



CT-Scan Image Segmentation of Liver Cancer Using the Active Contour Method

Nurazizah¹, Dwina Kuswardani², Herman Bedi Agtriadi³

^{1,3}Department of Informatics Engineering, Institut Teknologi PLN, Indonesia, 11750

nurazizah2031097@itpln.ac.id

<https://doi.org/10.37339/e-komtek.v10i1.3273>

Published by Politeknik Piksi Ganesha Indonesia

Abstract

Artikel Info

Submitted:

24-06-2026

Revised:

25-06-2026

Accepted:

30-06-2026

Online first :

30-06-2026

Liver cancer is one of the most common types of cancer both in Indonesia and throughout the world. The increase in liver cancer cases is thought to be related to the increase in hepatitis B and C virus infections. According to statistical data from Globocan, in 2022 there will be 866,000 cases of liver cancer recorded worldwide, with 758,000 deaths due to this disease. To overcome this challenge, image processing plays an important role in improving image quality and performing segmentation to separate objects based on certain characteristics. In this research, the Contrast Limited Adaptive Histogram Equalization (CLAHE) and Contrast Stretching methods are used to improve image quality, while the Active Contour method is applied for image segmentation. Validation of segmentation results was carried out using Receiver Operating Characteristic (ROC) calculations. Testing was conducted on 21 CT-scan images of liver cancer, yielding an accuracy of 97.16%, a sensitivity of 75.69%, and a specificity of 98.85%. This research was conducted using the MATLAB application (R2015a). These findings demonstrate the effectiveness of the methods used in supporting the diagnosis and treatment of liver cancer.

Keywords: *Active Contour, Liver Cancer, Matlab, ROC*

Abstrak

Kanker hati merupakan salah satu jenis kanker yang paling umum baik di Indonesia maupun di seluruh dunia. Peningkatan kasus kanker hati diduga berkaitan dengan meningkatnya infeksi virus hepatitis B dan C. Menurut data statistik dari Globocan, pada tahun 2022 akan tercatat 866.000 kasus kanker hati di seluruh dunia, dengan 758.000 kematian akibat penyakit ini. Untuk mengatasi tantangan ini, pemrosesan citra memainkan peran penting dalam meningkatkan kualitas citra dan melakukan segmentasi untuk memisahkan objek berdasarkan karakteristik tertentu. Dalam penelitian ini, metode Contrast Limited Adaptive Histogram Equalization (CLAHE) dan Contrast Stretching digunakan untuk meningkatkan kualitas citra, sedangkan metode Active Contour diterapkan untuk segmentasi citra. Validasi hasil segmentasi dilakukan dengan perhitungan Receiver Operating Characteristic (ROC). Pengujian dilakukan pada 21 gambar CT scan kanker hati, yang menghasilkan akurasi sebesar 97,16%, sensitivitas sebesar 75,69%, dan spesifisitas sebesar 98,85%. Penelitian ini dilakukan menggunakan aplikasi MATLAB (R2015a). Temuan ini menunjukkan keefektifan metode yang digunakan dalam mendukung diagnosis dan pengobatan kanker hati.

Kata-kata kunci: *Kontur Aktif, Kanker Hati, MATLAB, ROC*



This work is licensed under a [Creative Commons Attribution-NonCommercial 4.0 International License](https://creativecommons.org/licenses/by-nc/4.0/).

1. Introduction

Liver cancer is one of the most common cancers in Indonesia and globally. The rise in hepatitis B and C transmission is thought to be linked to this increase. According to the Global Burden of Cancer (Global Burden of Cancer) report, in 2022, there were 866,000 cases of liver cancer worldwide, and 758,000 deaths from the disease [1]. Liver cancer detection is still carried out through imaging media such as CT scans, on the liver, which produce liver image data. However, CT scans of the liver also include other organs such as the kidneys, gallbladder, and pancreas, which can hinder the process of detecting liver disease [2]. Segmentation is the process of separating or dividing one object from another in an image. With segmentation, users can identify good and bad parts of an object in an image. This is the initial step in image analysis before proceeding to the image recognition stage from a specific input. As explained previously, the purpose of image segmentation is to divide an image into several regions based on similarities in texture, color, shape, and various other attributes.

