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Original Research Article

An improved feature based image fusion technique for enhancement of liver lesions

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ARTICLE INFO

Article history:
Received 7 October 2017
Received in revised form
1 February 2018
Accepted 13 March 2018
Available online xxx

MSC:
00-01
99-00

Keywords:
Range filter
Optimal filter kernel
Image enhancement
Image fusion and gradient image

ABSTRACT

This paper describes two methods for enhancement of edge and texture of medical images. In the first method optimal kernel size of range filter suitable for enhancement of liver and lesions is deduced. The results have been compared with conventional edge detection algorithms. In the second method the feasibility of feature based pixel wise image fusion for enhancing abdominal images is investigated. Among the different algorithms developed in the medical image fusion pixel level fusion is capable of retaining the maximum relevant information with better implementation and computational efficiency. Conventional image fusion includes multi-modal fusion and multi-resolution fusion. The present work attempts to fuse together, texture enhanced and edge enhanced images of the input image in order to obtain significant enhancement in the output image. The algorithm is tested in low contrast medical images. The result shows an improvement in contrast and sharpness of output image which will provide a basis for a better visual interpretation leading to more accurate diagnosis. Qualitative and quantitative performance evaluation is done by calculating information entropy, MSE, PSNR, SSIM and Tenengrad values.

1. Introduction

Medical images play a vital role in modern diagnostic systems, especially in cancer diagnosis. These imaging systems mainly include ultra-sonography (USG), computed tomography (CT) and magnetic resonance imaging (MRI). In addition to this, the family of medical images includes images from nuclear imaging and microscopical systems. These medical images provide the visualization of internal structure of body and visual representation of organs or tissues. The development of these imaging technologies has made diagnosis easier to the medical personnel. Most of the medical images are low contrast in nature. Moreover, noise and artifacts cause some vagueness and difficulty in identifying object and back ground. To overcome these difficulties several filtering and image enhancement techniques have been derived. By image filtering the unwanted noise and artifacts can be removed. The image enhancement improves the contrast and sharpness of the image and provides better visual perception and makes it more suitable for further processing. There are several image enhancement methods; the most common techniques are

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https://doi.org/10.1016/j.bbe.2018.03.004

Please cite this article in press as: Sreeja P, Hariharan S. An improved feature based image fusion technique for enhancement of liver lesions. Biocybern Biomed Eng (2018), https://doi.org/10.1016/j.bbe.2018.03.004

based on histogram equalization. The histogram equalized image has uniform distribution of intensity values [1,2]. This may cause severe loss of important information content and sharpness in edges and boundaries. However, the fusion imaging enhances the image quality and retains significant information.

Medical image fusion is the process of combining multiple images from single or multiple imaging modalities to improve the quality of image. Medical image fusion is employed to the study diseases affecting important organs such as brain, breast, lungs, prostate and liver [3].

The complexity of liver tissue and the presence of other organs nearly situated make the imaging study challenging. Liver is the largest metabolic organ which is responsible for the filtering of blood from digestive tract and detoxifying drugs and chemicals. The metabolic function itself makes the liver a potential candidate for the development of malignant neoplasm. Moreover, the dual blood supply from hepatic artery and portal vein favors the deposit of metastasis arising from the primary tumors in colon, breast, lung, pancreas and stomach [4,5]. Liver diseases can be focal or diffused. Focal liver lesions can be benign or malignant which have to be differentially diagnosed. These lesions present similar appearance in the images taken using various imaging modalities. This similarity presents difficulty in differential diagnosis. Numerous computer aided diagnostic (CAD) systems are developed to distinguish the benign and malignant nature of these lesions which can provide a second opinion to the medical practitioner and help to avoid painful surgical procedure up to a certain extent.

A computer aided diagnostic system consists mainly of three modules, viz preprocessing, segmentation and classification. In the image pre-processing module, the enhancement of significant features which are relevant for the further processing of segmentation and classification takes place. Various image enhancement algorithms have been developed for improving contrast, sharpness, texture content and detection of edges in the images. These algorithms include histogram equalization, contrast limited adaptive histogram equalization (CLAHE), wavelet decomposition and fuzzy logic based techniques [6,7].

This paper is organized as follows. Section 2 presents a literature review. Section 3 describes the image enhancement and filtering preliminaries. The range filtering and proposed image fusion scheme are discussed in Section 4. Section 5 includes the experimental results, the resulting images and discussions. Qualitative, quantitative and comparative analyses are also presented. Describing the merits of both systems the final conclusion is drawn.

2. Literature reviews

Considerable volume of research work in image enhancement has been reported in the literature recently. Notable among such work includes image de-noising, edge extraction and texture enhancement using different mathematical, fuzzy, filtering and image fusion techniques. Li and Xie proposed a medical image enhancement technique based on adaptive fractional differential approach. This algorithm extracts edges in the image and preserves smooth areas and weak textures [8]. The fractional order differentiation model by He et al. comprises image denoising of standard test images [9]. This model is successful in preserving edges and edge features of 3D MRI images. The study of Isa et al. proposed a method to enhance the brain MRI image by replacing the average intensity based on adaptive histogram equalization [10].

Li et al. proposed a novel method for image enhancement using maximum fuzzy sure entropy, fuzzy c partition and fuzzy complement [11]. Chaira presented an edge enhancement scheme for medical image using intuitionistic fuzzy entropy and Type II fuzzy set. The enhancement is done by computing the variation of image pixel with the central pixel of median filter. Hamacher Tco-norm is also used for defining new membership function [12,13].

The image fusion is the process of combining the information of two or more images into a single image. The resulting image contains more information than the input images. The clinicians use medical image fusion to comprehend the lesions by combining the images from different imaging modalities. Reviews and surveys on multi modal medical image fusion explain techniques, application, merits and demerits of the image fusion [14,3].

Maurya et al. describe a technique to fuse high sharpness images having maximum entropy and PSNR together to get contrast enhanced image with brightness preservation [15].

Maurya et al. describe image enhancement using fusion techniques. In this work, image contrast has been enhanced while preserving the brightness by the fusion of high sharpness images having maximum entropy and PSNR.

Multi modal fusion approach is a recently emerged approach. Mohammadi-Nejad et al. present a structured and sparse canonical correlation approach to overcome the difficulties of multi modal fusion [16]. Manchanda et al. have also described a multimodal fusion of medical images using fuzzy transform. In this work, maximum entropy in the neighborhood based fusion rule in fuzzy transform domain for multimodal image fusion is proposed [17]. Another multimodal medical image fusion based on multi level local extrema is presented by Xu [18]. In addition to this, numerous works have been reported in literature in the field of enhancement and fusion both medical and non-medical images [19–22].

The literature survey outlines the scenario of different image enhancement scheme and image fusion techniques. Medical image fusion usually means the combination of multiple images of the same patients overlying or merging to get additional information. Otherwise combining images from different imaging modalities such as CT, MRI, etc. provides fused images for better interpretation and diagnosis. The fusion imaging also helps for precise monitoring of interventional procedure.

Medical images usually have poor visual perception capability because of the presence of noise from various sources in image acquisition system. These noise and artifacts have considerable effect on the small differences which may exist between the normal and abnormal tissues [23]. This work presents image enhancement scheme for abdominal images. The process involves combining Gaussian filtered image and gradient magnitude image to get fused image with enhanced edge and texture. The pixel wise addition, averaging and

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