The Algorithm of Initial Processing of the Manuscript Image

Sayyora Nurmamatovna Iskandarova[1][a] and Shoxrux Khudayarov Turaqulov[2][b]
[1]*Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, Amir Temur street, 108, 100200, Tashkent, Uzbekistan*
[2]*Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, Amir Temur street, 108, 100200, Tashkent, Uzbekistan*

Keywords: Recognition, Initial Processing, Pre-Processing, Relevancy Function, Normalization.

Abstract: This article presents the problems of initial image processing, the logical hardware of solving them and the efficiency of pre-processing with the relevancy functions. The initial process has a vital role in recognition systems. Algorithmic steps of image pre-processing based on the fuzzy sets theory are presented. Image quality improvement and results are explained.

1 INTRODUCTION

The quality of manuscript image does not always meet our expectations. The diversity of pho-tographic devices and differences between their technologies lead to image processing. Initial image processing algorithms usually increases the recognizing efficiency of image recognizing system by pre-processing and noise removal. A lot of fuzzy algorithms are used in the tasks of initial image processing. These algorithms serve to remove excess points from the image effec-tively, thereby increasing the quality of different images. In recent years, there are being con-ducted researches on making use of fuzzy techniques in image processing in the developed countries of the world, they are connected with the followings:

1) The existence of advanced mathematic devices of displaying the knowledge and processing it;
2) They are estimated by controlling fuzziness effectively.

Many image programs demand specialist's expertise in order to overcome some difficulties. The theory of fuzzy sets and fuzzy logics are able to display human knowledge as the fuzzy IF rules and to process. On the other hand, while processing the image majority difficulties are caused by the randomness and fuzziness of the data used in the considered problems (Mancuso et. el.,1994; Peli et.al.,1982).

There is a technique in the mathematic apparatus of the fuzzy logics that is able to show fuzzy elements in the color of the image more clearly, so it may be used to increase this image's quali-ty. The recovery of missing parts in improving the quality of the original image is one of the first steps in recognition problems. Image enhancement techniques usually remove small points and shadows, smooth regions where gray levels do not change significantly, and cause sharp changes in gray levels (Peng,1994).

Fuzzy logic is well-suited for building image enhancement systems because its mathematical framework allows knowledge of its specific application to be incorporated in the form of rules. This has led to the development of different image enhancement methods based on the color of various fuzzy logic mathematical model points. Below we will briefly consider some of them.

2 ALGORITHM OF INITIAL PROCESSING

Mancuso, M., Poluzzi, R. and Rizzotto, G. A. proposed to reduce the narrowing of luminance range dynamically with the help of fuzzy rule approach and to pre-process it for contrast en-hancement (Mancuso

[a] https://orcid.org/0000-0003-3628-6146
[b] https://orcid.org/0000-0003-0716-6145

Iskandarova, S. and Turaqulov, S.
The Algorithm of Initial Processing of the Manuscript Image.
DOI: 10.5220/0011906800003612
In *Proceedings of the 3rd International Symposium on Automation, Information and Computing (ISAIC 2022)*, pages 121-124
ISBN: 978-989-758-622-4; ISSN: 2975-9463

et. al.,1994; Peli et.al.,1982; Peng,1994). Thereby, the necessary initial image process is carried out. The algorithms of image quality enhancement based on the methods developed by Peli T. and Lim are also effec-tive (Shi,1998). In their article, Peng, S. and Lucke propose the fuzzy filter for initial image processing and present the filter efficiency (Kadnichanskiy,2018). It is clear that the median filters are capable to effectively remove the Gaussian noise and such filters as medium filters based on the order statistics are used to remove impulse noise. In order to combine these two filters, we use fuzzy logic, where-by the value l indicates the fuzzy logic apparatus is designed (Matkovic K. et al.,2005; Boujemaa,1992 ; Kadnichanskiy et.al. 2018).

