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Using a Split and Merge Algorithm Based on Superpixels, Automatic Brain Tumor Segmentation from MRI Images

Bhandari Yagnik Ishwarbhai , Sheetal A Wadhai

Bachelor's of Computer Engineering , Universal College of Engineering, Sasewadi, Pune

Asst prof., Universal College of Engineering, Sasewadi, Pune

Abstract: The medical imaging community has long been interested in brain tumor segmentation, which is an important yet difficult issue. Successful applications of sparse coding and dictionary learning in different vision issues, including picture segmentation, have recently emerged. A superpixel-based framework for automated brain tumor segmentation is presented in this research. It is proposed that the procedures that make up the split and merge technique be reformulated. First, a recursive split is performed; subsequently, after the merge procedure, an image segmentation is acquired. This is possible because the merging is done as a growth process, removing the need for grouping. The usage of a complete quadtree aids in the reformulation process. Because of the differences in nature of the two processes, the region homogeneity in each process is determined using a different predicate. Experiments with a blocks world image and an industrial components image are presented to demonstrate the algorithm's effectiveness.

Keywords: MRI, Brain Tumor, Segmentation, Superpixel, Split and Merge

1. INTRODUCTION

Many people have been afflicted and devastated by brain tumor's, which are one of the most common brain disorders. According to the International Agency for Research on Cancer (IARC), more than 126000 persons worldwide are diagnosed with a brain tumor each year, with more than 97000 deaths [1]. Despite ongoing efforts to address brain tumor issues, statistics demonstrate that brain tumor patients have a low survival rate. To tackle this, researchers have lately begun to employ a multi-disciplinary strategy that incorporates knowledge from medical, mathematics, and computer science to better understand the condition and develop more effective treatment options.

The most common tests to establish the presence of a brain tumor and to define its location for selected specialist treatment choices are magnetic resonance imaging (MR) and computer tomography (CT) scanning of the brain. There are several therapeutic options for brain tumor's now available. Surgery, radiation therapy, and chemotherapy are some of the alternatives available. The therapy choices available are determined by the tumor's size, kind, and grade. It also depends on whether or not the tumor is pressing on the brain's important areas. When choosing on treatment alternatives, it's vital to examine if the tumor has migrated to other parts of the CNS or the body, as well as potential negative effects on the patient's treatment preferences and general health [2].

In order to reduce diagnostic errors, accurate diagnosis of the type of brain dysfunction is critical for therapy planning. Using computer-aided diagnostic (CAD) systems can enhance accuracy. The primary idea behind CAD is to provide a computer output as a second opinion to help radiologists Analyse images and shorten image reading time. This enhances radiological diagnosis accuracy and consistency. Brain tumor picture segmentation, on the other hand, is a tough task. To begin with, there are many different types of tumor's that come in a variety of shapes and sizes [3]. Another element that makes automated brain tumor picture recognition and segmentation problematic is the appearance of brain tumors at multiple sites in the brain with variable image intensities [2].

This paper describes a superpixel-based split and merge method for MRI image segmentation-based brain tumor detection.

2. MAGNETIC RESONANCE IMAGING

Medical imaging techniques such as magnetic resonance imaging (MRI), nuclear magnetic resonance imaging (NMRI), and magnetic resonance tomography (MRT) are used in radiology to visualize inside body structures in great detail. The property of nuclear magnetic resonance (NMR) is used by MRI to image atom nuclei inside the body. An MRI scanner is a machine that places the patient inside a big, strong magnet and uses a magnetic field to align the magnetization of some atomic nuclei in the body, as well as radio frequency fields to systematically change the alignment of this magnetization.

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MRI is of mainly 2 types:

★ T1-weighted MRI Spin-lattice relaxation time.
★ T2-weighted MRI Spin-spin relaxation time.

3. WHAT IS SEGMENTATION?

The division of one image into several related areas is known as segmentation. Segmentation can be done using one of two definitions of region: A region is a collection of comparable pixels connected together, or a collection of connected pixels surrounded by discontinuities (edges). The first method is split and combine.
Mathematically, if the entire image is represented by a set of pixels (called R), then it should have subsets like:

♦ the segmentation is complete, all sub-regions add up to the total R. R1 U R2 U... U Rn = R is the union of all regions.
♦ Ri is connected.
♦ There are distinct regions. Ri∩Rj=∅ given that i≠j
♦ The qualities of regions are comparable. The homogeneity criterion is a function that can represent this (P). It should return TRUE for members of the provided region and FALSE for everyone else.
♦ Neighbor regions cannot be merged. For all regions P(Ri U Rj)=FALSE given that i≠j.

