AMERICAN JOURNAL OF MANAGEMENT AND IOT MEDICAL COMPUTING
E-ISSN: 3069-0110
Vol.4, No. 4(1)(2025)
www.ajmimc.com

FUZZY ENHANCED KIDNEY TUMOR DETECTION INTEGRATING MACHINE LEARNING OPERATIONS FOR A FUSION OF TWIN TRANSFERABLE NETWORK AND WEIGHTED ENSEMBLE ML CLASSIFIER

[1]Mr. Sai krishna Goud Nemuri, [2]K.Sravanthi, [3]M.Kushmitha,[4]S.Neha

[1]Assistant Professor, Department of CSE (Cyber Security), School of CSE, Malla Reddy Engineering college for women, Hyderabad, India.

[2,3,4] Students, Department of Computer Science & Engineering(IOT), School of CSE , Malla Reddy Engineering college for women , Hyderabad, India.

ABSTRACT:

This study addresses the critical challenge of kidney tumor detection from CT scans by proposing a novel framework called "Fuzzy Enhanced Kidney Tumor Detection." The approach incorporates fuzzy image enhancement techniques to improve the quality and contrast of kidney CT images, thereby facilitating more accurate tumor detection. This preprocessing step is crucial for reducing noise and highlighting tumor boundaries effectively, allowing downstream models to better differentiate between healthy and tumorous tissues.The core innovation lies in integrating machine learning operations through a fusion of a Twin Transferable Network and a Weighted Ensemble Machine Learning Classifier to perform tumor classification. The Twin Transferable Network is designed to leverage transferable features across different datasets or imaging conditions, enhancing the model's generalization capability. Meanwhile, the Weighted Ensemble classifier combines predictions from multiple machine learning algorithms, weighted by their individual performance, to produce a robust and reliable final classification. This hybrid approach not only capitalizes on the strengths of various classifiers but also mitigates their weaknesses, resulting in higher accuracy and robustness in kidney tumor detection. The proposed system holds significant potential for aiding radiologists and improving diagnostic workflows in clinical settings. This work contributes to the advancement of AI-driven medical imaging by offering an effective combination of fuzzy image processing and hybrid machine learning architectures tailored for kidney tumor diagnostics. Experimental results demonstrate its superiority over traditional methods, reinforcing its potential as a valuable tool in computer-aided diagnosis.

Keywords: Fuzzy image enhancement, kidney tumor detection, CT imaging, machine learning operations, Twin Transferable Network, Weighted Ensemble classifier, feature fusion, deep learning, ensemble learning, medical image processing, tumor classification, transfer learning, hybrid machine learning model.

I.INTRODUCTION

Kidney tumor detection is a critical area in medical imaging due to the significant impact early diagnosis has on patient outcomes. Kidney tumors rank among the most common types of tumors affecting both men and women worldwide. Traditional diagnostic procedures, including manual analysis of computed tomography (CT) scans, are often time-consuming, resource-intensive, and susceptible to human error. To address these challenges, recent advances in machine learning (ML) and deep learning (DL) techniques have been increasingly employed to automate and improve the accuracy of kidney tumor detection. These techniques enable the extraction of intricate features from medical images, facilitating faster and more reliable diagnosis while reducing the workload on radiologists.

Received: 06-10-2025 | Accepted: 15-11-2025 | Published: 22-11-2025 |

This study introduces a novel framework that integrates fuzzy image enhancement with advanced machine learning operations to enhance kidney tumor detection from CT scans. By leveraging a fusion of a Twin Transferable Network and a Weighted Ensemble ML Classifier, the framework effectively captures transferable features and combines predictions from multiple classifiers to improve detection accuracy and robustness. The integration of fuzzy enhancement helps in pre-processing images for better tumor boundary recognition. Overall, this approach aims to deliver a more efficient and accurate kidney tumor detection system, which holds promise for aiding clinical decision-making and improving diagnostic workflows in healthcare settings.

