

# Healthy and Pathological Tissue Classification in MRI Brain Images Using HCSOONN Algorithm

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**ABSTRACT:** Nature enthused algorithms are the most potent for optimization .Cuckoo Search (CS) algorithm is one such algorithm which is efficient in solving optimization problems in varied fields. This paper appraises the basic concepts of cuckoo search algorithm and its application towards the segmentation of brain tumor from the Magnetic Resonance Images(MRI).The human brain is the most complex structure where identifying the tumor like diseases are extremely challenging because differentiating the components of the brain is complex. The tumor may sometimes occur with the same intensity of normal tissues. The tumor, edema, blood clot and some part of the brain tissues appear as same and make the work of the radiologist more complex. In general the brain tumor is detected by radiologist through a comprehensive analysis of MRI images, which takes substantially a longer time. The key inventiveness is to develop a diagnostic system using the best optimization technique called the cuckoo search that would assist the radiologist to have a second opinion regarding the presence or absence of tumor. This paper explores the CS algorithm, performing a profound study of its search mechanisms to discover how it is efficient in detecting tumors and compare the results with the other commonly used optimization algorithms.

## I. INTRODUCTION

Manipulating data in the form of an image through several possible techniques. An image is usually interpreted as a two-dimensional array of brightness values, and is most familiarly represented by such patterns as those of a photographic print, slide, television screen, or movie screen. An image can be process adoptically or digitally with a computer.To digitally process an image, it is first necessary to reduce the image to a series of numbers that can be manipulated by the computer. Each number representing the brightness value of the image at a particular location is called a picture element, or pixel. A typical digitized image may have  $512 \times 512$  or roughly 250,000 pixels, although much larger images are becoming common. Once the image has been digitized, there are three basic operations that can be performed on it in the computer. For a point operation, a pixel value in the output image depends on a single pixel value in the input image. For local operations, several neighboring pixels in the input image determine the value of an output image pixel. In a global operation, all of the input image pixels contribute to an output image pixel value. These operations, taken singly or in combination, are the means by which the image is enhanced, restored, or compressed. An image is enhanced when it is modified so that the information it contains is more clearly evident, but enhancement can also include making the image more visually appealing. An example is noise smoothing. To smooth a noisy image, median filtering can be applied with a  $3 \times 3$  pixel window. This means that the value of every pixel in the noisy image is recorded, along with the values of its nearest eight neighbors. These nine numbers are then ordered according to size, and the median is selected as the value for the pixel in the new image. As the  $3 \times 3$  window is moved one pixel at a time across the noisy image, the filtered image is formed.

### 1.1 Brain Tumor

A brain tumor is an intracranial solid neoplasm or abnormal growth of cells within the brain or the central spinal canal. Brain tumor is one of the most Common and deadly diseases in the world. Detection of the brain tumor in its early stage is the key of its cure. There are many different types of brain tumors that make the decision very complicated. So classification of brain tumor is very important, in order to classify which type of brain tumor really suffered by patient. A good classification process leads to the right decision and provide good and right treatment. Treatments of various types of brain tumor are mostly depending on types of brain tumor.

Treatment may different for each type, and usually determined by:

- Age, overall health, and medical history
- Type, location, and size of the tumor
- Extent of the condition
- Tolerance for specific medications, procedures, or therapies
- Expectations for the course of the condition.
- Opinion and preferences

Classification of tumor is to identify what type of tumor it is the conventional methods, which are present in diagnosis, are Biopsy, Human inspection, Expert opinion and etc. The biopsy method takes around ten to fifteen days of time to give a result about tumor. The human prediction is not always correct, sometimes it becomes wrong but a computer cannot. The expert, himself cannot take the decision rather he refers to another expert to give his opinion, this process continues for long time.

Brain tumor is one of the major causes for the increase in mortality among children and adults. A tumor is a mass of tissue that grows out of control of the normal forces that regulates growth. The complex brain tumors can be separated into two general categories depending on the tumors origin, their growth pattern and malignancy. Primary brain tumors are tumors that arise from cells in the brain or from the covering of the brain. A secondary or metastatic brain tumor occurs when cancer cells spread to the brain from a primary cancer in another part of the body. Most Research in developed countries show that the number of people who develop brain tumors and die from them has increased perhaps as much as 300 over past three decades.

