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# A non-invasive methodology for the grade identification of astrocytoma using image processing and artificial intelligence techniques

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ABSTRACT

Brain tumor grade identification is an invasive technique and clinicians rely on biopsy and spinal tap method. The proposed method takes an effort to develop a non-invasive method for the tumor grade (Low/High) identification using magnetic resonant images. The process involves preprocessing, image segmentation, tumor isolation, feature extraction, feature selection and classification. An analysis on the performance of the segmentation techniques, feature extraction methods, automatic feature selection (SFLA) and constructed classifiers (support vector machines, learning vector quantization and Naives Bayes) is done on the basis of accuracy, efficiency and elapsed time. This analysis motivates towards the accurate determination of tumor grade from MR images instead of depending on magnetic resonant spectroscopy and biopsy. Fuzzy c-means segmentation outperformed other segmentation techniques, shape and size based textural feature promoted the demarcation of tumor grades, Naive Bayes classifier succeeded in terms of efficiency, error and elapse time when compared with SVM and LVQ. The study was carried out with 200 images consisting training set (164 images) and testing set (36 images). The results revealed that the system is robust and accurate (91%), consumed less time in grade identification, an alternative for biopsy and MRS in the brain tumor grade identification diagnosis procedure.

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## 1. Introduction

A brain tumor is an abnormal growth of cells in the brain or the spinal canal which can cause uncontrollable cell division in the brain or in the lymphatic tissue or blood vessels that can prove to be life threatening. However, brain tumors can be cancerous or benign depending on the rapidity of their growth and nature. Brain tumors are to be detected at the earliest possible stage and treated before it can prove to be fatal. The proposed method deals with a unique class of brain tumors namely the Astrocytoma which is malignancy of a type of glial cells called Astrocytes found mostly in the cerebrum of the brain. There are four types (grades) of Astrocytoma based on the grading provided by the World Health Organization (WHO) which is generally followed internationally. Pilocytic Astrocytoma is the first type (grade) of Astrocytoma common in children that grows gradually and usually are benign. Low grade astrocytoma is the second type whose borders are not well defined and they spread rarely to the other parts of the central nervous system. The third type is the Anaplastic Astrocytoma which invade neighboring tissues and they are not uniform in appearance. They fall under the high grade Glioma category with poor clinical prognosis. Glioblastoma multiforme is the most malignant fourth type brain tumor which is very common and tends to grow and spread to other parts of the brain quickly. Grade I and Grade II form the low grade Glioma brain tumors whereas Grade III and Grade IV form the high grade Glioma brain tumors. The methodology deals with the classification of Astrocytoma into low grade and high grade Gliomas respectively.

Medical Image analysis for brain tumor detection relies on magnetic resonant images and magnetic resonant spectroscopy in the initial diagnosis procedure. Recent works on brain tumor grade identification entirely depend on MR images and spectroscopy (Arizmendi, Vellido, & Romero, 2012) methods to promote non-invasive techniques. (Metwally et al., 2014) has demonstrated that magnetic resonant spectroscopy is a complimentary tool which saves a patient from biopsy to identify the type/grade. (Luts, Heerschap, Suykens & Van Huffel, 2007) combined MRI with MRS data for the construction of multi classifier system in brain tumor classification based on least squares support vector machines. Grading of astrocytic brain tumors is also based on gene expression microarray data, which

*Abbreviations:* MR, Magnetic Resonance; PD, Proton Density; CSF, Cerebro Spinal Fluid; CT, Computer Tomography; FCM, Fuzzy Clustering Means; SVM, Support Vector Machines; LVQ, Learning Vector Quantization; PSO, Particle Swarm Optimization; GLCM, Gray Level Co-occurrence Matrix; ROI, Region Of Interest; SFLA, Shuffling Frog Leaping Algorithm; PCA, Principle Component Analysis; MRI, Magnetic Resonance Image; MRS, Magnetic Resonant Spectroscopy; PCNN, Pulse Coupled Neural Network.

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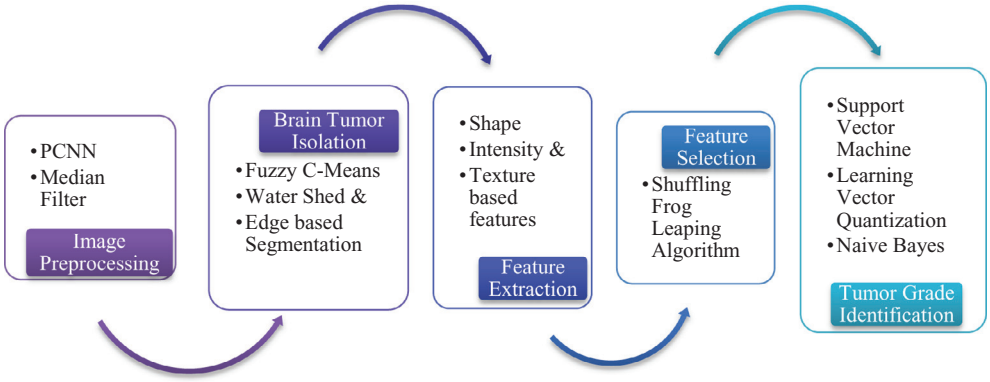


