
Supplementary Material for “Effective End-to-end Unsupervised Outlier Detection via Inlier Priority of Discriminative Network”

1 Operation Set \mathcal{O} for Surrogate Supervision

For \mathcal{O} , each operation $O(\cdot|y) \in \mathcal{O}$ is defined as a combination of one or more basic transformations from transformation sets below: **1) Rotation**, which includes simple rotation transformations that clock-wisely rotates images by integer times of 90° : $\mathcal{T}_{SR} = \{Rot(\cdot, (y-1) \cdot 90^\circ)\}_{y=1}^4$, and irregular rotation transformations by integer times of 30° (transformations already in \mathcal{T}_{SR} are excluded): $\mathcal{T}_{IR} = \{Rot(\cdot, (y-1) \cdot 30^\circ)\}_{y=1}^{12} - \mathcal{T}_{SR}$. **2) Flip**: $\mathcal{T}_F = \{Flip(\cdot, y)\}_{y=0}^1$, where $y = 1/0$ refers to flipping the image or not. **3) Shifting**, which includes x-axis shifting: $\mathcal{T}_{Sx} = \{S_x(\cdot, (y-2) \cdot D)\}_{y=1}^3$ and y-axis shifting: $\mathcal{T}_{Sy} = \{S_y(\cdot, (y-2) \cdot D)\}_{y=1}^3$ (D is the step of shifting). **4) Patch re-arranging**, which partitions the image into M equally-sized patches and re-organizes them into a new image by a permutation selected from $M!$ possible permutations: $\mathcal{T}_{PR} = \{PR(\cdot, perm_y)\}_{y=1}^{M!}$. Then we join the transformation sets into three operation subsets, regular affine operation set \mathcal{O}_{RA} , irregular affine operation set \mathcal{O}_{IA} and patch re-arranging operation set \mathcal{O}_{PR} :

$$\mathcal{O}_{RA} = \mathcal{T}_{SR} \times \mathcal{T}_F \times (\mathcal{T}_{Sx} \times \mathcal{T}_{Sy}), \quad \mathcal{O}_{IA} = \mathcal{T}_{IR} \times \mathcal{T}_F, \quad \mathcal{O}_{PR} = \mathcal{T}_{PR} \quad (1)$$

where “ \times ” refers to Cartesian product. Therefore, we obtain $4 \times 2 \times (3 \times 3) = 72$ operations for \mathcal{O}_{RA} , $(12 - 4) \times 2 = 16$ operations for \mathcal{O}_{IA} and $4! = 24$ operations for \mathcal{O}_{PR} , so the final \mathcal{O} has $72 + 16 + 24 - 1 = 111$ operations in total (The permutation that corresponds to the original image in \mathcal{O}_{PR} is excluded). In our experiments, we set $D = 8$ pixels and $M = 4$. There are several remarks: **1)** The reason why we construct operation sets as (1) is to augment the number of operations without joining two transformations that both produce image artifact (e.g. shifting and irregular rotation), which will degrade the UOD performance. **2)** It is NOT compulsory to apply all operations in \mathcal{O} to provide surrogate supervision. In fact, our experiments show that \mathcal{O}_{RA} can produce good UOD performance as well, but a union of \mathcal{O}_{RA} , \mathcal{O}_{IA} and \mathcal{O}_{PR} will produce the best results. **3)** Other operations like colorization [1] or temporal shuffle [2] can be incorporated into the surrogate supervision for better UOD performance or deal with other data types, such as videos or optical flow.

2 Theoretical Derivation on Priority by Gradient Magnitude

To obtain (3) in the original manuscript, we consider an SSD with its network weights randomly initialized by i.i.d. uniform distribution on $[-1, 1]$. Suppose that the network of SSD has an $(L + 1)$ -node penultimate layer and a final K -node softmax layer. We discuss the case of inliers X_{in} first: For cross-entropy loss \mathcal{L} , only transformed inliers generated by the c -th operation $X_{in}^{(c)} = \{\mathbf{x}^{(c)} | \mathbf{x} \in X_{in}\}$ are used to update \mathbf{w}_c . The gradient vector incurred by $X_{in}^{(c)}$ is denoted by $\nabla_{\mathbf{w}_c}^{(in)} \mathcal{L} = [\nabla_{w_{s,c}} \mathcal{L}]_{s=1}^{(L+1)}$ with its element $\nabla_{w_{s,c}} \mathcal{L}$ given by:

$$\nabla_{w_{s,c}} \mathcal{L} = \sum_{i=1}^{N_{in}} \nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_i) = \sum_{i=1}^{N_{in}} (P^{(c)}(\mathbf{x}_i) - 1) h^{(s)}(\mathbf{x}_i) \quad (2)$$

where N_{in} is the inlier number (N_{out} is the outlier number), $P^{(c)}(\mathbf{x}_i)$ is the c -th node's output of the softmax layer and $h^{(s)}(\mathbf{x}_i)$ is the s -th node's output of the penultimate layer for $\mathbf{x}_i \in X_{in}^{(c)}$. Since SSD is randomly initialized, we compute the expectation of inliers' gradient magnitude to update \mathbf{w}_c , i.e. $E(\|\nabla_{\mathbf{w}_c}^{(in)} \mathcal{L}\|_2^2)$. As $\|\nabla_{\mathbf{w}_c}^{(in)} \mathcal{L}\|_2^2 = \sum_{s=1}^{L+1} (\nabla_{w_{s,c}} \mathcal{L})^2$, it needs to compute the term below:

$$E((\nabla_{w_{s,c}} \mathcal{L})^2) = E((\sum_{i=1}^{N_{in}} \nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_i))^2) = \sum_{i=1}^{N_{in}} \sum_{j=1}^{N_{in}} E(\nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_i) \nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_j)). \quad (3)$$

To compute (3), we first define a function $g_{ij}^{(s,c)}$ as follows:

$$g_{ij}^{(s,c)} = \nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_i) \nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_j) = (P^{(c)}(\mathbf{x}_i) - 1)(P^{(c)}(\mathbf{x}_j) - 1)h^{(s)}(\mathbf{x}_i)h^{(s)}(\mathbf{x}_j) \quad (4)$$

where $h^{(s)}(\mathbf{x}_i)$ is the penultimate layer's s -th node's output and $P^{(c)}(\mathbf{x}_i)$ denotes the softmax layer's c -th node's output for \mathbf{x}_i . Our goal is to compute $E(g_{ij}^{(s,c)})$ w.r.t the weights between the penultimate layer and the final softmax layer, which is a $(L+1) \times K$ vector $\mathbf{w} = [\mathbf{w}_c]_{c=1}^K$, with the weights associated with the c -th class ($1 \leq c \leq K$) to be a $(L+1)$ column vector $\mathbf{w}_c = [w_{s,c}]_{s=1}^{L+1}$. To simplify computation, we use the second-order Taylor series expansion of $g_{ij}^{(s,c)}$:

$$g_{ij}^{(s,c)}(\mathbf{w}) \approx g_{ij}^{(s,c)}(\boldsymbol{\mu}) + \nabla_{\mathbf{w}} g_{ij}^{(s,c)}(\boldsymbol{\mu}) \cdot (\mathbf{w} - \boldsymbol{\mu}) + \frac{1}{2}(\mathbf{w} - \boldsymbol{\mu})^T \cdot \nabla_{\mathbf{w}}^2 g_{ij}^{(s,c)}(\boldsymbol{\mu}) \cdot (\mathbf{w} - \boldsymbol{\mu}) \quad (5)$$

where $\boldsymbol{\mu}$ is the expectation of \mathbf{w} . Since each weight in \mathbf{w} is drawn from i.i.d uniform distribution on $[-1, 1]$, we have $\mu_{s,c} = E(w_{s,c}) = 0$, $E(w_{s,c}^2) = \frac{1}{3}$ and $E(w_{s,c}w_{t,c}) = 0$ ($s \neq t$). Therefore, the expectation of $g_{ij}^{(s,c)}$ w.r.t. \mathbf{w} is approximated as

$$E(g_{ij}^{(s,c)}(\mathbf{w})) \approx g_{ij}^{(s,c)}(\mathbf{0}) + \frac{1}{2} \sum_{t=1}^{L+1} \sum_{l=1}^K \nabla_{w_{t,l}}^2 g_{ij}^{(s,c)}(\mathbf{0}) E(w_{s,c}^2) = g_{ij}^{(s,c)}(\mathbf{0}) + \frac{1}{6} \sum_{t=1}^{L+1} \sum_{l=1}^K \nabla_{w_{t,l}}^2 g_{ij}^{(s,c)}(\mathbf{0}). \quad (6)$$

Thus, computing $E(g_{ij}^{(s,c)}(\mathbf{w}))$ requires the computation of $\nabla_{w_{t,l}}^2 g_{ij}^{(s,c)}(\mathbf{0})$. Recall the softmax probability is computed by:

$$P^{(c)}(\mathbf{x}_i) = \frac{e^{\mathbf{h}^\top(\mathbf{x}_i) \cdot \mathbf{w}_c}}{\sum_{l=1}^K e^{\mathbf{h}^\top(\mathbf{x}_i) \cdot \mathbf{w}_l}} \quad (7)$$

where $\mathbf{h}(\mathbf{x}_i) = [h^{(s)}(\mathbf{x}_i)]_{s=1}^{L+1}$ is penultimate layer's output for \mathbf{x}_i . Since $\mathbf{h}(\mathbf{x}_i)$ is independent of \mathbf{w} , we have:

$$\nabla_{w_{t,l}} P^{(c)}(\mathbf{x}_i) = -P^{(c)}(\mathbf{x}_i)(\delta_{c,l} - P^{(l)}(\mathbf{x}_i)) \cdot h^{(t)}(\mathbf{x}_i) \quad (8)$$

where $\delta_{c,l} = 1$ if $c = l$ and $\delta_{c,l} = 0$ otherwise. Using (4), (7) and (8), we can calculate $\nabla_{w_{t,l}}^2 g_{ij}^{(s,c)}$ by:

$$\begin{aligned} \nabla_{w_{t,l}}^2 g_{ij}^{(s,c)} &= h^{(s)}(\mathbf{x}_i)h^{(s)}(\mathbf{x}_j) \left[-(h^{(t)}(\mathbf{x}_i))^2 \cdot P^{(c)}(\mathbf{x}_i)(\delta_{c,l} - P^{(l)}(\mathbf{x}_i))^2(1 - P^{(c)}(\mathbf{x}_j)) \right. \\ &\quad + (h^{(t)}(\mathbf{x}_i))^2 \cdot P^{(c)}(\mathbf{x}_i)P^{(l)}(\mathbf{x}_i)(1 - P^{(l)}(\mathbf{x}_i))(1 - P^{(c)}(\mathbf{x}_j)) \\ &\quad + 2 \cdot h^{(t)}(\mathbf{x}_i)h^{(t)}(\mathbf{x}_j) \cdot P^{(c)}(\mathbf{x}_i)P^{(c)}(\mathbf{x}_j)(\delta_{c,l} - P^{(l)}(\mathbf{x}_i))(\delta_{c,l} - P^{(l)}(\mathbf{x}_j)) \\ &\quad - (h^{(t)}(\mathbf{x}_j))^2 \cdot P^{(c)}(\mathbf{x}_j)(\delta_{c,l} - P^{(l)}(\mathbf{x}_j))^2(1 - P^{(c)}(\mathbf{x}_i)) \\ &\quad \left. + (h^{(t)}(\mathbf{x}_j))^2 \cdot P^{(c)}(\mathbf{x}_j)P^{(l)}(\mathbf{x}_j)(1 - P^{(l)}(\mathbf{x}_j))(1 - P^{(c)}(\mathbf{x}_i)) \right]. \quad (9) \end{aligned}$$

Therefore, in the summation term of (6), we have $(L + 1)$ terms that satisfy $c = l$, and in this case $\nabla_{w_{t,l}}^2 g_{ij}^{(s,c)}|_{\mathbf{w}=\mathbf{0}}$ is:

$$h^{(s)}(\mathbf{x}_i)h^{(s)}(\mathbf{x}_j) \left[(h^{(t)}(\mathbf{x}_i))^2 \frac{(K-1)^2(2-K)}{K^4} + (h^{(t)}(\mathbf{x}_j))^2 \frac{(K-1)^2(2-K)}{K^4} + 2h^{(t)}(\mathbf{x}_i)h^{(t)}(\mathbf{x}_j) \frac{(K-1)^2}{K^4} \right]. \quad (10)$$

For the rest $(L + 1)(K - 1)$ terms in the summation term that satisfy $c \neq l$, $\nabla_{w_{t,l}}^2 g_{ij}^{(s,c)}|_{\mathbf{w}=\mathbf{0}}$ is:

$$h^{(s)}(\mathbf{x}_i)h^{(s)}(\mathbf{x}_j) \left[(h^{(t)}(\mathbf{x}_i))^2 \frac{(K-1)(K-2)}{K^4} + (h^{(t)}(\mathbf{x}_j))^2 \frac{(K-1)(K-2)}{K^4} + 2h^{(t)}(\mathbf{x}_i)h^{(t)}(\mathbf{x}_j) \frac{1}{K^4} \right]. \quad (11)$$

By substituting (10) and (11) into (6), we can obtain the result of (5) in the original manuscript:

$$E(\nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_i) \nabla_{w_{s,c}} \mathcal{L}(\mathbf{x}_j)) = E(g_{ij}^{(s,c)}(\mathbf{w})) \approx h^{(s)}(\mathbf{x}_i)h^{(s)}(\mathbf{x}_j) \left[\frac{(K-1)^2}{K^2} + \frac{(K-1)}{3K^3} \sum_{t=1}^{L+1} h^{(t)}(\mathbf{x}_i)h^{(t)}(\mathbf{x}_j) \right]. \quad (12)$$

It remains to calculate the expectation of $h^{(t)}(\mathbf{x}_i)h^{(t)}(\mathbf{x}_j)$ in (12). To make its calculation tractable, we consider a simplified case of a network with a single hidden-layer and sigmoid activation. In this case, by [3, Lemma 3.b], the expectation of $h^{(s)}(\mathbf{x}_i)h^{(s)}(\mathbf{x}_j)$ w.r.t. the randomly initialized weights between the input and hidden layer satisfies $E(h^{(s)}(\mathbf{x}_i)h^{(s)}(\mathbf{x}_j)) \approx \frac{1}{4}$ and $E(h^{(s)}(\mathbf{x}_i)^2 h^{(s)}(\mathbf{x}_j)^2) \approx \frac{1}{16}$. Thus, by definition of $\|\nabla_{\mathbf{w}_c}^{(in)} \mathcal{L}\|_2^2$ and (3), we yield:

$$E(\|\nabla_{\mathbf{w}_c}^{(in)} \mathcal{L}\|_2^2) \approx N_{in}^2 \left[(L+1) \left(\frac{(K-1)^2}{4K^2} + \frac{(K-1)(L+1)}{48K^3} \right) \right] \triangleq N_{in}^2 \cdot A. \quad (13)$$

Since L, K, A are constant, (13) suggests that the magnitude of inliers' gradient $E(\|\nabla_{\mathbf{w}_c}^{(in)} \mathcal{L}\|_2^2)$ is proportional to N_{in}^2 . Similarly, outliers' gradient magnitude $E(\|\nabla_{\mathbf{w}_c}^{(out)} \mathcal{L}\|_2^2) \approx N_{out}^2 \cdot A$. Thus, it is easy to obtain:

$$\frac{E(\|\nabla_{\mathbf{w}_c}^{(in)} \mathcal{L}\|_2^2)}{E(\|\nabla_{\mathbf{w}_c}^{(out)} \mathcal{L}\|_2^2)} \approx \frac{N_{in}^2}{N_{out}^2} \quad (14)$$

3 Implementation Details of Compared Methods

For all AE based methods, we adopt a deep CAE with the architecture below: *conv*($k = 3, s = 2$) – *bn* – *Relu* – *conv*($k = 3, s = 2$) – *bn* – *relu* – *conv*($k = 3, s = 2$) – *bn* – *relu* – *reshape* – *fc*(4096, 256) – *tanh* – *fc*(256, 4096) – *bn* – *relu* – *reshape* – *deconv*($k = 3, s = 2$) – *bn* – *relu* – *deconv*($k = 3, s = 2$) – *bn* – *relu* – *deconv*($k = 3, s = 2$) – *tanh*, while k and s refer to kernel size and stride. For each individual method, the parameters are set as follows: **1)** CAE [4]. CAE is trained by Mean Square Error Loss (MSE) and its reconstruction loss is directly used to perform UOD. The CAE is trained by default Adam optimizer in PyTorch¹ for 250 epochs with learning rate 0.001 and weight decay 0.0005. The batch size is 128. **2)** CAE-IF. CAE-IF is a decoupled/hybrid method that feeds the learned representations of CAE into isolation forest (IF) [5]. The training of CAE is the illustrated above, and the IF is realized by scikit-learn framework². The contamination parameter of IF is set by $p = \rho$ to yield better UOD performance for comparison with *E³Outlier*, and other parameters are set to default values in scikit-learn. **3)** Discriminative reconstruction based autoencoder (DRAE) [6]. We set DRAE's encouraging term weight $\lambda = 0.1$ as recommended in [6], while other training setting is the same as CAE. **4)** Robust deep autoencoder (RDAE) [7]. We set $\lambda = 0.00065$ for RDAE's regularization, which performs best in the empirical evaluation of [7]. To yield the best performance, we use 20 outer epochs and 1 inner epochs for the

¹<https://pytorch.org/>

²<https://scikit-learn.org/>

alternating optimization. **5)** Deep autoencoding gaussian mixture model (DAGMM) [8]. As suggested by [8], we adopt $\lambda_1 = 0.1$, $\lambda_2 = 0.005$ for the energy regularization term and the singularity penalty term respectively. An Adam optimizer with the recommended learning rate 0.0001 is used to optimize the CAE and density estimation network for 200 epochs. The batch size is 1024 as set in [8]. **6)** SSD-IF. SSD-IF shares $E^3Outlier$'s SSD part but directly feeds SSD's learned representations into IF to perform UOD, which is a comparison to $E^3Outlier$'s end-to-end UOD. SSD-IF shares exactly the same IF setting with CAE-IF. The experiments are run on a PC with dual NVIDIA Titan Xp GPU, 64 GiB RAM and Intel 7820X CPU, under a programming environment with Python 3.6, PyTorch 0.4.1 and Keras 2.2.0.

4 Detailed Results of UOD Performance

We present detailed results of UOD performance comparison on each class of benchmarks in Table 1-15. The AUROC results are given in Table 1-5, while the AUPR results are given in Table 6-15. Note that only NE based performance is shown for $E^3Outlier$ due to limit of space. In each table, the best overall UOD performance ("average") on each benchmark is shown in bold.

References

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Table 1: AUROC (%) when $\rho = 0.05$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	57.43 \pm 3.06	92.78 \pm 0.93	62.39 \pm 3.62	69.63 \pm 2.39	71.30 \pm 21.72	92.54 \pm 0.99	96.25 \pm 0.28
	1	99.31 \pm 0.09	99.39 \pm 0.06	83.05 \pm 11.22	99.36 \pm 0.08	87.19 \pm 12.48	97.69 \pm 0.21	96.99 \pm 0.55
	2	59.89 \pm 5.24	77.84 \pm 2.17	69.23 \pm 9.98	62.82 \pm 3.49	50.32 \pm 11.76	94.68 \pm 0.49	93.86 \pm 0.44
	3	63.72 \pm 1.96	85.18 \pm 1.08	63.11 \pm 7.12	68.33 \pm 2.49	47.45 \pm 4.02	97.59 \pm 0.50	97.72 \pm 0.22
	4	71.30 \pm 2.10	85.94 \pm 2.85	70.51 \pm 6.28	74.74 \pm 1.52	62.07 \pm 4.94	96.47 \pm 0.59	96.62 \pm 0.35
	5	61.38 \pm 3.40	81.62 \pm 2.11	57.36 \pm 4.21	67.80 \pm 1.71	53.07 \pm 3.56	96.22 \pm 0.99	93.42 \pm 0.58
	6	71.89 \pm 4.76	90.45 \pm 1.43	66.68 \pm 9.13	77.43 \pm 1.87	52.15 \pm 12.88	98.50 \pm 0.35	97.36 \pm 0.18
	7	82.70 \pm 2.55	93.60 \pm 0.58	79.31 \pm 3.45	88.57 \pm 1.44	71.52 \pm 8.51	95.45 \pm 0.54	94.54 \pm 0.45
	8	47.98 \pm 6.95	74.71 \pm 1.49	49.91 \pm 5.14	50.91 \pm 4.25	52.67 \pm 6.14	89.52 \pm 2.44	89.43 \pm 0.81
	9	77.08 \pm 2.13	91.21 \pm 0.78	74.00 \pm 7.22	79.99 \pm 2.47	59.45 \pm 7.92	96.44 \pm 0.55	95.42 \pm 0.14
	<i>average</i>	69.27 \pm 1.02	87.27 \pm 0.34	67.56 \pm 2.84	73.96 \pm 0.83	60.72 \pm 2.09	95.51 \pm 0.30	95.16 \pm 0.15
Fashion-MNIST	t-shirt	65.88 \pm 5.02	87.28 \pm 0.79	66.83 \pm 6.48	77.48 \pm 1.10	64.53 \pm 15.40	90.77 \pm 1.31	94.00 \pm 0.39
	trouser	97.02 \pm 0.21	96.76 \pm 0.52	88.31 \pm 4.18	97.07 \pm 0.27	69.94 \pm 18.29	98.42 \pm 0.10	98.73 \pm 0.18
	pullover	65.89 \pm 5.19	84.24 \pm 1.21	66.56 \pm 3.36	73.83 \pm 4.12	50.17 \pm 10.66	90.00 \pm 1.11	91.59 \pm 1.41
	dress	79.74 \pm 1.96	87.97 \pm 1.84	76.50 \pm 3.09	80.18 \pm 2.61	77.50 \pm 14.41	92.39 \pm 0.42	92.73 \pm 0.67
	coat	72.91 \pm 2.44	84.74 \pm 1.44	64.64 \pm 1.91	74.10 \pm 3.76	55.17 \pm 7.93	90.61 \pm 1.02	91.50 \pm 1.13
	sandal	80.91 \pm 4.66	70.19 \pm 2.17	76.13 \pm 6.09	75.56 \pm 12.49	84.09 \pm 6.49	90.34 \pm 1.04	93.42 \pm 0.70
	shirt	56.62 \pm 5.11	79.67 \pm 1.25	55.87 \pm 1.99	69.43 \pm 2.39	59.90 \pm 6.33	82.58 \pm 1.46	84.46 \pm 1.15
	sneaker	94.26 \pm 1.04	94.60 \pm 1.09	92.75 \pm 1.77	95.00 \pm 0.48	67.44 \pm 26.98	98.66 \pm 0.30	99.17 \pm 0.29
	bag	51.22 \pm 4.38	70.40 \pm 1.61	48.00 \pm 2.27	58.78 \pm 4.68	44.84 \pm 8.31	91.37 \pm 0.69	95.47 \pm 0.52
	ankle-boot	86.44 \pm 2.16	91.65 \pm 0.93	79.24 \pm 3.36	87.82 \pm 2.43	67.16 \pm 16.22	98.72 \pm 0.17	99.47 \pm 0.09
	<i>average</i>	75.09 \pm 0.45	84.75 \pm 0.15	71.48 \pm 0.61	78.93 \pm 1.17	64.07 \pm 5.95	92.39 \pm 0.20	94.05 \pm 0.13
CIFAR10	airplane	69.24 \pm 2.48	62.68 \pm 0.86	72.09 \pm 0.62	64.37 \pm 3.64	52.24 \pm 9.36	57.98 \pm 3.45	79.44 \pm 1.15
	automobile	41.79 \pm 1.73	31.72 \pm 0.86	39.55 \pm 2.12	33.38 \pm 2.07	58.65 \pm 7.06	75.47 \pm 2.96	95.31 \pm 0.38
	bird	65.19 \pm 1.49	66.77 \pm 1.25	66.01 \pm 0.78	68.30 \pm 1.80	48.27 \pm 2.65	57.91 \pm 1.95	75.40 \pm 1.94
	cat	59.19 \pm 1.74	52.70 \pm 1.69	59.72 \pm 1.09	57.74 \pm 1.17	49.26 \pm 3.83	57.04 \pm 2.65	73.91 \pm 0.55
	deer	61.16 \pm 2.54	68.57 \pm 2.20	62.22 \pm 3.42	69.09 \pm 2.04	52.72 \pm 5.71	64.60 \pm 2.48	84.09 \pm 1.39
	dog	55.86 \pm 2.06	51.57 \pm 0.68	60.85 \pm 1.01	55.28 \pm 1.74	52.67 \pm 3.55	62.28 \pm 2.57	87.88 \pm 1.32
	frog	49.96 \pm 3.02	61.70 \pm 0.69	46.00 \pm 1.30	57.31 \pm 3.26	64.59 \pm 2.15	66.89 \pm 4.23	84.98 \pm 1.02
	horse	49.05 \pm 1.78	46.81 \pm 0.84	52.00 \pm 1.25	48.72 \pm 0.81	55.46 \pm 5.33	77.00 \pm 2.23	93.38 \pm 1.00
	ship	72.79 \pm 2.31	67.66 \pm 1.23	72.59 \pm 1.21	70.06 \pm 2.51	55.48 \pm 5.76	73.07 \pm 3.10	92.34 \pm 0.89
	truck	37.94 \pm 1.37	32.35 \pm 2.63	38.69 \pm 3.16	34.25 \pm 3.42	61.91 \pm 4.75	75.17 \pm 2.24	89.74 \pm 1.14
	<i>average</i>	56.22 \pm 0.79	54.25 \pm 0.28	56.97 \pm 0.46	55.85 \pm 0.64	55.12 \pm 1.76	66.74 \pm 0.32	85.65 \pm 0.42
CIFAR100	aquatic mammals	63.71 \pm 2.30	63.77 \pm 1.73	67.14 \pm 2.66	66.63 \pm 2.18	49.93 \pm 6.68	55.26 \pm 3.29	77.22 \pm 1.56
	fish	65.17 \pm 2.02	60.19 \pm 1.34	63.22 \pm 1.13	62.06 \pm 1.51	44.59 \pm 3.47	57.57 \pm 1.83	70.32 \pm 2.41
	flowers	38.88 \pm 2.59	36.27 \pm 1.72	37.21 \pm 1.85	37.51 \pm 5.36	66.02 \pm 10.09	54.31 \pm 1.76	79.04 \pm 2.54
	food containers	60.73 \pm 4.23	59.80 \pm 2.64	61.84 \pm 0.43	60.11 \pm 1.53	46.68 \pm 3.95	52.21 \pm 3.19	83.32 \pm 0.98
	fruit and vegetables	55.21 \pm 4.32	45.63 \pm 0.86	53.41 \pm 2.24	48.58 \pm 3.19	65.91 \pm 2.93	53.69 \pm 3.10	78.31 \pm 1.05
	household electrical devices	52.16 \pm 1.47	44.09 \pm 2.21	56.95 \pm 1.88	49.75 \pm 1.88	50.11 \pm 1.26	48.73 \pm 4.67	64.23 \pm 2.02
	household furniture	59.73 \pm 4.97	53.85 \pm 2.90	66.22 \pm 2.04	56.15 \pm 3.38	50.62 \pm 7.51	50.67 \pm 2.93	82.26 \pm 0.93
	inserts	46.31 \pm 0.92	50.45 \pm 1.82	46.26 \pm 2.11	48.20 \pm 2.68	51.36 \pm 1.29	52.93 \pm 2.99	76.14 \pm 0.92
	large carnivores	50.41 \pm 2.65	55.42 \pm 2.76	54.01 \pm 2.75	58.02 \pm 4.39	59.22 \pm 3.13	61.47 \pm 3.48	87.59 \pm 1.34
	large man-made outdoor things	65.53 \pm 3.69	63.06 \pm 3.87	70.15 \pm 4.05	66.28 \pm 4.59	57.15 \pm 9.20	67.45 \pm 2.07	88.67 \pm 2.38
	large natural outdoor scenes	83.36 \pm 1.74	82.40 \pm 2.64	80.88 \pm 0.96	82.01 \pm 2.28	51.37 \pm 6.78	62.61 \pm 2.48	85.93 \pm 0.65
	large omnivores and herbivores	51.13 \pm 3.09	51.06 \pm 3.35	56.66 \pm 1.77	56.04 \pm 3.43	57.51 \pm 1.90	55.61 \pm 0.85	83.65 \pm 0.69
	medium-sized mammals	58.80 \pm 2.47	57.48 \pm 1.80	62.64 \pm 2.64	63.09 \pm 3.76	61.02 \pm 2.59	58.72 \pm 2.98	84.72 \pm 1.08
	non-insert invertebrates	52.91 \pm 1.39	57.02 \pm 1.97	50.59 \pm 0.92	54.87 \pm 0.77	49.94 \pm 2.39	49.14 \pm 0.57	63.87 \pm 1.65
	people	46.69 \pm 1.61	39.44 \pm 2.70	47.94 \pm 1.95	42.20 \pm 2.74	56.84 \pm 2.61	56.42 \pm 3.45	90.61 \pm 0.93
	reptiles	54.38 \pm 1.44	55.95 \pm 2.71	53.88 \pm 0.65	56.69 \pm 2.82	48.79 \pm 2.97	52.66 \pm 1.96	69.78 \pm 3.44
	small mammals	59.34 \pm 2.09	62.87 \pm 0.70	62.37 \pm 2.23	64.68 \pm 1.14	54.79 \pm 3.84	57.95 \pm 1.80	75.05 \pm 0.88
	trees	62.66 \pm 4.30	63.74 \pm 3.50	60.81 \pm 3.37	63.36 \pm 2.66	58.04 \pm 3.05	75.59 \pm 2.72	91.91 \pm 0.57
	vehicles 1	36.04 \pm 2.54	36.45 \pm 1.35	37.85 \pm 4.59	37.72 \pm 3.15	58.24 \pm 3.25	61.66 \pm 3.38	89.94 \pm 0.81
	vehicles 2	48.37 \pm 2.26	47.00 \pm 0.79	53.43 \pm 2.34	48.34 \pm 1.41	49.17 \pm 5.60	57.30 \pm 5.00	84.18 \pm 1.60
	<i>average</i>	55.57 \pm 0.60	54.30 \pm 0.26	57.17 \pm 0.58	56.11 \pm 0.65	54.37 \pm 0.51	57.10 \pm 0.67	80.34 \pm 0.20
SVHN	0	52.16 \pm 1.67	60.13 \pm 0.98	53.52 \pm 1.50	51.90 \pm 1.10	49.68 \pm 1.87	78.25 \pm 1.08	80.95 \pm 1.23
	1	54.74 \pm 1.59	61.06 \pm 0.59	55.20 \pm 1.72	58.03 \pm 0.92	48.28 \pm 1.32	69.28 \pm 2.99	78.02 \pm 0.85
	2	51.42 \pm 1.24	53.94 \pm 0.94	49.88 \pm 0.65	51.87 \pm 0.81	49.57 \pm 1.11	78.31 \pm 2.61	93.12 \pm 0.38
	3	50.09 \pm 0.85	52.51 \pm 0.65	49.37 \pm 0.61	50.10 \pm 0.94	50.41 \pm 0.55	71.82 \pm 2.49	89.39 \pm 0.61
	4	52.34 \pm 1.45	56.98 \pm 1.29	52.45 \pm 0.96	53.25 \pm 0.97	49.47 \pm 1.55	76.67 \pm 2.47	94.01 \pm 0.19
	5	49.42 \pm 1.24	52.68 \pm 0.77	48.55 \pm 1.34	50.18 \pm 0.87	51.16 \pm 0.67	75.18 \pm 2.50	93.25 \pm 0.35
	6	49.71 \pm 0.98	52.21 \pm 0.66	47.65 \pm 0.73	50.00 \pm 0.69	48.64 \pm 1.31	79.73 \pm 1.72	91.70 \pm 0.48
	7	54.28 \pm 1.94	57.62 \pm 1.32	52.22 \pm 1.29	54.47 \pm 1.82	49.59 \pm 1.57	84.72 \pm 0.62	95.03 \pm 0.19
	8	50.13 \pm 1.34	53.90 \pm 1.09	48.94 \pm 1.77	50.78 \pm 1.53	49.54 \pm 1.57	68.04 \pm 2.50	81.39 \pm 1.24
	9	50.17 \pm 0.77	52.86 \pm 1.72	48.58 \pm 0.36	51.21 \pm 1.06	50.46 \pm 1.28	80.24 \pm 1.37	92.17 \pm 0.73
	<i>average</i>	51.45 \pm 0.27	55.39 \pm 0.46	50.64 \pm 0.41	52.18 \pm 0.15	49.68 \pm 0.46	76.22 \pm 0.31	88.90 \pm 0.24

