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Detection of Colloid Cyst in Brain through Image Processing Techniques

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Abstract

Colloid Cysts, also called neuroepithelial cysts are located in the rostral aspect of the third ventricle in the brain [1]. It appears near the center of the brain and grows along the roof of the third ventricle that holds spinal fluid. Increase in the size of cyst can block the flow of cerebrospinal fluid causing hydrocephalus (water on the brain or a buildup of CSF in the brain). The buildup of CSF in the brain can increase intracranial pressure that compresses surrounding brain tissues in the skull and may cause enlargement of the brain, convulsions, brain damage and even sudden death [2]. Detection of Colloid Cyst at early stages is very important. Analysis and manual interpretation of Magnetic Resonance Images and Computed Tomography Images by radiologists are time consuming and sometimes difficult and error prone. In this paper we propose an algorithm to automate the process of detecting Colloid Cysts in Brain through the use of image processing techniques.

Keywords*: Colloid Cyst detection, Threshold Segmentation, Median Filtering, Gaussian High-pass filtering, Region of Interest*

1. Introduction

Brain is the main organ of the central nervous system that coordinates and controls the activities of other organs in our body. Cysts in brain are group of cells, clustered together to form a sac that contain fluid or semi-solid material, such as cerebrospinal fluid, blood, tissue or tumor cells [17]. Cysts are generally benign, but are harmful when it is found in parts of the brain where it restricts crucial functioning of the brain. Types of Cysts found in brain are, Arachnoid Cyst, Colloid Cyst, Dermoid Cyst, Epidermoid Cyst, Pineal Cyst and Tumor-associated Cyst. Symptoms of cyst vary depending upon its location, size and type.

In this paper we focus on the automatic detection of Colloid Cyst in Brain from MRI or CT scanned images. Colloid cysts are known to be formed during the embryonic formation of the Central Nervous System. It contains a thick, gelatinous substance called colloid which came from the Greek word *Kollodes* (Kolla meaning glue and eidos meaning appearance). Apart from the colloid filling, the cyst may contain blood, minerals or cholesterol crystals [3]. Colloid Cysts are found in the center of the brain that holds spinal fluid, or, in the lining of the third ventricle. Cysts in this location block the foramina of Monro causing obstructive hydrocephalus that increases pressure in the brain.

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Familiar symptoms are severe headache, nausea, vomiting, seizures, vertigo, memory loss, insomnia, gait disorder, drop attack and many more. Mortality rate due to Colloid cyst has been between 58% and 77% [1]. Its size may vary from 3 to 40 mm. Since, even small Colloid cyst can cause sudden death, it is vital to identify or detect the cyst at an early stage.

Medical Image Processing has become an essential feature in the fields of Bio-Medical research. Imaging Technology like Magnetic Resonance Imaging, CT scanner, digital mammography provides an detailed or third dimension view of the body. The digital images acquired from these imaging technologies can be enhanced and analyzed by MATLAB and Image Processing Toolbox for easier diagnosis. Image Processing Techniques reduces the complicated manual tasks of the radiologists to identify any abnormalities in the brain; it saves time and is cost effective. It involves preprocessing of the digital images by passing them through different types of filters to reduce noise and improve the quality of the image. It also includes emphasizing on the region of interest and automating the process of segmentation of Cysts to extract complex information. Morphological operations can be used to remove imperfections from these images depending on the relative ordering of the pixels. We have proposed here an algorithm that uses many advanced image processing techniques to automatically detect Colloid cyst of all sizes from the digital images. To test our algorithm, we have used 100 neuroimages that contained Colloid Cyst and 50 neuroimages where there was absence of any abnormalities or contained cysts but not Colloid Cyst. The result demonstrated that the simple algorithm was efficient enough to automatically detect Colloid Cyst of any size. According to the region of interest or location the algorithm was successful to recognize if there was an absence of cyst or the cyst present was colloid cyst or not.

2. Literature Review

In past, various algorithms has been developed to automate the system of detecting Cysts and Tumors in Brain by using Image Processing techniques like Threshold Segmentation, Edge Detection, Clustering based segmentation, Watershed Segmentation and many more.