Receiver Operating Characteristic (ROC) is a curve used to evaluate the performance of a classification model by displaying the relationship between the True Positive Rate (TPR) and False Positive Rate (FPR) at various classification thresholds. True Positive Rate, also known as sensitivity or recall, is the proportion of positive examples that are actually detected by the model [3]. Liver segmentation in CT-Scan images is a problem due to variations in liver size and intensity levels similar to neighboring organs such as the heart and kidneys. In addition, unclear anatomical boundaries, low contrast in medical images, the effects of patient motion that cause partial volume, spatial smoothing, and reconstruction artifacts are also factors that make liver segmentation difficult and complex.

2. Method

This study began with a requirements analysis phase to identify problems and determine system requirements for the diagnosis of liver cancer using CT-scan images. The next phase involved image preprocessing using the Inverse and Contrast-Limited Adaptive Histogram Equalization (CLAHE) methods to improve image quality and clarify the characteristics of the objects to be analyzed.

After preprocessing, image segmentation was performed using the Active Contour method with an Edge model to more accurately separate the liver area from the surrounding

tissue. The segmentation results were then evaluated using the Receiver Operating Characteristic (ROC) curve to measure the performance and accuracy of the segmentation in supporting the diagnostic process [3].

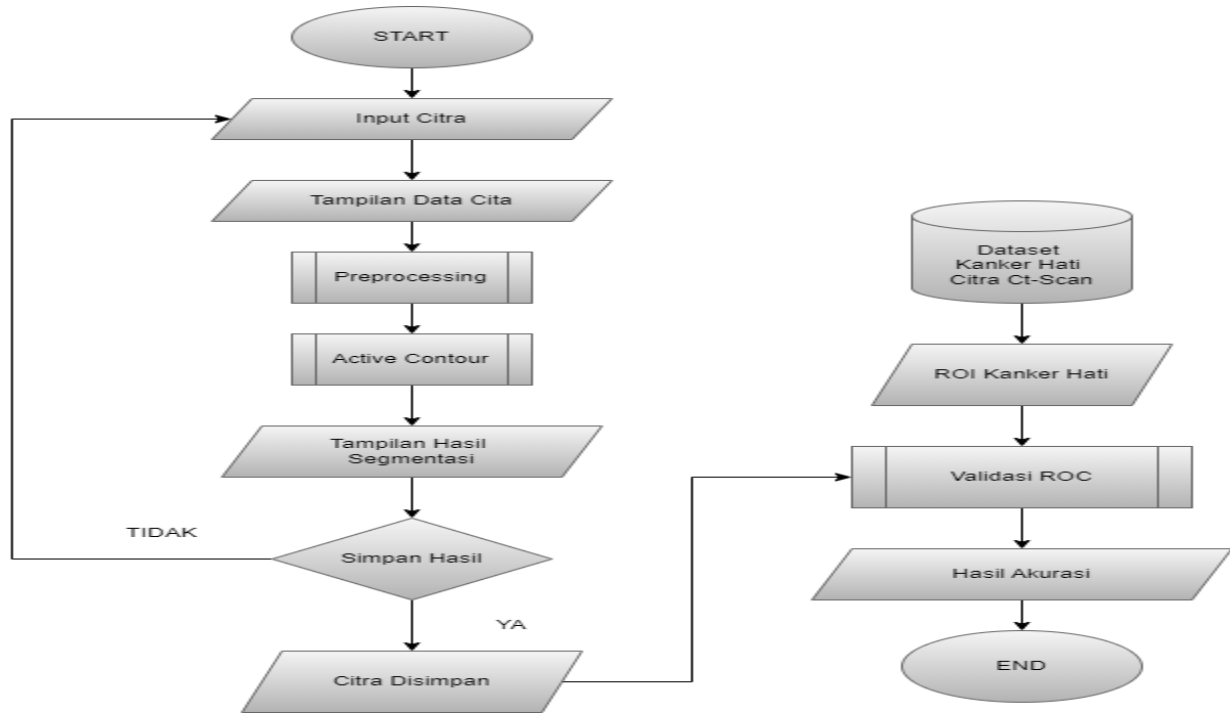


Figure 1. Research Design.

