Computer Vision and Medical Image Processing:
A brief survey of application areas

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Abstract. Every day is greater the number of images obtained to characterize the anatomy and functions of the human body, because of this the automation of the medical image processing has become a practice to improve the diagnosis and treatment of certain diseases. In this study the main areas of application of computer vision to the digital processing of medical images are reviewed. It begins with the selection of the three edges with more publications available in Springer, ScienceDirect, Wiley, and IEEE which are: segmentation of organs and lesions, feature extraction in optical images and labelling machine on x-ray images. Over them, latest algorithms, techniques and methods for medical imaging processing are analyzed exposing its main characteristics and ways of use.

Keywords: Medical Image, Segmentation, Feature Extraction, Labelling, Application Areas.

1 Introduction

The digital image processing, includes a set of techniques that operate on the digital representation of an image to highlight some of the elements of the scene, to facilitate future analysis, either by a user or a machine visión system. In general, image processing techniques are applied when necessary to enhance an image to highlight some aspect of the information contained in it, or when required, measure, or classify an item contents in the same. [1]

Medical images, for its part, consider a set of techniques, processes and art of creating visual representations (images) inside a body for clinical analysis and medical intervention. [2] Using these images, it has become a basic tool in both medical diagnosis and biomedical research. Almost all specialties of a modern hospital handled some kind of images on your clinical routine. The increasing introduction of digital imaging modalities allows efficient storage thereof, and what is more important, the possibility of image processing and analysis to obtain quantitative data from them. [3]

At present, and as shown in [4], due to advances in diagnostic methods in medicine,the medical images are used daily in clinical routine: *Diagnostic assistance*, *Assistance to treatment and research of the pathophysiology of the disease*. But mostly, they have become a field of work with a large number of applications, among which are: - Tomodensitometry (*x-rays*) or scanner, - Magnetic resonance, - Tomography, - Echocardiography, - Angiography. Although these images provide information on the morphology and function of the organs, their objective and quantitative interpretation is still difficult to perform, as it requires extensive knowledge of the subject and ability to manipulate vast wealth of images and information about the same. [5] Hence, this study aims to review the main techniques, algorithms and methods of medical image processing, in different application areas in order to facilitate the task of clinical interpretation and provide insight to future researchers of the state of the art in this area of computer science.

2 Main Application Areas

Today, the medical image processing (*MIP*) It is an area of very specific research in computing and is closely related to the digital signal processing. This relationship stems from the fact that essentially the *MIP* is a very special form of digital signal processing in two or three dimensions. [6] The application of signal processing techniques to the field of medical imaging takes several decades to produce progress in assisting the diagnosis. Main areas of application include the ***Segmentation of organs and lesions***, ***Feature extraction in optical images***; and ***Labelling Machine on x-ray images***. [7]. In Fig. 1 flowchart of this review is shown.

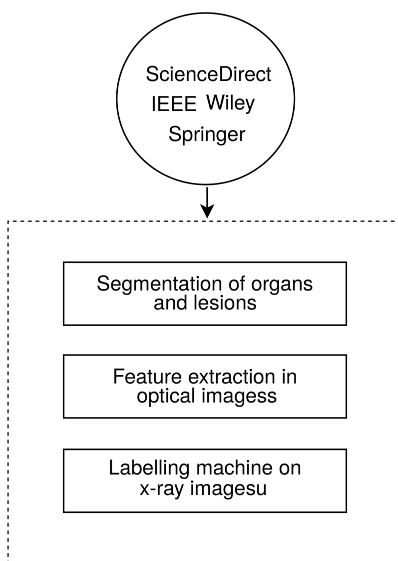

Fig. 1: Flowchart of this survey.

2.1 Segmentation of organs and lesions

The medical image analysis by visual inspection by a specialist presents many difficulties, due to the subjectivity of the physician, data complexity and variety of procedures for image acquisition. One application that has received more interest in recent years is the segmentation of organs or injuries (lesions).

