

Efficient Brain Tumor Classification using PCA and SVM

Athul Sukumar A M¹ and Peter Augustine²,

^{1,2}(Department of Computer Science, Christ University, Bangalore, Karnataka, India)

Abstract: A brain tumor is a cancerous or noncancerous growth caused by cells reproducing in an uncontrolled manner. Magnetic Resonance Imaging (MRI) is an important technique for image diagnostic in the detection of the brain tumor. MRI brain image plays a vital role for radiologists in diagnosis and treatment. To analyse the medical image the process of segmentation is widely used. Manual segmentation of tumor by doctors is very time consuming and risky job. Segmentation of tumor is an important step in treatment and surgical planning. So, the use of computer technology become very useful to overcome these limitations. When the spatial property of input file to associate degree rule is just too giant then it will be tough to a method that may cause redundancy and low accuracy rate. In image processing, a feature extraction may be a special variety of spatial property reduction. The visual content of the image is going to be captured by feature extraction methodology. The target of the paper is to render a novelty in reducing the extracted features using PCA and classifying the given tomography image as malignant or benign using SVM. The result shows that the proposed method can improve the classification accuracy and is more efficient and robust when compared to earlier works.

Keywords: PCA, SVM, Image Segmentation, MRI.

I.INTRODUCTION

The brain is the frontal-most part of the central nervous system. The position of tumors in the brain is one of the elements that decides how a brain tumor affects a human being functioning and what symptoms the tumor causes. Magnetic Resonance Imager (MRI) is the frequently used device for diagnosis. In MR images, the size of data is too much for manual understanding and inspection. Throughout past few years, brain tumor segmentation in magnetic resonance imaging (MRI) has become a rising research area in the domain of the medical imaging process. Exact identification of size and location of brain tumor plays a crucial role in the diagnosis of the tumor.

Brain tumors are unusual and out of control expansion of cells. Some stand up inside the brain itself, during which case they may be known as primary. Others diffuse to the present position from in different places within the body through metastasis and are termed secondary. Primary brain tumors don't scatter to different body components and might be malignant or benign. Secondary brain tumors are perpetually malignant. Due to the diploma in the cranium is finite, their growth expands some of the crania and will motive puffiness, decreased blood float, and displacement, with on the spot degradation of wholesome tissue that controls crucial functions. Brain tumors are, in truth, the second essential reason behind most cancers-related deaths in kids and teens.

The usage of technology in clinical determination support is presently extensive and pervasive across a huge range of the clinical area corresponding to cancer evaluation, clinical specialty, brain tumors and so on. Imaging is that the feasible choice presently for the research of tumor in tender tissues. The technique obviously discovers tumor types, length, and placement. Imaging may be a flux that establishes an image and has no notable aspect outcomes concerning radiation publicity, its lots of better information in soft tissues. The investigator had proposed totally exclusive options for a classifying tumor in imaging. The carried out math, depth, Symmetry, Texture alternatives and so forth, that create use of the gray really worth of tumors are used right here for classifying the tumor.

Primarily based mostly on facts, tumors are the second reason of most cancers related deaths in youngsters (each man and women) whose are under the age of 20 and in guys whose age 20 to 39. This ailment is also the fifth number one motive of maximum cancers related deaths in women a long term 20 - 39. This fact expands the importance of the researchers on the tumor detection and this may present the chance for clinical docs to help store lives with the resource of detecting the disorder in advance and execute vital actions. Several sorts of photo processing techniques are available to be finished on numerous imaging modalities for tumor detection so as to discover effective talents of the tumors which include the shape, border, calcification, and texture. These skills will make the invention techniques more correct and less hard as there are a few notable tendencies of every characteristic for a particular tumor.

