Pre-processing of digital images to improve the efficiency of liver fat analysis

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Abstract:

Research based on digital image analysis is widely used in medical diagnostics. This allows you to study the problem in detail and possibly without surgical intervention. We can get information about the microcosm and justify the necessary treatment options. Such a study of the task at hand also contributes to obtaining additional information as a result of a more detailed analysis. It is also possible to conduct a comparative analysis, which is important in the diagnostic process. However, in order to produce the most reliable results, it is important to have a good quality digital image. There should be no interference or distortion here. For these purposes, special methods of pre-processing of medical images are used. This allows you to significantly improve the quality of the input image. As a specific example, we consider digital images of fatty liver lesions taken under a microscope. The paper presents real medical images and the results of their analysis after pre-processing and searching for lesions.

Key words: Analysis, Diagnostics, Medicine, Liver, Image processing techniques, Pre-processing, Microscopic image

Introduction

The analysis should be considered as a research tool in the diagnosis of various diseases. This tool helps to investigate the process or phenomenon that we are studying. In this case, various digital images [1]-[6] can be used as an object to be studied. Among such images, it is advisable to single out images that are made under a microscope. These images reflect small details that should be taken into account in the process of diagnosis, a detailed study of the subject area of the study. Moreover, we can get additional information, which is also an important point. This approach has found wide application in medicine [7]-[10]. This helps to improve the efficiency of diagnosis, the choice of methods for treating the disease and/or preventing its development.

Please note that some images may have certain defects (the image is fuzzy, there is some noise). This makes it difficult to analyze them and obtain reliable results. Here, too, erroneous conclusions can be obtained, which will affect the course of treatment or the prevention of the development of the disease. In this case, it is advisable to apply the methods of image preprocessing. At the same time, the choice of such approaches should not impair the understanding of what is represented in the digital image. The use of methods for preliminary processing of the input image should contribute to the expansion of obtaining reliable information and substantiation of the results obtained for their subsequent use in the treatment and prevention

of the disease. This, in the end, determines the relevance of the chosen research topic, its practical significance.

Among the diagnosis of various diseases, we will focus on the degree of damage to the liver as a result of its fatty disease. This choice is due to the fact that

on the one hand, fatty liver disease does not have pronounced symptoms in its early stages of development [11]-[13];

on the other hand, this article is a continuation of our previous study and helps to complete the overall picture of the research issues [14].

Thus, the main goal of this work is to consider pre-processing of images for diagnosing the development of fatty liver disease. In this aspect, at the beginning of our study, we will conduct a small comparative analysis of the relevant publications.

Some related work

In this section, we will consider several works of other researchers that are devoted to the problems of pre-processing of medical digital images. This will help to better understand the essence of the question.

R. B. Jeyavathana, R. Balasubramanian and A. A. Pandian provide a detailed analysis of medical image preprocessing methods [15]. The authors note the importance of this stage for the analysis of information presented in a digital image. The article discusses various approaches and gives their comparative characteristics. In this case, the consideration of pre-processing is directed to the segmentation of the input image.

E. Vocaturo, E. Zumpano, and P. Veltri explore advanced imaging techniques for diagnosing melanoma [16]. At the same time, the authors also take into account the need for pre-processing of images to obtain more reliable results, the possibility of their effective application in practice. The paper focuses on the choice of the best approaches in order to take into account errors in the diagnosis. It is also shown that the stage of image pre-processing is the main one for both improving image quality and obtaining reliable results. But for these purposes, it is necessary to take into account the general problems of research, the scope of such approaches.

The study by R. Ramani, N. S. Vanitha and S. Valarmathy is devoted to the methods of pre-processing of medical mammographic images [17]. These methods are used to detect breast cancer. At the same time, the study states that pre-processing is important for correcting the original image, preparing it for further processing. And we must fully agree with this. The authors consider the possibility of using various filtering and noise suppression methods. For the purposes of solving their problem, the authors consider the possibility of using the Wiener filter, average or mean filter, adaptive median filter [17].

