

Exploiting *spatial consistency* is important, and
BLURS BEHAVE LIKE ENSEMBLES

NAMUK PARK, SONGKUK KIM

NAVER AI Lab, Yonsei University

`namuk.park@{navercorp.com, gmail.com}`



What Is a Spatial Ensemble?

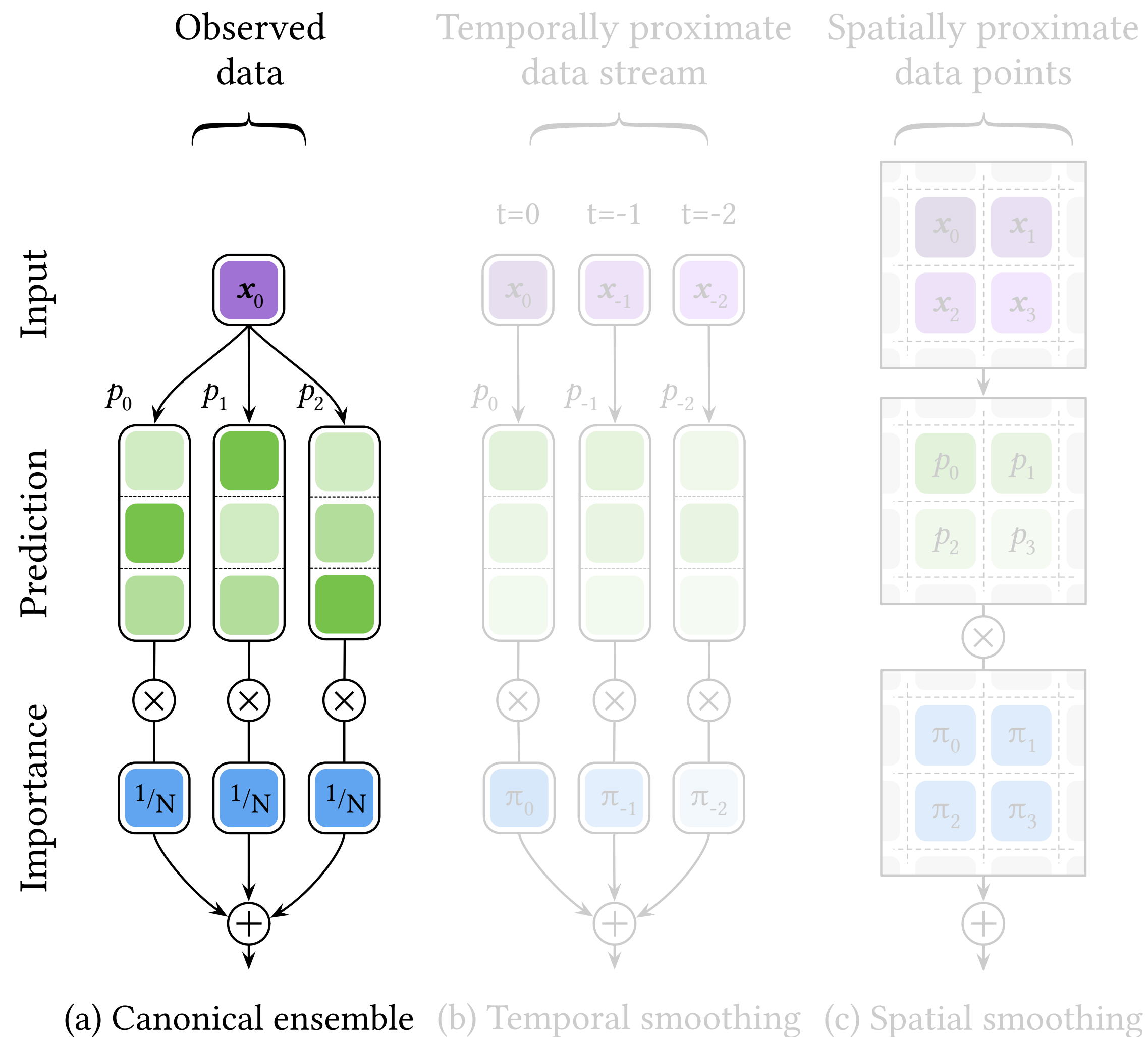


Figure 1. **Comparison of three different neural network ensembles:** canonical ensemble average, temporal smoothing (Park et al., AAAI 2021), and spatial smoothing (*ours*).

By exploiting spatial consistency of images, this *spatial ensemble* averages neighboring feature maps to aggregate predictions for proximate data points.

