Sinus Diagnostic System

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Abstract

Automated Tool for Diagnosis of Sinus Analysis CT Scans [1] is a computer-based analysis and diagnosing system that used in the medical field for diagnosing sinus diseases . Where the doctors and radiologists need a system as an aid to help them to diagnosis of sinus patients.The proposed system can analyze and diagnose different types of sinuses like maxillary , ethmoid , sphenoid and frontal using several sections of CT scan on different angels.The sinus image were passed in three phases begin from preprocessing image , extraction region of interest , diagnosing and analyses the sinuses.This paper presents techniques and comparison between the experiments used during the development of the proposed system. The study uses CT scan images of sinus as input data. The proposed used many techniques most important is the Contrast Limited Adaptive Histogram Equalization (CLAHE) method in preprocessing ,Active Contour in segmentation and Gradient Boosting Tree algorithm and Fuzzy logic in diagnosing by artificial intelligence.

1 Introduction :

The diagnosis of sinusitis is very difficult even for good doctors. This is because the doctor is not depend on one test and he needs to conduct various types of diagnosis for take the necessary information to understand the patient's condition and doctors use their experience to bring together various forms of information to come up with a best diagnosis, including the patient's: symptoms, physical exam findings, culture results, nasal endoscopy and CT scans. Difficulty in diagnosing sinuses due to the symptoms of sinusitis overlap with many other diseases because these processes take a lot of time and effort as mentioned previously therefore doctors need a computerized system to utilized the features of smart systems to help them in the diagnostic. The proposed system choose diagnose in CT-scan to diagnose sinus diseases using techniques image processing and machine learning where CT is a computerized tomography scan combines a series of x-ray images taken from different angels, the computer uses this information to create an image through the browser – slices of the bones, blood vessels and soft tissues inside human body. Provide more detailed information than plain x-rays do were obtained from radiography department in hospitals. For an integrated system with potential diagnostic abilities and artificial intelligence [2] are good candidates that can combine image processing and diagnostic abilities in a single system.

2 Sinus Diagnosis and Medical Imaging :

There are three principal modalities now used by the radiologist to investigate the nose and paranasal sinuses. These are: plain X-ray [3], magnetic resonance [4] (MR) and computerised tomography (CT) It's also known as a CAT scan; the two terms refer to the same procedure. "CT" stands for "computed tomography," which means that the machine takes many x-rays of the same body part at different depths. The cross-sectional images generated during a CT scan can be reformatted in multiple planes, and can even generate three-dimensional images. These images can be

viewed on a computer monitor, printed on film or transferred to a CD or DVD.

CT images of internal organs, bones, soft tissue and blood vessels provide greater detail than traditional x-rays, particularly of soft tissues and blood vessels.A CT scan of the face produces images that also show a patient's paranasal sinus cavities. The paranasal sinuses are hollow, air-filled spaces located within the bones of the face and surrounding the nasal cavity [**5**] they are named the frontal, maxillary, ethmoid, and sphenoid sinuses.

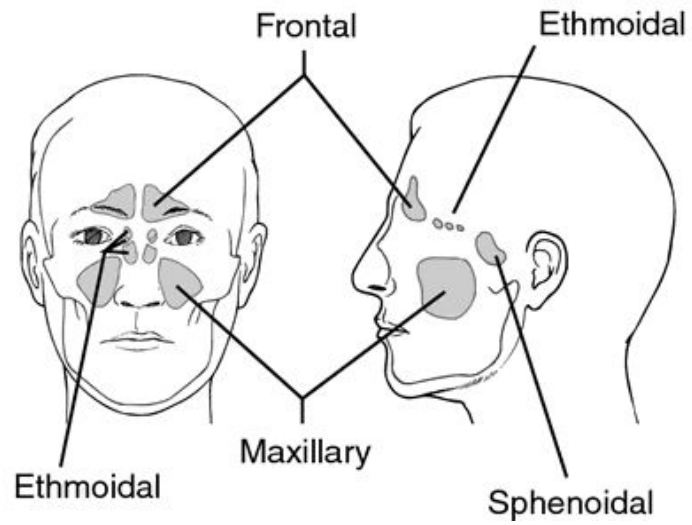


Figure 1 : Sinus paranasal (Paranasal sinuses).

