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Color-aware digital image segmentation procedure as a tool for studying fatty liver disease

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Abstract:

Digital medical images are one of the sources of information for timely prevention of possible diseases. In this case, color medical images are widely used. One example of such use is in the diagnosis of fatty liver disease. Based on this, the paper considers the possibility of studying fatty liver disease based on digital image segmentation taking into account color. The results of digital processing are presented for real images depicting lesions of fatty liver disease.

Key words: Segmentation, Diagnostics, Analysis, Liver, Fatty disease, Medical image, Color space

Introduction

The study and analysis of information is the basis for diagnosis and timely detection of possible diseases. One source of information is digital medical imaging [1], [2]. This source of information allows you not only to see the features of the development and course of a certain disease, but also to obtain a certain quantitative characteristic of it. For these purposes, you can use various data analysis methods, both classical and special, which are used in various fields of research [3]-[8].

Among the classical methods of information analysis based on the study of digital images, we highlight a number of approaches to medical image processing [9],

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[10]. Among such approaches, it should be noted the segmentation of the input image, which allows you to divide such an image into a number of areas of interest [11], [12]. In this case, a special place is occupied by segmentation taking into account the color space for color medical images.

Medical images presented in color include a digital image of a liver showing signs of fatty disease [13]-[15]. Such information about liver disease allows us to identify possible lesions and the extent of such damage. We also have an effective tool for visualizing the diagnostic process.

Therefore, the main purpose of this paper is to examine the applicability of color-aware digital image segmentation procedure as a tool for studying fatty liver disease.

Related works

Segmentation of a digital medical image is one of the stages in obtaining additional information about a possible disease. Therefore, the use of this tool has found wide application in the practice of digital processing of medical images.

S. Masood, M. Sharif, A. Masood, M. Yasmin and M. Raza conduct extensive research regarding medical image segmentation [16]. The authors classified various segmentation approaches that allow analysis and diagnosis of various medical images. It is noted that there is scope for improving this procedure and this encourages new research.

P. Malhotra, S. Gupta, D. Koundal, A. Zaguia, and W. Enbeyle explore the possibility of using deep neural networks for medical image segmentation [17]. First of all, the authors emphasize the importance of the segmentation procedure in image research. The article also draws attention to segmentation as a tool for analyzing organs, diseases or anomalies. This emphasizes the complexity of solving such a problem, where it is possible to use other image processing methods [17], [18].

L. K. Lee, S. C. Liew, and W. J. Thong provide a critical review of image segmentation methodologies in medical images [19]. The authors say that effective segmentation is an important step for image contour processing. The importance of medical image analysis in treatment planning is also emphasized. The review contains the limitations and advantages of the considered segmentation methods for various medical images.

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M. A. M. Salem, A. Atef, A. Salah, and M. Shams also review segmentation methods for medical images [20]. The authors distinguish three groups depending on the image features used by this method. The advantages and disadvantages of each of the existing methods are discussed. The importance of analyzing color images, which are a function of three variables, is also noted. This justifies the use of new approaches to segmentation, considering the possibility of using classical methods for certain types of medical images.

O. Avalos, E. Ayala, F. Wario, and M. Pérez-Cisneros explore the feasibility of performing accurate segmentation for medical images based on cluster chaotic optimization [21]. In this case, the authors consider multi-level segmentation. For these purposes, evolutionary algorithms with minimum cross-entropy (CEMS-CCO) are used. This allows the definition of multimodal features to optimally solve the segmentation process of complex medical images.

S. H. Chae, H. M. Moon, Y. Chung, J. Shin, and S. B. Pan consider the application of automatic lung segmentation in medical image research [22]. First of all, the authors note that digital medical images help specialists improve the efficiency of diagnosis and treatment of diseases [22]. It is important not to lose all the necessary information. For these purposes, the authors propose image compression based on their segmentation. This allows you to select and store only regions of interest (ROI). The paper discusses the Level-set method using robust approaches to irregular noise.

P. L. Chang and W. G. Teng explore the possibility of using self-organizing map (SOM) for medical image segmentation [23]. The authors propose a two-step approach that allows one to effectively determine the dominant color components. This helps to divide the input image into several parts and carry out further research. The paper notes that the proposed approach is effective when processing various types of medical images.

The study [24] discusses and compares various medical image segmentation methods and algorithms in detail. The paper also describes non-standard segmentation methods used in the analysis of medical images. The advantages and disadvantages of each method are considered, and their comparative characteristics are given. Moreover, the entire analysis is based on the study of images in shades of gray.

