Investigating Hepato-Cellular-Carcinoma Based on CT-scan Tumor Edge Detection

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Abstract

Abnormalities in the liver include masses which can be benign or malignant. Due to the presence of these abnormalities, the regularity of the liver structure is altered, which changes its fractal dimension. In this paper, Hepato cellular carcinoma liver tumor is detected automatically using Computed Tomography Images. The method proposed has three stages. In the first stage, all kind of noises are such as speckles removed using image filtering. The overlap between different peaks is a strong evidence of noisy image. In the second stage, hepato cellular carcinoma tumor candidates are detected using histogram based analysis and K-mean based analysis. Suspected area was recognized successfully as the outcome of histogram based analysis. Tumor pattern shows gradual change from dark to light. The darker tune means worse damage as well as older damage compared to the lighter tune. The dark tune indicates severity and age. The light tune indicates new development of the tumor. Quantitative evaluation was done using ANOVA single factor test analysis to test whether there is any significant relation between the classes. Since, $P < 0.05$, there is insignificant relation between all the classes and we reject the null hypothesis. Further, validation between manual and automated segmentation was made and it is found that the error between manual segmentation and automated segmentation is smaller than 8.2 % which shows an evidence of success. In the final stage, the performance capability of K-means versus HBAA was analyzed. The error percentage in (HBAA) is (8.2 %), while in (K-mean classifier) the 139.4 %. The estimated area by (K-mean classifier) was exaggerated to more than double. The estimated area by (HBAA) was 92 % of the calculated area by the radiologist. The result is a proof of the superiority of (HBAA) over (K-mean classifier).

Keywords — *Medical Imaging, Liver Tumor Segmentation, K-Mean, HBAA.*

I. INTRODUCTION

Liver cancer is one of the most common cancers worldwide and is a type of cancer which is one the rise. It is rated as the fifth most common cancer disease endangering human life among men and ninth among women. More than 80% of these cases are affected by Hepato Cellular Carcinoma (HCC) that originates from Hepatocytes which are the predominant cells in the liver. Incidence and mortality rates are more than twice in men as compared to women. Early diagnosis of liver tumours can promote early treatment.

In modern years, the development of medical imaging technology has grown rapidly. To diagnose liver tumour medical imaging modality, especially Computed Tomography has been extensively applied. Diagnosis is a tedious task, which requires extensive calculations in order to understand a large number of abdominal CT images. These kinds of procedures are very expensive and prone to miscalculation as it requires pretty amount of expert's time. In order to investigate tumour Computer-Aided Diagnosis systems are useful in getting a promising result. CAD systems use advanced technologies to identify irregularity in bio medical images and these results are used by radiologists to diagnose early detection of liver tumour.

The liver is the body's major solid organ. Which Lye next to the stomach on the right side of the abdomen, it has numerous jobs like cleansing the toxins present in the blood by producing bile and to store energy in the form of a sugar called glycogen.

Liver cancer is usually called as hepatic cancer, which begin in the liver. It is the sixth most common cancer and the second for cancer death [2]. Liver tumours are discovered from medical imaging tool. Liver cancer is the source either from hepatitis B, hepatitis C, or alcohol. Liver cancers are unlike from liver metastases, which start in a different part of the body and expand to the liver. Liver cancers originate from either the liver itself or from constitution inside the liver, together with bile duct or the blood vessels.

The sources of malignant liver tumors are unknown. But risk factors for hepatoblastoma include Beckwith-Wiedemann syndrome (a disorder that can cause too much growth in the body, including in the internal organs), familial adenomatous polyposis (a condition that causes polyps to form in the large intestine), being male, and having a very low birth weight.

Medical conditions that are linked with hepatocellular carcinoma include the infections from either hepatitis B or C, or conditions connected with long-term damage of the liver, such as hereditary hemo chromatosis and autoimmune hepatitis. Tumors related to blood vessels such as angiosarcoma, hemangioendothelioma, embryonal sarcoma and fibrosarcoma are produced from a type of connective tissue known as mesenchyme. Other less common

liver cancers include carcinosarcomas, teratomas, yolk sac tumours, carcinoid tumours and lymphomas[7]. Lymphomas typically have gentle penetration to the liver; however it may also form a liver mass in unusual occasions.Occasionally the tumour from other parts of the body may spread to the liver and leads to break down of liver. These are not commonly called as liver tumours. Gastrointestinal tract is the origin of such tumours

Hepatocellular carcinoma is more familiar in adults but it also affects older children. Because of these it is very hard to remove the tumour surgically and may not respond to chemotherapy, hepatocellular carcinoma can be difficult to cure. Hepotoma is the most frequent tumor, accounting for 75% of all liver tumors, generally named as HCC. It is a cancer formed by the cells that are present in liver, identified as hepatocytes, which becomes malignant. [7] [8] Hepatoblastoma is another type of cancer formed by liver cells.