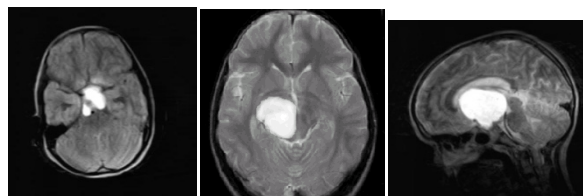


Fig: 1.1 Example of Brain Tumor images

Magnetic resonance imaging (MRI) of the brain is often used to monitor tumor response to treatment process. The segmentation of the brain tumor from the magnetic resonance images is important in medical diagnosis because it provides information associated to anatomical structures as well as potential abnormal tissues necessary to treatment planning and patient follow-up. It can also be helpful for general modeling of pathological brains and the construction of pathological brain atlases. One example is to analyze and estimate quantitatively the growth process of brain tumors, and to assess the response to treatment and in guiding appropriate therapy in serial studies. In spite of numerous efforts and promising results in the medical imaging community, accurate and reproducible segmentation and characterization of abnormalities are still a challenging and difficult task because of the variety of the possible shapes, locations and image intensities of various types of tumors. This task involves various disciplines including medicine, MRI physics, radiologist's perception, and image analysis based on intensity and shape. Brain tumor segmentation process consists of separating the different tumor tissues, such as solid tumor, edema, and necrosis from the normal brain tissues, such as gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF). Although manual segmentation by qualified professionals remains superior in quality to automatic methods, it has two drawbacks. The first drawback is that producing manual segmentations or

semi-automatic segmentations is extremely time-consuming, with higher accuracies on more finely detailed volumes demanding increased time from medical experts.

## 1.2 SEGMENTATION:

Image segmentation is a fundamental yet still challenging problem in computer vision and image processing. In many practical applications, as a large number of images are needed to be handled, human interactions involved in the segmentation process should be as less as possible. This makes automatic image segmentation techniques more appealing. Moreover, the success of many high-level segmentation techniques (e.g. class-based object segmentation) also demands sophisticated automatic segmentation techniques. Dating back over decades, there is a large amount of literature on automatic image segmentation. For example, the edge detection algorithms are based on the abrupt changes in image intensity or color, thus salient edges can be detected. However, due to the resulting edges are often discontinuous or over-detected, they can only provide candidates for the object boundaries. Another classical category of segmentation algorithms is based on the similarities among the pixels within a region, namely region-based algorithms.

A good segmentation algorithm should preserve certain global properties according to the perceptual cues. This leads to another essential problem in a region merging algorithm: the order that is followed to perform the region merging. Since the merging process is inherently local, most existing algorithms have difficulties to possess some global optimality. However, we demonstrate that the proposed algorithm holds certain global properties, i.e., being neither over-merged nor under-merged, using the defined merging predicate. In addition, to speed up the region merging process, we introduce the structure of nearest neighbor graph (NNG) to accelerate the proposed algorithm in searching the merging candidates. The experimental results indicate the efficiency of the acceleration algorithm.



Fig 1.2 Image Segmentation

## II. EXISTING METHODS

### 2.1 FUZZY CLUSTERING

As a major health problem to human, cancer has become a main research area for science researchers in all over the world. There are over 200 different cancer types that have been found so far. In Britain, the lifetime risk of developing cancer is more than one in three. The detection of early invasive cancer is essential in reducing mortality rate. Fourier-transform infrared spectroscopy (FTIR) technology has been recently developed to study biomedical conditions and used as a diagnostic tool for various human cancers and other diseases. This technology is based on Fourier-transform infrared spectroscopy. Different functional groups of chemical compounds absorb infrared radiation (IR) at characteristic frequencies and the intensities of IR bands depend on their concentration. This technology can detect changes in cellular composition that reflect the onset of a disease and changes in intermolecular interactions in cells. This makes it a potentially powerful tool in cancer diagnosis, as it can help detecting abnormal cells at molecular levels that occur before the change in morphology seen under the light microscope.

An advantage of the FTIR technique is that it may be fully automated and hence be less time-consuming than visual inspection. For one sample, measuring the spectrum on FTIR equipment only takes approximately one minute. In addition, it is a sensitive, computer-operated system. Very small amounts of samples are adequate and

they can be studied regardless of the sample's form and physical state. These attributes make the technique of significant potential interest to large scale screening procedures, such as routine screening of cervical smears.