The article by the authors Z. R. Hussein and others discusses the issues of pre-processing of medical images to solve the problem of extracting the contours of individual objects [18]. The paper notes the importance of solving such a problem. This allows a more detailed and qualitative assessment of the objects under study. The authors emphasize that pre-processing helps to avoid fuzzy boundaries and obtain an accurate image of the area of interest. The same problem arises in the process of analyzing liver lesions, when it is important for us to know the clear contours of this area in order to determine the area of the lesion.

The work [19] describes various methods of digital image preprocessing. This issue is considered in the context of the use of training in prostate cancer research. The authors note that in most cases such training cannot be done without preliminary processing of the original images.

There are several pre-processing steps in this process. At the same time, special attention is paid to the preservation of the original information, its least distortion. It is also emphasized that such stages depend on the type and type of the input image. It is also necessary to take into account the ultimate goal for which appropriate algorithms and approaches are applied. It is advisable to take a comprehensive approach to solving the issues raised, which will allow you to get the best result, conduct an effective diagnosis.

Z. Qian, Y. Lv, D. Lv, H. Gu, K. Wang W. Zhang, and M. M. Gupta propose an approach based on input image preprocessing [20]. It is noted that this is important from the point of view of increasing the level of early diagnosis. In this case, pre-processing of the original image is done to obtain the most complete characterization of the polyps. The authors emphasize that they are trying to reduce the number of mirror images of polyps in the image. This contributes to the improvement of diagnostic results, obtaining more accurate results, which is noted in the article. Thus, the stage of preliminary diagnostics is uncontested and important.

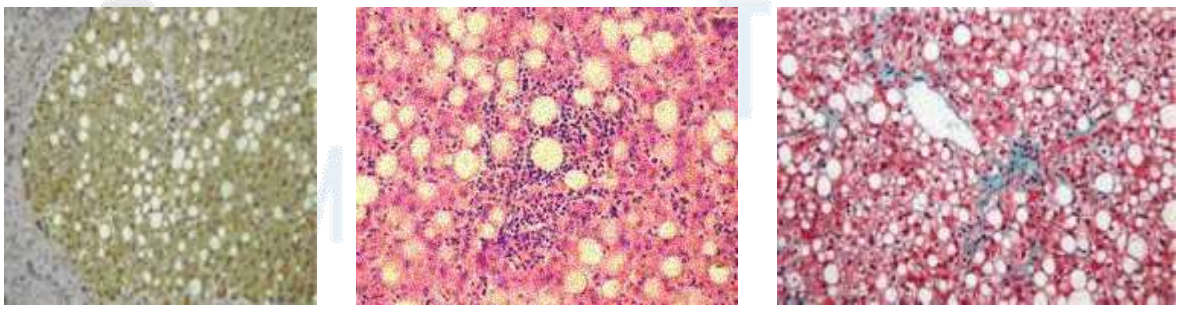
Also consider the fact that many medical images are stained. This is necessary for accurate localization of the area of interest. The book by M. M. Escobar discusses in detail a number of color image preprocessing methods [21]. Such approaches are used to diagnose various tumors, their isolation against the general background. This can also be facilitated by image binarization and the use of other approaches [22]-[24].

Thus, further we will show how interference negatively affects the processing of images with foci of fatty liver disease. We will not focus on the subtleties of formalization. We present a series of images, highlight some preliminary methods, and show the results. The main task is to show the need for pre-processing of input images in the problem of detecting foci of fatty liver lesions.

Data for analysis (noisy and non-noisy digital images)

So, the bases of our consideration are images with noise (the so-called noisy images) and images without noise (non-noisy images).

On Fig. 1 shows a series of images, which have interference and / or distortion of various kinds.



a) b) c)