What Is a Spatial Ensemble?

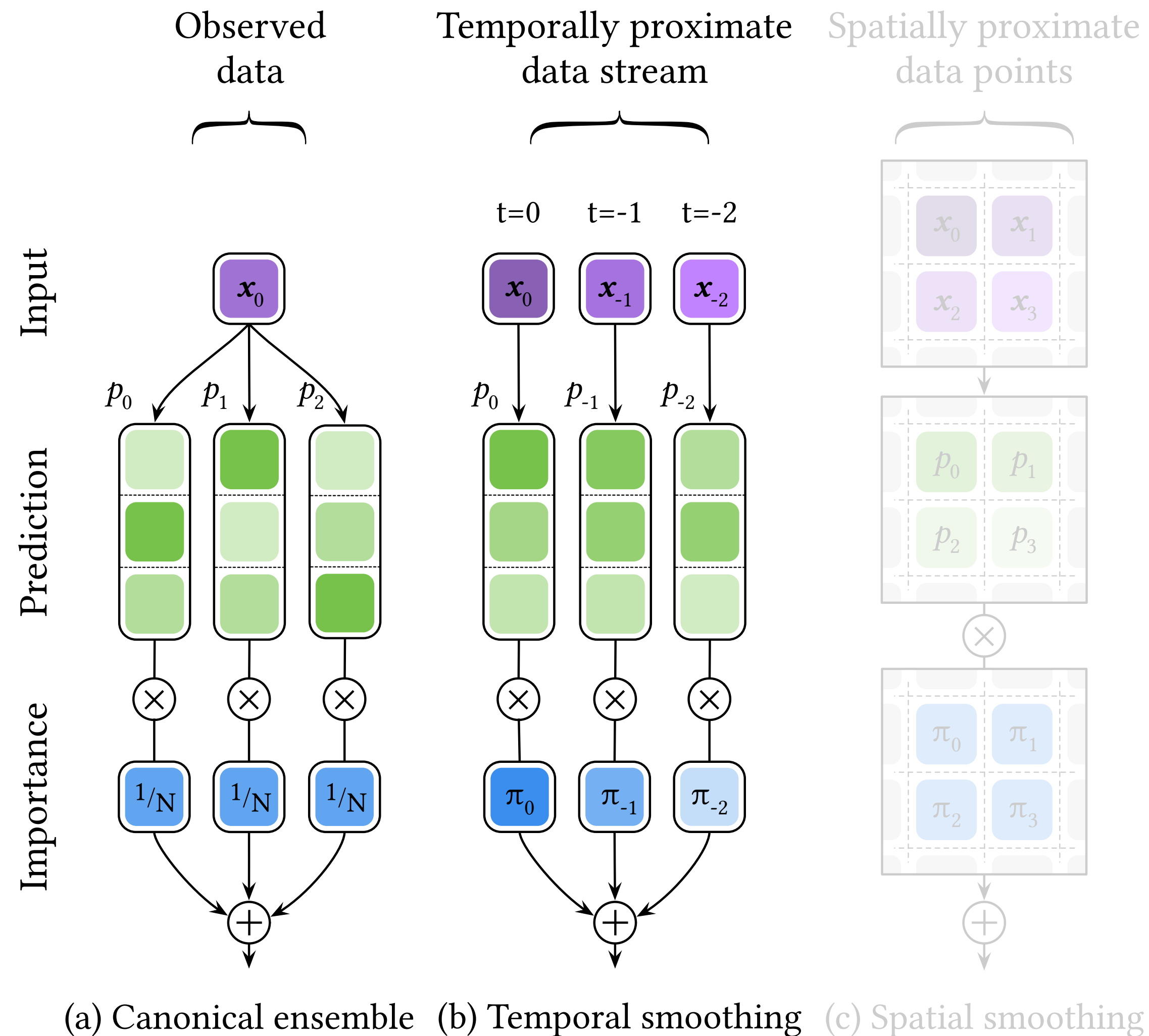


Figure 1. **Comparison of three different neural network ensembles:** canonical ensemble average, temporal smoothing (Park et al., AAAI 2021), and spatial smoothing (*ours*).

By exploiting spatial consistency of images, this *spatial ensemble* averages neighboring feature maps to aggregate predictions for proximate data points.

What Is a Spatial Ensemble?