The detection of primary liver tumour is done using various image modalities such as ultrasound, computed tomography and magnetic resonance imaging . During the process of ultrasound detection, if a mass greater than 2 cm is found then there is a chance of around 95% of being HCC. The majority of HCC happen in the hilar region of the liver, and are frequently present as bile duct obstruction. If the basis of obstruction is suspected to be malignant, endoscopic retrograde cholangiopancreatography, ultrasound, CT, MRI and magnetic resonance cholangiopancreatography are used [10].

The main goal of MIC is to take out clinically related information from medical images. While closely relating to the field of medical imaging, MIC concentrates on the computational analysis of the images and not their acquisition. The methods are generally grouped into several broad categories such as image segmentation, image registration, image-based physiological modelling, and others.

Obesity- mediated mechanisms are factors for pathogenesis of HCC which leads to low-grade chronic inflammation. Obesity and diabetes leads to high risk in HCC that constitutes for two major risks for NAFLD [5]. Even without the presence of cirrhosis, development from NASH to HCC is not addressed in clinical studies. Current research Targets the obesity-related irritation and development of insulin resistance for chemoprevention of hepatocarcinogenesis [6,7]. In order to reduce incidence of HCC with patients affected from diabetics, metformin is used [8-10]. Intake of statins decreases the risk of HCC in observational studies. There is a proof from premature studies which points the possibility to treat HCC [11, 12].

The main objective of the current study is to develop a Semi-Automated Algorithm capable for identifying, Segmentation and Diagnosis of Liver Abnormalities.

II. DATA PRODUCTS & INSTRUMENTS

A. *Data Products*

Table I
Characteristics Of The Ct-Scan Image Of Liver Tumor (Hepato-Cellular-Carcinoma)

CT Image	In004: Patient-2
Date of Acquisition	02/01/2016
Resolution (in mm)	W=1.2; L =1.35
Resolution (in Pixels)	1008x832
DFOV with STND/ SS50	34.9 cm
Type of Disease	Hepato-Cellular-Carcinoma

The Table-I provides the specification of CT-scan image data being utilized in this study. These medical data were procured from Padmashree Diagnostics, Vijayanagar, Bangalore.

B. *Computing Machine*

1) *Features of Computing Machine:*

- Processor: Intel ®, Core (TM) i3, CPU 550 @3.2 GHz, RAM: 2 GB
- Operating System (32-bit): Microsoft Windows 7, NVIDIA GeForce 8400 GS

III.METHODOLOGY

A. *Filtering*

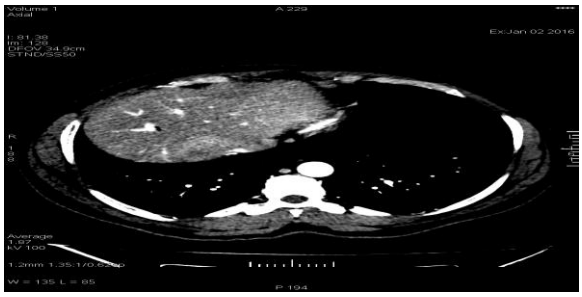

Fig 1: Raw Image In004: Portal Venous

Fig 1 shows the input raw CT scan image of a patient-2 in hepato-cellular-carcinoma. The length of the image is 1008 columns and the width is 831 rows. It was taken in 2nd Jan 2016.