Sinusitis is the inflammation or infection of the sinus cavities behind the nose, caused by bacteria, viruses, fungi and allergies. is characterized as acute when lasting less than 4 weeks, subacute when lasting 4 to 8 weeks, and chronic when lasting longer than 8 weeks, chronic sinusitis symptoms are similar but might be even more subtle. Figure 2 and 3 show Infections in different sinusitis areas with some cases of maxillary sinus.

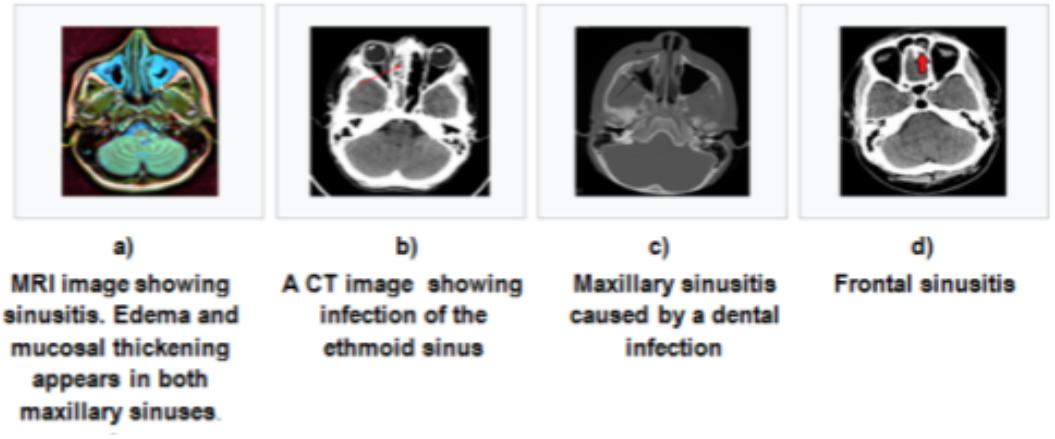


Figure 2 : CT and MRI images of infected sinuses

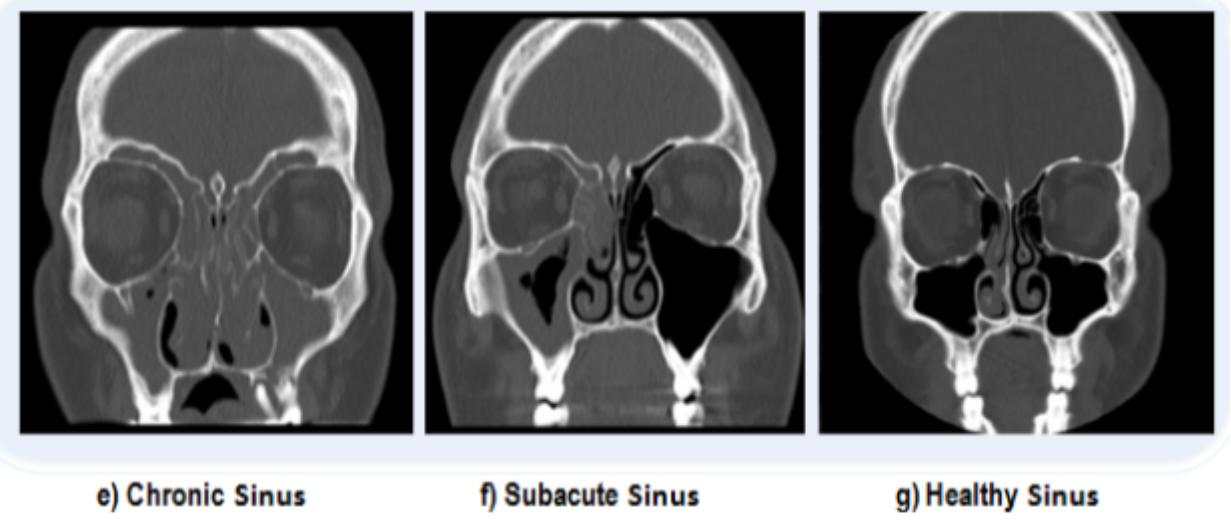


Figure 3 : CT-scans of a healthy and infected sinuses

3 Image Enhancement

3.1 Noise Reduction

The median filter is used to reduce noise in the images ,it preserves edges while removing the noise , Median filter of size 9*9 is applied to CT Sinus images , as it is found the most appropriate size to reduce noise and preserve edges in the images .The results of median filter shown in Figure 4.