All tumors will start small and increase with time. As they enlarge, they will turn out to be extra seen and boom the risk of showing their characters. A person with tumor commonly has nice signs and symptoms and signs and symptoms and signs and symptoms and this can lead that individual to a medical doctor. From this, they will be capable of coming across the tiny possible symptomatic malignant (cancerous) tumors which may be in early degree and the tiny possible asymptomatic tumors within the screening manner.

essentially, there are various elements that could have an effect on the prevalence of tumors in one in every of a type shape of processed snap shots regardless of a few everyday functions of malignancies due to dissimilarity inside the kind of tissue and tumor. For a huge tumor, trait capabilities often to be observed even as in small tumors, these features of malignancy do now not look like many and some of them might also represent themselves thru secondary upshot which incorporates deformation in its structure.

Inside the case of a suspected tumor, “a scientific health practitioner can also moreover perform a neurologic examination to determine if the patient's senses, reflexes, highbrow recognition and reminiscence are functioning properly. The medical health practitioner also can moreover order imaging tests, containing computed tomography (CT) or magnetic resonance imaging (MRI) of the mind, to determine the tumor and show its period.

An imaging generation has improved immensely in current years. a unique type of photographs may be produced without a doubt via the use of a single-click on and particular image processing techniques can be finished to those snap shots to have a look at in detail approximately it. System learning and tool vision technology have additionally been used to remedy several issues in the medicine. Photograph-based total tumor detection uses one or greater algorithms due to the primary modelling. Some can find out edges, some can locate shapes at the same time as others can come across special competencies. With the development of digicam sensing and computational technologies, development in tumor detection with the use of those abilities has been surely lively research vicinity in the wise clinical community. Without a doubt, latest researches and trials have sincerely assisted in advancing diagnostic equipment for medical functions however still, the truth that income in survival wants to be executed with the useful resource of higher diagnostic equipment.

A brain tumor is defined as unusual growth of cells within the brain or central spinal canal. Some tumors can be cancerous thus they need to be discovered and heal in time. The correct reason of brain tumors is not clear and neither is exact set of symptoms defined, thus, people may be suffering from it without realizing the danger. Primary brain tumors can be either malignant (contain cancer cells) or benign (do not contain cancer cells).

Brain tumor arises when the cells were separated and growing abnormally. It appears to be a solid mass when it diagnosed with diagnostic medical imaging techniques. There are two types of brain tumor which are the primary brain tumor and metastatic brain tumor. A primary brain tumor is a condition when the tumor is formed in the brain and tended to stay there while the metastatic brain tumor is the tumor that is formed elsewhere in the body and spread to the brain.

The symptom having a brain tumor depends on the location, size, and type of the tumor. It occurs when the tumor compressing the surrounding cells and gives out pressure. Besides, it also occurs when the tumor blocks the fluid that flows throughout the brain. The common symptoms are having a headache, nausea, and vomiting, and having a problem with balancing and walking. A brain tumor can be detected by the diagnostic imaging modalities such as CT scan and MRI. Both of the modalities have advantages in detecting depending on the location type and the purpose of examination needed.

Need of the Study

The need of this study is to classify the tumor in the early stage. In most of the cases, the tumors are not able to detect and may lead to danger. The main reason for the increasing death rates in brain tumor is the disease is not getting detected in the early stage and not getting proper treatment. If the tumors can able to find in the early stage and can able to classify it as Benign or Malignant, the doctors can able to give better treatment and can able to save a precious life. In my study, I am using the techniques of PCA and SVM in order to get a better accuracy. PCA is used to reduce the features and SVM is used to classify it.

II.LITERATURE REVIEW

2.1 Brain Tumor and MRI

In current times, a brain tumor is one of the most challenging cases for escalation in fatality among the children and adults suffering from this disease. A brain tumor or intracranial neoplasm is a collection of mass accumulated from abnormal cells within the brain. Basically, there are two main types of tumors called malignant and benign tumors (Kleihues P and Ohgaki, 1999). Benign tumors are harmless in nature. Malignant tumors are denoted as cancerous tumors which can be classified as primary and secondary tumors. Primary tumors originate from within the brain itself whereas the secondary tumors are caused by migration of cancerous cells from somewhere else. Secondary tumors are named as brain metastasis tumors.

