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   NEED/IMPORTANCE OF THE STUDY

   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

   ACKNOWLEDGMENTS

   REFERENCES

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**CONTRIBUTIONS TO BOOKS**

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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# BRAIN TUMOR SEGMENTATION USING ALGORITHMIC AND NON ALGORITHMIC APPROACH

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**ABSTRACT**

*Tumor segmentation from Magnetic Resonance image (MRI) data is an important but time consuming manual task performed by medical experts. The aim of our research is to develop an effective algorithm for the segmentation of brain MR images and the ultimate goal to assist radiologists in the diagnosis of brain tumors. This paper describes two parallel approaches for brain tumor detection namely algorithmic and non algorithmic approaches. The performance of the paper is divided in to three phases, such as preprocessing & enhancement, segmentation and performance evaluation of two parallel approaches. In first phase, film artifacts and unwanted portions of MRI Brain image are removed, the noise and high frequency components of the MR images are removed using weighted median filter (WM). Second one is segmentation phase. It has two different approaches namely block based (BB) non algorithmic approach and algorithmic approach using meta heuristic algorithms such as Ant Colony Optimization (ACO) and Particle Swarm Optimization( PSO), Finally the performance of the above two algorithms and two approaches are evaluated. The results of our analysis are similar to the original radiologist findings. The original study is based on 50 real patients brain MRI in which an expert identified the brain tissue classes as well as the superior temporal gyros, amygdale, and hippocampus.*

**KEYWORDS**

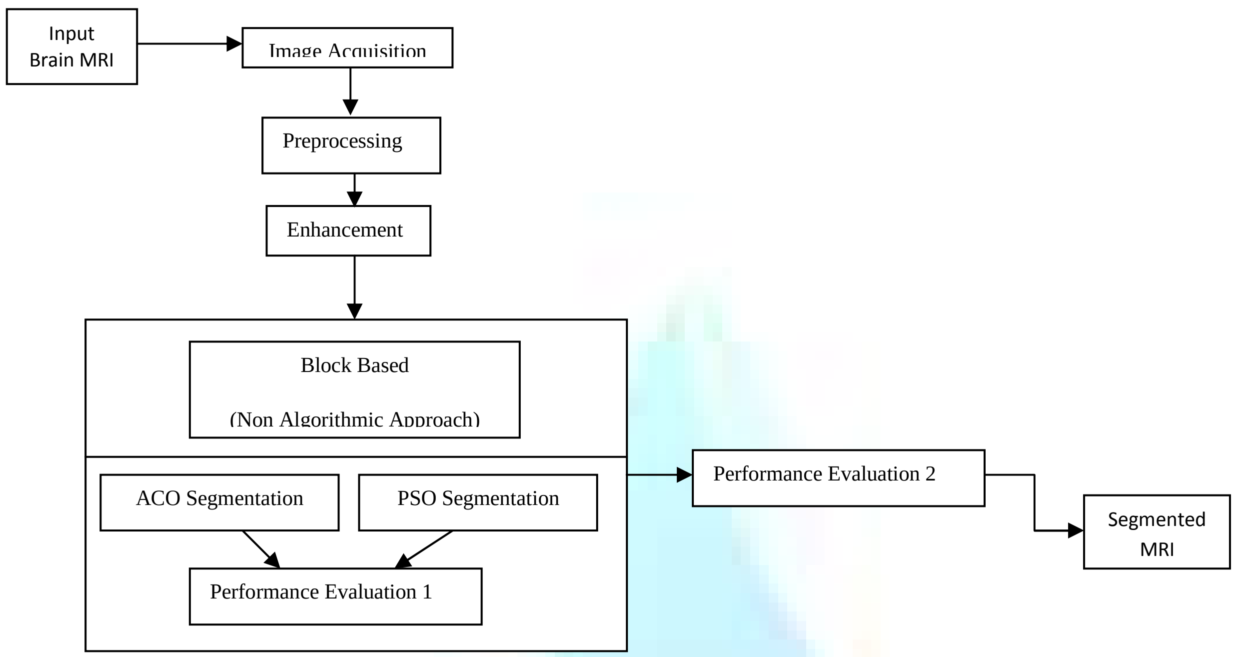
Ant colony optimization (ACO), Brain tumor, Block Based Technique (BB), Enhancement, Weighted Median Filter (WF), Magnetic Resonance Image (MRI), Particle swarm optimization (PSO), Preprocessing and Segmentation.