Research in [8] [9] [10] [11] use interesting approaches through different methods and techniques to perform the segmentation of magnetic resonance imaging (MRI) of the head. In [8] propose a fuzzy c-means (FCM)-based algorithm with incorporated spatial neighborhood information. This is determined using a factor that represents the spatial influence of the neighboring pixels on the current pixel achieving robust to noisy images even at increased levels of noise, thereby enabling effective segmentation of noisy medical images. In [11] propose a novel method considering the hidden Markov random field model (HMRF) to model the image class labels. To combine the spatial coherency modeling capabilities of the HMRF model and the enhanced flexibility obtained by fuzzy c-means (FCM) algorithm, they use a fuzzy clustering expectation maximization (FCEM) algorithm. Finally, both model parameters as well as class labels of medical images are estimated recursively using proposed algorithm until the model parameters converge to the optimal ones. Another approach in [9] use K-means clustering to produce a primary segmentation of the input image, after that apply the improved watershed segmentation algorithm to the primary segmentation to obtain the final segmentation map. TThis improve use a automated thresholding on the gradient magnitude map and post-segmentation merging on the initial partitions to reduce the number of false edges and over-segmentation. In [10], [12] also, propose a segmentation algorithm based on watershed. The first, uses this algorithm together with rough set theory but without consider some clustering algorithm. they partitioned the image into the edge-detail sub-image and smooth sub-image according to indiscernibility relation of rough set theory. Two enhancement methods are designed for the two sub-images, and watershed transformation is used for the further segmentation in the smooth sub-image. Finally, combine the two processed sub-images to obtain the segmentation result. While the second is based on graph theory that reconstructs gradient before watershed segmentation, based on the reconstruction, a floating-point active-image is introduced as the reference image of watershed transform. Finally, a graph theory based algorithm Grab Cut is used for fine segmentation. False contours of over-segmentation are effectively excluded and total segmentation quality significant improved as suitable for medical image segmentation.

Other studies more recents, such as in [13] proposes a hierarchical fully unsupervised model selection framework for neuroimaging data that enables the distinction between different types of abnormal image patterns without pathological a priori knowledge. This is carried out by Gaussian mixture model (GMM) and Bayesian inference criterion (BIC). In [14] propose a wavelet transform to segment medical image. Firstly the gray level histogram of the medical image is processed using multiscale wavelet transform. Then the gray threshold is gradually emerged by the performance from large scale factor to small scale factor.

At last, of trachea segmentation is achieved. In [15] [16] use segmentation based in histograms. First, proposes a new technique to increase the resolution of the medical images to identify the features and edges of the medical images by using multi-class histogram based segmentation method. While the second proposes a dualistic sub-image histogram equalization based enhancement and segmentation techniques. They subdivide an image into its constituent objects. Technique is based on directional homogeneity using modified metric in [17].

The table 1 shows a summary of the revised approaches.

Table 1: Summary of approaches of segmentations of organs and lesions.

Method	**Type of Image**	**Improvement**	**Type**	**Study**
FCM	MRI of the head	Spatial neighborhood information	Organ	[8]
FCM, HMRF	Cancerous kidney	FCEM	Lesion	[11]
K-means, Watershed	MRI of the head	Watershed improvement	Organ	[9]
Watershed	MRI of the head	Rough set theory	Organ	[10]
Watershed	MRI of the head	Graph theory	Organ	[12]
GMM	MRI of the head	Bayesian inference criterion	Lesion	[13]
Wavelet transform	Image of trachea	-	Organ	[14]
Histogram	Image of breast	Multi-class histogram	Lesion	[15]
Histogram	MRI of the head and legs	Improvement directional homogeneity	Lesion	[16]

2.2 Feature extraction in optical images

Optical images are photographs of the eye used by optometrists to measure characteristics such as tear film thickness or the amount of red in the eyeball, and diagnosis of diseases. In this type of images relevant structures such as the eyelashes or eyelids, they should be isolated so as not to influence the further processing. [18]

In the study [19], an algorithm for automatic detection and removal of blood vessels in retinal images of the eye is proposed. Morphology operators using multi-structure elements are applied to the enhanced image in order to find the retinal image ridges. Afterward, morphological operators by reconstruction eliminate the ridges not belonging to the vessel tree while trying to preserve the thin vessels unchanged. Finally, a simple thresholding method along with connected components analysis (CCA) indicates the remained ridges belonging to vessels. Similarly in [20] a catheter-based medical imaging technique that produces cross-sectional images of blood vessels. This carried out on-line on the Optical coherence tomography (OCT)-workstation through lumen segmentation and the identification of the main tissues in the artery wall.