Table II
Raw CT-Scan Image Information of Patient-2 in Hepato-Cellular-Carcinoma

	No. of Columns	No. of Rows	Width	Length
In Pixels	1008	832		
In mm			135	85

DFOV = 34.9 cm, STND / SS50

Resolution of the image:
W = 1.2 mm L = 1.35

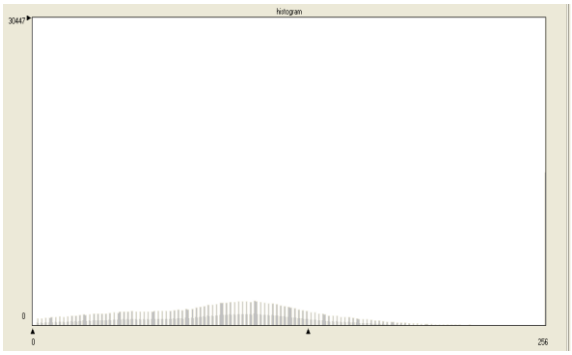

Fig 2: Histogram of the Raw In004

The Fig 2 indicates different objects of the abdomen including liver. Each peak represent different object in patient abdomen. It is clear that all peaks are overlapping, which makes it difficult for analysis before separation from each other.

Image filtering is an essential process to remove all kind of noise suck as speckles. The overlap between different peaks is an strong evidence of noisy image.

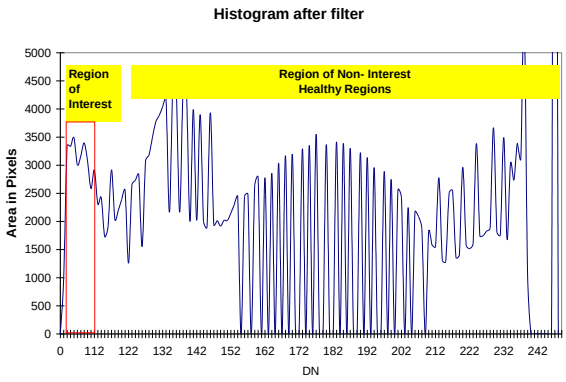

Fig 3: Histogram of the Filtered Image In004

The Fig 3 indicates 3 regions. The liver is in the middle, the extreme right is the blood vessels and the extreme left is liver tumor. Based on histogram analysis, highlighting the tumor is possible.

B. Automatic Detection Of Hepato Cellular Tumor Candidates

1) Histogram Based Analysis

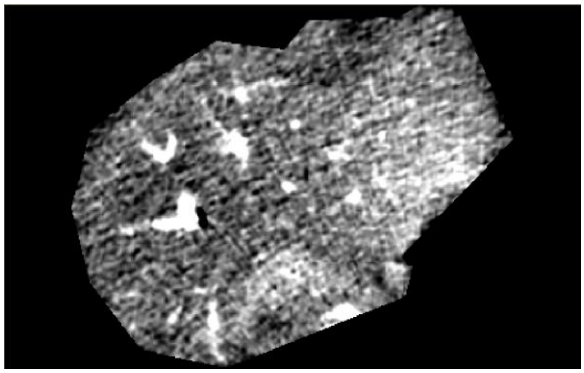

Fig 4: Liver

Liver was extracted and the rest of the abdomen was masked as shown in Fig 4.

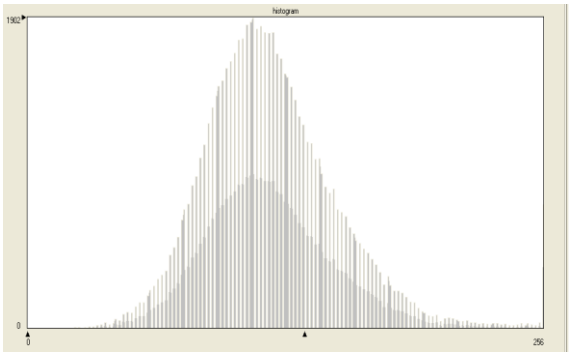

Fig 5: Histogram of extracted liver

Histogram of the highlighted liver in Fig 5 is left skew, the reason is the overlap between the liver peak and the tumor peak.

2) K-mean Based Analysis

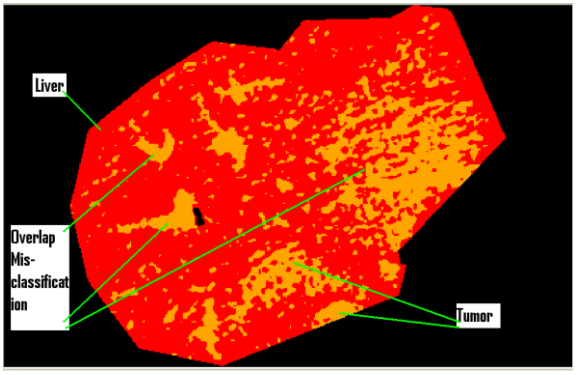

Fig 6: K-Mean unsupervised Classification

K-Mean unsupervised classification is used to classify liver into two classes (Liver "Red color" and "hepato-cellular-carcinoma" in Yellow color. K-Mean unsupervised classification failed to discriminate between liver and tumor in the overlapped areas. The area of the tumor is larger than the real area because of the overlap. There is need for advanced technique to remove the overlap.

