Open-set Recognition with Adversarial Autoencoders

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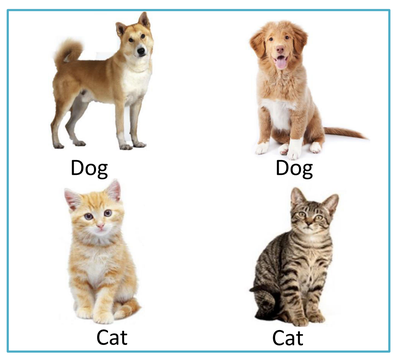
Introduction

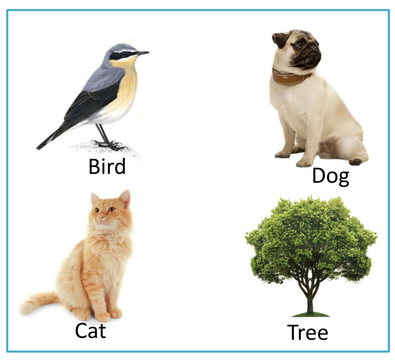
Problem: Learning models should consider multiple known classes and also be able to reject unknown classes or detect them as novel during testing. This is the **open-set** condition.

Why: Real-world tasks in computer vision are multi-class recognition with incomplete knowledge of the world and many unknown inputs.

How: Learn the manifold and the distribution of the known samples by training an adversarial auto-encoder (AAE) network, compute novel score and then classify.



Training Phase



Testing Phase

Traditional Recognition Model

- Despite the open nature of the world, typical recognition tasks are defined under closed-set conditions (all categories are fixed and known).
- Learning models will select the most likely class from a closed known set.
- Learning models should consider multiple known classes and also be able to reject unknown classes.

Open-set Problems Techniques

- SVM Based Approaches
- Statistical Based Approaches (EVT)
- Deep Learning Approaches
- Generative Based Approaches

Our Approach

Training Data

$$x_1, \ldots, x_N \qquad x_i \in \mathbb{R}^m$$

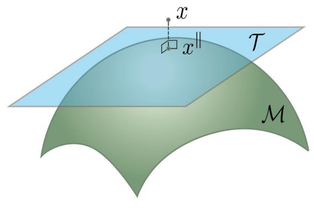
Model

$$x_i = f(z_i) + \xi_i \qquad i = 1, \cdots, N\,, \qquad z_i \in \Omega \subset \mathbb{R}^n$$