P. Tyagi, T. Singh, R. Nayar, and S. Kumar evaluate the performance and effectiveness of various medical image segmentation methods [25]. In this case, the

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authors consider pre-processing of images before starting their segmentation. The end result of this approach is a clear delineation of the boundaries of areas of interest.

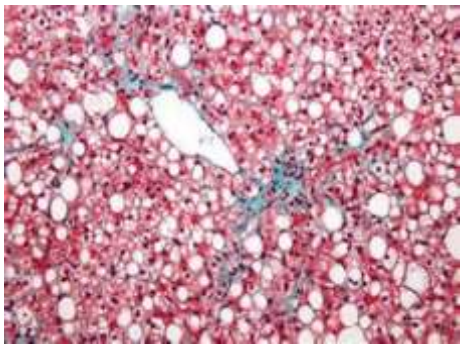
We see different directions in the research of segmentation procedures in the analysis of medical images. An important point is the possibility of using segmentation for color medical images. Such an analysis is possible in the context of solving a specific medical problem, for example, identifying foci of fatty liver disease.

General preliminary questions for image segmentation of liver tissue with fatty lesions

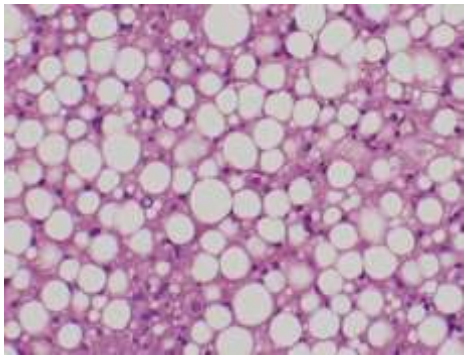
As noted earlier, digital medical image segmentation is an important step in research for the purpose of diagnosis, identifying diseases and prescribing treatment. Therefore, it is necessary to take into account all points when implementing the segmentation procedure.

One of these aspects is the presentation of the original image. When examining fatty liver disease, the digital image is typically presented as a color image. This enhances the visualization of the processes being studied and helps to better understand the specific areas of interest. At the same time, this forms its own characteristics when processing and analyzing such images. Thus, it is important to understand how and what we will segment.

Figure 1 shows various examples of color digital images of fatty disease lesions.



a)



b)

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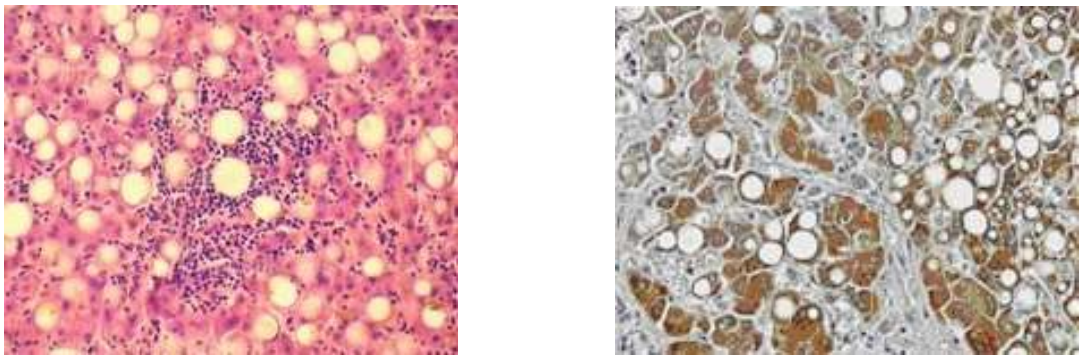

c) d)

Figure 1: Selected examples of color images of fatty liver disease lesions

We see images that differ in color characteristics, background complexity, and the general nature of the image details. What is common is the geometry of the foci of liver damage by fatty disease. We also see that these lesions are lighter in color compared to the background. Some images are simple, and we can use the methods we described earlier to analyze them [13]-[15]. However, in this study, we will focus on the possibility of using color segmentation to study liver lesions of fatty disease.

To solve this problem, we use the k-means method [26]-[28]. This method is based on minimizing the total square deviation of the points of individual clusters from the centers of these clusters. The algorithm ends when at some iteration there is no change in the intra-cluster distance. In this case, the initial information is the a priori number of clusters. In our case, each cluster is defined by its own color space. We can see that the number of clusters for each of the presented images (see Figure 1) will be different.