Karishma Sheikh, VidyaSutar and SilkeshaThigale in their paper proposed a system that used pixel to pixel comparison, gray scale and K-means segmentation algorithm to detect tumor from MRI images [4]. They used clustering to differentiate between affected and unaffected cells. Ed-EdilyMohd. Azhari, Muhd. MudzakkirMohd. Hatta, ZawZawHtike and Shoon Lei Win detected and localized Brain Tumor in Magnetic Resonance Imaging by applying edge detection method, modified histogram clustering and morphological operations [5]. They used a method where histogram values were plotted and threshold value was kept fixed based on the pixels and grey level value in the images. Tumor part was extracted by using morphological operations and by specifying the Region of Interest. Vrushali D. Dharmale and P.A. Tijare used Canny Edge detection and segmentation method for Cyst detection from MRI brain images and mentioned the accuracy rate to be 100% [6]. Mr. Lalit P. Bhaiya, Ms. SuchitaGoswami and Mr. VivekPali classified abnormalities in Magnetic Resonance Brain images by developing a hybrid model that combined advantages of both Artificial Neural networks and Fuzzy Logic [7]. In this system textural features were extracted using principal component analysis (PCA) technique. The extracted features were then used to train the neuro fuzzy classifier. The Adaptive Network based Fuzzy interference system (ANFIS) was tested for classification of different Brain MRI samples. Results illustrated that the model was effective enough in terms of classification accuracy and convergence rate. Mashal Tariq, AttaullahKhawajah and Munawer-Hussain presented a system that focused on the early detection of tumor [8]. In this paper Noise Reduction was done by the use of Median Filter, information about the object boundaries in an image was obtained through Sobel Edge Detector. The algorithm proposed that several morphological operations along with morphological reconstruction could accurately segment out Solid cum Cystic Tumor from T1 and T2 images.

On a different note Alexander C. Mamourian, Laurence D. Cromwell and Robert E. Harbaugh presented different cases and tried to prove that Colloid Cyst are sometimes more perceptible or noticeable on Computed Tomography Images than Magnetic Resonance Images. They stated cases where Colloid Cyst were found without any association with hydrocephalus and 55 cases where the cause of sudden death was due to Colloid Cyst in Brain ranging from 1 to 8cm. They concluded that "Ventricular size is not a reliable predictor of the outcome" [9]. Emanuela Turillazzi, Stefania Bello, MargheritaNeri, Irene Riezzo and Vittorio Fineschi in their article mentioned reasons that proved that "As the hypothalamic structures which are involved in neuroendocrine and autonomic regulation playing a key role in cardiovascular control are located close to the walls of the third ventricle which is the most frequent anatomical site of colloid cyst, this may suggest that reflex cardiac effects due to the compression of the hypothalamic cardiovascular regulatory centers by the cyst explain the sudden death in patients harboring a colloid cysts when signs of hydrocephalus or brain herniation are lacking" [10]. ShreetamBehera, Miihir Narayan Mohanty and SrikantaPatnaik have done a "Comparative Analysis on Edge Detection of Colloid Cyst" [11]. Based on simple mathematical morphology they provided edge detection method to detect Colloid Cyst in Brain. Sameer S Shaktawat, Walid D Salman, ZuhairTiwaj and Abdul Al-Dawoud wrote an article on "Unexpected death after headache due to colloid cyst of the third ventricle". They presented a case of a 17 year old female who had mild headaches for a period of two years died suddenly and the findings in the post mortem report concluded that the death was due to Colloid cyst of 1cm. Their report highlighted "the difficulty in diagnosis and the importance of recognizing Colloid cyst in Brain" [12].

3. Proposed Methodology

We propose an algorithm that uses Image Processing techniques like Median Filtering, Gaussian High Pass Filtering, Multilevel Thresholding, Threshold Segmentation, Tracing Region Boundaries, plotting and Region of Interest to accurately detect Colloid Cyst from MRI and CT Scanned images of Brain.

3.1. Proposed Algorithm to Detect Colloid Cyst

Step 1: Start
Step 2: Read input MRI or CT Scanned Brain image.
Step 3: Convert input image into Gray Scale Image.
Step 4: Pass Gray Scale Image through Median Filter.
Step 5: Pass the filtered image through Gaussian High Pass Filter.
Step 6: Implement Multilevel Thresholding on the filtered image.
Step 7: Implement Segmentation using Threshold value.
Step 8: Define Region of Interest and crop the portion.
Step 9: **If** Cyst Present in that location
  Step 9.1: Trace Region Boundaries and plot the shape and location of the cyst in the actual image
  Step 9.1.1: Display the actual Image with the Colloid Cyst superimposed with red color boundary.
  Step 9.1.2: Calculate size of the Colloid Cyst in mm^2
  Step 9.1.3: Display a message box with the message "Colloid Cyst Detected and Approximate size of the Colloid Cyst in mm^2 = size".
Else
  Step 9.2: Display the actual image with the message "No Colloid CystPresent".
Step 10: Stop

4. Algorithm Analysis

4.1. Input Image and Gray Scale Image

We have taken Magnetic Resonance and Computed Tomography (MRI or CT Scan) images of Brain as Input Image. *uigetfile*function in MATLAB displays a dialog box containing files in the current directory and helps users to browse and select files of any format.