There has been a study going on in developed countries to understand the death rate of people suffering from brain tumor. Lin et al. (2004) have given in the study that the death rate has increased due to brain tumor over the last thirty years. Normal healthy cells are eaten up by cancerous cells of tumors. These cells spread across brain and instigating swelling in the brain, infection, destruction of the functions of the brain and increasing the pressure within the skull. Since brain tumors may occur in different locations with varying sizes, doctors need more clarity and efficiency to diagnose them clearly.

There are CT scan and MRI scan used to find the problems in the brain when doctors need to proceed with confirmation for further analysis and treatment. As it is well known, the skull is the protector of the brain

from any injury. But at the same time, skull prevents healthcare professionals to study the functions of the brain in different health scenario. MRI is capable of defining the accurate point and position of the tumor and produce images in different planes. When the contrast discrimination is increased in MRI, it can give a still clearer definition of the location of tumor corresponding to key neuroanatomic structures. It is highly essential to treat the patient with a surgical procedure or radiotherapy (Maravilla and Sory, 1986).

MRI has transformed the procedure for diagnosis on the brain. CT and MRI are the great support for the doctors as well as the researchers working on the brain anatomy to have a clear map of brain image without invasive procedures. This revolution of non-invasive procedure of CT and MRI helps doctors to deduce causes of the unusual function of the brain due to different diseases. When there are two different modalities of brain imaging for such as CT (Voros, 2009) and MRI, the question arises why MR images are taken for processing in the research? MRI has its own advantages and overcomes the disadvantages of CT to give a better report for analysis (William and Wilbur, 2009).

- First and foremost advantage of MRI is that there is no use of ionizing radiation. So it is highly favored for children and the patients who need to go through several imaging examinations.
- MRI can give a report of very depth analysis of brain. MRI has the caliber to produce the image of soft tissues with miniature differences in anatomy because it has the sophisticated series of contrast for soft tissues. Because of such sensitiveness, MRI can be highly preferred for abnormalities within the brain itself.
- Physical movement of the patient will have no impact since MRI scanning is not very specific about the imaging plane.
- The risk of instigating possibly lethal allergic reaction by MRI contrast agents is less.

MRI has the advantage of distinguishing between tumor and perifocal edema which is swelling of the brain tissue, whereas CT is not capable of finding the same (Sanghvi, 2009). MRI provisions completely cerebral perfusion imaging which give a clear portrait of blood flow in the pathway of the vascular network in the brain. So MRI is able to provide a complete radiological evaluation of brain tumors through procedural diagnosis (Sanghvi, 2009).

Related Works

For the diagnostic methodology in pathology, we're able to renowned vital steps. To begin with pathologists recognize tissue and decide sure microscopic anatomy elements concerning the diploma of neoplasm malignancy. At some point of a second step depict their microscopic anatomy discovery and are available up to a preference regarding neoplasm class. In most of the cases, pathologists are oblivious of in particular what number attributes are reviewed in their name but they're capable of classifying tumors nearly immediately and unconscious of the pleasant of the assignment completed.

Pathologists are able to verbalize their impact of specific options. as an instance, they may call cellular division and caspase-mediated cell demise as "present" or "absent" but they're doing now not savvy exactly these thoughts should be pressured to be considered within the call technique. To the existing end, despite the fact that a similar set of options is known by using completely distinctive histopathologists, everybody is suitable to acquire a completely unique diagnostic output. It proposes records-pushed grading models such as carried out math vector machines, artificial neural networks and makes contact with bushes similarly to photograph analysis strategies to combine quantitative microscopic anatomy alternatives.