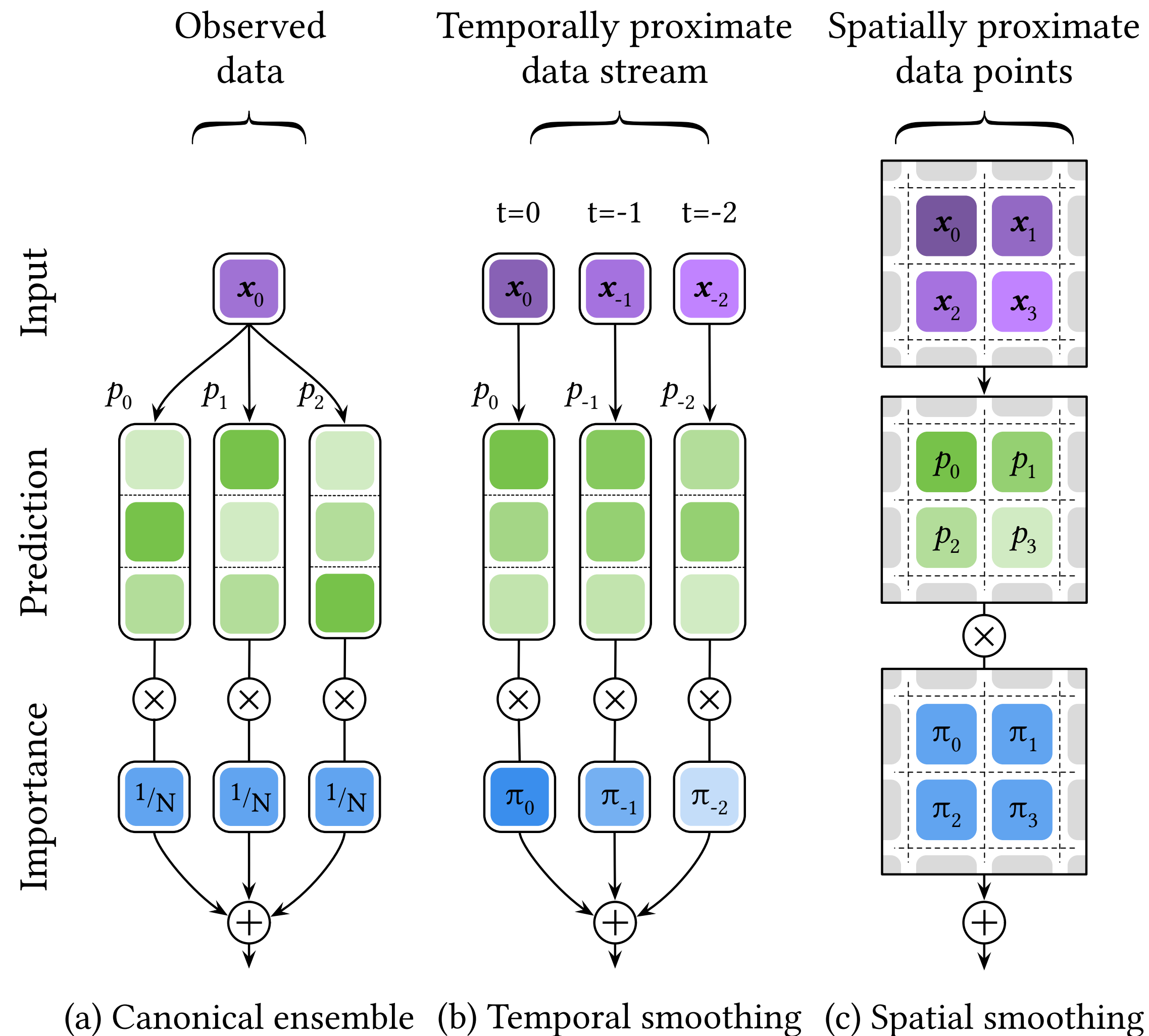


Figure 1. **Comparison of three different neural network ensembles:** canonical ensemble average, temporal smoothing (Park et al., AAAI 2021), and spatial smoothing (*ours*).

By exploiting spatial consistency of images, this *spatial ensemble* averages neighboring feature maps to aggregate predictions for proximate data points.

How Can We Apply Spatial Smoothing to Our Models?

