International Journal of Advance Research in Science and Engineering
Volume No. 14, Issue No. 09, September 2025
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Fuzzy Based Image Segmentation Method for Efficient Text Extraction from Scene Images

Somnath Saha [1], Dr. Narendra Chaudhari [2]
[1,2] Department of Computer Science & Engineering,
Mansarovar Global University, Sehore, MP, India.

Abstract
Discovering important and useful information from the scene is greatly assisted by Scene Text Recognition. To recognize text in a picture, one must first be able to identify, localize, track, extract, improve, and finally recognize the text. When faced with varied font properties, noisy backgrounds, and unpredictable illumination, traditional text segmentation methods frequently fail. The suggested method greatly improves the readability and coherence of segmented text by integrating region-based splitting with a merging process controlled by fuzzy logic. This technique is designed to address these problems. Precision, recall, and accuracy are used as measures to evaluate the performance of the suggested method compared to a structure-guided character identification algorithm. The experimental findings show that the fuzzy-based approach always beats the benchmark in terms of accuracy, recall, and precision. This method has the potential to revolutionize scene text understanding in a number of computer vision applications by reducing computing complexity while simultaneously improving the reliability of text recognition in real-world photos.

Keywords: Text Extraction, Fuzzy Logic, Precision, Recall, Accuracy

1. Introduction

As our culture becomes more visually rich and digital, the ability to automatically extract text from images has become an essential part of computer vision and pattern recognition. Text extraction from scene images is an intriguing and challenging area of research within this discipline. Cameras capture real-life, uncontrolled environments, such as street signs, billboards, product labels, store names, license plates, or handwritten notes, as opposed to scanned documents or well-formatted digital content. The text in these images is affected by several factors such as lighting, orientation, occlusion, blur, and perspective distortion; they are often buried in complex and disorderly backgrounds. Autonomous vehicles, augmented reality, digitization of documents, surveillance, language translation, and a host of other practical applications are made possible by the precise extraction and identification of this content.

The primary goal of scene text extraction is to locate and catalog all textual elements inside an image; a secondary goal is to extract and convert the text into a format that computers can understand. The two primary processes that make up what is commonly known as Optical Character Recognition (OCR) in the real world are text detection and text recognition. Customized for use with high-resolution, perfectly-aligned documents, conventional optical character recognition systems, on the other hand, algorithms that can generalize to numerous circumstances need to be significantly stronger due to the unpredictable and dynamic nature of scene photographs.

The field of word extraction from scene images has made great strides in the past twenty years, moving from early heuristic and hand-crafted feature-based algorithms to modern deep learning-based systems. In the beginning, algorithms would look for regions that likely contained text by detecting edges, color consistency, and texture properties. The enormous variety in real images rendered these approaches ineffective, even if they worked well in controlled environments. Since the introduction of Convolutional Neural Networks (CNNs) and, more since, Transformer-based architectures, models have accomplished remarkable feats in accurately learning context-aware traits and high-level representations from raw image data.

The availability of open-source benchmarks such as ICDAR, COCO-Text, and SynthText, as well as large annotated datasets, has expedited these advancements even further. In most scene photos, the first step in the text identification process is to identify potential text locations. An assortment of methods has been proposed over the years, including linked component analysis (using tools like MSER, or Maximum Stable Extremal Regions), sliding window approaches, and, more recently, deep learning models based on segmentation and region proposal networks. Notable approaches include EAST (Efficient and Accurate Scene Text Detector), TextBoxes, and CTPN (Connectionist Text Proposal Network). These algorithms' goal is to create bounding boxes that enclose the text regions, which might be horizontal or quadrilateral in shape. To further address challenges caused by twisted, curved, or perspective-skewed material, modern detectors now consider multi-scale and multi-oriented text.

Reading the indicated region and converting it into a string of letters is text recognition, which follows text translation. When faced with complex scene text, traditional optical character recognition systems such as Tesseract and ABBYY have performed poorly. Convolutional Recurrent Neural Networks (CRNNs) and other neural sequence models, as well as attention-based encoder-decoder architectures, have greatly improved recognition accuracy. These models excel at learning context and temporal correlations, making them ideal for languages with intricate scripts or closely linked letters. Vision Transformers (ViT) and self-supervised learning are two methods that have lately paved the way for improved scenario text recognition systems.

Complicating matters further is the fact that photography on a global scale employs a diverse array of scripts, fonts, languages, and character sets. Logographic scripts (e.g., Japanese and Chinese) and complex cursive languages (e.g., Arabic and Urdu) are also part of scene text extraction, in addition to Latin-based alphabets. Therefore, script-agnostic and multilingual models are becoming more and more important for real-world deployment, especially in mobile applications, internationalized software, and surveillance systems.

