

REPORT DOCUMENTATION PAGE

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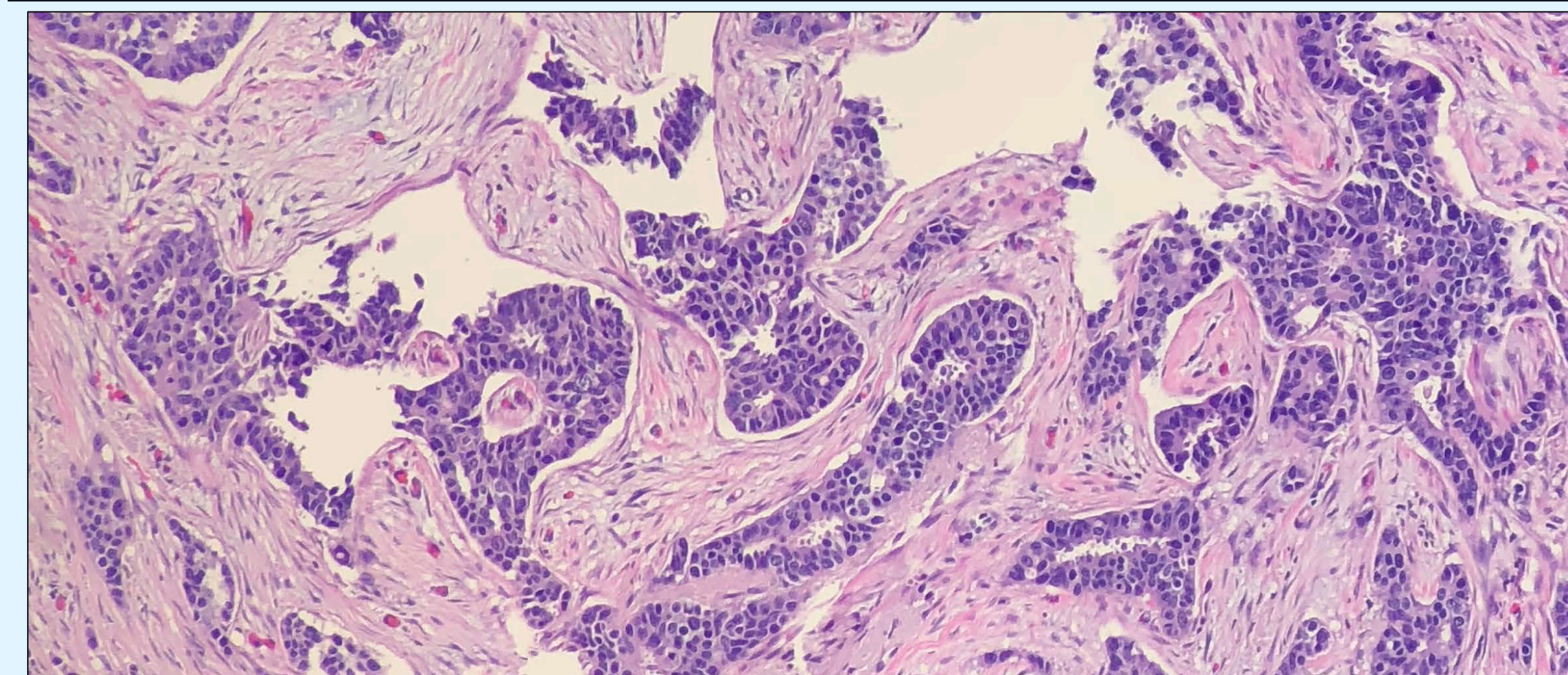
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- Convolutional Neural Networks (CNNs) have revolutionized the field of computer vision.
- While application of CNNs in pathology has been increasing, it's utilization is still minimal.
- The majority of popularized studies focus on the identification of malignant cells in a background of normal.
- Multiple studies have been published demonstrating effective classification of common tumors with a focus on whole slide imaging.¹⁻³
- No published studies have looked at identification of various classes with the potential to help train resident pathologist, or reduce work load by screening slides through readily available images.
- Here, we demonstrate fine-tuning an InceptionV3 CNN model with relatively few training images accurately and confidently distinguishes between various benign and malignant lesions of the breast.