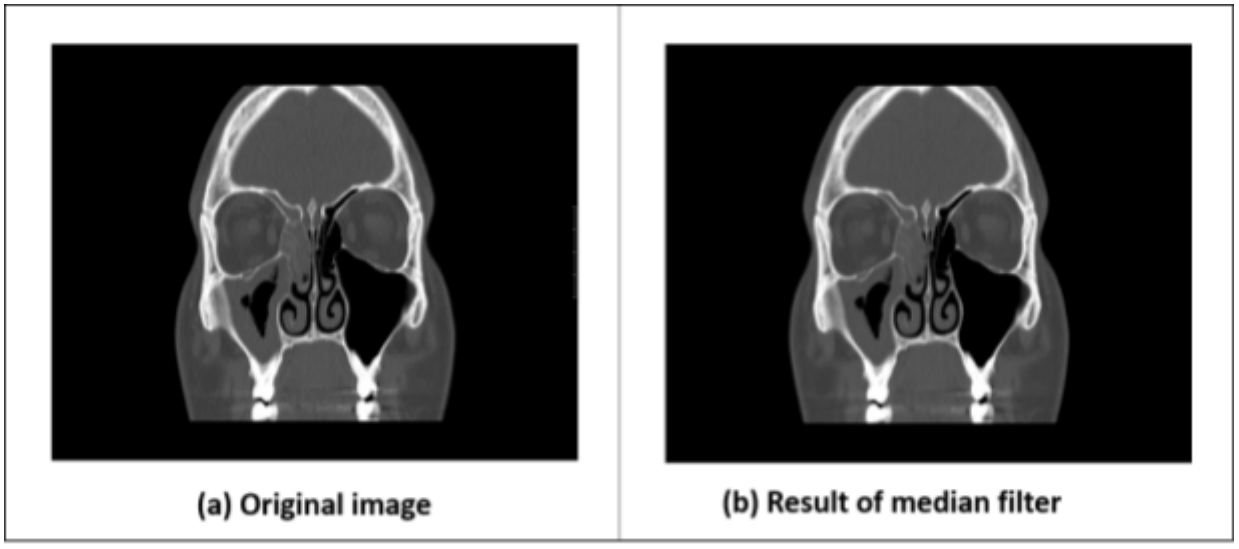


Figure 4 : The Median filter applied to the CT image with a mask size 9x9

3.2 Get Rid Of Unwanted Data

Eliminate unnecessary data from CT image is an essential work to facilitate image processing and preprocessing step in computer-aided diagnosis. The CT scan images may contain many noise or arrows or annotations that causes problems in the segmentation so was used a connected-component labeling technique to determine these unnecessary data and on another hand was applied background autocrop operation that depend on “first order” values to determine the background this operation git rid of the black background and crop it around the skull from the image as shown in Figure 3 below , and the other operation

was remove mandible bone from skull because it unnecessary part and also to facilitate extract regions of interest in image as shown in the Figure 5 below.

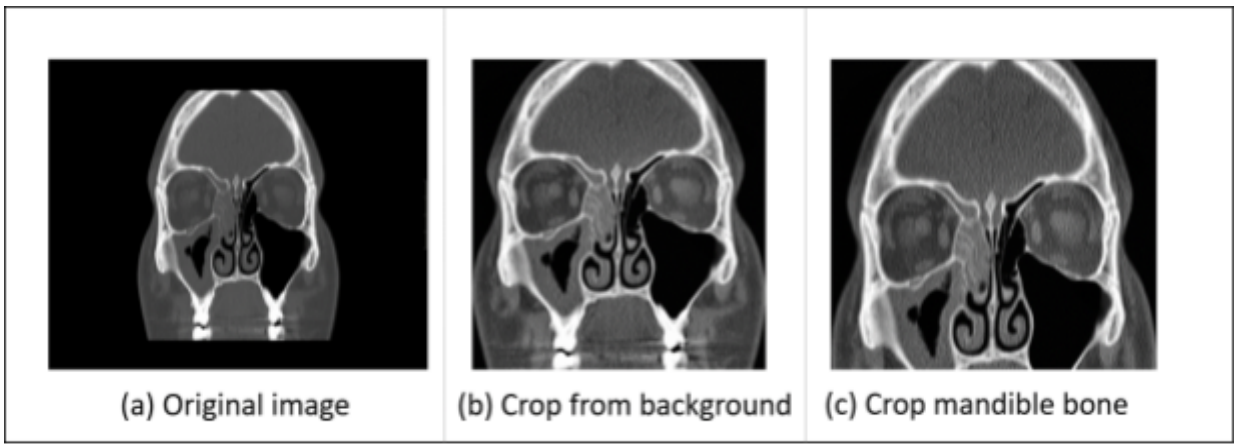


Figure 5 :Get rid of unwanted data from image

4 Edge Detection :

In proposed system many edge detection techniques were used to find the boundaries of the skull which helped in identifying ROI areas [6] like Canny, statistical and sobel filter which explained respectively starting with canny , Figure 6 shows the result of using canny technique.