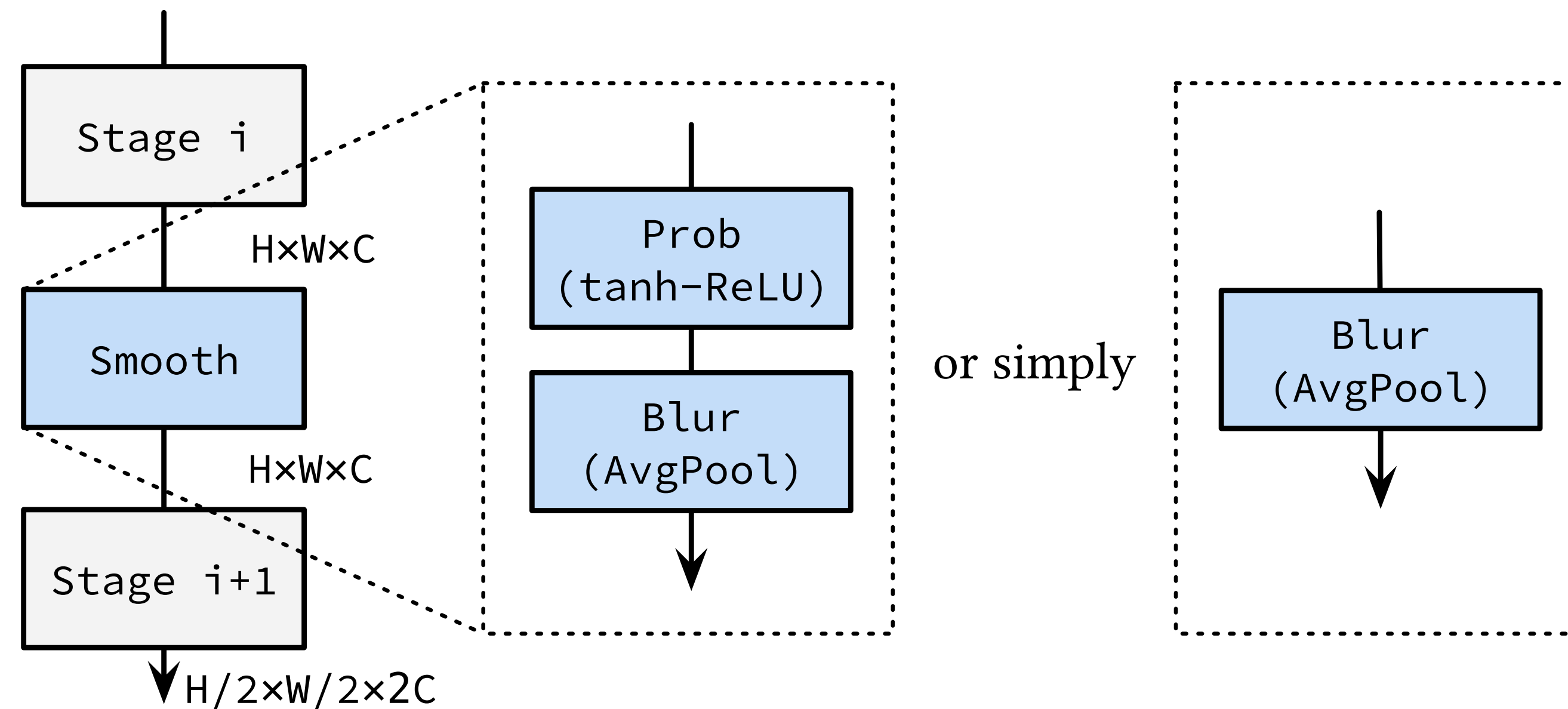


Figure 4. **Spatial smoothing is easy to implement.** Simply add average pooling (AvgPool) before the subsampling layers (*right*), or add tanh-ReLU-AvgPool (*left*) for better results.

