

# DECOUPLED NEURAL NETWORKS FOR CLASSIFICATION OF BREAST MICROSCOPY IMAGES

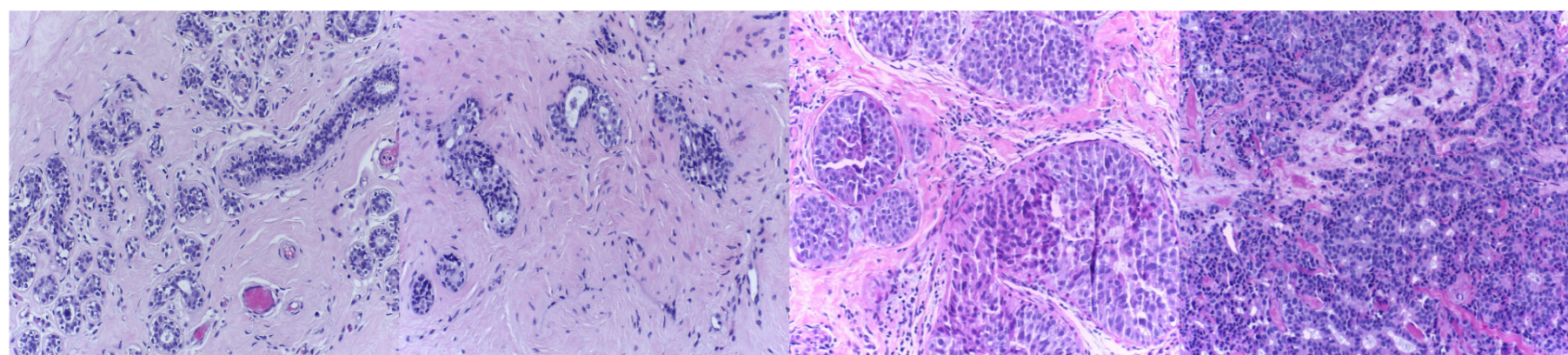
Stone R.<sup>1,4</sup>, Wright A.<sup>1,2</sup>, Clarke E.<sup>2,3</sup>, Hanby A.<sup>2,3</sup>, Treanor D.<sup>2,3</sup>, Hogg D.<sup>1</sup>, Bulpitt A.<sup>1</sup><sup>1</sup>School of Computing, University of Leeds, UK<sup>2</sup>Leeds Institute of Cancer and Pathology, University of Leeds, UK<sup>4</sup>sc16rsm@leeds.ac.uk<sup>3</sup>Leeds Teaching Hospitals, NHS Trust

