Brain tumor diagnosis with MRI, PET and CT using soft computing techniques

Brain tumor is referred to the aggregation of abnormal cells in some tissues of the brain or central spine canal. The term "tumor", which literally means swelling, can be applied to any pathological process that produces a lump or mass in the body. Primary brain tumors and metastatic brain tumors form the two basic kinds of tumors. Primary brain tumors start and stay in the brain itself whereas metastatic brain tumors begin as cancer in different parts of the body and then spread to the brain. Tumors can be cancerous (or malignant) or non-cancerous (or benign). Malignant brain tumors grow fast and spread to other areas of the brain and spine and compared to benign tumors, they are more life-threatening.

The World Health Organization (WHO) classifies brain tumors by cell origin and behavior, from least to most aggressive. Many non-malignant brain tumors are classified as Grade I or II, also known as low grade (LG) tumors, and malignant tumors as Grade III or IV, as high grade (HG). While HG tumors are threatening with a maximum life expectancy of two years, LG tumors may allow the sufferer to have many years of life expectancy. A tumor which occurs in the brain or spinal cord is called as glioma and the tumor that arises from the meninges is called as meningioma. The abnormal cell growth in the pituitary gland is observed as pituitary tumor.

The American Cancer Society's estimates for brain and spinal cord tumors in the United States for 2020 include both adults and children.

- About 23,890 malignant tumors of the brain or spinal cord (13,590 in males and 10,300 in females) will be diagnosed. These numbers would be much higher if benign (non-cancer) tumors were also included.
- About 18,020 people (10,190 males and 7,830 females) will die from brain and spinal cord tumors.

This cancer can drastically influence the quality of life, for both patients and their families. The key factor in treating brain tumor and increasing its survivability rate is early diagnosis and correctly determining its type. Since manual segmentation of brain tumors is a highly time-consuming, expensive and subjective task. Brain tumor segmentation is a critical step towards improving disease diagnosis, treatment planning, monitoring and clinical trials. Reliable brain tumor segmentation is required to detect the location and also the extent of the tumor. However, brain tumors have properties that make their accurate segmentation challenging. These tumors are highly heterogeneous in terms of location, shape, texture and size. In addition, they are usually poorly contrasted and the intensity value of a tumor may overlap with the intensity value of healthy brain tissue. Therefore, it is not easy to distinguish healthy tissue from the tumor.

The early brain tumor detection plays a major role in treatment and recovery of the patient. For medical image diagnosis, the images can be obtained from various imaging modalities namely Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI) and Computed Tomography (CT). These imaging techniques differ in terms of effectiveness, price, type of physical phenomenon, the impact on the patient and its availability.

Among different screening technologies, Magnetic Resonance Imaging (MRI) is, typically, selected as the utilized technique for brain tumor classification, due to the high resolution images it can provide on brain tissue and MRI is harmless because it is based on magnetic field and radio waves and do not pose any radiation hazard to human body. Computer Aided (CAD) brain imaging programs have been developed to overcome the constraints of MRI such as needing significant time to acquire, process and interpret images. The proposed method consists of three phases including pre-processing, thresholding, and identification of region of interest (ROI).

Computed Tomography (CT) uses high dose x-ray radiation to generate the detailed scans or images of inside body. In most of the cases, CT machines generate continuous pictures in a helical (or spiral) fashion rather than producing a series of pictures of individual slices of the body. Helical CT has several advantages such as it is fast, it produces better 3-D images and it has better sensitivity in the detection of small abnormalities. The newest CT scanners, called multislice CT or multidetector CT scanners, allow more slices to be imaged in a shorter period of time.

In Positron Emission Tomography (PET) imaging system, a radioactive substance is injected into the blood to identify the most active body cells, especially the cancerous tissues. PET scan can be added with computed tomography (CT) so that both anatomical and functional views of the suspected cells can be observed. PET is useful in identifying axillary nodes and distant metastates. However, it has poor sensitivity in detecting small tumors because of their small size.

MRI has a higher sensitivity and PET/CT has a higher specificity in predicting the pathologic response in patients with brain tumor. PET/CT has some limitations compared with MRI. First, as a functional imaging technology, the anatomic discriminative resolution of PET/CT is lower than that of MRI. Second, the most appropriate pSUV cut-off value for predicting a pCR with PET/CT cannot be determined. The cost of PET/CT is higher, which could lead to a greater financial burden for patients.

CNN is one of the deep learning techniques for image recognition. Unlike conventional machine learning techniques, CNN trains itself using existing data without requirement of human-made feature values. Therefore, CNN has potential to discover unknown patterns of MRI, CT and PET that are associated with tumor hypoxia. Because localizing hypoxia is important for surgical resection and radiation therapy planning.

The aim is to develop an automated approach for the diagnosis of brain tumors using histopathological images which can be trained in convolutional neural network, for brain tumor image classification. To develop a model which can learn rich and discriminative features from the histopathological images and classifies different images obtained from MRI, PET and CT into benign and malignant classes with higher accuracy.

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