Images taken on different devices are often displayed on the computer with low clarity, i.e., their brightness changes are smaller compared to their average value, and the range is represent-ed with a large differrence in appearance. In this case, the brightness changes not from black to white, but from gray to light-gray. In other words, the original range get lower than one that is allowed. To reduce the contrast, the brightness of the image should be increased in full range. We will indicate image process through the image points as following: f(x,y) and g(x,y) is initial brightness value and the value of processed image. The image corresponds to the screen coordinates by matching the screen point x - row number and y - column number.

Processing the value of given point indicates the existence of functional connection with the quality of this image, i.e.:

$$g(x,y) = F(f(x,y)).$$

The value that provides the original image quality allows to determine the output value.

While designing and analyzing the initial image processing systems, it would be useful to have a description of a mathematic apparatus of the images to be processed. There are such kind of basic approaches, and they are the followings: deterministic, statistics and fuzzy approaches. The deterministic approach requires to entry a mathematical function that describes the image and the features of each its element will be examined. In the statistic approach, the image is defined by the averaged characteristics, while in fuzzy approach by fuzzy-averaged features.

In order to implement the brightness by shape transformation, it is of great importance to process the digital images. With the help of it, it is possible to correct the exposition mistakes, to divide the image's black or bright sides. Now, we will consider the definition of "brightness". In photometry, luminous flux is identified as the scalar product of $V(\lambda)$ (spectral luminous efficiency function) of $P_e(\lambda)$ (radiant power). The task of determining the contrast is related to improving the quality of the image and its compatibility with the display screen. If 1 byte (8 bits) is allocated for the digital representation of each image sample, then input or output signals can take one of 256 values. Usually, the operating range constitutes of 0 ... 255, whereby 0 corresponds to the black level at the time of display, and 255 corresponds to the white level. For instance, the values of f_{min} and f_{max} of the original image in a given segment a and b are correspondingly equal to its minimal and maximal brightness.

It is convenient to examine the image in a given segment as a fuzzy random process with the help of logic apparatus and it provides with quality image processing in a given segment. The random process serves to provide a continuous image with a current function $f(x,y)$. The random process $f(x,y)$ is defined by a joint probability.

It is possible to solve this task using a point-to-point transformation of a linear contrast in different ways, i.e.:

The algorithm of a linear implementation of the brightness of the image in cases where given data are fuzzy. The membership function of $\mu^f(x,y)$ is determined as following:

The first step - Normalization:

$$u(x,y) = l\,\frac{f(x,y) - f_{min}}{fmin_{max}}$$

The second step – Fuzzification:

$$\mu_i^f(x,y) = \frac{1}{1 + \frac{u(x,y) - c_i}{\sigma_f}}, i = \overline{1,k}.$$

The third step – Determination of fuzzification:

$$\mu_i^f(x,y) = \begin{cases} 2(\mu_i^f(x,y))^2, 0 \le \mu_i^f(x,y) \le \frac{1}{2}, \\ 1 - 2(1 - \mu_i^f(x,y))^2, \frac{1}{2} < \mu_i^f(x,y) \le 1. \end{cases}$$

In this case, c_i , σ_f are the parameters of the membership function.

The fourth step:

$$\sigma[\overline{g}(x,y)] = \frac{\overline{g}_{g\max} - \overline{g}_{g\min}}{f_{l\max} - f_{l\min}} \cdot \sigma[f(x,y)]$$

The fifth step:

$$M[\bar{g}(x,y)] = \bar{g}_{l\min} + M[f(x,y)]\frac{\bar{g}_{g\max} - \bar{g}_{g\min}}{f_{l\max} - f_{l\min}} - \frac{\bar{g}_{g\max} - \bar{g}_{g\min}}{f_{l\max} - f_{l\min}} f_{\min}$$

