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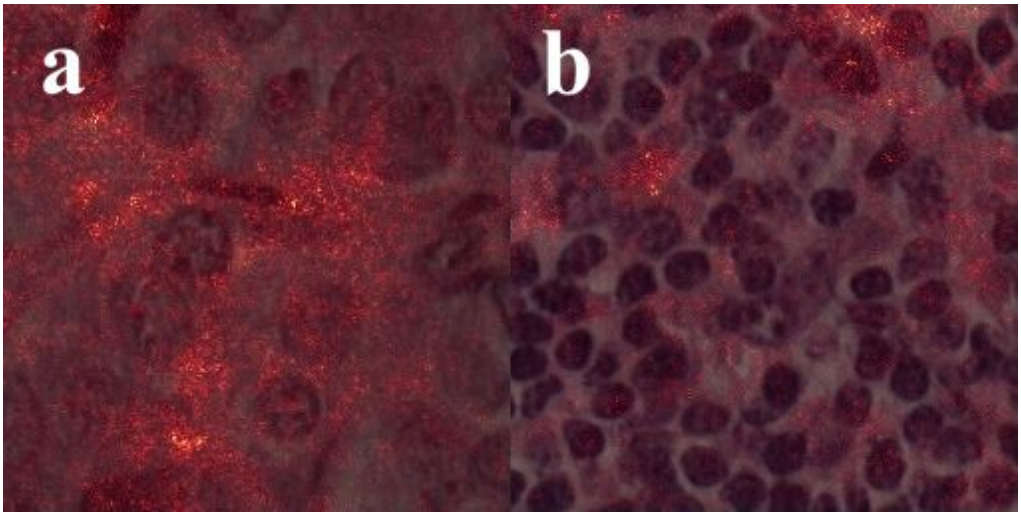
**Title:**
Class Saliency Maps Reveal Computer Vision's Basis for Diagnosing Metastatic Carcinoma in Lymph Nodes

**Background:**
We and others have successfully applied computer vision to diagnosing a variety of malignant neoplasms in histopathologic images. Machine learning being an opaque process, little is known about the basis on which computer vision makes its diagnostic decisions in surgical pathology. Here, we use class saliency maps to determine which parts of the image the electronic classifier considers important for its diagnosis of carcinoma of the breast metastatic to lymph nodes.

**Design:**
We extracted 32,027 benign and 22,560 malignant 256x256-pixel patches from the publicly available CAMELYON breast cancer lymph node metastasis dataset and classified them using a Deep Neural Network (DNN) model called DenseNet 201. The DNN was pretrained on the Imagenet dataset, a very large collection of natural images of everyday scenes. Only the final two layers (one convolutional, one dense) were trained for the CAMELYON recognition task. We trained the model at various magnifications and found that the 20x objective yielded the best results. To produce the visualizations, the logit corresponding to the correct class was differentiated with respect to the pixels in the input patch, and a Euclidean norm was computed over the three image channels. Therefore, the bright pixels in the heatmap may be interpreted as the pixels most likely to influence the model's decision if changed. These are called "Class Saliency Maps."

**Results:**
A balanced diagnosis accuracy of 95% was achieved on the testing dataset, comparable to the accuracy of the best-performing previously reported classifiers. On the heatmaps of both malignant and benign patches diagnosed with high confidence, the bright pixels concentrated in the cytoplasm of the benign and malignant cells, avoiding the nuclei (Figure 1; a, malignant; b, benign).

**Figure 1:**




**Conclusion:**
We used class saliency maps to see which parts of the image the electronic classifier considers important for its diagnosis of breast carcinoma metastatic to lymph nodes. To our great surprise, the pixels of highest diagnostic importance were concentrated in the cytoplasm, instead of the nucleus. Human pathologists mostly base their diagnosis of malignancy on the nuclear features, which we also teach to our trainees. It appears that computer vision bases its diagnostic decisions, at least in cases of nodal metastasis, on the cytoplasm, a part of the image that is harder for humans to evaluate than the nucleus. Whether this preference applies to other histopathologic settings remains to be determined.