However, besides the retention and development of carried out diagnostic accuracies in helping the clinical name, one among the most goals, is to amplify the ability and increase readability in selection-making. The latter is essential significance in medical custom, wherever a top class is located on the reasoning and understandability of consulting systems.

III. DATASET AND PREPROCESSING

3.1 Pre-Processing

Pre-processing basically technique getting rid of noise and refining or rework picture nice to wholesome a cause. For this artwork, best regularly used enhancement and noise reduction strategies had been carried out. The photograph enhancement that the have a take a look at is inquisitive about have to yield the end result of extra famous edges and a sharpened picture, noise may be reduced therefore reducing the blurring or salt paper impact from the photograph that might produce mistakes.

After image enhancement, photo segmentation can be finished. This step is essential because the delicate and more positive picture will yield higher effects when figuring out edges and beautify the pleasant of the very last photo. Side detection will manual to coming across and grasping the defining form of the tumor. The following steps may be done in the pre-processing level:

- (a) Noise elimination: there may be a broad form of filters available to be used to cast off the noise from the pix. Linear filters present on Matlab with the easy line of code also can carry out the motive including Gaussian and averaging filters. Salt and pepper noise is a recurrent noise exists in authentically captured photos. Common filters, for example, can cast off that noise but with the give up

of sharpness of the image. The median filter out is likewise a few differentan instance of a clean out used to get rid of the noise like salt and pepper. Inside the median clear out fee of the pixel is decided by using the median of the values of its neighbouring pixels. This clear out, however, is plenty much less sensitive to the outliers.

- (b) Any filter able to take away the noise exist inside the true photograph might be used because of this. However, in tumor detection, the sharpness of the rims, acquired from the unexpected change of intensity, is a focal speck and need to be saved maintained. the subsequent step will assist decorate the sharpness of the rims.
- (c) Picture polishing: sharpening is commonly carried out thru the use of immoderate skip filters. After relating low skip filters (noise getting rid of step), we now need to sharpen the photograph to assure edges are saved. That is important as edges will come upon and spotlight the tumor for us. Gaussian filter (an immoderate skip clear out) is used to bolster the boundaries of the gadgets. It's miles appreciably used and the paper proposes to imitate.

3.2 Feature Extraction

Features, the elements of the items of appeal, if choose fastidiously are the consultant of the utmost relevant info that the picture should offer for a whole characterization of a lesion. Feature extraction strategies take a look at objects and pics to extract the most wonderful options that are the consultant of the varied classes of objects. Features are used as inputs to classifiers that assign them to the class that they constitute. The cause for characteristic extraction is to cut back the preliminary data through calculative sure residences, or options that differentiate one input pattern from any other pattern. The extracted characteristic must trouble the characteristics of the input type to the classifier via thinking about the motive of the relevant residences of the image into characteristic vectors. All through this planned technique we have a tendency to extract the beneath options.

- Shape Features
- Intensity features
- Texture features

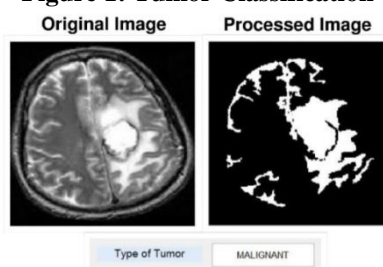
Therefore, three sorts of options are extracted, that explains the structured knowledge of intensity, shape, and texture. These options undoubtedly have some redundancy, however the motivation of this step is to seek out the attitude by helpful options. Within the next step, the featured choice is going to be executed to scale back the redundancy.

3.3 Classification

There are more than one capability strategies for the category of data. Principal component analysis (PCA) and Linear Discriminant Analysis (LDA) are the two ordinarily used techniques for knowledge type and spatial belongings reduction. Linear Discriminant analysis simply holds the case wherever the inside-magnificence frequencies are multiple and their overall performance has been reviewed on haphazardly generated check know-how. This method will boom the quantitative relation of between-class variance to the inside-magnificence variance in any isolated expertise set thereby making sure outside disconnection. The employment of Linear Discriminant analysis for know-how type has pertained to type downside in speech popularity.