Table 2: AUROC (%) when $\rho = 0.1$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	57.50 \pm 5.33	90.19 \pm 2.19	61.86 \pm 13.38	62.51 \pm 5.83	74.52 \pm 26.99	90.90 \pm 1.01	94.38 \pm 0.28
	1	99.09 \pm 0.16	99.27 \pm 0.14	81.80 \pm 7.54	99.19 \pm 0.08	89.23 \pm 15.65	96.59 \pm 0.42	95.22 \pm 0.33
	2	53.78 \pm 5.92	74.54 \pm 1.23	56.94 \pm 5.53	61.12 \pm 1.81	48.74 \pm 10.55	91.70 \pm 1.08	93.07 \pm 0.35
	3	61.16 \pm 6.48	81.80 \pm 2.60	67.41 \pm 5.25	65.91 \pm 1.84	50.51 \pm 3.41	95.61 \pm 0.87	97.20 \pm 0.29
	4	69.94 \pm 3.91	83.30 \pm 2.22	66.22 \pm 4.98	76.05 \pm 1.20	62.22 \pm 8.78	95.81 \pm 0.82	95.64 \pm 0.30
	5	60.38 \pm 0.49	79.06 \pm 1.11	64.34 \pm 3.64	65.11 \pm 2.43	52.77 \pm 5.37	92.77 \pm 1.28	91.72 \pm 0.54
	6	73.47 \pm 4.88	91.10 \pm 0.91	74.66 \pm 5.53	75.03 \pm 1.94	66.57 \pm 11.11	97.53 \pm 0.08	96.79 \pm 0.12
	7	81.79 \pm 2.46	91.90 \pm 0.93	77.47 \pm 3.57	85.64 \pm 1.11	75.49 \pm 10.55	93.89 \pm 0.83	93.30 \pm 0.21
	8	48.20 \pm 1.78	73.93 \pm 2.57	48.75 \pm 5.28	51.38 \pm 2.30	56.98 \pm 8.17	87.80 \pm 1.49	88.51 \pm 0.99
	9	74.61 \pm 1.90	89.92 \pm 1.16	69.50 \pm 16.65	75.71 \pm 2.60	63.08 \pm 4.61	95.76 \pm 0.54	95.12 \pm 0.34
	<i>average</i>	67.99 \pm 0.70	85.50 \pm 0.53	66.90 \pm 2.55	71.76 \pm 0.99	64.01 \pm 3.70	93.84 \pm 0.32	94.09 \pm 0.13
Fashion-MNIST	t-shirt	57.17 \pm 6.39	85.55 \pm 0.94	61.27 \pm 6.82	70.56 \pm 4.18	58.67 \pm 13.52	88.09 \pm 0.76	92.55 \pm 0.43
	trouser	96.05 \pm 0.30	96.34 \pm 0.55	76.73 \pm 13.97	96.94 \pm 0.36	74.20 \pm 12.80	97.82 \pm 0.42	98.12 \pm 0.16
	pullover	60.73 \pm 2.57	82.82 \pm 1.33	61.55 \pm 3.28	68.79 \pm 4.73	52.09 \pm 16.12	89.41 \pm 0.97	91.86 \pm 0.90
	dress	77.34 \pm 1.80	85.22 \pm 0.70	75.43 \pm 3.23	79.12 \pm 3.22	73.04 \pm 23.18	91.00 \pm 0.71	89.99 \pm 0.84
	coat	67.42 \pm 2.27	82.68 \pm 1.05	60.42 \pm 3.50	73.23 \pm 1.59	49.92 \pm 14.90	89.95 \pm 0.37	91.41 \pm 0.44
	sandal	73.94 \pm 4.21	67.28 \pm 2.28	72.57 \pm 4.08	73.64 \pm 1.33	84.47 \pm 6.00	88.09 \pm 1.08	93.64 \pm 0.29
	shirt	52.09 \pm 3.99	77.53 \pm 0.78	54.25 \pm 3.28	66.34 \pm 3.00	57.02 \pm 7.42	82.06 \pm 0.79	83.50 \pm 1.15
	sneaker	91.00 \pm 1.69	91.56 \pm 0.75	91.69 \pm 1.48	91.15 \pm 1.14	75.66 \pm 28.60	98.18 \pm 0.33	99.11 \pm 0.14
	bag	45.82 \pm 3.31	67.18 \pm 1.16	46.09 \pm 1.75	51.25 \pm 2.93	52.68 \pm 7.54	82.36 \pm 1.83	93.16 \pm 0.38
	ankle-boot	81.37 \pm 2.64	86.68 \pm 1.47	71.20 \pm 5.33	82.35 \pm 5.15	61.76 \pm 24.67	98.58 \pm 0.27	99.40 \pm 0.09
	<i>average</i>	70.29 \pm 0.92	82.28 \pm 0.19	67.12 \pm 1.76	75.34 \pm 1.19	63.95 \pm 9.90	90.55 \pm 0.18	93.27 \pm 0.14
CIFAR10	airplane	68.34 \pm 4.04	61.93 \pm 1.11	71.21 \pm 0.83	62.65 \pm 2.21	49.29 \pm 7.83	52.22 \pm 2.43	78.22 \pm 1.19
	automobile	37.81 \pm 3.07	32.69 \pm 1.78	38.41 \pm 0.90	33.35 \pm 2.22	61.62 \pm 3.92	71.70 \pm 2.12	93.78 \pm 0.49
	bird	61.87 \pm 4.59	66.43 \pm 1.20	65.56 \pm 1.06	66.73 \pm 1.33	48.97 \pm 4.87	54.23 \pm 2.75	71.28 \pm 1.36
	cat	59.15 \pm 2.38	51.05 \pm 1.14	59.72 \pm 1.17	55.14 \pm 2.34	50.61 \pm 0.82	55.55 \pm 1.78	70.40 \pm 1.29
	deer	64.54 \pm 2.29	70.42 \pm 1.34	61.60 \pm 1.55	70.94 \pm 2.37	57.03 \pm 4.41	64.80 \pm 1.19	82.18 \pm 0.22
	dog	57.40 \pm 3.15	50.59 \pm 1.03	61.05 \pm 0.91	55.62 \pm 1.20	54.53 \pm 4.55	62.05 \pm 2.88	84.80 \pm 0.92
	frog	53.99 \pm 4.20	61.93 \pm 1.10	41.03 \pm 1.32	56.82 \pm 2.22	62.58 \pm 5.92	64.62 \pm 3.74	81.88 \pm 1.55
	horse	46.49 \pm 1.29	46.01 \pm 1.32	50.75 \pm 1.06	49.40 \pm 1.86	57.27 \pm 3.10	73.76 \pm 0.94	91.60 \pm 0.48
	ship	72.33 \pm 2.63	66.72 \pm 0.84	72.58 \pm 1.78	67.77 \pm 2.02	54.55 \pm 14.22	68.77 \pm 2.78	92.00 \pm 0.16
	truck	36.39 \pm 2.79	33.26 \pm 1.49	38.24 \pm 1.54	35.98 \pm 1.67	64.36 \pm 7.05	72.27 \pm 1.77	89.19 \pm 0.78
	<i>average</i>	55.83 \pm 1.37	54.10 \pm 0.11	56.01 \pm 0.10	55.44 \pm 0.58	56.08 \pm 2.00	64.00 \pm 0.30	83.53 \pm 0.29
CIFAR100	aquatic mammals	64.21 \pm 3.67	61.34 \pm 0.70	65.61 \pm 2.19	63.76 \pm 1.16	49.45 \pm 2.51	54.87 \pm 1.73	75.45 \pm 2.51
	fish	63.53 \pm 3.38	57.71 \pm 1.17	64.65 \pm 1.38	60.61 \pm 2.92	43.67 \pm 3.19	56.08 \pm 1.51	69.72 \pm 1.69
	flowers	37.26 \pm 9.90	38.46 \pm 1.95	35.15 \pm 1.80	36.16 \pm 4.81	64.37 \pm 6.98	55.77 \pm 1.87	77.44 \pm 0.72
	food containers	61.06 \pm 5.31	57.61 \pm 1.67	63.25 \pm 0.96	59.11 \pm 2.01	50.12 \pm 2.28	48.60 \pm 2.97	80.03 \pm 1.44
	fruit and vegetables	50.21 \pm 4.25	42.54 \pm 1.95	53.08 \pm 1.97	41.96 \pm 5.07	62.67 \pm 7.49	53.85 \pm 2.59	76.17 \pm 1.38
	household electrical devices	52.50 \pm 3.31	43.65 \pm 0.47	52.18 \pm 5.58	46.37 \pm 2.02	48.37 \pm 2.48	49.04 \pm 0.97	63.25 \pm 2.31
	household furniture	59.89 \pm 4.51	52.25 \pm 1.04	62.48 \pm 1.68	53.67 \pm 2.66	52.23 \pm 4.69	46.60 \pm 1.03	80.08 \pm 0.98
	inserts	48.57 \pm 2.52	52.56 \pm 2.03	46.68 \pm 1.27	49.33 \pm 4.21	49.26 \pm 2.34	52.70 \pm 0.83	72.60 \pm 0.94
	large carnivores	54.25 \pm 3.41	57.01 \pm 2.21	50.74 \pm 2.87	59.44 \pm 3.12	61.05 \pm 0.75	61.26 \pm 3.29	86.23 \pm 1.09
	large man-made outdoor things	65.25 \pm 3.51	63.03 \pm 1.13	66.00 \pm 2.66	67.77 \pm 1.29	65.50 \pm 6.67	62.01 \pm 1.11	88.44 \pm 1.03
	large natural outdoor scenes	76.84 \pm 8.52	81.77 \pm 2.56	82.53 \pm 0.93	79.70 \pm 4.07	56.33 \pm 5.02	61.26 \pm 2.72	85.05 \pm 1.21
	large omnivores and herbivores	53.57 \pm 1.32	53.13 \pm 1.11	55.69 \pm 1.14	59.60 \pm 2.37	59.10 \pm 2.18	57.03 \pm 3.32	83.02 \pm 0.87
	medium-sized mammals	59.30 \pm 3.97	57.63 \pm 1.16	56.93 \pm 1.21	61.60 \pm 2.32	61.95 \pm 2.64	58.56 \pm 2.35	82.99 \pm 0.50
	non-insert invertebrates	52.15 \pm 1.83	58.10 \pm 0.90	51.55 \pm 0.74	53.07 \pm 1.33	47.09 \pm 2.04	50.52 \pm 1.38	62.62 \pm 1.52
	people	47.10 \pm 2.76	38.68 \pm 0.70	47.47 \pm 1.57	45.05 \pm 1.35	54.60 \pm 2.37	53.95 \pm 2.20	89.23 \pm 0.51
	reptiles	55.48 \pm 0.85	57.29 \pm 1.18	54.41 \pm 1.35	56.80 \pm 0.62	49.98 \pm 1.71	52.28 \pm 2.20	70.09 \pm 1.81
	small mammals	60.12 \pm 4.90	63.57 \pm 1.20	61.92 \pm 1.75	65.07 \pm 2.18	56.21 \pm 3.30	55.94 \pm 1.44	75.50 \pm 1.62
	trees	57.28 \pm 5.18	65.36 \pm 1.33	57.70 \pm 2.59	63.95 \pm 2.67	59.59 \pm 6.26	69.69 \pm 4.03	91.66 \pm 0.54
	vehicles 1	36.98 \pm 1.86	40.56 \pm 1.01	34.45 \pm 2.06	39.18 \pm 1.42	56.28 \pm 1.44	58.32 \pm 2.77	89.62 \pm 0.62
	vehicles 2	47.82 \pm 4.64	48.10 \pm 2.26	49.44 \pm 2.34	48.83 \pm 1.63	50.36 \pm 2.52	54.38 \pm 0.38	84.96 \pm 1.15
	<i>average</i>	55.17 \pm 1.51	54.52 \pm 0.40	55.59 \pm 0.68	55.55 \pm 0.81	54.91 \pm 0.74	55.63 \pm 0.21	79.21 \pm 0.29
SVHN	0	50.61 \pm 1.80	58.86 \pm 1.51	51.59 \pm 1.06	52.16 \pm 1.70	49.83 \pm 0.99	78.89 \pm 1.65	73.51 \pm 1.19
	1	56.45 \pm 1.86	60.91 \pm 1.43	56.54 \pm 2.10	57.97 \pm 1.86	49.75 \pm 0.33	66.66 \pm 1.28	72.50 \pm 1.26
	2	51.17 \pm 0.91	54.70 \pm 1.43	51.44 \pm 1.34	52.15 \pm 0.89	49.68 \pm 1.08	73.45 \pm 1.54	91.63 \pm 0.45
	3	50.51 \pm 0.49	52.18 \pm 0.58	49.96 \pm 0.77	50.88 \pm 0.86	50.95 \pm 0.56	68.46 \pm 2.44	87.44 \pm 0.23
	4	52.18 \pm 1.50	56.26 \pm 1.50	52.47 \pm 0.67	54.94 \pm 0.69	49.53 \pm 1.33	70.15 \pm 3.21	92.54 \pm 0.39
	5	49.06 \pm 0.79	52.15 \pm 1.04	48.49 \pm 1.05	49.59 \pm 0.87	50.44 \pm 1.03	74.63 \pm 3.12	92.05 \pm 0.38
	6	49.86 \pm 1.09	51.21 \pm 1.38	48.11 \pm 1.01	50.11 \pm 0.57	50.55 \pm 1.92	75.12 \pm 2.22	89.94 \pm 0.37
	7	51.91 \pm 0.47	57.12 \pm 0.92	53.15 \pm 1.16	52.41 \pm 1.61	48.85 \pm 1.97	78.91 \pm 3.34	93.26 \pm 0.30
	8	49.42 \pm 1.40	53.38 \pm 1.17	48.03 \pm 1.37	49.79 \pm 1.56	49.51 \pm 0.68	69.96 \pm 2.11	77.24 \pm 2.22
	9	50.77 \pm 0.67	53.57 \pm 0.79	49.83 \pm 0.62	51.39 \pm 0.51	50.98 \pm 1.33	77.23 \pm 1.17	90.00 \pm 0.35
	<i>average</i>	51.20 \pm 0.37	55.03 \pm 0.67	50.96 \pm 0.59	52.14 \pm 0.56	50.00 \pm 0.45	73.35 \pm 0.62	86.01 \pm 0.18

