frac{\sigma_{cl}^2(k)}{\sigma_{all}^2}\right)$, where N is general image pixel quantity; n_i is i-level brightness image pixel quantity; $k \in Z, \in \overline{0, L}$; $\omega_0 \omega_1$ is relative frequencies of the corresponding classes; $\mu_0 \mu_1$ is average levels for each of the image classes; $\eta(k)$ is maximum value of image section quality; $\sigma_{cl}^2 = \omega_0 \omega_1 (\eta_1 - \eta_0)^2$ is inter-class dispersion; σ_{all}^2 is general dispersion of whole image.

5 Correlation is realized by MSE

$$MSE = \frac{1}{m*n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \left| I(i,j) - K(i,j) \right|^2 ,$$

were $I(i,j)$ is pixel brightness value on the point (i,j) ; K and I have $m*n$ resolution.

6 Experiment results

Correlation MSE method was used. The method with the lower threshold of binary process was used as the reference image. Studied image was an image obtained as a result of the processing of the original one by each of the methods. The error was calculated by the next formula.

$$MSE = \frac{1}{w*h} \sum_{i=0}^{w-1} h \sum_{j=0}^{n-1} \left| I(i,j) - K(i,j) \right|^2 ,$$

where $I(i,j)$ is the value of the pixel's brightness at the point (i,j) of the under study image; where $K(i,j)$ is the value of the pixel's brightness at the point (i,j) of the standard image; w is image width characteristic; h is image height characteristic; MSE is mean squared error value.

Experiment results are in the table 1.

Table 1. Comparison of results

	1	2	3	4	5	6	7	8	9	Похибка
Global thresholds	9275	1032	2635	1916	1865	2128	1089	2799	2921	±248
Niblack's method	13581	16124	16388	16856	14841	11073	15014	3724	11600	±412
Bernsen's method	2494	2357	4869	2790	4891	3002	3406	3714	3887	±211
Yen	7049	9618	10518	7915	9765	10141	7360	11302	10295	±352
Method of minimal	7946	4351	2562	2791	1944	2248	4382	7216	3835	±339
Method of average	4261	5563	6783	4598	5999	6360	4272	7322	6450	±216
Triangle's method	7005	8723	9541	7625	9726	9952	7281	10713	9461	±285
Otsu	7670	984	2421	1871	1831	1952	1052	2519	2675	±231

The errors regarding the same pattern obtained from the evaluation of various methods in the table is reflected.

7 Conclusion

Using table 1 results, we can build adaptive to illumination system. System can use different threshold to different situation.

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