Scene text extraction also has a number of significant challenges with real-time performance and computational efficiency. Mobile translation apps, autonomous vehicle navigation systems, and real-time video analytics are just a few examples of the numerous real-world applications that rely on fast image data processing. Models that are tiny yet accurate and can infer on devices at the edge are required for this. Knowledge distillation, quantization, and model pruning are some of the ways that deep learning models are being fine-tuned for environments with limited resources.

Word extraction from scene images raises broader concerns about accessibility, ethics, and privacy, in addition to technical considerations. For assistive technology like text-to-speech apps and smart glasses to work, scene text extraction is essential so that visually impaired persons may get up-to-the-minute information about their surroundings. On the other side, problems with consent, data privacy, and potential misuse arise when images from social media or surveillance footage are automatically extracted. Researchers and developers must strike a balance between the demand for technological innovation and the requirement for suitable AI legislation and robust data management.

A diverse and fast developing area combining aspects of computer vision, deep learning, and linguistics, and human-computer interaction, text extraction from scene photos draws on many disciplines. From finding and identifying various text in uncontrolled settings to guaranteeing real-time performance and ethical deployment, it presents a broad range of obstacles. Ongoing developments in computing hardware, data production, and algorithm design are probably going to increase even more the accuracy, scalability, and influence of this technology across sectors and communities.

Fuzzy Based Image Segmentation

The inherent uncertainty and imprecision handling capabilities of fuzzy logic have made it a potentially attractive approach for picture segmentation. When attempting to distinguish between different areas of a picture, traditional image segmentation techniques often resort to making hard and fast judgments. Problems arise when using these techniques to real-world photographs; for example, when dealing with scene images that have complicated backdrops and varied textures, these approaches often fail because they do not take into consideration the fuzzy and ambiguous character of picture areas. A more versatile framework for segmentation is provided by fuzzy logic, which allows each pixel to be partly associated with numerous areas with varying degrees of confidence, by assigning membership values. Since the lines between the foreground and background in scene photos are often blurry and imprecise, this method is very useful in such cases.

One major benefit of using a fuzzy-based segmentation approach for text extraction is its enhancement of segmentation resilience and accuracy via capturing the image's inherent ambiguity. Whether a pixel is part of a certain area is determined using traditional segmentation techniques using clear, binary criteria, such as whether the pixel value is greater than a specific threshold. Nevertheless, it is fairly uncommon for scene photos to include pixels whose area of origin is unclear. In some cases, the blurred, shaded, or distorted lettering in a scene photograph may partially overlap with the backdrop. This may happen when the lighting isn't just ideal. It is possible that traditional approaches may incorrectly label these areas, resulting in subpar text extraction. In order to achieve more precise demarcation of text sections, fuzzy logic makes the segmentation process more tolerant of such uncertainties by assigning a degree of membership to each pixel.

Fuzzy membership functions are often used in fuzzy-based image segmentation to describe the extent to which each pixel belongs to a certain segment or area. Many fuzzy-based methods, such as fuzzy watershed segmentation, fuzzy connectedness, and fuzzy c-means (FCM) clustering, have been suggested for this specific task. The capacity of fuzzy c-means clustering to divide a picture into groups defined by pixels' similarities in hue, saturation, or texture has made it a popular choice. One fast and versatile method for separating text from background is fuzzy content modeling (FCM), which uses fuzzy logic in clustering algorithms. This approach works well for text area segmentation when the intensities and textures of the surrounding text are not uniform, as it permits a soft categorization of pixels, where each pixel may be part of numerous clusters with different degrees of membership.

The post-processing steps of text extraction, including text recognition, may also be improved using fuzzy-based approaches, which improve segmentation accuracy. Prior to doing optical character recognition (OCR), it is more efficient to use fuzzy-based algorithms for accurate text area segmentation. Text areas in the input picture should be well defined with little background noise for optical character recognition algorithms to work successfully. Fuzzy segmentation approaches greatly enhance optical character recognition (OCR) accuracy by accurately separating text from its context, therefore decreasing the rate of mistakes brought about by distortion, noise, and other picture aberrations.