## 1. INTRODUCTION

The incidence of brain tumors is increasing rapidly, particularly in the older population than compared with younger population. Brain tumor is a group of abnormal cells that grows inside of the brain or around the brain. Tumors can directly destroy all healthy brain cells. It can also indirectly damage healthy cells by crowding other parts of the brain and causing inflammation, brain swelling and pressure within the skull. Over the last 20 years, the overall incidence of cancer, including brain cancer, has increased by more than10%, as reported in the National Cancer Institute statistics (NCIS), with an average annual percentage change of approximately 1%.2-6 between 1973 and 1985, there has been a dramatic age-specific increase in the incidence of brain tumors. Death rate extrapolations for USA for Brain cancer: 12,764 per year, 1,063 per month, 245 per week, 34 per day, 1 per hour, 0 per minute, 0 per second. Now days, Magnetic resonance imaging (MRI) is a noninvasive medical test that helps physicians diagnose and treat medical conditions.MR imaging uses a powerful magnetic field, radio Frequency pulses and a computer to produce detailed pictures of organs, soft tissues, bone and virtually all other internal body structures. It does not use ionizing radiation (X-rays) and MRI provides detailed pictures of brain and nerve tissues in multiple planes without obstruction by overlying bones.

The proposed system focuses the brain MRI segmentation using metaheuristics algorithms. Recently, many researchers have focused their attention on a new class of algorithms, called metaheuristics. A metaheuristic is a set of algorithmic concepts that can be used to define heuristic methods applicable to a wide set of different problems. In other words, a metaheuristic is a general algorithmic framework, which can be applied to different optimization problems with relatively few modifications to make them, adapted to a specific problem. The use of metaheuristics has significantly increased the ability of finding very high-quality solutions to hard, practically relevant combinatorial optimization problems in a reasonable time. This is particularly true for large and poorly understood problems. The remainder of the paper is organized as follows: section (3) focuses on the process of preprocessing and enhancement. Section (4) describes the segmentation, Section (5) displays the segmentation using algorithmic approach, Section (6) denotes the non algorithmic approach, section (7) displays experiments and results of the segmentation finally Section (8) tells conclusion of the paper. The following figure 1 displays the overall structure of the proposed system.

**FIG 1: THE STRUCTURE OF BRAIN TUMOR MR IMAGE SEGMENTATION**




This intelligent system uses medical images as a input to analyses tumor tissue from MRI brain images. The images were acquired on a Siemens MAGNETOM1 1.0 tesla MRI system. The images were digital and 256 X 256 pixels in size. The gray scale was quantized into 12 bits, which allowed 4096 different pixel intensities. A 3D FLASH technique was used to generate 64 or 128 contiguous thin slices. The MR images were transferred to a KONTRON MIPRON2 image processing workstation, and existing enhancement techniques were applied. The workstation used eight bits for each pixel, or 256 intensity levels. A software program compressed the 12 bit magnetic resonance images linearly to a maximum intensity of 255.