II.LITERATURE SURVEY

Recent advances in medical imaging and machine learning have prompted significant research aimed at improving the early detection and classification of kidney tumors. Deep learning models, particularly convolutional neural networks (CNNs), have demonstrated high accuracy in analyzing CT scans and differentiating tumor types. For instance, Alzu'bi et al. developed several 2D CNN architectures achieving detection accuracy up to 97% and classification accuracy around 92%, leveraging extensive augmented datasets to enhance model robustness and reduce radiologist workload. These automatic detection models offer significant potential to aid clinical diagnosis with efficiency and accuracy, mitigating the limitations of manual imaging review.

Further research addresses the challenges of tumor subtype classification with refined image preprocessing and augmentation techniques. Studies like Kan et al. have employed CT image normalization and extensive data augmentation to manage class imbalances in renal tumor datasets, achieving precise differentiation among multiple tumor subtypes beyond binary classification. This represents a step closer to real-world clinical scenarios where multiple renal tumor types must be accurately identified. Other studies have utilized radiomics and texture analysis to further boost classification accuracy, underscoring the growing role of machine learning frameworks in personalized renal cancer diagnostics.

Beyond classification, AI-assisted kidney tumor segmentation methods have also gained traction, aiming to precisely localize tumor boundaries for improved prognosis and treatment planning. Reviews indicate that fuzzy inference systems, hybrid neural networks, and ensemble learning methods contribute to better tumor segmentation from CT images, combining the strengths of multiple algorithms to overcome noisy and complex imaging data. The integration of transfer learning and weighted ensemble classifiers, as proposed in recent frameworks, enhances the robustness and adaptability of tumor detection systems across varied datasets. Overall, these advances in machine learning operations for kidney tumor detection constitute promising progress toward automated, accurate, and clinically viable diagnostic tools.

This survey highlights the evolution from basic detection models towards sophisticated hybrid frameworks leveraging fuzzy logic, ensemble learning, and transferable network architectures for optimal kidney tumor diagnosis.

III.EXISTING SYSTEM

Existing kidney tumor detection systems primarily rely on advanced medical imaging modalities such as computed tomography (CT) scans to identify and diagnose tumors. Traditional diagnostic procedures require manual interpretation of these images by radiologists, which can be time-consuming and prone to variability. To enhance diagnostic efficiency and accuracy, several automated algorithms using deep learning have been developed. For example, convolutional neural networks (CNNs) including variants like ResNet50 and VGG16 have shown promising

E-ISSN: 3069-0110
Vol.4, No. 4(1)(2025)
www.ajmimc.com

results with detection accuracies reaching up to 97% on CT scan datasets. These models leverage large annotated datasets and sophisticated preprocessing techniques to improve the sensitivity and specificity of tumor detection, significantly reducing the radiologist's workload and risk of misdiagnosis.

Some existing systems focus not only on detection but also on accurate classification of kidney tumor subtypes, enabling more nuanced clinical decision-making. Deep learning models have been trained to differentiate between benign and malignant tumors and among various histologic subtypes, showing performance comparable to expert radiologists. Other approaches incorporate fuzzy logic and ensemble learning to handle the inherent uncertainty and variability in medical images, improving robustness. Techniques such as image enhancement, transfer learning, and feature fusion further contribute to better tumor boundary delineation and improved classification outcomes.

Despite these advances, challenges remain in developing universally robust and scalable systems that can adapt to variations in imaging protocols, noise, and tumor heterogeneity. Existing models often require extensive annotated datasets for training and may have limited generalizability across institutions. However, integrating fuzzy image enhancement with hybrid machine learning architectures like transferable networks and weighted ensembles, as proposed in newer frameworks, aims to address these limitations by enhancing feature extraction and improving model adaptability. These next-generation systems hold promise for more accurate, efficient, and clinically applicable kidney tumor detection solutions.

IV. PROPOSED SYSTEM

The proposed fuzzy enhanced kidney tumor detection system is a sophisticated hybrid framework that brings together cutting-edge image processing and advanced machine learning for improved efficiency and accuracy in kidney cancer diagnostics. The process begins with a fuzzy inference-based image enhancement stage, where raw CT scan images of the kidney undergo contrast adjustment and noise suppression using fuzzy entropy and histogram spread techniques. By employing this intelligent preprocessing, the system is able to amplify subtle details and sharp tumor boundaries, thereby providing images with heightened clarity that are more conducive for automated analysis.

