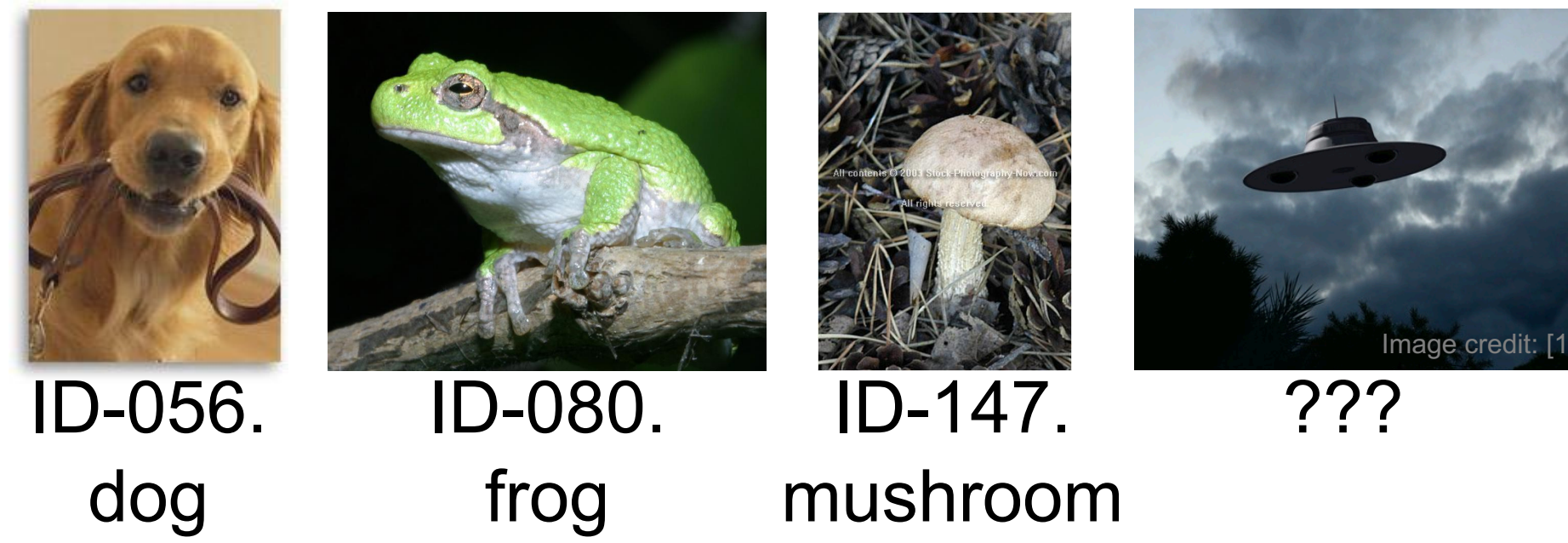


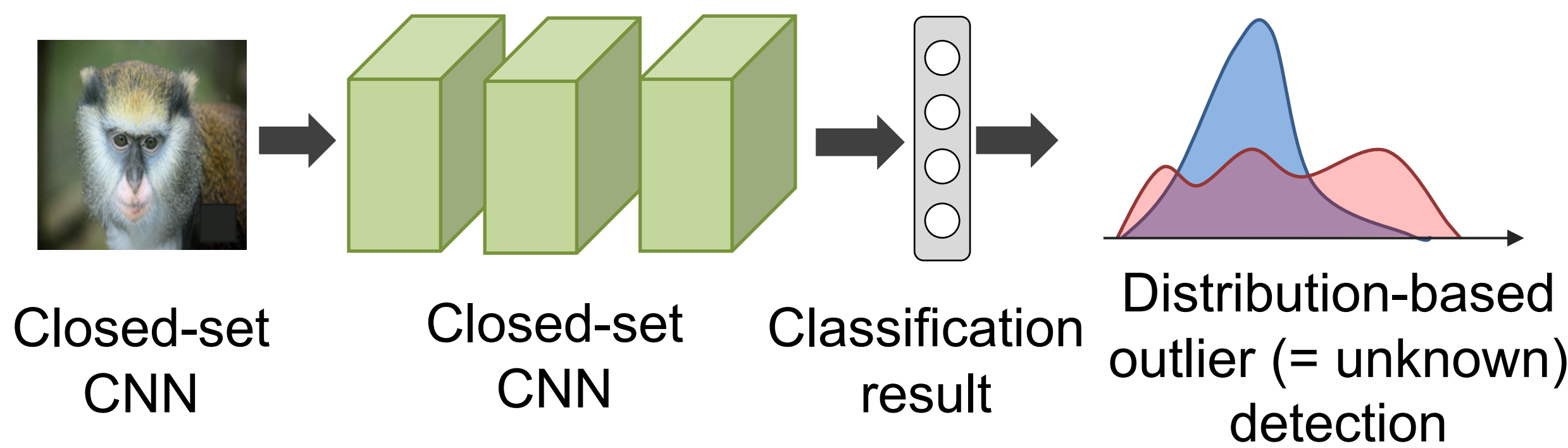
Introduction

Most of existing machine learners are *closed-set classifiers*



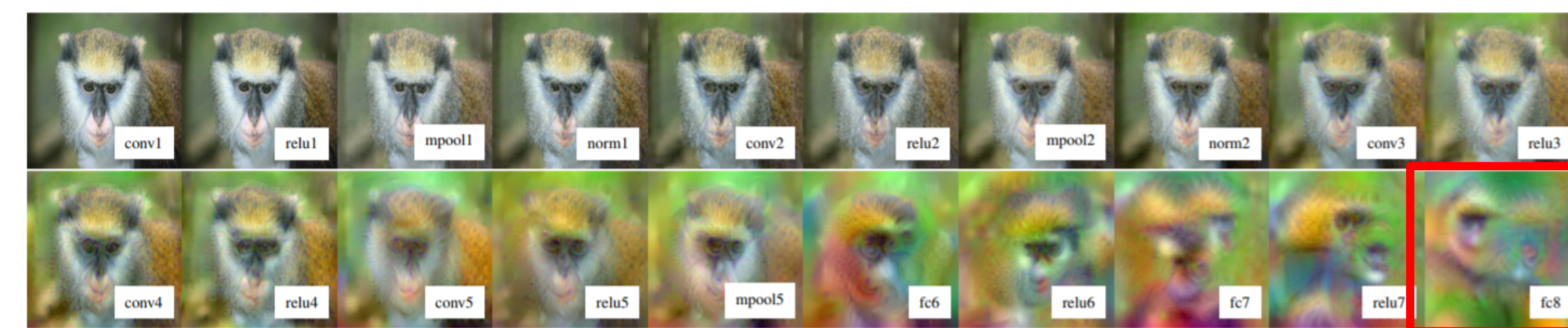
They may cause misrecognition of unknowns (classes not included in the training dataset), even when they perform well for known classes.