The fundamental goal of segmentation is to recognize predetermined labels automatically (i.e. human, vehicle, grass, sky and etc.) Superpixels, also known as regions in an image over segmentation, would be more natural and, supposedly, result in more efficient processing. The super pixel approach, which groups pixels based on their degree of feature similarity and acquires redundant picture information, has become increasingly popular in the image processing industry. As a result, the complexity of image post-processing tasks can be considerably reduced.
Superpixels are becoming more popular in computer vision applications. Segmentation offers limited support for computing region-based features. The desired properties of superpixel segmentation vary depending on the application. The following are some general properties that are required by various vision applications.
The following properties are generally desirable:
Superpixels should adhere to image borders well.
Superpixels should be fast to compute, memory efficient, and simple to use when used as a preprocessing step to reduce computational complexity.
When used for segmentation, superpixels should improve both the speed and the quality of the results.

4 MERGE AND SPLIT ALGORITHM

Fully merging methods are, mostly; computationally expensive because the starting point of such a method is small regions (individual points). This method can be made more efficient by recursively splitting the image into smaller and smaller regions until all individual regions are coherent, then recursively merging these to produce larger coherent regions. The steps of this algorithm are shown in figure 1.

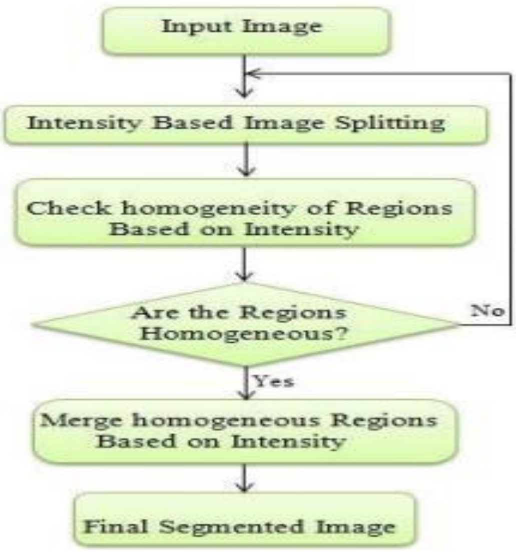

Figure 1: Merge and Split Algorithm

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First, We need to divide the image. Begin by viewing the entire image as a single region.
If the entire region is coherent (that is, if all pixels in the region have enough similarity), leave it alone.
If the entire region is coherent (that is, if all pixels in the region are sufficiently similar), leave it alone.
Split-and-merge segmentation is based on an image’s quad tree partition. It is also known as quad tree segmentation. Rather than the old method of seeds distributed regularly as rows and columns, a quadratic tree (split and merge) algorithm was used in this paper to locate and initialize the seed number and location through the image space. This method begins at the top of the tree, which represents the entire image. If it is discovered to be non-uniform (not homogeneous), it is split into four son-squares (the splitting process), and so on.
If, on the other hand, four son-squares are homogeneous, they can be merged as a series of connected components (the merging process) [10]. This proposed method isolates the symmetry block first, which generally clusters the image more uniformly than the traditional method.

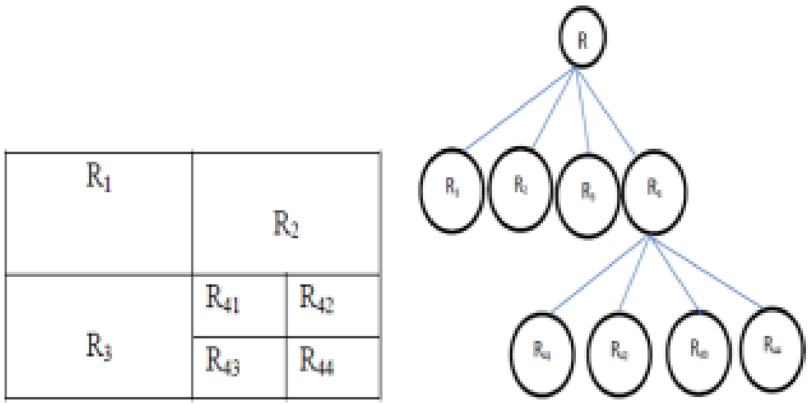

Figure 2: Partitioned image and Quad tree Image.

5. PSEUDO CODE

The following is a pseudo-code for the split and merge algorithm:

- ❖ Initial: we have only one big region (the whole image).
- ❖ Split: If P(Ri)=TRUE proceed to next step. Otherwise subdivide Ri to four sub-regions and perform step 2 on them.
- ❖ Merge: If Ri and Rj are neighbors and P(Ri U Rj) = TRUE, merge the two regions, then repeat step 3. If there are no such regions we are finished.

6. RESULTS AND DISCUSSIONS

When implementing and testing many MRI segmentation systems, Digital Imaging and Communications in Medicine (DICOM) is used as a benchmark database.

The DOCOM, which was built by Doctor Antoine Rosset (CEO and OsiriX company Guru) and Joris Heuberger, is discussed in this paper (CTO and Problem Solver), Many cases from the DICOM database are used to evaluate the proposed method's performance for each patient.