## 1. Abstract

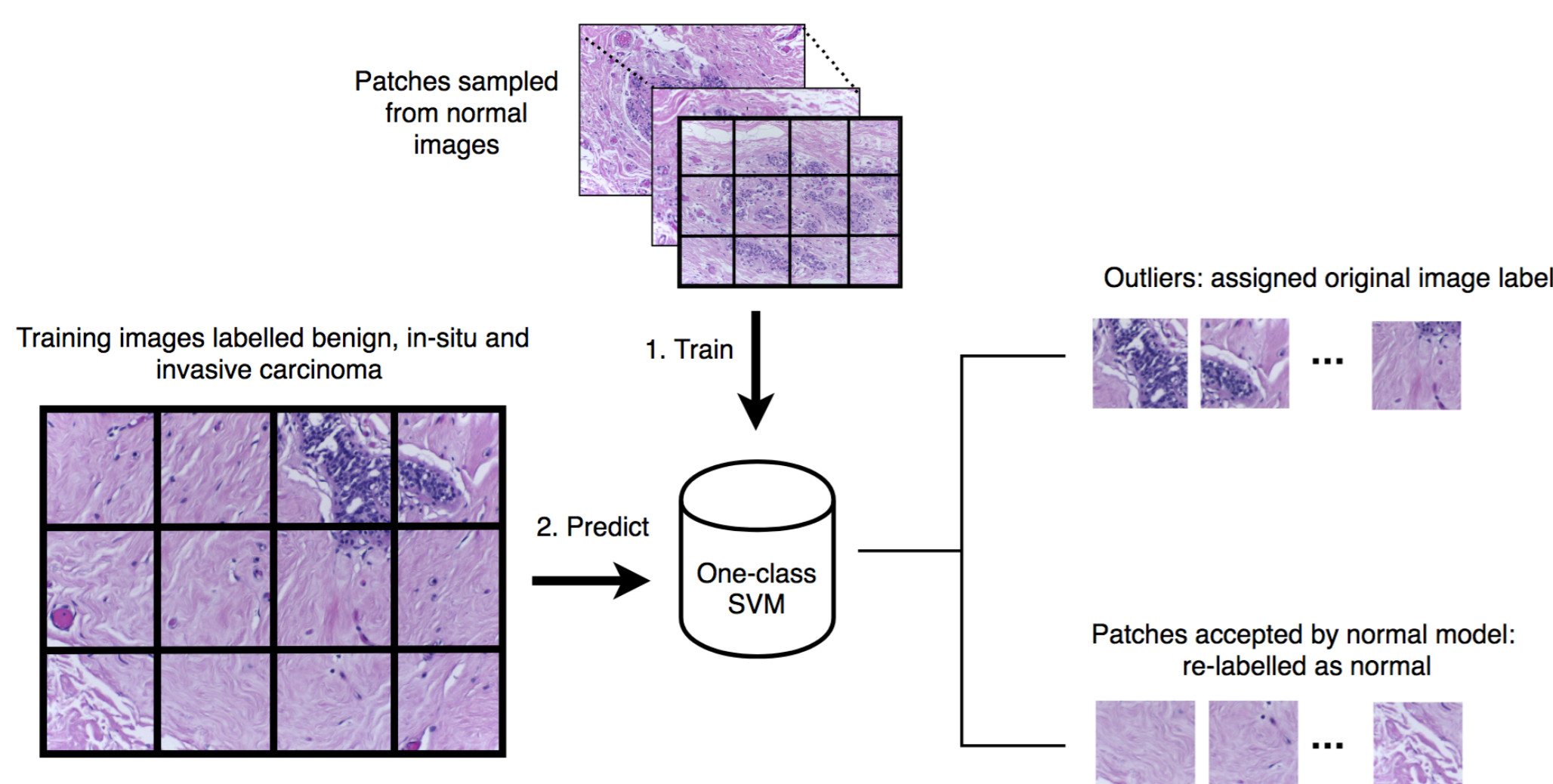
Pathologists classify tissue samples by identifying cell diversity, spatial relationships and abnormal features. Our approach to breast microscopy image classification aims to model the pathologist diagnostic process by purifying patch labels using a simple model for normal morphologies, then training a convolutional neural network for patch feature extraction. Feature representations of the original images are then learned by a second network, yielding a final 4-class accuracy of 90.6%.

## 2. Dataset

- The images used for this study are from the 2018 Breast Cancer Histology Challenge [1] (BACH) dataset.
- Dataset consists of 400 breast microscopy images, 2048x1536 pixels each, with image-wise labels: normal, benign, *in-situ* carcinoma and invasive carcinoma.



## 3. Patch sampling and model for normality



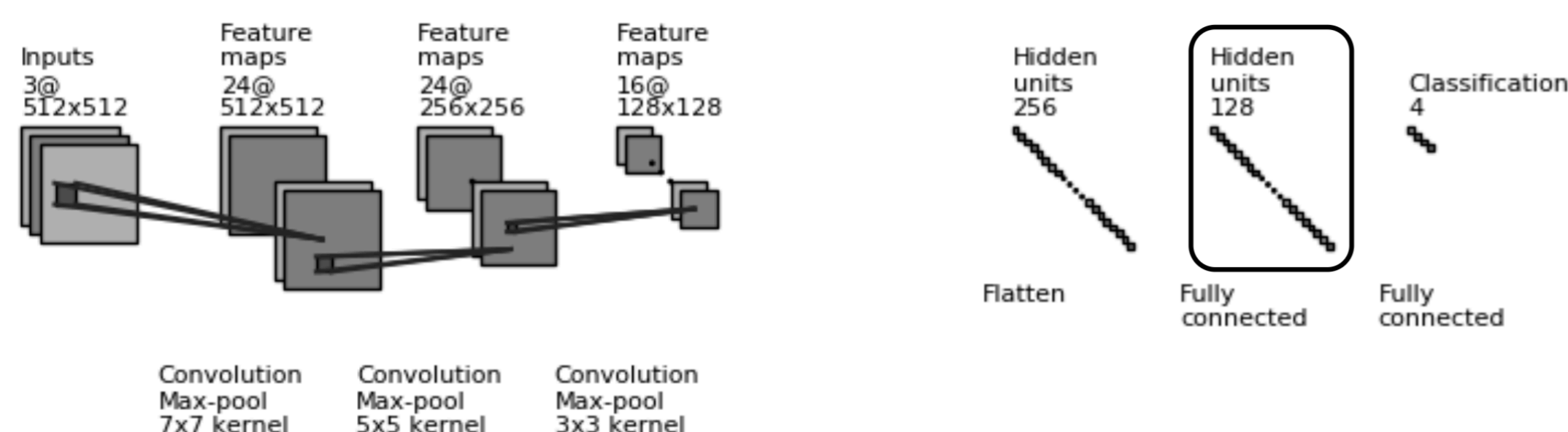
- 13% of the combined patches from all benign, *in-situ*, and invasive images are labelled as normal.
- They are unlikely to contain discriminative characteristics of any other label.
- All other patches are assigned the same label as their source image.
- Models tested for ranges  $\nu = \{0.05 \dots 0.15\}$  and  $\gamma = \{1e-8 \dots 1e-6\}$ .