Having a reliable method for extracting text from scene photos is crucial. Photographing scenes often involves working in unpredictable, ever-changing settings with highly variable lighting, perspective, and background textures. The inclusion of non-textual components, complex patterns, and shifting foreground-background contrasts makes scene photos, in comparison to controlled document images, often much more complicated to comprehend. When faced with such new obstacles, traditional text extraction approaches fail miserably; nevertheless, fuzzy-based methods show great promise. Fuzzy logic allows us to create text extraction methods that are more resilient to things like noise, fluctuations in picture quality, and other flaws in scene photos.

A number of real-world applications have seen considerable advancements in text extraction using fuzzy-based segmentation algorithms in the last few years. These applications include a wide variety of sectors, from smart city development—where text extraction from urban surroundings helps improve public safety and urban planning—to autonomous cars, where text recognition from street signs and billboards is vital for navigation. As an added bonus, text extraction algorithms' performance has become much better when fuzzy logic and deep learning were combined.

Text recognition is only one of several image processing tasks where deep learning models, especially CNNs, have shown exceptional performance. Integrating convolutional neural networks (CNNs) with fuzzy-based segmentation allows for the development of end-to-end systems capable of text segmentation and recognition, as well as dynamic adaptation to fluctuating surroundings, making them applicable for use in the real world.

An excellent strategy for word extraction from scene photos is the fuzzy-based image segmentation technique. When it comes to text extraction applications, fuzzy logic is a perfect match for the segmentation job since it can handle complicated visual patterns, uncertainty, and imprecision. Strong, quick, and versatile text extraction algorithms are going to be in high demand since scene photographs are popping up in all sorts of different fields. Advanced and intelligent applications in areas like information retrieval, assistive technologies, and autonomous systems can be achieved by improving text extraction systems with fuzzy-based segmentation techniques. This will lead to more accurate and practical systems.

I. Review of Literature

Lahbib, Khrissi et al., (2021) The straightforward, quick, and effective clustering method has made it the de facto standard for picture segmentation. Its significant role in picture analysis, extraction, and interpretation justifies its widespread use across many domains and applications. Here, we provide an alternative method for picture segmentation that combines the Cuckoo Search Algorithm (CSA), an optimization algorithm, with the Fuzzy C-means Clustering Technique (FCM), a clustering method. Our proposed clustering approach consists of two main phases. To begin, CSA determines the best clustering centers by searching the full search space of the given data. Then, a different objective function is used to assess these centers. In step two, we initialize the FCM algorithm using the first step's result. We evaluate the proposed method's performance on a number of pictures taken from the BSD300 database and compare it to others, including FCM-GA and FCM-PSO, two methods that optimize FCM using genetic algorithms. By analyzing the best values of fitness, MSE, PSNR, CC, RI, GCE, BDE, and VOI, the experimental findings on the various methods utilized in this study demonstrate that the suggested technique enhances the segmentation outcomes.

Rehman, Syed & Hussain, Mohameed. (2018) To effectively segment the satellite pictures, this work proposes an enhanced version of the Fuzzy C-Means (FCM) method. A promising and busy area of study in recent years is image segmentation. Since studies have shown that area segmentation yields superior outcomes. When it comes to collecting semantic information from images, human visual perception is much superior than any machine vision technology. In order to estimate parameters for both the prior and likelihood probabilities, an FCM method is created. Background segmentation is accomplished using the FCM method, while island extraction is performed using pixel intensity. In the end, it yields superior results when compared to other methods by calculating the Peak Signal to Noise Ratio (PSNR).

Chen, Jinlin et al., (2018) One of the most talked-about areas of digital image processing and a crucial component of computer vision applications is picture segmentation. One kind of picture segmentation technique is fuzzy C-means clustering, which is both efficient and easy to understand. One problem with FCM is that it may easily be fooled by picture noise. This work presents a new fuzzy C-mean clustering approach that utilizes multi-objective optimization to address the issue. To enhance the optimization of multiple objectives, we augment the fuzzy distance measurement formula with a parameter λ. The weights of the local information for each pixel may be modified using the parameter λ. The approach optimizes the clustering rate by adding the local correlation of surrounding pixels to the revised multi-objective mathematical model. When it comes to picture segmentation using various types of noise, two separate testing findings demonstrate that the new fuzzy C-means method offers efficient performance and computational time.

