# Artificial Intelligence (AI) based Image Analysis and Decision Support System (iADSS) to Aid Pathologists in Analysis and Classification of Histopathology Images of WISTAR Rat Kidneys

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## OBJECTIVE

- Automated analysis and classification of histopathology images of Wistar Rat kidneys into "Normal" (N) and "Not Normal" (NN) using iADSS based on advanced algorithms of Digital Image Processing and Deep Learning.
- To establish efficacy of the system by comparison with results of pathologists.

## INTRODUCTION

Histopathological examination of animal tissue by pathologists forms a crucial part of preclinical drug toxicology. Conventionally, pathologists spend valuable time scrutinising slides under the microscope, majority of which are within normal limit. Moreover, this method is subjective and dependent on the experience and expertise of the reporting pathologist. In recent years, Machine Learning techniques have helped in providing increasingly reliable and accurate image analysis solutions in Digital Pathology. iADSS combines advanced Image Processing and Deep Learning algorithms to analyse and accurately classify Wistar rat kidney histopathology images into "Normal" and "Not Normal" categories.

## MATERIALS AND METHODS

### MATERIALS

**Specimen**

Kidney histopathology slides of Wistar Rats aged 14, 24 and 36 weeks from a preclinical toxicology study, including control and treated, male and female groups.

**Images**

- Image Acquisition Device – Leica SCN400, Nanozoomer XR scanner (40X magnification)
- Image Format - Collection of JPG tiles (512x512 pixels) at magnifications (40X, 10X, 2.5X, and 0.625X) in the form of a multi-resolution pyramid

### METHODS

**A) Training, Testing and Fine-tuning**

1. Knowledge transfer from domain experts – Normal histology and possible abnormalities
2. Preparation of training data set (including images & corresponding labels) – Using 500 tiles of 10 animals at 40X magnification
3. Development of DeepLab model - Segmentation of various tissue parameters using Deep Learning
4. Refining results - Based on observation of abnormal parameters in the segmented regions of Capsule, Cortex, Medulla and Papilla
5. DeepLab deployment - Trained models deployed on test data
6. Classification of test images – "Normal" and "Not Normal" based on structural and statistical properties of the detected parameters
7. Fine-tuning models - Based on test results

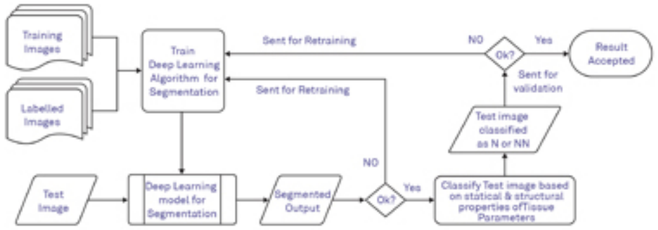
**B) Validation**

1. 100 images of three age groups of Wistar Rats randomly selected and classified as "Normal" and "Not Normal".
2. Results validated by internal reviewers and fine-tuned.
3. Independent validation on new data-set of 100 images by external experts.

**C) Case Study**

Case study on 119 Wistar rats to compare results of iADSS analysis with expert pathologists.

**Diagram 1: Process Flow for Image Classification using Deep Learning**




**Figures 1 & 2: H & E stained images of kidney showing perivascular MNC infiltration surrounding renal pelvis (5X & 20X magnification).**

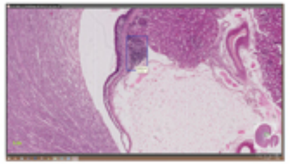


Figure 1

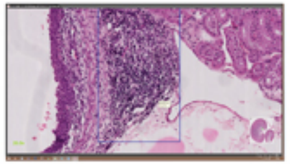


Figure 2

**Figures 3 & 4: H & E stained images of kidney showing tubular necrotic changes (5X & 20X magnification).**

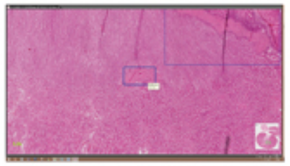


Figure 3

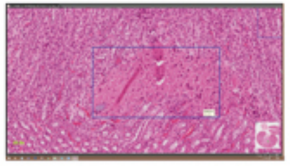


Figure 4

**Figures 5 & 6: H & E stained images of kidney showing urothelial hyperplasia in renal pelvis as a regenerative lesion associated with inflammatory changes (5X & 20X magnification).**

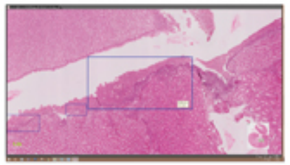


Figure 5

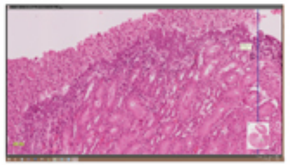


Figure 6

## RESULTS

- **Validation :** Accuracy of 99% noted during internal and external validation.
- **Case Study :** Accuracy (for "Normal"Class) of 98.86% noted with one false-negative due to presence of a small focus of polymorphonuclear cells.

**Table 1: Observation of case study**

| | | Pathologist's Results | | | |
|---|---|---|---|---|---|
| | | Not Normal | Normal | | |
| iADSS Results | Not Normal | TP = 14 | FP = 17 | Not Normal Accuracy (PPV) = TP/(TP+FP) | 45.16 |
| | Normal | FN = 1 | TN = 87 | Normal Accuracy (NPV) = TN/(FN+TN) | 98.86 |
| | | Sensitivity (TPR) = TP/(TP+FN) | Specificity (TNR) = TN/(TN+FP) | | |
| | | 93.33 | 83.65 | | |

(TP: True Positive, TN: True Negative, FP: False Positive, FN: False Negative)

Accuracy measures for iADSS:

- Normal Accuracy: Percentage of images correctly classified as "Normal"
- Not-Normal Accuracy: Percentage of images correctly classified as "Not Normal"

## CONCLUSION/FUTURE DIRECTION

- iADSS accurately classified histopathology renal images of Wistar rat into "Normal "and "Not Normal" categories with a high sensitivity and negative predictive value.
- Results were comparable with Pathologist results.
- iADSS can hence serve as an effective decision support system in pre-clinical toxicology studies with future development as a diagnostic tool.

**References**

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