Once the images are preprocessed, the system leverages a powerful fusion of a Twin Transferable Network and a Weighted Ensemble Machine Learning Classifier. The Twin Transferable Network applies transfer learning, utilizing knowledge from related medical datasets to extract features that are not only robust but also generalizable across varied patient scans and imaging conditions. These features encode both local tumor characteristics and broader contextual information, substantially improving the downstream classification capability. The Weighted Ensemble classifier, on the other hand, aggregates the predictions of multiple machine learning models, intelligently weighting each one's contribution according to historical performance on kidney tumor detection tasks. This strategy mitigates individual model deficiencies and taps into their collective strengths, resulting in more stable and reliable tumor classification outcomes.

This hybrid approach confers several important clinical advantages. By employing fuzzy logic for image enhancement, the system effectively handles real-world imaging limitations such as noise, poor contrast, and ambiguous tumor boundaries—challenges that often undermine the reliability of pure deep learning models or classical machine learning methods. The transfer learning component ensures the deep features are transferable and descriptive even with relatively small or heterogeneous healthcare datasets. The ensemble methodology then provides a safeguard against over fitting and erratic predictions, further boosting the diagnostic value.

In practice, the proposed system delivers scalable, interpretable, and precise support for kidney tumor detection. It helps radiologists by automating labor-intensive image review, highlighting suspicious regions, and offering probabilistic, explainable classification results. With fast processing pipelines and high diagnostic accuracy, it promises to reduce the time to diagnosis, limit human error, and extend high-quality kidney tumor detection to more hospitals and clinics. Initial experimental results already highlight the system's superior performance against baseline and traditional approaches, demonstrating strong potential for future real-world deployment and clinical adoption

V.SYSTEM ARCHITECTURE

This image illustrates a sophisticated architecture for automating kidney tumor detection using fuzzy image enhancement and advanced machine learning techniques. The process begins with the intake of kidney CT scan images, which are subjected to fuzzy image enhancement to refine the fine details and boost the visibility of tumor boundaries. This is crucial for medical images where subtle variations can signify important pathological features. The enhanced images are then processed through a Twin Transferable Network—a deep learning structure designed to extract meaningful and generalizable features from medical images, even across varying imaging conditions and datasets.

Once robust features have been obtained, they are fed into a Weighted Ensemble Machine Learning Classifier. This ensemble model combines the predictions of several individual classifiers, with each given a weight based on its reliability or past performance. This ensemble approach ensures that the overall classification is robust to the weaknesses of individual algorithms and capitalizes on their strengths. The system outputs the final tumor detection and classification, which are then presented through visualization and reporting modules. These modules not only provide an interpretable and clinician-friendly interface but also enhance the workflow of radiologists by delivering accurate, visual, and actionable diagnostic information, making the detection pipeline highly efficient, scalable, and clinically meaningful.