Zheng, Jia et al., (2017) A fuzzy c-means with spatial information (FCM_S) based adaptive picture segmentation algorithm is presented in this paper. Initially, the benefits of the local FCM_S and its segmentation properties are discussed. Then, the cumulative local FCM_S is suggested to categorize every pixel in a picture by using data from several local windows that encompass them. Automatic calculation of the local window size and storage of all pixel categorization results in the cumulative result are both implemented. By converting the collected result into a picture, we can see that the background and object pixels' grey levels cluster around 0 and the maximum gray level. Where the rate of change of the count of object pixels reaches a minimum, it may be segregated by the gray level. In all, sixteen images—two from the actual world and four from a synthetic source—and sixteen from the Weizmann database are used in the experiments. The results shown that the suggested approach is capable of accurately segmenting pictures with inhomogeneity and achieves a higher area overlap measure in comparison to other recent segmentation techniques. In addition, there are no parameters in the suggested approach.

Gomez, Daniel et al., (2015) A technique for building fuzzy borders is presented in this study, which introduces the notion of Fuzzy picture Segmentation and builds on the known linkages between the fuzzy boundary set problem and the (crisp) hierarchical picture segmentation problem. We provide the idea of fuzzy image segmentation based on these edges as they allow us to define a crisp image segmentation as a collection of boundaries that divides neighboring sections of the segmentation. Fuzzy sets over sets of edges, which together form the fuzzy border of an image, are therefore used to characterize fuzzy image segmentation. A few computational examples are provided to illustrate the acquired fuzzy borders of specific digital pictures.

Ghoshal, Ranjit & Dhara, Bibhas. (2014) In order to automatically extract text from scene photos, this article suggests a system. Next, we take the RGB scene image and perform a color image segmentation process based on statistical characteristics. Connected components (CCs) that are visually similar (in terms of brightness and color) are extracted from the picture by means of segmentation. The inclusion of text components in these CCs is presumed. Examining these CCs for potential text components is, then, the primary goal of this work. Differentiating text from non-text components is made possible by defining a variety of shape-based characteristics here. Additionally, parametric distribution families are used to approximatively examine the distribution of these characteristics independently during learning. In this case, we use a likelihood criteria to choose the distribution that fits the data the best. A distribution for a class, whether text or non-text, is obtained by multiplying the distributions of the specific features. So, the CC is part of the class that has the best class distribution score while testing is underway. The Born Digital Dataset from ICDAR 2011 is the basis for our experiments. When it comes to differentiating text from non-text, we have achieved good results.

Rawat, Tarun. (2013) Segmentation algorithms that can effectively combat noise are essential for medical picture segmentation. When it comes to picture segmentation, Fuzzy C-Means clustering is by far the most common approach. Since it relies solely on intensity values for grouping, it is extremely vulnerable to noise. Fuzzy C-Means (FCM), Intuitionistic Fuzzy C-Means (IFCM), and Type-II Fuzzy C-Means (T2FCM) are three basic fuzzy logic image segmentation algorithms that are compared in this work. We use these algorithms on two types of images—a bacterial picture and a CT scan of the brain—and in two different noise settings. Clustering is employed to distinguish the bacterial image from the background in the bacterium picture and to locate the area of abnormality in the brain CT scan image. Cluster validity functions, runtime, and convergence rate are used to evaluate performance. Additionally, while analyzing brain images, the misclassification error is computed.

Mondal, Koushik et al., (2012) One of the most difficult problems in image processing has always been segmenting images and then extracting them from backgrounds that are noisy. In this regard, a number of approaches have been detailed in published works. A few examples of these approaches are methods based on intensity histograms, Genetic Algorithms (GAs), and Artificial Neural Networks (ANNs), the majority of which are supervised models. Even more intriguing is the challenge of providing an extraction system that operates in unsupervised mode. Fundamentally, fuzzy systems deal with how to describe and handle imprecision and uncertainty in language data. Fuzzy Rule Base Systems (FRBS) are a type of fuzzy system that represents domain knowledge about the problem using fuzzy rules. It would appear from the literature that there has been just a very basic attempt in this area. In this post, we provide a new approach that is led by fuzzy rules and can work without any outside help when put into action. When compared to other methods discussed at length in the literature, experimental data indicate that this strategy is the most effective. We go to reliable measures like Peak Signal to Noise Ratio (PSNR), Mean Absolute Error (MAE), and Mean Squared Error (MSE) to back up our claim that our suggested method outperforms the competition.

II. Research Methodology

The study presented here presents a novel approach known as fuzzy-based picture segmentation for variable font size text. This approach will result in an improvement in the extraction of text from scene photographs. To simplify the processing of the picture is the purpose of the segmentation procedure. In addition to this, it will lessen the complexity of the computations. In this suggested technique of segmentation, there are two processes that are involved: splitting and merging. During the merging process, a unique fuzzy-based approach is utilized, while the splitting process is based on region-based segmentation. An illustration of the suggested system design may be found in Figure 1. As an input, a text image is provided. The subsequent steps are then carried out on it.