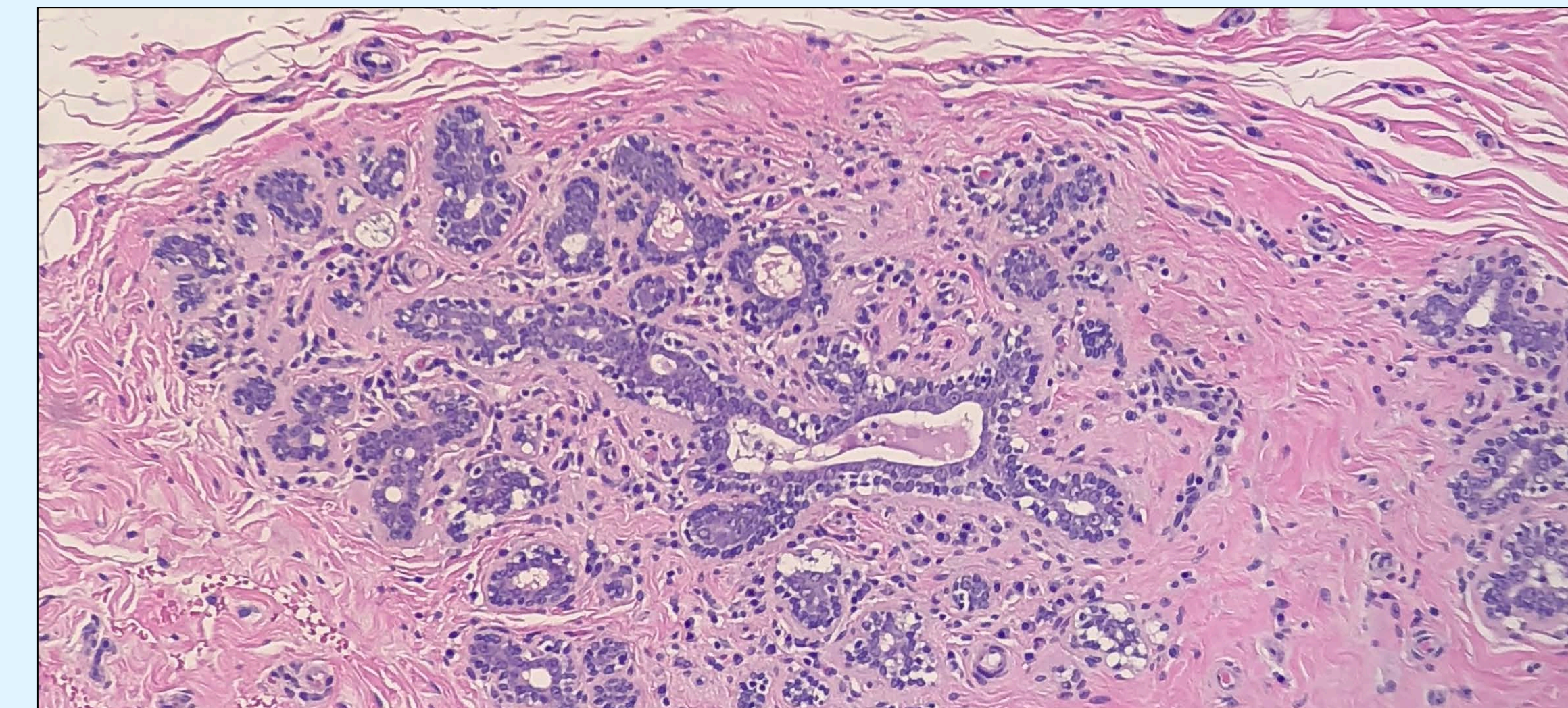
Design

- 4 classes of breast pathology were considered for image analysis:
 - Benign lobules
 - Duct ectasia
 - Ductal carcinoma in situ
 - Invasive ductal carcinoma
- Images were taken by a 12 megapixel smart phone camera at 1.9x zoom at a 10, 20, and 40x microscope lens optics.
- Images were randomly partitioned into training (80%) and validation sets (20%).
- The training set was used to fine-tune a customized fully-connected (FC) layer on top of the InceptionV3 CNN architecture utilizing pre-trained ImageNet convolutional layer weights.
- The customized FC layer contained a single 256-unit hidden layer and 4 final output units with softmax activation to output a probability distribution.
- "Accurate prediction" was defined as the model outputting its maximum probability prediction on the true class.

0% probability of a given class.