Research Stages with the Active Contour Method

a. Collecting Image Data

In this study, the authors used Computed Tomography Scan (CT-Scan) Liver Tumor image data derived from a public dataset published on the Kaggle website in 2020 <https://www.kaggle.com/datasets/andrewmvd/liver-tumor-segmentation/data> [4].

b. Digital Image

An image can be understood mathematically as a two-dimensional representation. Digital image processing refers to techniques used to enhance image quality so that it becomes easier for humans or computer systems to interpret, often using photographic data as input. The primary purpose of this process is to make images clearer and more meaningful for analysis. As a branch of artificial intelligence, image processing utilizes digital representations of objects to address various problems. These techniques often involve geometric or mathematical operations, such as analyzing pixel values to quantify objects within an image. Each element in an image

carries measurable values that represent different attributes of an object and how they relate to one another.

Objects within an image can be differentiated based on characteristics like color, texture, and shape. In a two-dimensional space, an image can also be described as a continuous function that represents variations in light intensity [5] [6].

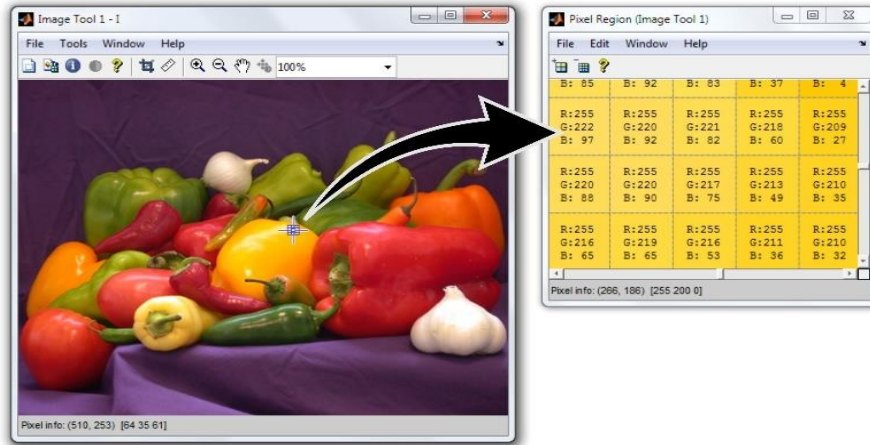


Figure 2. Digital Images and Their Composition of Pixels

c. Inverse Process

In CT scans, the inverse process can be used to clarify the difference between healthy and unhealthy tissue, thus aiding in medical diagnosis and analysis. This image inversion process functions to reverse the image values by reflecting pixel values around the middle of the intensity range. The result of this process will form a negative image, this process is done by subtracting the pixel values in the image from 255. The equation for the inverse process is as follows [7].

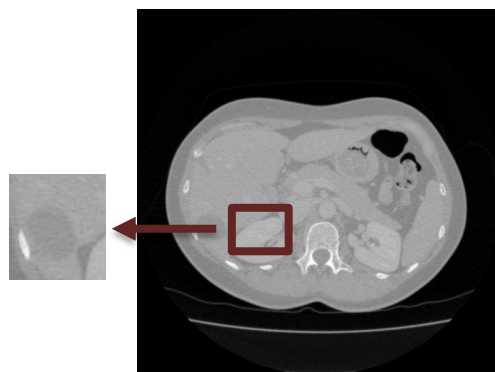


Figure 3. Liver Cancer CT Scan Image Data

$$g(x, y) = 255 - f(x, y) \tag{1}$$

Keterangan ;

$g(x, y)$ = Citra Negatif

$f(x, y)$ = Citra Asli

d. Contrast Limited Adaptive Histogram Equalization (CLAHE)

CLAHE (Contrast Limited Adaptive Histogram Equalization) is used to operate on small areas in the image called blocks. After the Inverse and grayscale processes are completed, the CLAHE (adapthisteq) process is performed on each block to increase its contrast [8]. After obtaining the inverse results, the next step is to perform histogram equalization with the following equation.

$$\beta = \frac{M}{N} \left(1 + \frac{\alpha}{100} (Smax - 1) \right) \quad (2)$$

e. Initialization Process

After deciding the number of iterations, the next step is to set up the initialization stage. This stage defines the region of interest in the image for the Active Contour process. The initialization is carried out using a polygon approach, where a polygon is a geometric shape formed by more than two points. In this study, polygons are utilized to specify coordinate regions within the image. Two initialization scenarios are applied: polygons with three points and polygons with four points, both positioned either inside or outside the object [5].