**Fig. 1.** Non-invasive procedure for the grade discrimination of astrocytoma (tumor).

utilized simple artificial neural network as classifier (Petalidis, Oulas, & Backlund, 2008). Machine learning schemes also supports efficient classification in tumor type identification. In the investigation made by (Yen & Langari, 2004), (Zhao et al., 2010) (Zacharaki et al., 2012), (El-Dahshan, Mohsen, Revett & Salem, 2014) the region of interest (tumor) was isolated from MR brain image which was followed by feature extraction. The predominant features were selected and support vector machines were employed for texture pattern classification. An efficient method with improved accuracy has to be implemented for the non-invasive tumor grade identification from MR images. The existing method (Zacharaki et al., 2009), provide 88% of accuracy with 102 brain images: The procedure involved: ROI definition (software package FSL), feature extraction (Gabor), feature selection (Ranking Selection) and classification (SVM).

We propose an expert system to improve the accuracy based on ROI definition (FCM & Watershed segmentation), feature extraction (GLCM, PCA and statistical methods), optimized feature selection (Shuffling Frog Leaping Algorithm) and classification (SVM, LVQ and Naive Bayes).

### 1.1. Motivation

The proposed non-invasive method involves grade identification of Astrocytoma (tumor) from MR images. MR images is efficient in the detection of tumor because of its high contrast, high spatial resolution and less radiation. Magnetic resonant images provide information about the size and location of tumor but unable to classify the type/grade of tumor. Hence clinicians proceed towards invasive methods in which biopsy and spinal tap methods are painful and time consuming. This inability motivated us towards the development of an expert system to improve the diagnostic ability of MRI. Moreover, there is no need to go for a biopsy at the earliest stage as the aim of this method is to classify the tumors with the help of the MR images alone. The analysis began with the isolation of tumor (region of interest) using segmentation methods (Section 2.3). The segmented tumor image is now subjected to feature extraction (Section 2.4), automatic feature selection (Section 2.5) and classification (Section 2.6) of features. The results (Section 3) proved that the method is accurate in grade demarcation since the ROI is considered for evaluation procedure. The developed automated system, assist premier diagnosis and it is efficient in provision of quick results in clinical outcomes.

## 2. Materials and methods

The proposed scheme is highlighted in Fig. 1 to comprehend the procedure involved in the non-invasive method of grade identification of Astrocytoma.

### 2.1. Image database

An MR scan or CT scan can provide a picture of the anatomy of the brain. MR scanned image is taken for the entire process implemented. MR scan is more sensitive than CT. It is non-invasive and has little exposure to radiation. There are three types of MR image scans, namelyT1 weighted MRI (gray matter (dark gray) and white matter (lighter gray) tissues are efficiently contrasted), T2 weighted MRI (gray matter (lighter gray) and white matter (darker gray)) and PD weighted MRI (The gray (bright) and white (darker gray) matter is differentiated with little contrast between brain and CSF).The proposed method utilized 200, T2 weighted images. Training set consisted of 164 images (82-low grade & 82-high grade) and testing set consisted of 36 images (18-low grade and 18-high grade).

### 2.2. Pre-processing

The medical data used is magnetic resonant head data carrying information on Astrocytoma. The data is obtained from a diagnostic lab and consists of abnormal MR brain images of human volunteers. The imaging modalities and artefacts are to be removed and hence subjected to pre-processing. The conventional methods of resizing and filtering are substituted using pulse coupled neural network and a median filter.

#### 2.2.1. Pulse coupled neural network

Removal of noise from the image is an important factor in image processing. The PCNN network (Subashini & Sahoo, 2014) can be used to achieve this as filtering of noise will always help in getting more accurate result. The advantage of this network is that it removes only the noisy pixels without disturbing the other pixels and thus the relevant details and the edges are preserved. The noise is pin pointed and filtered based on the spatial information and time information of the original image. A median filter is used in conjunction with PCNN to remove common noise occurring in medical images like the Binary or salt and pepper noise (Wen & Wen, 2013).

### 2.3. Tumor segmentation and isolation

Image segmentation is the process of dividing a digital image in to multiple segments that have a strong correspondence with original image. There are numerous types of segmentation techniques are available such as threshold based segmentation, edge based segmentation, region based segmentation and clustering based segmentation. The segmentation methods applied for tumor isolation in this grade identification process is discussed in Sections 2.3.1 and 2.3.2.

#### 2.3.1. Fuzzy c-means segmentation

Fuzzy c-means clustering is the best known unsupervised clustering algorithm. It is generally used to find the interesting patterns

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