## 2. REVIEW OF LITERATURE

The initial objective of MRI brain image segmentation is to partition the given MRI brain image into non-intersecting regions describing real anatomical structures. Over the last decade, many methods have been proposed to tackle this problem. A partial list includes surface model, Deformable and dynamic Contour model, Iterative growing model. One of the earliest approaches to segmentation of brain MRI was presented by Ahmed et al [1]. demonstrate the qualitatively and quantitatively that the physiologically based algorithm outperforms two classical segmentation techniques. Angela et al[2]. Developed a gamma camera based on a multi-wire proportional chamber equipped with a high rate, digital electronic read-out system for imaging applications in nuclear medicine. Azadeh [3] presents our proposed methods and results for the analysis of the brain spectra of patients with three tumor types. Benedicte et al[4] report describes initial use of an accumulating healthy database currently comprising 50 subjects aged 20–72. Bricq[5] presents a unifying framework for unsupervised segmentation of multimodal brain MR images including partial volume effect, bias field correction, and information given by a probabilistic atlas. Chunyan et al[6] presents deformable model-based method is adapted in the system. And by the graphic user interface, the segmentation can be intervened by user interactively at real time. Corina et al[7] focuses on the automated extraction of the cerebrospinal fluid-tissue boundary, particularly around the ventricular surface, from serial structural MRI of the brain acquired in imaging studies of aging and dementia.Elizabeth et al[8]reports to detect and quantify tortuosity abnormalities on high-resolution MRA images offers a new approach to the noninvasive diagnosis of malignancy. Erik et al[9] integrates automatic segmentation based on supervised learning with an interactive multi-scale watershed segmentation method. The combined method automatically provides an initial segmentation that applies the building blocks that the user can use in the interactive method. Guido et al[10] uses an EM-type algorithm that includes tissue classification, inhomogeneity correction and brain stripping into an iterative optimization scheme using a mixture distribution model. Hideki et al[11] used region segmentation techniques to extract boundaries of the brain tumor and edematous regions. Iftekharuddin et al[12]presents Two novel fractal-based texture features are exploited for pediatric brain tumor segmentation and classification in MRI. One of the two texture features uses piecewise-triangular-prism-surface-area (PTPSA) algorithm for fractal feature extraction. Jason[13]focused formulation for incorporating soft model assignments into the calculation of affinities, which are traditionally model free. Jeffreyet al[14] introduced an automated method using probabilistic reasoning over both space and time to segment brain tumors from 4D spatio-temporal MRI data. Kabir etal[15] addressed in this paper is the automatic segmentation of stroke lesions on MR multi-sequences. Lesions enhance differently depending on the MR modality and there is an obvious gain in trying to account for various sources of information in a single procedure.

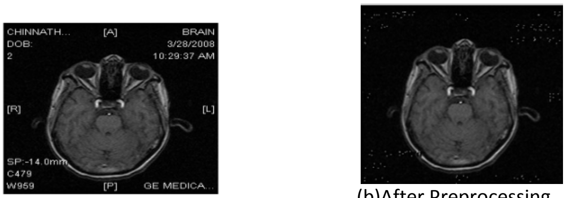
## 3. PREPROCESSING AND ENHANCEMENT

This proposed system for pre-processing and enhancement through Magnetic Resonance Image (MRI) is a gradient based image enhancement method and is based on the first derivative, local statistics. In Preprocessing and Enhancement stage, medical Image is converted into standard format with contrast manipulation; noise reduction by background removal, edge sharpening, filtering process and removal of film artifacts. Preprocessing functions involve those operations that are normally required prior to the main data analysis and extraction of information, and are generally grouped as radiometric or geometric corrections. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, removal of non-brain voxels and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor. This Automatic system proposes a gradient-based image enhancement method in order to improve the image quality and visibility of low-contrast features while suppressing the noises. Image enhancement is the improvement of image quality without knowledge about the source of degradation.

### 3.1 REMOVAL OF FILM ARTIFACTS

This paper presents an integrated method of the adaptive enhancement for an unsupervised global-to-local segmentation of brain tissues in three-dimensional (3-D) MRI (Magnetic Resonance Imaging) images. The MRI brain image consists of film artifacts or label on the MRI such as patient name, age and marks. Film artifacts that are removed using tracking algorithm .It is based on image intensity .In this algorithm, starting from the first row and first column, the intensity value of the pixels are analyzed and the threshold value of the film artifacts are found. The threshold value, greater than that of the threshold value is removed from MRI. The high intensity value of film artifacts are removed from MRI brain image. During the removal of film artifacts, the image consists of salt and pepper noise .The above image is given to enhancement stage for removing high intensity components and the above noise. The following figure 2 displays that the input and output of preprocessing stage.

**FIG 2: REMOVAL OF FILM ARTIFACTS**




(a) (b)After Preprocessing

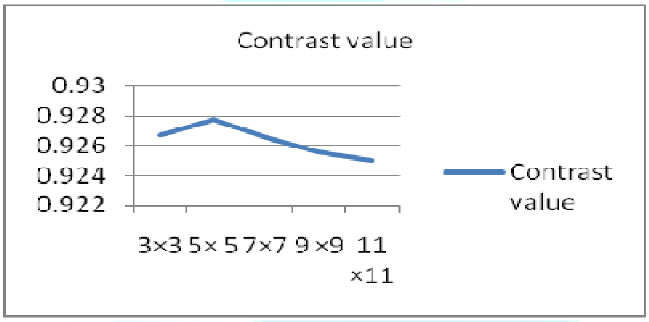
Before Preprocessing

The above figure (a) displays the natural brain MRI, it contains number of film artifacts and labels. After the preprocessing the output of the brain MRI is displayed (Fig 2: b) without artifacts and labels.