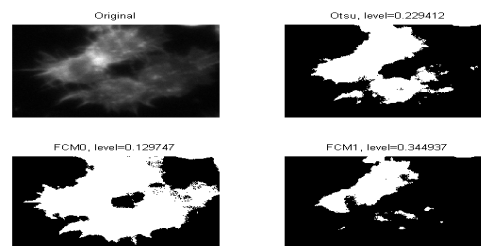


Fig 2.1 Fuzzy Clustering

In fact cluster analysis has the virtue of strengthening the exposure of patterns and behavior as more and more data becomes available. A cluster has a center of gravity which is basically the weighted average of the cluster. Membership of a data item in a cluster can be determined by measuring the distance from each cluster center to the data point. The data item is added to a cluster for which this distance is a minimum. This provides an overview of the crisp clustering technique, advantages and limitations of fuzzy c-means clustering and a new fuzzy clustering method which is simple and superior to c-means clustering in handling outlier points.

## 2.2 K Means Clustering method

The K-means algorithm is an iterative technique that is used to partition an image into  $K$  clusters. The basic algorithm is:

1. Pick  $K$  cluster centers, either randomly or based on some heuristic
2. Assign each pixel in the image to the cluster that minimizes the distance between the pixel and the cluster center.
3. Re-compute the cluster centers by averaging all of the pixels in the cluster
4. Repeat steps 2 and 3 until convergence is attained (e.g. no pixels change clusters)

## 2.3 C-MEANS CLUSTERING

Fuzzy c-means clustering involves two processes: the calculation of cluster centers and the assignment of points to these centers using a form of Euclidian distance. This process is repeated until the cluster centers stabilize. The algorithm is similar to k-means clustering in many ways but it assigns a membership value to the data items for the clusters within a range of 0 to 1. So it incorporates fuzzy set's concepts of partial membership and forms overlapping clusters to support it.

The algorithm needs a fuzzification parameter  $m$  in the range  $[1, n]$  which determines the degree of fuzziness in the clusters. When  $m$  reaches the value of 1 the algorithm works like a crisp partitioning algorithm and for larger values of  $m$  the overlapping of clusters is tend to be more.

This is a special form of weighted average. We modify the degree of fuzziness in  $x_i$ 's current membership and multiply this by  $x_i$ . The product obtained is divided by the sum of the fuzzified membership. The first loop of the algorithm calculates membership values for the data points in clusters and the second loop recalculates the cluster centers using these membership values. When the cluster center stabilizes (when there is no change) the algorithm ends.

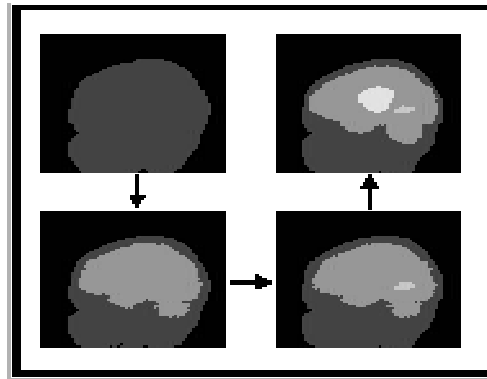


Fig 2.2 Brain Tumor Segmentation and Clustering

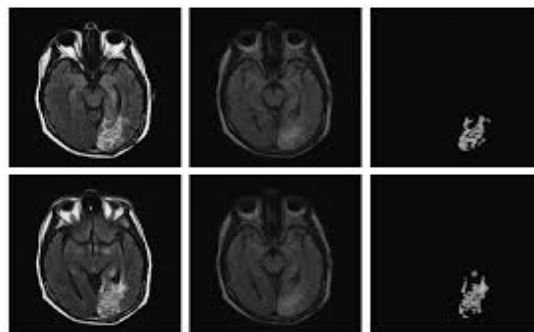


Fig 2.3 Classification of clustering

**2.3.1 THE ALGORITHM OF FUZZY C-MEANS CLUSTERING:**

- Step1. Choose a number of clusters in a given image.
- Step2. Assign randomly to each point coefficients for being in a cluster.
- Step3. Repeat until convergence criterion is met.
- Step4. Compute the center of each cluster.
- Step5. For each point, compute its coefficients of being in the cluster



