DWI-Agent: LLM-Powered Agent for Automated DWI Processing and Clinical Interpretation

Yunxiang Li[1], Yen-Peng Liao[1], Yan Dai[1], Jie Deng[1], You Zhang[1]
[1]Department of Radiation Oncology, UT Southwestern Medical Center, Dallas, Texas

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

ABSTRACT

Purpose:
Diffusion-weighted MRI (DWI) and its derived parameters, including apparent diffusion coefficient (ADC) and intravoxel incoherent motion (IVIM) metrics, are valuable for assessing tumor response to radiotherapy. However, DWI processing workflows are complex, and clinical interpretation of ADC and IVIM remains challenging. We propose DWI-Agent, which leverages Large Language Models (LLMs) to address the challenges.

Methods:
DWI-Agent is built on LangChain [1] (an agent framework), enabling LLMs to dynamically invoke specialized tools. It implements an end-to-end workflow from raw data processing to clinical interpretation, integrating in-house tools for format conversion, DWI distortion correction, denoising, and ADC/IVIM parameter fitting. In addition, DWI-Agent uses retrieval-augmented generation (RAG) to automatically retrieve relevant literature and generate clinical interpretation reports.

Conclusion:
DWI-Agent delivers one-stop, literature-grounded analysis from raw data to clinical interpretation, lowering both the technical and interpretive barriers to quantitative DWI.

INTRODUCTION

In recent years, Large Language Model (LLM)-driven intelligent agents have shown tremendous potential in medical imaging. Systems such as MedRAX [2] have been successfully applied to automated analysis of chest X-rays. However, in the diffusion weighted MRI (DWI) field, such tools remain absent. DWI analysis faces unique technical challenges: **(1) Diverse data types and complex processing workflows**: Data exported from clinical systems include not only multi-b-value DWI sequences but also anatomical MRI such as T1, T2, and FLAIR (used as reference for registration-driven distortion correction and for anatomical localization), as well as physician-delineated GTV and CTV segmentations. Complete DWI analysis requires multiple steps including resampling alignment between different sequences, registration across time points, denoising, distortion correction, and parameter fitting, where the IVIM bi-exponential model fitting is particularly sensitive to noise, and low signal-to-noise ratio can lead to unstable parameter estimation. **(2) Difficult clinical interpretation**: The biological significance of ADC and IVIM metric changes needs to be analyzed in conjunction with specific tumor types and treatment regimens. For example, ADC elevation typically suggests decreased cell density and treatment response, but in some cases may also reflect edema or necrosis; the IVIM model involves three parameters, true diffusion (Dt), pseudo diffusion (Dp), and perfusion fraction (fp), each of which may exhibit different or even opposite trends, requiring comprehensive analysis combining multiple sources of information. This complexity requires clinicians to have a fundamental understanding in DWI biology and familiarity with relevant literature, increasing the difficulty of interpretation. To address these issues, we propose DWI-Agent **(Fig. 1)**, with the following main contributions: (1) Integration of a modular DWI processing toolchain covering data conversion, registration, denoising, distortion correction, and parameter fitting; (2) Introduction of a RAG-based clinical interpretation module that automatically retrieves literature and generates parameter interpretations.

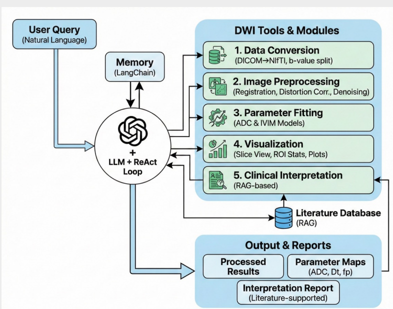

Fig. 1. Architecture and workflow of DWI-Agent.

RESULTS

Denoising (Fig. 2). The INR-based tool [3] suppresses high-frequency noise by limiting the bandwidth of Fourier positional encoding and uses the signal relationship across b-values as a contextual constraint. Across all b-values (1–1000), noise dropped by ~60% while signal magnitude was preserved (Std: 86.2 → 39.3 at b=1; 21.3 → 8.4 at b=1000).

Distortion correction (Fig. 3). Using T2 as the distortion-free reference, a deformable INR + B-spline model estimates the DWI deformation field [4], with mutual information as the similarity loss and landmark matching from the MINIMA foundation model [5] for added supervision. The DWI (b=0)–T2 Dice coefficient improved from 0.648 to 0.955 (red contour = ROI on T2; cyan = ROI on DWI).

Parameter fitting. A self-supervised ADC/IVIM fitting tool reduced error by >50% versus least-squares on the AAPM-IVIM-dMRI dataset.