**3.2 WEIGHTED MEDIAN FILTER**

Weighted Median (WM) filters have attracted a growing number of interests in the past few years. In this paper, a weighted median (WM) filter is proposed for improving the performance of brain MRI with out high frequency noise. The merit of using weighted median filter is, it can remove salt and pepper noise from MRI without disturbing of the edges. In this enhancement stage, It adjusts the size of filtering window adaptively according to number of noise points in window, the pixel points in the filtering window are grouped adaptively by certain rules and gives corresponding weight to each group of pixel points according to similarity, finally the noise detected are filtering-treated. The evaluation criteria for weighted Median filtering is considered as follows:

**FIG 3: PERFORMANCE ANALYSIS OF WEIGHTED MEDIAN FILTER**




the weighted median filtering is applied for each pixel of an 3 ×3, 5 ×5, 7 ×7, 9 ×9, 11 ×11 sliding window of neighborhood pixels are extracted and analyzed the mean gray value of foreground , mean value of background and contrast value.

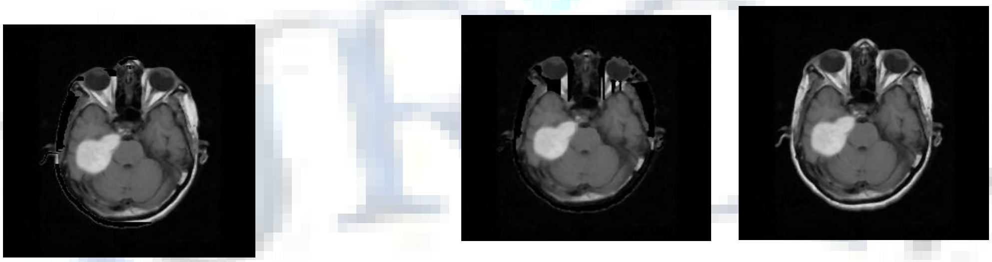
## 4. SEGMENTATION

Medical image segmentation refers to the segmentation of known anatomic structures from medical images. Structures of interest include organs or parts thereof, such as cardiac ventricles or kidneys, abnormalities such as tumors and cysts, as well as other structures such as bones, vessels, brain structures etc. This Segmentation is the partitioning of image data into related sections or regions. This paper has led to the development of a wide range of segmentation methods addressing specific problems in medical applications. Some methods proposed in the literature are extensions of methods originally proposed for generic image segmentation.

**4.1 REMOVAL OF SKULL AREAS FROM BRAIN MRI**

First stage of the segmentation is removal of skull portion from MR brain images. The human skull is a bony structure, part of the skeleton that is in the human head, the brain is enclosed by skulls, these are provides the fundamental security to brain which supports the structures of the face and forms a cavity for the brain. The third section of this automatic system explains the removal of skull portions from MR brain images. These skull portions are divided in to left, right and bottom of skull. The following table shows the tracking algorithm is used to remove unwanted portion of MRI that means left, right and top skull portions that are not required for further processing.

**FIG 4: BRAIN MRI WITHOUT UNWANTED LEFT, TOP AND RIGHT SKULL PORTIONS**



(a) (b) (c)

The below figure 4 displays the segmented brain MRI without skull areas like left, right and top of the brain image.