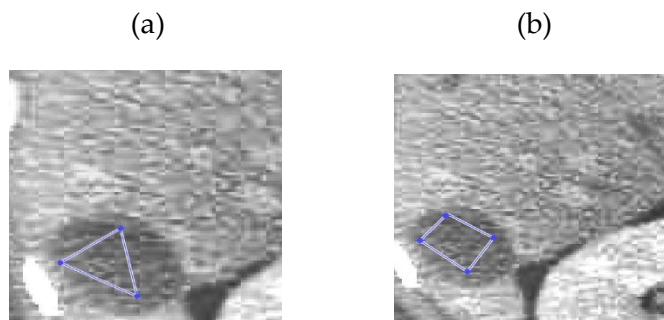


Figure 4. (a) Example of 3-Point Polygon, (b) Example of 4-Point Polygon

f. Active Contour Process

Liver cancer segmentation in CT scan images using the Active Contour method. In digital images, there are internal and external energies that affect the Active Contour curve. Active Contour will minimize this energy to find the contrast intensity inside and outside the contour. The Active Contour method performs segmentation through an initialization process, where these initialization points will expand and contract to find the object's edge. The number of iterations input also determines how many iterations are required for the initialization points to find the object's edge. The parameters used in this study are 'Chan-Vese' and 'ContractionBias'[9].

g. Receiver Operating Characteristic (ROC) Testing Method

In ROC there are four possibilities that will occur, namely:

1. If there is a value that is actually positive and the model results are also positive, then it is included in the True Positive (TP) value.
2. If there is a value that is actually negative and the model results are also negative, then it is included in the True Negative (TN) value.
3. If there is a value that is actually positive, but the model results are negative, then it is included in the False Negative (FN) value.
4. If there is a value that is actually negative, but the model results are positive, then it is included in the False Positive (FP) value.

From the four values above, accuracy, sensitivity, and specificity can be calculated. The formula is as follows:

$$\text{Akurasi} = \frac{TP+TN}{TP+TN+FP+FN} \dots\dots\dots(3)$$

$$\text{Sensitifitas} = \frac{TP}{TP+FN} \dots\dots\dots(4)$$

$$\text{Spesifisitas} = \frac{TN}{TN+FP} \dots\dots\dots(5)$$

Where the areas that represent the TP, TN, FP and FN sections are shown in the image below:

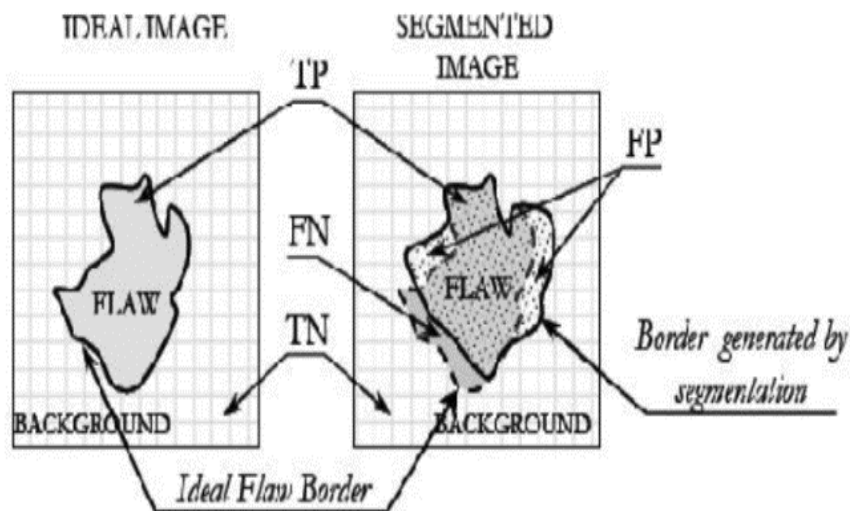


Figure 5. Differences Between Manually Segmented Images and Program-Segmented Image Results

In this study, the Receiver Operating Characteristic (ROC) method was used to evaluate the accuracy or validity of image segmentation results. ROC measures system performance and indicates potential errors or successes in matching. In this ROC test, the authors selected manual segmentation data samples from the Kaggle dataset, consisting of liver CT scan image data, as well as segmentation results from the program being tested [10].



