Developing a Deep Learning Convolutional Neural Network Method to Detect Small Intestine Pathology in Rat Ileum

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1 INTRODUCTION

The rat is an important animal model in assessing small intestinal injury after administration of drugs suspected to have radiomimetic effects. Histologic scoring methods are used in the evaluation of intestine in both standard short- and long-term toxicology studies. These scoring methods are qualitative, subjective, and prone to inter- and intra-study and observer variability. We hypothesized that a deep learning method using a convolutional neural network (CNN) would facilitate small intestinal lesion detection and scoring for the toxicologic pathologist.

2 METHODS

A CNN was trained to identify normal structures of the ileum and four classes of small intestinal lesions in rat ileum: Apoptosis / necrosis in the mucosa or Peyer's patches, decreased cellularity in Peyer's patches, attenuation or hyperplasia in epithelium, and villous atrophy.
Ileum samples from rats were sectioned, stained with hematoxylin and eosin, digitally scanned at 40x magnification, and uploaded into a cloud server. Training annotations were completed based on a strict ground truth established by two trained scientists.
Model performance was first assessed by comparing model masks with the original training annotations (verification step) using both confusion matrix calculations and visual confirmation. When the F-value of CNN performance was at least 0.7 for all classes, the model underwent additional qualification steps using new, not previously annotated samples from the original study (testing set) as well as samples from additional studies not previously used for training (generalization).

3 RESULTS

The performance of the algorithm for the normal and abnormal classes was both acceptable quantitatively (F1 scores>0.7) and visually verified by a board certified pathologist as appropriate for the intended use (lesion detection decision support).

4 CONCLUSIONS

We successfully developed a deep learning-based decision support tool for application in toxicologic pathology. The tool will facilitate the primary analyses and peer-review of studies. We anticipate that the decision support tool will improve ease and speed of histo-pathologic analyses as well as interobserver concordance, and, ultimately, reduce time and cost of the evaluation.

5 FIGURES & TABLES

Figure 1. **Annotation Strategy and Model Training.** **A & B.** Annotation examples. A. Ileum from an untreated control rat (background – turquoise; mucosa – bright green; submucosa/muscularis/mesentery – purple. **B.** Ileum from a rat treated with test article (hyperplasia epithelium - dark green; attenuation epithelium – brown).

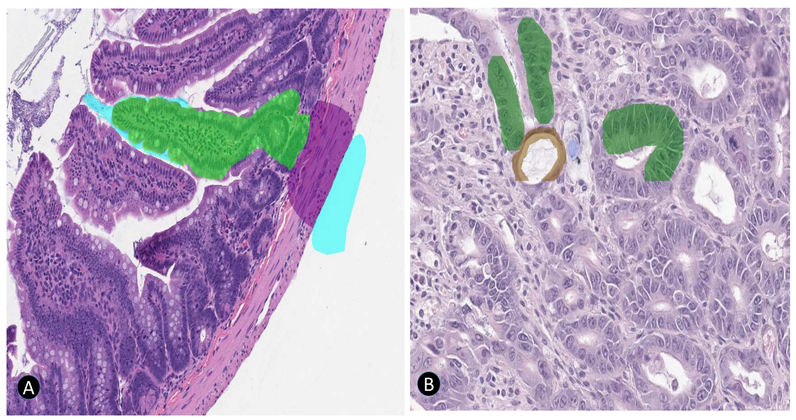
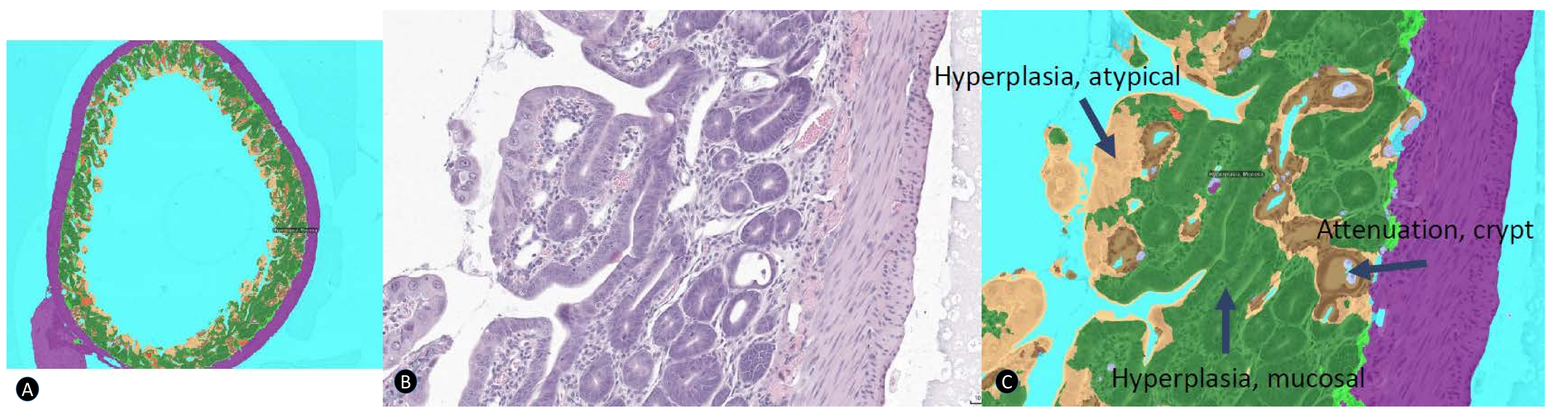


Figure 2. Analysis by the CNN Model and Data Output. Ileum from a rat treated with test article. **A & C. Example masks** (background – turquoise; mucosa – bright green; submucosa/muscularis/mesentery – purple; hyperplasia epithelium - dark green; atypical hyperplasia epithelium – pale tan; attenuation epithelium – brown). **B. HE.**



6 REFERENCES

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