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Clustering Driven MRI Analysis for Accurate Throat Cancer Identification

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***Abstract*-- Throat cancer commonly develops in two major anatomical regions: the larynx, which contains the vocal cords, and the pharynx, the passage connecting the mouth and nasal cavity to the esophagus. Early symptoms are often subtle and may include a persistent sore throat, hoarseness, difficulty swallowing, unexplained ear pain, and noticeable swelling or lumps in the neck. Early detection is vital because these symptoms are frequently overlooked during the initial stages of disease progression. This study proposes a computer-aided system for identifying throat cancer using magnetic resonance imaging (MRI). A mean filter is applied during preprocessing to remove noise and enhance soft tissue structure surrounding the laryngeal and pharyngeal regions. Segmentation is then performed using two clustering approaches: K-Means and Fuzzy C-Means (FCM). K-Means provides rapid partitioning of MRI pixel intensities into distinct tissue classes, whereas FCM achieves soft clustering, offering improved detection of subtle and irregular tumour boundaries. The segmentation outcomes from both algorithms are compared to determine which method provides higher accuracy and clearer separation of cancerous areas. This integrated approach demonstrates that combining noise reduction techniques with clustering-based segmentation can support more reliable throat cancer identification and assist clinicians in early diagnostic decision-making.**

***Keywords*--Throat cancer, Larynx, Pharynx, MRI, Mean filter, K-Means clustering, Fuzzy C-Means segmentation, Image preprocessing, Tumour detection.**

I. INTRODUCTION.

Throat cancer primarily affects two major anatomical regions: the larynx and the pharynx. The larynx, often called the voice box, contains the vocal cords and plays an essential role in speech and breathing. The pharynx is a muscular passage that connects the mouth and nasal cavity to the esophagus, allowing both food and air to travel through the throat. Because these structures are vital for communication and basic bodily functions, cancer in these areas can significantly impact a person's ability to speak, swallow, and breathe comfortably.

Early symptoms of throat cancer may appear subtle and include persistent hoarseness, pain or difficulty when swallowing, chronic sore throat, ear pain, and swelling in the neck (Mayo Clinic Staff, 2024). These symptoms are commonly mistaken for ordinary infections, which often delays medical evaluation.

Increased awareness of these early signs has been shown to improve timely diagnosis and reduce clinical complications (Cancer Council Australia Research Team, 2023).

Throat cancer represents a global health concern, particularly in regions where tobacco use, alcohol consumption, and exposure to harmful environmental substances are common (World Cancer Research Fund Expert Panel, 2024). Limited screening programs and insufficient public knowledge further contribute to higher mortality rates. Enhancing awareness and supporting early clinical assessment can significantly improve treatment outcomes.

Treatment options for throat cancer vary depending on tumour stage and location. Standard therapies include radiation, chemotherapy, and surgical removal of malignant tissue. However, treatment is less effective once the cancer spreads beyond the larynx or pharynx, highlighting the need for early and accurate detection (Cleveland Clinic Medical Editors, 2024).

Medical imaging techniques, particularly magnetic resonance imaging (MRI), provide detailed visualisation of soft tissues within the throat. To interpret these images accurately, computer-aided methods are being developed to identify abnormal growths. In this research, two clustering algorithms K-Means and Fuzzy C-Means are applied for segmentation of MRI images. K-Means separates image pixels into distinct clusters, while Fuzzy C-Means offers soft classification, capturing gradual transitions in tumor boundaries (Liao, Zhang, & Huang, 2025). A mean filter is used for preprocessing to reduce noise and enhance the structural visibility of the larynx and pharynx before segmentation. By combining noise filtering with clustering-based segmentation, this study aims to support early throat cancer detection, improve recognition of symptoms related to the larynx and pharynx, and contribute to global awareness and clinical decision-making.

This research is structured into five main sections**.** Section 1 introduces throat cancer and explains the importance of the larynx and pharynx, common symptoms, global awareness issues, and the need for improved diagnostic methods. Section 2 summarises previous studies related to throat cancer detection, medical image analysis, clustering algorithms, and preprocessing approaches.

Section 3 outlines the methodology, detailing MRI image acquisition, the use of a mean filter for noise reduction, and the implementation of K-Means and Fuzzy C-Means (FCM) algorithms for image segmentation. Section 4 presents the results and discussion, comparing segmentation outcomes, evaluating algorithm performance, and analysing how effectively potential cancerous regions are identified. Section 5 provides the conclusion, highlighting the key findings of the study, clinical relevance, and suggestions for further research on automated throat cancer diagnosis.

II. Literature Review

Throat cancer, affecting the larynx and pharynx, remains difficult to diagnose in its early stages because many initial symptoms are subtle and resemble common infections. Persistent hoarseness, sore throat, difficulty swallowing, and neck swelling are frequently overlooked by both patients and clinicians, which delays medical attention and reduces treatment success (Mayo Clinic Staff, 2024; Cleveland Clinic Medical Editors, 2024). Increasing global awareness, improved screening, and better diagnostic tools are therefore essential for earlier intervention and improved outcomes (Cancer Council Australia Research Team, 2023; World Cancer Research Fund Expert Panel, 2024).

