ProHOC: Probabilistic Hierarchical Out-of-Distribution Classification via Multi-Depth Networks

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Introduction

Out-of-distribution (OOD) detection is important for deep learning applications.

OOD detection is traditionally framed as a binary problem: ID (in-distribution) or OOD.

We utilize **class hierarchies** to classify OOD as internal nodes in the hierarchy.

ProHOC

Probabilistic:
We factorize the probability distribution according to the hierarchy. For example

$$p(\text{ood}(\text{cat})|x) = p(\text{ood}(\text{cat})|\text{cat}, x)p(\text{cat}|x)$$

and

$$p(\text{lynx}|x) = p(\text{lynx}|\text{cat}, x)p(\text{cat}|x).$$

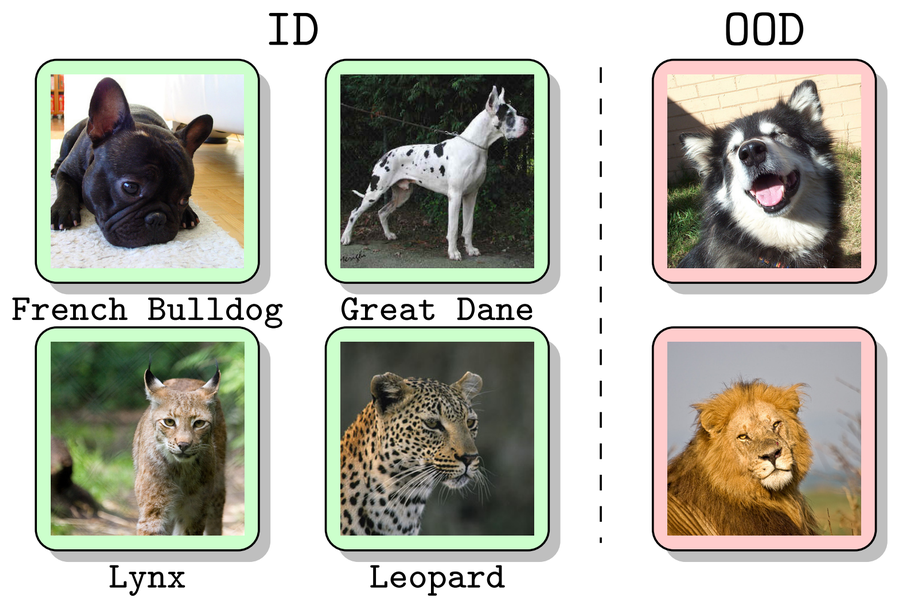
Multi-depth:
We train classification networks for each hierarchy depth. These networks focus on features at different granularity levels.

OOD classification:
We model the OOD probability at node c:

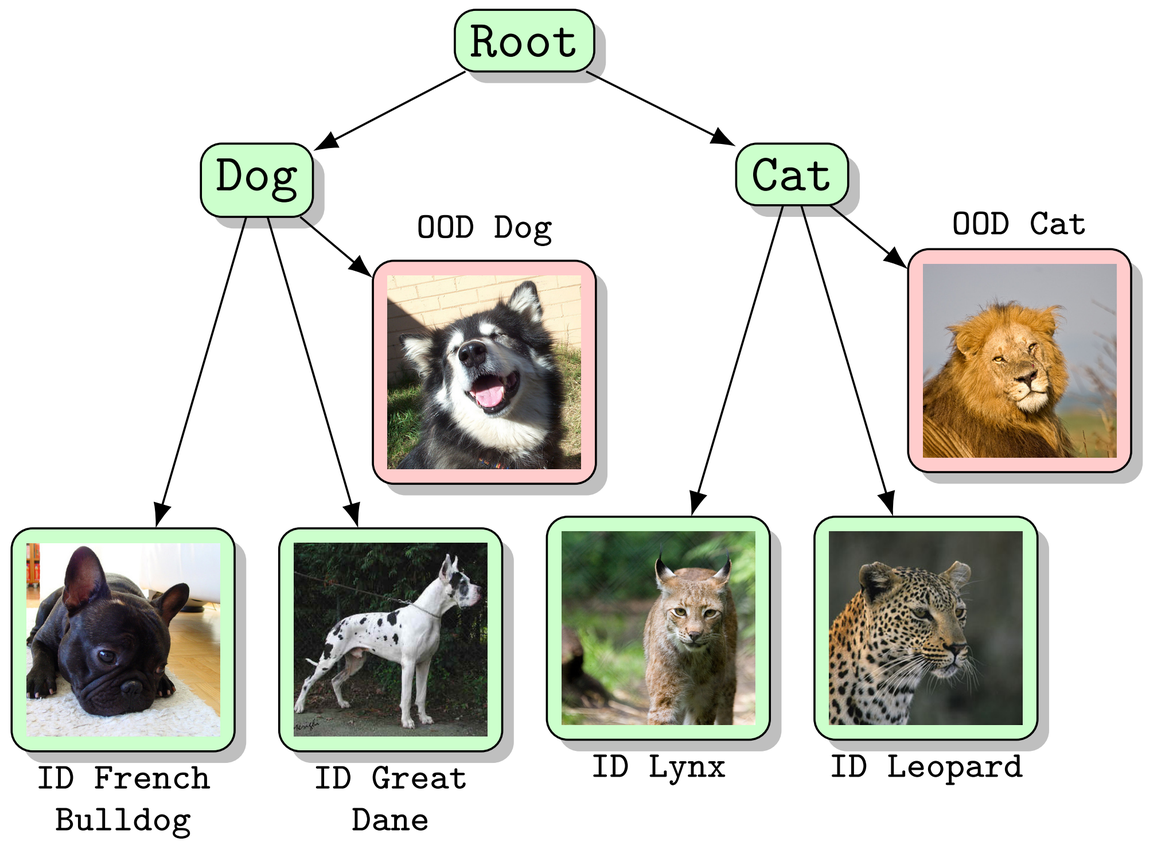
$$p(\text{ood}(c)|c, x) \propto 1 - \sum_{c' \in \text{children}(c)} \hat{p}(c'|x) + \text{entropy}\left[\{\hat{p}(c'|x)|c' \in \text{children}(c)\}\right]$$

$\hat{p}(c'|x)$ are predictions from the multi-depth networks.

Traditional binary OOD detection



Hierarchical OOD classification (ours)



Results on image classification

- Datasets with predefined hierarchies
- Test set: mix of ID and OOD
- Balanced accuracy
- Balanced mean hierarchical distance

iNaturalist19	Acc ↑	HierDist ↓
Depth oracle	74.15	0.834
Leaf model	36.22	1.542
HSC (Linderman et.al.)	38.23	1.281
ProHOC	**44.57**	**0.956**