## 5. ALGORITHMIC APPROACH

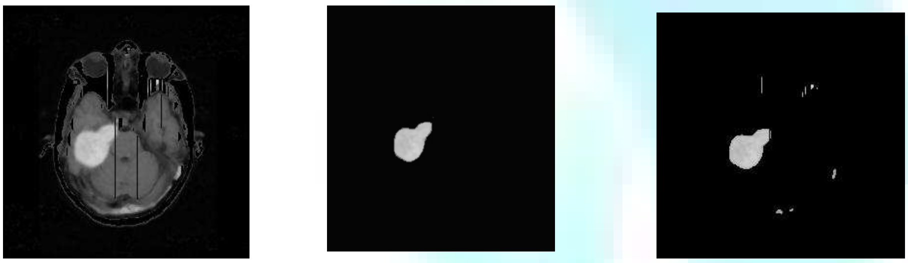
The proposed intelligent technique based on histogram thresholding used to produce a binary image to segment tumor region from background brain MRI. In segmentation the threshold value is used to find the suspicious region from brain MRI .The local optimum in the histogram is selected as the threshold value. Starting from the first row and first column of the MRI brain image, the intensity values are analyzed. The intensity values smaller than this threshold are changed to zero(black)and the intensity values greater than the threshold are changed to one(white) in order to perform the morphological operation to remove the four and eight connected pixels in the MRI binary image. Once the connected components are removed the MRI binary image contains only the brain tumor tissue. The special coordinates of the tissue points are mapped and suspicious regions are enhanced using ACO and PSO.

### 5.1 ANT COLONY OPTIMIZATION

Ant colony optimization (ACO) is a population-based meta heuristic that can be used to find approximate solutions to difficult optimization problems. In ACO, a set of software agents called artificial ants search for good solutions to a given optimization problem. To apply ACO, the optimization problem is transformed into the problem of finding the best path on a weighted graph. The artificial ants (hereafter ants) incrementally build solutions by moving on the graph. The solution construction process is stochastic and is biased by a pheromone model, that is, a set of parameters associated with graph components (either nodes or edges) whose values are modified at runtime by the ants. The ant colony optimization algorithm (ACO), is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs.This algorithm is a member of ant colony algorithms family, in swarm intelligence methods, and it constitutes some metaheuristic optimizations.In our implementation, we are using 20 numbers of iterations. Select the image pixels, which are having optimim level, are stored as a separate image. This segmented image is used for the next step, to extract the textural features for classification microcalcifications. The ACO algorithm for our implementation is as follows:

Step 1: Read the MRI image or the ROI image and stored in a two dimensional matrix.
Step 2: Pixels with same gray value are labeled with same number.
Step 3: For each kernel in the image, calculate the posterior energy U (x) value.
Step 4: The posterior energy values of all the kernels are stored in a separate matrix.
Step 5: Ant Colony System is used to minimize the posterior energy function. The procedure is as follows:
Step 6: Initialize the values of number of iterations (N), number of ants (K), initial pheromone value ($T_0$), a constant value for pheromone update (ρ).[here,we are using N=20,K=10, $T_0$=0.001 and ρ =0.9]
Step 7: Create a solution matrix (S) to store the labels of all the pixels, posterior energy values of all the pixels, initial pheromone values for all the ants at each pixels, and a flag column to mention whether the pixels is selected by the ant or not.
Step 8: Store the labels and the energy function values in S.
Step 9: Initialize the pheromone values, $T_0$=0.001.
Step 10: Initialize all the flag values for all the ants with 0,it means that pixels is not selected yet,if it is set to 1 means selected.
Step 11: Select a random pixel for each ant, which is not selected previously.
Step 12: Update the pheromone values for the selected pixels by all the ants.
Step 13: Using GA, select the minimum value from the set, assign as local minimum (Lmin).
Step 14: Compare this local minimum (Lmin) with the global minimum (Gmin), if Lmin is less than Gmin,assign Gmin = Lmin.
Step 15: Select the ant, whose solution is equal to local minimum, to update its pheromone globally.
Step 16: Perform the steps (13) to (15) till all the image pixels have been selected.
Step 17: Perform the steps (7) to (16) for M times.
Step 18: The Gmin has the optimum label which minimizes the posterior energy function.
Step 19: Store the pixels has the optimum label in a separate image that is the segmented image.
The above algorithm is used to segment brain tumor tissue from brain MRI.The following figure displays the tumor tissue from brain MRI.