[filename,pathname] = uigetfile('.*','Pick MRI or CT Scanned Image of Brain');* (1)

In MATLAB the function in (1) would display all types of file (*.* signifies *All Files*) as shown in Figure 1, from the current directory in the dialog box with the title "*Pick MRI or CT Scanned Image of the Brain*". User can search in the current directory path or any other path from the dialog box to select the required image.

The Input Image as we can see in Figure 2 is then converted into Gray Scale Image by using the function *rgb2gray*. For *e.g. I = rgb2gray (RGB);*

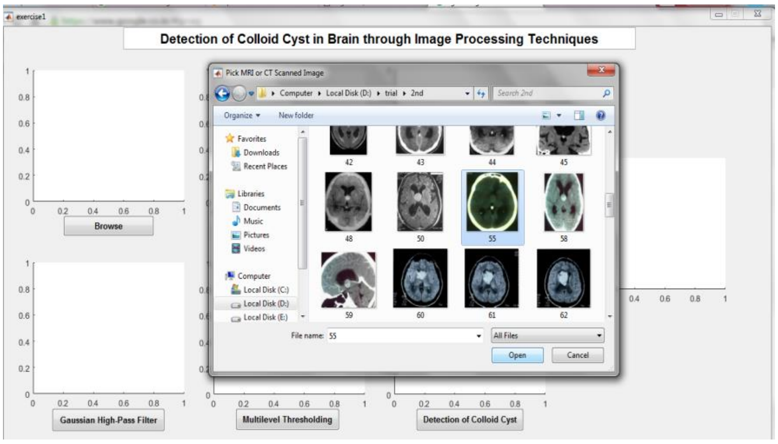


Figure 1. Dialog Box to Browse MRI/CT Scanned Images

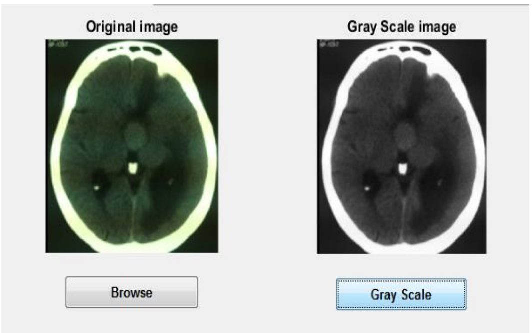


Figure 2. Conversion Into Gray Scale Image

4.2. Median Filtering and Gaussian High-Pass Filtering

For formation of the image, MRI and CT Scanners use strong radio waves, magnetic fields, field gradients and radiation. Before automating the process of detecting the Colloid Cyst, it is important to remove any noise or unnecessary information present in the image that would lead to errors. Therefore preprocessing of the image is required to improve the image quality and extract finer details of the image by removing noise and sharpening the image for producing prominent edges. An image can be affected by different types of noise. The most common type of noise is the Salt-and-pepper noise that has dark pixels in bright regions and bright pixels in dark regions [13]. Median Filters are best known for removing Salt-and-Pepper noise from an image as shown in Figure 5. Formula (2) describes that Median Filters considers each pixel and replaces them by the median in a neighborhood around the pixel as shown in the below example in Figure 3 and 4 [14].