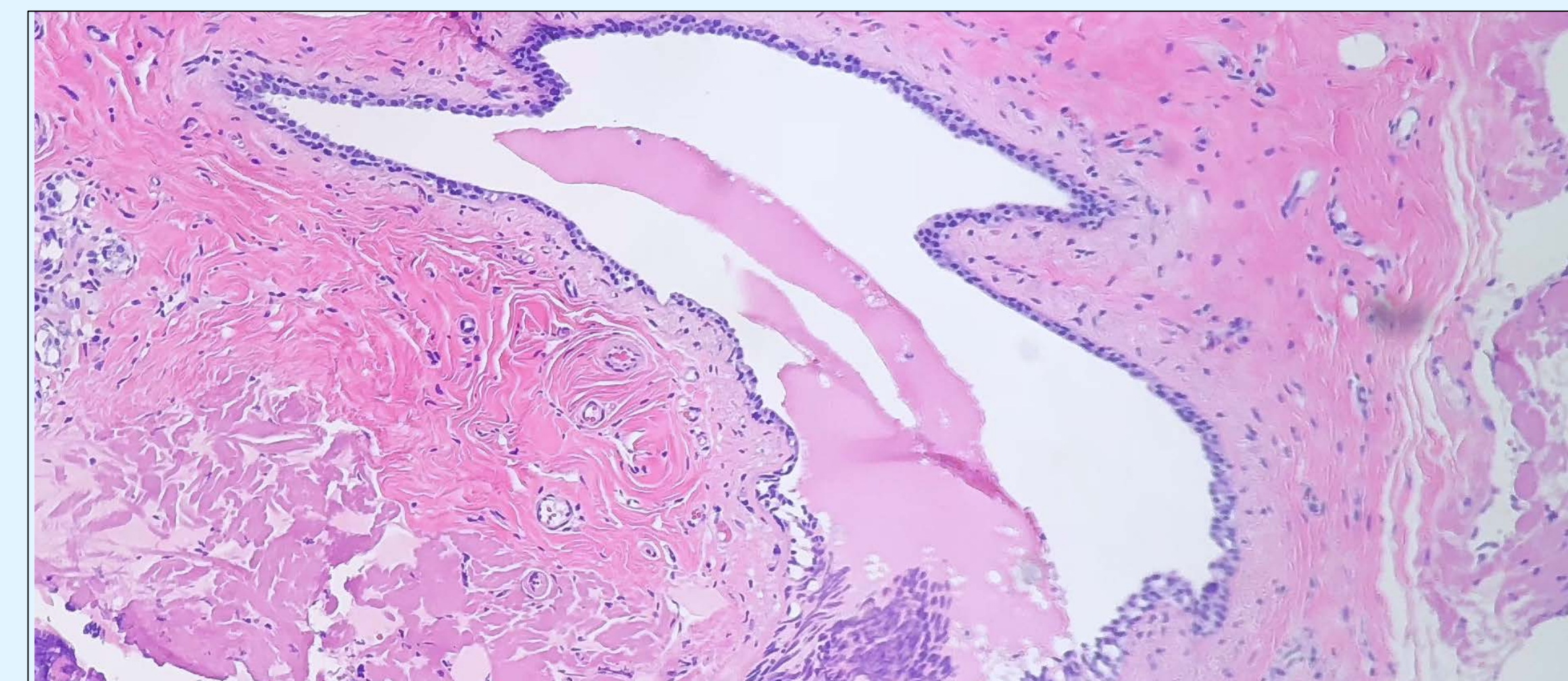
Invasive: 0.998, Duct ectasia: 0.001,
Lobules: 0.001, DCIS: 0.000.



Lobules: 0.882, DCIS: 0.110,
Duct ectasia: 0.008, Invasive: 0.000.



DCIS: 0.4998, Lobules: 0.4997,
Duct ectasia: 0.0003, Invasive: 0.0001.



Duct ectasia: 0.489, DCIS: 0.465,
Invasive: 0.016, Lobules: 0.034.

- A total of 354 images of 4 classes were collected:
 - Benign lobules: 154 images
 - Duct ectasia: 38 images
 - Ductal carcinoma in situ: 84
 - Invasive ductal carcinoma:
- **The CNN showed 100% accuracy**
 - The mean predicted probability of the entire validation set was 0.9 with a standard deviation of 0.105.
 - 88% of validation images showed a maximum class probability of ≥ 0.90 :
 - 100% of invasive
 - 92.3% of benign lobules
 - 81.8% of ductal carcinoma in situ
 - 71.4% of duct ectasia
 - Two validation images showed a maximum class probability of less than 0.5 (both benign lobules or DCIS).

Conclusion

- Fine-tuning the InceptionV3 architecture was remarkably accurate and confident in distinguishing between malignant and benign breast pathology.
- Importantly, adequately InceptionV3 was validated with extremely accessible images as a smart phone camera.
- Large models could provide framework for resident learning and reduced

References

1. Sornapudi S, Stanley RJ, Stoecker WV, et al. Deep learning in digitized histology images by superpixels.
2. Couture HD, Williams LA, Geradts J, et al. Deep learning to predict breast cancer grade, ER status, hormone receptor subtype. *Npj Breast Cancer* (2018)4:30.
3. Dayong W, Aditya K, Rishab G, et al. Deep learning for breast cancer. *Camelyon Grand Challenge*