

Highlights of the Manuscript

- We propose an enhanced **DenseNet201+** architecture tailored for knee osteoarthritis grading based on radiographic images.
- The model integrates multi-scale pooling, spatial attention modules, and statistical feature engineering to improve classification accuracy.
- A hybrid learning framework combines CNN feature extraction with classical machine learning classifiers (SVM, RF, k-NN).
- The method achieves **94.68% accuracy**, with strong performance across all Kellgren–Lawrence grades, especially Grade 1 and Grade 4.
- Our framework offers **clinically interpretable** GradCAM-based visualizations and is computationally efficient for real-world deployment.