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Review

MRI based medical image analysis: Survey on brain tumor grade classification

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ABSTRACT

A review on the recent segmentation and tumor grade classification techniques of brain Magnetic Resonance (MR) Images is the objective of this paper. The requisite for early detection of a brain tumor and its grade is the motivation for this study. In Magnetic Resonance Imaging (MRI), the tumor might appear clear but physicians need quantification of the tumor area for further treatment. This is where the digital image processing methodologies along with machine learning aid further diagnosis, treatment, prior and post-surgical procedures, synergizing between the radiologist and computer. These hybrid techniques provide a second opinion and assistance to radiologists in understanding medical images hence improving diagnostic accuracy. This article aims to retrospect the current trends in segmentation and classification relevant to tumor infected human brain MR images with a target on gliomas which include astrocytoma. The methodologies used for extraction and grading of tumors which can be integrated into the standard clinical imaging protocols are elucidated. Lastly, a crucial assessment of the state of the art, future developments and trends are dissertated.

Contents

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1. Introduction

Over the past several decades' diseases have fallen before the scythe of human intelligence in the form of biomedical advances in our understanding of various diseases but still cancer, by virtue of its unstable nature, remains a curse to the mankind [1]. A qualified clinician visually examines many types of medical images, further identifies the probable locations and signs of malignant tumors. This is the method followed for non-invasive diagnosis of tumors. Initially, for the detection of a tumor, imaging systems are used to record medical images. The captured images are passed through various software-based algorithms so as to segregate the suspicious region of the tumor from the healthy region in the image.

Image segmentation secludes the infectious region from rest of the image. Treatment planning is assisted when an accurate segmentation method helps to determine tumor size and location. For this purpose, a skilled clinician has to either set the initial conditions or provide training data for classification. Various researches have been carried out to detect many types of the tumor based on the extraction of visual information from medical images.

The current World Health Organization (WHO) guidelines for brain tumor classification [2] are strictly histopathological, which limits clinical application. This constraint triggers the application of medical imaging for diagnosis and treatment planning including more automated methods. The ever-increasing amount of brain MR image data has created new opportunities for neurosurgeons and medical scientists at the same time burden of excessive accurate data analysis and diagnosis has become tiresome [3]. Hence computer-aided diagnosis can be implemented to enhance physicians' diagnostic capabilities and reduce the time required for accurate diagnosis. In current clinical studies and routine, MR images are assessed either by depending on elementary quantitative measures or based on qualitative criteria only. Hence substituting the routine evaluations with greatly reproducible and precise image processing routines and tumor substructure measurements which can automatically inspect brain tumor scans would enhance improved diagnosis and treatment planning. The majority of the current algorithms used for the analysis of brain tumor targets on the glial tumor segmentation [4].

In medical imaging, segmentation is a mandatory task which can be done manually by an expert with good accuracy but time-consuming. At the same time, fully accurate and automatic segmentation approaches are not yet authentic. Currently, for clinical application, partial automatic segmentation methods are adapted. These time consuming and challenging tasks by radiologists' drives towards the demand for a semi-automatic segmentation method. This could alleviate the drawbacks of automatic segmentation method simultaneously the radiologists will also have control over the segmentation process. Several semi-automatic methods need only user initialization. Repeated user interaction is mandatory to assure accuracy.

The review is further structured as follows: Image processing and computer vision (Section 2), where we briefly summarized about Preprocessing, Segmentation (with subsections on Manual segmentation, Semi-automatic and fully automatic methods), Feature extraction, Feature selection, Dimensionality reduction and Classification. Further (Section 3) the current trends in MRI-CAD scheme are explained. Lastly, we discuss the current state of the art in the area of segmentation and classification that would benefit grading of brain tumors and compared it to the clinical requirements.

2. Image processing and computer vision

The field of computer vision has the ultimate goal to use computers to imitate learning and human vision. It also has the ability to form inferences and take action on the basis of visual inputs. The field of image understanding or analysis lies between computer vision and image processing [5]. The general computerized processes are low, mid and high- level processes. Low-level processes involve basic operations like noise reduction by image pre-processing, image sharpening and contrast enhancement. Mid-level processing includes segmentation and classification. High-level processing involves performing cognitive functions normally associated with vision.

Image analysis takes the aid of semi-automatic or automatic methods to illustrate the captured images. The abundance of clinical data generation has made it impossible to manually define and segment the data in appropriate time. The medical image analysis domain is divided into enhancement, registration, segmentation, visualization, quantization and modeling [6]. Among this registration, segmentation and modeling are the most important and challenging when it comes to brain tumor studies.

Despite the expert's experience and skills, the manual qualitative analysis is always bounded by the human vision system. The reason is the inability of the human eye to discriminate between several tens of gray levels [7]. The abundance of information contained in an MR image is much more than what the human vision can visualize because the present MRI systems can produce images equal to 65,535 gray levels [7]. This leads to using the computer as the second eye to play the role of understanding high bit-depth and high-resolution MRI images. For instance, a mathematical framework using both rough sets and fuzzy sets that deals with the uncertainties associated with the human cognition process are studied in [8].

2.1. Pre-processing

A wide variety of pre-processing techniques like linear, nonlinear, fixed, adaptive, pixel- based or multi-scale, are applicable for different circumstances [6]. Applications where discrimination between abnormal and normal tissue is delicate, precise interpretations become severe for relatively high noise levels. The small