Credal Wrapper of Model Averaging for Uncertainty Estimation in Classification

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Epistemic AI
A new learning paradigm

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ICLR
International Conference On Learning Representations

Background and Motivation

Uncertainty resources in neural networks

- **Aleatoric uncertainty (AU):** data uncertainty, inherent randomness of the data generation process
- **Epistemic uncertainty (EU):** model uncertainty, a lack of knowledge

Effectively estimating uncertainties in predictions and the proper distinction between its aleatoric and epistemic forms are both crucial to:

- **achieve robust performance of neural networks**
- **benefit various downstream decision-based tasks**, such out-of-distribution (OOD) detection

Background and Motivation

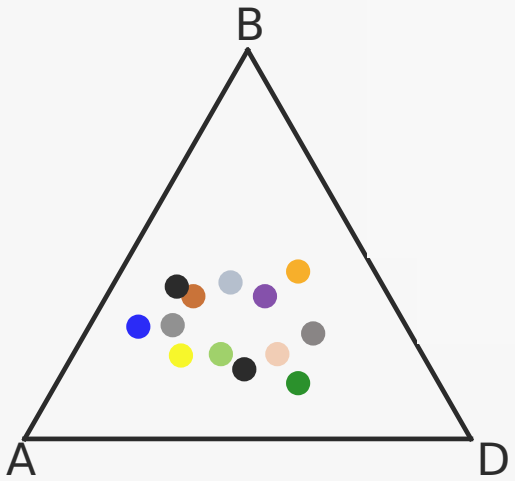
Widely applied approaches enabling total uncertainty (TU, AU and EU) estimation:

- **Bayesian neural networks (BNNs)** & **Deep ensembles (DEs)**
- **multiple (SoftMax) probabilities** for uncertainty estimation and **averaging these probabilities** for prediction, via multiple forward passes
- However, **a limited number** of forward passes at prediction time

Main research objective:

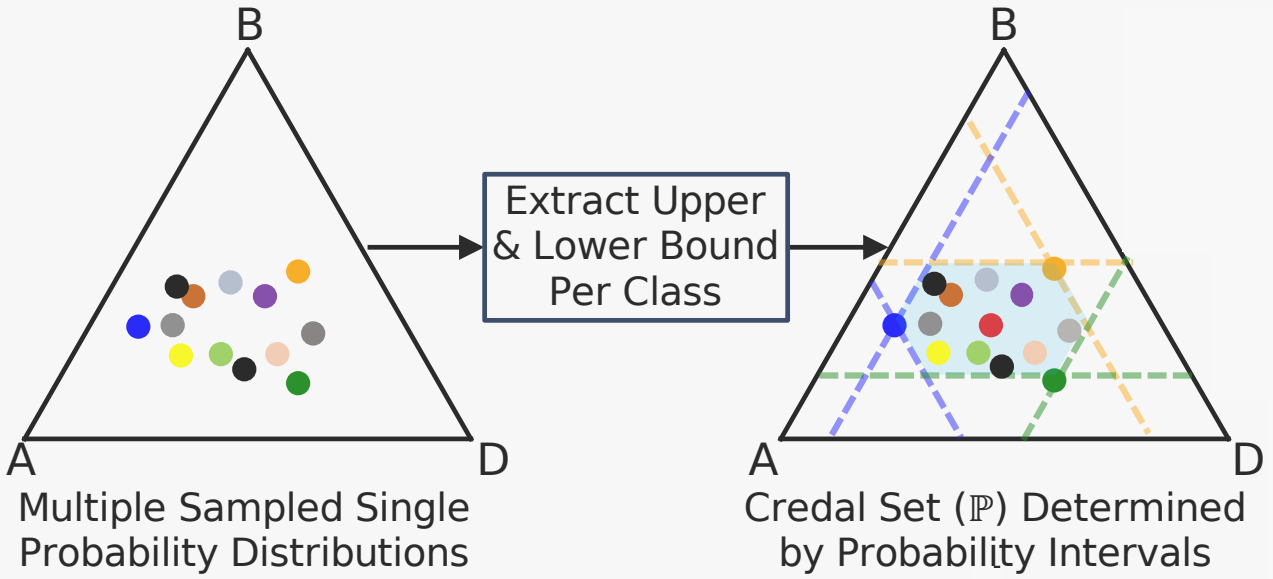
- *To **enhance** the **uncertainty quantification** and **prediction performance** of these approaches given this **constrained number** of predictive probabilities.*