### One-class support vector machine (OC-SVM) model evaluation by:

- Qualitative analysis based on expected distribution of predictions.
- Quantified evaluation by pathologist using 200 random patches accepted by each model from images labelled benign and cancer.

The best-performing model has  $\nu = 0.1$ ,  $\gamma = 3.0e-7$ , and an estimated error rate of 1.5%.

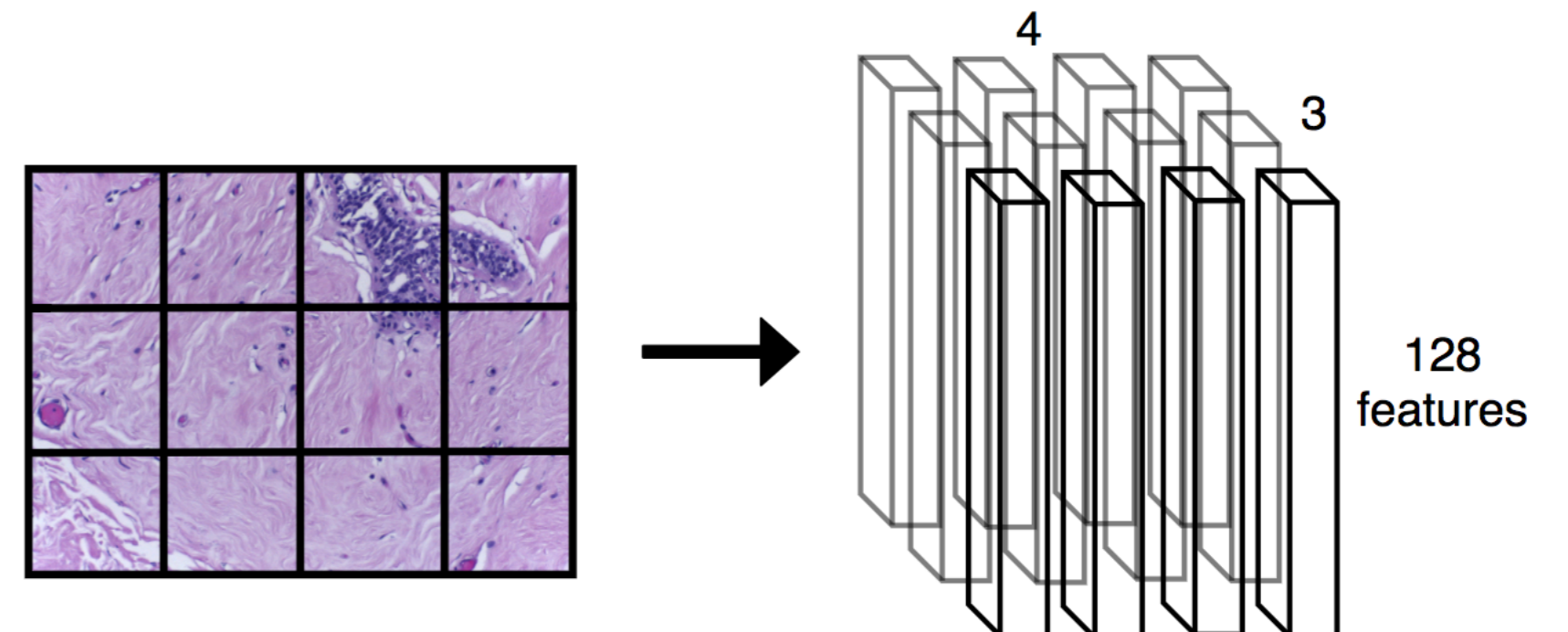
## 4. Convolutional neural network for feature generation



- Network architecture based on the proposed deep network for gastric cancer classification by Sharma et al. [2], with slight adjustments.
- The last fully-connected layer is used to extract features for each patch.