**FIG 5: BRAIN IMAGE SEGMENTATION USING ACO**



(a) Brain MRI without skull (b) Manual Segmentation (c) ACO Segmentation

**TABLE 1: COMPARISON OF MANUAL AND ACO SEGMENTATION**

| Results | Number of segmented Pixels | | Adaptive Threshold | | Average Intensity | |
|---|---|---|---|---|---|---|
| | Manual | ACO | Manual | ACO | Manual | ACO |
| Patient1 | 1172 | 1304 | - | 155 | 186.7159 | 188.4747 |
| Patient2 | 818 | 837 | - | 150 | 211.1149 | 213.8566 |
| Patient3 | 457 | 746 | - | 189 | 197.4661 | 180.1099 |
| Patient4 | 317 | 365 | - | 184 | 198.1009 | 202.8247 |

### 5.2 PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (pso) is one of the modern heuristic algorithms that can be applied to non linear and non continuous optimization problems. It is a population-based stochastic optimization technique for continuous nonlinear functions.PSO learned from the scenario and used it to solve the optimization problems. Particle Swarm Optimization is an optimization technique which provides an evolutionary based search. This search algorithm was introduced by Dr Russ Eberhart and Dr James Kennedy in 1995. The term PSO refers to a relatively new family of algorithms that may be used to find optimal or near to optimal solutions to numerical and qualitative problems. The PSO algorithm for our implementation is as follows:

**Step 1:** Load the image the size is 256x256 (each element corresponds to a gray value Between 0 to 256 and their classes are determined.
**Step 2:** Divide the image to 3x3(or) 5 x5(or)7 x7 labels etc.
**Step 3:** Initialize all particles inside the labels.
**Step 4:** Calculate the fitness value for all pixels in the label.
**Step 5:** Select the best optimum (pBest) value for the label.
If (fitness value<best fitness value (pBest) in history update current value =new pBest else current value= fitness value
After selection of current value elements are put in their respective labels.
**Step 6:** Repeat Step 4 and 5 for all elements until end of the label.
**Step 7:** Choose the particle with the best fitness value of all the particles as the gBest.
**Step 8:** Calculate particle velocity for each particle.
v [cp] = v[cp] + c1 * rand() * (pbest[p] - present[p]) + c2 * rand() * (gbest[p] - present[]) v [cp] = current particle velocity, pbest[cp] =best fitness value, gbest[] = fitness values of the all particles, rand()= random number between (0,1), c1, c2 are learning factors. Usually c1 = c2 = 2.
**Step 9:** Update particle position for each particle according the given solution.
present[] = persent[] + v[]
persent[] is the current particle

After updation of velocity and position of each particle

**Step 10:** Go to step 2 for further labels.

**TABLE 2:** COMPARISON OF MANUAL AND PSO SEGMENTATION

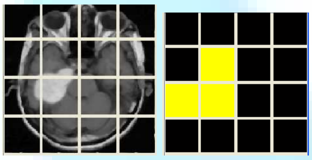
| Results | Number of segmented Pixels | | Adaptive Threshold | | Average Intensity | |
|---|---|---|---|---|---|---|
| | Manual | PSO | Manual | PSO | Manual | PSO |
| Patient1 | 1172 | 1372 | - | 245 | 186.7159 | 188.5767 |
| Patient2 | 818 | 987 | - | 240 | 211.1149 | 217.1015 |
| Patient3 | 457 | 845 | - | 220 | 197.4661 | 183.4333 |
| Patient4 | 317 | 456 | - | 222 | 198.1009 | 210.6767 |

## 6. NON ALGORITHMIC APPROACH

### 6.1 BLOCK BASED APPROACH

This paper consists of an efficient registration framework which has features of block based technique. Here normal patient image is compared with reference images. The following table shows normal image and reference image taken for comparison. In Block based technique, both the given reference MR brain image (256 × 265) and the normal image (256 × 265) has been divided into several blocks. Each and every block of both the images is 64 ×64. After blocking, subtraction has been done between the two images. This subtracted value is then checked with the threshold value, in our method. Then first block from both the images were subtracted and the average value of all the pixels in that block were calculated. This average value is then compared our threshold value of 80,000 and if any of which is found to cross this limit, those patient details will be stored in the database as a doubtful case. This method based on Average intensity measure for blocks of both normal and target image was calculated and compared. If there is any abnormality found in the normal image then it is stored in segmented database. Otherwise it is stored in normal database. In the following table, block 1 to block 4 of both source and target image does not have difference in average intensity but in block5 to block 8 has different values. Those values are stored in segmented database. The below figure 5 shows block based method with brain MRI.