Clinical interpretation (Table 1). In three head-and-neck cancer patients on concurrent chemoradiotherapy, RAG-grounded reports—validated by a functional-MRI expert—integrated ADC, Dt, and fp into three distinct response patterns: (1) a marked fp increase masked a Dt decline → poor response despite minimal ADC change; (2) concordant ADC/IVIM increases → effective response; and (3) discordant ADC decrease with Dt increase, attributed to fp reduction → partial response needing close follow-up. Case 3 highlights the unique value of combined ADC/IVIM over ADC alone: the agent identifies and explains directionally inconsistent changes, giving more comprehensive information for clinical decision-making.

Table 1. DWI/IVIM Parameter Changes, and Corresponding DWI-Agent's Interpretations.

	Case 1	Case 2	Case 3
Tumor Site	Head and Neck Cancer	Tongue Base Cancer	Tonsillar Fossa Cancer
ADC Change	-4.3%	+17.4%	-11.3%
Dt Change	-44.2%	+8.3%	+9.8%
fp Change	+64.7%	+8.3%	-13.3%
Agent Interpretation	Significant Dt decrease suggests worsening restricted diffusion, associated with high cell density; substantial fp increase may reflect inflammatory hyperemia or persistent tumor angiogenesis; ADC shows only mild decrease because fp increase partially offsets the effect of Dt decrease. Overall pattern does not conform to effective treatment response characteristics (Dt should increase), suggesting poor treatment response.	ADC increase of 17% suggests decreased cell density, within the "sensitive" range reported in literature; Dt increase of 8% supports true diffusion increase; mild fp increase is consistent with improved microvascular environment in responders. Overall pattern conforms to effective treatment mode.	Dt increase of 10% is a favorable signal (partial treatment effect), but ADC paradoxically decreases because fp reduction (-13%) lowers the perfusion contribution to ADC; low baseline Dt (0.51) is consistent with treatment-sensitive phenotype. Overall presents an intermediate/indeterminate pattern.
Clinical Recommendations	Multidisciplinary discussion recommended, combining morphological MRI, PET-CT, and clinical examination for comprehensive evaluation.	Diffusion-perfusion change directions consistent with good radiotherapy response, recommend confirmation with anatomical imaging.	Mixed diffusion-perfusion pattern suggests close follow-up needed rather than assuming complete response.

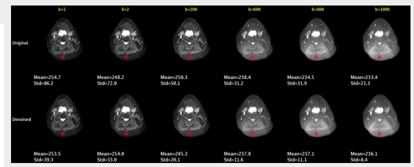

Fig. 2. Comparison of DWIs before and after DWI-Agent's denoising tool processing.

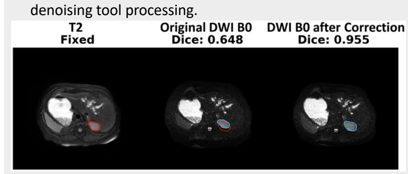

Fig. 3. Processing results with DWI-Agent's distortion correction tool. The red contour outlines the ROI on T2, and the cyan contour outlines the ROI on DWI.

DISCUSSION

First LLM-based agent for DWI, integrating end-to-end processing and clinical interpretation in a single workflow.

Robust tool performance: ~60% noise reduction with signal preserved; distortion-correction Dice 0.648 → 0.955; >50% lower IVIM fitting error vs. least-squares.

Multi-parameter ADC/IVIM outperforms ADC alone — the agent separates perfusion (fp) and diffusion (Dt) contributions, revealing response patterns a single ADC metric misses (e.g., fp rise masking a Dt decline; ADC–Dt discordance).

RAG grounds each interpretation in retrieved literature, improving transparency and reducing hallucination; reports confirmed by a functional-MRI expert.

Limitations: small single-center cohort with qualitative single-reader review; multi-center prospective validation with outcome correlation is warranted.

REFERENCES

[1] https://github.com/langchain-ai/langchain

[2] A Fallahpour., et al., MedRAX: Medical Reasoning Agent for Chest X-ray. Forty-second International Conference on Machine Learning, 2025

[3] Y Li et al., Band-limited implicit neural representations for diffusion-weighted imaging denoising. Physics in Medicine & Biology, 2026

[4] Y Li et al., Landmark matching and B-spline implicit neural representations for diffusion-weighted imaging distortion correction. Physics in Medicine & Biology, 2026

[5] J Ren et al., Minima:Modality invariant image matching. IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2025

CONTACT

You Zhang, PhD
You.Zhang@UTSouthwestern.edu