In our experiments, we used a database that contained 22 slices of T1-weighted MRI images and 22 slices of T2-weighted MRI images. Some of the 2D slices may be tumor-free. MHA read the function was used to extract a single slice from a 3D image. A real dataset from Oncology Teaching Hospital, Medical City, Baghdad, Iraq, was also used.

Each patient database contains 20-30 slices of T1-weighted MRI images and 20-30 slices of T2-weighted MRI images in axial, sagittal, and coronal planes. In MATLAB, the proposed split and merge image segmentation algorithm was implemented. Several MRI images were subjected to scrutiny.

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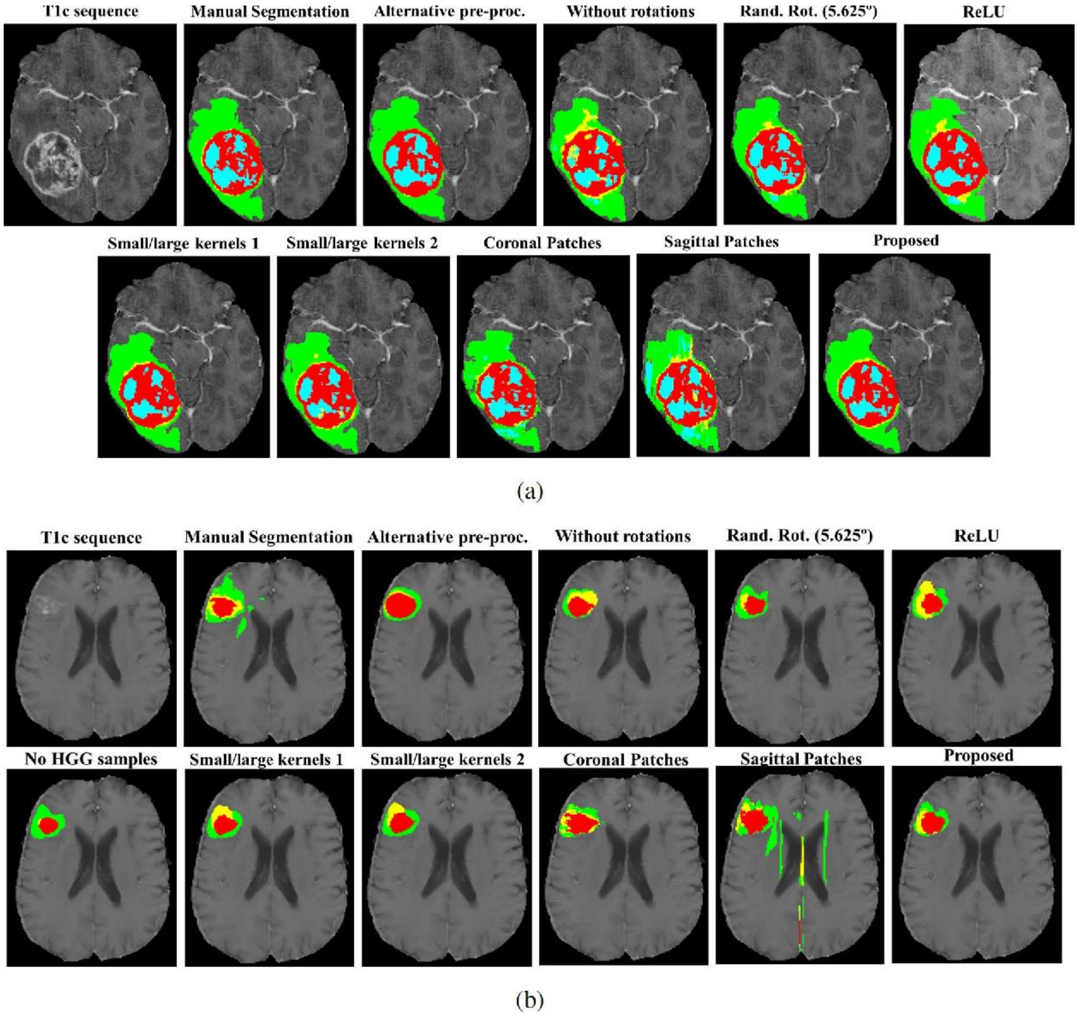

Examples of segmentations obtained with cross-validation, showing the effect of each component of the proposed method. In the first row, we have a

7. CONCLUSIONS

An automatic Superpixel-based split and merge method for automatically segmenting 2D MRI images is proposed in this paper. The implementation results show satisfactory image segmentation results. This implies that the proposed algorithm can be used to successfully achieve automatic image segmentation in various MRI brain images. One of the benefits of this algorithm is that it does not allow for user intervention. Another advantage of this algorithm is that it is capable of consuming less execution time.

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