$f : \Omega \to \mathbb{R}^m$ Defines $\mathcal{M} \equiv f(\Omega)$

For every $x \in \mathcal{M}$ $\quad f(g(x)) = x$

Given a point $\bar{x} \in \mathbb{R}^m$

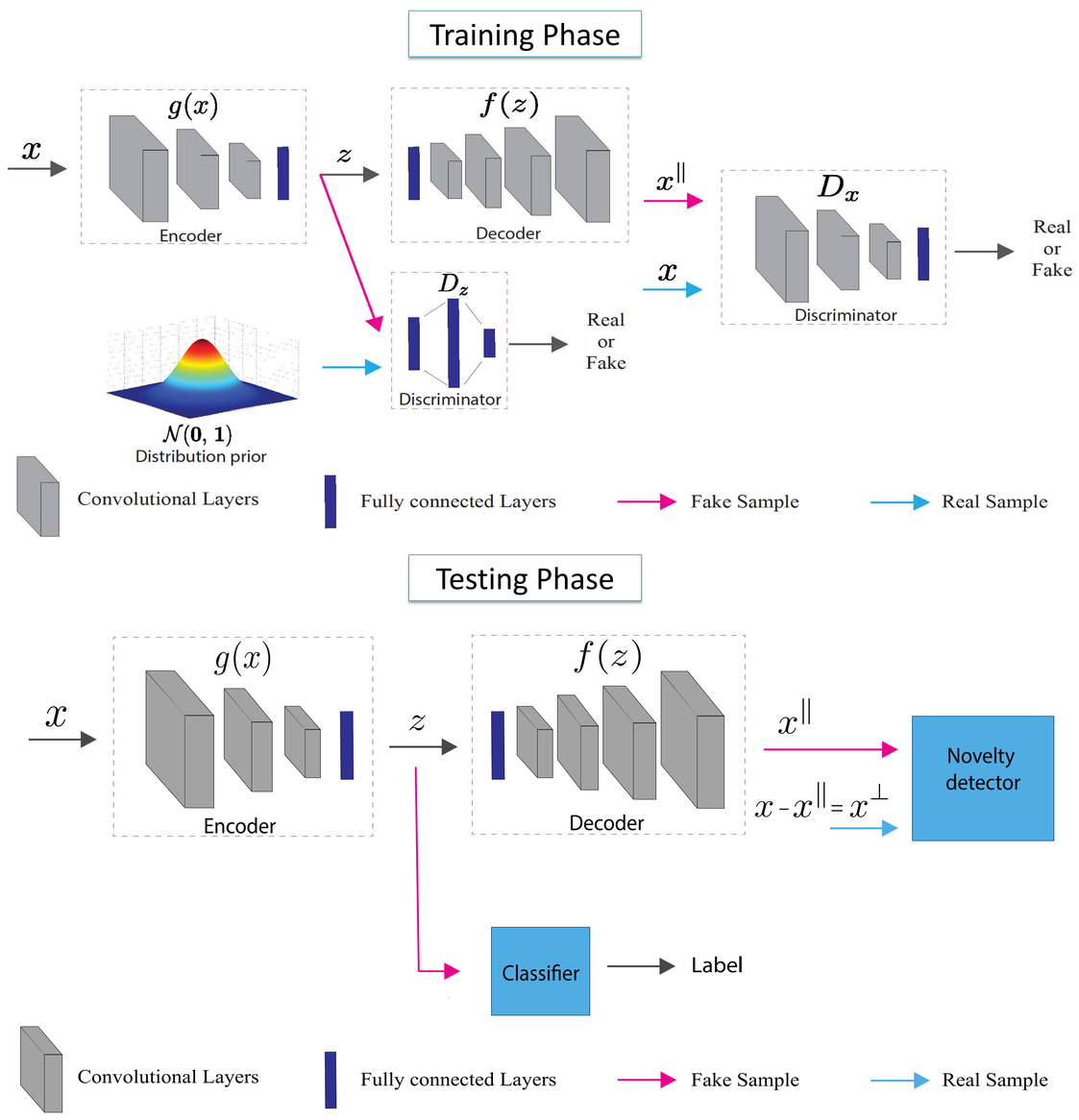


$$x = x^{\|} + x^{\perp}$$

$$p_X(\bar{x}) = p_{X^{\|}}(\bar{x}^{\|}) p_{X^{\perp}}(\bar{x}^{\perp}) \quad \text{Where} \quad p(x^{\perp}) \approx \frac{p(\|x^{\perp}\|)}{\|x^{\perp}\|^{m-n}}$$

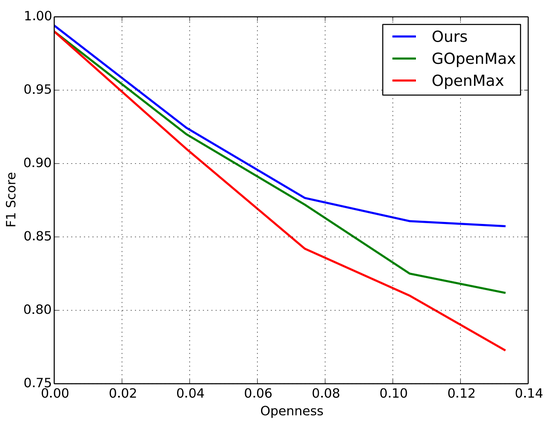
Novelty detection test:

$$p_X(\bar{x}) = p_{X^{\|}}(\bar{x}^{\|}) p_{X^{\perp}}(\bar{x}^{\perp}) = \begin{cases} \text{Inlier} & \text{if } \geq \gamma \\ \text{Outlier} & \text{if } < \gamma \end{cases}$$

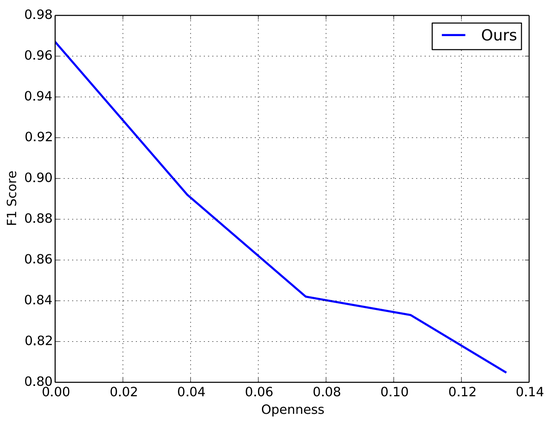


Result

Result on MNIST Dataset



Result on Fashion-MNIST Dataset



	F1 Score on MNIST Dataset				
Ours	0.994	**0.924**	**0.876**	**0.869**	**0.875**
GOpenMax	0.994	0.921	0.872	0.825	0.812
OpenMax	0.994	0.910	0.842	0.810	0.773

References

1. S. Pidhorskyi, R. Almohsen, D. Adjeroh, G. Doretto, “Generative Probabilistic Novelty Detection with Adversarial Autoencoders”, *NeurIPS*, 2018.
2. Z. Y. Ge, S. Demyanov, Z. Chen, and R. Garnavi. “Generative openmax for multi-class open set classification”, *BMVC*, 2017.
3. A. Bendale and T. E. Boult.”Towards openset deepnetworks”, *CVPR*, 2016.