$$g(x,y) = \textbf{median}\ \{ f(x,y);\ (x,y) \in t \} \quad (2)$$

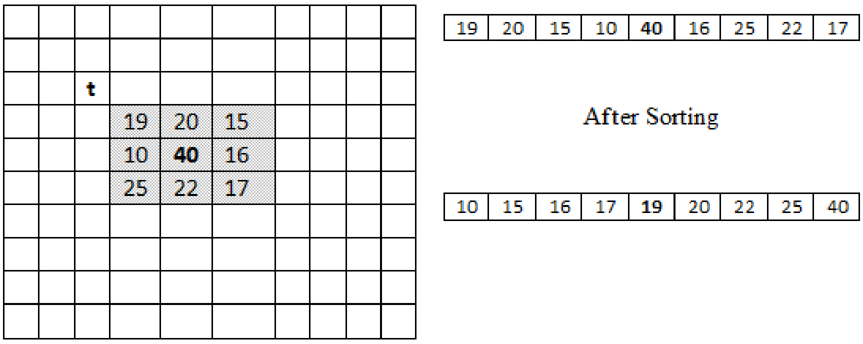


Figure 3. Input Image f

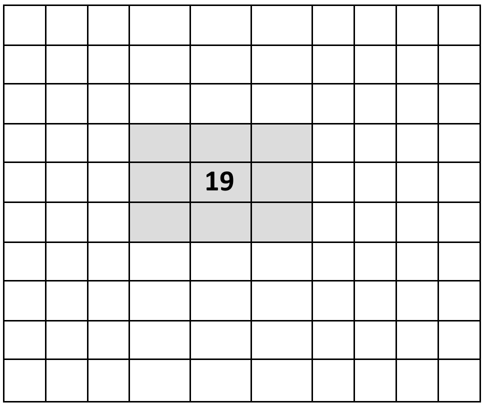


Figure 4. Output Image g

For sharpening the edges in the image we have used Gaussian High-Pass Filters as shown in Figure 6. Low-Pass Filters are used to reduce noise and eliminate small details from the image. High-Pass Filtering is nothing but subtracting Low-Passed Filtered Image from the Original Image. Gaussian High-Pass Filters generates finer details of the image, enhances the edges and sharpens the boundaries that help in highlighting or extracting the Cyst part from the entire image.

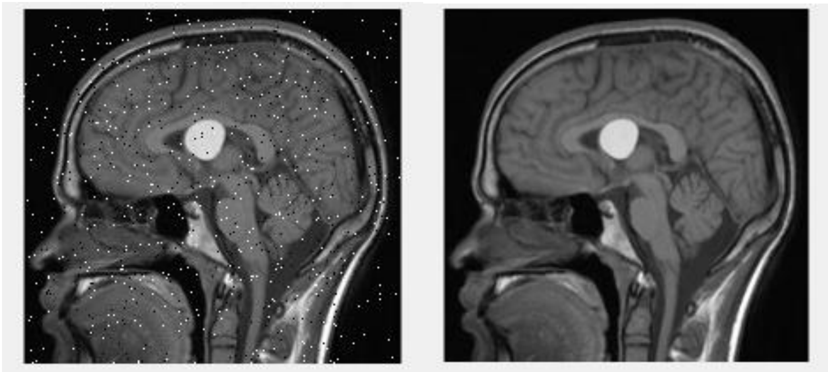


Figure 5. Applying Median Filter to Remove Salt and Pepper Noise

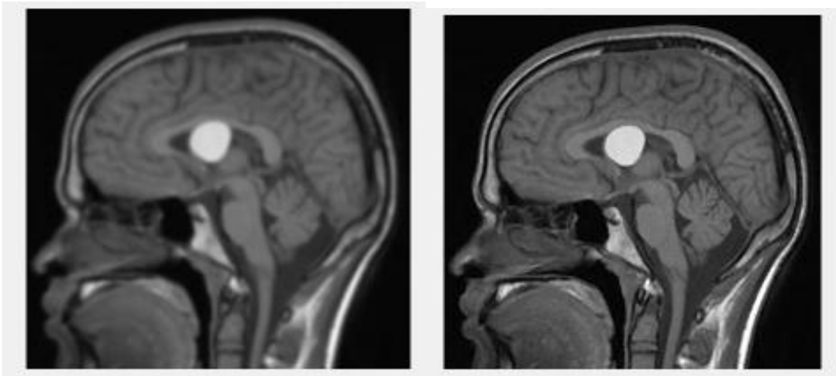


Figure 6. Applying Gaussian High-Pass Filter

4.3. Detection of Colloid Cyst and its Approximate Size

After completion of the Pre-Processing techniques, we applied Segmentation techniques to extract the cyst part from the image. Since Image Segmentation to identify the cyst manually is very hectic as well as time consuming, it's vital to automate the segmentation process of identifying the object of interest, its location and boundaries. The main purpose of Segmentation is to divide an image into regions that share the same characteristics. Segmentation makes the analyzing part easier by extracting meaningful features and identifying the region of interest. Various methods are available for image segmentation. For *e.g.* Clustering method, Histogram-based method, Region-growing method, Compression based method *etc.* Threshold Segmentation is one of the oldest and simplest segmentation methods. It firstly converts an input gray scale image to binary format. We have used Multilevel Thresholding where the number of thresholds is given in advance and the best thresholds are found by minimizing or maximizing a criterion [15]. Figure 7 shows the implementation of Multilevel Thresholding and Threshold segmentation on the pre-processed image. By using formula (3) we have determined multiple thresholds $\{ T_1, T_2, \ldots, T_N \}$ in the histogram of the image $f(x, y)$ to segregate the pixels with similar attributes and identify the object of interest in the image [15].

$$S(f(x,y)) = \begin{cases} G_0 & \text{if } f(x,y) \leq T_1 \\ G_1 & \text{if } T_1 < f(x,y) \leq T_2 \\ G_N & \text{if } f(x,y > T_N \end{cases} \quad (3)$$

Where $S(f(x,y))$ is the Segmented image and G_L is the gray-level assigned to the pixel in region L .