Credal Wrapper Method



Multiple Sampled Single Probability Distributions

Credal Wrapper Method



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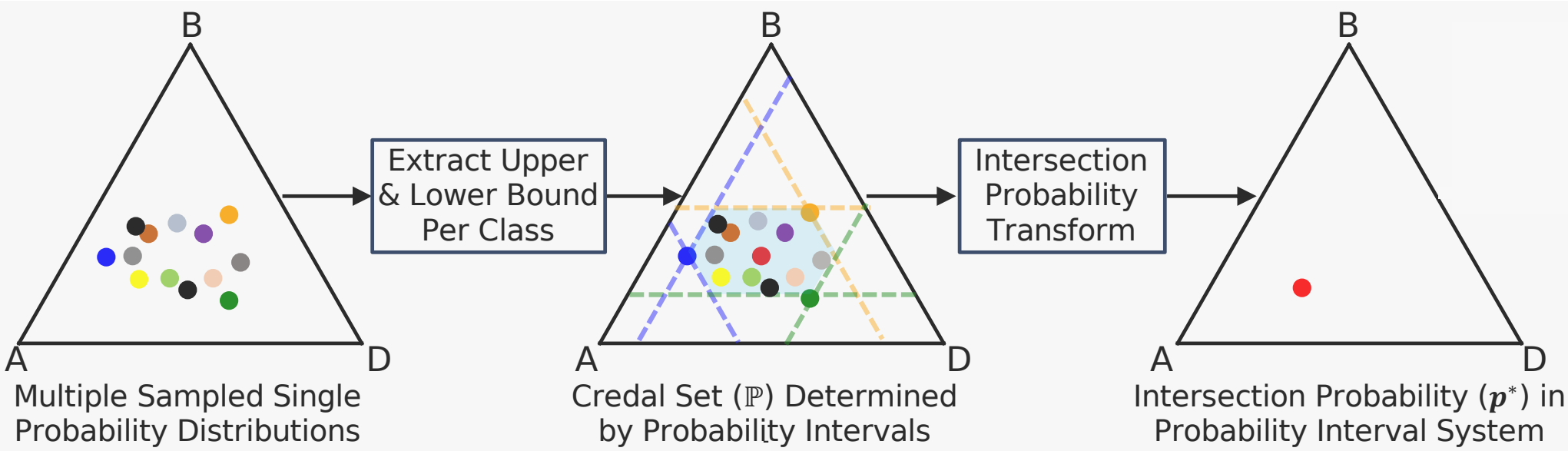

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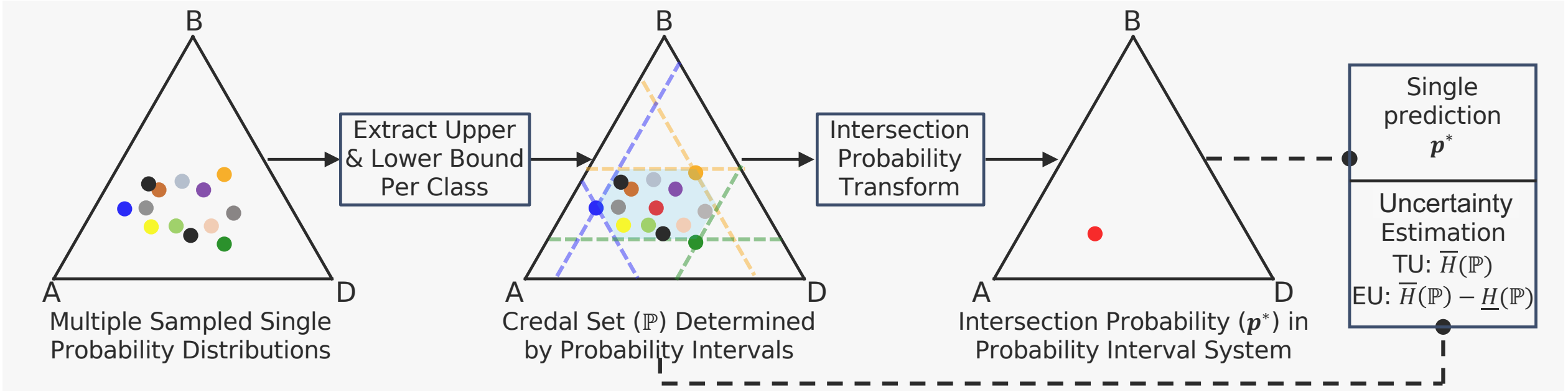

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Performance of Credal Wrapper

- **Experiment validations are conducted on:** several OOD detection benchmarks, encompassing various dataset pairs (CIFAR10/100 vs SVHN/Tiny-ImageNet, CIFAR10 vs CIFAR10-C, CIFAR100 vs CIFAR100-C and ImageNet vs ImageNet-O) and using different network architectures (such as VGG16, ResNet-18/50, EfficientNet B2, and ViT Base)
- Compared to the BNN and DE baselines:
  - The proposed credal wrapper method exhibits **superior performance in uncertainty estimation**, leading to **improved OOD detection quality**
  - The usage of intersection probability achieves a **lower expected calibration error on corrupted data**

Thank You for Your Attention!