Below are some results of processing images of livers with fatty lesions using the k-means method for color digital images.

Results

Figure 2 presents the individual image segmentation steps for the data in Figure 1a.

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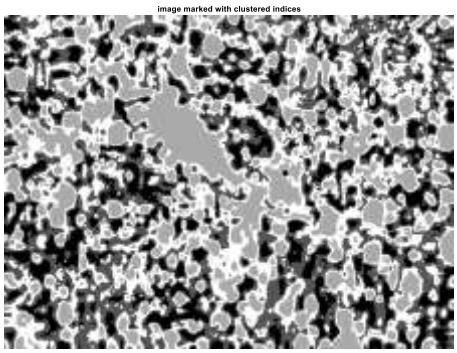
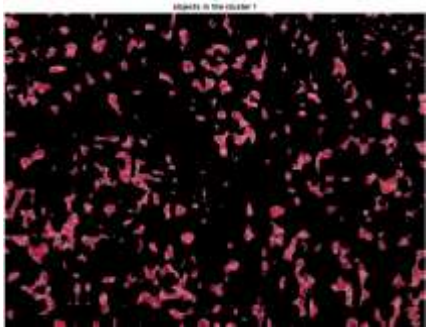
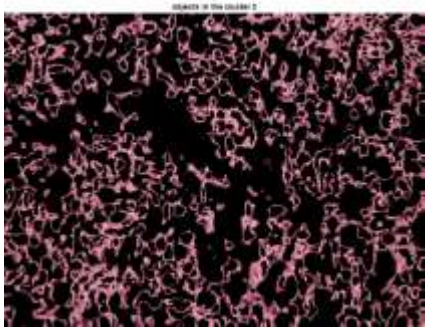


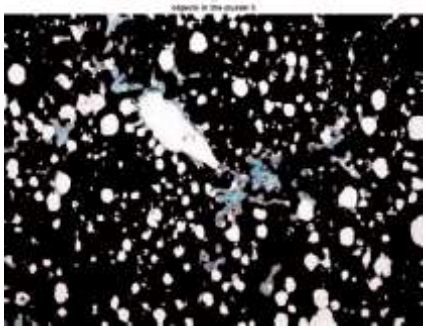
a)



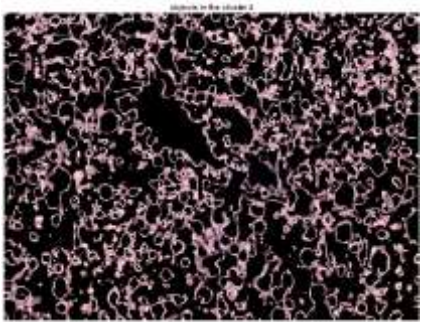
b)



c)



d)



e)

Figure 2: Image segmentation results for the data in Figure 1a

Figure 2a shows an image with markers for different clusters. Here 4 clusters were studied. Figure 2b – Figure 2e is an image of objects for individual clusters.

We see that some images of the clusters are similar to each other. This can be adjusted by changing the number of clusters. This aspect of the problem is discussed in

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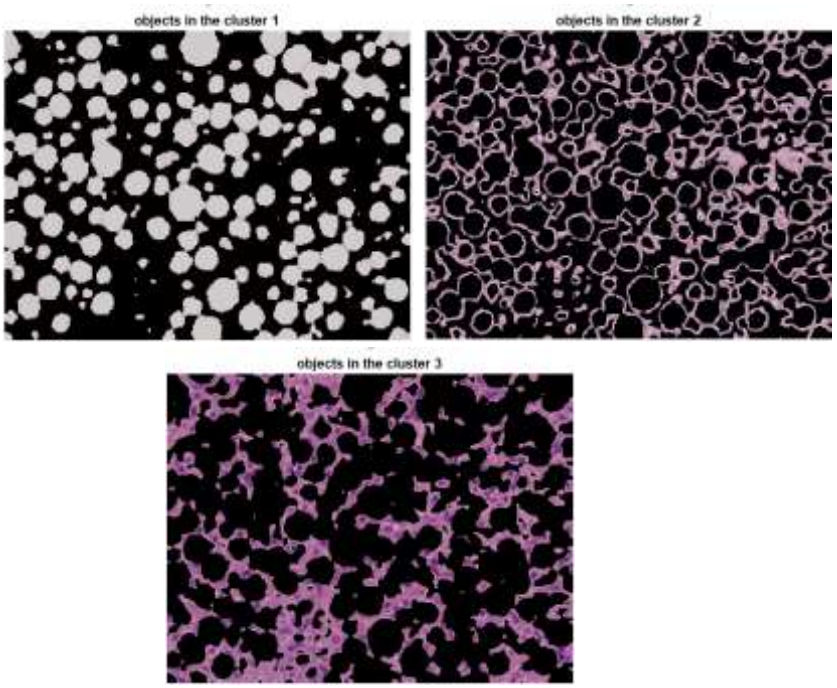
more detail below. At the same time, we note that objects in the cluster of liver lesions (Figure 2d) are highlighted much more clearly. This suggests the feasibility of using this approach in the task of identifying fatty lesions of the liver.