Figure 6. (a) Manual Data Segmentation, (b) Program Segmentation

ROC will calculate the TP (True Positive), TN (True Negative), FP (False Positive), and FN (False Negative) values. The results will be as follows:

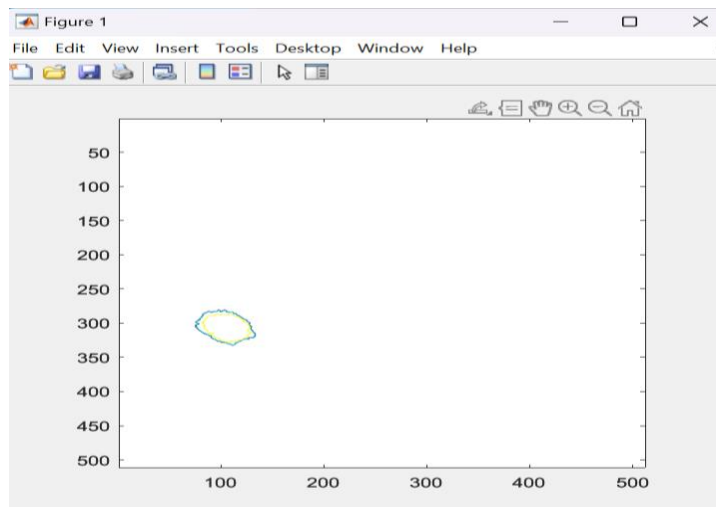


Figure 7. Merging Dataset Images With Segmentation Results

The equations used to calculate accuracy, sensitivity, and specificity are as follows:

$$\text{Accuracy} = 100\% * \frac{TP+TN}{TP+TN+FP+FN} \quad (6)$$

$$\text{Sensitivity} = 100\% * \frac{TP}{TP+FN} \quad (7)$$

$$\text{Specificity} = 100\% * \frac{TN}{TN+FP} \quad (8)$$

3. Results and Discussion

The results of the implementation of the proposed approach, namely applying the Active Contour method to the segmentation of liver cancer CT-Scan images, will be reported in this study. The segmentation findings indicate how well this technique separates the liver cancer region from the surrounding organs. Matlab was used for testing and evaluation. MATLAB (R2022b) was used to implement the Contrast Limited Adaptive Histogram Equalization,

Contrast stretching, and Active Contour techniques. The results of using Active Contour for segmentation of liver cancer CT-Scan images can be confirmed through the use of this program.

a. Implementation of the Main Menu Interface in Matlab

The main menu is the first menu that appears upon opening the application, where the segmentation process can be performed. There are seven processes in this main menu: image input, grayscale, histogram equalization, contrast stretching, initialization, Active Contour processing, and saving the output image.



Figure 8. Main Menu Interface View

b. Implementation of the ROC Menu Interface in Matlab

The ROC menu has 3 processes, namely: opening the manual segmentation image from the initial dataset, opening the segmentation result image from the program, and calculating ROC.

