

Test-Time Mixup Augmentation for Uncertainty Estimation in Skin Lesion Diagnosis

Hansang Lee¹, Haeil Lee¹, Helen Hong^{2*}, and Junmo Kim¹

¹School of Electrical Engineering, KAIST, Daejeon, Republic of Korea

²Department of Software Convergence, Seoul Women's University, Seoul, Republic of Korea

hansanglee@kaist.ac.kr, *hlhong@swu.ac.kr

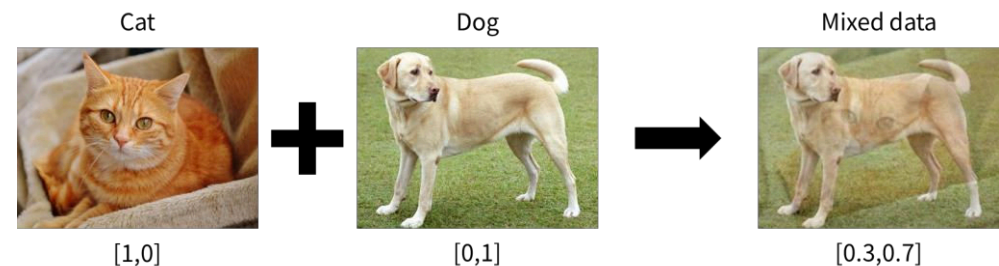
What is Uncertainty?

- Uncertainty
 - Indicates how likely the prediction is incorrect
- Estimation methods
 - Bayesian neural network (Gal, 2016)
 - Monte-Carlo drop-out (Gal et al., 2016)
 - Test-time augmentation (TTA) (Wang et al., 2019)
- Applications
 - Error correction (by human experts)
 - Active learning

What is Mixup?

- Mixup augmentation (Zhang et al., 2018)
 - Generates (training) data by a linear combination of two data
 - Assigns soft label for the mixed data
 - Improves generalization and robustness to adversarial perturbation

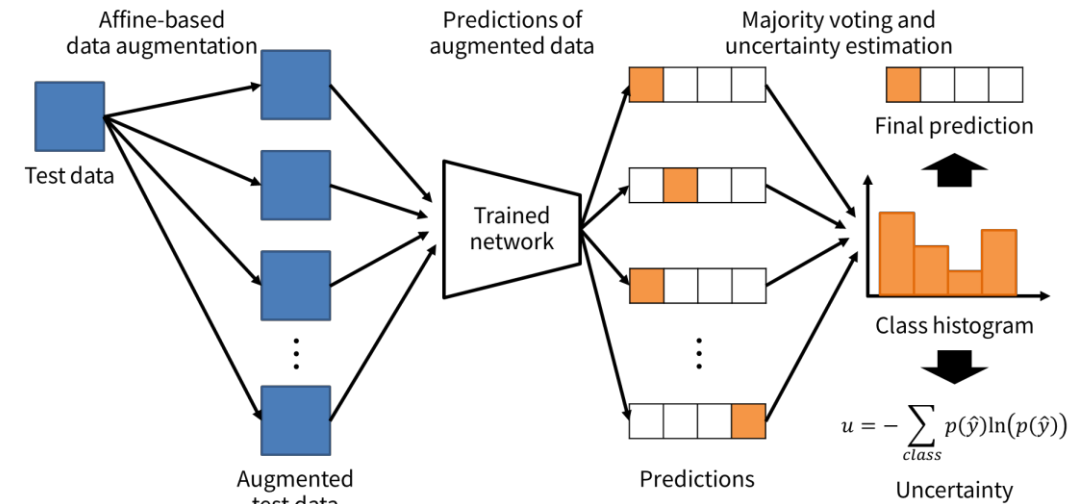
$$x_{mixed} = \lambda x_i + (1 - \lambda)x_j$$



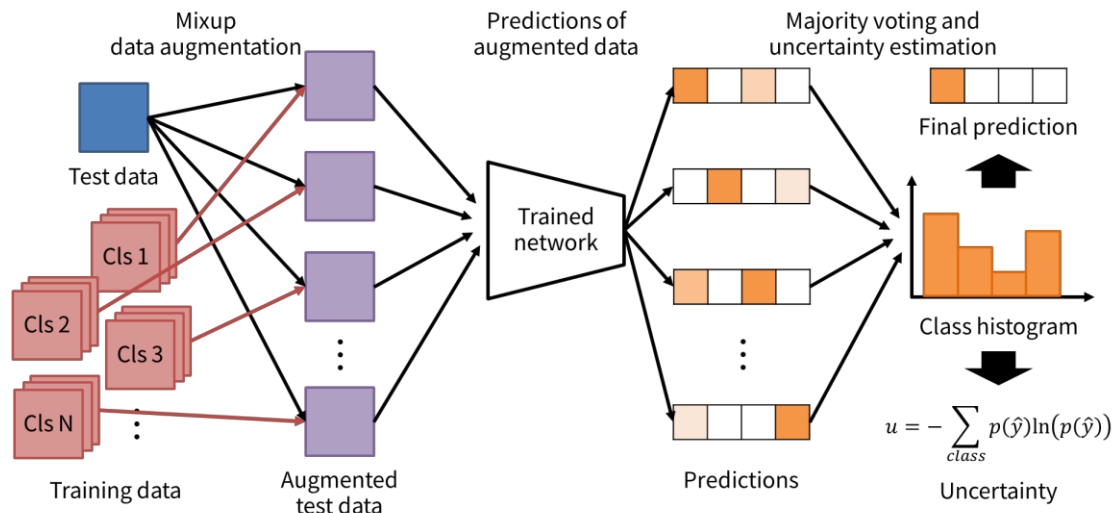
Methods

- Test-time mixup augmentation (TTMA)
 - TTA uncertainty indicates prediction instability caused by affine-based data perturbation
 - TTMA uncertainty indicates prediction instability caused by **stronger mixup data perturbation**
 - Class-specific uncertainty indicates **class distance** in the feature space
 - Similar class \rightarrow Low perturbation \rightarrow Low uncertainty
 - Dissimilar class \rightarrow High perturbation \rightarrow High uncertainty