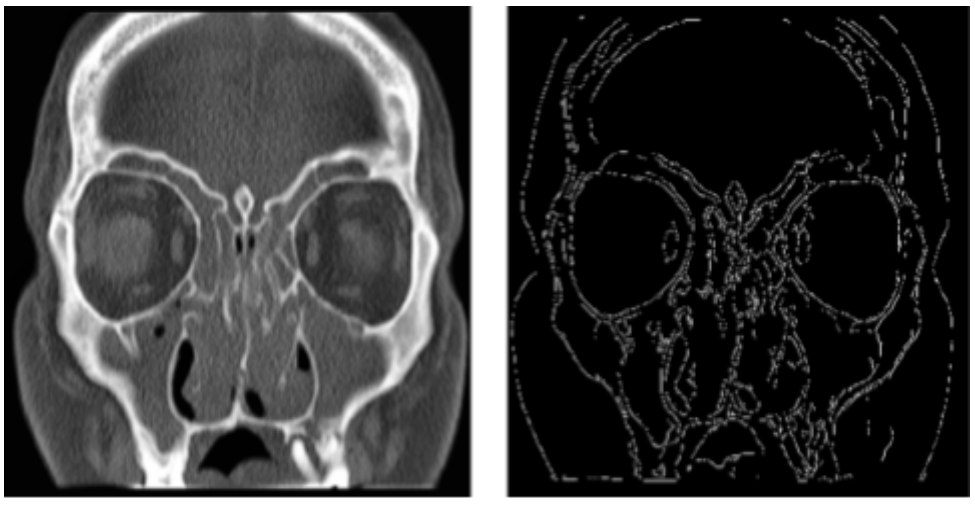


Figure 6 : CT image after applying Canny Edge Detection Technique

by focusing on the nature of edges in the previous result concludes that the edges drawn intermittently thats means there are gaps between the edges surrounding

target area which causes a negative impact .The second technique is laplacian the results were worse compared to the canny where the edges are hardly appear and very weak in all sections not only around the sinus area so it was the worst among all the results.on the other hand with statistical technique noise problem plus unwanted data appeared clearly

it's clear from figure 7 bellow that the third technique (sobel) solved the problem of incomplete edges in canny with less amount of noise compared to the statistical, however it was not good choice for most CT images cases due to the weakness of the edges around the eyes and some sinus regions,all these previous problems was solved by apply dilation morphological operation on canny technique which in turn succeeded to make edges connected ,make it stronger and clear, figure 8 shows the result of canny using morphological operation