Spatial Smoothing Significantly Improves MC Dropout

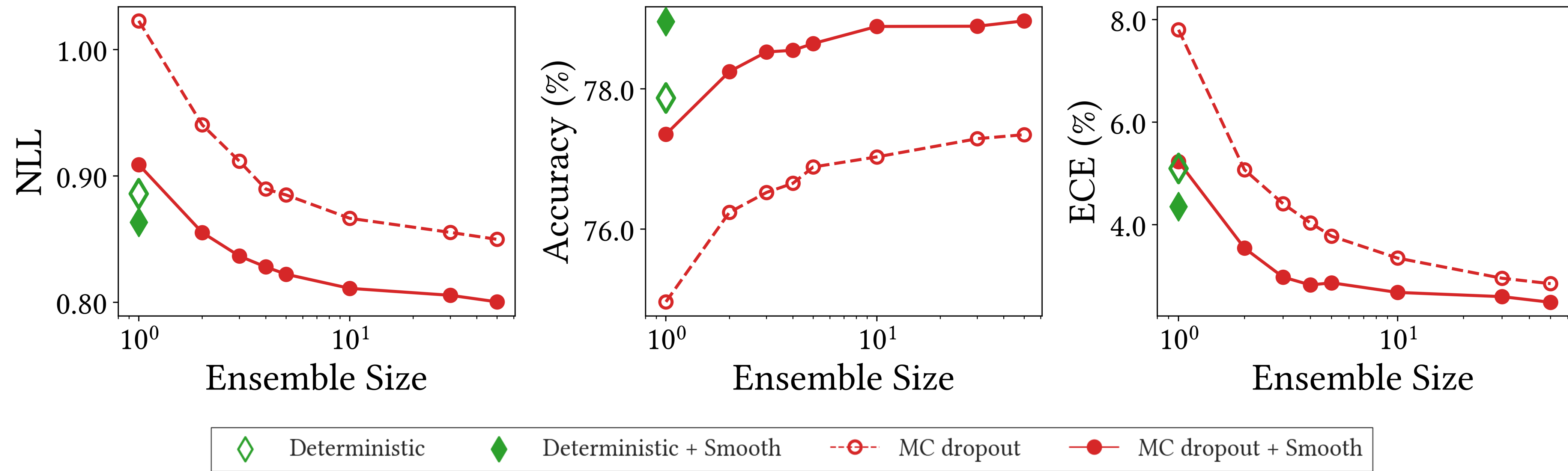


Figure 2 & 3. **Spatial smoothing improves both accuracy and uncertainty of MC dropout across a whole range of ensemble sizes.** In particular, “MC dropout + spatial smoothing” is 25× faster than canonical MC dropout with similar predictive performance.

How Does Spatial Smoothing Improve Neural Nets?