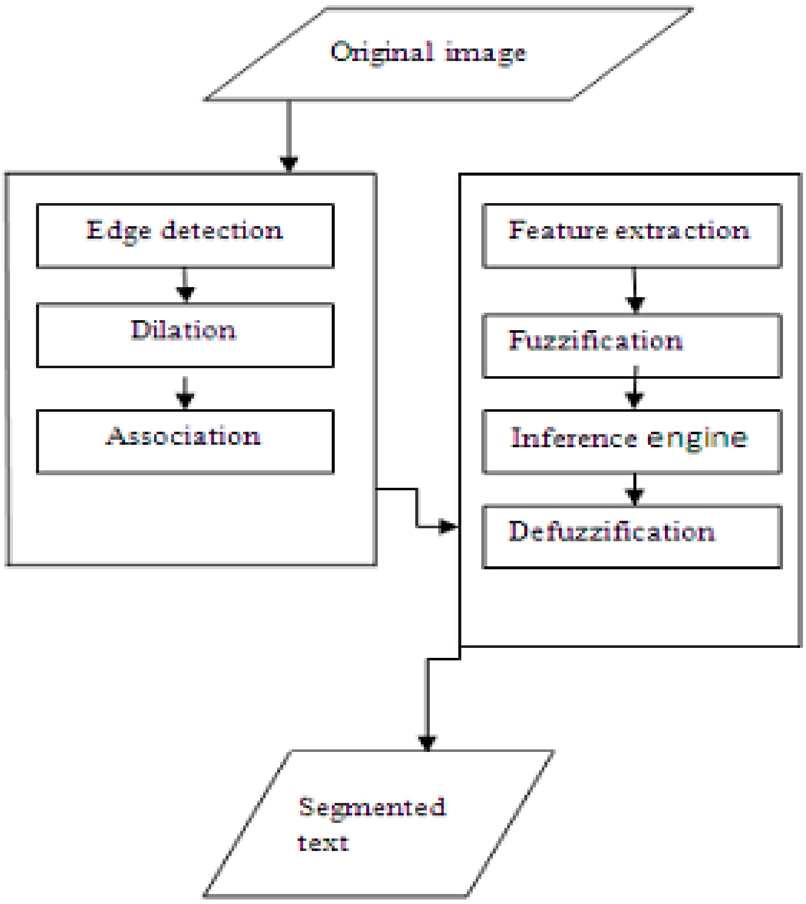

Figure 1: Architecture of proposed system

Edge Detection

Segmentation is accomplished by the utilization of edge detection in conjunction with the labeling of related components in the methodology that has been presented. The Sobel edge detection technique is utilized for edge detection.

Image Dilation

The fractured edges are connected with the application of image dilation. Prior to the fuzzy merger, dilation is carried out for the sole purpose of reducing the amount of computing work required.

Feature Extraction

The consolidation of character candidates is contingent upon a variety of different elements. In order to make a choice on whether or not to link items as words or sentences, four characteristics are extracted. Color, height, location, and distance are the characteristics that they possess.

Fuzzification

Both fuzzy rule bases and linguistic rules are utilized in this process. This particular module incorporates individual rule-based inference along with union combination, minimum implication, minimum operator for t-norm, and maximum operator for s-norm.

Fuzzy Inference Engines

Both fuzzy rule bases and linguistic rules are utilized in this process. This module includes individual rule-based inference with union combination, min implication, min operator for t-norm, and max operator of s-norm. Additionally, it includes min implication.

Defuzzification

In other words, it converts fuzzy values into real-world values.

Metrics used

This research extracts and recognizes text of varied font sizes from scene photos using fuzzy-based segmentation. Recall, precision, and accuracy are the primary metrics employed to assess the proposed system. The Precision, Recall, and Accuracy metrics of text extracted from scene photos using the structure-guided character identification and linguistic knowledge technique are shown.

