Review of Optimization Methods of Medical Image Segmentation

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Abstract Medical image segmentation is an important component in medical image analysis and diagnosis which is used as a useful application for medical image processing. Image segmentation of medical images has been implemented and studied by numerous researchers in their various research activities. Robustness of the method is all-time challenge in this type of application of medical image processing. The robustness has been addressed by few researchers but still remains challenging task. The performance of existing research work on medical image segmentation is improved by using optimization techniques. This paper studies and presents a critical review of existing research work that has been used for optimizing the segmentation results. An attempt has also been made to suggest a plan for further formulating a more powerful optimization method to optimize the results that could help in the automated diagnosis of different types of medical images.

Keywords Medical image segmentation · Optimization · Image diagnosis · Robustness

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1 Introduction

Segmentation of an image is a very important component of automated medical image processing, image analysis, and applications. Actually, in all modern diagnosis centers and hospitals nowadays, modern equipment is used for scanning, analysis, and diagnosis of the medical images such as X-rays, Computed Tomography (CT), mammograms. If a radiologist or physician is interested to extract a certain region, then that portion needs to be brought out; this is possible with the help of segmentation techniques, as highlighted and discussed in several research contributions by Sinha et al. [1–5].

There are various methods in the literature used for this purpose of different categories such as region-based methods, pixel-based methods, and others. The biggest challenge in all these research works is the lack of robustness. There are researches for airborne images, medical images, fingerprints, and their segmentation, which are highly sensitive but again the same problem arises that is robustness and scope of improvement of the performance are always there [6]. Boundaries of anatomical structures, structures of tissues in cancerous images are important things that are required in automatic medical image analysis and diagnosis of images, and in such important and sensitive applications, mistake of few mill inches or micro-inches creates huge difficulties in medical image diagnosis, and therefore, there is need of scope of improvement and robust method so that the method can be applied as versatile method to different types of images for their segmentation and subsequent applications in medical science.

This paper highlights about critical review of what has been done in this field and few major optimization methods that were used by the researchers for optimizing the performance of medical image segmentation.

2 Related Research and Problem Identification

Baatz and Schape [6] suggested about prerequisite method used for object-oriented image processing aiming at the implementation of image segmentation of medical images. Scale parameter and homogeneity definition were involved and controlled in providing and obtaining better results in comparison with current research in the area of medical image segmentation. Chabrier et al. [7] stressed on study of optimization of evaluation parameters and metrics useful for segmentation of medical images. Local ground truth was added with desired level precision along with the contribution of genetic algorithm. Similar to this method could be applied for grayscale images of multicomponent type of medical images successfully.

Ghassabeh et al. [8] attempted in study, analysis, and the implementation of Fuzzy C-Means (FCM) method as clustering method and attempted to minimize the amount of uncertainty level using the concept of fuzzy logic inference. Magnetic Resonance Imaging (MRI) images were subjected to the method, and the method

was actually applied in the process of image enhancement that is also very important for obtaining accurate medical image analysis-based results. Computation and accuracy advantages both were achieved slightly better than non-fuzzy methods. Neural network was used in the training method of medical MRI images. Neuro-fuzzy as hybrid method was felt a need for future implementation for improved performance.

Chen et al. [9] discussed a minimization problem concept of optimization for segmentation results of medical images. Shape-related energy and the contour parameters were controlled and optimized. The study of minimization provides a fixed parameter for aligning segmentation and prior shape in medical images. Proper intensity profile of images was created using the method, and it was claimed that the method could be used for all different types of medical images, that is, all modalities of the medical imaging. However, the claim was not substantiated by enough results and proof of optimized performance. Lathen et al. [10] studied about optimization methods that can be used in multiscale filtering and integration-related medical imaging and analysis. The methods were compared for synthetic medical images of blood vessels and structures. No substantial proofs of evaluating robust way of implementation could be established.