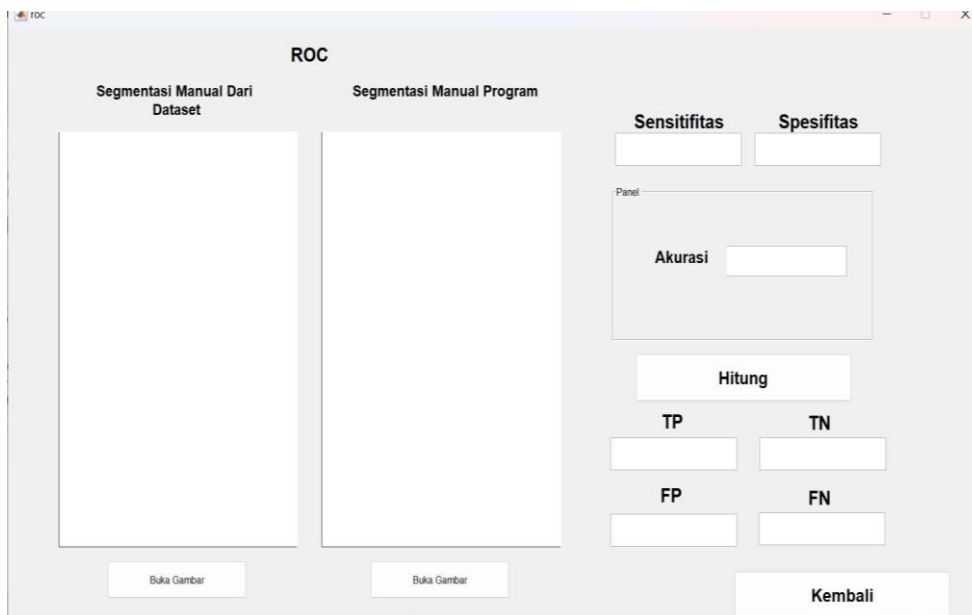


Figure 9. ROC Menu Interface View

c. Implementation of Active Contour Process View

After selecting the area to be segmented using Active Contour, the user can click on it. The segmentation results of the liver cancer CT scan image will then appear. This process allows the user to view the resulting segmentation boundaries, aiding in further analysis of the medical image.

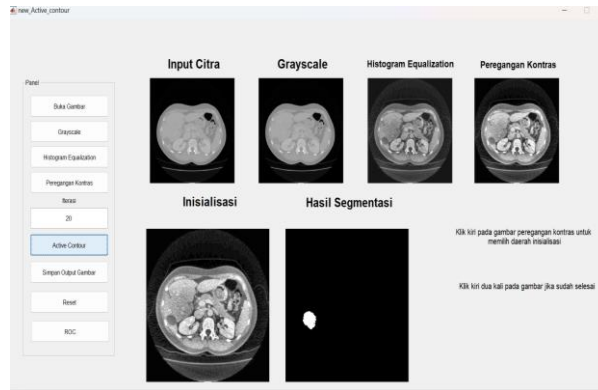


Figure 10. Active Contour Process

d. Implementation of the ROC Calculation Process

After opening the manually segmented image and the program-segmented image, the next step is to press the "Calculate" button. This button will calculate the accuracy, sensitivity, and specificity values of the program-generated segmentation results compared to the manual segmentation results from the dataset. This process is important for evaluating how well the program performs segmentation compared to manual methods, thus providing a clear understanding of the program's effectiveness and reliability in identifying and separating desired areas in the image. Furthermore, the results of this calculation can be used to identify areas that require further improvement or adjustment.

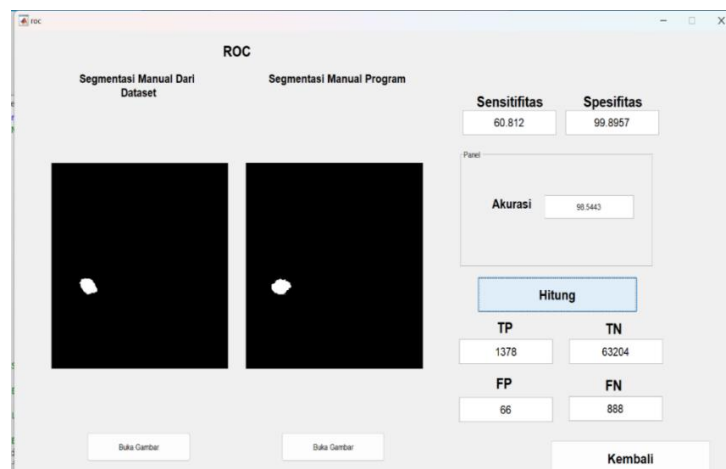


Figure 11. ROC Calculation Process

e. Program using ROC

The output generated by the program will be tested using the ROC (Receiver Operating Characteristic) method to measure the percentage of accuracy, sensitivity, and specificity. This test was conducted using 20 CT scan images. The ROC method helps in evaluating the program's performance by providing an overview of the program's ability to detect important details and distinguish between true and false segments. By analyzing the results of 20 images, we can understand how well the program performs under various conditions and how consistently it performs in segmenting liver cancer CT scan images. The results of this test will provide important information about the program's reliability and effectiveness in practical applications.

Tabel 1. Average Results of Calculation of Active Contour Method of Liver Cancer CT-Scan Images Using ROC

Average	Accuracy (%)	Sensitivity (%)	Specificity (%)
	97.1657%	75.6970%	98.8542%

Table 1 shows the average results of calculations using ROC (Receiver Operating Characteristic). ROC is used to calculate the accuracy, sensitivity, and specificity of the application segmentation results using the Active Contour method in Matlab 2022b. These segmentation results were then compared with the manual segmentation results taken from the dataset.