Open-set classifiers can handle *unknown unknowns*, that were not anticipated in the training phase



Existing method: pre-trained CNN + outlier detection [Openmax 2016]

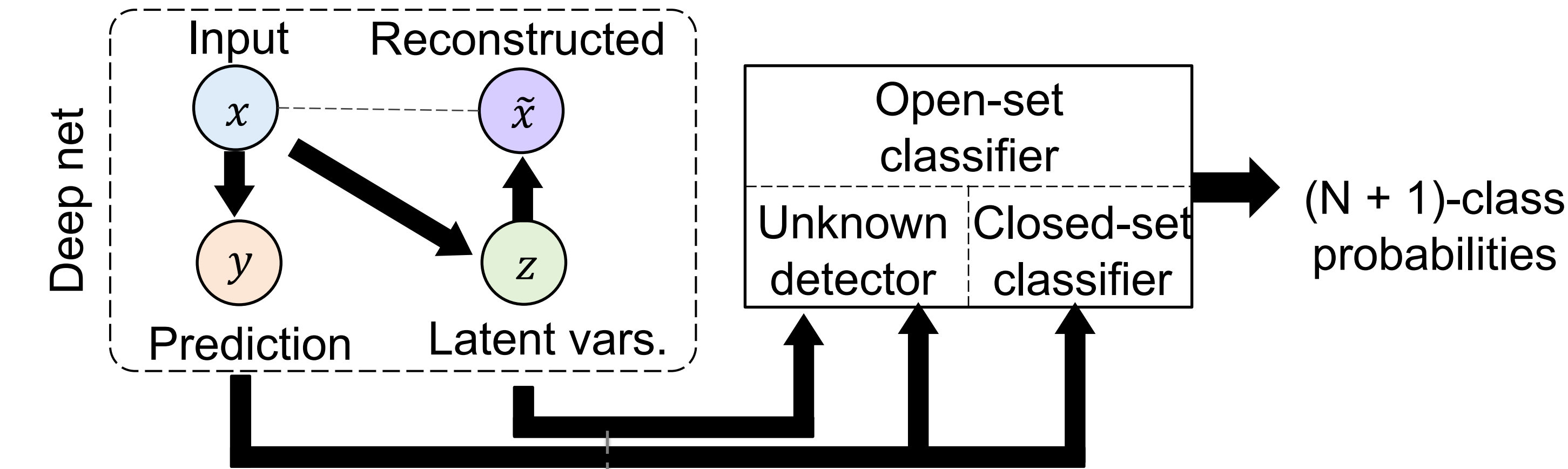
Our motivation: Are closed-set supervisedly-trained CNNs the best for open-set classification?