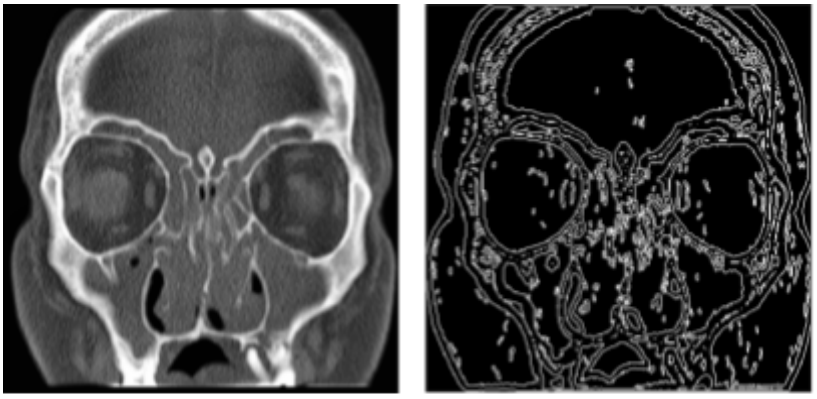


Figure 7: CT image after applying Sobel Edge Detection Technique

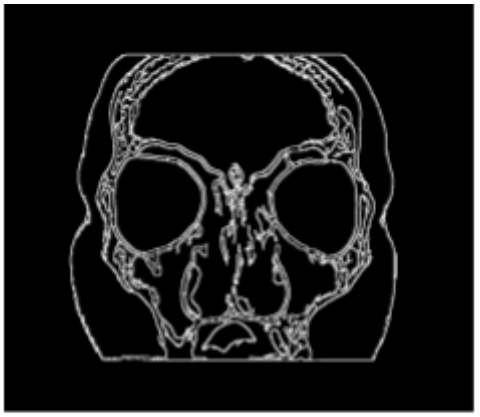


Figure 8 : CT image after applying morphological operation on canny

5 Threshold Bones Structure:

The main objective of the analysis process is to find common features that can be used for identifying the ROI areas, one of the most features that help to find the ROI areas is the bone structure,The proposed system were interested to get best bone structure as much as possible with minimal loss using the global thresholding technique.This section will provide comparison of techniques to show bone structure based on accuracy, clarity, and details.

- **Global thresholding**

  Global thresholding was selected in this proposed as the first technique .Figure 9 shows the results of applying global thresholding on the CT-images.

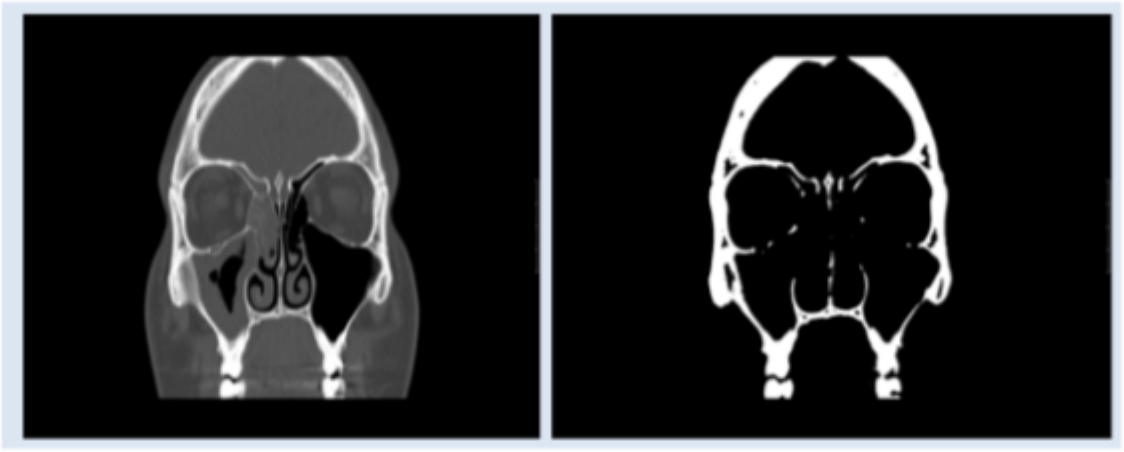


Figure 9: CT image after applying Global thresholding

there is no fixed threshold value fit all images due to the inconstancy of the grey level distribution in the CT-images, this technique fails in closing the boundaries that lie between the eye and the maxillary and ethmoid so another technique will be clarified in the following paragraph were used.

- **Bit Plane Slicing**

The results of bit slicing were checked by masking all bits (making them zero) but keeping the LSB (Least Significant Bit) unchanged. And so on for all other bits. Figure below shows the results.