Table 3: AUROC (%) when $\rho = 0.15$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	48.20 \pm 5.76	88.03 \pm 1.81	61.63 \pm 17.32	54.03 \pm 5.75	74.75 \pm 24.67	89.48 \pm 2.75	91.42 \pm 0.29
	1	98.75 \pm 0.33	99.22 \pm 0.14	87.47 \pm 9.82	98.93 \pm 0.17	80.34 \pm 29.29	96.14 \pm 0.61	91.94 \pm 0.87
	2	51.38 \pm 4.00	71.94 \pm 1.99	55.99 \pm 6.25	53.31 \pm 3.83	49.72 \pm 4.39	89.60 \pm 0.78	92.33 \pm 0.24
	3	55.72 \pm 2.85	79.23 \pm 2.30	66.26 \pm 8.38	64.73 \pm 1.44	56.79 \pm 9.84	93.83 \pm 0.49	96.89 \pm 0.13
	4	68.00 \pm 2.40	80.53 \pm 1.20	69.45 \pm 9.19	72.22 \pm 1.06	65.42 \pm 11.04	94.38 \pm 0.75	94.50 \pm 0.32
	5	55.61 \pm 3.69	85.37 \pm 0.98	58.19 \pm 2.84	51.99 \pm 6.43	54.14 \pm 4.10	89.39 \pm 1.09	90.41 \pm 0.55
	6	66.14 \pm 3.38	88.75 \pm 1.94	60.31 \pm 11.78	69.38 \pm 1.35	57.53 \pm 12.61	96.21 \pm 0.24	96.38 \pm 0.14
	7	75.57 \pm 5.34	91.47 \pm 0.59	77.40 \pm 2.35	80.66 \pm 2.86	62.94 \pm 16.16	92.70 \pm 1.00	92.49 \pm 0.08
	8	46.34 \pm 4.51	71.36 \pm 1.37	58.80 \pm 9.70	49.18 \pm 5.09	54.19 \pm 5.41	84.48 \pm 1.26	87.49 \pm 0.94
	9	73.01 \pm 2.44	89.10 \pm 0.87	69.74 \pm 5.35	75.23 \pm 3.18	63.72 \pm 8.46	94.98 \pm 0.53	94.60 \pm 0.39
	<i>average</i>	63.87 \pm 0.96	84.50 \pm 0.32	66.52 \pm 2.72	66.97 \pm 1.77	61.95 \pm 2.81	92.12 \pm 0.45	92.85 \pm 0.15
Fashion-MNIST	t-shirt	60.61 \pm 3.73	84.49 \pm 0.56	64.85 \pm 2.07	70.40 \pm 3.24	54.69 \pm 14.71	86.86 \pm 0.40	92.19 \pm 0.32
	trouser	95.42 \pm 0.57	95.67 \pm 0.86	93.12 \pm 1.51	96.41 \pm 0.56	51.66 \pm 15.28	97.36 \pm 0.65	97.48 \pm 0.14
	pullover	59.83 \pm 6.78	81.61 \pm 0.66	60.95 \pm 5.63	65.04 \pm 6.54	51.20 \pm 12.41	89.00 \pm 0.63	91.73 \pm 0.85
	dress	75.63 \pm 1.67	82.62 \pm 1.51	73.70 \pm 1.81	75.31 \pm 3.97	59.73 \pm 10.67	89.44 \pm 0.99	87.66 \pm 1.04
	coat	64.16 \pm 1.92	81.28 \pm 1.25	60.31 \pm 2.28	65.96 \pm 8.46	53.04 \pm 17.50	89.34 \pm 0.66	90.74 \pm 0.40
	sandal	69.33 \pm 2.03	63.26 \pm 1.67	72.39 \pm 1.27	71.89 \pm 4.61	82.14 \pm 12.76	86.01 \pm 1.63	92.63 \pm 0.45
	shirt	51.55 \pm 2.41	75.81 \pm 0.87	52.37 \pm 1.37	62.19 \pm 5.14	49.20 \pm 4.68	81.49 \pm 0.85	82.85 \pm 0.55
	sneaker	87.78 \pm 3.06	90.94 \pm 0.86	88.48 \pm 2.18	89.97 \pm 1.96	60.34 \pm 18.65	98.04 \pm 0.36	98.94 \pm 0.20
	bag	43.85 \pm 8.22	61.98 \pm 1.95	44.98 \pm 2.90	46.16 \pm 8.05	47.70 \pm 11.69	77.60 \pm 2.37	89.44 \pm 0.86
	ankle-boot	76.88 \pm 4.26	81.43 \pm 2.67	70.67 \pm 2.30	78.04 \pm 2.70	69.76 \pm 12.80	98.12 \pm 0.28	99.34 \pm 0.08
	<i>average</i>	68.50 \pm 1.66	79.91 \pm 0.56	68.18 \pm 0.81	72.14 \pm 0.89	57.95 \pm 6.79	89.33 \pm 0.20	92.30 \pm 0.10
CIFAR10	airplane	72.24 \pm 3.19	62.41 \pm 1.45	72.02 \pm 0.77	64.64 \pm 2.13	52.56 \pm 6.24	52.05 \pm 1.46	76.93 \pm 0.48
	automobile	37.28 \pm 2.39	32.54 \pm 0.73	37.84 \pm 1.11	33.26 \pm 2.21	61.53 \pm 2.87	70.47 \pm 2.94	93.42 \pm 0.66
	bird	61.74 \pm 1.33	65.88 \pm 0.38	64.73 \pm 0.73	66.80 \pm 0.89	46.26 \pm 4.70	52.68 \pm 1.72	69.16 \pm 0.92
	cat	58.60 \pm 1.14	52.07 \pm 0.89	59.94 \pm 0.46	55.47 \pm 1.10	52.13 \pm 2.25	54.22 \pm 2.06	66.28 \pm 1.22
	deer	62.84 \pm 2.50	70.29 \pm 0.73	62.08 \pm 0.20	70.04 \pm 1.89	53.80 \pm 2.75	63.81 \pm 1.51	80.24 \pm 0.48
	dog	57.39 \pm 1.72	50.61 \pm 0.75	60.37 \pm 1.14	55.09 \pm 1.87	53.00 \pm 1.99	62.91 \pm 1.67	80.15 \pm 1.34
	frog	52.43 \pm 3.20	61.39 \pm 0.69	43.62 \pm 1.86	55.69 \pm 1.91	60.94 \pm 4.26	63.55 \pm 1.85	78.37 \pm 1.21
	horse	47.64 \pm 0.85	46.02 \pm 0.80	50.09 \pm 0.81	48.50 \pm 0.61	57.69 \pm 4.33	68.98 \pm 2.44	89.37 \pm 0.86
	ship	70.92 \pm 3.31	66.50 \pm 1.01	72.76 \pm 1.13	67.00 \pm 5.70	54.72 \pm 13.11	67.87 \pm 3.79	90.85 \pm 0.51
	truck	40.12 \pm 4.11	32.59 \pm 0.92	39.61 \pm 0.65	34.06 \pm 2.38	60.97 \pm 4.48	69.26 \pm 1.54	88.49 \pm 0.67
	<i>average</i>	56.12 \pm 0.47	54.03 \pm 0.08	56.31 \pm 0.22	55.06 \pm 0.63	55.36 \pm 0.54	62.58 \pm 0.76	81.33 \pm 0.27
CIFAR100	aquatic mammals	64.76 \pm 1.48	61.36 \pm 1.32	65.65 \pm 1.03	64.54 \pm 0.90	49.52 \pm 1.87	57.00 \pm 2.34	74.54 \pm 1.32
	fish	65.21 \pm 0.92	58.83 \pm 0.69	63.43 \pm 0.75	60.55 \pm 1.93	43.35 \pm 5.10	56.08 \pm 0.65	70.39 \pm 0.89
	flowers	35.86 \pm 3.60	34.66 \pm 1.16	33.76 \pm 2.31	35.15 \pm 4.08	59.45 \pm 9.27	55.77 \pm 1.15	76.84 \pm 2.26
	food containers	61.67 \pm 1.81	59.74 \pm 0.59	60.94 \pm 0.79	57.54 \pm 2.76	47.03 \pm 1.06	52.25 \pm 1.91	77.87 \pm 0.79
	fruit and vegetables	52.51 \pm 4.58	44.93 \pm 1.14	52.60 \pm 1.57	48.55 \pm 4.36	58.92 \pm 8.45	54.07 \pm 2.50	74.51 \pm 1.61
	household electrical devices	52.64 \pm 2.22	43.85 \pm 0.87	56.27 \pm 1.07	45.34 \pm 2.26	51.85 \pm 4.27	50.16 \pm 1.12	62.57 \pm 2.45
	household furniture	59.55 \pm 2.31	54.00 \pm 1.83	64.79 \pm 1.63	55.87 \pm 2.88	51.45 \pm 5.34	47.99 \pm 1.41	78.98 \pm 1.07
	inserts	49.74 \pm 3.41	50.17 \pm 1.39	45.83 \pm 1.37	48.83 \pm 0.98	49.61 \pm 5.28	52.53 \pm 1.56	71.86 \pm 0.88
	large carnivores	49.29 \pm 1.79	54.29 \pm 2.52	52.95 \pm 1.30	54.58 \pm 0.47	59.94 \pm 1.74	59.70 \pm 1.83	84.97 \pm 2.15
	large man-made outdoor things	63.75 \pm 2.18	62.99 \pm 1.15	69.23 \pm 1.25	66.91 \pm 2.11	63.31 \pm 4.17	63.42 \pm 3.07	88.10 \pm 0.87
	large natural outdoor scenes	82.94 \pm 1.20	81.92 \pm 1.35	80.87 \pm 0.52	82.24 \pm 1.56	51.00 \pm 3.40	56.81 \pm 6.28	83.81 \pm 0.75
	large omnivores and herbivores	53.23 \pm 1.23	51.65 \pm 0.47	58.33 \pm 0.78	56.39 \pm 2.05	58.92 \pm 2.88	54.93 \pm 1.52	81.51 \pm 1.31
	medium-sized mammals	53.45 \pm 4.20	55.41 \pm 1.11	56.76 \pm 1.17	60.14 \pm 1.99	60.68 \pm 1.91	57.72 \pm 2.14	81.26 \pm 1.44
	non-insert invertebrates	51.75 \pm 1.41	56.54 \pm 0.83	49.94 \pm 1.08	53.14 \pm 0.69	47.63 \pm 1.87	49.60 \pm 0.85	59.93 \pm 1.01
	people	47.20 \pm 1.90	39.39 \pm 0.75	48.55 \pm 1.37	44.22 \pm 1.31	56.19 \pm 3.39	51.79 \pm 2.71	88.26 \pm 1.28
	reptiles	51.82 \pm 1.87	55.31 \pm 1.02	53.02 \pm 1.52	55.61 \pm 0.64	49.80 \pm 2.43	53.97 \pm 2.13	68.07 \pm 2.21
	small mammals	59.50 \pm 2.27	62.28 \pm 1.39	61.31 \pm 1.25	65.04 \pm 1.78	55.69 \pm 3.04	57.72 \pm 2.59	73.37 \pm 1.51
	trees	59.88 \pm 2.13	63.23 \pm 1.62	58.18 \pm 2.71	62.42 \pm 1.25	60.98 \pm 5.25	69.51 \pm 2.78	91.13 \pm 0.80
	vehicles 1	36.12 \pm 1.18	36.96 \pm 1.09	37.99 \pm 1.50	36.98 \pm 1.82	58.17 \pm 2.02	56.77 \pm 2.47	89.05 \pm 0.79
	vehicles 2	47.38 \pm 2.69	45.91 \pm 1.65	51.48 \pm 1.50	46.81 \pm 0.91	51.43 \pm 3.29	52.79 \pm 1.67	84.14 \pm 0.97
	<i>average</i>	54.91 \pm 0.23	53.67 \pm 0.45	56.09 \pm 0.45	55.04 \pm 0.44	54.25 \pm 0.68	55.53 \pm 0.48	78.06 \pm 0.42
SVHN	0	51.13 \pm 1.69	57.53 \pm 0.73	51.67 \pm 0.87	53.24 \pm 1.27	49.77 \pm 1.08	77.38 \pm 2.97	68.03 \pm 2.17
	1	54.35 \pm 1.78	59.87 \pm 0.60	56.24 \pm 1.61	56.86 \pm 0.53	49.25 \pm 0.99	65.39 \pm 2.59	69.19 \pm 1.81
	2	51.19 \pm 0.90	54.09 \pm 0.90	51.25 \pm 0.52	52.58 \pm 1.07	49.50 \pm 0.76	72.52 \pm 3.46	90.04 \pm 0.78
	3	50.00 \pm 0.67	51.43 \pm 0.27	49.20 \pm 0.62	49.85 \pm 0.55	50.42 \pm 0.46	67.13 \pm 2.24	85.95 \pm 0.28
	4	52.42 \pm 0.83	55.14 \pm 1.47	52.84 \pm 0.46	54.28 \pm 1.09	49.50 \pm 1.11	69.07 \pm 1.75	90.45 \pm 0.36
	5	49.81 \pm 0.56	51.99 \pm 0.33	48.84 \pm 0.56	50.42 \pm 0.39	49.94 \pm 0.46	69.14 \pm 2.21	90.59 \pm 0.19
	6	49.28 \pm 0.98	51.12 \pm 0.52	47.83 \pm 0.87	49.74 \pm 0.57	50.01 \pm 0.43	71.52 \pm 1.43	87.92 \pm 0.29
	7	53.95 \pm 0.97	56.44 \pm 0.59	53.54 \pm 0.78	54.45 \pm 0.53	49.87 \pm 0.78	77.60 \pm 1.34	91.38 \pm 0.49
	8	49.22 \pm 1.07	52.60 \pm 1.06	48.46 \pm 0.80	49.94 \pm 1.10	50.52 \pm 1.06	69.52 \pm 2.47	71.38 \pm 1.43
	9	50.41 \pm 0.85	53.13 \pm 0.72	49.79 \pm 0.59	51.10 \pm 0.78	50.75 \pm 1.37	73.13 \pm 1.64	88.30 \pm 0.56
	<i>average</i>	51.18 \pm 0.38	54.33 \pm 0.33	50.97 \pm 0.23	52.24 \pm 0.26	49.95 \pm 0.25	71.24 \pm 0.38	83.32 \pm 0.46

Table 4: AUROC (%) when $\rho = 0.2$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	47.40 \pm 5.97	87.03 \pm 3.48	57.02 \pm 9.40	52.81 \pm 6.82	70.39 \pm 26.55	86.53 \pm 2.71	89.26 \pm 0.64
	1	98.77 \pm 0.21	99.16 \pm 0.15	90.07 \pm 12.60	98.78 \pm 0.08	89.85 \pm 12.77	94.51 \pm 0.61	87.63 \pm 1.13
	2	49.47 \pm 4.52	69.93 \pm 2.67	51.93 \pm 7.26	53.36 \pm 4.15	50.75 \pm 1.82	86.21 \pm 1.10	90.71 \pm 0.45
	3	58.64 \pm 4.61	79.21 \pm 1.22	71.82 \pm 10.77	62.89 \pm 2.87	60.84 \pm 10.12	91.24 \pm 1.15	96.25 \pm 0.09
	4	69.64 \pm 3.14	78.71 \pm 1.41	70.44 \pm 5.44	71.95 \pm 2.05	66.32 \pm 13.11	93.71 \pm 0.35	92.90 \pm 0.36
	5	58.58 \pm 2.31	72.34 \pm 1.30	57.21 \pm 4.44	58.67 \pm 2.29	54.22 \pm 2.29	88.67 \pm 0.66	88.73 \pm 0.71
	6	62.92 \pm 1.65	87.52 \pm 2.09	63.89 \pm 8.90	65.40 \pm 3.01	72.08 \pm 15.48	95.03 \pm 0.81	95.75 \pm 0.12
	7	78.79 \pm 3.42	88.67 \pm 0.88	74.75 \pm 7.94	80.94 \pm 1.13	76.95 \pm 8.80	91.57 \pm 0.84	91.76 \pm 0.29
	8	44.17 \pm 2.43	66.18 \pm 1.89	65.30 \pm 6.30	51.03 \pm 2.28	55.42 \pm 11.44	83.32 \pm 0.73	86.00 \pm 0.80
	9	71.28 \pm 1.91	86.47 \pm 1.87	70.10 \pm 5.64	74.20 \pm 1.39	61.99 \pm 9.79	93.86 \pm 0.66	94.14 \pm 0.29
Fashion-MNIST	average	63.97 \pm 1.00	81.52 \pm 0.86	67.25 \pm 2.07	67.00 \pm 0.69	65.88 \pm 2.89	90.46 \pm 0.28	91.31 \pm 0.16
	t-shirt	52.15 \pm 7.19	82.04 \pm 1.37	60.33 \pm 4.96	70.86 \pm 2.05	62.36 \pm 19.64	86.52 \pm 0.65	90.76 \pm 0.48
	trouser	94.83 \pm 0.63	94.72 \pm 0.27	90.36 \pm 4.71	95.39 \pm 0.93	77.39 \pm 14.51	96.88 \pm 0.45	96.68 \pm 0.18
	pullover	57.76 \pm 2.09	79.12 \pm 1.32	59.91 \pm 2.98	68.59 \pm 3.36	41.03 \pm 9.34	87.98 \pm 0.42	91.37 \pm 0.48
	dress	69.04 \pm 4.36	80.17 \pm 0.87	75.28 \pm 1.84	74.12 \pm 2.56	82.69 \pm 3.28	86.21 \pm 1.13	84.58 \pm 0.47
	coat	65.55 \pm 3.46	80.29 \pm 1.56	58.62 \pm 2.87	67.29 \pm 5.13	46.52 \pm 18.72	89.05 \pm 0.45	90.61 \pm 0.51
	sandal	62.53 \pm 6.39	59.14 \pm 1.43	69.98 \pm 3.09	62.00 \pm 6.63	83.05 \pm 4.82	83.26 \pm 2.43	91.09 \pm 0.85
	shirt	50.44 \pm 2.45	74.77 \pm 0.56	52.79 \pm 2.50	60.30 \pm 2.39	53.22 \pm 9.40	79.89 \pm 0.88	82.48 \pm 0.37
	sneaker	82.19 \pm 3.95	88.60 \pm 0.41	78.41 \pm 15.06	88.90 \pm 1.83	84.25 \pm 8.10	97.79 \pm 0.16	98.84 \pm 0.14
	bag	42.24 \pm 2.63	57.68 \pm 1.73	42.94 \pm 1.61	44.93 \pm 3.49	56.85 \pm 15.87	71.45 \pm 0.97	86.17 \pm 0.77
CIFAR10	ankle-boot	67.66 \pm 4.45	81.51 \pm 1.88	68.61 \pm 6.88	77.06 \pm 3.55	72.69 \pm 16.26	97.33 \pm 0.26	99.19 \pm 0.03
	average	64.44 \pm 1.81	77.81 \pm 0.61	65.72 \pm 1.93	70.94 \pm 1.13	66.00 \pm 4.96	87.64 \pm 0.28	91.18 \pm 0.15
	airplane	65.69 \pm 6.20	61.96 \pm 0.66	71.06 \pm 0.78	63.37 \pm 4.40	49.73 \pm 6.13	51.10 \pm 2.74	75.91 \pm 0.40
	automobile	39.08 \pm 4.45	32.72 \pm 0.94	37.67 \pm 1.04	31.94 \pm 1.36	61.93 \pm 2.17	66.55 \pm 3.87	92.74 \pm 0.59
	bird	62.61 \pm 2.37	65.86 \pm 0.69	65.49 \pm 0.57	67.51 \pm 0.82	47.19 \pm 5.58	53.55 \pm 2.95	66.29 \pm 1.05
	cat	58.02 \pm 2.31	51.92 \pm 0.86	58.95 \pm 0.44	54.70 \pm 2.24	53.12 \pm 1.50	53.53 \pm 3.16	61.47 \pm 2.24
	deer	62.10 \pm 2.45	69.89 \pm 0.64	62.16 \pm 0.93	70.11 \pm 0.72	52.27 \pm 5.44	61.49 \pm 2.07	78.33 \pm 1.00
	dog	55.38 \pm 2.20	50.49 \pm 0.67	59.97 \pm 0.36	54.66 \pm 0.72	54.45 \pm 4.28	60.45 \pm 1.55	77.15 \pm 1.95
	frog	49.61 \pm 4.28	61.16 \pm 0.35	42.92 \pm 1.63	53.48 \pm 2.49	57.74 \pm 6.99	61.52 \pm 1.93	75.79 \pm 1.52
	horse	45.86 \pm 1.46	45.20 \pm 0.77	48.87 \pm 0.70	46.02 \pm 0.34	53.26 \pm 8.04	64.63 \pm 2.51	88.67 \pm 0.63
CIFAR100	ship	70.17 \pm 4.04	66.56 \pm 0.48	71.49 \pm 0.92	67.67 \pm 4.57	51.41 \pm 8.13	64.93 \pm 2.95	89.85 \pm 0.58
	truck	38.23 \pm 2.60	31.77 \pm 0.69	37.85 \pm 0.65	32.86 \pm 1.75	65.72 \pm 6.64	64.38 \pm 1.94	86.95 \pm 0.46
	average	54.67 \pm 1.18	53.75 \pm 0.10	55.64 \pm 0.32	54.23 \pm 0.89	54.68 \pm 0.70	60.21 \pm 0.82	79.32 \pm 0.16
	aquatic mammals	65.03 \pm 2.19	61.19 \pm 1.11	66.23 \pm 1.83	64.99 \pm 0.88	51.91 \pm 3.85	54.54 \pm 2.02	74.42 \pm 1.20
	fish	63.52 \pm 2.50	58.95 \pm 0.79	63.23 \pm 0.99	60.76 \pm 2.44	45.19 \pm 2.85	55.70 \pm 1.81	68.56 \pm 0.91
	flowers	35.24 \pm 2.94	34.65 \pm 0.81	33.00 \pm 1.40	36.57 \pm 4.25	62.87 \pm 5.93	53.80 \pm 1.25	77.16 \pm 1.34
	food containers	60.68 \pm 2.02	60.27 \pm 0.65	60.56 \pm 0.73	58.81 \pm 1.93	42.55 \pm 3.33	48.15 \pm 2.13	76.41 \pm 1.16
	fruit and vegetables	51.40 \pm 4.99	43.92 \pm 1.18	52.71 \pm 0.69	45.91 \pm 2.84	60.61 \pm 3.85	51.89 \pm 1.39	73.18 \pm 1.06
	household electrical devices	50.91 \pm 1.41	43.34 \pm 0.49	55.87 \pm 0.62	45.86 \pm 2.80	49.73 \pm 2.81	49.49 \pm 2.28	60.99 \pm 1.60
	household furniture	58.24 \pm 2.97	54.19 \pm 0.35	63.86 \pm 0.59	57.46 \pm 2.15	47.54 \pm 3.38	47.38 \pm 1.13	78.01 \pm 1.65
CIFAR100	inserts	48.78 \pm 2.33	49.31 \pm 1.12	45.02 \pm 0.37	47.89 \pm 2.27	49.55 \pm 2.97	52.52 \pm 1.48	68.89 \pm 0.86
	large carnivores	49.30 \pm 3.77	53.34 \pm 1.47	52.04 \pm 1.69	55.09 \pm 2.51	57.76 \pm 2.22	56.10 \pm 1.13	83.77 \pm 1.83
	large man-made outdoor things	65.23 \pm 1.79	62.65 \pm 1.85	68.63 \pm 1.52	65.86 \pm 1.12	59.61 \pm 7.38	61.25 \pm 4.10	87.65 \pm 0.55
	large natural outdoor scenes	79.64 \pm 2.47	81.86 \pm 1.04	79.54 \pm 0.92	80.81 \pm 2.54	49.87 \pm 3.88	57.45 \pm 1.92	83.32 \pm 0.75
	large omnivores and herbivores	53.34 \pm 2.10	51.87 \pm 1.01	58.39 \pm 1.23	57.22 \pm 1.00	58.69 \pm 2.23	55.98 \pm 2.14	80.57 \pm 0.71
	medium-sized mammals	53.87 \pm 2.03	55.62 \pm 1.74	56.76 \pm 1.73	61.91 \pm 2.92	61.36 \pm 2.37	58.52 \pm 1.34	80.11 \pm 1.51
	non-insert invertebrates	51.48 \pm 1.79	56.30 \pm 1.18	49.33 \pm 0.75	53.20 \pm 1.36	46.49 \pm 2.26	50.06 \pm 1.73	59.03 \pm 0.80
	people	49.22 \pm 2.67	39.42 \pm 1.51	48.44 \pm 1.78	43.86 \pm 1.55	57.82 \pm 1.65	53.03 \pm 2.78	88.27 \pm 0.68
	reptiles	52.92 \pm 0.94	55.67 \pm 0.47	52.08 \pm 0.92	55.54 \pm 0.91	50.13 \pm 1.36	52.40 \pm 1.30	67.33 \pm 1.33
	small mammals	59.11 \pm 1.61	62.78 \pm 0.39	60.75 \pm 0.14	63.06 \pm 1.19	53.96 \pm 1.00	56.14 \pm 1.37	71.88 \pm 0.98
SVHN	trees	58.00 \pm 3.25	62.55 \pm 1.80	56.64 \pm 2.11	60.07 \pm 1.82	59.22 \pm 3.03	66.21 \pm 2.24	90.16 \pm 0.33
	vehicles 1	34.41 \pm 3.14	36.77 \pm 1.07	36.92 \pm 1.25	36.03 \pm 1.06	59.11 \pm 1.98	54.72 \pm 2.86	88.46 \pm 0.30
	vehicles 2	48.39 \pm 2.44	46.09 \pm 1.58	50.29 \pm 1.48	46.99 \pm 2.47	51.97 \pm 3.31	50.26 \pm 2.11	82.85 \pm 1.05
	average	54.44 \pm 0.92	53.54 \pm 0.42	55.51 \pm 0.34	54.89 \pm 0.56	53.80 \pm 0.61	54.28 \pm 0.34	77.05 \pm 0.17
	0	50.47 \pm 1.80	56.47 \pm 0.90	50.97 \pm 0.50	52.15 \pm 0.86	50.33 \pm 1.17	77.10 \pm 2.23	62.41 \pm 1.00
	1	54.42 \pm 1.08	59.45 \pm 0.63	55.67 \pm 0.65	55.82 \pm 0.81	49.15 \pm 0.57	63.49 \pm 1.81	65.99 \pm 0.86
	2	50.27 \pm 0.72	53.34 \pm 0.85	51.04 \pm 0.84	51.63 \pm 0.74	49.42 \pm 0.78	69.23 \pm 2.88	87.90 \pm 0.90
	3	49.65 \pm 0.32	51.32 \pm 0.76	48.95 \pm 0.26	50.14 \pm 0.57	50.33 \pm 0.48	62.81 \pm 0.89	84.68 \pm 0.54
	4	52.21 \pm 1.52	54.99 \pm 0.55	52.66 \pm 1.07	53.35 \pm 0.61	50.53 \pm 0.91	64.27 \pm 2.93	88.74 \pm 0.29
	5	49.06 \pm 1.05	51.97 \pm 0.53	48.93 \pm 0.28	50.10 \pm 0.86	50.00 \pm 0.73	67.25 \pm 3.35	89.37 \pm 0.34
SVHN	6	49.40 \pm 1.31	50.95 \pm 0.78	47.72 \pm 0.96	49.72 \pm 0.40	49.51 \pm 0.56	71.80 \pm 1.24	85.78 \pm 0.51
	7	53.06 \pm 0.93	55.60 \pm 0.86	52.89 \pm 0.48	53.46 \pm 1.84	49.50 \pm 1.03	73.55 \pm 3.72	90.20 \pm 0.36
	8	49.22 \pm 1.22	51.86 \pm 0.46	48.06 \pm 0.73	49.95 \pm 0.71	50.04 \pm 0.70	70.70 \pm 3.10	68.50 \pm 1.06
	9	49.56 \pm 1.09	54.22 \pm 0.32	49.57 \pm 0.44	51.18 \pm 0.77	51.07 \pm 0.56	72.19 \pm 1.58	86.18 \pm 0.52
	average	50.73 \pm 0.38	54.02 \pm 0.20	50.64 \pm 0.34	51.75 \pm 0.30	49.99 \pm 0.24	69.24 \pm 0.83	80.97 \pm 0.25