Results And Discussion

Table 1: Performance Comparison of Structure Guided and Fuzzy-Based Methods for Text Extraction

Method	Recall	Precision	Accuracy
Structure guided	0.8882	0.8871	88.762
Fuzzy based	0.9458	0.9486	94.6671

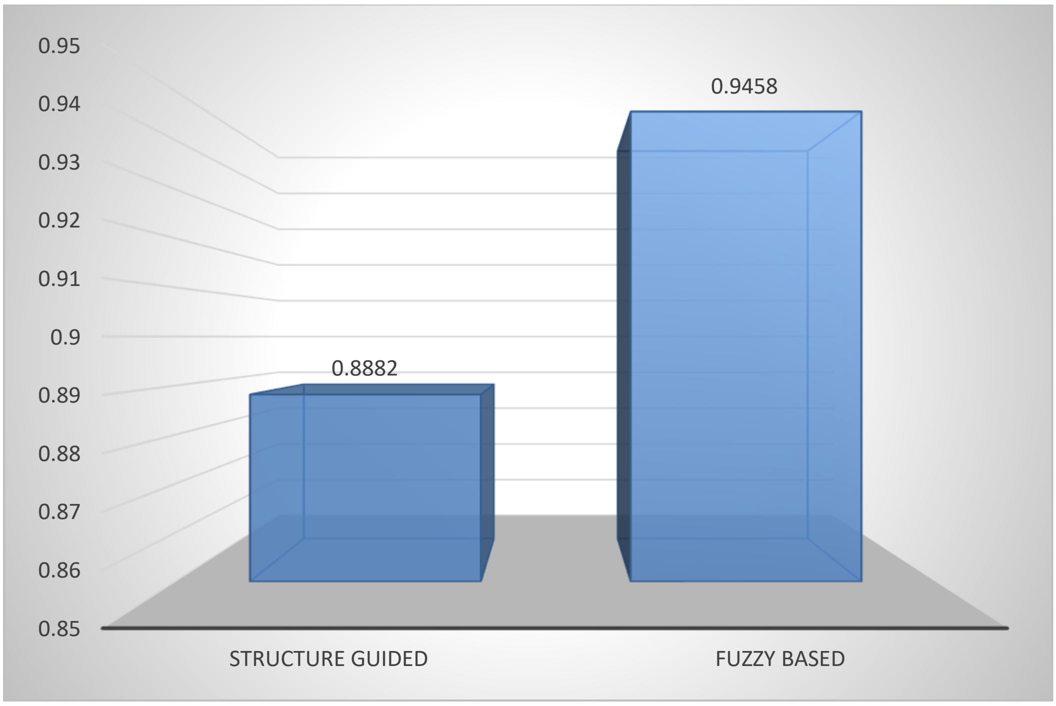

Figure 2: Comparison of Recall between Structure Guided and Fuzzy-Based Segmentation Methods for Text Extraction

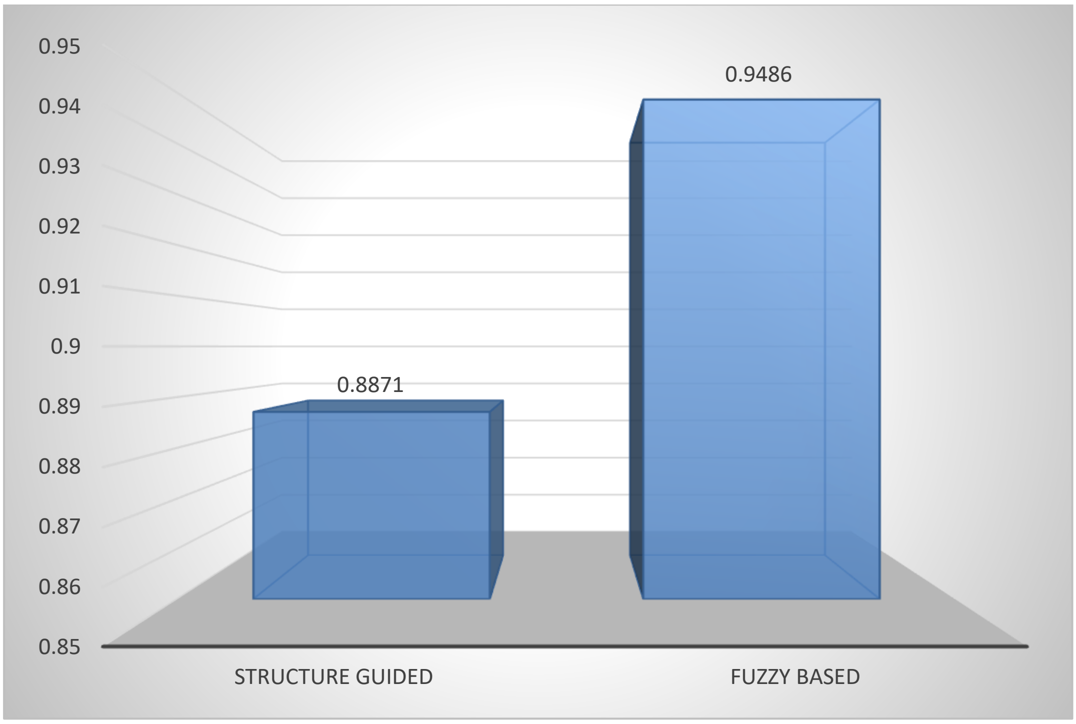

Figure 3: Comparison of Precision between Structure Guided and Fuzzy-Based Segmentation Methods for Text Extraction