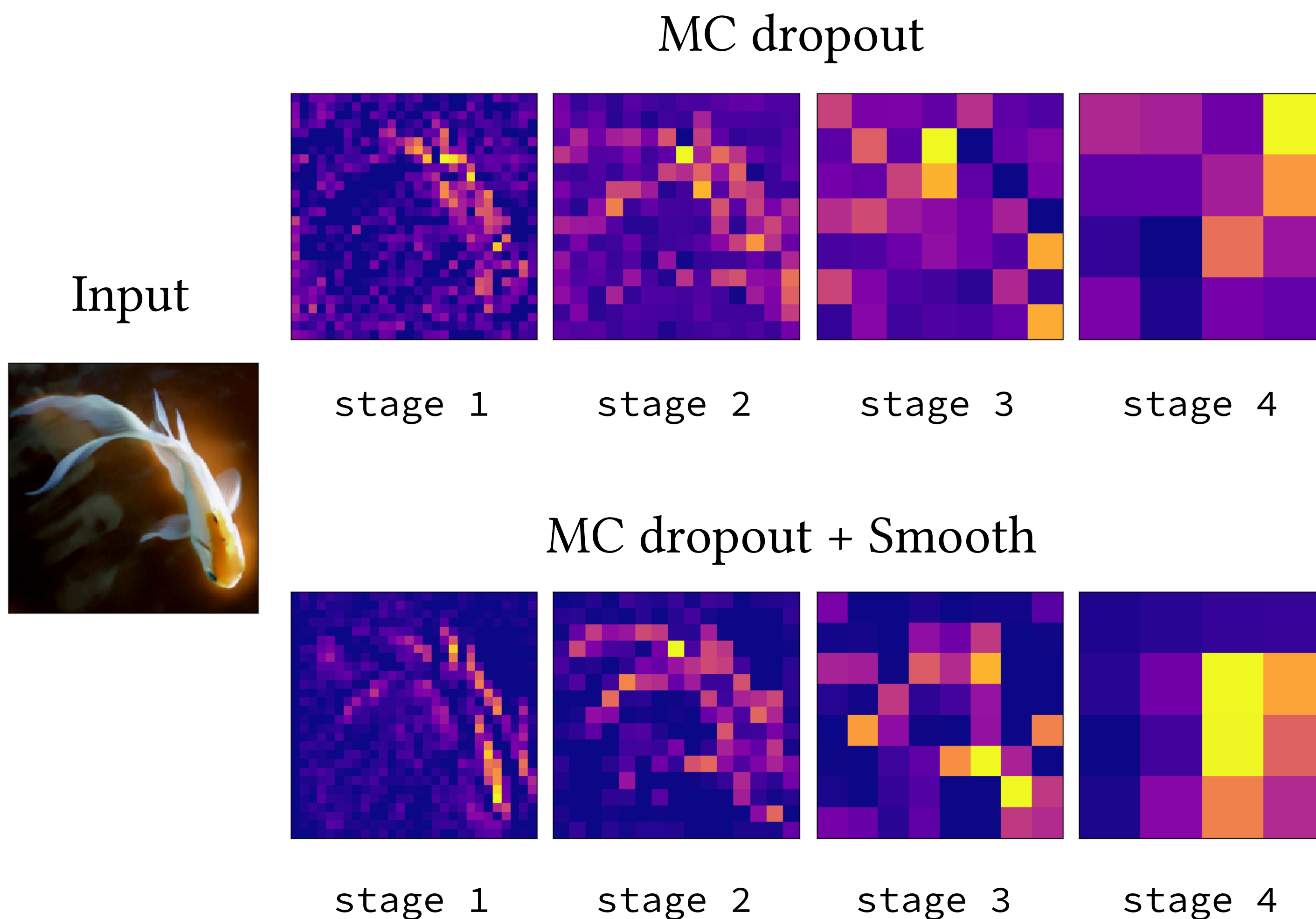
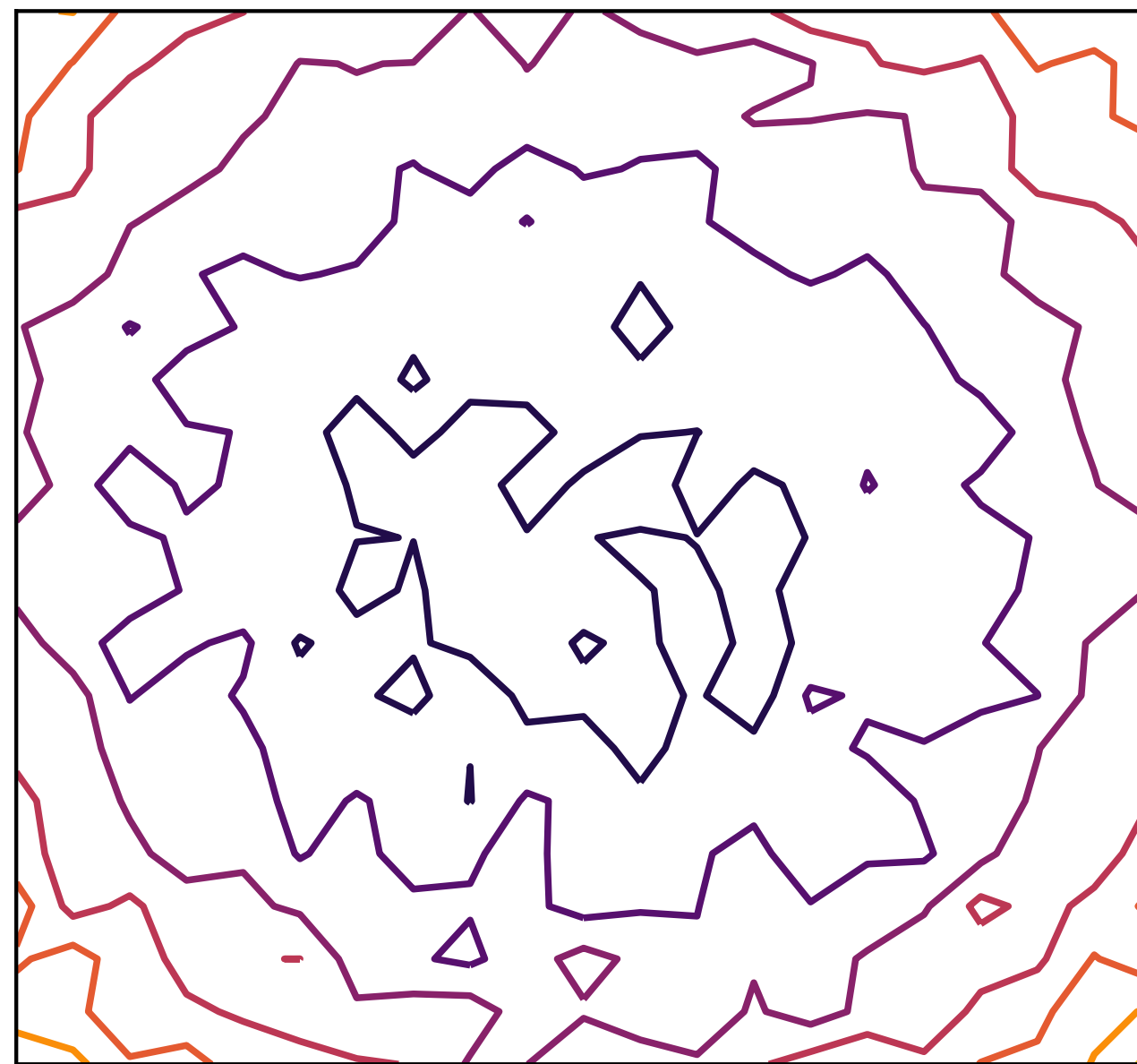