Fig 2.4 Fuzzy means Clustering

### **III. PROPOSED METHOD**

MRI is an advanced medical imaging technique providing rich information about the human soft-tissue anatomy. It is mostly used in radiology in order to visualize the structure and function of the human body. It produces the very detailed images of the body in any direction. particularly, MRI is useful in neurological (brain), musculoskeletal, and oncological (cancer) imaging because it offers much greater contrast between the diverse soft tissues of the body than the computer tomography (CT). MRI is different from CT, it does not use ionizing radiation, but uses an effective magnetic field to line up the nuclear magnetization of hydrogen atoms in water in the body.

#### **3.1 PREPROCESSING**

##### **Noise Removal**

In medical image processing, it is very important to obtain precise images to facilitate accurate observations for the given application. Low image quality is an obstacle for effective feature extraction, analysis, recognition and quantitative measurements. Therefore, there is a fundamental need of noise reduction from medical images. There are currently a number of imaging modalities that are used for study of medical image processing. Among the newly developed medical imaging modalities, Magnetic Resonance Imaging (MRI) and Ultrasound imaging are believed to be very potential for accurate measurement of organ anatomy in a minimally invasive way. MRI is a powerful diagnostic technique

Preprocessing performs filtering of noise and other artifacts in the image and sharpening the edges in the image. RGB to grey conversion and Reshaping also takes place here. It includes median filter for noise removal. The possibilities of arrival of noise in modern MRI scan are very less. It may arrive due to the thermal effect. The main aim of this paper is to detect and segment the tumor cells. But for the complete system it needs the process of noise removal. For better understanding the function of median filter, we added the salt and pepper noise artificially and removing it using median filter.

##### **Median Filtering**

Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. It is particularly effective at removing 'salt and pepper' type noise. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels. The pattern of neighbours is called the "window", which slides, pixel by pixel over the entire image pixel, over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value.

#### **CUCKOO SEARCH ALGORITHM**

Cuckoos are attractive birds. The attractiveness is owing to the beautiful sounds produced by them and also due to their reproduction approach which proves to be combative in nature. These birds are referred to as brood parasites as they lay their eggs in communal nests. They remove the eggs in the host bird nest in order to increase the hatching probability of their own eggs. There are three types of brood parasites - the intra specific brood parasite, cooperation breed and nest take over type. The host bird involves in direct combat with the encroaching cuckoo bird. If the host bird discovers the presence of an alien egg, it either throws away the egg or deserts the nest. Some birds are so specialized that they have the characteristic of mimicking the color and the pattern of the egg which reduces the chances of the egg being left out thereby increasing their productivity. The timely sense of egg laying of cuckoo is quite interesting. Parasitic cuckoo birds are in search of host bird nests which have just laid their own eggs. In general the cuckoo birds lay their eggs earlier than the host bird's eggs in order to create space for their own eggs and also to ensure that a large part of the host bird feed is received by their chicks. CSA is one of the modern nature inspired meta-heuristic algorithms. The Greek terms "meta" and "heuristic" refer to "change" and "discovery oriented by trial and error" respectively. CS algorithm is based on the obligate brood parasitic behavior of some cuckoo species in combination with the Levy flight behavior of some birds and fruit flies. Some species of Cuckoo birds lay their eggs in communal nests. If a host bird discovers the eggs are not their own, they will either throw these alien eggs away or simply abandon its nest and build a new nest elsewhere. CS can be described using following three idealized rules:

- a) Each Cuckoo lays one egg at a time, and dumps its egg in randomly chosen nest;
- b) The best nests with high quality of eggs will carry over to the next generations;
- c) The number of available host nests is fixed, and the egg laid by a Cuckoo is discovered by the hosts birth a probability  $P_a \in [0, 1]$ .