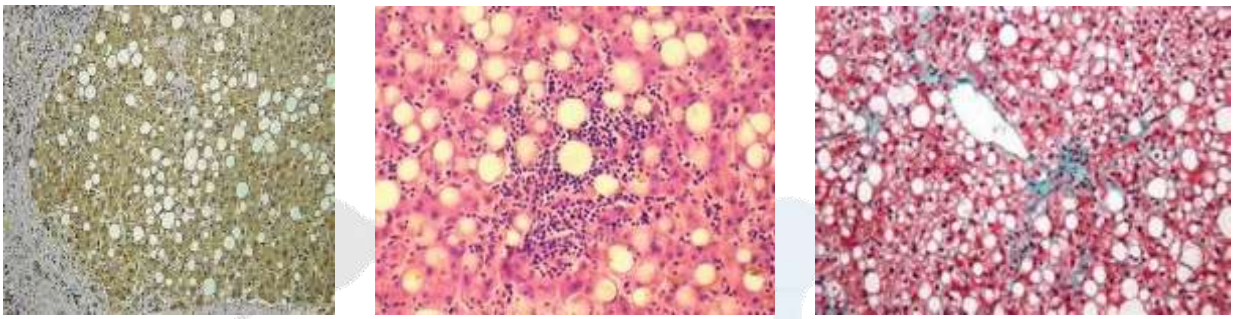
Figure 1: Distorted Images of Lesions of Fatty Liver Disease

On Fig. 1a shows a fuzzy, so-called blurry image. This image does not clearly identify the contours of the lesions, making it difficult to determine their true size.

On Fig. 1b and Fig. 1c shows images with different levels of their noisiness. The manifestations of such noise are individual point noise. It also makes it difficult to accurately

determine the contours of the required objects and, as a result, their size. We also pay attention to the different colors that are typical for individual images. Foci of fatty lesions of liver tissues also have different shades. All this makes it difficult to carry out the necessary analysis.

On Fig. 2 shows the corresponding non-noisy images, according to the data in Fig. 1



a) b) c)

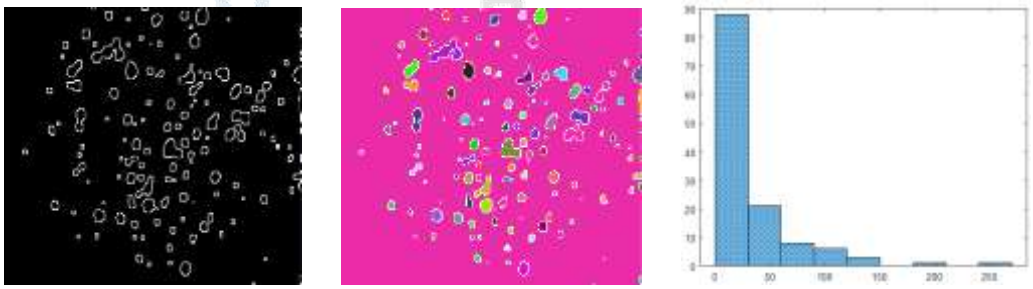
Figure 2: Non-noisy images of liver adipose tissue

Even visually, you can see the key differences between noisy and non-noisy images. At the same time, it should be noted that the process of eliminating individual defects is a process consisting of several stages. The first stage of these transformations is the transition from a color image to a monochrome image. We can also view individual color channels as monochrome images. Then for each such channel we do the same type of operations to eliminate distortion and interference. Then we connect such channels together and get again a color image, which has already been processed.

Various methods have been used to eliminate interference in each individual case. These methods include: deblur image using Wiener filter, median filtering, averaging filtering, fuzzy masking, and color contrasting.

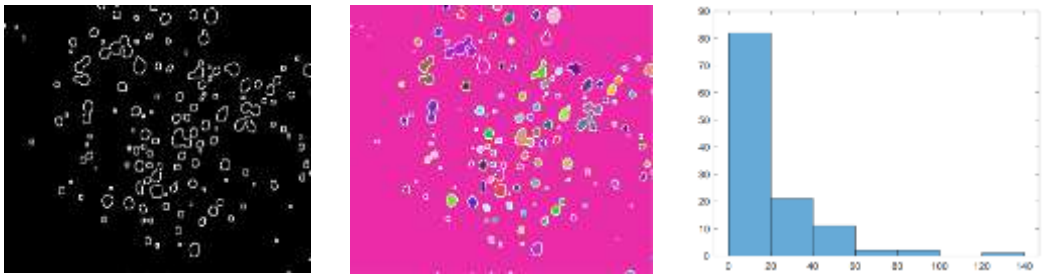
Results

On Fig. 3 and Fig. 4 shows the results of the allocation of fatty lesions of the liver for data Fig. 1a and Fig. 2a, respectively. In this case, the same algorithms with the same parameters were used.



a) b) c)

Figure 3: Results of image processing in Fig. 1a



a) b) c)

Figure 4: Results of image processing in Fig. 2a

On Fig. 3a and Fig. 4a shows the results of highlighting the contour of fatty foci of damage to liver tissues.