Table 5: AUROC (%) when $\rho = 0.25$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	44.50 \pm 5.86	83.08 \pm 2.45	61.27 \pm 9.24	49.53 \pm 3.85	64.22 \pm 24.96	84.20 \pm 1.42	85.52 \pm 1.74
	1	98.18 \pm 0.96	98.54 \pm 0.29	97.07 \pm 0.66	97.75 \pm 0.95	81.83 \pm 19.71	93.62 \pm 1.10	82.77 \pm 0.51
	2	46.92 \pm 2.16	64.45 \pm 2.93	57.49 \pm 7.90	52.42 \pm 3.46	45.93 \pm 6.86	82.79 \pm 1.32	89.74 \pm 0.57
	3	54.43 \pm 3.24	75.92 \pm 1.84	58.29 \pm 12.36	58.66 \pm 2.83	55.16 \pm 7.52	89.35 \pm 0.86	95.46 \pm 0.49
	4	63.21 \pm 3.60	77.60 \pm 1.80	62.12 \pm 2.29	68.82 \pm 2.90	65.82 \pm 14.37	91.76 \pm 0.37	92.42 \pm 0.35
	5	55.63 \pm 2.30	71.44 \pm 1.85	62.00 \pm 12.01	62.65 \pm 3.27	51.54 \pm 3.39	84.60 \pm 1.48	87.46 \pm 0.62
	6	60.05 \pm 3.85	84.12 \pm 1.14	57.92 \pm 10.02	68.12 \pm 3.35	59.33 \pm 17.67	93.04 \pm 0.97	95.13 \pm 0.27
	7	77.74 \pm 2.94	87.58 \pm 1.31	75.43 \pm 3.23	80.65 \pm 2.67	67.69 \pm 10.77	90.24 \pm 1.02	90.97 \pm 0.15
	8	38.03 \pm 5.44	67.08 \pm 2.50	44.06 \pm 4.47	41.77 \pm 1.98	53.44 \pm 4.44	81.74 \pm 1.37	84.24 \pm 0.62
	9	70.43 \pm 1.83	85.71 \pm 1.25	66.54 \pm 8.09	74.04 \pm 2.06	59.80 \pm 8.80	93.18 \pm 0.75	93.94 \pm 0.23
	<i>average</i>	60.91 \pm 0.90	79.55 \pm 0.35	64.22 \pm 3.40	65.44 \pm 0.47	60.48 \pm 2.17	88.45 \pm 0.30	89.77 \pm 0.25
Fashion-MNIST	t-shirt	51.35 \pm 5.03	82.35 \pm 0.65	61.18 \pm 7.42	65.58 \pm 4.53	62.07 \pm 20.08	85.13 \pm 1.59	89.58 \pm 0.64
	trouser	94.45 \pm 0.58	92.85 \pm 0.85	87.03 \pm 8.43	95.02 \pm 0.95	66.81 \pm 11.67	96.06 \pm 0.33	95.79 \pm 0.30
	pullover	51.09 \pm 2.75	79.38 \pm 0.85	59.24 \pm 2.50	67.71 \pm 2.89	41.70 \pm 13.02	87.12 \pm 0.60	91.06 \pm 0.61
	dress	70.15 \pm 2.27	79.68 \pm 0.96	73.83 \pm 1.22	73.57 \pm 2.90	53.85 \pm 16.78	84.23 \pm 1.75	83.23 \pm 0.50
	coat	61.87 \pm 6.75	78.71 \pm 0.37	57.67 \pm 1.63	67.58 \pm 2.44	48.46 \pm 9.78	89.15 \pm 0.77	89.94 \pm 0.22
	sandal	62.20 \pm 7.20	57.61 \pm 2.12	66.46 \pm 2.24	63.48 \pm 6.44	76.87 \pm 10.95	79.99 \pm 2.21	85.62 \pm 0.90
	shirt	48.71 \pm 2.60	73.97 \pm 0.76	52.32 \pm 2.02	62.51 \pm 3.12	55.12 \pm 5.27	78.60 \pm 0.59	81.35 \pm 0.20
	sneaker	82.02 \pm 2.40	87.01 \pm 0.92	85.73 \pm 3.35	85.86 \pm 1.50	73.12 \pm 27.97	97.13 \pm 0.35	98.77 \pm 0.12
	bag	38.24 \pm 6.38	55.94 \pm 1.52	42.14 \pm 2.58	40.97 \pm 5.54	49.15 \pm 8.40	64.85 \pm 3.36	81.84 \pm 0.79
	ankle-boot	68.29 \pm 5.62	77.23 \pm 3.00	67.48 \pm 2.54	74.06 \pm 3.69	56.02 \pm 26.03	96.20 \pm 0.50	98.94 \pm 0.04
	<i>average</i>	62.84 \pm 1.59	76.47 \pm 0.36	65.31 \pm 0.73	69.63 \pm 1.72	58.32 \pm 9.69	85.85 \pm 0.54	89.61 \pm 0.55
CIFAR10	airplane	68.18 \pm 3.42	61.77 \pm 1.12	70.68 \pm 1.08	62.92 \pm 3.98	46.75 \pm 8.26	49.26 \pm 1.13	73.72 \pm 1.03
	automobile	37.69 \pm 2.33	32.52 \pm 0.46	37.49 \pm 0.86	30.95 \pm 0.42	62.80 \pm 3.80	64.81 \pm 2.31	91.29 \pm 0.88
	bird	61.70 \pm 1.26	65.92 \pm 0.45	64.84 \pm 0.24	66.72 \pm 0.58	45.55 \pm 2.42	52.59 \pm 1.69	64.81 \pm 1.59
	cat	58.12 \pm 0.61	51.82 \pm 0.70	59.44 \pm 0.48	54.50 \pm 1.86	52.10 \pm 3.73	53.62 \pm 1.06	57.06 \pm 0.93
	deer	61.78 \pm 2.55	69.98 \pm 0.44	61.77 \pm 1.18	68.40 \pm 0.77	52.24 \pm 3.50	60.73 \pm 1.08	76.38 \pm 1.47
	dog	55.10 \pm 1.15	49.89 \pm 0.63	59.59 \pm 0.57	54.49 \pm 1.02	56.66 \pm 3.16	59.29 \pm 2.14	75.80 \pm 1.41
	frog	48.09 \pm 2.73	61.07 \pm 0.68	42.07 \pm 0.69	55.68 \pm 2.32	55.95 \pm 5.20	60.45 \pm 2.72	72.56 \pm 1.72
	horse	45.19 \pm 1.86	45.12 \pm 1.04	49.00 \pm 0.87	45.84 \pm 1.14	56.45 \pm 4.57	65.23 \pm 2.53	86.74 \pm 1.46
	ship	68.15 \pm 4.72	66.19 \pm 0.44	71.01 \pm 0.90	68.99 \pm 2.73	50.48 \pm 7.22	63.22 \pm 4.36	88.99 \pm 0.79
	truck	38.15 \pm 1.39	31.61 \pm 0.75	37.87 \pm 0.69	31.44 \pm 2.13	61.64 \pm 6.80	61.04 \pm 1.98	86.41 \pm 0.32
	<i>average</i>	54.21 \pm 0.72	53.59 \pm 0.12	55.38 \pm 0.27	53.99 \pm 0.33	54.06 \pm 2.00	59.02 \pm 0.77	77.37 \pm 0.20
CIFAR100	aquatic mammals	63.65 \pm 1.99	61.24 \pm 0.72	65.99 \pm 0.81	63.20 \pm 2.28	48.76 \pm 3.15	54.68 \pm 1.15	73.16 \pm 0.87
	fish	65.34 \pm 2.22	58.84 \pm 1.31	63.35 \pm 1.02	61.16 \pm 2.23	42.34 \pm 4.43	56.13 \pm 3.24	68.24 \pm 1.41
	flowers	33.31 \pm 2.29	34.94 \pm 0.93	32.12 \pm 0.85	36.28 \pm 3.20	53.53 \pm 10.34	56.32 \pm 2.77	74.20 \pm 1.50
	food containers	61.64 \pm 1.71	59.15 \pm 0.81	60.58 \pm 0.90	54.74 \pm 3.53	45.46 \pm 3.91	49.07 \pm 1.96	74.25 \pm 1.36
	fruit and vegetables	53.06 \pm 4.49	44.35 \pm 0.95	52.14 \pm 0.78	47.43 \pm 2.36	59.34 \pm 3.85	51.83 \pm 1.73	72.70 \pm 1.01
	household electrical devices	53.86 \pm 1.71	42.74 \pm 0.84	55.48 \pm 0.81	45.72 \pm 2.75	49.85 \pm 4.72	48.92 \pm 1.57	58.62 \pm 1.37
	household furniture	61.31 \pm 0.40	52.85 \pm 0.75	62.89 \pm 0.92	54.10 \pm 5.09	50.90 \pm 6.71	45.07 \pm 1.06	76.86 \pm 0.87
	inserts	46.16 \pm 2.05	49.31 \pm 0.78	45.08 \pm 0.77	46.89 \pm 1.90	46.74 \pm 3.78	53.48 \pm 1.43	67.86 \pm 0.70
	large carnivores	49.06 \pm 2.19	53.09 \pm 1.39	51.08 \pm 0.91	53.89 \pm 1.63	58.98 \pm 1.78	56.95 \pm 2.40	81.59 \pm 1.35
	large man-made outdoor things	63.98 \pm 5.13	62.29 \pm 1.26	68.30 \pm 1.36	65.69 \pm 2.70	62.44 \pm 2.67	57.60 \pm 1.61	88.01 \pm 0.51
	large natural outdoor scenes	81.47 \pm 0.92	81.20 \pm 0.25	79.50 \pm 0.52	80.08 \pm 1.68	49.68 \pm 5.38	59.53 \pm 1.74	83.34 \pm 0.80
	large omnivores and herbivores	52.35 \pm 2.08	51.90 \pm 0.73	56.70 \pm 0.85	56.45 \pm 1.33	57.75 \pm 3.62	54.23 \pm 1.16	80.64 \pm 1.09
	medium-sized mammals	55.50 \pm 1.74	54.86 \pm 0.82	55.15 \pm 1.34	58.00 \pm 1.76	58.99 \pm 1.67	56.15 \pm 1.40	77.84 \pm 0.78
	non-insert invertebrates	51.59 \pm 0.66	56.49 \pm 0.70	49.62 \pm 0.82	53.54 \pm 1.77	45.97 \pm 2.21	49.07 \pm 1.61	57.37 \pm 1.25
	people	47.30 \pm 1.64	38.96 \pm 1.39	48.49 \pm 1.48	43.11 \pm 2.73	57.04 \pm 2.56	51.35 \pm 2.03	86.00 \pm 0.87
	reptiles	52.25 \pm 1.05	55.74 \pm 0.41	52.07 \pm 0.71	56.29 \pm 1.33	49.14 \pm 3.40	53.49 \pm 1.24	67.28 \pm 0.72
	small mammals	60.15 \pm 1.55	62.96 \pm 0.51	59.96 \pm 0.99	64.62 \pm 0.67	53.91 \pm 2.25	54.96 \pm 1.17	71.26 \pm 0.52
	trees	58.89 \pm 3.12	62.31 \pm 1.14	56.51 \pm 1.33	63.35 \pm 1.93	59.46 \pm 1.49	63.09 \pm 1.23	90.00 \pm 0.48
	vehicles 1	33.99 \pm 0.89	36.68 \pm 1.03	36.75 \pm 1.52	38.95 \pm 2.38	56.58 \pm 2.49	52.23 \pm 2.79	88.20 \pm 0.56
	vehicles 2	47.13 \pm 2.39	45.81 \pm 0.77	50.12 \pm 1.11	46.82 \pm 2.45	49.54 \pm 2.44	49.46 \pm 2.38	83.05 \pm 0.95
	<i>average</i>	54.60 \pm 0.41	53.29 \pm 0.37	55.09 \pm 0.31	54.52 \pm 0.32	52.82 \pm 1.22	53.68 \pm 0.76	76.02 \pm 0.17
SVHN	0	50.62 \pm 0.10	56.24 \pm 0.72	50.53 \pm 0.80	52.28 \pm 0.45	50.13 \pm 0.66	74.71 \pm 0.83	56.63 \pm 1.28
	1	54.99 \pm 1.51	58.86 \pm 0.51	55.26 \pm 0.53	55.65 \pm 1.33	50.11 \pm 0.49	64.13 \pm 1.88	63.59 \pm 0.38
	2	51.19 \pm 0.82	52.71 \pm 0.85	50.87 \pm 0.67	51.81 \pm 0.93	50.11 \pm 0.58	65.21 \pm 1.07	86.58 \pm 0.73
	3	49.52 \pm 0.54	50.71 \pm 0.56	49.11 \pm 0.88	49.88 \pm 0.44	50.08 \pm 0.74	58.98 \pm 3.55	82.94 \pm 0.43
	4	51.83 \pm 0.91	54.57 \pm 0.50	52.52 \pm 0.63	53.38 \pm 0.18	50.59 \pm 0.68	62.90 \pm 2.15	87.40 \pm 0.91
	5	48.61 \pm 0.41	51.68 \pm 0.63	48.81 \pm 0.63	49.69 \pm 0.77	50.67 \pm 0.40	65.47 \pm 2.63	88.47 \pm 0.26
	6	48.83 \pm 0.74	50.65 \pm 0.80	47.90 \pm 1.04	49.14 \pm 0.67	49.79 \pm 0.47	68.29 \pm 2.31	84.30 \pm 0.42
	7	53.22 \pm 1.23	56.07 \pm 0.67	52.14 \pm 1.29	53.93 \pm 0.56	49.04 \pm 1.41	73.25 \pm 2.03	88.79 \pm 0.25
	8	48.55 \pm 0.77	52.08 \pm 0.41	48.56 \pm 0.96	50.06 \pm 0.58	50.56 \pm 0.47	67.52 \pm 1.78	64.92 \pm 1.14
	9	49.48 \pm 1.14	52.53 \pm 0.94	49.23 \pm 0.34	50.31 \pm 0.55	50.94 \pm 0.74	69.56 \pm 2.29	84.74 \pm 0.81
	<i>average</i>	50.68 \pm 0.20	53.61 \pm 0.17	50.49 \pm 0.35	51.61 \pm 0.17	50.20 \pm 0.25	67.00 \pm 0.71	78.84 \pm 0.26

Table 6: AUPR-in (%) (inliers as positive class) when $\rho = 0.05$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	94.08 \pm 0.52	99.58 \pm 0.06	95.02 \pm 0.68	96.22 \pm 0.61	97.23 \pm 2.65	99.55 \pm 0.07	99.79 \pm 0.02
	1	99.96 \pm 0.00	99.97 \pm 0.00	98.53 \pm 1.43	99.97 \pm 0.00	99.03 \pm 1.13	99.88 \pm 0.01	99.82 \pm 0.04
	2	94.89 \pm 0.90	98.21 \pm 0.26	96.65 \pm 1.86	95.34 \pm 0.66	94.85 \pm 1.97	99.68 \pm 0.04	99.66 \pm 0.03
	3	95.26 \pm 0.32	99.04 \pm 0.09	96.05 \pm 1.14	96.33 \pm 0.54	94.31 \pm 0.82	99.86 \pm 0.03	99.87 \pm 0.01
	4	96.26 \pm 0.62	98.94 \pm 0.30	96.68 \pm 0.94	96.83 \pm 0.22	96.49 \pm 0.64	99.78 \pm 0.04	99.81 \pm 0.02
	5	95.02 \pm 0.50	98.76 \pm 0.20	95.35 \pm 0.81	95.93 \pm 0.37	95.35 \pm 0.65	99.77 \pm 0.07	99.62 \pm 0.04
	6	96.53 \pm 0.71	99.41 \pm 0.09	96.28 \pm 1.45	97.15 \pm 0.54	95.10 \pm 1.91	99.92 \pm 0.02	99.86 \pm 0.01
	7	98.06 \pm 0.41	99.61 \pm 0.04	98.21 \pm 0.37	99.00 \pm 0.14	97.37 \pm 0.89	99.68 \pm 0.05	99.67 \pm 0.04
	8	92.59 \pm 1.01	97.99 \pm 0.19	93.56 \pm 1.22	93.29 \pm 0.84	95.46 \pm 0.86	99.31 \pm 0.21	99.29 \pm 0.06
	9	97.12 \pm 0.57	99.45 \pm 0.05	97.57 \pm 0.97	97.70 \pm 0.53	96.06 \pm 1.24	99.78 \pm 0.05	99.74 \pm 0.01
Fashion-MNIST	<i>average</i>	95.98 \pm 0.16	99.10 \pm 0.04	96.39 \pm 0.46	96.78 \pm 0.15	96.13 \pm 0.28	99.72 \pm 0.03	99.71 \pm 0.01
	t-shirt	97.05 \pm 0.59	99.19 \pm 0.07	97.21 \pm 0.95	98.43 \pm 0.12	96.53 \pm 1.91	99.41 \pm 0.10	99.64 \pm 0.04
	trouser	99.83 \pm 0.02	99.82 \pm 0.04	99.09 \pm 0.44	99.83 \pm 0.02	96.74 \pm 2.77	99.92 \pm 0.01	99.93 \pm 0.01
	pullover	96.61 \pm 0.99	98.88 \pm 0.12	96.97 \pm 0.59	97.89 \pm 0.45	95.05 \pm 1.85	99.08 \pm 0.17	99.24 \pm 0.18
	dress	98.50 \pm 0.20	99.17 \pm 0.15	98.24 \pm 0.28	98.50 \pm 0.27	97.95 \pm 1.42	99.43 \pm 0.05	99.54 \pm 0.05
	coat	97.58 \pm 0.39	98.70 \pm 0.18	96.19 \pm 0.45	97.67 \pm 0.52	95.82 \pm 1.10	99.19 \pm 0.09	99.23 \pm 0.15
	sandal	98.54 \pm 0.45	97.32 \pm 0.29	98.16 \pm 0.58	97.56 \pm 1.85	98.58 \pm 0.52	99.19 \pm 0.12	99.54 \pm 0.06
	shirt	96.09 \pm 0.70	98.53 \pm 0.12	96.05 \pm 0.32	97.75 \pm 0.19	96.42 \pm 0.92	98.47 \pm 0.15	98.85 \pm 0.10
	sneaker	99.62 \pm 0.09	99.66 \pm 0.08	99.42 \pm 0.14	99.66 \pm 0.05	86.98 \pm 18.99	99.92 \pm 0.02	99.95 \pm 0.02
	bag	94.86 \pm 0.94	97.40 \pm 0.22	94.72 \pm 0.40	96.41 \pm 0.71	94.56 \pm 1.07	99.45 \pm 0.07	99.75 \pm 0.03
CIFAR10	ankle-boot	98.98 \pm 0.21	99.47 \pm 0.07	98.19 \pm 0.40	99.14 \pm 0.20	96.83 \pm 2.15	99.92 \pm 0.01	99.97 \pm 0.01
	<i>average</i>	97.77 \pm 0.09	98.81 \pm 0.02	97.42 \pm 0.11	98.28 \pm 0.15	95.54 \pm 1.95	99.40 \pm 0.02	99.56 \pm 0.02
	airplane	97.45 \pm 0.32	96.74 \pm 0.12	97.82 \pm 0.09	96.96 \pm 0.40	95.30 \pm 1.25	96.04 \pm 0.40	98.44 \pm 0.16
	automobile	93.63 \pm 0.43	90.57 \pm 0.21	92.70 \pm 0.29	91.03 \pm 0.41	95.94 \pm 1.23	97.98 \pm 0.36	99.70 \pm 0.03
	bird	96.87 \pm 0.25	97.16 \pm 0.21	97.05 \pm 0.23	97.36 \pm 0.32	94.53 \pm 0.45	96.09 \pm 0.32	98.25 \pm 0.17
	cat	96.20 \pm 0.18	95.04 \pm 0.22	96.13 \pm 0.23	95.79 \pm 0.12	94.87 \pm 0.59	95.89 \pm 0.37	98.12 \pm 0.06
	deer	96.06 \pm 0.47	97.25 \pm 0.30	96.30 \pm 0.34	97.32 \pm 0.26	95.26 \pm 0.76	96.94 \pm 0.41	98.80 \pm 0.17
	dog	95.44 \pm 0.34	94.81 \pm 0.20	96.09 \pm 0.15	95.30 \pm 0.36	95.35 \pm 0.42	96.66 \pm 0.38	99.19 \pm 0.09
	frog	94.89 \pm 0.42	96.16 \pm 0.23	93.84 \pm 0.30	95.69 \pm 0.41	96.66 \pm 0.32	97.09 \pm 0.45	99.00 \pm 0.09
	horse	94.27 \pm 0.20	93.69 \pm 0.26	94.41 \pm 0.25	94.08 \pm 0.32	95.54 \pm 0.76	98.21 \pm 0.21	99.60 \pm 0.07
CIFAR100	ship	97.69 \pm 0.27	97.22 \pm 0.14	97.83 \pm 0.09	97.49 \pm 0.28	95.70 \pm 0.45	97.81 \pm 0.28	99.46 \pm 0.08
	truck	92.67 \pm 0.21	90.86 \pm 0.43	92.39 \pm 0.61	91.39 \pm 0.61	96.29 \pm 0.54	97.93 \pm 0.24	99.16 \pm 0.15
	<i>average</i>	95.52 \pm 0.14	94.95 \pm 0.07	95.46 \pm 0.09	95.24 \pm 0.09	95.54 \pm 0.22	97.06 \pm 0.06	98.97 \pm 0.04
	aquatic mammals	96.50 \pm 0.31	96.65 \pm 0.27	96.96 \pm 0.24	96.96 \pm 0.24	95.03 \pm 0.79	95.70 \pm 0.42	98.28 \pm 0.13
	fish	96.96 \pm 0.26	96.45 \pm 0.20	96.69 \pm 0.18	96.65 \pm 0.31	94.14 \pm 0.65	95.92 \pm 0.26	97.69 \pm 0.31
	flowers	93.46 \pm 0.45	92.20 \pm 0.27	92.31 \pm 0.68	92.22 \pm 1.12	96.90 \pm 1.25	95.67 \pm 0.21	98.43 \pm 0.24
	food containers	96.69 \pm 0.54	96.52 \pm 0.39	96.92 \pm 0.11	96.66 \pm 0.25	94.60 \pm 0.53	95.59 \pm 0.40	98.92 \pm 0.08
	fruit and vegetables	95.91 \pm 0.72	94.14 \pm 0.30	95.73 \pm 0.31	94.37 \pm 0.59	97.14 \pm 0.24	95.43 \pm 0.57	98.47 \pm 0.08
	household electrical devices	95.54 \pm 0.20	94.08 \pm 0.50	95.96 \pm 0.30	94.78 \pm 0.38	94.94 \pm 0.31	94.89 \pm 0.63	97.02 \pm 0.24
	household furniture	96.41 \pm 0.54	95.43 \pm 0.35	97.07 \pm 0.31	95.69 \pm 0.49	94.99 \pm 1.06	95.12 \pm 0.40	98.87 \pm 0.07
CIFAR100	inserts	94.87 \pm 0.38	94.77 \pm 0.35	94.42 \pm 0.34	94.73 \pm 0.28	95.27 \pm 0.20	95.38 \pm 0.58	98.22 \pm 0.12
	large carnivores	94.46 \pm 0.37	95.14 \pm 0.53	94.78 \pm 0.31	95.37 \pm 0.63	96.08 \pm 0.46	96.47 \pm 0.31	99.18 \pm 0.15
	large man-made outdoor things	96.64 \pm 0.40	96.47 \pm 0.58	97.25 \pm 0.57	96.72 \pm 0.68	95.95 \pm 1.06	97.27 \pm 0.16	99.17 \pm 0.24
	large natural outdoor scenes	98.86 \pm 0.11	98.74 \pm 0.23	98.68 \pm 0.09	98.70 \pm 0.15	95.23 \pm 1.16	96.71 \pm 0.30	99.10 \pm 0.06
	large omnivores and herbivores	94.42 \pm 0.40	94.81 \pm 0.57	95.17 \pm 0.34	95.39 \pm 0.59	95.80 \pm 0.23	95.88 \pm 0.14	98.91 \pm 0.03
	medium-sized mammals	95.93 \pm 0.31	95.76 \pm 0.28	96.20 \pm 0.43	96.36 \pm 0.46	96.23 \pm 0.41	96.03 \pm 0.16	98.92 \pm 0.11
	non-insert invertebrates	95.76 \pm 0.21	96.36 \pm 0.23	95.51 \pm 0.15	96.11 \pm 0.18	94.95 \pm 0.41	95.02 \pm 0.20	96.96 \pm 0.21
	people	94.11 \pm 0.31	92.71 \pm 0.56	94.25 \pm 0.30	93.15 \pm 0.51	95.96 \pm 0.38	95.79 \pm 0.56	99.45 \pm 0.06
	reptiles	95.28 \pm 0.22	95.88 \pm 0.28	95.27 \pm 0.14	95.92 \pm 0.31	94.72 \pm 0.57	95.35 \pm 0.42	97.41 \pm 0.52
	small mammals	95.74 \pm 0.50	96.40 \pm 0.20	96.13 \pm 0.30	96.60 \pm 0.23	95.39 \pm 0.68	96.17 \pm 0.14	98.14 \pm 0.08
SVHN	trees	96.16 \pm 0.81	96.17 \pm 0.47	95.46 \pm 0.57	96.09 \pm 0.45	95.74 \pm 0.66	98.11 \pm 0.25	99.52 \pm 0.04
	vehicles 1	92.11 \pm 0.53	92.10 \pm 0.39	92.13 \pm 0.77	92.35 \pm 0.61	96.00 \pm 0.48	96.54 \pm 0.37	99.28 \pm 0.05
	vehicles 2	94.62 \pm 0.23	94.36 \pm 0.18	95.38 \pm 0.27	94.52 \pm 0.19	95.04 \pm 0.90	96.12 \pm 0.62	98.89 \pm 0.15
	<i>average</i>	95.52 \pm 0.11	95.26 \pm 0.08	95.61 \pm 0.13	95.47 \pm 0.13	95.51 \pm 0.09	95.96 \pm 0.09	98.54 \pm 0.03
	0	95.40 \pm 0.32	96.49 \pm 0.21	95.51 \pm 0.23	95.25 \pm 0.12	94.87 \pm 0.27	98.39 \pm 0.11	98.44 \pm 0.19
	1	95.64 \pm 0.16	96.49 \pm 0.09	95.80 \pm 0.32	96.14 \pm 0.21	94.71 \pm 0.38	97.42 \pm 0.35	98.49 \pm 0.09
	2	95.13 \pm 0.29	95.56 \pm 0.16	94.94 \pm 0.12	95.32 \pm 0.16	94.92 \pm 0.32	98.46 \pm 0.25	99.62 \pm 0.03
	3	94.95 \pm 0.17	95.32 \pm 0.11	94.94 \pm 0.23	95.01 \pm 0.21	95.04 \pm 0.17	97.84 \pm 0.23	99.38 \pm 0.05
	4	95.31 \pm 0.17	96.02 \pm 0.16	95.47 \pm 0.10	95.50 \pm 0.15	94.97 \pm 0.31	98.29 \pm 0.23	99.68 \pm 0.01
	5	94.90 \pm 0.17	95.48 \pm 0.13	94.75 \pm 0.30	95.06 \pm 0.17	95.22 \pm 0.17	98.23 \pm 0.24	99.61 \pm 0.03
SVHN	6	95.03 \pm 0.20	95.44 \pm 0.21	94.73 \pm 0.10	95.03 \pm 0.08	94.87 \pm 0.21	98.59 \pm 0.14	99.50 \pm 0.03
	7	95.61 \pm 0.24	96.03 \pm 0.16	95.36 \pm 0.22	95.57 \pm 0.35	94.90 \pm 0.25	99.03 \pm 0.07	99.73 \pm 0.01
	8	94.90 \pm 0.25	95.67 \pm 0.21	95.00 \pm 0.26	95.17 \pm 0.21	94.94 \pm 0.29	97.39 \pm 0.35	98.68 \pm 0.13
	9	95.00 \pm 0.10	95.41 \pm 0.26	94.83 \pm 0.14	95.23 \pm 0.18	95.03 \pm 0.13	98.66 \pm 0.11	99.55 \pm 0.05
	<i>average</i>	95.19 \pm 0.06	95.79 \pm 0.08	95.13 \pm 0.04	95.33 \pm 0.05	94.95 \pm 0.09	98.23 \pm 0.03	99.27 \pm 0.03