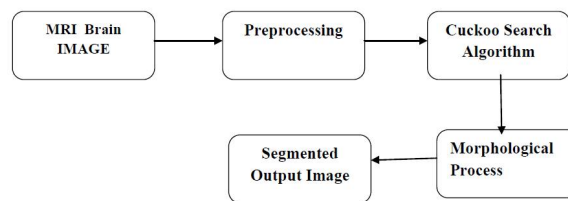


Fig 3.1 Block Diagram

### PRINCIPLE BEHIND CUCKOO SEARCH ALGORITHM

Each Cuckoo bird lays a single egg at a time which is discarded into a randomly chosen nest. The optimum nest with great quality eggs is carried over to next generations. The number of host nests is static and a host can find an alien egg with a probability ( $P_a$ )  $[0, 1]$ , whose presence leads to either throwing away of the egg or abandoning the nest by the host bird. One has to note that each egg in a nest represents a solution and a cuckoo egg represents a new solution where the objective is to replace the weaker fitness solution by a new solution.

The flowchart for CSA is as shown which involves the following steps:

- Step (1) - Introduce a random population of  $n$  host nests,  $X_i$ .
  - Step (2) - Obtain a cuckoo randomly by Levy flight behaviour,  $i$ .
  - Step (3) - Calculate its fitness function,  $F_i$ .
  - Step (4) - Select a nest randomly among the host nests say  $j$  and calculate its fitness,  $F_j$ .
  - Step (5) - If  $F_i < F_j$ , then replace  $j$  by new solution else let  $j$  be the solution.
  - Step (6) - Leave a fraction of  $P_a$  of the worst nest by building new ones at new locations using Levy flights.
  - Step (7) - Keep the current optimum nest, Go to Step (2) if  $T$  (Current Iteration)  $<$   $MI$  (Maximum Iteration).
  - Step (8) - Find the optimum solution. The alien egg, as a result of which it may throw the egg or forsake the nest.
- Important Stages involved in CSA are:

**Initialization:** Introduce a random population of  $n$  host nest ( $X_i = 1, 2, 3...n$ ).

**Levy Flight Behaviour:** Obtain a cuckoo by Levy flight behaviour equation which is defined as follows:

$$X_i(t+1) = X_i(t) + \alpha \oplus \text{Levy}(\lambda), \alpha > 0 \quad (1)$$

$$\text{Levy}(\lambda) = t(-\lambda), 1 < \lambda < 3$$

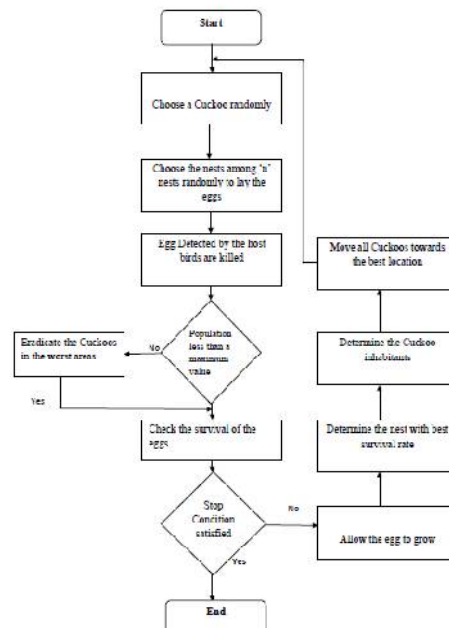


Fig 3.2 Flow Diagram

**Fitness Calculation:** Calculate the fitness using the fitness function in order to obtain an optimum solution. Select a random nest, let us say  $j$ . Then the fitness of the cuckoo egg (new solution) is compared with the fitness of the host eggs (solutions) present in the nest. If the value of the fitness function of the cuckoo egg is less than or equal to the fitness function value of the randomly chosen nest then the randomly chosen nest ( $j$ ) is replaced by the new solution. Fitness Function = Current Best Solution – Previous Best Solution (3) Since the Fitness function = Current best solution - Previous best solution, the value of the fitness function approaching the value zero means that the deviation between solutions decreases due to increase in the number of iterations. The conclusion is that if the cuckoo egg is similar to a normal egg it is hard for the host bird to differentiate between the eggs. The fitness is difference in solutions and the new solution is replaced by the randomly chosen nest. Otherwise when the fitness of the cuckoo egg is greater than the randomly chosen nest, the host bird recognizes.