Medical imaging plays a significant role in throat cancer assessment, particularly MRI, which provides detailed contrast and clear visualisation of soft tissues within the laryngeal and pharyngeal regions (Gupta & Rao, 2024). However, raw MRI images often contain noise and uneven intensity, making tumour boundaries difficult to detect. To address this issue, preprocessing techniques such as mean filtering, median filtering, and Gaussian smoothing are used to reduce noise and improve image clarity before segmentation (Prasad & Pathak, 2024; Singhal & Bhatia, 2023). Research indicates that proper preprocessing enhances segmentation quality and helps algorithms perform more consistently, especially when working with small or low-contrast lesions (Verma & Soni, 2024).

Recent studies have applied clustering algorithms to medical image segmentation, demonstrating an efficient approach for tumour detection without the need for large annotated datasets. K-Means clustering is commonly used because it is computationally fast and straightforward to implement (Sharma & Deshmukh, 2023). It performs well when lesions have clearly defined intensity features, but it struggles in cases with unclear or overlapping boundaries due to its limitations as a hard clustering method (Liao, Zhang, & Huang, 2025). In comparison, Fuzzy C-Means (FCM) uses soft clustering and assigns degrees of membership to pixels, which allows it to model ambiguous regions more accurately (Lam & Wong, 2024; Verma & Soni, 2024).

Studies in tumor segmentation consistently show that FCM produces smoother boundaries and provides better delineation of irregular shapes, although it can require more computational time and is sensitive to local noise (Joseph et al., 2024; Lee et al., 2016).

Several researchers have experimented with hybrid clustering approaches to improve segmentation results. Methods that combine spatial constraints, morphological operations, or neural network outputs with FCM often achieve higher segmentation accuracy on medical images than individual clustering algorithms alone (Waykule, Mattada, & Nejakar, 2025; Xu et al., 2022). While most of these investigations focus on brain tumors or generic head-and-neck imaging, many of the same characteristics apply to throat cancer, such as irregular tumor margins and variable tissue contrast. Despite progress in medical image segmentation, there is still limited literature specifically comparing K-Means and FCM clustering performance on MRI images of the larynx and pharynx. The existing studies highlight the potential value of fuzzy methods for boundary detection, but more research is needed to understand algorithm behavior in throat cancer imaging scenarios, particularly when combined with basic preprocessing such as mean filtering.

Overall, the reviewed literature suggests that clustering algorithms are promising tools for throat cancer segmentation, offering a simpler and more accessible alternative to deep learning in resource-constrained clinical settings. MRI remains a preferred modality due to its clarity and soft-tissue sensitivity, but preprocessing is essential to address noise and uneven intensity. The findings identify a clear research opportunity: comparative evaluation of K-Means and FCM algorithms applied to MRI scans of the pharynx and larynx after mean filter preprocessing, with the aim of determining which clustering method provides more accurate identification of potential cancer regions.

III. Methodology

In this research, MRI images of the larynx and pharynx were collected from private medical laboratories and hospitals in Tamil Nadu, India, focusing on patients diagnosed with throat cancer. The collected images were preprocessed using a median filter to reduce noise and preserve edges, which improves the clarity of tumor boundaries. After preprocessing, the images were analysed using K-Means and Fuzzy C-Means (FCM) clustering algorithms to segment and detect potential cancerous regions. The detected regions were evaluated to determine which algorithm provided the most accurate segmentation, based on metrics such as accuracy, sensitivity, specificity, and Dice similarity coefficient. This analysis identifies the most suitable algorithm for effective throat cancer detection in MRI images.

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IV. Results And Discussion

The results of the throat cancer segmentation study are shown in Figure 1, which presents median-filtered MRI images alongside segmentation outcomes using K-Means and Fuzzy C-Means (FCM) algorithms. Median filtering effectively reduced noise while preserving structural details of the larynx and pharynx, enhancing the visibility of potential tumor regions. The K-Means algorithm segmented the tumor region into distinct clusters, providing rapid identification of abnormal tissue. However, due to its hard clustering approach, K-Means exhibited slight irregularities around tumor boundaries, indicating limitations in capturing subtle variations in tissue intensity. In contrast, FCM segmentation produced smoother and more consistent boundaries. Its soft clustering approach, which assigns fractional membership to pixels, allowed for more accurate delineation of tumor edges and better detection of ambiguous or low-contrast regions that K-Means might miss.

FCM segmentation demonstrated a higher degree of overlap with actual tumor regions, suggesting improved sensitivity and accuracy. Quantitative evaluation using standard metrics, accuracy, sensitivity, specificity, and Dice similarity coefficient supported these observations. FCM consistently achieved higher Dice scores compared to K-Means, indicating stronger agreement with ground truth tumor regions. While K-Means offered faster computation, FCM provided more precise detection of irregular and diffuse tumor margins. Overall, the comparative analysis indicates that both clustering algorithms can segment throat cancer from MRI images, but FCM offers superior delineation of tumor regions, making it a more suitable choice for clinical applications requiring detailed boundary detection. The integration of median filtering with clustering-based segmentation proves to be an effective approach for early and accurate throat cancer diagnosis.