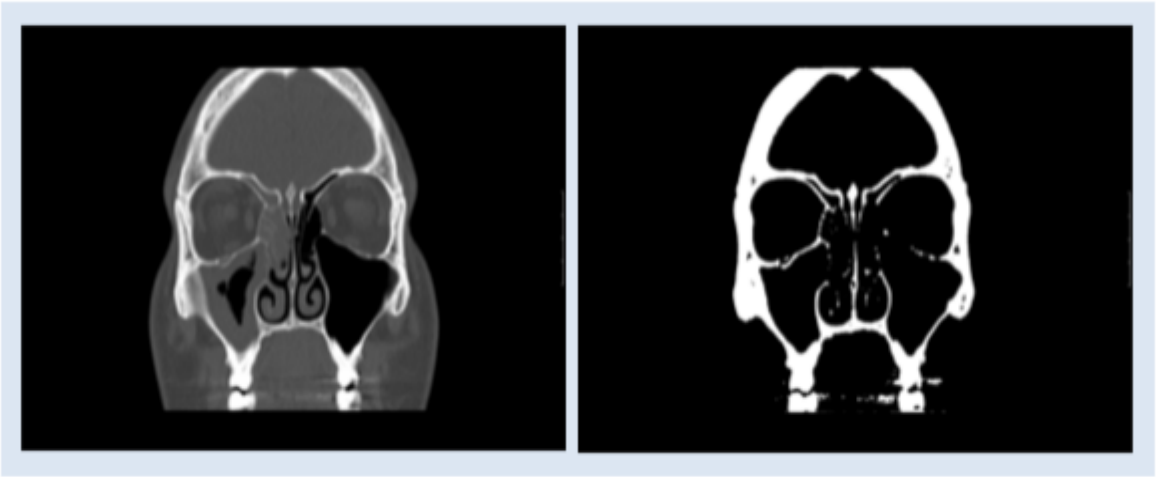


Figure 10 : CT image after applying bit slicing

This technique has succeeded in showing the parts of bones that have been lost in global thresholding.

❖ Local Contrast Enhancement :

In the proposed system has been applied the Contrast Limited Adaptive Histogram Equalization (CLAHE) method on the median filtered images.

CLAHE filter of size 8*8 is applied to CT Sinus images where the CLAHE divide the images to small regions of filter size and calculate the histogram equalization for every region separately and uses it to redistribute the intensity values of the image which makes hidden and unclear features more visible. This method helped to highlight the bone clearly. After LSB was applied on the equalized histogram images, we obtained better results and the bone structure became apparent as shown in Figure 5.

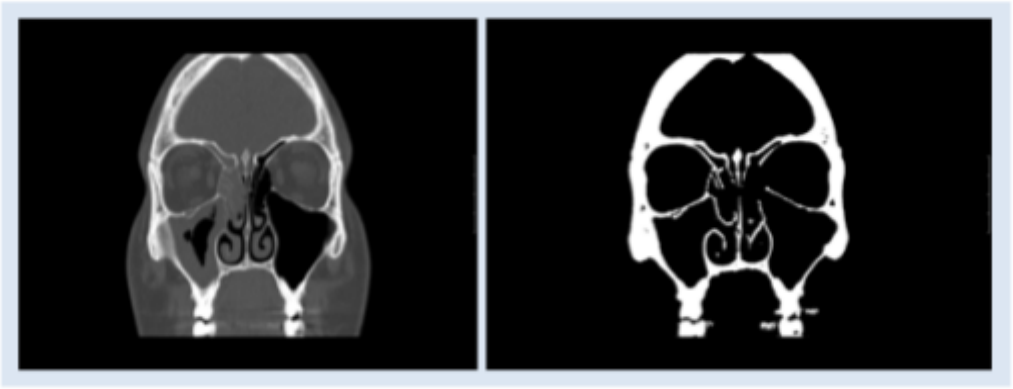


Figure 11 : CT image after applying Local contrast Enhancement (CLAHE)

6 Image Segmentation

The main objective of the segmentation is to find common features that used for identifying ROI areas from CT_scan images for these features, the following segmentation techniques were used:

❖ Merge Edge Detection with Bone Structure :

The problem of use the bone structure or edge detection separately as outline of the ROI boundary is the incomplete boundaries between different objects .This problem occurs when parts of the bone appear gray color between two objects resulting in incomplete boundaries and therefore, two adjacent organs may be miss-detected as one object on bone structure and to avoid this problem, there was a merging of bone structure and edge detection in the same image.The advantage of this step is to facilitate identification the objects based on bone structure
and close the weak boundaries in bone structure using the edges structure.

