Detecting Mitoses with a Convolutional Neural Network for MIDOG 2022 Challenge

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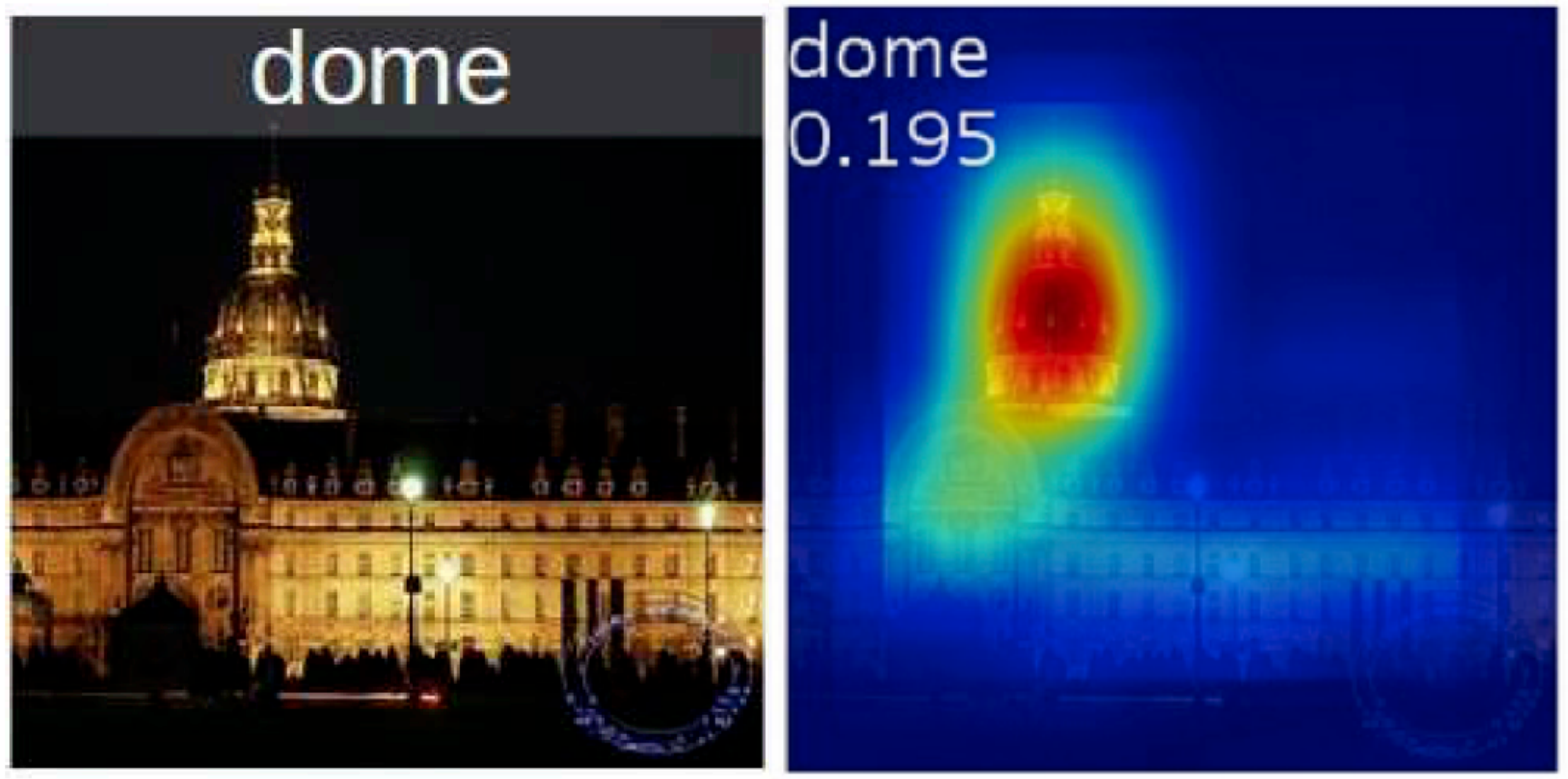
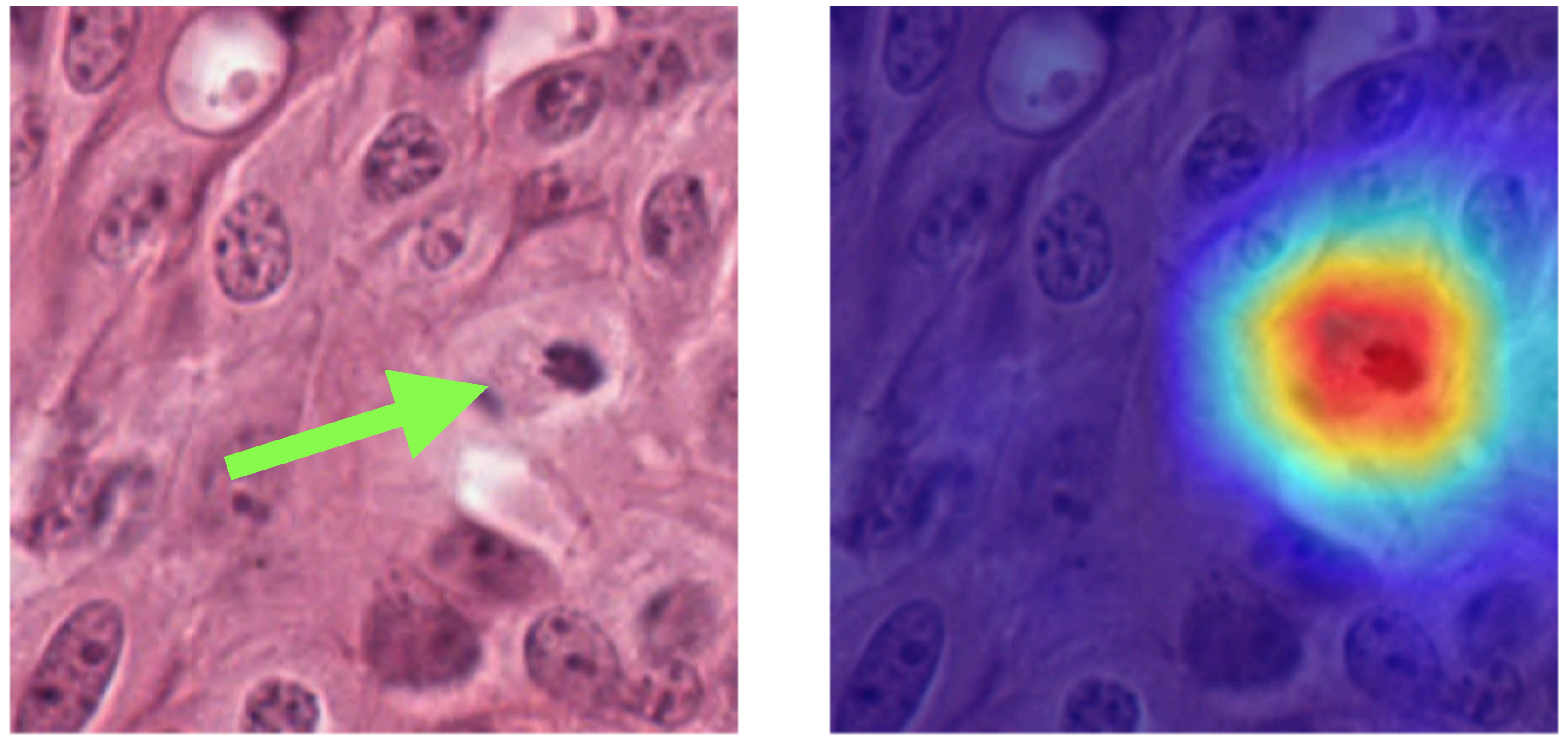
Extracting Locations with Class Activation Map