Based on Table 1, it can be concluded that the Active Contour method has good capabilities in segmenting liver cancer CT scan images. This method produced an accuracy of 97.1657%, a sensitivity of 75.6970%, and a specificity of 98.8542%. These values indicate that the Active Contour method is quite reliable in identifying and segmenting relevant areas in CT scan images, making it suitable for medical purposes and further research.

4. Conclusion

This study demonstrates that converting liver cancer CT scan images to grayscale, followed by image enhancement using CLAHE and Contrast Stretching, effectively improves image quality by increasing contrast and clarifying details. Segmentation evaluation using the Active Contour method on 21 image datasets demonstrated 97.16% accuracy, 75.69% sensitivity, and 98.85% specificity, indicating the method's high ability to identify and separate cancerous areas in CT scan images.

Future research is recommended to further test the developed model in the medical field using real-world medical data, such as CT scan images, to evaluate and verify the accuracy of the developed model. This testing will provide a clearer picture of the model's performance in real-life clinical settings, thus determining whether the model is effective and reliable enough for application in the diagnosis or management of diseases in a medical setting.

References

- [1] R. Farahi and N. Derakhshanfard, "A comprehensive review of the methods of diagnosing and predicting liver diseases using smart methods," vol. 7, 2025.
- [2] N. Fadillah and C. Rizka Gunawan, "Segmentasi Citra Ct Scan Paru-Paru Dengan Menggunakan Metode Active Contour," *Jurikom*), vol. 6, no. 2, pp. 126–132, 2019, [Online]. Available: <http://ejurnal.stmik-budidarma.ac.id/index.php/jurikom%7CPage%7C126>
- [3] T. Gneiting and P. Vogel, "Receiver operating characteristic (ROC) curves: equivalences, beta model, and minimum distance estimation," *Mach. Learn.*, vol. 111, no. 6, pp. 2147–2159, 2022, doi: 10.1007/s10994-021-06115-2.
- [4] Ş. K. Çorbacioğlu and G. Aksel, "Receiver operating characteristic curve analysis in diagnostic accuracy studies : A guide to interpreting the area under the curve value," pp. 195–198, 2023, doi: 10.4103/tjem.tjem.
- [5] M. A. Djohar et al., "Segmentasi Citra Hati Menggunakan Metode Convolutional Neural Network dengan Arsitektur U-Net," *J. Informatics Telecommun. Eng.*, vol. 6, no. 1, pp. 221–234, 2022.
- [6] D. I. Mulyana and I. Wahyudi, "Deteksi Kerusakan Jalan Berdasarkan Citra Digital Menggunakan Convolutional Neural Network (CNN)," vol. 6, no. 1, pp. 294–302, 2025.
- [7] Rinaldi Munir, "Perbaikan Kualitas Citra," *Pengolah. Citra Digit.*, pp. 91–120, 2004.
- [8] A. Mahmood et al., "Image dehazing using dark channel prior-based adaptive filtering and contrast-limited adaptive histogram equalization," *Imaging Sci. J.*, vol. 2199, pp. 1–19, 2026, doi: 10.1080/13682199.2026.2639258.
- [9] S. A. Hussein and Q. O. Mosa, "Medical Image Segmentation with active contour and optimization Techniques: Survey," *J. Al-Qadisiyah Comput. Sci. Math.*, vol. 14, no. 4, pp. 1–6, 2022, doi: 10.29304/jqcm.2022.14.4.1115.
- [10] M. Faheem, A. H. Khan, N. Zahra, and A. Y. Gill, "Optimizing Liver Cancer Detection : Leveraging Gabor Features and Machine Learning for Enhanced Abdominal CT Image Segmentation," pp. 224–230, 2025.
- [11] P. Riesthuis, H. Otgaar, and C. Bücken, "Ready to ROC ? A tutorial on simulation - based power analyses for null hypothesis significance , minimum - effect , and equivalence testing for ROC curve analyses," *Behav. Res. Methods*, vol. 57, no. 4, pp. 1–20, 2025, doi: 10.3758/s13428-025-02646-x.