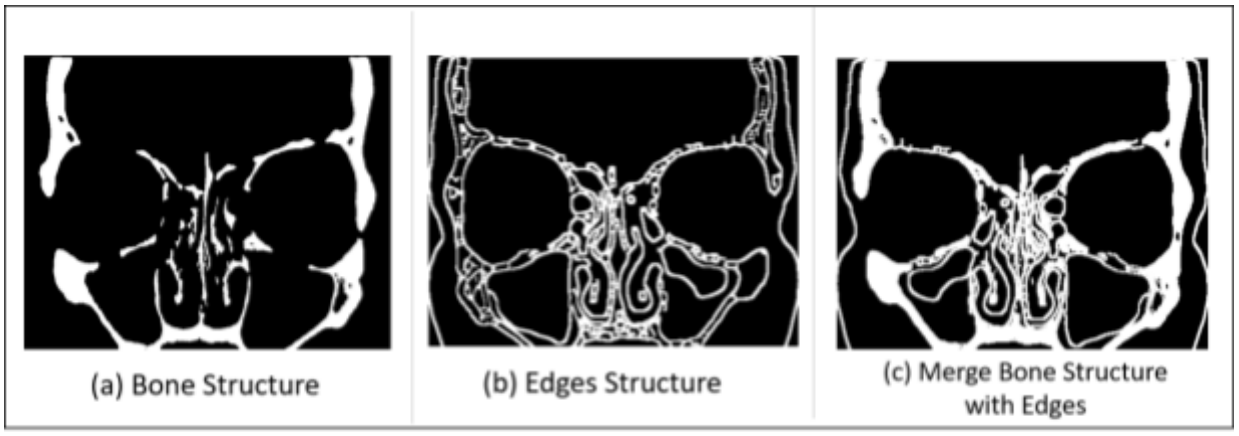


Figure 12 : Result of merge bone Structure with edges

❖ Mathematical calculations features used to detect ROI areas :

The frontal section of face in CT image have several geometry features in this section that used the following attributes:

a. Center of the skull.
b. Symmetry of the middle of the skull.
c. Distance between the top of the eye until the middle of the maxillary sinus.
d. Distance between the begin of cheekbones and center of the skull.

These features was used to detect the position for both sinusitis as is evident in the Figure 13.

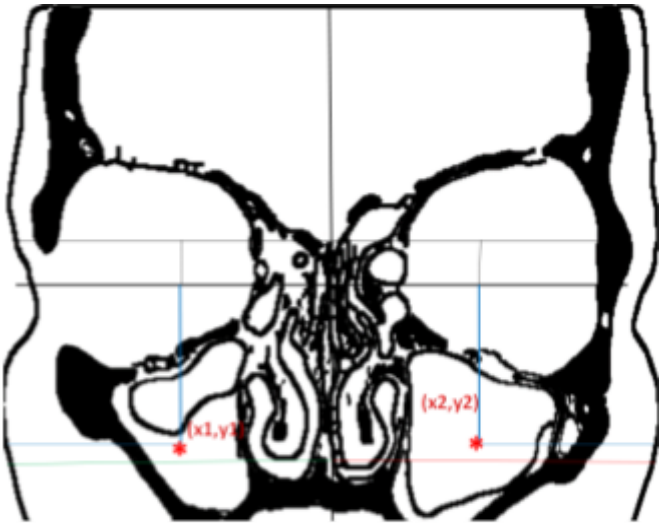


Figure 13 : illustrates the use of features that detect the ROI areas

❖ Active Contour :

Active contours have been widely used as attractive image segmentation methods because they always produce sub-regions with continuous boundaries.In this proposed system was used active contour to select the sinus cavity as shown in figure 14.