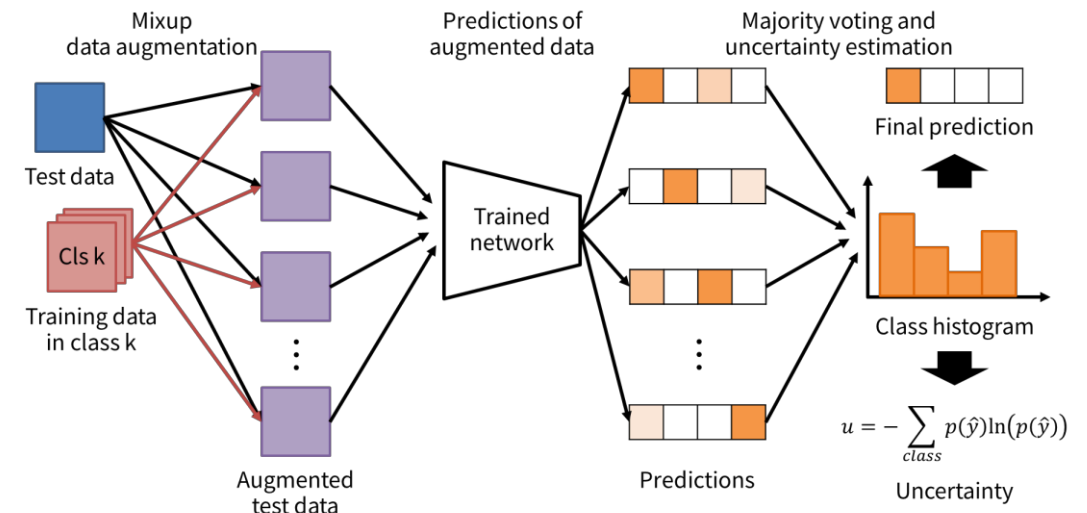
Test-time (affine) augmentation (TTA)



Test-time mixup augmentation (TTMA)



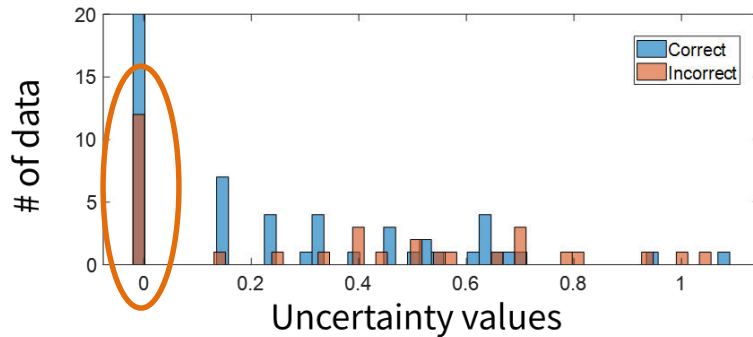
TTMA class-specific uncertainty



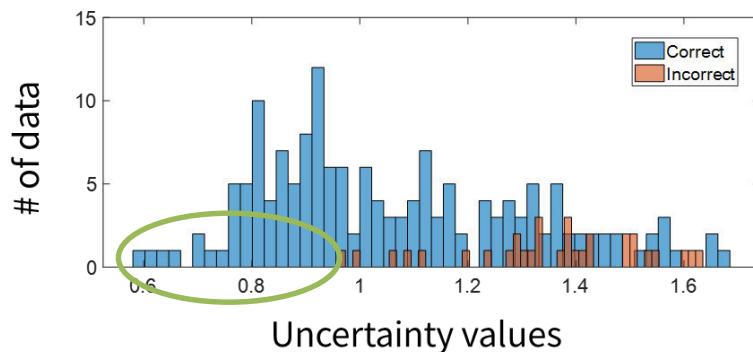
Results

- Skin lesion diagnosis on ISIC 2018 dataset
 - TTMA shows better separation between correct and incorrect test samples than TTA
 - Class-specific uncertainty indicates class distance in the feature space

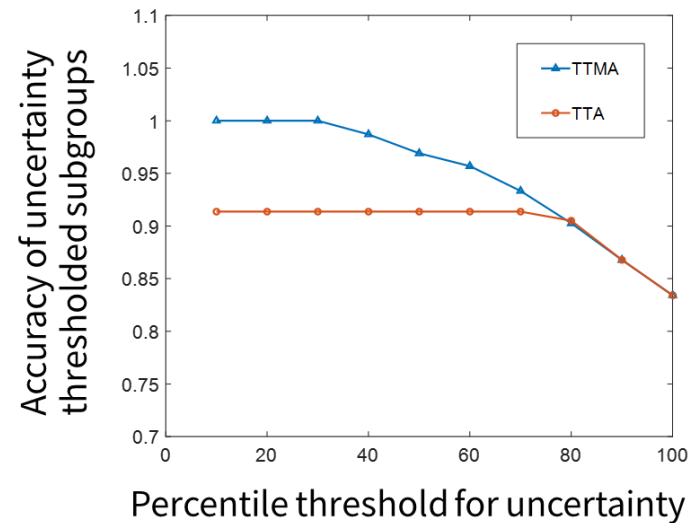
Histogram of TTA uncertainty



Histogram of TTMA uncertainty



Accuracy of subgroups of test data with uncertainty lower than the threshold



Low mean CSU class \rightarrow High mean CSU class