## 5. Feature representation construction

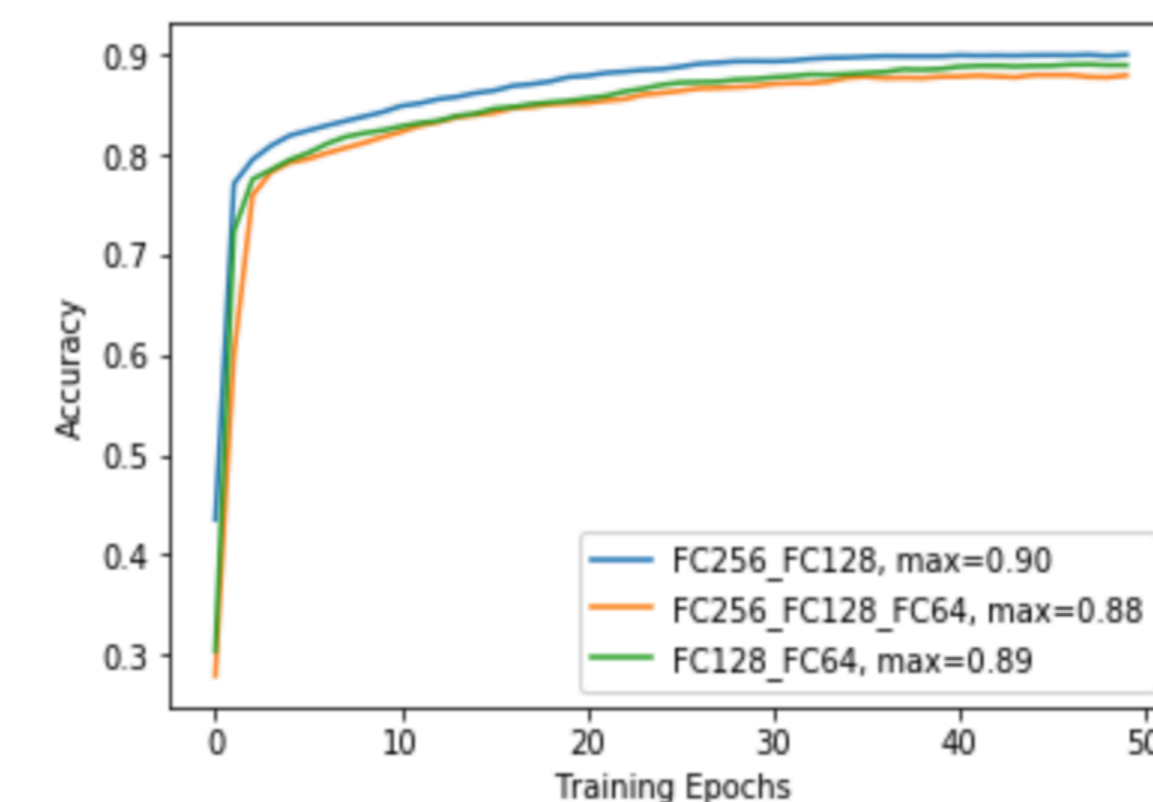
- 12 patches of 512x512x3 (9,437,184 features) reduced to 4x3x128 (1,536 features) with spatial relationships preserved.



- This aggregation method is similar to the aggregation-representation approach used in [3].

## 6. Fully-connected network for image classification

- Training accuracy of top three best-performing architectures over 50 epochs:



	Dimensions
Input features	3x4x128
Fully-connected layer 1	256
Fully-connected layer 2	128
Classification	4

Architecture of best-performing network.

- Note:** reported accuracy below is using k-fold cross validation. Other results use different test sets so a direct comparison cannot be made.

	Classification accuracy (%)		
	No classes	Patch	Image
Patch CNN + SVM [4]	2	76.9	83.3
	4	65.0	77.8
Patch CNN + majority vote [4]	2	77.6	80.6
	4	66.7	77.8
Best performing method from [1], unofficial	2	-	-
	4	-	87.0
Our proposed approach	2	83.3	98.2
	4	71.2	90.6

## 7. Conclusion and acknowledgements

Our proposed approach to classification of breast microscopy images demonstrates that:

- Simple models can be used to strengthen patch labels.
- We can reduce the input dimensionality by building feature representations.
- Incorporating more contextual information has much potential to improve overall performance.

Many thanks to the organizers of the BACH Challenge for making their dataset available, and to the Rabin Ezra Scholarship Trust for supporting this research.

## 8. References

- Grand Challenge on Breast Histology Images. URL <https://iciar2018-challenge.grand-challenge.org/home/>
- Sharma, Harshita, et al. "Deep convolutional neural networks for automatic classification of gastric carcinoma using whole slide images in digital histopathology." *Computerized Medical Imaging and Graphics* 61 (2017): 2-13.
- Agarwalla, Abhinav, Muhammad Shaban, and Nasir M. Rajpoot. "Representation-Aggregation Networks for Segmentation of Multi-Gigapixel Histology Images." *arXiv preprint arXiv:1707.08814* (2017).
- Araújo T, Aresta G, Castro E, Rouco J, Aguiar P, Eloy C, et al. (2017) Classification of breast cancer histology images using Convolutional Neural Networks. PLoS ONE 12(6): e0177544.