We have a tendency to decide to put in the force associated algorithmic program for LDA in hopes of offering higher type in comparison to predominant components analysis. The important thing difference among LDA and PCA is that PCA does additional of function type and LDA will understand the class. In PCA, the form and placement of the first know-how set to change once made over to a completely unique residence while LDA does now not alternate the position but totally attempts to supply additional class disconnection and draw a name area between the given categories. The class assignment is allotted into the coaching phase and additionally the trying out segment. Inside the coaching phase, diagnosed information are given. Inside the checking out phase, covert know-how is given and also the class is accomplished exploitation the classifier while coaching. The accuracy of the classification depends on at the potency of the training. The conversion from original image to processed image is mentioned below (Figure 1).

Figure 1: Tumor Classification



IV. METHODOLOGY

4.1 Proposed System

Grouping strategy constructs absolutely with respect to Support Vector Machines (SVM) are prescribed and connected to brain image classification and division. The feature extraction from MRI pictures will be performed through the grey scale, symmetrical and surface elements. The fundamental objective of this contraption is to offer a marvellous outcome (i.e. better precision rate and lower botches rate) of MRI mind tumor characterization.

Logical medicinal pictures are debased by a method for a different kind of clamors like Rician commotion and so forth it's miles particularly vital to have a decent awesome of pictures for precise examination of the given usage. The middle channel is utilized to get rid of commotions in the meantime as keeping up as a considerable measure as conceivable the fundamental flag capacities. Head ensuring is utilized to refine non-brain tissue like the skull, fat, scalp, eyes, neck, etc from MRI. For skull securing, a morphological leisure activity which incorporates disintegration and widening are utilized. It encourages to strengthen the rate and exactness of analytic and prescient strategies in logical applications. Segmentation is the technique for keeping separated a photograph into various portions. It used to discover items and constraints in pictures. Trademark extraction alludes to various quantitative measurements of clinical depictions ordinarily utilized for determination making. On this work, 18 elements are figured for each picture. Extracted feature set is applied to PCA.

PCA is utilized to lessen the list of capabilities which is separated from photographs. The minimized capacities are provided to a guide vector framework for preparing and testing. Consequently this method will lessen the calculation time and many-sided quality. The classification procedure is parcelled into two sections i.e. the preparation and the testing part. At first, in the preparation part, known information are given to the classifier for preparing. Moreover, in the testing part, undisclosed information are given to the classifier and the grouping is executed in the wake of preparing part. The precision rate and blunder rate of the grouping rely on upon the productivity of the preparation.

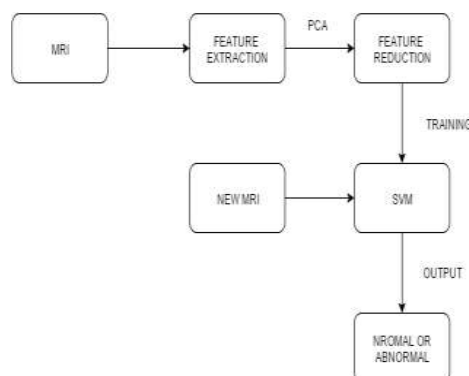
4.2 Architecture

Image pre-processing is used to refine the excellence of photos. Scientific photos are corrupted through a distinctive kind of noises. Its miles exceptionally tremendous to have a decent standard of pictures for an exact exam for the given programming. The middle channel is direct to get it. It rations brilliance contrasts bringing about least obscuring of territorial hindrances. It likewise protects the places of obstructions in a picture, making this framework helpful for noticeable examination and measurement. X-ray cerebrum picture is an RGB picture. This picture is at first remade into the grayscale picture. A grayscale picture is in like manner called a power picture. A variety of modernity pixel values characterizes profundity values. For single and two fold exhibits, values assortment from [0, 1].