**Termination:** In the current iteration the solution is compared and the best solution is only passed further which is done by the fitness function. If the number of iterations is less than the maximum then it keeps the best nest. After the execution of the initialization process, the levy flight and the fitness calculation processes, all cuckoo birds are prepared for their next actions. The CSA will terminate after maximum iterations [MI], have been reached. These steps can be matched any optimization problem. Each cuckoo egg and cuckoo nest plays an important role in such problems. Therefore as per this algorithm: a) Egg in a Nest b) Solution or the Available Voice Samples Cuckoo Egg c) New Solution or the Voice Sample to be matched Each Nest d) One Egg, One Solution or Features of Voice Samples

## IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

### 4.1 MORPHOLOGICAL PROCESS

Morphological image processing is a collection of nonlinear operations related to the shape or morphology of features in an image. A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value. Morphological operations transform the image.



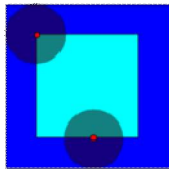


Fig 4.1 The erosion of the dark-blue square by a disk, resulting in the light-blue square.

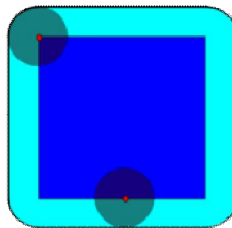


Fig 4.2 The dilation of the dark-blue square by a disk, resulting in the light-blue square with rounded corners.

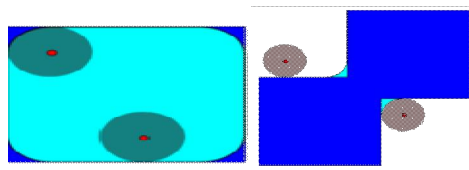


Fig 4.3 The closing of the dark-blue square by a disk, resulting in the light-blue square with rounded corners

#### 4.2 DILATION AND EROSION

From these two Minkowski operations we define the fundamental mathematical morphology operations dilation and erosion:

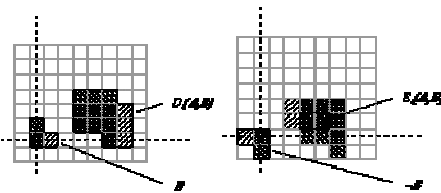


Fig 4.4 (a) Dilation  $D(A,B)$  (b) Erosion  $E(A,B)$

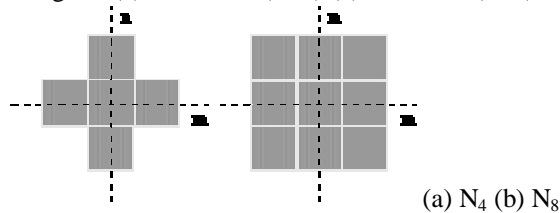
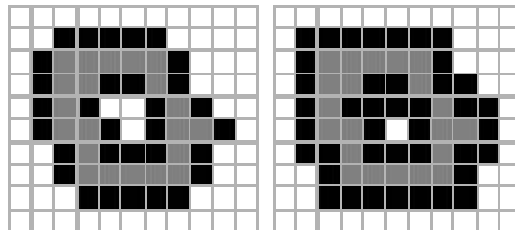


Fig 4.5 The standard structuring elements  $N_4$  and  $N_8$ .



(a)  $B = N_4$  (b)  $B = N_8$

Fig 4.6 Illustration of dilation. Original object pixels are in gray; pixels added through dilation are in black.



Fig 4.7 a) Image Ab)Dilation with 2Bc)Erosion with 2B



d)Opening with 2Be)Closing with 2Bf)it-and-Miss with  $B_1$  and  $B_2$   
Fig 4.8 Examples of various mathematical morphology operations.

## V. CONCLUSION

In medical decision, the use of computer science plays an important role for analyzing various diseases. Magnetic resonance image (MRI) is a critical part in many researches. So the MRI brain image is used to implement the system. And cuckoo search algorithm and morphological operation is used to detect the tumor region. It is easy to implement and reasonably fast. In this work, the brain image testing process has been done. This method is given the reliable result for the brain image. If the brain image has the tumor region, the further processing steps are needed to be done. The preprocessing step is important to segment the brain image. After the preprocessing, the brain image is free from noise and this smoothed image is ready to be used in further processing. Then the Cuckoo search algorithm is applied to the preprocessed image for segmentation. After segmentation, this resulted image is divided into the normal brain region and the tumor region to get the final segmentation output. After that, the tumor region is detected from the final segmentation using morphological operation.

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