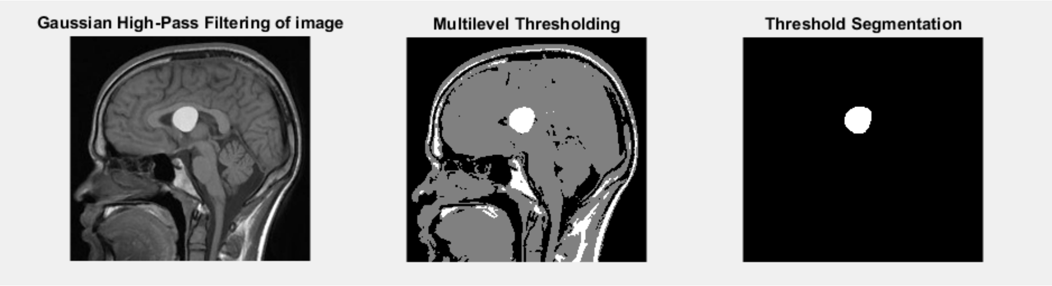


Figure 7. Multilevel Thresholding and Threshold Segmentation

As stated in *National Center for Biotechnology Information* that the classical feature of colloid cyst is its location. It is present in the center of the Brain. In our work, we have defined the region of interest and cropped the area to detect the presence of Colloid Cyst. If Colloid Cyst is present then we have traced the exterior boundaries of the cyst using ***bwboundaries(cyst,'noholes')*** and then plotted the points as shown in Figure 8.

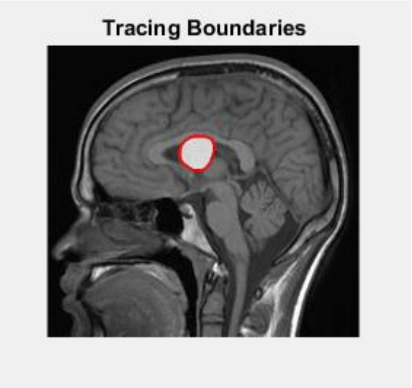


Figure 8. Tracing Boundaries

After plotting the exterior boundaries, we have calculated the approximate size of the Colloid Cyst by using Formula (7), considering that the image contains only two values, black and white. The maximum image size is taken as 256 x 256 and the binary image can be represented as

$$\text{Img, BI} = \sum_{WT=0}^{255} \sum_{HT=0}^{255} [f(0) + f(1)] \quad (4)$$

Where **f(0)** is white pixel , **f(1)** is black pixel, **WT** is width and **HT** is height [16]. Pixel = Width (WT) x Height (HT) = 256 x 256

As we have extracted and marked the Colloid Cyst in white pixels. Therefore,

$$no\_of\_WhitePixel\ W = \sum_{WT=0}^{255} \sum_{HT=0}^{255} [f(0)] \quad (5)$$

We have calculated the approximate size of the Colloid Cyst in mm^2.

$$1\ Pixel = 0.264mm$$

$$(Number\ of\ White\ Pixel)\ W = width \times height \quad (6)$$

$$\textbf{Approximate Size of Colloid Cyst} = [(\sqrt{W}) \times 0.264]\ mm^2 \quad (7)$$

A message box like in Figure 9 is used to display whether Colloid cyst is present or not. If it is present, the approximate size of the Colloid cyst is also mentioned.

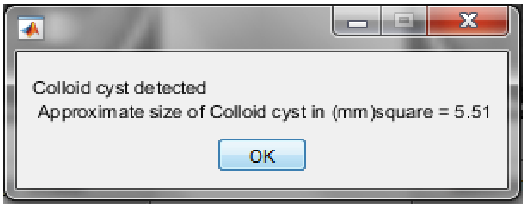


Figure 9. Message Box to Display Result

5. Result Analysis

Case 1: Figure 10 and 11 shows every step that the proposed algorithm follows to detect the presence of Colloid Cyst from MRI or CT Scanned Images. It is also capable of detecting very small sized Colloid Cyst.