Table 7: AUPR-in (%) (inliers as positive class) when $\rho = 0.1$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	88.93 \pm 1.38	98.76 \pm 0.31	90.84 \pm 4.12	90.61 \pm 1.84	94.66 \pm 6.03	98.84 \pm 0.14	99.33 \pm 0.03
	1	99.90 \pm 0.02	99.92 \pm 0.01	97.46 \pm 1.17	99.91 \pm 0.01	98.26 \pm 2.79	99.60 \pm 0.05	99.43 \pm 0.05
	2	88.81 \pm 1.63	95.66 \pm 0.40	89.84 \pm 1.85	90.49 \pm 0.55	89.24 \pm 3.08	98.92 \pm 0.16	99.20 \pm 0.05
	3	90.84 \pm 1.87	97.43 \pm 0.47	93.14 \pm 1.49	91.90 \pm 0.46	89.78 \pm 0.80	99.47 \pm 0.12	99.68 \pm 0.04
	4	92.36 \pm 1.39	97.28 \pm 0.54	92.94 \pm 1.53	93.73 \pm 0.73	92.69 \pm 2.24	99.46 \pm 0.12	99.48 \pm 0.04
	5	90.06 \pm 0.28	96.87 \pm 0.27	92.49 \pm 1.59	91.54 \pm 0.72	90.73 \pm 1.54	99.02 \pm 0.22	98.98 \pm 0.08
	6	93.29 \pm 1.09	98.88 \pm 0.13	94.81 \pm 1.94	93.99 \pm 0.70	93.53 \pm 2.48	99.72 \pm 0.01	99.64 \pm 0.01
	7	95.82 \pm 1.31	98.95 \pm 0.14	95.71 \pm 0.75	97.05 \pm 0.52	95.43 \pm 2.17	99.14 \pm 0.19	99.12 \pm 0.03
	8	86.54 \pm 0.35	95.59 \pm 0.76	88.06 \pm 1.78	87.54 \pm 0.59	91.47 \pm 2.25	98.29 \pm 0.24	98.39 \pm 0.18
	9	93.22 \pm 0.71	98.67 \pm 0.20	94.23 \pm 4.20	93.94 \pm 0.91	93.10 \pm 0.88	99.46 \pm 0.09	99.42 \pm 0.05
	<i>average</i>	91.98 \pm 0.27	97.80 \pm 0.12	92.95 \pm 0.87	93.07 \pm 0.32	92.89 \pm 0.77	99.19 \pm 0.05	99.27 \pm 0.02
Fashion-MNIST	t-shirt	91.59 \pm 1.73	98.10 \pm 0.14	93.29 \pm 1.49	95.38 \pm 0.92	91.58 \pm 3.80	98.33 \pm 0.13	99.08 \pm 0.06
	trouser	99.54 \pm 0.03	99.58 \pm 0.07	95.95 \pm 3.30	99.66 \pm 0.05	95.64 \pm 2.46	99.76 \pm 0.05	99.80 \pm 0.02
	pullover	92.07 \pm 0.62	97.41 \pm 0.31	92.35 \pm 1.00	94.38 \pm 1.33	90.77 \pm 4.41	97.99 \pm 0.25	98.46 \pm 0.25
	dress	96.62 \pm 0.33	97.82 \pm 0.14	96.22 \pm 0.71	96.86 \pm 0.57	93.07 \pm 8.49	98.63 \pm 0.14	98.65 \pm 0.13
	coat	93.59 \pm 0.77	96.97 \pm 0.24	91.18 \pm 1.17	94.78 \pm 0.36	89.56 \pm 3.81	98.29 \pm 0.07	98.34 \pm 0.21
	sandal	95.71 \pm 1.05	93.97 \pm 0.68	95.69 \pm 0.85	95.90 \pm 0.30	97.32 \pm 0.82	97.95 \pm 0.20	99.11 \pm 0.04
	shirt	90.25 \pm 1.35	96.69 \pm 0.20	91.78 \pm 0.81	94.79 \pm 0.68	91.63 \pm 1.79	96.79 \pm 0.18	97.45 \pm 0.23
	sneaker	98.65 \pm 0.27	98.85 \pm 0.12	98.72 \pm 0.21	98.79 \pm 0.18	94.14 \pm 8.05	99.77 \pm 0.05	99.88 \pm 0.02
	bag	88.46 \pm 1.04	94.00 \pm 0.27	89.02 \pm 0.66	90.56 \pm 1.07	91.05 \pm 2.11	97.25 \pm 0.36	99.19 \pm 0.05
	ankle-boot	96.91 \pm 0.55	98.08 \pm 0.26	94.28 \pm 1.54	96.80 \pm 1.43	92.28 \pm 7.00	99.81 \pm 0.04	99.93 \pm 0.01
	<i>average</i>	94.34 \pm 0.25	97.15 \pm 0.06	93.85 \pm 0.44	95.79 \pm 0.34	92.70 \pm 2.92	98.46 \pm 0.04	98.99 \pm 0.04
CIFAR10	airplane	94.61 \pm 1.02	93.06 \pm 0.33	95.35 \pm 0.26	93.48 \pm 0.47	90.03 \pm 1.78	90.70 \pm 0.77	96.56 \pm 0.20
	automobile	86.35 \pm 0.99	82.78 \pm 0.49	85.35 \pm 0.28	83.33 \pm 0.61	92.68 \pm 0.58	95.20 \pm 0.35	99.12 \pm 0.12
	bird	92.71 \pm 1.47	94.24 \pm 0.41	93.98 \pm 0.34	94.44 \pm 0.34	89.48 \pm 1.61	91.17 \pm 0.72	95.62 \pm 0.33
	cat	92.23 \pm 0.61	89.71 \pm 0.31	92.08 \pm 0.56	90.85 \pm 0.82	89.96 \pm 0.26	91.50 \pm 0.52	95.50 \pm 0.28
	deer	93.18 \pm 0.95	94.76 \pm 0.43	92.43 \pm 0.46	94.99 \pm 0.46	91.34 \pm 1.03	93.85 \pm 0.30	97.16 \pm 0.11
	dog	91.31 \pm 0.80	89.39 \pm 0.33	92.10 \pm 0.23	90.91 \pm 0.34	91.11 \pm 0.96	93.24 \pm 0.66	97.86 \pm 0.16
	frog	91.14 \pm 1.07	92.43 \pm 0.44	86.72 \pm 0.41	91.21 \pm 0.62	92.90 \pm 1.29	93.75 \pm 0.73	97.42 \pm 0.26
	horse	88.14 \pm 0.18	87.56 \pm 0.44	88.66 \pm 0.36	88.72 \pm 0.59	91.63 \pm 0.89	95.67 \pm 0.24	98.94 \pm 0.07
	ship	95.26 \pm 0.55	94.21 \pm 0.21	95.53 \pm 0.38	94.37 \pm 0.46	90.67 \pm 2.99	94.67 \pm 0.52	98.87 \pm 0.03
	truck	85.32 \pm 1.00	83.31 \pm 0.50	85.15 \pm 0.57	84.20 \pm 0.50	93.03 \pm 1.93	95.22 \pm 0.22	98.29 \pm 0.19
	<i>average</i>	91.03 \pm 0.35	90.15 \pm 0.05	90.73 \pm 0.06	90.65 \pm 0.17	91.28 \pm 0.57	93.50 \pm 0.10	97.53 \pm 0.06
CIFAR100	aquatic mammals	92.97 \pm 1.02	92.72 \pm 0.19	93.38 \pm 0.45	93.11 \pm 0.17	89.71 \pm 0.89	91.21 \pm 0.51	96.08 \pm 0.54
	fish	93.53 \pm 0.87	92.30 \pm 0.27	93.65 \pm 0.43	93.00 \pm 0.74	88.16 \pm 0.57	91.43 \pm 0.41	95.24 \pm 0.31
	flowers	86.32 \pm 3.56	85.38 \pm 0.28	84.67 \pm 0.45	84.70 \pm 1.65	93.43 \pm 1.65	91.71 \pm 0.38	96.47 \pm 0.22
	food containers	93.29 \pm 1.21	92.30 \pm 0.58	93.98 \pm 0.23	92.81 \pm 0.56	90.23 \pm 0.56	90.16 \pm 0.81	97.20 \pm 0.26
	fruit and vegetables	90.71 \pm 1.36	87.19 \pm 0.67	91.44 \pm 0.80	86.94 \pm 1.71	93.07 \pm 1.75	90.92 \pm 0.76	96.60 \pm 0.22
	household electrical devices	91.31 \pm 0.95	88.25 \pm 0.13	90.72 \pm 1.49	88.76 \pm 0.62	89.38 \pm 0.48	89.75 \pm 0.20	93.65 \pm 0.66
	household furniture	92.62 \pm 1.13	90.25 \pm 0.48	93.02 \pm 0.59	90.82 \pm 0.81	90.65 \pm 0.91	89.12 \pm 0.53	97.28 \pm 0.14
	inserts	90.07 \pm 1.26	90.35 \pm 0.65	88.93 \pm 0.49	89.86 \pm 0.97	90.29 \pm 0.56	90.62 \pm 0.18	95.65 \pm 0.23
	large carnivores	90.37 \pm 1.20	91.05 \pm 0.69	88.66 \pm 1.04	91.36 \pm 0.74	92.30 \pm 0.18	92.48 \pm 0.75	98.08 \pm 0.22
	large man-made outdoor things	93.27 \pm 0.96	92.83 \pm 0.35	93.68 \pm 0.76	93.73 \pm 0.45	93.59 \pm 1.71	93.31 \pm 0.41	98.26 \pm 0.23
	large natural outdoor scenes	95.97 \pm 1.89	97.26 \pm 0.47	97.53 \pm 0.20	96.92 \pm 0.71	91.35 \pm 1.39	93.13 \pm 0.73	97.97 \pm 0.21
	large omnivores and herbivores	89.62 \pm 0.63	90.38 \pm 0.35	90.05 \pm 0.23	91.80 \pm 0.69	91.98 \pm 0.59	91.61 \pm 1.06	97.62 \pm 0.17
	medium-sized mammals	92.04 \pm 1.03	91.81 \pm 0.20	90.92 \pm 0.65	92.34 \pm 0.67	92.29 \pm 0.72	92.05 \pm 0.56	97.55 \pm 0.12
	non-insert invertebrates	91.21 \pm 0.52	93.00 \pm 0.29	91.44 \pm 0.11	91.86 \pm 0.32	89.19 \pm 0.56	90.00 \pm 0.40	93.56 \pm 0.44
	people	88.44 \pm 0.94	85.70 \pm 0.29	88.11 \pm 0.64	87.44 \pm 0.50	91.29 \pm 0.64	91.15 \pm 0.50	98.69 \pm 0.07
	reptiles	90.88 \pm 0.50	91.98 \pm 0.32	90.79 \pm 0.45	91.69 \pm 0.15	90.04 \pm 0.42	90.50 \pm 0.66	94.87 \pm 0.46
	small mammals	91.84 \pm 1.30	93.06 \pm 0.36	92.21 \pm 0.46	93.33 \pm 0.58	91.15 \pm 1.17	91.56 \pm 0.20	96.20 \pm 0.34
	trees	90.85 \pm 1.79	92.49 \pm 0.40	90.51 \pm 0.60	92.16 \pm 0.61	92.17 \pm 1.63	95.10 \pm 0.80	98.95 \pm 0.10
	vehicles 1	85.29 \pm 0.39	86.51 \pm 0.36	84.10 \pm 0.57	85.92 \pm 0.47	91.61 \pm 0.44	92.32 \pm 0.80	98.53 \pm 0.11
	vehicles 2	89.13 \pm 1.39	88.97 \pm 0.54	89.85 \pm 0.58	89.22 \pm 0.63	90.53 \pm 0.69	91.22 \pm 0.41	97.79 \pm 0.23
	<i>average</i>	90.99 \pm 0.39	90.69 \pm 0.08	90.88 \pm 0.21	90.89 \pm 0.26	91.12 \pm 0.23	91.47 \pm 0.06	96.81 \pm 0.06
SVHN	0	90.02 \pm 0.66	92.42 \pm 0.46	90.48 \pm 0.27	90.69 \pm 0.34	90.08 \pm 0.16	96.76 \pm 0.32	95.20 \pm 0.24
	1	91.65 \pm 0.55	92.93 \pm 0.38	91.77 \pm 0.74	92.18 \pm 0.52	89.95 \pm 0.50	94.23 \pm 0.43	95.99 \pm 0.28
	2	90.12 \pm 0.30	91.27 \pm 0.49	90.43 \pm 0.48	90.43 \pm 0.33	89.75 \pm 0.25	96.01 \pm 0.32	99.05 \pm 0.07
	3	90.18 \pm 0.14	90.60 \pm 0.21	90.09 \pm 0.29	90.30 \pm 0.28	90.20 \pm 0.19	94.94 \pm 0.58	98.48 \pm 0.05
	4	90.49 \pm 0.39	91.71 \pm 0.36	90.92 \pm 0.22	91.46 \pm 0.30	89.83 \pm 0.50	95.30 \pm 0.65	99.16 \pm 0.05
	5	89.59 \pm 0.29	90.75 \pm 0.32	89.66 \pm 0.18	90.02 \pm 0.19	89.96 \pm 0.30	96.27 \pm 0.56	99.07 \pm 0.04
	6	90.08 \pm 0.32	90.52 \pm 0.34	89.60 \pm 0.40	90.19 \pm 0.18	90.19 \pm 0.56	96.26 \pm 0.45	98.73 \pm 0.04
	7	90.58 \pm 0.05	91.82 \pm 0.35	90.82 \pm 0.40	90.67 \pm 0.36	89.94 \pm 0.63	96.96 \pm 0.53	99.23 \pm 0.04
	8	89.78 \pm 0.30	91.04 \pm 0.32	89.60 \pm 0.43	90.03 \pm 0.48	89.84 \pm 0.28	95.18 \pm 0.38	96.33 \pm 0.49
	9	90.17 \pm 0.19	91.02 \pm 0.21	90.02 \pm 0.18	90.43 \pm 0.24	90.22 \pm 0.53	96.66 \pm 0.21	98.79 \pm 0.05
	<i>average</i>	90.27 \pm 0.08	91.41 \pm 0.19	90.34 \pm 0.15	90.64 \pm 0.14	90.00 \pm 0.14	95.86 \pm 0.12	98.00 \pm 0.05

Table 8: AUPR-in (%) (inliers as positive class) when $\rho = 0.15$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	80.78 \pm 1.94	97.60 \pm 0.46	86.77 \pm 7.19	83.40 \pm 2.27	92.69 \pm 7.89	97.88 \pm 0.63	98.36 \pm 0.06
	1	99.78 \pm 0.06	99.87 \pm 0.02	97.44 \pm 2.24	99.81 \pm 0.03	93.55 \pm 10.88	99.30 \pm 0.12	98.44 \pm 0.19
	2	82.33 \pm 1.19	91.92 \pm 0.74	85.58 \pm 3.06	83.33 \pm 1.32	84.61 \pm 1.79	97.86 \pm 0.15	98.62 \pm 0.05
	3	84.14 \pm 1.00	95.18 \pm 0.74	90.32 \pm 3.20	87.02 \pm 0.93	86.94 \pm 2.74	98.83 \pm 0.10	99.44 \pm 0.02
	4	87.48 \pm 0.49	94.79 \pm 0.34	91.07 \pm 3.35	89.27 \pm 0.19	89.82 \pm 3.76	98.83 \pm 0.17	98.97 \pm 0.05
	5	84.04 \pm 1.73	96.90 \pm 0.35	84.95 \pm 0.98	83.23 \pm 2.22	86.32 \pm 2.20	97.67 \pm 0.24	98.15 \pm 0.13
	6	87.22 \pm 1.15	97.70 \pm 0.48	87.58 \pm 5.50	89.16 \pm 0.64	87.78 \pm 4.73	99.33 \pm 0.04	99.38 \pm 0.03
	7	91.05 \pm 1.98	98.32 \pm 0.14	92.80 \pm 0.74	93.85 \pm 1.04	88.21 \pm 5.35	98.41 \pm 0.28	98.45 \pm 0.03
	8	80.19 \pm 1.50	92.35 \pm 0.67	87.25 \pm 4.61	81.16 \pm 1.88	85.54 \pm 1.30	96.51 \pm 0.33	97.27 \pm 0.23
	9	89.49 \pm 1.09	97.73 \pm 0.22	91.10 \pm 1.80	90.86 \pm 0.91	89.18 \pm 3.23	98.99 \pm 0.13	99.01 \pm 0.08
	<i>average</i>	86.65 \pm 0.25	96.23 \pm 0.12	89.49 \pm 1.20	88.11 \pm 0.56	88.47 \pm 0.84	98.36 \pm 0.11	98.61 \pm 0.03
Fashion-MNIST	t-shirt	88.16 \pm 1.92	96.82 \pm 0.19	90.84 \pm 0.99	92.77 \pm 1.37	76.51 \pm 14.59	97.04 \pm 0.04	98.50 \pm 0.07
	trouser	99.16 \pm 0.11	99.21 \pm 0.17	98.61 \pm 0.34	99.34 \pm 0.12	78.62 \pm 18.27	99.55 \pm 0.11	99.57 \pm 0.02
	pullover	87.15 \pm 2.83	95.66 \pm 0.22	88.13 \pm 2.21	90.43 \pm 2.02	86.20 \pm 4.64	96.88 \pm 0.16	97.54 \pm 0.29
	dress	94.01 \pm 0.49	95.80 \pm 0.36	93.83 \pm 0.51	93.92 \pm 1.41	86.91 \pm 3.51	97.53 \pm 0.27	97.35 \pm 0.24
	coat	88.70 \pm 0.89	94.94 \pm 0.28	87.31 \pm 1.28	89.25 \pm 2.80	82.60 \pm 10.02	97.16 \pm 0.21	97.15 \pm 0.12
	sandal	92.01 \pm 0.61	89.45 \pm 0.48	93.37 \pm 0.41	93.19 \pm 1.04	94.87 \pm 3.58	96.26 \pm 0.53	98.38 \pm 0.16
	shirt	85.54 \pm 1.48	94.50 \pm 0.22	86.92 \pm 0.78	90.65 \pm 1.67	85.18 \pm 2.77	94.80 \pm 0.30	95.83 \pm 0.14
	sneaker	97.04 \pm 0.95	98.08 \pm 0.24	96.99 \pm 0.67	97.82 \pm 0.46	72.83 \pm 19.02	99.61 \pm 0.08	99.79 \pm 0.05
	bag	82.00 \pm 3.48	88.51 \pm 0.88	83.19 \pm 1.29	82.94 \pm 3.90	82.85 \pm 3.71	94.20 \pm 1.09	97.95 \pm 0.22
	ankle-boot	92.70 \pm 2.14	95.47 \pm 0.98	91.70 \pm 0.95	94.13 \pm 1.02	90.41 \pm 4.48	99.62 \pm 0.06	99.87 \pm 0.02
	<i>average</i>	90.65 \pm 0.61	94.84 \pm 0.19	91.09 \pm 0.34	92.44 \pm 0.28	83.70 \pm 3.52	97.27 \pm 0.08	98.19 \pm 0.03
CIFAR10	airplane	93.13 \pm 1.25	89.65 \pm 0.54	93.14 \pm 0.23	90.66 \pm 0.65	85.56 \pm 2.30	85.80 \pm 0.42	94.36 \pm 0.09
	automobile	79.77 \pm 1.23	75.76 \pm 0.26	78.90 \pm 0.43	76.39 \pm 0.88	89.17 \pm 0.56	92.33 \pm 0.64	98.60 \pm 0.18
	bird	88.91 \pm 0.57	90.79 \pm 0.26	90.37 \pm 0.32	91.41 \pm 0.27	83.24 \pm 1.60	86.14 \pm 0.68	92.48 \pm 0.42
	cat	88.13 \pm 0.36	84.87 \pm 0.29	88.08 \pm 0.51	86.26 \pm 0.24	85.36 \pm 0.67	86.77 \pm 0.69	91.71 \pm 0.48
	deer	89.00 \pm 1.23	91.86 \pm 0.31	88.68 \pm 0.33	91.95 \pm 0.66	85.72 \pm 0.91	90.25 \pm 0.64	95.13 \pm 0.22
	dog	86.79 \pm 0.68	84.14 \pm 0.33	87.85 \pm 0.42	85.96 \pm 0.71	85.77 \pm 0.76	89.85 \pm 0.64	95.53 \pm 0.36
	frog	85.98 \pm 1.25	88.24 \pm 0.33	81.41 \pm 0.70	86.31 \pm 0.77	88.46 \pm 1.31	89.95 \pm 0.55	94.97 \pm 0.33
	horse	83.21 \pm 0.35	81.75 \pm 0.32	83.11 \pm 0.51	82.81 \pm 0.38	87.56 \pm 1.37	91.65 \pm 0.79	97.88 \pm 0.21
	ship	91.91 \pm 1.41	91.06 \pm 0.39	93.23 \pm 0.40	91.08 \pm 2.03	85.83 \pm 4.03	91.51 \pm 1.23	97.94 \pm 0.13
	truck	80.33 \pm 1.79	76.06 \pm 0.39	79.39 \pm 0.41	76.87 \pm 0.92	88.83 \pm 1.55	91.80 \pm 0.40	97.13 \pm 0.26
	<i>average</i>	86.71 \pm 0.18	85.42 \pm 0.07	86.42 \pm 0.12	85.97 \pm 0.22	86.55 \pm 0.26	89.61 \pm 0.24	95.57 \pm 0.09
CIFAR100	aquatic mammals	89.58 \pm 0.78	88.64 \pm 0.63	89.92 \pm 0.55	89.82 \pm 0.50	84.42 \pm 0.67	87.55 \pm 0.69	93.69 \pm 0.43
	fish	90.56 \pm 0.49	88.70 \pm 0.10	89.81 \pm 0.24	89.09 \pm 0.74	82.78 \pm 1.68	87.29 \pm 0.22	92.90 \pm 0.43
	flowers	79.81 \pm 1.91	77.46 \pm 0.39	77.04 \pm 0.90	77.58 \pm 1.47	87.93 \pm 3.18	87.22 \pm 0.56	94.23 \pm 0.76
	food containers	89.98 \pm 0.75	88.82 \pm 0.21	89.99 \pm 0.40	88.40 \pm 1.29	84.05 \pm 0.51	86.71 \pm 0.53	95.20 \pm 0.15
	fruit and vegetables	86.66 \pm 2.13	82.42 \pm 0.46	86.70 \pm 0.85	83.84 \pm 2.54	87.39 \pm 3.05	86.38 \pm 1.08	94.20 \pm 0.49
	household electrical devices	86.84 \pm 0.82	82.53 \pm 0.44	87.56 \pm 0.67	83.05 \pm 0.78	85.59 \pm 1.39	85.04 \pm 0.69	90.26 \pm 0.89
	household furniture	88.31 \pm 1.06	85.98 \pm 0.95	90.13 \pm 0.81	86.61 \pm 1.12	85.47 \pm 1.94	83.98 \pm 0.55	95.50 \pm 0.26
	inserts	86.07 \pm 1.42	84.69 \pm 0.66	83.11 \pm 0.68	84.65 \pm 0.55	84.54 \pm 1.69	85.69 \pm 0.54	92.90 \pm 0.38
	large carnivores	83.60 \pm 1.30	85.20 \pm 1.17	84.29 \pm 0.52	85.24 \pm 0.34	87.99 \pm 0.64	88.16 \pm 0.67	96.71 \pm 0.57
	large man-made outdoor things	89.03 \pm 1.01	88.88 \pm 0.62	90.99 \pm 0.64	90.03 \pm 1.02	89.23 \pm 1.84	90.08 \pm 1.09	97.07 \pm 0.39
	large natural outdoor scenes	96.06 \pm 0.44	95.83 \pm 0.36	95.80 \pm 0.09	95.86 \pm 0.46	84.94 \pm 1.29	87.66 \pm 2.09	96.62 \pm 0.17
	large omnivores and herbivores	84.52 \pm 0.58	84.66 \pm 0.42	86.41 \pm 0.24	86.33 \pm 0.83	87.90 \pm 1.20	86.69 \pm 0.33	95.92 \pm 0.35
	medium-sized mammals	85.32 \pm 2.51	86.27 \pm 0.53	86.16 \pm 0.53	87.70 \pm 0.96	88.19 \pm 0.81	87.71 \pm 0.67	95.60 \pm 0.45
	non-insert invertebrates	86.59 \pm 0.56	88.75 \pm 0.33	86.38 \pm 0.34	87.60 \pm 0.27	84.10 \pm 0.83	84.73 \pm 0.22	89.21 \pm 0.44
	people	83.21 \pm 1.09	79.23 \pm 0.45	83.02 \pm 0.58	81.10 \pm 0.88	87.02 \pm 1.19	85.68 \pm 0.85	97.77 \pm 0.28
	reptiles	85.11 \pm 1.00	86.96 \pm 0.52	85.47 \pm 0.67	87.11 \pm 0.29	85.24 \pm 0.80	86.28 \pm 0.71	91.50 \pm 0.98
	small mammals	87.19 \pm 1.29	88.75 \pm 0.57	87.90 \pm 0.31	89.74 \pm 0.89	86.54 \pm 1.07	88.02 \pm 1.04	93.44 \pm 0.66
	trees	87.11 \pm 1.28	87.93 \pm 0.70	85.30 \pm 1.30	87.57 \pm 0.57	88.86 \pm 1.87	92.10 \pm 0.93	98.29 \pm 0.20
	vehicles 1	78.41 \pm 0.43	78.54 \pm 0.50	78.49 \pm 0.44	78.54 \pm 0.61	87.76 \pm 1.00	87.64 \pm 0.92	97.54 \pm 0.20
	vehicles 2	84.10 \pm 1.03	82.86 \pm 0.49	85.59 \pm 0.51	83.32 \pm 0.29	85.62 \pm 1.15	86.52 \pm 0.47	96.28 \pm 0.31
	<i>average</i>	86.40 \pm 0.12	85.66 \pm 0.16	86.50 \pm 0.17	86.16 \pm 0.19	86.28 \pm 0.28	87.06 \pm 0.16	94.74 \pm 0.12
SVHN	0	85.08 \pm 0.68	87.99 \pm 0.27	85.83 \pm 0.21	86.33 \pm 0.49	85.04 \pm 0.53	94.59 \pm 0.99	90.34 \pm 0.92
	1	86.55 \pm 0.73	88.87 \pm 0.27	87.53 \pm 0.66	87.64 \pm 0.28	84.60 \pm 0.44	90.83 \pm 0.77	92.93 \pm 0.44
	2	85.35 \pm 0.52	86.55 \pm 0.54	85.59 \pm 0.32	86.07 \pm 0.47	84.78 \pm 0.44	93.57 \pm 1.01	98.25 \pm 0.14
	3	85.01 \pm 0.32	85.55 \pm 0.22	84.80 \pm 0.22	84.89 \pm 0.20	85.05 \pm 0.20	91.88 \pm 0.83	97.36 \pm 0.07
	4	85.84 \pm 0.43	86.98 \pm 0.57	86.55 \pm 0.25	86.90 \pm 0.51	84.65 \pm 0.66	92.35 \pm 0.65	98.31 \pm 0.07
	5	84.74 \pm 0.28	85.90 \pm 0.27	84.73 \pm 0.38	85.18 \pm 0.32	84.79 \pm 0.22	92.55 \pm 0.69	98.28 \pm 0.05
	6	84.80 \pm 0.44	85.71 \pm 0.32	84.26 \pm 0.40	85.15 \pm 0.35	76.69 \pm 17.10	93.28 \pm 0.40	97.63 \pm 0.06
	7	86.73 \pm 0.26	87.33 \pm 0.22	86.26 \pm 0.37	86.66 \pm 0.24	85.15 \pm 0.67	94.86 \pm 0.33	98.44 \pm 0.10
	8	84.51 \pm 0.44	86.13 \pm 0.61	84.38 \pm 0.39	84.97 \pm 0.50	85.39 \pm 0.42	92.38 \pm 0.76	92.25 \pm 0.59
	9	85.01 \pm 0.32	86.40 \pm 0.40	84.95 \pm 0.25	85.47 \pm 0.33	85.22 \pm 0.46	93.74 \pm 0.56	97.79 \pm 0.10
	<i>average</i>	85.36 \pm 0.13	86.74 \pm 0.13	85.49 \pm 0.06	85.93 \pm 0.14	84.14 \pm 1.61	93.00 \pm 0.14	96.16 \pm 0.14