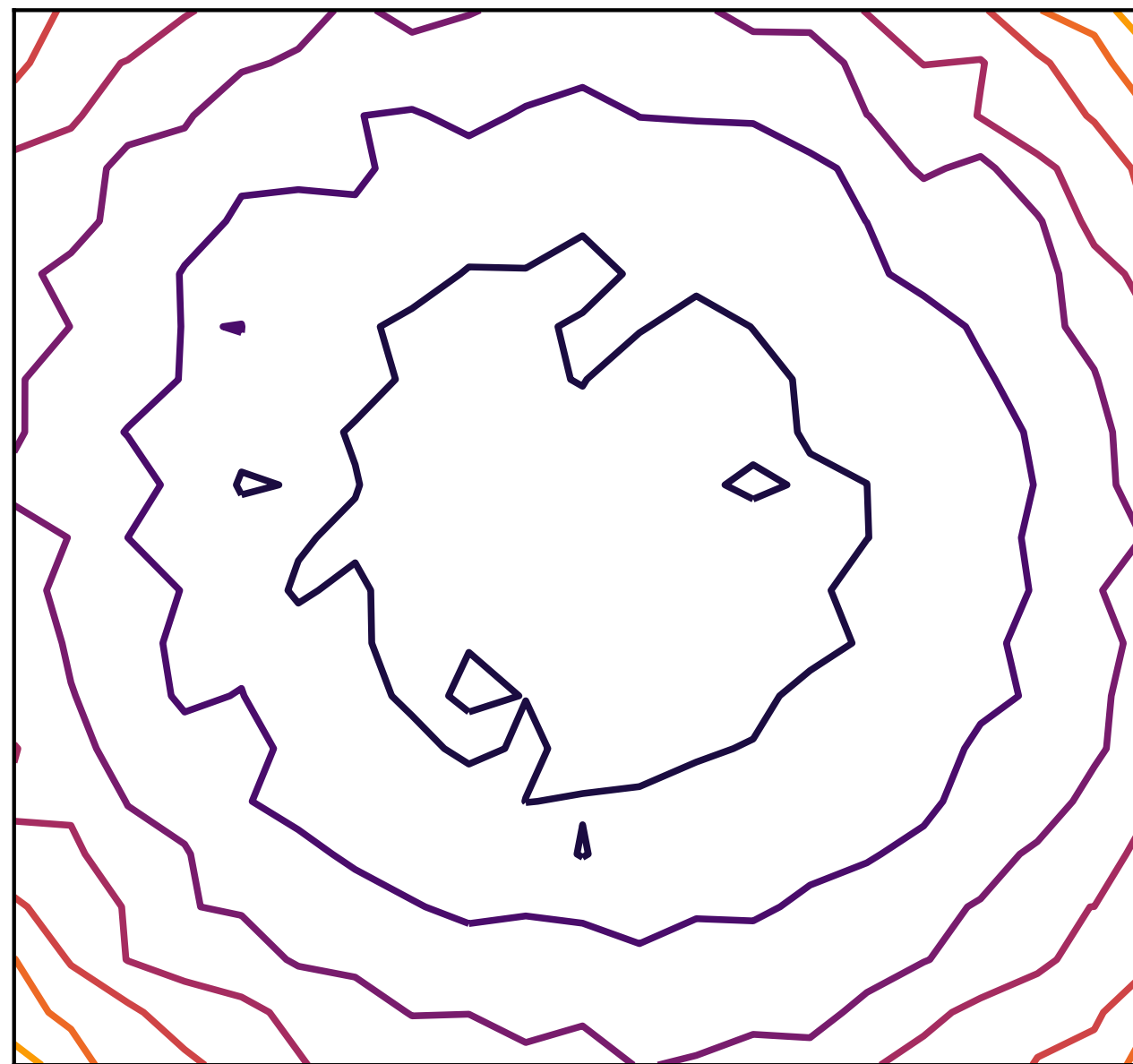


