# Automated Segmentation of Brain Tumors in MRI Using Force Data Clustering Algorithm

Masoumeh Kalantari Khandani[1], Ruzena Bajcsy[2], and Yaser P. Fallah[2,3]

[1] School of Engineering Science, Simon Fraser University, Canada
mka47@sfu.ca
[2] Electrical Engineering and Computer Sciences, University of California, Berkeley, USA
[3] Institute of Transportation Studies, University of California, Berkeley, USA

**Abstract.** In this paper, we present a novel automated method for detecting tumor location in brain magnetic resonance (MR) images, and identifying the tumor boundary. This method employs an unsupervised learning algorithm called Force for coarse detection of the tumor region. Once tumor area is identified, further processing is done in the local neighborhood of the tumor to determine its boundary. The Force method, which is based on the rules of electrostatics, is used for finding spatial clusters of high intensity in the 2D space of MR image. Further analysis of the identified clusters is performed to select the cluster that contains the tumor. This method outperforms many existing methods due to its accuracy and speed. The performance of the proposed method has been verified by examining MR images of different patients.

**Keywords:** Tumor detection, segmentation, data clustering, brain MRI.

## 1 Introduction

Automated detection of the abnormalities in medical images is an important and sometimes necessary procedure in medical diagnostics, planning, and treatment. While detection of abnormalities such as tumors is possible by experts, manual segmentation is usually tedious and time consuming [5][9], and subject to error [6]. There are many methods that find a tumor in MR images (MRI) semi-automatically. In such methods, human intervention is required, which again makes the process time consuming and expensive. The critical problem is finding the tumor location automatically and later finding its boundary precisely. The objective of this work is to present an automated unsupervised method for finding tumor (high-grade gliomas) in slices of T2 FLAIR MRI of Brain (no enhancements by contrast agent). In such images the tumor needs to be identified amongst brain soft tissues, white matter (WM), gray matter (GM) and cerebrospinal fluid.

An important factor in detecting tumor from healthy tissues is the difference in intensity level. However, relying only on the intensity level is usually not enough. The spatial information available in clusters of pixels that form a tumor should also be used in the detection process. In this work we propose a new method that is comprised of three tasks of preprocessing, coarse detection of tumor area, and fine detection of tumor boundary. The coarse detection is done using an enhanced version of the

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Force clustering algorithm [11]. 'Force' is applied to a data set that is created from a preprocessed slice of brain MRI. In 'Force', the rules of electrostatics are used to determine clusters of pixels with higher intensity. Once these clusters are found, the algorithm identifies the cluster/region of the brain that contains the tumor. In the last step, the tumor cluster is further analyzed and the tumor boundaries are determined. The proposed algorithm is designed to be robust to variations in MR images and is able to efficiently and accurately identify tumor boundaries in different brain MRIs; this is shown through comparing this method by ground truth manually produced by experts.

### 1.1 Related Work

There have been significant efforts to develop automated computer algorithms for locating tumors in brain MRI. A review of pattern recognition methods for MRI segmentation is presented in [1], and methods and applications of MRI segmentation can be found in [3]. We describe few notable algorithms in this section.

Among supervised methods, the work in [6] combines information from a registered atlas template and user input to train a supervised classifier. The method in [7] detects tumors based on outlier detection and uses affine transformation for the registration. However, this method fails in case of large tumors. The method described in [8] is based on training on healthy brain images instead of training on pathology. To recognize deviations from normalcy, a multi-layer Markov random field is used which is computationally expensive. In the work reported in [4], the authors employ an atlas based pathological segmentation using affine transformation. They assume tumor growth has a radial expansion from its starting point. All of the above methods are time consuming, and also need expert input for large set of data. Supervised pattern recognition methods have exhibited problems with reproducibility [2], due to significant intra and inter-observer variance introduced over multiple training trials.

The unsupervised method reported in [9] divides the T2 weighted images into few blocks, and calculates the number of edges, the intensity and the contrast parameter in each block. It assumes the abnormalities occupy less that 10% of all pixels, and that the blocks containing tumor pixels exhibit fewer edge pixels. However, tumor may fall in different blocks, making parts of the tumor undetectable. In another method, presented in [10], color-based clustering is used. The MR image is translated to RGB, and RGB to L*a*b* planes. K-means clustering [12] is used on a* and b* planes to find thresholds and mark the tumor. The issue with such methods is that they rely on intensity level classification, which is susceptible to misclassification.

In our paper, a new approach toward tumor detection and segmentation is introduced. Our method is based on the use of a new unsupervised data clustering algorithm called 'Force' [11] for initial tumor detection. The unsupervised nature of this method avoids the problems of observer variability found in supervised methods; therefore, the results of our method are reproducible. The proposed method can also be combined with prior methods to enhance them in initial tumor location detection. Section 2 provides a brief background on "Force". Section 3 describes the proposed method. The evaluation of the proposed method is presented in section 4.