Table 9: AUPR-in (%) (inliers as positive class) when $\rho = 0.2$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	74.97 \pm 2.44	96.38 \pm 1.11	80.59 \pm 5.14	77.65 \pm 2.76	88.47 \pm 11.29	96.26 \pm 0.83	97.04 \pm 0.23
	1	99.70 \pm 0.06	99.80 \pm 0.03	95.74 \pm 6.62	99.71 \pm 0.02	96.79 \pm 4.20	98.54 \pm 0.19	96.48 \pm 0.38
	2	76.10 \pm 1.94	88.03 \pm 1.40	79.41 \pm 4.76	78.15 \pm 1.84	80.55 \pm 0.75	95.92 \pm 0.45	97.62 \pm 0.13
	3	80.36 \pm 2.15	93.59 \pm 0.48	89.29 \pm 5.38	81.91 \pm 1.41	84.43 \pm 4.65	97.59 \pm 0.30	99.06 \pm 0.02
	4	84.94 \pm 2.11	92.40 \pm 0.51	88.24 \pm 3.26	85.72 \pm 0.93	86.39 \pm 5.14	98.22 \pm 0.13	98.12 \pm 0.11
	5	79.99 \pm 1.05	90.37 \pm 0.75	82.44 \pm 2.56	80.37 \pm 0.96	81.66 \pm 1.46	96.60 \pm 0.31	96.93 \pm 0.26
	6	82.18 \pm 0.84	96.41 \pm 0.65	84.39 \pm 5.21	83.41 \pm 1.49	88.85 \pm 6.41	98.75 \pm 0.23	99.00 \pm 0.02
	7	89.59 \pm 1.97	96.60 \pm 0.33	90.03 \pm 4.31	91.41 \pm 0.77	90.43 \pm 3.06	97.49 \pm 0.31	97.62 \pm 0.14
	8	73.67 \pm 1.11	86.72 \pm 1.16	86.62 \pm 2.82	76.77 \pm 1.10	82.41 \pm 5.55	94.87 \pm 0.22	95.68 \pm 0.33
	9	85.85 \pm 0.96	95.86 \pm 0.73	89.33 \pm 2.23	86.86 \pm 0.83	84.17 \pm 4.65	98.25 \pm 0.22	98.52 \pm 0.08
	<i>average</i>	82.73 \pm 0.46	93.62 \pm 0.29	86.61 \pm 1.16	84.20 \pm 0.30	86.42 \pm 1.04	97.25 \pm 0.09	97.61 \pm 0.05
Fashion-MNIST	t-shirt	79.47 \pm 3.87	94.88 \pm 0.54	85.85 \pm 2.34	90.60 \pm 1.11	85.04 \pm 8.64	95.88 \pm 0.27	97.49 \pm 0.14
	trouser	98.61 \pm 0.28	98.63 \pm 0.07	97.26 \pm 1.47	98.78 \pm 0.37	92.16 \pm 5.52	99.27 \pm 0.11	99.20 \pm 0.04
	pullover	81.64 \pm 1.83	93.13 \pm 0.52	83.72 \pm 1.73	88.20 \pm 1.94	76.63 \pm 5.58	95.32 \pm 0.17	96.38 \pm 0.23
	dress	89.07 \pm 2.67	93.42 \pm 0.38	92.28 \pm 0.66	91.01 \pm 1.22	92.88 \pm 0.73	95.31 \pm 0.62	95.13 \pm 0.24
	coat	85.34 \pm 2.51	92.65 \pm 0.66	82.21 \pm 1.53	85.47 \pm 3.00	77.65 \pm 8.80	96.03 \pm 0.23	95.90 \pm 0.36
	sandal	85.59 \pm 3.24	83.80 \pm 0.99	89.40 \pm 1.67	85.76 \pm 3.66	93.39 \pm 2.26	93.78 \pm 1.06	97.27 \pm 0.34
	shirt	79.39 \pm 1.21	92.07 \pm 0.25	82.74 \pm 0.78	86.33 \pm 0.64	82.00 \pm 4.07	92.11 \pm 0.37	94.17 \pm 0.18
	sneaker	93.77 \pm 1.74	96.58 \pm 0.17	91.06 \pm 7.45	96.70 \pm 0.68	94.36 \pm 3.09	99.39 \pm 0.07	99.69 \pm 0.04
	bag	75.16 \pm 0.97	82.75 \pm 1.13	76.55 \pm 1.18	77.49 \pm 2.42	84.12 \pm 6.97	89.34 \pm 1.28	96.16 \pm 0.20
	ankle-boot	85.28 \pm 2.62	93.90 \pm 0.74	87.45 \pm 3.25	91.47 \pm 1.61	88.35 \pm 7.66	99.27 \pm 0.07	99.78 \pm 0.01
	<i>average</i>	85.33 \pm 0.82	92.18 \pm 0.30	86.85 \pm 0.92	89.18 \pm 0.67	86.66 \pm 2.70	95.57 \pm 0.13	97.12 \pm 0.07
CIFAR10	airplane	87.49 \pm 2.97	85.68 \pm 0.29	90.18 \pm 0.40	86.53 \pm 2.07	80.45 \pm 2.69	80.71 \pm 1.41	91.84 \pm 0.12
	automobile	74.55 \pm 2.35	69.43 \pm 0.41	72.64 \pm 0.54	69.39 \pm 0.59	85.21 \pm 0.90	87.61 \pm 1.62	97.81 \pm 0.26
	bird	85.55 \pm 1.21	87.48 \pm 0.39	87.19 \pm 0.26	88.36 \pm 0.70	78.72 \pm 3.08	81.85 \pm 1.21	88.46 \pm 0.60
	cat	83.47 \pm 1.39	79.75 \pm 0.43	83.39 \pm 0.23	80.96 \pm 0.99	81.04 \pm 0.57	81.64 \pm 1.59	86.40 \pm 0.90
	deer	84.68 \pm 1.46	88.80 \pm 0.48	84.68 \pm 0.55	89.23 \pm 0.32	80.45 \pm 2.05	85.85 \pm 0.99	92.67 \pm 0.38
	dog	81.40 \pm 1.10	78.84 \pm 0.38	83.47 \pm 0.27	80.85 \pm 0.42	81.92 \pm 1.87	84.96 \pm 0.72	92.69 \pm 0.78
	frog	79.95 \pm 1.91	83.91 \pm 0.40	75.20 \pm 0.91	80.68 \pm 1.27	82.23 \pm 3.45	85.67 \pm 0.95	91.92 \pm 0.69
	horse	76.93 \pm 0.91	75.62 \pm 0.38	77.20 \pm 0.42	76.05 \pm 0.31	80.93 \pm 3.71	87.15 \pm 1.26	96.84 \pm 0.15
	ship	88.52 \pm 1.89	87.82 \pm 0.31	90.10 \pm 0.42	88.30 \pm 2.30	80.45 \pm 3.22	87.20 \pm 1.11	96.80 \pm 0.23
	truck	73.74 \pm 1.77	69.34 \pm 0.28	72.46 \pm 0.40	70.08 \pm 0.85	86.16 \pm 2.99	86.91 \pm 0.99	95.47 \pm 0.24
	<i>average</i>	81.63 \pm 0.68	80.67 \pm 0.12	81.65 \pm 0.16	81.04 \pm 0.44	81.76 \pm 0.37	84.95 \pm 0.40	93.09 \pm 0.07
CIFAR100	aquatic mammals	86.21 \pm 1.42	84.67 \pm 0.73	86.52 \pm 0.95	86.19 \pm 0.70	80.32 \pm 1.68	82.09 \pm 1.06	91.36 \pm 0.59
	fish	86.59 \pm 1.63	84.82 \pm 0.50	86.01 \pm 0.54	85.33 \pm 1.31	77.60 \pm 1.29	82.61 \pm 0.88	89.22 \pm 0.57
	flowers	73.48 \pm 1.73	71.14 \pm 0.35	70.15 \pm 0.53	71.71 \pm 1.57	85.61 \pm 2.77	81.89 \pm 0.64	92.39 \pm 0.66
	food containers	85.89 \pm 1.07	85.03 \pm 0.34	86.17 \pm 0.59	84.83 \pm 1.46	76.56 \pm 1.36	79.91 \pm 1.14	92.83 \pm 0.48
	fruit and vegetables	81.83 \pm 2.95	76.13 \pm 0.80	82.14 \pm 0.66	77.08 \pm 1.17	84.89 \pm 1.41	81.00 \pm 0.83	91.56 \pm 0.55
	household electrical devices	81.54 \pm 0.72	76.74 \pm 0.44	83.08 \pm 0.24	78.14 \pm 1.20	80.02 \pm 1.48	79.98 \pm 1.13	85.70 \pm 0.90
	household furniture	83.88 \pm 1.35	81.34 \pm 0.39	86.10 \pm 0.56	82.54 \pm 1.14	79.12 \pm 1.49	78.48 \pm 0.44	93.42 \pm 0.60
	inserts	81.45 \pm 1.41	79.14 \pm 0.84	77.43 \pm 0.30	79.05 \pm 1.09	79.85 \pm 1.70	81.06 \pm 0.79	89.13 \pm 0.37
	large carnivores	77.78 \pm 2.40	79.79 \pm 0.94	78.84 \pm 0.99	80.69 \pm 1.68	82.53 \pm 0.47	82.99 \pm 0.51	95.06 \pm 0.77
	large man-made outdoor things	85.71 \pm 1.19	84.70 \pm 0.85	87.59 \pm 0.84	86.16 \pm 0.70	83.65 \pm 3.58	85.35 \pm 1.67	95.96 \pm 0.33
	large natural outdoor scenes	92.62 \pm 1.64	94.23 \pm 0.45	93.83 \pm 0.42	93.66 \pm 1.15	79.56 \pm 2.36	83.76 \pm 0.56	95.19 \pm 0.24
	large omnivores and herbivores	79.86 \pm 1.25	79.65 \pm 0.61	81.67 \pm 0.66	81.93 \pm 0.38	83.34 \pm 1.00	82.92 \pm 1.26	94.10 \pm 0.23
	medium-sized mammals	80.67 \pm 1.43	81.90 \pm 0.88	81.52 \pm 0.92	84.62 \pm 1.42	83.98 \pm 0.80	83.85 \pm 0.52	93.51 \pm 0.64
	non-insert invertebrates	81.85 \pm 0.65	84.57 \pm 0.68	81.29 \pm 0.42	83.40 \pm 0.69	78.09 \pm 1.16	80.05 \pm 0.81	85.12 \pm 0.45
	people	79.03 \pm 1.22	73.10 \pm 0.82	77.58 \pm 0.96	75.05 \pm 0.86	83.46 \pm 0.74	81.59 \pm 1.15	96.89 \pm 0.22
	reptiles	80.18 \pm 0.42	82.50 \pm 0.48	79.80 \pm 0.48	82.49 \pm 0.57	80.24 \pm 0.70	81.10 \pm 0.72	87.87 \pm 0.76
	small mammals	82.46 \pm 1.06	84.94 \pm 0.23	83.51 \pm 0.16	85.10 \pm 0.31	81.45 \pm 0.76	83.23 \pm 0.18	90.23 \pm 0.38
	trees	81.66 \pm 1.55	83.32 \pm 0.85	79.89 \pm 1.34	81.95 \pm 0.86	83.39 \pm 1.57	87.89 \pm 0.78	97.34 \pm 0.12
	vehicles 1	71.50 \pm 1.30	72.21 \pm 0.36	71.77 \pm 0.39	71.81 \pm 0.35	84.25 \pm 0.66	82.13 \pm 1.36	96.29 \pm 0.21
	vehicles 2	79.42 \pm 1.47	77.37 \pm 0.72	80.17 \pm 0.79	78.12 \pm 0.98	81.00 \pm 1.61	80.52 \pm 1.12	94.56 \pm 0.40
	<i>average</i>	81.68 \pm 0.48	80.86 \pm 0.18	81.75 \pm 0.19	81.49 \pm 0.27	81.45 \pm 0.42	82.12 \pm 0.16	92.39 \pm 0.06
SVHN	0	79.72 \pm 0.88	83.35 \pm 0.43	80.28 \pm 0.58	80.98 \pm 0.39	80.18 \pm 0.62	92.22 \pm 0.83	83.28 \pm 0.69
	1	82.16 \pm 0.24	84.88 \pm 0.40	82.79 \pm 0.47	83.16 \pm 0.56	79.27 \pm 0.41	86.72 \pm 0.78	89.13 \pm 0.26
	2	79.92 \pm 0.43	81.63 \pm 0.45	80.50 \pm 0.52	80.63 \pm 0.43	79.39 \pm 0.49	89.60 \pm 1.25	97.01 \pm 0.24
	3	79.77 \pm 0.20	80.49 \pm 0.38	79.54 \pm 0.25	79.83 \pm 0.39	79.94 \pm 0.24	86.73 \pm 0.60	95.96 \pm 0.16
	4	80.81 \pm 0.77	82.52 \pm 0.19	81.74 \pm 0.49	81.67 \pm 0.48	80.16 \pm 0.74	87.60 \pm 1.59	97.21 \pm 0.07
	5	79.38 \pm 0.39	81.11 \pm 0.36	79.59 \pm 0.28	80.06 \pm 0.57	79.90 \pm 0.23	88.96 \pm 1.46	97.33 \pm 0.10
	6	79.69 \pm 0.70	80.73 \pm 0.41	78.99 \pm 0.53	79.96 \pm 0.32	79.85 \pm 0.22	90.90 \pm 0.49	96.13 \pm 0.16
	7	81.79 \pm 0.56	82.59 \pm 0.51	81.28 \pm 0.38	81.85 \pm 0.87	79.79 \pm 0.49	91.38 \pm 1.66	97.54 \pm 0.10
	8	79.41 \pm 0.58	80.85 \pm 0.36	79.18 \pm 0.40	79.95 \pm 0.45	80.19 \pm 0.45	89.99 \pm 1.35	87.76 \pm 0.74
	9	79.58 \pm 0.38	82.25 \pm 0.20	79.82 \pm 0.48	80.56 \pm 0.32	80.31 \pm 0.21	91.03 \pm 0.63	96.37 \pm 0.15
	<i>average</i>	80.22 \pm 0.21	82.04 \pm 0.12	80.37 \pm 0.19	80.87 \pm 0.13	79.90 \pm 0.09	89.51 \pm 0.40	93.77 \pm 0.10

Table 10: AUPR-in (%) (inliers as positive class) when $\rho = 0.25$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	68.43 \pm 2.90	93.31 \pm 1.11	79.59 \pm 6.89	71.32 \pm 1.69	82.83 \pm 13.56	94.19 \pm 0.57	94.53 \pm 0.80
	1	99.41 \pm 0.29	99.56 \pm 0.09	99.08 \pm 0.22	99.26 \pm 0.32	91.93 \pm 8.24	97.73 \pm 0.46	93.21 \pm 0.28
	2	69.97 \pm 0.99	81.25 \pm 2.79	77.27 \pm 6.77	72.33 \pm 1.61	72.60 \pm 4.03	92.85 \pm 0.63	96.55 \pm 0.27
	3	73.61 \pm 1.63	89.74 \pm 1.20	79.89 \pm 6.58	75.84 \pm 1.28	76.36 \pm 3.77	96.17 \pm 0.43	98.51 \pm 0.16
	4	77.46 \pm 1.68	88.61 \pm 1.56	77.39 \pm 1.09	80.49 \pm 1.38	82.88 \pm 6.21	96.82 \pm 0.22	97.38 \pm 0.12
	5	74.59 \pm 1.56	87.23 \pm 0.97	80.98 \pm 7.39	77.81 \pm 1.71	75.65 \pm 2.15	93.77 \pm 0.70	95.53 \pm 0.20
	6	76.49 \pm 1.54	93.81 \pm 0.80	78.78 \pm 6.15	80.51 \pm 1.71	79.84 \pm 8.62	97.71 \pm 0.35	98.53 \pm 0.08
	7	86.15 \pm 2.66	95.06 \pm 0.56	88.77 \pm 2.40	88.79 \pm 2.35	83.74 \pm 4.47	96.14 \pm 0.49	96.57 \pm 0.10
	8	65.42 \pm 2.36	83.58 \pm 1.80	68.20 \pm 1.99	67.34 \pm 1.03	75.94 \pm 1.70	92.64 \pm 0.69	93.53 \pm 0.38
	9	81.28 \pm 1.50	94.30 \pm 0.62	82.02 \pm 5.55	83.48 \pm 1.83	79.41 \pm 4.41	97.43 \pm 0.32	98.02 \pm 0.08
	<i>average</i>	77.28 \pm 0.58	90.64 \pm 0.25	81.20 \pm 2.15	79.72 \pm 0.39	80.12 \pm 1.05	95.55 \pm 0.12	96.24 \pm 0.13
Fashion-MNIST	t-shirt	74.97 \pm 3.25	93.61 \pm 0.30	82.09 \pm 4.37	84.85 \pm 2.79	81.34 \pm 11.32	93.85 \pm 0.97	96.28 \pm 0.26
	trouser	98.11 \pm 0.26	97.42 \pm 0.43	93.37 \pm 5.85	98.32 \pm 0.39	82.72 \pm 6.82	98.81 \pm 0.10	98.69 \pm 0.10
	pullover	73.55 \pm 2.51	91.31 \pm 0.25	78.43 \pm 2.18	84.42 \pm 2.81	69.98 \pm 6.86	93.41 \pm 0.36	95.22 \pm 0.50
	dress	86.67 \pm 1.22	91.20 \pm 0.42	89.62 \pm 0.53	88.87 \pm 1.90	75.80 \pm 8.88	92.87 \pm 1.09	93.04 \pm 0.30
	coat	79.32 \pm 5.13	89.22 \pm 0.41	76.50 \pm 1.24	81.75 \pm 2.45	74.10 \pm 6.64	94.96 \pm 0.39	94.24 \pm 0.15
	sandal	80.99 \pm 5.04	78.53 \pm 1.17	85.25 \pm 1.69	83.84 \pm 3.36	88.33 \pm 5.10	90.77 \pm 0.95	93.72 \pm 3.79
	shirt	73.97 \pm 2.18	89.59 \pm 0.22	77.18 \pm 0.98	83.91 \pm 1.72	78.66 \pm 2.45	88.85 \pm 0.53	91.85 \pm 0.19
	sneaker	91.28 \pm 1.62	94.83 \pm 0.56	93.87 \pm 1.87	94.50 \pm 0.71	84.41 \pm 16.75	98.96 \pm 0.11	99.56 \pm 0.04
	bag	67.32 \pm 3.51	77.29 \pm 1.07	70.34 \pm 1.87	69.07 \pm 3.68	73.81 \pm 5.72	83.51 \pm 1.53	93.29 \pm 0.27
	ankle-boot	82.61 \pm 3.86	89.30 \pm 2.15	83.67 \pm 1.14	87.32 \pm 2.84	76.99 \pm 16.10	98.68 \pm 0.18	99.62 \pm 0.02
	<i>average</i>	80.88 \pm 1.12	89.23 \pm 0.19	83.03 \pm 0.57	85.69 \pm 1.21	78.61 \pm 5.70	93.47 \pm 0.22	95.55 \pm 0.30
CIFAR10	airplane	85.96 \pm 1.89	81.64 \pm 0.66	87.27 \pm 0.64	82.48 \pm 2.27	73.15 \pm 3.79	74.58 \pm 0.66	88.46 \pm 0.46
	automobile	68.41 \pm 1.34	63.41 \pm 0.18	66.65 \pm 0.40	63.01 \pm 0.12	81.51 \pm 2.01	83.36 \pm 0.98	96.46 \pm 0.39
	bird	80.95 \pm 0.84	84.00 \pm 0.40	83.27 \pm 0.22	84.55 \pm 0.41	72.23 \pm 1.08	76.58 \pm 0.80	84.27 \pm 0.96
	cat	79.72 \pm 0.46	74.83 \pm 0.39	79.48 \pm 0.33	76.01 \pm 1.11	76.03 \pm 2.01	76.88 \pm 0.73	79.62 \pm 0.75
	deer	80.72 \pm 1.83	85.66 \pm 0.52	80.24 \pm 0.90	84.93 \pm 0.34	75.17 \pm 1.77	81.14 \pm 0.60	89.54 \pm 0.75
	dog	76.43 \pm 0.49	73.44 \pm 0.49	78.95 \pm 0.40	76.09 \pm 0.47	78.07 \pm 2.05	80.30 \pm 1.10	89.76 \pm 0.63
	frog	74.11 \pm 1.68	79.65 \pm 0.45	69.21 \pm 0.26	77.22 \pm 1.32	76.91 \pm 3.06	81.12 \pm 1.47	87.59 \pm 1.17
	horse	71.03 \pm 1.22	69.98 \pm 0.59	71.84 \pm 0.49	70.49 \pm 0.67	77.98 \pm 2.56	83.49 \pm 1.22	95.09 \pm 0.54
	ship	83.84 \pm 3.15	84.25 \pm 0.30	87.07 \pm 0.57	85.93 \pm 1.80	74.81 \pm 4.09	82.80 \pm 2.27	95.54 \pm 0.39
	truck	67.61 \pm 1.06	63.23 \pm 0.28	66.66 \pm 0.41	63.40 \pm 0.99	80.15 \pm 4.09	81.45 \pm 1.04	93.77 \pm 0.23
	<i>average</i>	76.88 \pm 0.44	76.01 \pm 0.09	77.06 \pm 0.16	76.41 \pm 0.20	76.60 \pm 1.14	80.17 \pm 0.40	90.01 \pm 0.13
CIFAR100	aquatic mammals	80.65 \pm 1.18	80.59 \pm 0.58	82.52 \pm 0.16	81.63 \pm 1.35	74.03 \pm 2.11	77.40 \pm 0.69	88.19 \pm 0.48
	fish	84.10 \pm 1.13	80.64 \pm 0.75	82.23 \pm 0.86	81.47 \pm 1.35	70.81 \pm 2.32	78.29 \pm 1.76	86.18 \pm 0.88
	flowers	66.40 \pm 1.94	65.18 \pm 0.42	63.89 \pm 0.52	65.71 \pm 1.49	76.80 \pm 5.94	78.70 \pm 1.44	88.49 \pm 0.95
	food containers	82.73 \pm 1.29	80.33 \pm 0.63	82.31 \pm 0.83	78.51 \pm 1.88	72.55 \pm 2.73	75.17 \pm 1.04	89.88 \pm 0.68
	fruit and vegetables	78.61 \pm 2.97	70.72 \pm 0.72	77.33 \pm 0.79	72.15 \pm 1.43	79.63 \pm 2.03	76.06 \pm 1.09	88.94 \pm 0.60
	household electrical devices	78.89 \pm 0.79	70.99 \pm 0.53	78.45 \pm 0.55	72.59 \pm 1.81	75.05 \pm 2.06	74.56 \pm 0.77	79.91 \pm 1.24
	household furniture	81.66 \pm 0.49	75.85 \pm 0.55	81.62 \pm 0.89	76.59 \pm 2.25	76.05 \pm 3.53	72.34 \pm 0.91	90.84 \pm 0.45
	inserts	74.61 \pm 1.85	74.07 \pm 0.72	72.33 \pm 0.66	73.34 \pm 1.28	73.58 \pm 1.79	76.52 \pm 1.02	85.27 \pm 0.61
	large carnivores	73.04 \pm 1.63	74.79 \pm 0.92	73.28 \pm 0.66	75.18 \pm 1.04	78.87 \pm 0.99	78.67 \pm 1.29	92.58 \pm 0.67
	large man-made outdoor things	80.89 \pm 3.13	80.51 \pm 0.86	83.96 \pm 1.12	81.95 \pm 1.64	80.82 \pm 1.83	79.63 \pm 1.30	94.79 \pm 0.41
	large natural outdoor scenes	92.06 \pm 1.08	92.16 \pm 0.22	92.15 \pm 0.32	91.42 \pm 0.91	73.87 \pm 2.97	80.46 \pm 0.97	93.87 \pm 0.30
	large omnivores and herbivores	74.09 \pm 1.53	74.64 \pm 0.37	76.06 \pm 0.45	76.89 \pm 0.88	78.61 \pm 2.10	77.21 \pm 0.64	92.37 \pm 0.50
	medium-sized mammals	77.08 \pm 1.62	76.67 \pm 0.36	75.88 \pm 1.05	77.90 \pm 1.35	78.31 \pm 0.80	78.59 \pm 0.96	90.52 \pm 0.34
	non-insert invertebrates	77.49 \pm 0.56	80.55 \pm 0.26	76.73 \pm 0.27	79.21 \pm 0.79	72.68 \pm 0.97	74.44 \pm 0.86	79.89 \pm 0.91
	people	73.07 \pm 0.92	67.02 \pm 0.78	72.17 \pm 0.83	69.28 \pm 1.50	78.92 \pm 1.18	76.00 \pm 1.45	95.13 \pm 0.34
	reptiles	75.39 \pm 0.61	78.13 \pm 0.38	74.99 \pm 0.61	78.33 \pm 1.13	74.05 \pm 2.06	77.22 \pm 0.77	84.36 \pm 0.81
	small mammals	78.78 \pm 1.16	81.01 \pm 0.28	78.69 \pm 0.67	81.76 \pm 0.75	76.20 \pm 1.28	78.12 \pm 0.58	87.37 \pm 0.35
	trees	77.27 \pm 1.90	79.19 \pm 0.68	75.27 \pm 0.83	79.74 \pm 1.20	78.99 \pm 1.55	82.92 \pm 0.60	96.46 \pm 0.21
	vehicles 1	65.03 \pm 0.47	66.23 \pm 0.45	65.86 \pm 0.58	67.15 \pm 1.05	78.55 \pm 1.52	76.27 \pm 1.68	95.09 \pm 0.32
	vehicles 2	73.95 \pm 1.58	72.03 \pm 0.40	75.19 \pm 0.62	72.74 \pm 1.12	75.33 \pm 1.39	74.97 \pm 1.48	92.95 \pm 0.43
	<i>average</i>	77.29 \pm 0.28	76.06 \pm 0.16	77.05 \pm 0.18	76.68 \pm 0.14	76.19 \pm 0.62	77.18 \pm 0.41	89.65 \pm 0.09
SVHN	0	74.76 \pm 0.25	78.71 \pm 0.29	75.23 \pm 0.64	76.17 \pm 0.46	75.05 \pm 0.44	88.74 \pm 0.61	75.19 \pm 0.86
	1	77.71 \pm 0.93	80.11 \pm 0.41	78.05 \pm 0.65	78.10 \pm 0.71	74.43 \pm 1.42	82.92 \pm 0.94	84.80 \pm 0.39
	2	75.15 \pm 0.76	76.35 \pm 0.54	75.35 \pm 0.46	75.70 \pm 0.76	74.93 \pm 0.34	84.36 \pm 0.88	95.67 \pm 0.26
	3	74.64 \pm 0.34	75.43 \pm 0.39	74.47 \pm 0.55	74.93 \pm 0.46	74.88 \pm 0.52	80.88 \pm 2.03	94.14 \pm 0.17
	4	75.86 \pm 0.60	77.49 \pm 0.18	76.56 \pm 0.47	77.09 \pm 0.39	75.65 \pm 1.16	83.28 \pm 1.13	95.93 \pm 0.35
	5	74.19 \pm 0.38	76.05 \pm 0.49	74.38 \pm 0.45	74.75 \pm 0.56	75.11 \pm 0.15	85.15 \pm 1.69	96.27 \pm 0.11
	6	74.32 \pm 0.49	75.78 \pm 0.27	73.83 \pm 0.60	74.73 \pm 0.38	74.82 \pm 0.18	86.41 \pm 1.45	94.45 \pm 0.18
	7	76.76 \pm 0.73	78.35 \pm 0.54	76.06 \pm 0.65	76.91 \pm 0.30	74.18 \pm 1.23	88.80 \pm 1.13	96.31 \pm 0.10
	8	73.82 \pm 0.46	76.25 \pm 0.32	74.00 \pm 0.61	75.12 \pm 0.19	75.21 \pm 0.59	85.43 \pm 0.95	81.58 \pm 0.64
	9	74.68 \pm 1.03	76.54 \pm 0.59	74.73 \pm 0.26	75.40 \pm 0.24	75.99 \pm 1.41	87.06 \pm 1.35	94.73 \pm 0.31
	<i>average</i>	75.19 \pm 0.21	77.11 \pm 0.14	75.27 \pm 0.25	75.89 \pm 0.13	75.02 \pm 0.32	85.30 \pm 0.38	90.91 \pm 0.13