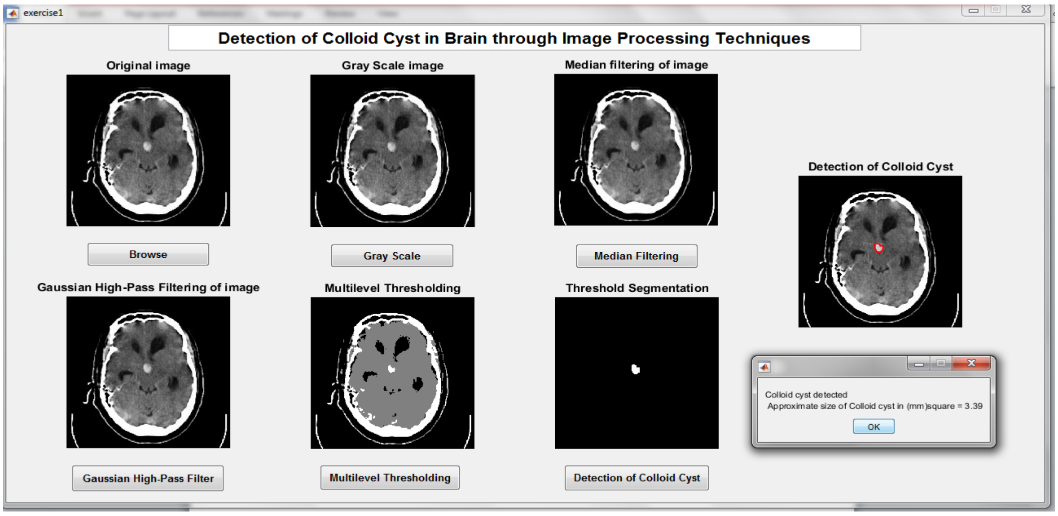


Figure 10. Detection of Colloid Cyst

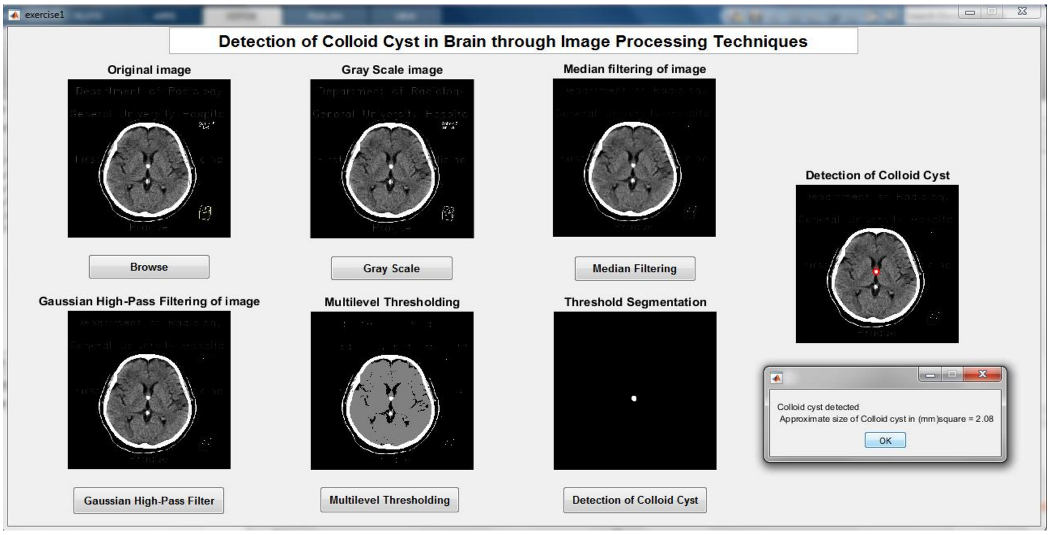


Figure 11. Detection of Small Colloid Cyst

Case 2: Figure 12 shows the result of the algorithm when there is an absence of Colloid Cyst in MRI or CT Scanned Images.