International Journal of Advance Research in Science and Engineering
Volume No. 14, Issue No. 09, September 2025
www.ijarse.com
IJARSE
ISSN 2319 - 8354

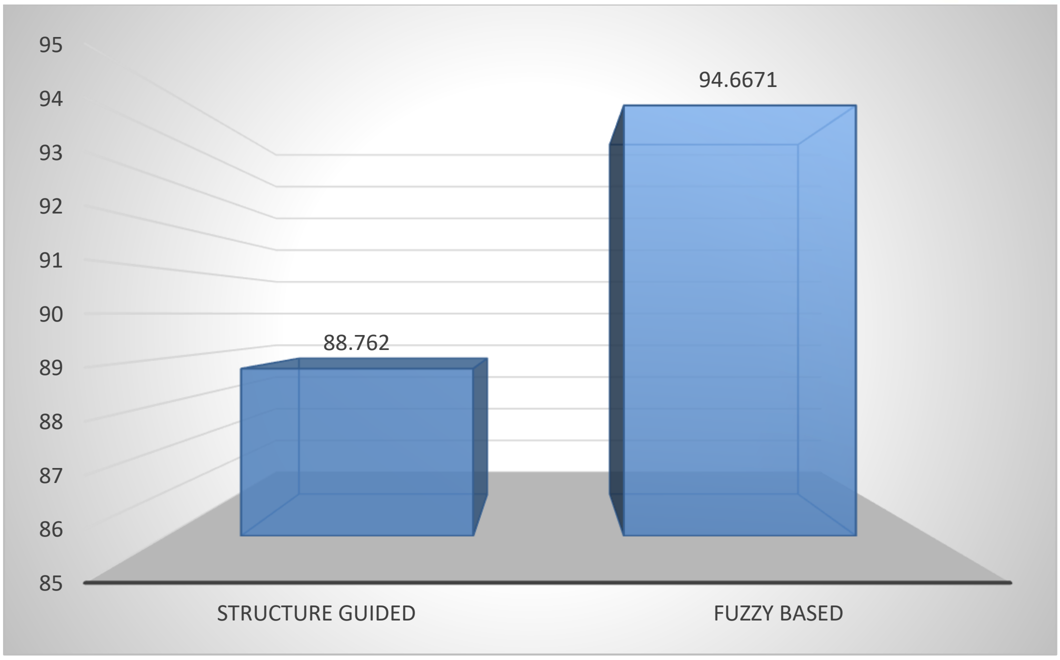

Figure 4: Comparison of Accuracy between Structure Guided and Fuzzy-Based Segmentation Methods for Text Extraction

The results in Table 1 reveals that the fuzzy-based approach had a recall value of 0.9458, suggesting a greater capacity to accurately identify key text elements inside the picture. Likewise, the accuracy score of 0.9486 shows the model's great ability to reduce false positives by correctly recognizing actual text elements. The fuzzy-based approach's total accuracy of 94.6671% also much surpasses the structure-guided approach's 88.762%.

Conclusion

For complicated scene photos, the suggested fuzzy-based image segmentation technique provides a reliable and effective way to extract and identify text with changing font sizes. Supported by Sobel edge detection, morphological dilation, and feature extraction (color, height, position, and distance), the system successfully overcomes obstacles presented by background clutter, uneven illumination, and diverse font characteristics by integrating region-based splitting with a novel fuzzy logic-driven merging process. The experimental findings show that the method is much better than the structure-guided one. This approach is well-suited for use in real-time applications since the fuzzy merging step requires less processing resources. Adaptive rule-base optimization and deep learning feature inclusion will be investigated in future work to expand the technique to multilingual and handwritten text contexts and to further improve segmentation accuracy.

References: -

[1] L. Khrissi, N. el Akkad, H. Satori, and K. Satori, “An Efficient Image Clustering Technique based on Fuzzy C-means and Cuckoo Search Algorithm,” *Int. J. Adv. Comput. Sci. Appl.*, vol. 12, no. 6, pp. 423–432, 2021.