Figure 5. **Spatial smoothing stabilizes feature maps and reduces feature map variance.** Since the randomness of feature maps (high-frequency noise) hinders NN optimization, spatial smoothing stabilizes NN optimization and improves the predictive performance.

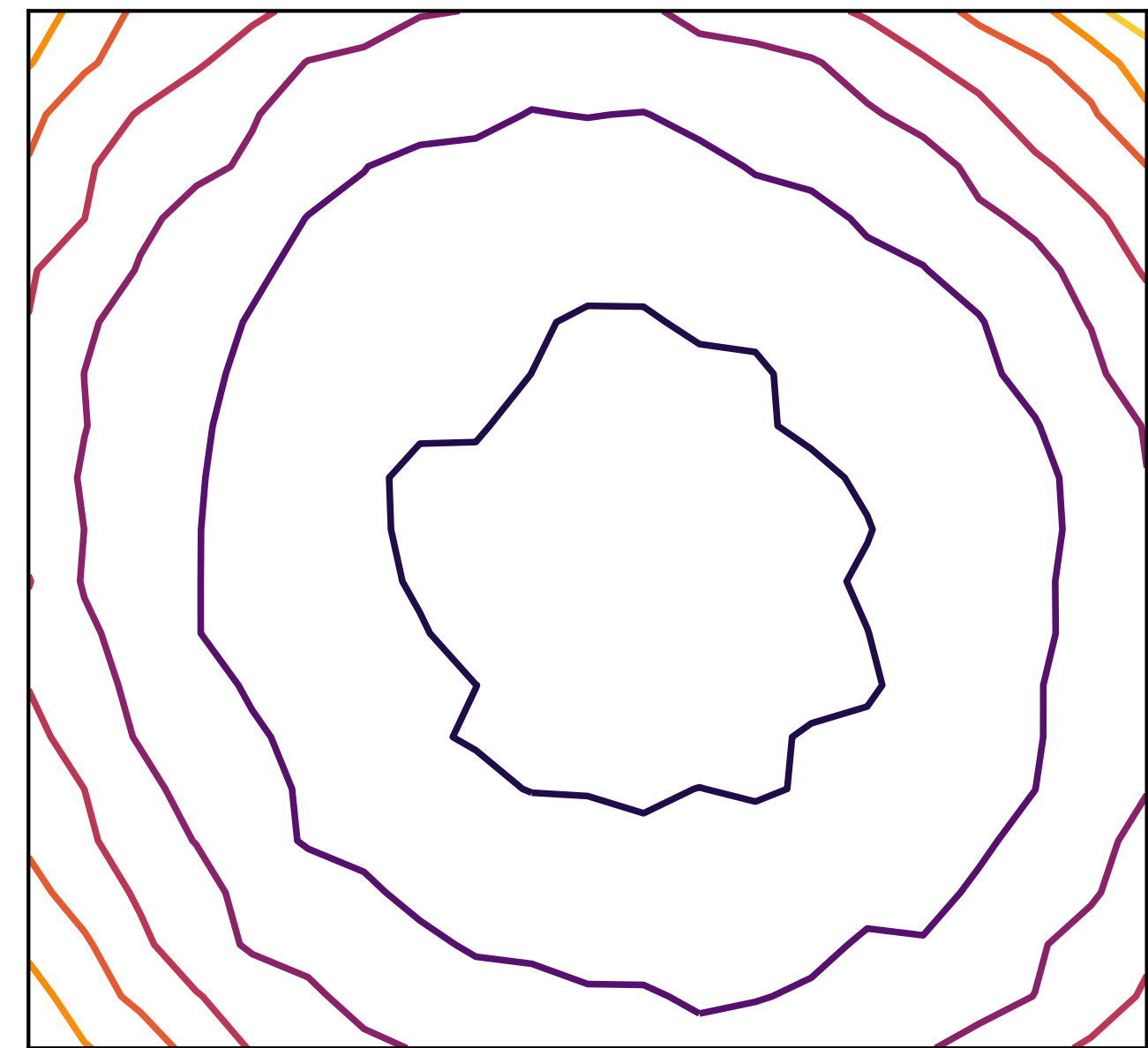
How Does Spatial Smoothing Improve Neural Nets?



(a) MLP classifier



(b) GAP classifier (*vanilla*)



(c) GAP classifier + Smooth

Figure 7 & 8. **Both spatial smoothing and GAP** (an extreme case of spatial smoothing) **stabilize and smoothen the loss landscapes**. MLP classifier hinders NN optimization, i.e., it does not overfit the training dataset.