Table 11: AUPR-out (%) (outliers as positive class) when $\rho = 0.05$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	10.76 \pm 1.73	43.01 \pm 3.25	25.43 \pm 7.71	17.60 \pm 1.79	36.38 \pm 33.30	48.88 \pm 3.25	72.36 \pm 1.86
	1	86.89 \pm 1.67	87.45 \pm 1.63	47.39 \pm 14.83	88.15 \pm 2.07	51.42 \pm 19.61	70.57 \pm 1.54	69.95 \pm 3.57
	2	9.70 \pm 1.74	21.46 \pm 2.66	19.68 \pm 3.59	11.90 \pm 1.68	6.94 \pm 2.01	55.14 \pm 1.43	41.99 \pm 1.69
	3	12.49 \pm 1.02	26.87 \pm 1.62	17.60 \pm 4.74	15.37 \pm 1.55	6.51 \pm 3.24	74.22 \pm 4.28	76.02 \pm 1.27
	4	22.94 \pm 2.88	41.33 \pm 6.87	29.56 \pm 4.26	26.35 \pm 2.06	14.48 \pm 5.74	72.85 \pm 4.42	63.10 \pm 2.78
	5	10.69 \pm 1.24	19.04 \pm 2.36	12.38 \pm 4.92	13.49 \pm 1.81	5.69 \pm 0.41	68.48 \pm 3.37	48.06 \pm 2.20
	6	20.27 \pm 6.25	38.98 \pm 5.54	25.57 \pm 8.45	29.17 \pm 4.54	8.00 \pm 1.58	80.24 \pm 3.70	64.37 \pm 2.49
	7	40.18 \pm 5.45	58.37 \pm 2.90	32.81 \pm 7.21	53.74 \pm 3.79	19.84 \pm 5.40	72.14 \pm 2.21	56.28 \pm 1.58
	8	7.19 \pm 2.68	16.88 \pm 2.41	8.38 \pm 1.64	6.88 \pm 1.18	20.51 \pm 16.23	37.19 \pm 5.03	46.40 \pm 1.07
	9	29.14 \pm 4.04	38.38 \pm 5.60	25.41 \pm 8.79	31.39 \pm 3.25	10.09 \pm 2.90	71.57 \pm 2.57	59.89 \pm 1.49
	<i>average</i>	25.03 \pm 1.10	39.18 \pm 0.88	24.42 \pm 3.41	29.40 \pm 1.39	17.99 \pm 4.15	65.13 \pm 0.70	59.84 \pm 0.70
Fashion-MNIST	t-shirt	8.91 \pm 1.61	23.62 \pm 1.72	10.17 \pm 2.31	12.23 \pm 0.70	18.80 \pm 10.24	56.19 \pm 2.63	57.81 \pm 2.01
	trouser	56.14 \pm 0.84	66.01 \pm 1.81	37.60 \pm 4.58	60.02 \pm 2.05	31.34 \pm 11.95	73.33 \pm 1.02	78.53 \pm 2.66
	pullover	9.74 \pm 1.98	23.28 \pm 2.38	9.06 \pm 0.99	11.95 \pm 2.30	7.82 \pm 2.89	67.15 \pm 2.07	72.90 \pm 2.37
	dress	16.79 \pm 2.04	33.51 \pm 4.96	21.44 \pm 3.71	18.34 \pm 1.88	39.37 \pm 14.85	66.05 \pm 2.50	58.35 \pm 2.54
	coat	14.09 \pm 1.12	31.07 \pm 3.54	15.62 \pm 1.45	15.92 \pm 2.44	12.06 \pm 6.65	68.94 \pm 1.95	69.36 \pm 1.91
	sandal	25.47 \pm 4.40	11.65 \pm 2.39	19.62 \pm 4.53	26.48 \pm 12.77	52.18 \pm 12.56	63.91 \pm 2.77	78.07 \pm 0.80
	shirt	5.82 \pm 0.88	16.05 \pm 1.64	5.75 \pm 0.42	8.46 \pm 1.06	7.76 \pm 1.60	54.80 \pm 3.98	53.97 \pm 2.29
	sneaker	61.69 \pm 6.47	63.16 \pm 7.42	64.41 \pm 7.38	65.74 \pm 2.02	49.66 \pm 19.16	86.18 \pm 2.84	94.55 \pm 0.96
	bag	5.38 \pm 0.48	12.56 \pm 0.89	4.83 \pm 0.30	6.46 \pm 0.86	5.13 \pm 1.52	36.88 \pm 1.46	45.49 \pm 2.30
	ankle-boot	34.43 \pm 2.90	50.47 \pm 4.63	30.86 \pm 3.86	37.24 \pm 5.05	28.61 \pm 11.32	91.50 \pm 1.11	94.94 \pm 0.54
	<i>average</i>	23.85 \pm 1.07	33.14 \pm 1.12	21.94 \pm 1.08	26.28 \pm 1.64	25.27 \pm 4.75	66.49 \pm 0.63	70.40 \pm 0.30
CIFAR10	airplane	9.68 \pm 0.81	7.76 \pm 0.36	10.55 \pm 0.18	8.17 \pm 1.21	6.42 \pm 2.94	6.54 \pm 0.83	17.85 \pm 1.62
	automobile	4.01 \pm 0.17	3.49 \pm 0.11	3.90 \pm 0.21	3.50 \pm 0.14	9.07 \pm 2.34	18.67 \pm 3.87	67.11 \pm 2.00
	bird	8.75 \pm 0.52	9.59 \pm 0.67	9.34 \pm 0.64	9.56 \pm 0.77	5.20 \pm 0.34	6.45 \pm 0.45	11.17 \pm 0.89
	cat	7.35 \pm 0.71	6.01 \pm 0.46	7.42 \pm 0.51	7.14 \pm 0.71	6.54 \pm 2.06	6.92 \pm 0.67	11.94 \pm 0.41
	deer	9.14 \pm 1.16	12.47 \pm 1.85	11.18 \pm 1.88	12.29 \pm 1.87	7.22 \pm 2.38	8.76 \pm 0.59	25.35 \pm 1.97
	dog	7.27 \pm 0.89	5.63 \pm 0.22	8.23 \pm 0.55	7.03 \pm 0.60	6.19 \pm 1.04	9.14 \pm 2.24	33.23 \pm 4.49
	frog	5.27 \pm 0.50	9.01 \pm 0.30	5.70 \pm 0.45	7.32 \pm 1.20	13.36 \pm 4.21	11.49 \pm 2.50	26.59 \pm 1.12
	horse	6.08 \pm 0.72	5.04 \pm 0.10	6.15 \pm 0.37	5.78 \pm 0.53	8.47 \pm 1.53	19.02 \pm 4.19	49.53 \pm 3.02
	ship	14.87 \pm 1.61	10.65 \pm 0.97	14.14 \pm 0.46	12.89 \pm 0.85	8.76 \pm 6.07	13.86 \pm 2.26	51.70 \pm 1.26
	truck	3.87 \pm 0.20	3.50 \pm 0.20	3.92 \pm 0.21	3.61 \pm 0.22	15.39 \pm 4.39	18.78 \pm 2.57	51.18 \pm 2.17
	<i>average</i>	7.63 \pm 0.31	7.32 \pm 0.22	8.05 \pm 0.28	7.73 \pm 0.35	8.66 \pm 0.82	11.96 \pm 0.62	34.56 \pm 1.06
CIFAR100	aquatic mammals	11.61 \pm 1.92	9.44 \pm 1.07	12.89 \pm 1.45	12.49 \pm 1.76	6.40 \pm 1.92	6.47 \pm 1.44	17.48 \pm 1.69
	fish	9.79 \pm 1.09	8.04 \pm 1.05	9.25 \pm 0.75	8.96 \pm 0.58	5.24 \pm 0.81	7.92 \pm 0.96	11.19 \pm 1.38
	flowers	3.77 \pm 0.21	3.78 \pm 0.28	3.98 \pm 0.14	4.17 \pm 0.56	12.41 \pm 5.66	6.11 \pm 0.50	18.46 \pm 2.82
	food containers	6.70 \pm 0.83	7.01 \pm 1.19	6.88 \pm 0.49	6.45 \pm 0.38	5.00 \pm 0.86	5.08 \pm 0.42	17.81 \pm 0.71
	fruit and vegetables	5.96 \pm 0.82	4.49 \pm 0.18	5.73 \pm 0.67	5.21 \pm 0.85	10.95 \pm 2.78	5.83 \pm 0.42	16.65 \pm 0.54
	household electrical devices	5.18 \pm 0.22	4.26 \pm 0.20	6.03 \pm 0.45	5.01 \pm 0.37	5.81 \pm 0.34	4.83 \pm 0.65	7.44 \pm 0.90
	household furniture	7.52 \pm 1.37	5.71 \pm 0.68	8.35 \pm 0.72	6.66 \pm 1.02	6.86 \pm 2.24	5.13 \pm 0.43	16.27 \pm 1.55
	inserts	4.44 \pm 0.20	5.37 \pm 0.44	4.91 \pm 0.39	5.14 \pm 0.48	6.67 \pm 1.04	5.76 \pm 0.40	14.55 \pm 1.16
	large carnivores	6.14 \pm 1.00	7.79 \pm 0.75	7.77 \pm 0.59	8.75 \pm 1.37	11.40 \pm 1.87	9.53 \pm 2.48	36.17 \pm 4.71
	large man-made outdoor things	13.40 \pm 3.65	9.89 \pm 1.62	15.88 \pm 2.89	13.44 \pm 2.68	10.14 \pm 1.96	9.63 \pm 0.82	36.57 \pm 4.35
	large natural outdoor scenes	22.22 \pm 3.94	23.95 \pm 4.78	23.62 \pm 3.46	24.15 \pm 5.41	7.12 \pm 1.54	8.00 \pm 0.96	23.87 \pm 1.29
	large omnivores and herbivores	8.32 \pm 0.98	5.89 \pm 0.73	8.93 \pm 0.53	8.31 \pm 1.05	9.24 \pm 2.10	6.21 \pm 0.43	25.93 \pm 2.02
	medium-sized mammals	10.40 \pm 1.33	7.11 \pm 0.34	10.94 \pm 1.50	11.18 \pm 1.23	11.47 \pm 2.64	8.17 \pm 1.95	34.30 \pm 3.51
	non-insert invertebrates	5.40 \pm 0.50	5.89 \pm 0.32	5.26 \pm 0.27	5.61 \pm 0.25	6.50 \pm 0.95	5.02 \pm 0.29	7.22 \pm 0.29
	people	5.09 \pm 0.40	4.02 \pm 0.28	5.33 \pm 0.71	4.86 \pm 0.82	8.02 \pm 1.08	6.99 \pm 0.60	31.45 \pm 3.31
	reptiles	7.45 \pm 0.96	7.19 \pm 1.13	7.79 \pm 1.23	7.92 \pm 1.05	6.08 \pm 0.71	5.70 \pm 0.49	13.22 \pm 2.61
	small mammals	8.79 \pm 0.75	9.34 \pm 0.71	10.76 \pm 0.86	11.41 \pm 1.56	8.92 \pm 1.05	6.72 \pm 0.72	18.53 \pm 1.34
	trees	11.81 \pm 1.74	10.67 \pm 2.04	13.37 \pm 2.14	12.08 \pm 1.68	11.04 \pm 1.20	14.71 \pm 2.55	40.48 \pm 2.96
	vehicles 1	3.72 \pm 0.24	3.73 \pm 0.15	3.94 \pm 0.50	3.87 \pm 0.36	8.15 \pm 1.67	9.28 \pm 0.89	45.14 \pm 2.73
	vehicles 2	6.23 \pm 0.85	5.15 \pm 0.27	7.81 \pm 0.82	6.36 \pm 0.75	5.70 \pm 0.90	6.23 \pm 1.11	20.94 \pm 1.86
	<i>average</i>	8.20 \pm 0.33	7.44 \pm 0.25	8.97 \pm 0.27	8.60 \pm 0.17	8.16 \pm 0.30	7.17 \pm 0.29	22.68 \pm 0.42
SVHN	0	5.22 \pm 0.17	6.81 \pm 0.38	5.68 \pm 0.19	5.27 \pm 0.28	9.04 \pm 4.88	17.06 \pm 1.93	21.77 \pm 1.63
	1	6.03 \pm 0.47	7.56 \pm 0.30	6.08 \pm 0.38	6.75 \pm 0.30	10.22 \pm 7.12	10.93 \pm 1.99	16.22 \pm 1.21
	2	5.28 \pm 0.08	5.82 \pm 0.24	5.09 \pm 0.20	5.37 \pm 0.13	15.45 \pm 8.89	13.82 \pm 1.34	28.57 \pm 1.18
	3	5.04 \pm 0.13	5.50 \pm 0.16	4.94 \pm 0.07	5.06 \pm 0.12	17.29 \pm 4.22	10.31 \pm 1.15	21.63 \pm 0.70
	4	5.55 \pm 0.43	6.67 \pm 0.47	5.47 \pm 0.24	5.56 \pm 0.17	18.69 \pm 11.30	13.32 \pm 1.53	32.12 \pm 0.91
	5	4.88 \pm 0.16	5.37 \pm 0.16	4.76 \pm 0.14	4.99 \pm 0.17	22.71 \pm 9.10	11.81 \pm 1.51	32.91 \pm 0.94
	6	4.84 \pm 0.16	5.23 \pm 0.13	4.65 \pm 0.12	4.91 \pm 0.17	19.19 \pm 13.63	15.25 \pm 2.48	31.25 \pm 1.05
	7	6.16 \pm 0.40	6.71 \pm 0.52	5.73 \pm 0.49	6.11 \pm 0.31	20.68 \pm 8.63	20.73 \pm 1.42	40.84 \pm 1.06
	8	5.03 \pm 0.23	5.57 \pm 0.15	4.82 \pm 0.19	5.11 \pm 0.28	11.09 \pm 7.50	9.78 \pm 1.26	16.27 \pm 0.70
	9	5.13 \pm 0.26	5.51 \pm 0.26	4.93 \pm 0.09	5.32 \pm 0.29	13.65 \pm 9.61	15.47 \pm 1.05	29.86 \pm 2.56
	<i>average</i>	5.32 \pm 0.09	6.08 \pm 0.10	5.21 \pm 0.09	5.44 \pm 0.04	15.80 \pm 2.21	13.85 \pm 0.49	27.15 \pm 0.46

Table 12: AUPR-out (%) (outliers as positive class) when $\rho = 0.1$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	19.41 \pm 3.89	53.24 \pm 7.39	28.59 \pm 13.07	21.21 \pm 3.30	49.61 \pm 34.50	55.13 \pm 3.27	73.08 \pm 1.15
	1	91.68 \pm 0.99	92.27 \pm 1.34	42.86 \pm 13.71	92.09 \pm 0.81	65.54 \pm 24.42	76.55 \pm 1.75	73.05 \pm 0.90
	2	13.74 \pm 2.12	28.26 \pm 1.66	20.44 \pm 0.95	18.87 \pm 1.54	12.00 \pm 3.67	59.02 \pm 4.19	54.66 \pm 1.08
	3	19.63 \pm 4.50	36.55 \pm 4.67	27.17 \pm 5.80	22.66 \pm 2.53	11.74 \pm 2.95	72.30 \pm 2.88	81.49 \pm 1.94
	4	32.07 \pm 6.00	49.19 \pm 4.80	31.97 \pm 5.96	40.08 \pm 2.19	19.45 \pm 6.46	77.80 \pm 3.21	71.34 \pm 1.83
	5	18.85 \pm 1.30	30.42 \pm 1.57	25.31 \pm 4.19	22.26 \pm 3.29	11.33 \pm 0.65	67.89 \pm 4.01	56.59 \pm 2.00
	6	31.20 \pm 6.41	54.11 \pm 1.96	37.10 \pm 8.89	33.66 \pm 4.55	25.78 \pm 16.43	80.49 \pm 1.03	72.47 \pm 0.96
	7	52.41 \pm 3.83	66.39 \pm 3.74	46.73 \pm 4.54	55.90 \pm 3.15	36.51 \pm 20.35	73.55 \pm 1.16	64.63 \pm 0.91
	8	12.40 \pm 1.16	27.29 \pm 2.61	13.70 \pm 2.71	13.39 \pm 1.02	15.77 \pm 5.52	47.96 \pm 3.61	57.04 \pm 1.45
	9	37.95 \pm 3.36	52.03 \pm 3.51	31.43 \pm 13.47	38.01 \pm 4.42	18.45 \pm 4.23	76.41 \pm 2.50	70.61 \pm 1.70
	<i>average</i>	32.93 \pm 0.74	48.98 \pm 1.06	30.53 \pm 1.99	35.81 \pm 0.77	26.62 \pm 5.31	68.71 \pm 1.17	67.50 \pm 0.31
Fashion-MNIST	t-shirt	13.50 \pm 2.24	34.19 \pm 2.51	14.76 \pm 2.93	18.19 \pm 2.04	21.51 \pm 8.91	59.56 \pm 2.03	66.31 \pm 1.95
	trouser	65.54 \pm 1.46	74.34 \pm 2.37	33.44 \pm 12.93	71.64 \pm 2.00	34.73 \pm 13.15	78.47 \pm 3.16	83.42 \pm 1.26
	pullover	15.04 \pm 1.01	34.81 \pm 2.46	14.63 \pm 1.28	18.97 \pm 3.00	12.63 \pm 4.92	69.48 \pm 2.74	79.16 \pm 1.59
	dress	23.77 \pm 1.97	41.97 \pm 2.10	27.16 \pm 4.02	26.82 \pm 3.73	47.57 \pm 15.22	67.29 \pm 2.49	64.01 \pm 1.65
	coat	20.54 \pm 1.22	41.62 \pm 2.48	19.14 \pm 2.23	26.76 \pm 1.83	18.24 \pm 10.26	71.59 \pm 0.57	77.48 \pm 0.94
	sandal	29.43 \pm 3.37	18.10 \pm 1.63	25.57 \pm 3.82	24.53 \pm 2.06	55.01 \pm 18.88	65.13 \pm 3.10	79.98 \pm 1.16
	shirt	10.47 \pm 1.11	24.61 \pm 0.76	10.59 \pm 0.82	14.53 \pm 1.03	15.93 \pm 2.81	56.96 \pm 2.12	60.57 \pm 1.73
	sneaker	65.39 \pm 3.41	63.96 \pm 2.97	69.15 \pm 3.79	61.69 \pm 2.45	56.93 \pm 22.49	88.30 \pm 2.21	95.79 \pm 0.24
	bag	9.25 \pm 0.75	20.11 \pm 1.05	9.15 \pm 0.39	10.32 \pm 0.67	11.46 \pm 2.05	36.25 \pm 2.75	55.71 \pm 1.08
	ankle-boot	39.58 \pm 3.68	49.69 \pm 3.57	31.19 \pm 3.52	43.79 \pm 5.38	28.86 \pm 20.98	92.70 \pm 1.11	96.73 \pm 0.24
	<i>average</i>	29.25 \pm 0.13	40.34 \pm 0.39	25.48 \pm 1.11	31.72 \pm 1.39	30.29 \pm 6.31	68.57 \pm 0.39	75.91 \pm 0.24
CIFAR10	airplane	18.24 \pm 2.40	14.68 \pm 0.33	19.65 \pm 0.29	14.59 \pm 1.01	10.88 \pm 3.32	10.43 \pm 0.78	28.53 \pm 2.68
	automobile	7.57 \pm 0.51	7.29 \pm 0.31	7.75 \pm 0.19	7.13 \pm 0.29	19.50 \pm 5.92	24.26 \pm 4.72	71.61 \pm 1.21
	bird	15.24 \pm 1.94	17.00 \pm 0.55	17.09 \pm 0.67	16.38 \pm 1.28	10.17 \pm 0.98	11.17 \pm 0.98	18.18 \pm 0.62
	cat	14.14 \pm 1.28	10.99 \pm 0.52	14.37 \pm 0.49	12.47 \pm 1.22	11.18 \pm 0.80	12.22 \pm 0.95	19.05 \pm 0.91
	deer	19.46 \pm 1.06	22.81 \pm 0.88	19.59 \pm 0.92	22.29 \pm 1.91	15.10 \pm 2.59	17.21 \pm 1.31	37.24 \pm 1.26
	dog	14.39 \pm 1.88	11.03 \pm 0.53	15.53 \pm 0.83	13.65 \pm 1.25	12.14 \pm 1.79	15.99 \pm 1.48	41.31 \pm 1.67
	frog	11.66 \pm 1.52	16.82 \pm 0.75	9.31 \pm 0.34	13.18 \pm 0.87	18.08 \pm 3.60	18.84 \pm 4.38	36.72 \pm 3.04
	horse	10.95 \pm 0.59	9.77 \pm 0.45	11.62 \pm 0.59	11.48 \pm 1.14	15.10 \pm 1.68	25.94 \pm 0.84	58.09 \pm 3.09
	ship	25.07 \pm 2.84	18.99 \pm 1.04	24.37 \pm 1.23	20.77 \pm 1.67	20.09 \pm 14.18	20.00 \pm 2.47	63.22 \pm 0.81
	truck	7.48 \pm 0.38	7.23 \pm 0.23	7.80 \pm 0.20	7.56 \pm 0.25	24.21 \pm 7.35	27.25 \pm 2.56	60.21 \pm 1.78
	<i>average</i>	14.42 \pm 0.68	13.66 \pm 0.18	14.71 \pm 0.11	13.95 \pm 0.30	15.64 \pm 1.34	18.33 \pm 0.55	43.42 \pm 0.47
CIFAR100	aquatic mammals	20.76 \pm 2.73	15.18 \pm 0.78	21.18 \pm 1.98	18.96 \pm 2.41	10.73 \pm 0.96	12.07 \pm 0.93	27.30 \pm 2.17
	fish	16.55 \pm 2.39	13.28 \pm 0.87	16.99 \pm 1.00	14.76 \pm 1.28	8.69 \pm 0.89	13.09 \pm 0.81	20.09 \pm 1.06
	flowers	7.68 \pm 1.45	8.17 \pm 0.52	7.60 \pm 0.35	7.75 \pm 0.81	19.45 \pm 5.82	12.37 \pm 1.34	28.87 \pm 1.09
	food containers	13.62 \pm 1.87	12.17 \pm 0.83	13.91 \pm 0.46	12.64 \pm 1.02	10.34 \pm 0.61	9.23 \pm 0.59	27.05 \pm 2.39
	fruit and vegetables	10.01 \pm 0.99	8.73 \pm 0.34	10.58 \pm 0.53	8.85 \pm 1.27	19.02 \pm 5.38	11.94 \pm 0.91	24.54 \pm 1.65
	household electrical devices	10.49 \pm 1.46	8.28 \pm 0.11	10.35 \pm 1.28	8.97 \pm 0.54	10.05 \pm 1.03	9.52 \pm 0.28	14.03 \pm 1.07
	household furniture	14.63 \pm 1.16	10.88 \pm 0.32	14.41 \pm 0.36	11.22 \pm 1.10	12.48 \pm 3.54	9.28 \pm 0.24	26.64 \pm 1.30
	inserts	9.67 \pm 0.32	11.35 \pm 0.45	10.02 \pm 0.43	10.36 \pm 1.19	9.86 \pm 0.52	11.41 \pm 0.35	22.39 \pm 1.05
	large carnivores	12.77 \pm 1.30	14.53 \pm 1.45	12.56 \pm 0.88	17.12 \pm 1.83	18.30 \pm 1.66	18.40 \pm 3.88	47.93 \pm 3.86
	large man-made outdoor things	20.79 \pm 3.02	18.40 \pm 0.91	21.11 \pm 1.51	24.87 \pm 2.28	21.88 \pm 3.73	15.88 \pm 1.92	49.89 \pm 1.91
	large natural outdoor scenes	33.77 \pm 6.48	38.32 \pm 4.21	37.91 \pm 2.92	33.81 \pm 6.97	15.16 \pm 3.15	14.51 \pm 1.19	35.79 \pm 1.96
	large omnivores and herbivores	15.53 \pm 0.55	11.97 \pm 0.80	16.29 \pm 0.94	16.77 \pm 1.79	17.23 \pm 1.19	13.42 \pm 1.93	38.28 \pm 1.06
	medium-sized mammals	17.22 \pm 1.21	12.91 \pm 0.52	15.74 \pm 0.63	18.47 \pm 1.85	20.08 \pm 1.43	15.60 \pm 2.21	43.57 \pm 2.63
	non-insert invertebrates	10.21 \pm 0.50	11.86 \pm 0.21	10.22 \pm 0.28	10.11 \pm 0.37	9.54 \pm 0.39	10.43 \pm 0.40	13.60 \pm 0.77
	people	10.12 \pm 0.78	7.98 \pm 0.16	10.04 \pm 0.50	10.03 \pm 0.93	13.03 \pm 1.22	11.92 \pm 1.15	44.16 \pm 2.99
	reptiles	13.79 \pm 1.10	13.13 \pm 0.65	13.83 \pm 0.50	13.77 \pm 0.99	10.22 \pm 0.33	11.22 \pm 0.81	22.71 \pm 1.84
	small mammals	16.92 \pm 2.01	19.30 \pm 1.29	18.13 \pm 1.39	20.81 \pm 1.30	14.90 \pm 0.86	13.48 \pm 0.73	29.54 \pm 2.53
	trees	17.14 \pm 3.19	21.37 \pm 0.92	19.58 \pm 1.80	21.38 \pm 2.93	18.12 \pm 3.25	20.31 \pm 3.83	56.26 \pm 2.17
	vehicles 1	7.84 \pm 0.52	8.09 \pm 0.21	7.36 \pm 0.44	7.91 \pm 0.37	13.82 \pm 1.10	13.95 \pm 1.36	56.68 \pm 1.98
	vehicles 2	10.72 \pm 1.30	10.77 \pm 1.00	11.33 \pm 0.94	11.63 \pm 1.30	10.90 \pm 0.84	11.50 \pm 0.39	36.67 \pm 2.35
	<i>average</i>	14.51 \pm 0.57	13.83 \pm 0.21	14.96 \pm 0.11	15.01 \pm 0.43	14.19 \pm 0.45	12.98 \pm 0.17	33.30 \pm 0.39
SVHN	0	10.34 \pm 0.37	13.17 \pm 0.62	10.65 \pm 0.29	10.59 \pm 0.58	15.27 \pm 6.31	30.87 \pm 3.14	25.89 \pm 1.45
	1	12.79 \pm 0.78	14.57 \pm 0.96	12.38 \pm 0.55	13.11 \pm 0.81	21.94 \pm 7.09	17.59 \pm 0.83	22.15 \pm 1.09
	2	10.75 \pm 0.16	11.73 \pm 0.20	10.67 \pm 0.27	10.93 \pm 0.25	17.36 \pm 8.07	20.92 \pm 1.69	40.71 \pm 1.28
	3	10.05 \pm 0.15	10.67 \pm 0.25	9.91 \pm 0.20	10.15 \pm 0.19	15.81 \pm 5.72	17.18 \pm 1.44	32.45 \pm 0.24
	4	11.01 \pm 0.44	12.43 \pm 0.75	10.85 \pm 0.30	11.72 \pm 0.29	21.97 \pm 5.98	18.62 \pm 2.11	44.26 \pm 1.43
	5	9.71 \pm 0.24	10.61 \pm 0.40	9.58 \pm 0.31	9.84 \pm 0.32	25.10 \pm 10.95	21.07 \pm 2.55	44.00 \pm 1.80
	6	9.83 \pm 0.26	10.34 \pm 0.37	9.44 \pm 0.22	9.89 \pm 0.18	16.63 \pm 6.96	22.18 \pm 1.82	41.63 \pm 1.23
	7	10.87 \pm 0.53	12.72 \pm 0.35	11.35 \pm 0.51	10.98 \pm 0.68	25.77 \pm 14.33	28.50 \pm 4.72	50.71 \pm 1.37
	8	9.95 \pm 0.27	11.14 \pm 0.32	9.58 \pm 0.22	9.98 \pm 0.31	14.60 \pm 8.64	19.40 \pm 1.99	25.04 \pm 2.20
	9	10.29 \pm 0.32	11.30 \pm 0.43	10.16 \pm 0.12	10.71 \pm 0.42	18.70 \pm 8.92	24.09 \pm 0.69	39.67 \pm 1.65
	<i>average</i>	10.56 \pm 0.12	11.87 \pm 0.26	10.46 \pm 0.18	10.79 \pm 0.21	19.31 \pm 2.43	22.04 \pm 0.79	36.65 \pm 0.12