Applying histogram based analysis algorithm leads to remove the overlap between liver and the tumor.

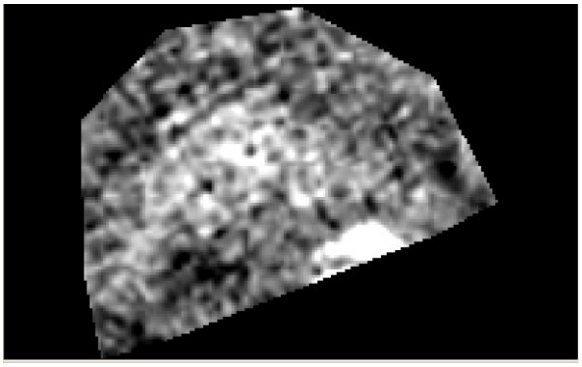

Fig 7: Hepato-cellular-carcinoma

Tumor is automatically highlighted using Equation 1. It is characterized by different tones from black to white, indicating different intensities.

$$\frac{(x_i - T_{\min})}{(T_{max} - T_{min})}(255-1)+1;\ if\ (T_{min} \le x_i \le T_{max})$$

$$0;\quad if\ (x_i < T_{min} \cup x_i > T_{max})$$

$$T_{min}: \mu_{tumor} - 3\sigma,\ T_{max}: \mu_{tumor} + 3\sigma \quad \ldots\ldots\ldots\ (1)$$

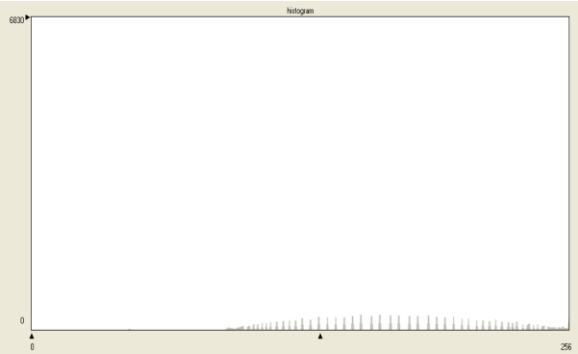

Fig 8: Histogram of the Suspected Tumor

Suspected area was recognized successfully as the outcome of histogram based analysis algorithm. It shows different tumor objects with different intensities based on the history of the objects.

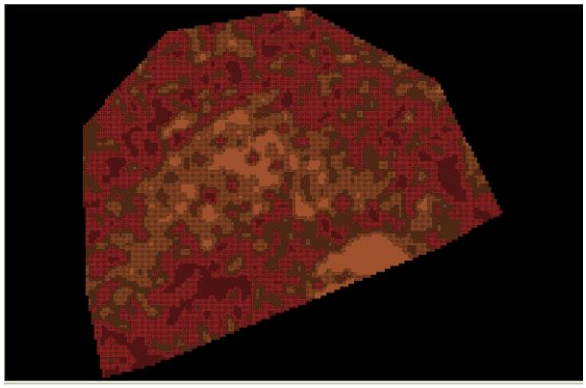

Fig 9: K-Mean Unsupervised Classification

The Fig 9 indicates Tumor Pattern shows gradual change from dark to light. The darker tune shows the worst as well as older damage than the lighter tune. The dark age tune indicates severity and age. The light tune indicates new development of the tumor.

Table III
Correlation Between Tumor Classes

	B1	B2	B3	B4	B5	B6
B1	1					
B2	-0.0718	1				
B3	-0.0767	-0.1290	1			
B4	-0.0854	-0.1437	-0.1535	1		
B5	-0.0769	-0.1294	-0.1381	-0.154	1	
B6	-0.0389	-0.0655	-0.0700	-0.078	-0.0702	1

Tumor was classified into six classes where they are not correlated, thus indicating different intensities.