Supervised nets learn to abstract input for classification. This may cause loss of useful features for unknown detection. — We mitigate this by incorporating unsupervised learning via reconstruction

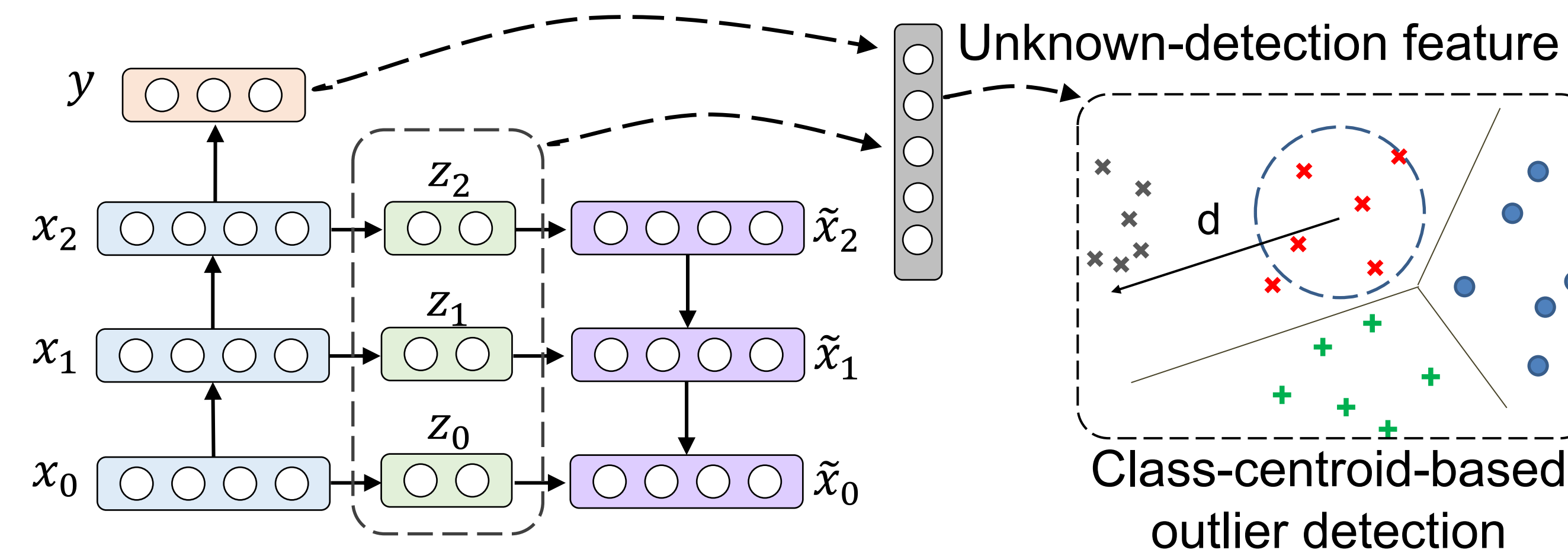
Classification-Reconstruction learning for Open-set Recognition (CROSR)

CROSR framework overview



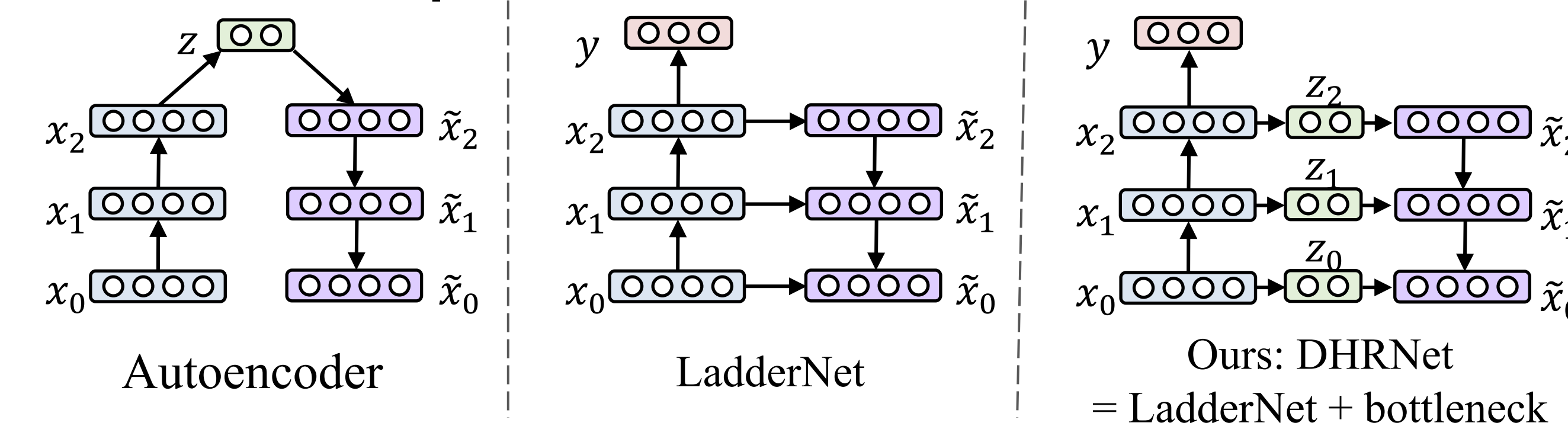
Exploiting latent representations learned via reconstruction for unknown detection