[2] S. Rehman and M. Hussain, “Fuzzy C-Means Algorithm Based Satellite Image Segmentation,” *Indones. J. Electr. Eng. Comput. Sci.*, vol. 9, no. 2, pp. 332–334, 2018.

[3] J. Chen, C. Yang, G. Xu, and L. Ning, “Image Segmentation Method Using Fuzzy C Mean Clustering Based on Multi-Objective Optimization,” *J. Phys.: Conf. Ser.*, vol. 1004, no. 1, pp. 1–6, 2018.

[4] P. Shan, “Image segmentation method based on K-mean algorithm,” *EURASIP J. Image Video Process.*, vol. 2018, no. 1, pp. 1–9, 2018.

[5] P. Parida and N. Bhoi, “Fuzzy clustering-based transition region extraction for image segmentation,” *Eng. Sci. Technol. Int. J.*, vol. 21, no. 4, pp. 547–563, 2018.

[6] J. Zheng, D. Zhang, K. Huang, and Y. Sun, “An Adaptive Image Segmentation Method Based on the Fuzzy C-means with Spatial Information,” *IET Image Process.*, vol. 12, no. 5, pp. 1–8, 2017.

[7] E. N. Ganesh, “Image Segmentation Using Contemporary Fuzzy Logic,” *Int. J. Comput. Sci. Eng.*, vol. 8, no. 1, pp. 4–10, 2017.

[8] D. Ghai, D. Gera, and N. Jain, “A New Approach to Extract Text from Images based on DWT and K-means Clustering,” *Int. J. Comput. Intell. Syst.*, vol. 9, no. 5, pp. 900–916, 2016.

[9] D. Gomez, C. Guada, J. Rodríguez, J. Montero, and E. Zarrazola, “Fuzzy Image Segmentation based upon Hierarchical Clustering,” *Knowl.-Based Syst.*, vol. 87, no. 10, pp. 26–37, 2015.

[10] R. Ghoshal and B. Dhara, “Text Extraction from Scene Images through Color Image Segmentation and Statistical Distributions,” *Int. J. Comput. Appl.*, vol. 91, no. 9, pp. 5–8, 2014.

[11] S. Tehsin, A. Masood, and S. Kausar, “Survey of Region-Based Text Extraction Techniques for Efficient Indexing of Image/Video Retrieval,” *Int. J. Image, Graph. Signal Process.*, vol. 6, no. 12, pp. 53–64, 2014.

[12] T. Rawat, “Fuzzy Clustering Algorithms for Effective Medical Image Segmentation,” *Int. J. Intell. Syst. Appl.*, vol. 5, no. 11, pp. 55–61, 2013.

[13] H. Zhang, K. Zhao, Y.-Z. Song, and J. Guo, “Text extraction from natural scene image: A survey,” *Neurocomputing*, vol. 122, no. 1, pp. 310–323, 2013.

[14] K. Mondal, P. Dutta, and S. Bhattacharyya, “Fuzzy Logic Based Gray Image Extraction and Segmentation,” *Int. J. Sci. Eng. Res.*, vol. 3, no. 4, pp. 1–14, 2012.

[15] C. P. Sumathi, T. Santhanam, and G. Devi, “A Survey on Various Approaches of Text Extraction In Images,” *Int. J. Comput. Sci. Eng. Surv.*, vol. 3, no. 4, pp. 27–41, 2012.

[16] E. Nadernejad and S. Sharifzadeh, “A new method for image segmentation based on Fuzzy C-means algorithm on pixonal images formed by bilateral filtering,” *Signal Image Video Process.*, vol. 7, no. 4, pp. 1–8, 2011.

[17] Y. Zhang, F.-L. Chung, and S. Wang, “Robust fuzzy clustering-based image segmentation,” *Appl. Soft Comput.*, vol. 9, no. 1, pp. 80–84, 2009.

[18] W. Rui, H. Jianhua, T. Xianglong, and L. Jiafeng, “A Text Image Segmentation Method Based on Spectral Clustering,” *Comput. Inf. Sci.*, vol. 1, no. 4, pp. 1–9, 2008.

[19] M. Alata and M. AlShabi, “Text detection and character recognition using fuzzy image processing,” *J. Electr. Eng.*, vol. 57, no. 5, pp. 1–12, 2006.

[20] S. Chuai-Aree, C. Lursinsap, P. Sophatsathit, and S. Siripant, “Fuzzy C-Mean A Statistical Feature Classification of Text and Image Segmentation Method,” *Int. J. Uncertain. Fuzziness Knowl.-Based Syst.*, vol. 9, no. 6, pp. 661–671, 2001.