Sivaramakrishnan et al. [11] implemented firefly algorithm in tumor detection of brain medical images and combined the approach with enhanced colony optimization method. The detection of breast cancer images found in mammographic images was studied, and few results were obtained. Around 350 different MRI images of a hospital were subjected to the methods, and their results were compared. It was also based on referring few standard databases of images and attempted comparing the results to get some artifacts and tumors present in the images of breast cancer patients. The focus was finding optimum solution for extracting cancerous elements with the help of an important metric called as maximizing a posterior. This metric was used to get the optimization level, and thus, the impact of this was observed in the applications related to segmentation and extraction of tumor in MR images of breast. Then the method was also tested for CT and other medical images, and it was claimed by the researchers that the results obtained are optimal enough that can be relied on the process of diagnosis and prescription.

Valsecchi [12] suggested and rather advocated about hybrid method of region-based segmentation for medical image segmentation. Genetic algorithm using some fine parameters and their tuning was implemented while implementing the process if the segmentation of the medical images. The optimization method was tested for two to three various modalities of medical images. Overall performance was evaluated and fund better than the methods without using such methods related to segmentation tasks. Smistad [13] designed and image-guided surgery method for enhancement as minimal invasive surgery, which is noninvasive but also using computer-aided diagnosis, and with the help of optimization method, the results were improved for various types of diseases. Model-based segmentation with priori knowledge was recommended for such applications. As per the scope to be implemented as future research, GPU computing was also claimed to have been

used in ultrasound images where the results were found most satisfactory. Szénási and Vámossy [14] studied the concept of optimization and its impact over the results produced by GPU implemented digital microscopy and diagnosis. Overall, the performance improvement using some optimization methods could be seen but robustness remained a big challenges.

3 Recommendation

Most of the research works that have attempted toward optimization of existing medical image segmentation-based results were applied over-utilize some metrics used in the process of segmentation. This is used as an evaluation criteria with the help of certain metrics. This applies to all medical images irrespective of shapes and structures and especially all the modalities, not even caring about robustness and versatility of the method being implemented or tested. One of the metrics, energy minimization function played important role in obtaining balanced results in image enhancement as well as segmentation related applications. The concept of minimization of energy could be used as versatile method in a number of applications in various stages of implementation to achieve good segmentation results in establishing greater diagnosis findings and outcome.

Major recommendations based on critical review and analysis of the current research on optimization of segmentation for medical images are:

- Different stages of medical segmentation and other components need optimizing their results to get improved and robust findings.
- Robust set of metrics need also to be finalized so that the set of metrics could exactly help in obtaining satisfactory and robust results.
- Focus is required for optimizing color image enhancement method as well as their subsequent stages after enhancement.

For instance, few steps of Sinha et al. [3] are given below to highlight the scope of applying optimization.

- A suitable fitness function is defined.
- Initial population is set or declared.
- A threshold is set.
- The results are compared with respect to threshold using fitness function.
- Rank of the method is evaluated.
- Results are analyzed and performance evaluated.

In the above implementation steps of suitable algorithm, highlighted in Sinha et al. [3], the scope of optimization is very wide that could be applied to all steps so that subsequent stages of implementation provide improved and much satisfying results. A suitable computer-aided diagnosis (CAD) can employ an appropriate optimization using robust set of metrics so as to achieve un-opposed and unique

results. This uniqueness could greatly improve the segmentation results in medical images for various applications such as detection of cancers, breast, or any other cancers.

CAD used few important metrics such as true positive, true negative, false positive, and false negative that could also be optimized to achieve robust values of accuracy, sensitivity, and reliability of the CAD system used for medical image segmentation.

4 Conclusions

This paper attempts to bring out major contributions on optimization applied to the segmentation of medical images, and accordingly based on few major problems identified, recommendation has been suggested how one could improve the performance along with addressing the concerns related to robustness of the results so that the methods could be applied as versatile methods in various types of medical image modalities.

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