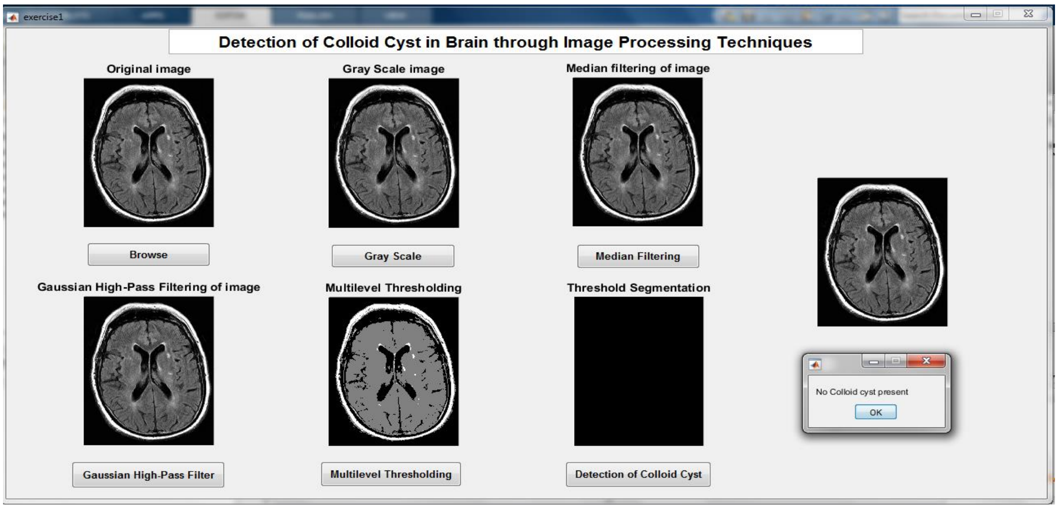


Figure 12. Absence of Colloid Cyst

Case 3: Implementation of the proposed algorithm on MRI or CT Scanned Images where there is a presence of Cyst, but not Colloid Cyst is shown in Figure 13.

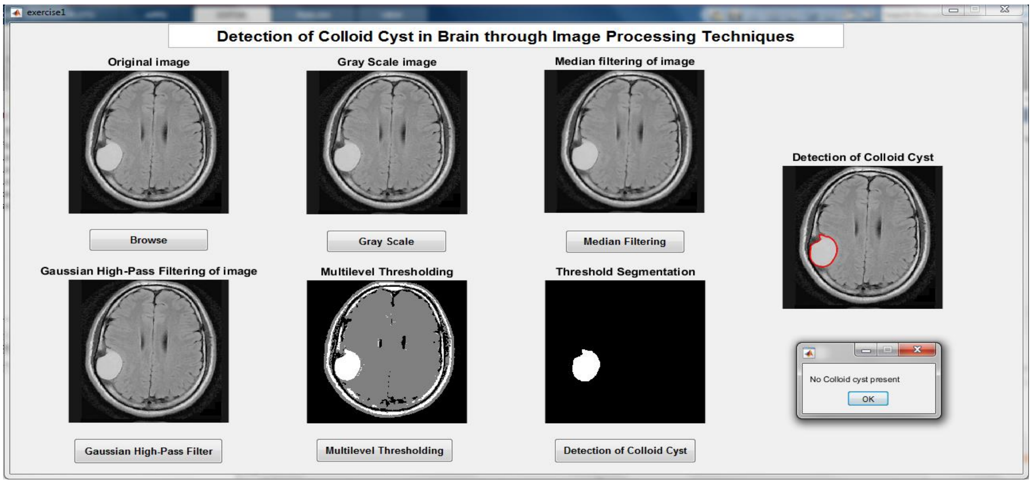
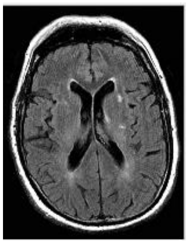


Figure 13. Absence of Colloid Cyst, but Presence of other Type of Cyst

Considering the high risk of sudden death due to Colloid Cyst, interestingly less work has been done to effectively use Image processing techniques to automate the process of detecting Colloid cyst in Brain from MRI or CT scanned images. In Table 1, we have analyzed the results of our proposed algorithm to demonstrate what sets it aside from other existing algorithms and to measure its effectiveness and accuracy by examining different cases. As we can see in Table 1, the proposed algorithm takes minimal amount of time to detect the presence or absence of Colloid Cyst, irrespective of the size of the image. Average time taken is between 10sec to 12 sec and the accuracy rate is 98%. It can detect very small size Colloid Cyst as well. It extracts and marks the exact shape of the cyst, therefore making the calculation for the size of the Colloid Cyst almost accurate.