Other approaches for feature extraction can be find in [21], [22] and [23]. In [21] propose a edge detection method customized on characteristics of optical coherence tomography images for stable feature extraction. They use a local window holding many pixels for tracking structural tendencies, edges are detected on reliably limited areas in reduced noise effect. Finally through clustering based on Gaussian mixture model (GMM) the features are obtained. In [22], propose a feature-based method for video mosaic with super-resolution for optical medical images through build of a minimal cost graph path for mosaic using topology inference. Then a mosaicing image with super-resolution is created by way of maximum a posterior (MAP) estimation and selective initialization. And last approach in [23] address the problem of feature extraction for automated classification of optical projection tomography images of colorectal polyp. 3D patches are classified using the bag of visual words framework and support vector machines (SVM) getting the feature extraction of colorectal polyp images.

The table 2 shows a summary of the revised approaches.

Table 2: Summary of approaches of feature extraction in optical images.

Method	**Type of Image**	**Improvement**	**Study**
Morphological operators	Retinal images	CCA	[19]
OCT	Retinal images	Lumen segmentation	[20]
GMM	Tomography various type	Local window of structural tendencies	[21]
Minimal Cost Graph Path	Fibered confocal microscopy	Local MAP	[22]
Bag of Visual Words	Colorectal Polyp Images	SVM	[23]

2.3 Labelling machine on x-ray images

A *x-ray* (radiography) is a noninvasive medical test that helps physicians diagnose and treat medical conditions. Shooting with *x-rays* involves exposing part of the body to a small dose of ionizing radiation to produce pictures of the inside of the body. [24]. *Rays-x* angiography is an imaging test whose function is to study the circulatory vessels that are not visible by conventional radiology and currently is the standard for studies of coronary arteries (CA). The coronary angiography is playing a decisive role in determine presence of heart disease and the consequences for a therapeutic approach. Due to its importance, studies in [25], [26] and [27] have considered methods to detect automatically coronary arteries in angiographies. In [25] propose a novel machine learning-based method to improve Hessian-based coronary artery detection from X-ray angiography. They divide Hessian-filtered images in patches, using feature extraction with a contour profiling algorithm, and classify using Support Vector Machines (SVM). The method is applied recursively on the detected connected components using patches of different sizes to extract the arteries. While in [26] propose a region growing segmentation method which implements using morphological image processing operations and flood fill method. It can extract the boundary of main CA for after to be labelling. Furthermore in [27] a method to increase the average density of microfibrillated cellulose (MFC) in X-ray microtomographic images is proposed. Labeling is based on attaching metals to the surface of MFC fibres. This is characterized using scanning electron microscope (SEM), X-ray fluorescent (XRF) measurements, electron energy dispersive scattering (EDS) analysis and inductively coupled plasma optical emission spectrophotometry (ICP-OES) measurements.

The table 3 shows a summary of the revised approaches.

Table 3: Summary of approaches of labelling machine on x-ray images.

Method	**Type of Image**	**Study**
Hessian-filtered, SVM	X-ray angiography	[25]
Morphological Operations	X-ray angiography	[26]
Attaching metals	X-ray microtomographic	[27]

3 Conclusions

At the end of this study, conclusions are:

- Application areas of medical image processing are varied, highlighting the radiology, nuclear medicine, endoscopy, thermography, angiography, magnetic resonance, ultrasound and microscopy; in all these fields the positive impact on the daily lives of human beings it is invaluable due to can be used as non-invasive methods of looking inside the human body and help to doctors in diagnosis diseases.

- Computational methods of segmentation facilitate the delimitation of tissues from noisy data, and allow quick and automatic extraction of parameters such as diameter, surface, or volume; aspects relating to the diagnosis and monitoring of diseases.

- The task of segmentation arteries is of great importance in the context of cardiovascular imaging, as the accuracy with which this work is done has a direct influence on diagnosis and therapy, or other clinical decisions associated with dangerous situations for life of patients.

- Automatic methods of detection and segmentation of retinal blood vessels are important for the automatic detection of diabetic retinopathy because allow diagnosis of abnormal lesions in this part of the human eye.

- Automatic labeling methods in x-ray analyzed are very similar due to technological advances of equipment that generates these images, all those can examine in detail X-ray image and realise labelling.

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