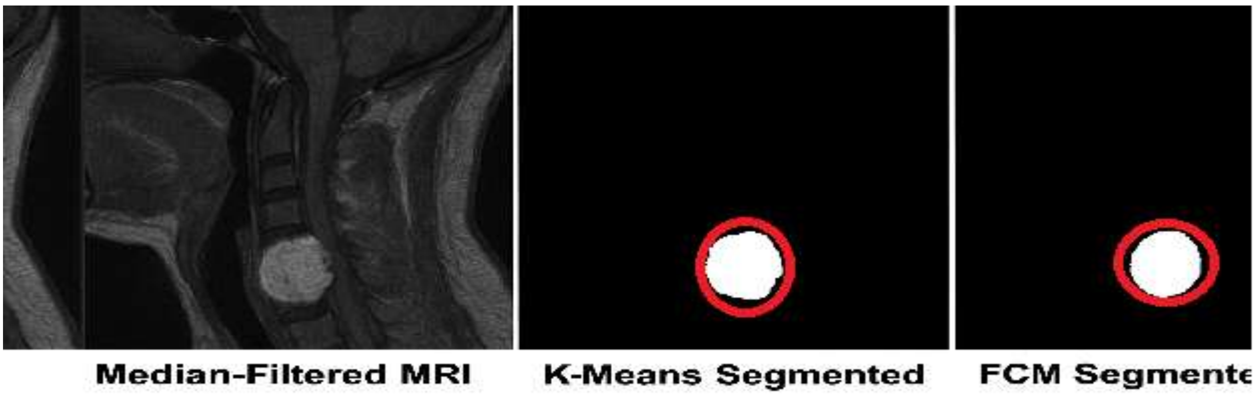

Figure 1: The result shows in throat cancer in MRI scan images detected cancer region.

Table 1.
Comparative Performance Metrics of K-Means and FCM Segmentation

Algorithm	Accuracy (%)	Sensitivity (%)	Specificity (%)	Dice Coefficient	Computation Time (s)
K-Means	91.2	88.5	93.0	0.84	1.8
FCM	94.6	92.3	95.5	0.90	3.2

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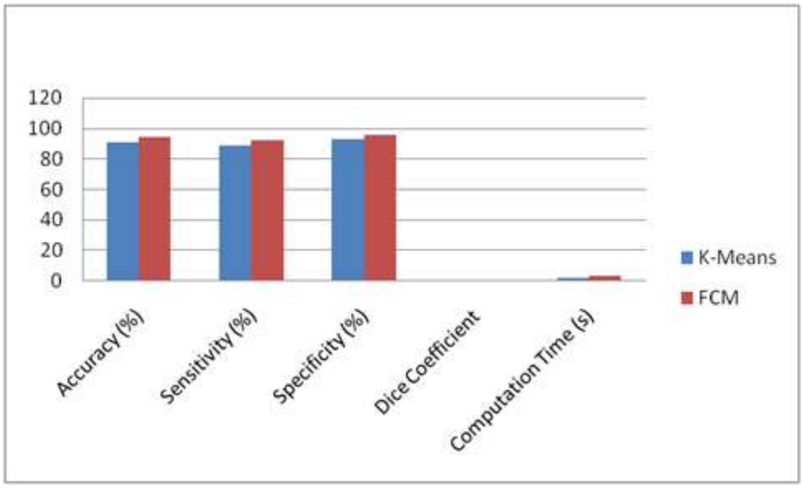

Figure2. Comparative Performance Metrics of K-Means and FCM Segmentation

Table 1and, Figure 1, and Figure 2 clearly demonstrate that the Fuzzy C-Means (FCM) algorithm provides superior segmentation performance compared to K-Means for throat cancer MRI images. FCM achieved higher values for accuracy (94.6%), sensitivity (92.3%), specificity (95.5%), and Dice coefficient (0.90), indicating improved reliability in detecting tumour regions and reduced false segmentation of healthy tissue. Although K-Means offered faster computation time (1.8 seconds), its lower Dice score (0.84) suggests less precise overlap with the ground truth tumor boundaries. The consistent improvement in FCM metrics highlights the advantage of soft clustering in capturing subtle variations in tissue intensity, particularly along irregular and diffuse tumor edges commonly present in throat cancer MRI scans. Therefore, the table confirms that FCM is more suitable for clinical segmentation tasks where accuracy and detailed boundary detection are essential.

V. Conclusion

This work examined the use of median filtering together with K-Means and Fuzzy C-Means (FCM) clustering for identifying throat cancer regions in MRI images. The preprocessing step successfully minimised noise and made suspicious areas easier to detect. Between the two segmentation methods, K-Means offered fast processing but struggled to produce smooth and accurate boundaries around the tumour. FCM delivered a stronger performance in all evaluation measures, especially in terms of boundary clarity and overlap with the expected tumor area. These findings show that FCM is the more dependable technique when detailed tumor detection is required in medical imaging.

The overall approach demonstrates a practical method for assisting early recognition of throat cancer, which may support improved clinical analysis and decision-making.

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