Figure 3 presents the segmentation results for the data in Figure 1b. Here we use a division into three clusters.



a) b) c)

Figure 3: Example of segmentation for the data in Figure 1b

We see that in this case two clusters make it possible to effectively isolate fatty liver lesions.

Figure 4 shows the segmentation results based on the data in Figure 1b in the case of a priori determination of two clusters.

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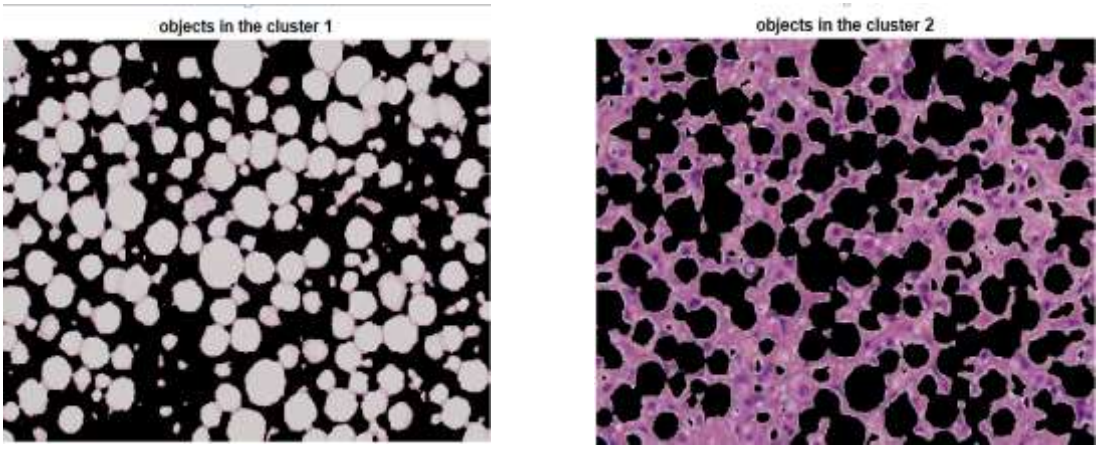

a) b)

Figure 4: Segmentation results based on the data in Figure 1b in the case of a priori determination of two clusters

We see that the first cluster with lesions in the first (Figure 3a) and second (Figure 4a) cases are almost identical. However, in the first case, we have the opportunity to correct the lesions using data from the second cluster (Figure 3b).

In this case, the determining point in determining the number of clusters can be the histogram data (Figure 5).

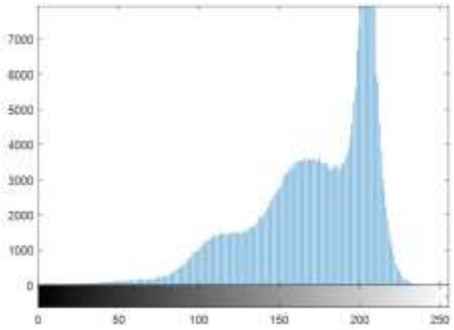

Figure 5: Histogram for the data in Figure 1b

We see three peaks in the histogram. This allows us to talk about three clusters when carrying out the appropriate segmentation. In general, we note the possibility of

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using an appropriate segmentation procedure in the task of identifying fatty lesions in liver tissue.

Conclusion

The choice of the topic of this study is due to the importance of the diagnostic stage in identifying the disease and prescribing the procedure for its treatment. In this case, one of the sources of information is a digital image. Processing such an image has several stages, where the key is segmentation - dividing the image into a number of areas of interest. However, there are some difficulties in processing color images. Based on this, the paper examines the possibility and feasibility of using the k-means method for color images when analyzing foci of fatty liver lesions. Individual images of such a lesion and the results of the corresponding segmentation procedure are presented.

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