Table IV Variance Between Groups

Groups	Count	Sum	Average	Variance
B1	20436	61278	2.998532	210.4458
B2	20436	211428	10.34586	885.5051
B3	20436	278977	13.65125	1352.057
B4	20436	385144	18.84635	2077.331
B5	20436	380483	18.61827	2502.304
B6	20436	145935	7.141075	1433.254

The Variance between six classes is very large indicating no possibility of merging.

IV. EXPERIMENTAL RESULTS

A. Performance Capability of K-Mean v/s HBAA

Fig 14: Exaggerated Area of Tumor by K-Mean Classifier

After the highlighting of liver, the image was classified using k-mean classifier. The result shows exaggeration of the area of suspected tumor (yellow color) as shown in previous figure.

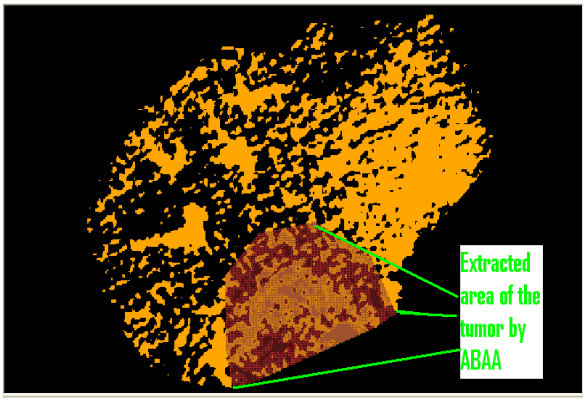

Fig 15: Area of the Tumor Extracted by HBAA Semivariogram

The extracted suspected tumor was extracted by Histogram Based Analysis Algorithm (HBAA) as shown in previous figure (small area in brown color). Area in yellow color is mis-classification done by K-mean classifier. The area of suspected Tumor in Pixels was calculated and compared as shown in Table 6.6.

Table V
Area of Suspected Tumor in Pixels

Segmentation	Manual	K-Mean	HBAA
Image	Area in Pixel	Area in Pixel	Area in Pixel
In015	13,583	32,520	12,474

The comparison between (K-mean classifier) and (HBAA) shown in next table. The error percentage in (HBAA) is (8.2 %), while in (K-mean classifier) the 139.4 %. The estimated area by (K-mean classifier) was exaggerated to more than double. The estimated area by (HBAA) was 92 % of the calculated area by the radiologist. The result is a proof of the superiority of (HBAA) over (K-mean classifier).

Table VI
Validation for the Area of Suspected Tumor

	HBAA	K-Mean
Image	% Error	% Error
In004	8.2%	139.4%

C. ANOVA Test

Table VII
ANOVA Single Factor Test

Source of Variation	Between Groups	Within Groups	Total
SS	4102444	1.73E+08	1.77E+08
df	5	122610	122615
MS	820488.8	1410.15	
F	581.8452		
P-value	0		
F crit	2.214122		

ANOVA Single Factor Test is used to test whether there is any significant relation between those six classes. Since $P < 0.05$, there is insignificant relation between all the classes and we reject the null hypothesis.

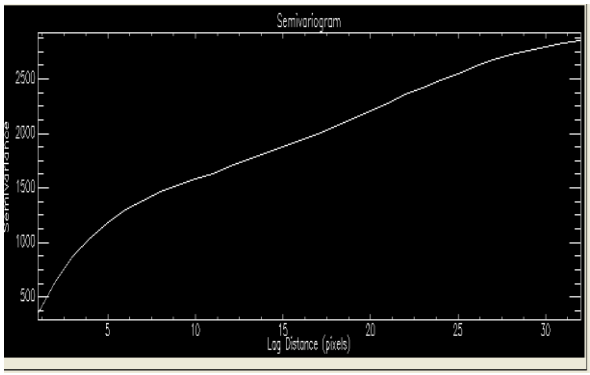

Fig 10: Horizontal Semivariogram

The horizontal exponential growth of the tumor is up to thirteen pixels and the horizontal linear growth of the tumor is up to Thirty two pixels.

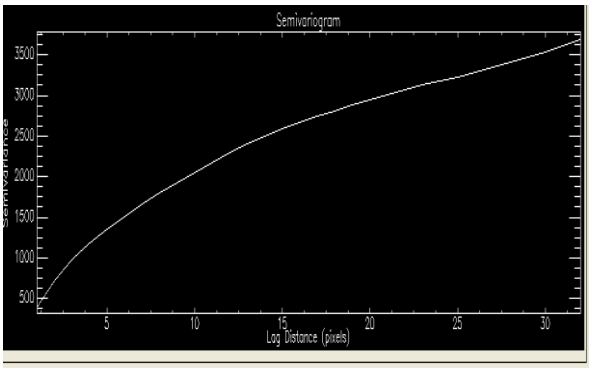

Fig 11: Vertical Semivariogram

The vertical exponential growth of the tumor is up to twelve pixels and the vertical linear growth of the tumor is up to twenty five pixels.