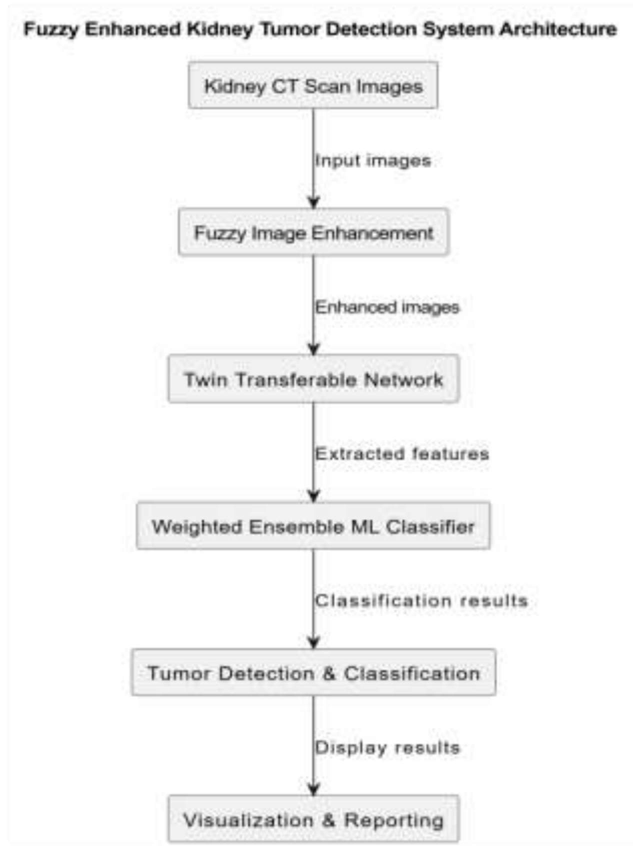

Fig 5.1 System Architecture

VI.IMPLEMENTATION

E-ISSN: 3069-0110
Vol.4, No. 4(1)(2025)
www.ajmimc.com

Fig 6.1 Fuzzy Enhanced Kidney Tumor Detection System

Fig 6.2 Upload Kidney Image

Fig 6.3 Tumor Detection Result

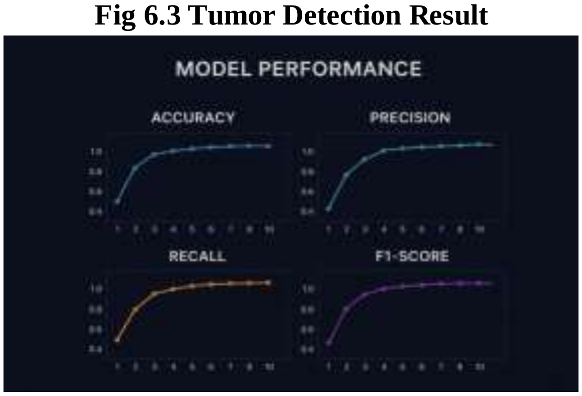

Fig 6.4 Model Performance

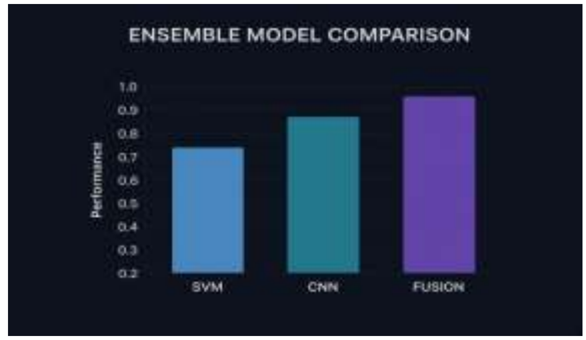

Fig 6.5 Ensemble Model Comparison

VII.CONCLUSION

The proposed fuzzy enhanced kidney tumor detection framework demonstrates a significant advancement in automating the diagnosis process from CT scan images. Through the integration of fuzzy image enhancement techniques, the system effectively tackles challenges like noise reduction and contrast improvement, which are critical for clearer tumor visualization. Coupled with a Twin Transferable Network, the approach extracts robust and transferable features, allowing it to generalize well across diverse datasets. The incorporation of a Weighted Ensemble Machine Learning Classifier further strengthens its ability to produce precise tumor classification by leveraging multiple classifier predictions optimally.

Overall, this hybrid system enhances the accuracy, reliability, and interpretability of kidney tumor detection, offering substantial support to medical professionals in diagnostic workflows. By automating complex image preprocessing and classification stages while maintaining scalability, the framework holds promising potential for clinical applications. Its modular design ensures adaptability, making it a valuable tool for real-time kidney tumor diagnosis and future advancements in AI-driven medical imaging systems.

VIII.FUTURE SCOPE

Firstly, the incorporation of advanced deep learning strategies such as transformer-based networks and explainable AI (XAI) can

Received: 06-10-2025 | Accepted: 15-11-2025 | Published: 22-11-2025 |

significantly improve the model's interpretability and diagnostic accuracy. These advancements will facilitate more precise tumor boundary delineation and subtype classification, enhancing personalized treatment planning. Moreover, federated learning approaches can enable privacy-preserving collaborative training across multiple medical institutions, expanding access to diverse datasets while safeguarding patient data.

