



Abstract Type : Poster exhibition

Abstract Submission No.: A-0332

Abstract Topic : Big Data

Automated Classification of Renal Pathologies From CT Imaging Using Deep Learning

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Objectives : Timely and accurate classification of kidney pathologies, including cysts, tumors, and stones, remains a critical clinical challenge. Manual interpretation of CT imaging is time-consuming and subject to inter-observer variability. This study presents a transfer learning framework leveraging EfficientNet-B0 to automate multi-class kidney disease detection from CT scans, aiming to support radiological workflows with a robust, generalizable diagnostic tool.

Methods : A dataset of 12,446 CT images was curated across four categories: Normal, Cyst, Tumor, and Stone. Images were partitioned into training (70%), validation (15%), and test (15%) subsets. Data augmentation and ImageNet-standard normalization were applied during preprocessing. The model utilized a pretrained EfficientNet-B0 backbone, modified with a dropout layer (rate = 0.3) and a fully connected output layer (4 nodes, Softmax activation). Training was conducted in PyTorch using stochastic gradient descent (learning rate = 0.01, momentum = 0.9) over 10 epochs with a batch size of 32. Performance was evaluated via accuracy and cross-entropy loss curves.

Results : The model demonstrated consistent improvement over 10 epochs, achieving a final training accuracy of approximately 97% and a test accuracy of approximately 92%. Training and test accuracy curves converged closely, with no evidence of overfitting. Test loss declined steadily from 1.2 to 0.4, confirming strong generalization. A sample inference on an unseen CT image yielded a correct prediction of "Tumor," validating the model's end-to-end utility.

Conclusions : EfficientNet-B0, fine-tuned on a large-scale kidney CT dataset, achieves high multi-class classification with minimal overfitting. The model's lightweight architecture and strong generalization make it a compelling candidate for clinical deployment in resource-constrained radiology settings. Future work will focus on explainability techniques (e.g., Grad-CAM) and external dataset validation to support clinical translation.

table 1.png

Table 1. Model Performance Summary Across Training And Test Sets

Metric	Epoch 1	Epoch 5	Epoch 10
Train Accuracy	~80%	~92%	~97%
Test Accuracy	~75%	~83%	~92%
Train Loss	~0.92	~0.55	~0.35
Test Loss	~1.20	~0.72	~0.40



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KSN SEOUL, KOREA
2026

The 46th Annual Meeting of the Korean Society of Nephrology



Jun 11 (Thu) – 14 (Sun), 2026
COEX, Seoul, Korea