**FIG. 6: BRAIN MRI SEGMENTATION USING BLOCK BASED METHOD**



### 6.2 AVERAGE INTENSITY MEASURE

Average intensity measure for blocks of both normal and target image was calculated and compared. If there is any abnormality found in the normal image then it is stored in segmented database. Otherwise it is stored in normal database. In the following table, block 1 to block 4 of both source and target image does not have difference in average intensity but in block5 to block 8 has different values. Those values are stored in segmented database.

**TABLE 3: AVERAGE INTENSITY VALUE BASED ON BLOCKS**

| Image | ***Block 9*** | ***Block 10*** | ***Block 11*** | ***Block 12*** | ***Block 13*** | ***Block 14*** | ***Block 15*** | ***Block 16*** |
|---|---|---|---|---|---|---|---|---|
| *Source* | 49 | 87 | 62 | 4 | 8 | 38 | 14 | 2 |
| *target 1* | 57 | 97 | 62 | 4 | 8 | 38 | 14 | 2 |
| *target 2* | 75 | 105 | 62 | 4 | 8 | 38 | 14 | 2 |
| *target 3* | 49 | 90 | 62 | 4 | 8 | 38 | 14 | 2 |
| Image | ***Block 1*** | ***Block 2*** | ***Block 3*** | ***Block 4*** | ***Block 5*** | ***Block 6*** | ***Block 7*** | ***Block 8*** |
| *Source* | *31* | *67* | *51* | *2* | *68* | *71* | *86* | *5* |
| *target 1* | *31* | *67* | *51* | *2* | *77* | *91* | *86* | *5* |
| *target 2* | *31* | *67* | *51* | *2* | *68* | *71* | *86* | *5* |
| *target 3* | *31* | *67* | *51* | *2* | *68* | *101* | *91* | *5* |

## 7. RESULTS AND EXPERIMENTS

**FIG. 7: BRAIN IMAGE SEGMENTATION USING PSO**

The performance evaluation of the algorithmic approaches are evaluated .This evaluation is use to compare Haralick feature of the brain MRI images are through ACO and PSO algorithms .the following table displayes the feature comparison of ACO and PSO algorithms. In this result, performance of the PSO algorithm is better than ACO. PSO gives more accuracy and it is use to segment tumor area from brain MRI is well and efficient than ACO.

TABLE 4: COMPARISON OF MRI HARALIC FEATURES

| Haralick Features | Normal Image | Manual | ACO | PSO |
|---|---|---|---|---|
| Angular Secend moment | 0.1762 | 0.1002 | 0.1225 | 0.1225 |
| Contrast | 0.0476 | 0.0439 | 0.0440 | 0.0440 |
| Correlation | 0.0667 | 0.0577 | 0.0575 | 0.0575 |
| Som of square ( Variance) | 0.0628 | 0.0579 | 0.0590 | 0.0596 |
| Invers distant moment | 0.3575 | 0.1734 | 0.1927 | 0.1927 |
| Som average | 0.0938 | 0.0780 | 0.0776 | 0.0776 |
| Sum Variance | 0.0556 | 0.0416 | 0.0424 | 0.0425 |
| Sum entropy | 0.1734 | 0.1202 | 0.1235 | 0.1245 |
| Entropy | 0.2828 | 0.1295 | 0.1473 | 0.1478 |
| Difference variance | 0.5211 | 0.1550 | 0.1729 | 0.1735 |
| Difference entropy | 0.1660 | 0.1178 | 0.1190 | 0.1197 |
| Information measures of correlation | 0.2784 | 0.1295 | 0.1472 | 0.1477 |
| Information measures of correlation | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Maximal Correlation Coefficient | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## 8. CONCLUSION

The Intelligent segmentation of brain tumor from Magnetic Resonance Images (MRI) described a gradient-based brain image segmentation using Ant colony optimization (ACO) Particle Swarm Optimization (PSO) and block based technique (BB). Initially the preprocessing stages are finished through tracking algorithms. Next the processed brain MRI is segmented using Ant colony optimization algorithm, particle optimization and Block based technique.The merit of this intelligent segmentation is detecting and evaluating the two Meta heuristic algorithms and their performance for the segmentation of brain tumor tissue from brain MRI. We are generalizing PSO algorithm to suit for the brain MRI from any database and the statistical result shows the proposed PSO algorithm can perform better than ACO and Block based technique for tumor detection.

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