Implementation with Deep Hierarchical Reconstruction (DHR) Net



DHRNet learns dimensionality reduction of each block in deep nets — This enables hierarchical outlier detection

Architectural comparison



Experiments

Task: open-set classification with N known classes + *unknowns* as another class

■ MNIST

Method	Unknowns	Characters	Noisy nums.	Noise
Openmax		0.680	0.720	0.890
LadderNet + Openmax		0.764	0.821	0.826
CROSR (ours)	0.793	0.827	0.826	

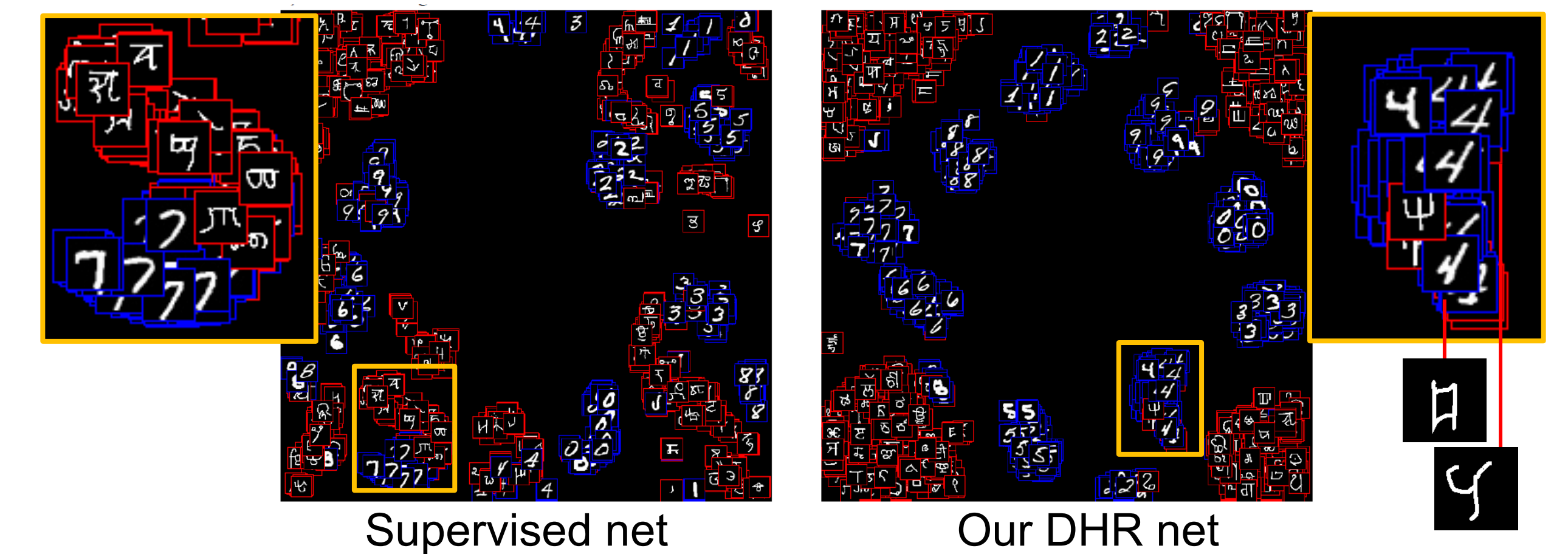
Metric: F1 score averaged over the classes

■ CIFAR-10

Method	Unknowns	ImageNetcrop	ImageNetresize	LSUNcrop	LSUNresize
Openmax		0.660	0.684	0.657	0.668
LadderNet + Openmax		0.653	0.670	0.652	0.659
GAN unknown aug.		0.636	0.635	0.650	0.648
CROSR (ours)	0.721	0.735	0.720	0.749	

More results are in our paper

Visualization



Better separation between **knowns** (0–9) and **unknowns** (others) without using unknowns during training

Conclusion

- Classification-reconstruction learning is useful in open-set recognition
- We developed CROSR framework and DHRNet that improves open-set classification performances
- Code: <https://nae-lab.org/~rei/research/crosr/> (under construction)