Segmentation is the method which divides an image into its constituent sectors or objects. Segmenting nontrivial images is one of the tough jobs in image processing. Segmentation accuracy decides the eventual success or failure of the computerized examination approach. Segmentation algorithms are engineered on one amongst two basic properties of associate intensity worth separation and similarity. the primary class is to partition a picture supported abrupt changes in intensity, appreciate edges in a picture. The second class is predicated on separating a picture into regions that are similar in line with the predefined commonplace.

Feature extraction computes function on the concept of which photo is virtually classified as traditional or odd. The characteristic extraction is that the methodology to depict the raw image to facilitate higher cognitive method reminiscent of pattern type. Options are going to be extracted from the increase areas from magnetic resonance imaging photos. Feature extraction is all about decreasing the number of facts needed to provide an explanation for an outsized set of facts exactly. The main aim of feature extraction is to reduce the local facts via smart nice properties, or options that differentiate one input specimen from some other.

Figure 2: System Architecture



Over the top components utilized for characterization no longer just increment calculation time additionally increment stockpiling memory. They every now and then make classification greater complex. It is required to reduce the variety of functions. PCA is a professional device to reduce the size of a statistics set including a big wide variety of interconnected elements at the same time as maintaining most of the versions. Reduce dimension way decreased characteristic set which fits as an input to the SVM all through education component as well as checking out part.

Support Vector Machine is a state of art technique used for classification, and it has been shown to demonstrate better accuracy and computational advantages over some other traditional classification approaches. SVM is a twofold classifier basically in light of regulated picking up information of which gives a propelled result than different classifiers. SVM characterizes between two preparing by building a hyperplane in unnecessary dimensional component territory which might be utilized for a classification. SVM is a characterization calculation that is constructed absolutely with respect to particular bit systems. The architecture of the project is depicted above (Figure 2).

4.3 Feature Reduction

In this paper for feature reduction, we are applying principle component analysis. As the images hold high dimensionality they will expand the computation time and the storage capacity. So it's miles vital to lessen the number of functions to conquer the above-noted trouble. PCA is an expert tool to lessen the size of facts set along with a huge range of interconnected variables whilst the preserving maximum of the versions. lessen measurement approach decreased characteristic set which acts as the contribution to the SVM for the duration of training element in addition to checking out part.

Steps for PCA are:

- Calculate the mean of the records matrix.
- Deduct the imply from each photograph.
- Calculate the covariance matrix.
- Calculate the Eigenvectors and values for the covariance matrix.
- Schedule the Eigen vectors in step with the Eigen values and as in keeping with the threshold cost.
- Calculate the function matrix (the distance to be able to use it to venture the trying out the photo on it).

V.RESULT

In this experiment we have used 120 MR images (both benign and malignant). The result is discussed below which consist of 60 benign tumors and 60 malignant tumor images. Inputting these images to the proposed system starts with feature extraction using principal component analysis which gives a better result. Further SVM is used to classify the images which give a better accuracy. The results are discussed below (Table 1). Various measures and their value are discussed in Table 2.

Table 1: Confusion Matrix for the input images

N = 120 images considered	True Positive	True Negative
Predicted Positive	56	4
Predicted Negative	6	54

Table 2: Multiply the values by 100 to get percentage

Measure	Value
Sensitivity	0.9032
Specificity	0.9310
Precision	0.9333
Negative Predictive Value	0.9000
False Positive Rate	0.0690
False Discovery Rate	0.0667
False Negative Rate	0.0968
Accuracy	0.9167
F1 Score	0.9180
Matthews Correlation Coefficient	0.8338

VI.CONCLUSION

Brain tumors are caused by the abnormal and uncontrolled growing of the cells in the brain. Treatment of a brain tumor depends on its size and location. However benign tumors do not tend to spread, they can lead to destruction by pressing on areas of the brain if they are not treated early. To avoid manual mistakes, an automatic intelligent category technique is proposed which caters the need for a class of the picture. The work on this research includes characteristic extraction, feature reduction accompanied by classification which is achieved the use of SVM with one-of-a-kind kernel functions to categorize the center which is MRI photo into regular and irregular. The result shows that the proposed method can improve the classification accuracy up to 91.67% and is more efficient and robust when compared to other works. The future works include working with

real patients with a real history. Also working with 3D MRI images rather than 2D MRI images, which helps in extracting more number of features.