The sixth step:

$$\bar{g}(x,y) = \frac{f(x,y) - M[f(x,y)]}{\sigma[f(x,y)]} \cdot \sigma[\overline{g}(x,y)] + M[\overline{g} = \frac{\sigma[\overline{g}(x,y)]}{\sigma[f(x,y)]} f(x,y) + M[\overline{g}(x,y)] - M[f(x,y)]\frac{\sigma[\overline{g}(x,y)]}{\sigma[f(x,y)]}$$

The seventh step:

$$g(x,y) = F(f(x,y)) = \begin{cases} 0, \bar{g}(x,y) < 0 \\ \bar{g}(x,y), 0 \le \bar{g}(x,y) \le 255 \\ 255, \bar{g}(x,y) > 255 \end{cases}$$

In the majority of cases, the images entered to the computer are noisy, i.e. they have a smaller change in their brightness value compared to their specified value. Therefore, the brightness is changed not from black to white, but from gray to gray. In other words, a real range of the brightness is lower than its allowed value. The task of contrast enhancement consists of extend-ing the brightness range of the image.

This problem can be solved by replacing the linear points with a corresponding point-by-point processing:

$$g(x,y) = af(x,y) + b$$

i.e. such excess α and β are obtained that serve to bring the fuzzy values of the brightness field to certain standard values. Here, $M[f(x,y)], \sigma[f(x,y)]$ are estimated beforehand and the coefficients a and b are selected so that $M[g(x,y)], \sigma[g(x,y)]$ are taken for output field:

$$\bar{g}(x,y) = \frac{f(x,y) - M[f(x,y)]}{\sigma[f(x,y)]} \cdot \sigma[\overline{g}(x,y)] + M[\overline{g}$$

$$= \frac{\sigma[\overline{g}(x,y)]}{\sigma[f(x,y)]} f(x,y) + M[\overline{g}(x,y)] - M[f(x,y)]\frac{\sigma[\overline{g}(x,y)]}{\sigma[f(x,y)]}$$

i.e.:

$$a = \frac{\sigma[\overline{g}(x,y)]}{\sigma[f(x,y)]}; b = M[\overline{g}(x,y)] - M[f(x,y)]\frac{\sigma[\overline{g}(x,y)]}{\sigma[f(x,y)]};$$

Here:

$$M[f(x,y)] = \frac{\sum_{i=1}^{k} f_i(x,y) \cdot \mu_i^f(x,y)}{\sum_{i=1}^{k} \mu_i^f(x,y)},$$

$$\sigma[f(x,y)] = \sqrt{\frac{1}{nm}\left(\frac{\sum_{j=1}^{n}[f_j(x,y) - M[f_j(x,y)]]^2 \mu_i^f}{\sum_{j=1}^{n} \mu_i^f}\right)}$$

3 CONCLUSIONS

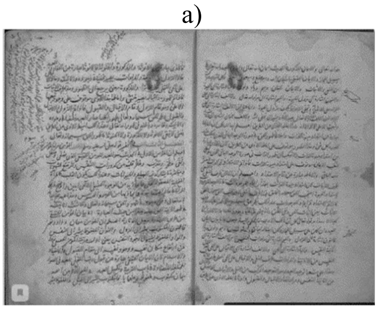
So, while processing the images it is required to select similar pieces of the image based on some features in correspondence to the membership function and to the values that are 1. The initial image processing reduces the effect on recognizing process and increases recognition effi-ciency.

These filtering algorithms are used in initial image processing, because they have an im-portance in increasing the percentage of the recognition. There have been achieved effective results on removing many low-quality and unnecessary points in the images of ancient manu-scripts.

We will repeat the procedures of replacing the points for each element of the image.

The recommended method is applied by replacing at the points based on given segment, in this case, such properties of the texture as similarity, roughness and graininess are taken into account. Therefore, this method is recommended to process the manuscript images that have tiny details (Figure 1).

a)



b)

c)

Figure 1. The result of initial image processing by using fuzzy and statistic descriptions.

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