Class Activation Map (CAM) [Zhou, 2016]:

- Indicates discriminative image regions used by the CNN to identify a category;



Left: an image sample (class label: dome);
Right: a CAM for the 'dome' class. [Zhou, 2016]



Left: H&E patch (size=240x240) with mitosis (pointed by arrow);
Right: a CAM for the 'mitosis' class

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Zhou, Bolei, et al. "Learning deep features for discriminative localization." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016.

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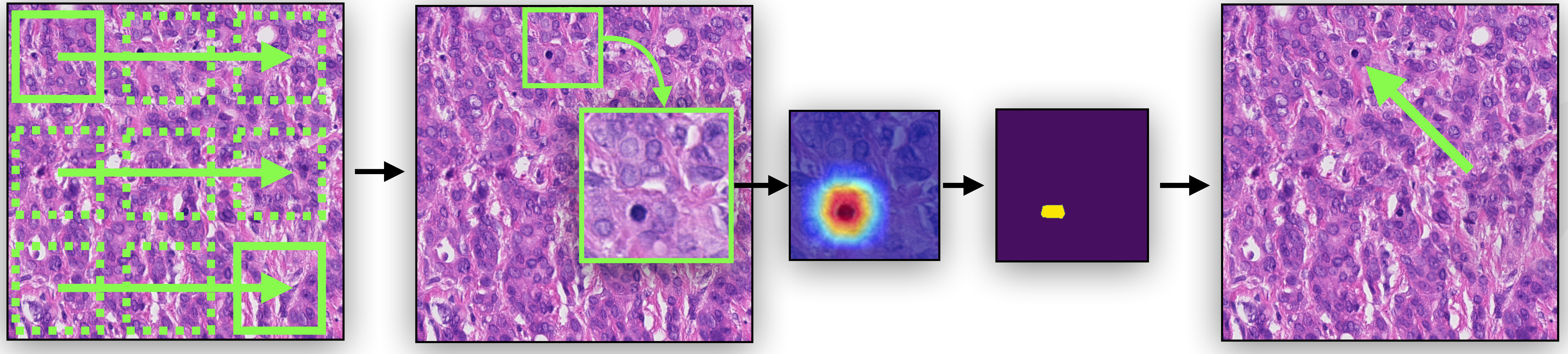
Data Processing Pipeline



1. Apply Sliding CNN — 2. Positive Classification — 3. CAM — 4. Post-Processing & Centroid Extraction — 5. Detection Result

1. EfficientNet-b3, window size=240x240, step size=30, no normalization method was used;
2. Probability threshold: 0.84, non-max suppression threshold: 0.22;
3. Grad-CAM++ [Chattopadhyay, 2017];
4. Binarizations with Otsu's thresholding;

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Chattopadhay, Aditya, et al. "Grad-cam++: Generalized gradient-based visual explanations for deep convolutional networks." *2018 IEEE winter conference on applications of computer vision (WACV)*. IEEE, 2018.

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Coping with Domain Generalization Challenge

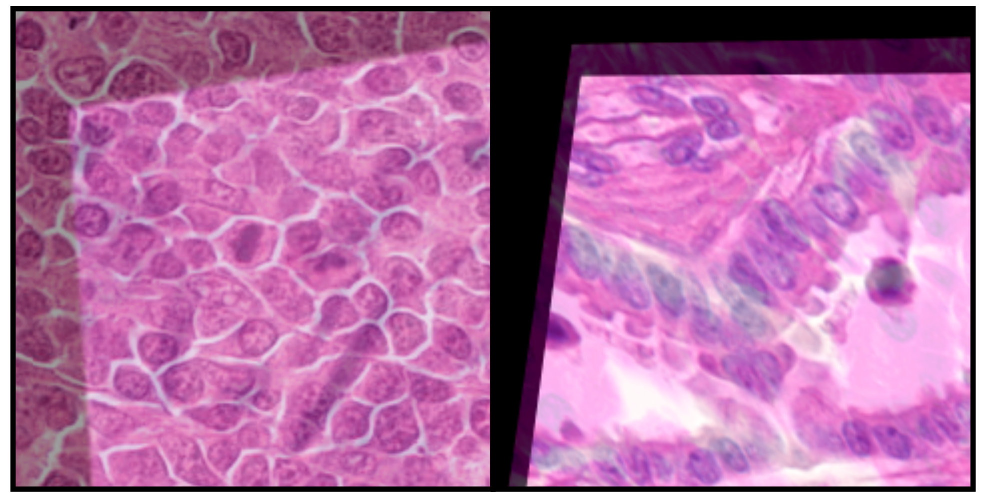
Three techniques were used to cope with the domain generalization challenge:

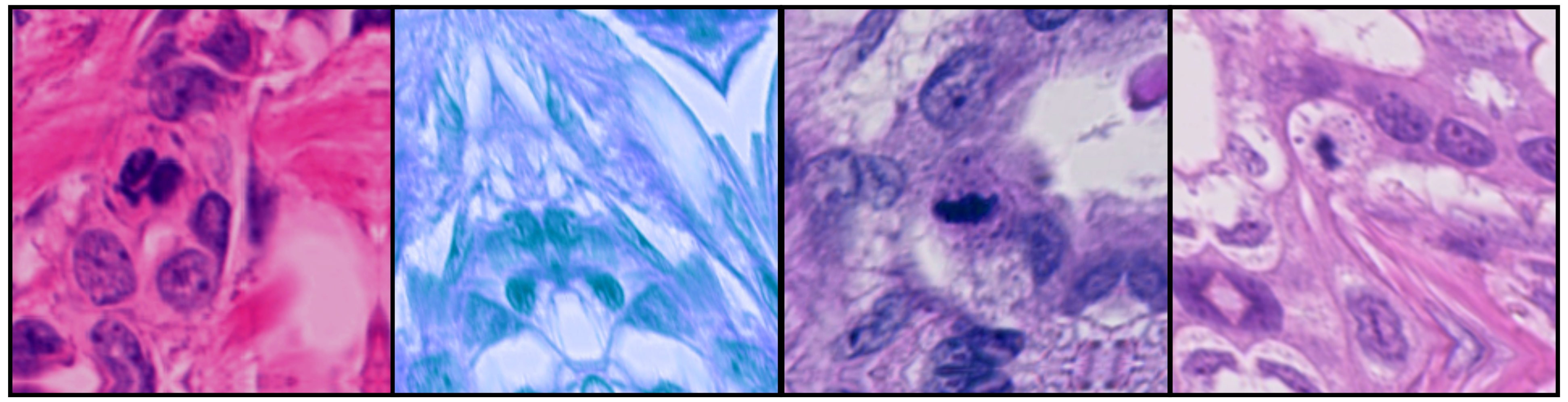
1. Data augmentation with balance-mixup and stain augmentation;
2. Leveraging the unlabeled images for model training;
3. Train CNNs with an active learning strategy.

Data Augmentation

Two special online augmentation techniques:

1. Balance-mixup [Galdran, 2021] to deal with class imbalance.
2. Stain augmentation [Tellez, 2017] to deal with domain shift.





Other online augmentation methods used: random rotation, flip, elastic transform, grid distortion, affine, color jitter, Gaussian blur, and Gaussian noise

Galdran, Adrian, Gustavo Carneiro, and Miguel A. González Ballester. "Balanced-mixup for highly imbalanced medical image classification." *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer, Cham, 2021.

Tellez, David, et al. "Whole-slide mitosis detection in H&E breast histology using PHH3 as a reference to train distilled stain-invariant convolutional networks." *IEEE transactions on medical imaging* 37.9 (2018): 2126-2136.

Training with Noisy Labels

Leveraging the unlabeled images for training:

- ~90% of MIDOG2022 images for model training, including unlabeled images;
- Treat unlabeled images as all negative (no mitoses);
- Use Online Uncertainty Sample Mining [Xue, 2019] to enable CNNs to deal with noisy labels.

Xue, Cheng, et al. "Robust learning at noisy labeled medical images: Applied to skin lesion classification." *2019 IEEE 16th International Symposium on Biomedical Imaging (ISBI 2019)*. IEEE, 2019.

Train CNNs with an Active Learning Strategy

```
While CNN's F1 score on validation images does not increase
DO: {
  1. Train the CNN (with 240x240 patches) and select the best model;
  2. Inference the CNN on validation images;
  3. Add false-positive, false-negative, hard-negative patches(size:
     240x240).
 }
```

After six rounds of active learning, there are

- 103,816 patches in the training set;
- 23,638 patches in the validation set;

Result and Take-Aways

Result: with an EfficientNet-b3 CNN (12M parameters)

- Preliminary test phase: overall F1 0.7323 (precision: 0.7313, recall: 0.7333).

Take-Aways:

- Class activation map can bridge the gap between CNNs and mitosis detection task;
- An active-learning sampling approach can improve the performance.

Manuscript:

- Gu, Hongyan, et al. "Detecting Mitoses with a Convolutional Neural Network for MIDOG 2022 Challenge." *arXiv preprint arXiv:2208.12437 (2022).*

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