Limitation of the Study

Since in the system we developed we can able to process only 2D images and the number of features that can be extracted from a 2D image is less than that of a 3D image. The 3D image will give a better view of the structure and more number of features can be extracted that will lead more accurate outcomes. The extracted features from a 2D image that are reduced using PCA may result in data loss.

Directions for Future Research

The future enhancement of this study is dealing with 3D MRI images instead of 2D MRI images, that will result in more accurate results and can able to extract more number of features. For the existing 2D MRI images, converting those images to 3D image using marching cubes algorithm is another enhancement. Using of latest Machine learning techniques can also be included. The future works can also include working with data of more real patients with real history.

VII. REFERENCES

- [1]Zhang, Yudong, and Lenan Wu. "An MR brain images classifier via principal component analysis and kernel support vector machine." *Progress In Electromagnetics Research* 130 (2012): 369-388.
- [2]Saini, Pankaj Kr, and Mohinder Singh. "Brain Tumor Detection In Medical Imaging Using Matlab." *International Research Journal of Engineering and Technology* 2.02 (2015): 191-196.
- [3]Selvaraj, D., and R. Dhanasekaran. "A review on tissue segmentation and feature extraction of MRI brain images." *International Journal of Computer Science & Engineering Technology* 4.10 (2013): 1313-1332.
- [4]AchaAcharya, Tinku, and Ajoy K. Ray. *Image processing: principles and applications*. John Wiley & Sons, 2005.rya, Tinku, and Ajoy K. Ray. *Image processing: principles and applications*. John Wiley & Sons, 2005.
- [5]Rathi, V. P., and S. Palani. "Brain tumor MRI image classification with feature selection and extraction using linear discriminant analysis." *arXiv preprint arXiv:1208.2128* (2012).
- [6]Afshan, Nailah, Shaima Qureshi, and Syed Mujtiba Hussain. "Comparative study of tumor detection algorithms." *Medical Imaging, m-Health and Emerging Communication Systems (MedCom), 2014 International Conference on*. IEEE, 2014.
- [7]Rathi, VP Gladis Pushpa, and Dr S. Palani. "A novel approach for feature extraction and selection on MRI images for brain tumor classification." *CCSEA, SEA, CLOUD, DKMP, CS & IT 5* (2012): 225-234.
- Kumari, Rozy, and Narinder Sharma. "A Study on the Different Image Segmentation Technique." *International Journal of Engineering and Innovative Technology (IJEIT)* Volume 4.
- [8]Liu, Jianwei, and Lei Guo. "A New Brain MRI Image Segmentation Strategy Based on K-means Clustering and SVM." *Intelligent Human-Machine Systems and Cybernetics (IHMSC), 2015 7th International Conference on*. Vol. 2. IEEE, 2015.
- [9]Chavan, Nikita V., B. D. Jadhav, and P. M. Patil. "Detection and classification of brain tumors." *International Journal of Computer Applications* 112.8 (2015).
- Laddha, Roopali R., and S. A. Ladhake. "A Review of Brain Tumor Detection Using Segmentation And Threshold Operations." *International Journal of Computer Science and Information Technologies* 5.1 (2014): 607-611.
- [10]Logeswari, T., and M. Karnan. "An improved implementation of brain tumor detection using segmentation based on soft computing." *Journal of Cancer Research and Experimental Oncology* 2.1 (2009): 006-014.