Table 1. Analysis of Result with Different Cases

Case	Image	Description	Detection Time
Case 1. Colloid Cyst detected		Size of Image : 3.99 KB Size of Colloid Cyst : 6.11 mm^2	10s 21ms
Case 1. Colloid Cyst detected		Size of Image : 114 KB Size of Colloid Cyst : 5.75 mm^2	11s 7ms
Case 1. Colloid Cyst detected		Size of Image : 34.2 KB Size of Colloid Cyst : 2.43 mm^2	10s 43ms

			
Case 2. Absence of Colloid Cyst		Size of Image : 99.3 KB No Abnormalities found	11s
Case 3. Absence of Colloid Cyst Presence of other Cyst		Size of Image : 31.6 KB Presence of cyst, but according to location it is not a Colloid Cyst	10s 30ms

6. Conclusion and Future Work

The proposed methodology accurately detects and simplifies the process of detecting the presence or absence of Colloid Cyst in Brain from MRI or CT Scanned images, through Image Processing techniques. The algorithm provides three cases.

Firstly when Colloid Cyst is detected, it mentions the approximate size of the cyst. Secondly, when there is an absence of any abnormalities, it would just show the original image mentioning that “No Colloid cyst present”. Thirdly if there is a Cyst present but not a Colloid cyst, the algorithm would mark the exterior boundaries of the cyst, but according to the location it would mention that it isn’t a Colloid Cyst. This would make the diagnosis of Colloid Cyst easier, accurate and less time consuming for doctors and radiologists. In future we would like to extend this work and develop algorithms to detect each and every type of Cyst in Brain depending upon its location as well as other identification criteria and mention the type of cyst along with its size and further important details required for faultless treatment.

References

[1] Q. Javed and A. Dutta, “Third Ventricular Colloid Cyst and Organic Hypomania”, Progress in Neurology and Psychiatry, **(2014)**, pp. 18.
[2] http://www.medicalnewstoday.com/articles/181727.php[Accessed 17.06.2016].
[3] http://www.abta.org/secure/resource-one-sheets/cysts.pdf[Accessed 18.06.2016].
[4] K. Sheikh, V. Sutar and S. Thigale, “Clustering based Segmentation Approach to Detect Brain Tumor from MRI Scan”, International Journal of Computer Applications (0975 – 8887), vol. 118, no. 8, **(2015)**, pp. 36-39.
[5] E. E. Mohd, A. Muhd, M. Mohd, H. Z. Z. Htike and S. L. Win, “Brain Tumor Convergence and Services (IJITCS), vol. 4, no. 1, **(2014)**, pp. 1-11.
[6] V. D. Dharmale and P. A. Tijare, “Segmentation and Canny Edge Method in MRI Brain Cyst Detection”, International Journal of Advanced Computer Research, vol. 3, no. 4, **(2013)**, pp. 289-293.

[7] L. P. Bhaiya, S. Goswami and V. Pali, "Classification of MRI Brain Images using NeuroFuzzy Model", International Journal of Engineering Inventions, Vol. 1, no. 4, **(2012)**, pp. 27-31.
[8] M. Tariq, A. Khawajah and M. Hussain, "Image Processing with the specific focus on early tumor detection", International Journal of Machine Learning and Computing, vol. 3, no. 5, **(2013)**, pp. 404-407.
[9] A. C. Mamourian, L. D. Cromwell and R. E. Harbaugh, "Colloid Cyst of third Ventricle: Sometimes More Conspicuous on CT than MR", AJNR Am J Neuroradiol, **(1998)**, pp. 875-878.
[10] https://diagnosticpathology.biomedcentral.com/articles/10.1186/1746-1596-7-144[Accessed 02.07.2016].
[11] https://www.researchgate.net/publication/286816381_A_Comparative_Analysis_on_Edge_Detection_of_Colloid_Cyst_A_Medical_Imaging_Approach[Accessed 03.07.2016].
[12] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1550234/[Accessed 03.07.2016].
[13] https://en.wikipedia.org/wiki/Image_noise#Low_and_high-ISO_noise_examples[Accessed 05.07.2016].
[14] http://mstrzel.eletel.p.lodz.pl/mstrzel/pattern_rec/filtering.pdf[Accessed 06.07.2016].
[15] http://www.mecs-press.org/ijisa/ijisa-v5-n11/IJISA-V5-N11-3.pdf[Accessed 07.07.2016].
[16] V. Kshirsagar and J. Panchal, "Segmentation of Brain Tumor and Its Area Calculation", International Journal of Advanced Research in Computer Science and Software Engineering, vol. 4, no. 5, **(2014)**, pp. 528-529.
[17] https://en.wikipedia.org/wiki/Cyst[Accessed 16.07.2016].