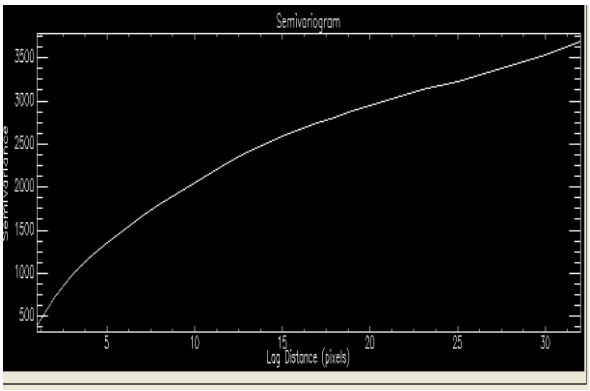

Fig 12: Positive Slope Semivariogram

The positive slope exponential growth of the tumor is up to three pixels and the positive slope linear growth of the tumor is up to sixteen pixels.

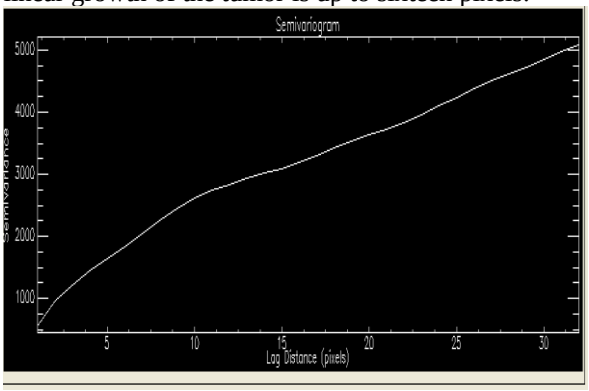

Fig 13: Negative Slope Semivariogram

The negative slope exponential growth of the tumor is up to two pixels and the negative slope linear growth of the tumor is up to twenty five pixels.

D. Validation

Table VIII
Validation between Manual and Automated Segmentation

Segmentation	Manual	Automatic	Standard Error
Image	**Area in Pixel**	**Area in Pixel**	
In015	13,583	12,474	8.2%

As shown in Table VIII, the error between manual segmentation and automated segmentation is smaller than 8.2 %. This is an evidence of success.

V. CONCLUSION

The proposed algorithm is capable of Detecting Liver, Detecting Tumor, Detecting tumor development, Classifying the tumor into different classes according to the intensity of growing cells, locating the most affected portion for each segment (Dark Tumor Region), locating the new affected portion for each segment (Light Tumor Region).

K-Mean unsupervised classification is used to classify liver in two classes (Liver and Tumor). In all the analyzed images, K-Mean unsupervised classification failed to discriminate between liver and tumor in the overlapped areas. The area of the tumor is larger than the real area because of the overlap. There was need for advanced technique to remove the overlap.

Applying histogram based analysis algorithm leads to remove the overlap between liver and the tumor. Tumor was classified into six classes where they are not correlated, thus indicating different intensities. The Variance between six classes is very large indicating no possibility of merging.

ANOVA Single Factor Test is used to test whether there is any significant relation between those six classes. Since $P < 0.05$, there is insignificant relation between all the classes and we reject the null hypothesis.

The impacts of applying the proposed algorithm in treatment plan are:

- Reducing the required dose whether it is chemotherapy or Radio-therapy
- The location of the most damaged part is clear and can easily be operated upon.
- The new growing cells can easily be located and surrounded for suppressing the diffusion / spread.

The validation of the algorithm indicates very small error between manual segmentation and automated segmentation. The comparison between (K-mean classifier) and (HBAA) is shown in Table VI. The error percentage in (HBAA) is very small compared to the calculated area by the radiologist while the estimated area of the suspected tumor done by (K-mean classifier) was usually exaggerated compared to the calculated area by the radiologist. The result is a proof of the superiority of (HBAA) over (K-mean classifier).

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