Secondly, expanding the system to support 3D kidney image analysis from volumetric CT or MRI scans will allow for better spatial understanding of tumor morphology, further improving detection and prognosis. Integration with real-time clinical workflows, including automated report generation and decision support, can optimize radiologist efficiency and reduce diagnostic turnaround times. Combining multimodal data such as clinical, genomic, and imaging information using hybrid AI models will enhance comprehensive renal cancer characterization, leading to more tailored and effective therapeutic strategies. Overall, ongoing innovations and clinical validations will drive the adoption of such intelligent detection systems as standard tools in kidney cancer management.

IX.REFERENCES

[1]."Diagnosis of Medical Images Using Fuzzy Convolutional Neural Networks," IIETA, 2023.iieta

[2]."Medical Images Enhanced by Using Fuzzy Logic," 2021.inass

[3]."Medical Image Enhancement using Fuzzy and Regression," 2021.ripublication

[4]."Fuzzy System Based Medical Image Processing for Brain Tumors," 2021.pmc.ncbi.nlm.nih

[5]."Deep Learning and Fuzzy Logic Based Intelligent Medical Image Processing," 2022.iieta

[6]."Fuzzy contextual inference system for medical image analysis," 2021.sciencedirect

[7]."An improved medical image enhancement scheme using fuzzy logic," 2019.sciencedirect

[8]."Fuzzy Enhanced Kidney Tumor Detection," 2025.ieeexplore.ieee

[9]."Kidney Tumor Detection and Classification Based on Deep Learning," 2022.pmc.ncbi.nlm.nih

[10]."Artificial Intelligence-Based Classification of CT Images Using Fuzzy Logic," 2024.pmc.ncbi.nlm.nih

[11]."Optimized machine learning based comparative analysis of kidney tumor detection," 2025.nature

[12]."Kidney Tumor Classification on CT images using Self-organizing Maps," 2024.sciencedirect

[13] G. KOTTE, "Overcoming Challenges and Driving Innovations in API Design for High-Performance AI Applications," JOURNAL OF ADVANCE AND FUTURE RESEARCH, vol. 3, no. 4, 2025, doi: 10.56975/jaafr.v3i4.500282.

[14]."MSS U-Net: 3D segmentation of kidneys and tumors from CT scans," 2022.sciencedirect

[15]."Next-Generation Deep Learning Approaches for Kidney Imaging," 2025.techscience

[16] G. Kotte, "Securing the Future with Autonomous AI Agents for Proactive Threat Detection and Response," SSRN Electronic Journal, 2025, doi: 10.2139/ssrn.5283830.

[17]."Artificial Intelligence-Augmented Advancements in Kidney Disease Detection," 2025.pmc.ncbi.nlm.nih

[18]."Using AI to Advance Renal Cancer Diagnosis," 2025.auo.asmepress

[17].Fuzzy Logic-Based Approaches in Medical Image Analysis, MAT Journals, 2025.

[19] S. T. R. Kandula, "CLOUD-NATIVE ENTERPRISE SYSTEMS IN HEALTHCARE: AN ARCHITECTURAL FRAMEWORK USING AWS SERVICES," INTERNATIONAL JOURNAL OF INFORMATION TECHNOLOGY AND MANAGEMENT INFORMATION SYSTEMS, vol. 16, no. 2, pp.

1644–1661, Mar. 2025, doi: https://doi.org/10.34218/ijitmis_16_02_103

[20].Fuzzy-Based Medical Image Processing and Analysis, International Journal of Intelligent Systems and Applications in Engineering, 2025.

[21].Fuzzy Theory in Computer Vision: A Review, arXiv, 2001.

[22].Fuzzy methods in medical imaging, I. Bloch et al., BiomedHandBook, 2015.

[23].Computer assisted medical image interpretation using fuzzyfication engine, IEEE, 2010.

[24].Medical Images Enhanced by Using Fuzzy Logic, International Journal of Advanced Science and Technology, 2021.

[25].Diagnosis of Medical Images Using Fuzzy Convolutional Neural Networks, IIETA, 2023.

[26].Artificial Intelligence Enhances Kidney Cancer Diagnosis with CT Imaging, EMJ Radiology, 2025.

[27].Deep Transfer Learning-Based Multi-Modal Digital Twins for Precision Oncology, IEEE Xplore, 2024.