On Fig. 3b and Fig. 4b – the results of the identification of fatty foci of damage to liver tissues.

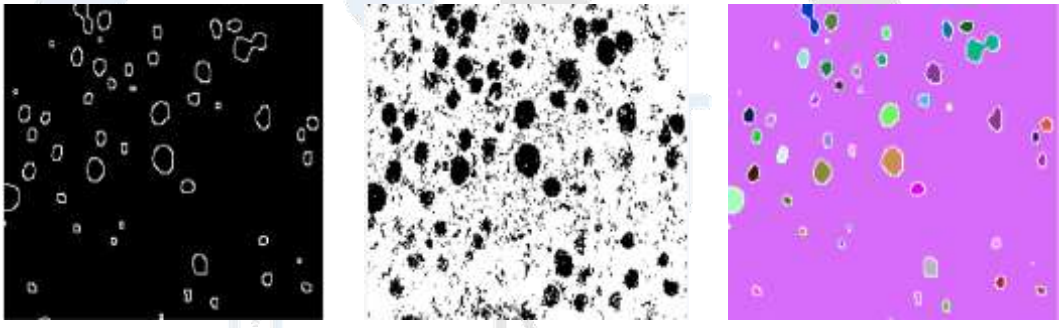
On Fig. 3c and Fig. 4c – the results of the distribution of lesions by area (abscissa axis – the area of the lesion, the ordinate axis – the number of lesions).

Comparing Fig. 3 and Fig. 4 we can see some differences. The key difference between the results shown is the identification of false lesions of liver tissues in the first case. This is clearly seen from the distribution histogram of such foci (see Fig. 3c and Fig. 4c).

On Fig. 5 and Fig. 6 shows the following example of image processing of liver lesions. This example for Fig. 1b and Fig. 2b, respectively.

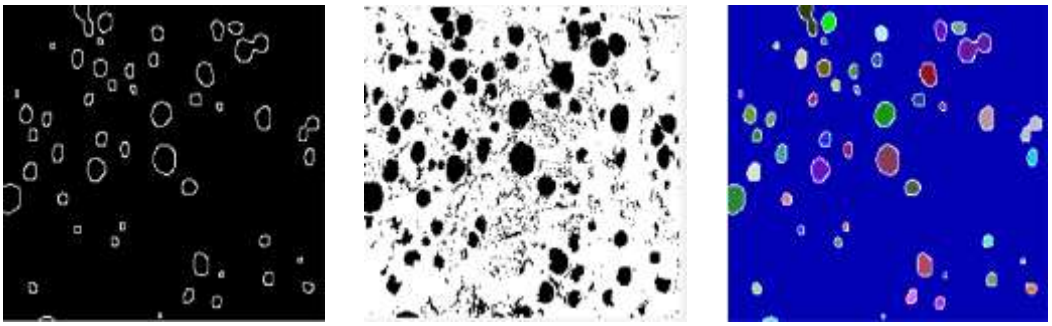
It also presents the contours of the selected objects (Fig. 5a and Fig. 6a) and their identification (Fig. 5c and Fig. 6c).

We also introduced the binarization of the input image. This is Fig. 5b and Fig. 6b.



a) b) c)

Figure 5: Results of image processing in Fig. 1b



a) b) c)

Figure 6: Results of image processing in Fig. 2b

Here you can also see the differences in the processing results. This is clearly seen from the data in Fig. 5b and Fig. 6b. At the same time, it should be noted that the binarization stage plays an important role in the preliminary processing of the original images, the possibility of accurately selecting the contour of objects.

Conclusion

The article deals with general issues of image analysis of foci of fatty lesions of liver tissues. Particular attention is paid to the preprocessing of such images. It is noted that this is an important step in the removal of noise and interference in the image for its further processing and analysis.

Real images of images with noise and without noise are presented. These images use the same analysis methods to identify liver lesions. The differences in the obtained results are shown. It is concluded that it is necessary to use methods of pre-processing of images in the study of fatty lesions of the liver.

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