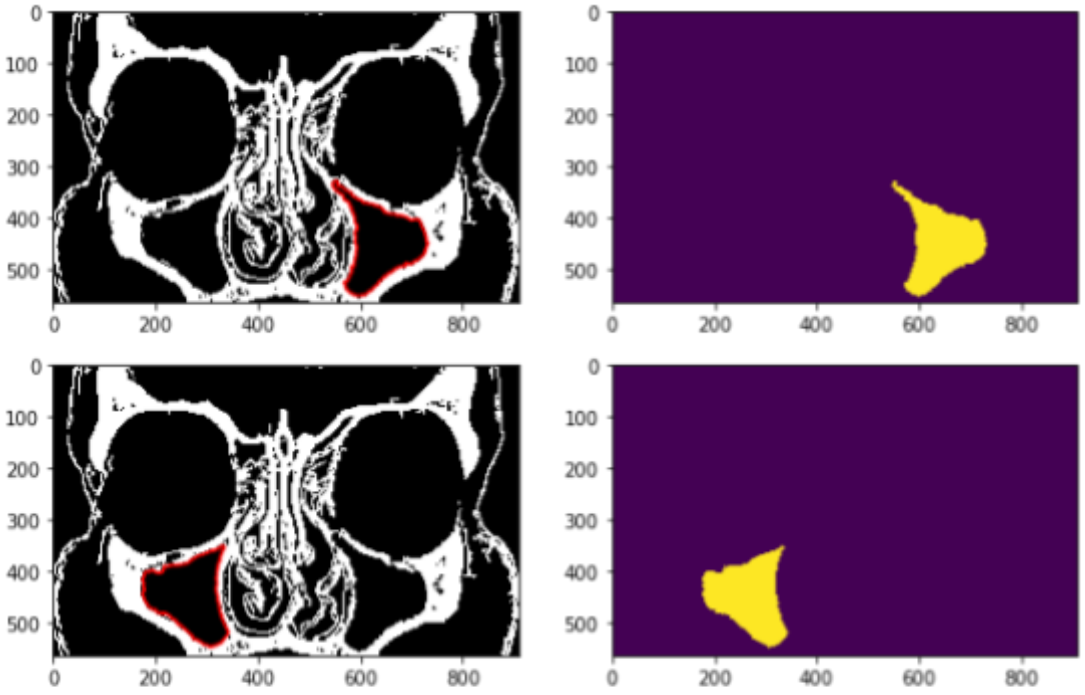


Figure 13 : Select the sinuses area using active contour.

7. Classification and Diagnosis:

The final stage in this research , during this phase will classify ROI and begin analyze it and diagnosing , The classification of ROI divide to three regions corresponding to air (Black), bone (White) and soft tissue (Grey). The percentage of grey region is to be used as an indicator (quantitative measure) of the extent of inflammation in the sinus area as shown in the (cf. Figure 15) .

The Artificial intelligence will also be used to improve the accuracy of the results and to train on the diagnosis of difficult chronic conditions.

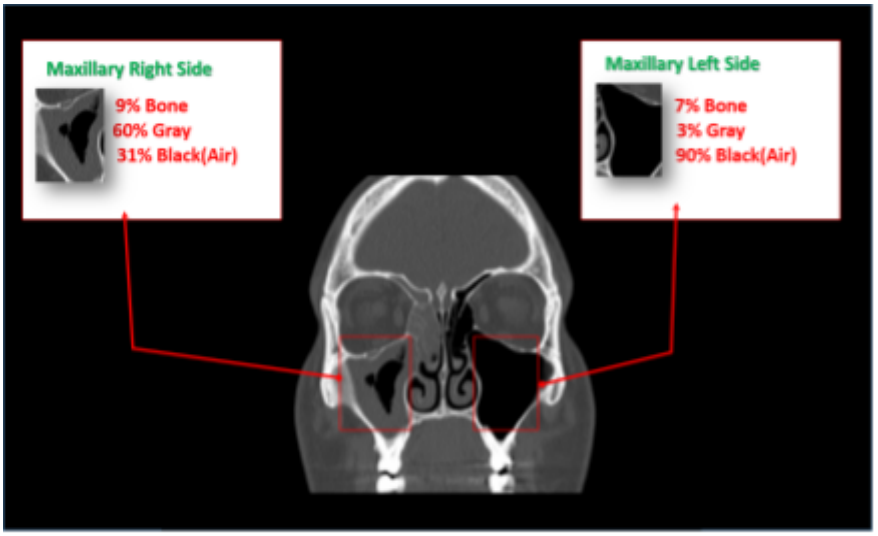


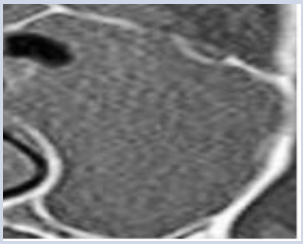
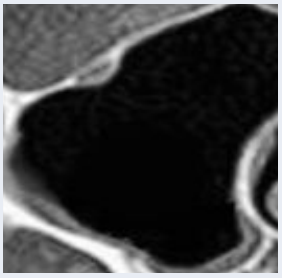
Figure 15 : Classification based on three regions air (Black) bone (White) and soft tissue (Grey).

The cases were analyzed and diagnosed proposed sinus diagnosis system. The gives the results as a percentage of black pixels in a given area) and percentage grey pixels in the area of interest). A scale is derived from both percentages to determine whether the sinus is healthy or not; if ill how severe the infection is

. The scale is defined in the following form which is used by ENT specialists:

- 0: healthy (grey %< 30%);
- 1 : Subacute(grey %< 75%);
- 2: Chronic (grey% > 75%)

The table below show the comparison between the fuzzy logic and gradient boosting algorithm results.

	sinus image	Unhealthy percentage in Fuzzy Logic	Unhealthy percentage in Gradient Boosting Tree
Right Sinus		**87%**	**99%**
Left Sinus		**17%**	**20%**

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