Table 13: AUPR-out (%) (outliers as positive class) when $\rho = 0.15$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	19.63 \pm 3.45	56.80 \pm 3.92	34.84 \pm 17.52	20.60 \pm 3.94	51.66 \pm 31.41	60.50 \pm 7.01	70.15 \pm 0.88
	1	92.84 \pm 1.76	94.57 \pm 0.99	63.41 \pm 13.90	93.78 \pm 0.76	69.22 \pm 28.68	80.60 \pm 2.59	71.06 \pm 2.21
	2	18.99 \pm 3.21	35.31 \pm 1.85	23.52 \pm 4.03	19.38 \pm 2.74	16.18 \pm 3.28	60.47 \pm 2.86	61.70 \pm 1.16
	3	21.95 \pm 2.07	42.16 \pm 3.65	32.10 \pm 8.41	29.69 \pm 2.20	25.17 \pm 12.63	73.27 \pm 1.84	84.90 \pm 0.55
	4	37.58 \pm 5.59	50.08 \pm 2.86	37.21 \pm 10.38	42.75 \pm 2.34	30.80 \pm 14.52	78.07 \pm 2.29	73.62 \pm 1.76
	5	20.65 \pm 1.71	51.51 \pm 1.03	24.97 \pm 1.52	17.81 \pm 3.57	17.18 \pm 1.68	65.53 \pm 2.68	61.18 \pm 1.44
	6	31.59 \pm 4.34	58.36 \pm 5.84	25.89 \pm 7.68	34.20 \pm 3.28	20.58 \pm 6.85	78.57 \pm 1.71	76.61 \pm 0.74
	7	44.50 \pm 11.65	66.81 \pm 1.79	48.08 \pm 3.25	50.74 \pm 5.18	38.57 \pm 20.82	74.09 \pm 2.56	69.14 \pm 0.42
	8	16.78 \pm 2.35	33.83 \pm 2.09	22.57 \pm 4.92	18.78 \pm 2.52	19.87 \pm 5.95	50.92 \pm 2.83	62.90 \pm 1.71
	9	43.68 \pm 4.63	59.83 \pm 1.89	37.61 \pm 8.89	43.89 \pm 5.99	26.06 \pm 6.49	79.04 \pm 1.23	75.14 \pm 1.42
	<i>average</i>	34.82 \pm 1.84	54.93 \pm 0.76	35.02 \pm 2.52	37.16 \pm 2.20	31.53 \pm 3.75	70.11 \pm 0.96	70.64 \pm 0.43
Fashion-MNIST	t-shirt	21.57 \pm 2.11	43.29 \pm 1.61	22.81 \pm 1.16	25.36 \pm 1.93	44.81 \pm 16.03	62.02 \pm 3.19	72.47 \pm 0.70
	trouser	71.85 \pm 2.31	79.02 \pm 3.27	66.75 \pm 4.11	77.47 \pm 2.30	50.89 \pm 7.97	81.51 \pm 4.08	85.37 \pm 1.11
	pullover	21.73 \pm 3.37	41.76 \pm 0.75	20.87 \pm 2.75	23.69 \pm 4.47	22.81 \pm 5.83	72.05 \pm 2.58	82.45 \pm 1.21
	dress	31.72 \pm 2.77	47.87 \pm 3.54	31.56 \pm 2.11	32.58 \pm 2.90	49.00 \pm 8.61	69.36 \pm 1.03	66.26 \pm 1.68
	coat	25.81 \pm 1.80	47.50 \pm 3.22	25.40 \pm 1.55	29.88 \pm 6.34	33.56 \pm 19.64	74.28 \pm 0.55	79.95 \pm 0.42
	sandal	33.17 \pm 2.53	21.92 \pm 1.94	32.66 \pm 1.48	31.39 \pm 7.72	71.38 \pm 14.66	64.65 \pm 3.23	80.60 \pm 1.07
	shirt	15.18 \pm 0.77	31.35 \pm 1.61	14.85 \pm 0.53	19.22 \pm 2.15	27.05 \pm 12.51	59.75 \pm 1.75	63.88 \pm 1.15
	sneaker	64.38 \pm 4.59	69.43 \pm 2.55	68.28 \pm 4.36	66.56 \pm 5.17	59.76 \pm 11.51	90.42 \pm 1.99	95.87 \pm 0.72
	bag	13.57 \pm 2.37	22.99 \pm 1.47	13.42 \pm 0.77	14.21 \pm 2.40	26.01 \pm 14.59	39.34 \pm 2.90	57.58 \pm 0.79
	ankle-boot	47.24 \pm 4.04	50.00 \pm 3.85	36.81 \pm 1.84	45.48 \pm 2.85	43.18 \pm 25.86	91.67 \pm 1.84	97.21 \pm 0.22
	<i>average</i>	34.62 \pm 1.14	45.51 \pm 0.91	33.34 \pm 1.03	36.58 \pm 1.36	42.84 \pm 8.88	70.51 \pm 0.55	78.16 \pm 0.24
CIFAR10	airplane	28.96 \pm 2.69	21.62 \pm 0.98	28.72 \pm 0.96	22.54 \pm 2.06	16.90 \pm 4.11	15.90 \pm 0.91	35.47 \pm 1.46
	automobile	11.31 \pm 0.39	10.99 \pm 0.19	11.58 \pm 0.25	10.85 \pm 0.43	24.02 \pm 5.03	31.48 \pm 4.78	76.88 \pm 1.60
	bird	22.03 \pm 0.73	24.27 \pm 0.39	24.24 \pm 0.36	24.02 \pm 1.08	14.16 \pm 2.11	16.10 \pm 0.94	24.80 \pm 0.52
	cat	20.05 \pm 0.76	16.93 \pm 0.51	20.68 \pm 0.23	18.73 \pm 1.17	17.47 \pm 1.54	17.10 \pm 1.17	24.04 \pm 0.83
	deer	25.01 \pm 1.51	31.54 \pm 0.86	27.07 \pm 0.47	30.60 \pm 1.35	19.00 \pm 2.68	23.24 \pm 1.06	44.35 \pm 1.01
	dog	21.32 \pm 1.08	16.54 \pm 0.58	22.22 \pm 1.02	19.83 \pm 1.46	17.14 \pm 1.26	24.36 \pm 1.91	44.63 \pm 2.11
	frog	16.51 \pm 1.55	23.36 \pm 0.73	14.58 \pm 0.59	18.64 \pm 1.32	22.42 \pm 3.85	25.66 \pm 3.27	40.98 \pm 1.98
	horse	15.96 \pm 0.78	14.56 \pm 0.44	16.73 \pm 0.49	16.47 \pm 0.59	21.53 \pm 3.31	30.66 \pm 3.61	60.66 \pm 1.13
	ship	32.49 \pm 2.49	26.70 \pm 1.26	33.55 \pm 0.96	28.66 \pm 4.67	25.81 \pm 15.68	27.90 \pm 4.04	68.33 \pm 1.41
	truck	12.06 \pm 0.96	10.81 \pm 0.12	11.96 \pm 0.07	11.00 \pm 0.51	26.47 \pm 6.72	30.02 \pm 1.79	66.14 \pm 0.75
	<i>average</i>	20.57 \pm 0.23	19.73 \pm 0.07	21.13 \pm 0.14	20.13 \pm 0.38	20.49 \pm 1.20	24.24 \pm 0.91	48.63 \pm 0.18
CIFAR100	aquatic mammals	29.51 \pm 1.00	23.27 \pm 0.79	29.46 \pm 0.87	27.64 \pm 1.90	16.03 \pm 0.85	19.37 \pm 1.70	34.82 \pm 1.87
	fish	25.04 \pm 1.33	20.32 \pm 1.28	23.92 \pm 0.60	22.81 \pm 1.66	13.30 \pm 1.78	19.21 \pm 0.43	28.85 \pm 1.23
	flowers	11.00 \pm 0.56	11.17 \pm 0.32	11.22 \pm 0.61	11.41 \pm 1.20	23.69 \pm 7.50	17.86 \pm 0.96	38.07 \pm 3.55
	food containers	19.45 \pm 1.01	19.37 \pm 0.58	19.12 \pm 0.70	17.69 \pm 0.83	14.29 \pm 0.50	15.06 \pm 0.71	32.55 \pm 1.07
	fruit and vegetables	15.65 \pm 1.36	13.70 \pm 0.48	15.97 \pm 0.49	15.02 \pm 1.17	25.03 \pm 5.12	17.58 \pm 1.67	32.06 \pm 1.44
	household electrical devices	15.41 \pm 0.84	12.66 \pm 0.28	16.97 \pm 0.45	13.25 \pm 0.70	16.29 \pm 2.37	14.77 \pm 0.29	19.67 \pm 1.26
	household furniture	20.84 \pm 1.59	17.26 \pm 0.89	22.76 \pm 1.09	18.47 \pm 1.74	17.47 \pm 3.15	14.33 \pm 0.58	34.62 \pm 1.89
	inserts	14.80 \pm 1.07	15.54 \pm 0.47	14.46 \pm 0.42	15.01 \pm 0.27	16.14 \pm 2.95	16.37 \pm 0.42	30.67 \pm 0.89
	large carnivores	16.17 \pm 0.98	19.68 \pm 1.88	19.46 \pm 0.92	19.51 \pm 0.53	24.64 \pm 0.53	23.39 \pm 3.18	55.01 \pm 4.95
	large man-made outdoor things	27.54 \pm 1.60	26.39 \pm 1.10	34.00 \pm 0.96	30.55 \pm 1.45	28.62 \pm 6.09	23.06 \pm 2.56	57.92 \pm 2.35
	large natural outdoor scenes	46.29 \pm 2.49	48.23 \pm 3.14	44.54 \pm 2.91	48.01 \pm 3.28	18.63 \pm 2.31	18.68 \pm 3.27	43.78 \pm 2.36
	large omnivores and herbivores	21.15 \pm 0.74	17.86 \pm 0.14	23.48 \pm 1.30	22.15 \pm 0.71	23.13 \pm 3.16	18.05 \pm 1.46	45.68 \pm 1.90
	medium-sized mammals	20.59 \pm 1.76	18.62 \pm 0.77	21.90 \pm 1.02	24.67 \pm 1.56	24.45 \pm 1.79	22.26 \pm 3.16	49.82 \pm 1.72
	non-insert invertebrates	15.25 \pm 0.45	16.91 \pm 0.54	14.86 \pm 0.46	15.40 \pm 0.34	14.25 \pm 0.69	15.04 \pm 0.45	18.24 \pm 0.47
	people	14.88 \pm 0.75	12.22 \pm 0.22	15.15 \pm 0.71	14.40 \pm 0.91	20.03 \pm 1.78	16.65 \pm 1.92	52.46 \pm 2.46
	reptiles	17.58 \pm 0.92	18.29 \pm 0.84	19.39 \pm 0.83	19.32 \pm 0.41	15.57 \pm 1.48	17.73 \pm 1.69	28.92 \pm 1.60
	small mammals	23.17 \pm 0.79	25.25 \pm 0.92	25.82 \pm 1.51	27.79 \pm 1.06	20.09 \pm 2.29	19.43 \pm 1.73	35.92 \pm 0.79
	trees	25.84 \pm 1.34	27.58 \pm 1.59	29.44 \pm 1.75	28.58 \pm 1.11	23.48 \pm 3.23	29.27 \pm 3.39	63.39 \pm 1.68
	vehicles 1	11.68 \pm 0.48	11.60 \pm 0.44	12.12 \pm 0.73	11.69 \pm 0.61	20.87 \pm 1.22	19.32 \pm 2.56	65.21 \pm 1.73
	vehicles 2	15.38 \pm 0.95	14.77 \pm 0.85	17.98 \pm 1.08	15.83 \pm 0.85	17.13 \pm 2.51	16.03 \pm 0.81	46.35 \pm 1.83
	<i>average</i>	20.36 \pm 0.22	19.53 \pm 0.35	21.60 \pm 0.18	20.96 \pm 0.24	19.66 \pm 0.44	18.67 \pm 0.27	40.70 \pm 0.46
SVHN	0	15.83 \pm 0.77	18.51 \pm 0.23	15.73 \pm 0.38	16.32 \pm 0.43	20.37 \pm 4.33	38.43 \pm 3.73	29.97 \pm 1.49
	1	17.59 \pm 0.65	20.30 \pm 0.68	18.08 \pm 0.99	18.65 \pm 0.81	21.37 \pm 6.57	24.24 \pm 2.65	27.28 \pm 2.15
	2	15.72 \pm 0.28	17.02 \pm 0.40	15.63 \pm 0.22	16.30 \pm 0.41	23.08 \pm 7.58	28.30 \pm 3.37	47.74 \pm 2.10
	3	15.01 \pm 0.23	15.65 \pm 0.20	14.69 \pm 0.27	14.95 \pm 0.25	24.86 \pm 5.48	24.08 \pm 1.89	40.33 \pm 0.66
	4	16.40 \pm 0.32	17.88 \pm 0.73	16.26 \pm 0.30	17.12 \pm 0.47	26.29 \pm 9.36	25.53 \pm 1.16	49.82 \pm 0.99
	5	14.92 \pm 0.23	15.85 \pm 0.18	14.52 \pm 0.18	15.06 \pm 0.11	23.13 \pm 13.29	24.87 \pm 1.95	50.54 \pm 0.89
	6	14.58 \pm 0.35	15.45 \pm 0.23	14.12 \pm 0.32	14.73 \pm 0.25	29.02 \pm 15.07	27.17 \pm 1.27	47.04 \pm 1.10
	7	17.42 \pm 0.50	18.69 \pm 0.67	17.09 \pm 0.65	17.59 \pm 0.50	30.14 \pm 7.67	36.04 \pm 2.12	55.95 \pm 1.52
	8	14.82 \pm 0.25	16.16 \pm 0.40	14.55 \pm 0.26	15.14 \pm 0.33	20.52 \pm 10.54	27.21 \pm 2.71	29.10 \pm 0.95
	9	15.28 \pm 0.52	16.46 \pm 0.49	15.17 \pm 0.19	15.68 \pm 0.59	23.63 \pm 5.31	28.39 \pm 1.72	46.74 \pm 1.46
	<i>average</i>	15.76 \pm 0.11	17.20 \pm 0.13	15.58 \pm 0.18	16.15 \pm 0.14	24.24 \pm 2.19	28.43 \pm 0.34	42.45 \pm 0.59

Table 14: AUPR-out (%) (outliers as positive class) when $\rho = 0.2$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	24.25 \pm 2.91	62.27 \pm 7.97	33.91 \pm 6.62	26.76 \pm 5.49	51.46 \pm 29.90	58.60 \pm 5.61	71.09 \pm 1.14
	1	94.72 \pm 0.76	95.66 \pm 0.89	80.07 \pm 15.25	94.57 \pm 0.26	74.00 \pm 23.72	81.35 \pm 1.71	68.21 \pm 1.78
	2	23.89 \pm 3.03	39.45 \pm 4.08	25.56 \pm 3.79	25.81 \pm 3.18	21.10 \pm 1.17	60.82 \pm 1.53	65.28 \pm 1.10
	3	30.11 \pm 3.97	48.24 \pm 2.61	44.39 \pm 11.30	35.18 \pm 2.99	32.53 \pm 11.64	71.18 \pm 2.77	86.03 \pm 0.46
	4	46.04 \pm 4.39	54.55 \pm 3.66	46.07 \pm 5.90	48.36 \pm 4.38	42.00 \pm 20.73	79.51 \pm 1.49	74.36 \pm 0.93
	5	29.21 \pm 2.04	38.47 \pm 2.53	26.66 \pm 4.23	30.33 \pm 2.85	23.83 \pm 2.52	68.62 \pm 1.34	63.27 \pm 1.75
	6	34.40 \pm 2.93	63.89 \pm 5.90	39.16 \pm 7.09	37.31 \pm 3.60	51.17 \pm 24.61	79.81 \pm 1.85	78.60 \pm 0.60
	7	58.80 \pm 5.55	71.69 \pm 2.60	53.66 \pm 6.73	61.22 \pm 2.33	57.72 \pm 18.90	75.56 \pm 2.11	72.44 \pm 0.52
	8	19.86 \pm 0.88	35.67 \pm 2.05	32.93 \pm 6.04	23.89 \pm 1.16	27.07 \pm 10.86	54.76 \pm 2.44	66.11 \pm 0.88
	9	46.01 \pm 2.95	62.02 \pm 2.85	42.44 \pm 6.51	48.90 \pm 3.06	32.57 \pm 10.13	80.10 \pm 1.75	77.75 \pm 1.01
	<i>average</i>	40.73 \pm 0.99	57.19 \pm 1.69	42.48 \pm 2.33	43.23 \pm 0.75	41.34 \pm 5.16	71.03 \pm 0.84	72.31 \pm 0.33
Fashion-MNIST	t-shirt	23.31 \pm 3.49	46.19 \pm 1.81	26.11 \pm 2.65	32.45 \pm 1.40	38.99 \pm 17.60	66.60 \pm 1.69	73.97 \pm 0.74
	trouser	76.39 \pm 1.01	80.92 \pm 1.16	67.48 \pm 7.84	79.83 \pm 1.34	54.67 \pm 18.42	84.15 \pm 1.98	85.84 \pm 0.77
	pullover	26.66 \pm 1.09	45.65 \pm 2.45	26.02 \pm 1.92	33.19 \pm 2.30	17.71 \pm 2.38	74.36 \pm 1.77	83.98 \pm 0.66
	dress	32.49 \pm 2.64	50.12 \pm 2.53	39.56 \pm 3.17	37.77 \pm 2.77	66.75 \pm 11.43	67.43 \pm 1.39	66.79 \pm 0.51
	coat	34.47 \pm 2.42	53.01 \pm 2.41	29.41 \pm 1.87	38.48 \pm 3.14	25.35 \pm 12.35	76.62 \pm 0.90	82.18 \pm 0.86
	sandal	33.55 \pm 5.41	24.77 \pm 0.65	38.98 \pm 2.88	30.15 \pm 4.28	63.53 \pm 11.03	62.88 \pm 5.87	78.96 \pm 1.52
	shirt	19.89 \pm 1.09	37.51 \pm 0.51	19.92 \pm 1.00	23.99 \pm 1.55	24.03 \pm 7.65	60.59 \pm 1.70	65.75 \pm 0.52
	sneaker	60.88 \pm 5.89	68.98 \pm 1.30	59.68 \pm 19.32	69.21 \pm 2.75	64.38 \pm 14.74	91.24 \pm 0.40	96.21 \pm 0.58
	bag	17.40 \pm 0.95	26.26 \pm 0.89	17.34 \pm 0.63	18.13 \pm 1.15	28.32 \pm 11.86	39.41 \pm 1.47	57.95 \pm 1.78
	ankle-boot	42.82 \pm 4.78	56.35 \pm 3.60	41.21 \pm 6.77	50.74 \pm 4.18	51.50 \pm 23.96	90.28 \pm 0.95	97.35 \pm 0.04
	<i>average</i>	36.79 \pm 1.34	48.97 \pm 0.97	36.57 \pm 2.52	41.40 \pm 0.88	43.52 \pm 2.89	71.36 \pm 0.76	78.90 \pm 0.32
CIFAR10	airplane	31.34 \pm 4.43	27.89 \pm 0.60	35.66 \pm 0.66	28.97 \pm 2.92	20.32 \pm 3.75	20.23 \pm 1.27	41.60 \pm 1.15
	automobile	15.91 \pm 1.22	14.95 \pm 0.31	15.62 \pm 0.30	14.38 \pm 0.30	32.31 \pm 4.03	33.73 \pm 4.39	79.73 \pm 0.71
	bird	28.71 \pm 1.48	30.73 \pm 0.70	31.25 \pm 0.88	31.90 \pm 0.54	18.95 \pm 2.30	22.01 \pm 2.16	29.45 \pm 0.94
	cat	26.01 \pm 1.59	22.48 \pm 0.59	26.31 \pm 0.56	24.59 \pm 1.55	22.79 \pm 1.29	22.39 \pm 2.15	27.81 \pm 1.73
	deer	31.61 \pm 1.79	38.29 \pm 0.72	33.79 \pm 0.72	37.69 \pm 1.04	23.90 \pm 4.55	28.57 \pm 1.92	48.52 \pm 1.60
	dog	25.96 \pm 1.48	21.62 \pm 0.57	28.28 \pm 0.61	25.45 \pm 0.65	23.61 \pm 3.02	29.78 \pm 2.47	47.05 \pm 3.04
	frog	20.44 \pm 2.29	29.81 \pm 0.78	19.31 \pm 0.65	23.17 \pm 1.51	29.39 \pm 5.21	28.80 \pm 2.11	45.62 \pm 1.81
	horse	20.25 \pm 0.91	19.15 \pm 0.54	21.56 \pm 0.32	20.25 \pm 0.23	25.77 \pm 5.59	32.38 \pm 2.19	66.72 \pm 1.68
	ship	38.81 \pm 4.02	33.61 \pm 1.02	40.14 \pm 0.88	36.11 \pm 3.39	26.21 \pm 10.64	31.80 \pm 2.66	72.48 \pm 1.70
	truck	15.58 \pm 0.61	14.40 \pm 0.17	15.64 \pm 0.20	14.48 \pm 0.40	39.80 \pm 8.34	31.89 \pm 1.99	68.15 \pm 1.77
	<i>average</i>	25.46 \pm 0.63	25.29 \pm 0.06	26.76 \pm 0.20	25.70 \pm 0.66	26.30 \pm 0.64	28.16 \pm 0.74	52.71 \pm 0.24
CIFAR100	aquatic mammals	36.66 \pm 2.20	29.09 \pm 1.15	37.22 \pm 1.66	35.87 \pm 1.39	23.02 \pm 3.30	23.26 \pm 1.57	41.89 \pm 1.35
	fish	30.51 \pm 2.17	26.26 \pm 0.47	30.55 \pm 0.93	29.02 \pm 1.86	18.46 \pm 1.59	25.19 \pm 1.83	34.24 \pm 0.79
	flowers	14.74 \pm 0.71	14.98 \pm 0.25	15.00 \pm 0.53	16.11 \pm 1.76	31.44 \pm 5.00	22.58 \pm 1.17	45.67 \pm 1.41
	food containers	24.99 \pm 1.19	25.80 \pm 0.73	25.02 \pm 0.39	24.17 \pm 0.74	17.65 \pm 1.82	18.28 \pm 0.91	39.26 \pm 1.32
	fruit and vegetables	20.23 \pm 1.96	17.91 \pm 0.46	21.13 \pm 0.51	18.98 \pm 1.46	29.48 \pm 4.84	21.98 \pm 0.76	38.17 \pm 1.69
	household electrical devices	19.65 \pm 0.64	16.83 \pm 0.11	22.26 \pm 0.42	17.91 \pm 1.05	20.48 \pm 1.18	19.16 \pm 0.88	25.08 \pm 1.04
	household furniture	25.99 \pm 2.64	22.77 \pm 0.38	28.40 \pm 0.34	25.26 \pm 1.72	19.72 \pm 1.98	18.95 \pm 0.65	41.66 \pm 2.13
	inserts	18.98 \pm 0.90	20.43 \pm 0.51	19.08 \pm 0.57	19.67 \pm 1.15	19.76 \pm 0.67	22.00 \pm 1.20	34.74 \pm 1.23
	large carnivores	22.03 \pm 1.94	24.64 \pm 1.35	24.20 \pm 1.01	26.55 \pm 2.33	28.81 \pm 3.13	26.56 \pm 1.98	59.16 \pm 2.97
	large man-made outdoor things	34.84 \pm 1.73	32.68 \pm 2.17	39.87 \pm 0.74	35.65 \pm 1.14	31.46 \pm 7.10	27.52 \pm 3.91	63.81 \pm 0.40
	large natural outdoor scenes	50.56 \pm 2.94	56.18 \pm 1.93	49.58 \pm 1.49	53.74 \pm 2.93	23.04 \pm 2.22	24.90 \pm 1.57	50.57 \pm 1.73
	large omnivores and herbivores	26.28 \pm 1.07	23.81 \pm 0.71	29.68 \pm 0.83	29.28 \pm 1.36	28.73 \pm 2.53	24.98 \pm 2.08	51.20 \pm 1.55
	medium-sized mammals	27.10 \pm 0.38	24.12 \pm 1.37	28.99 \pm 1.67	31.94 \pm 2.70	32.96 \pm 2.30	27.86 \pm 1.44	54.05 \pm 2.46
	non-insert invertebrates	20.32 \pm 0.87	22.18 \pm 0.60	19.71 \pm 0.36	20.43 \pm 0.61	18.69 \pm 0.86	19.88 \pm 0.90	23.41 \pm 0.46
	people	20.36 \pm 1.06	16.54 \pm 0.52	20.09 \pm 0.78	18.95 \pm 0.72	27.29 \pm 1.33	22.76 \pm 1.81	61.09 \pm 1.17
	reptiles	23.66 \pm 0.76	24.82 \pm 0.49	24.53 \pm 0.98	24.97 \pm 1.20	19.94 \pm 0.50	21.78 \pm 0.73	35.34 \pm 0.90
	small mammals	29.41 \pm 1.26	32.44 \pm 1.25	31.71 \pm 0.77	33.25 \pm 1.55	24.36 \pm 1.29	24.22 \pm 1.84	42.04 \pm 0.88
	trees	30.73 \pm 3.21	34.51 \pm 1.98	34.08 \pm 1.45	32.95 \pm 2.07	29.95 \pm 2.59	32.09 \pm 3.10	68.32 \pm 1.04
	vehicles 1	15.06 \pm 0.91	15.51 \pm 0.39	15.79 \pm 0.41	15.30 \pm 0.47	27.42 \pm 2.77	24.05 \pm 2.14	69.71 \pm 0.83
	vehicles 2	20.66 \pm 1.63	19.68 \pm 0.86	22.59 \pm 1.01	20.65 \pm 1.58	21.52 \pm 2.03	20.07 \pm 1.14	50.69 \pm 2.06
	<i>average</i>	25.64 \pm 0.58	25.06 \pm 0.40	26.97 \pm 0.19	26.53 \pm 0.37	24.71 \pm 0.65	23.40 \pm 0.49	46.51 \pm 0.39
SVHN	0	20.71 \pm 0.90	23.42 \pm 0.52	20.54 \pm 0.25	21.10 \pm 0.43	27.42 \pm 6.70	46.08 \pm 4.35	33.12 \pm 0.92
	1	23.18 \pm 0.72	25.92 \pm 0.84	23.34 \pm 0.70	23.55 \pm 0.41	28.19 \pm 6.77	28.43 \pm 1.74	30.96 \pm 1.14
	2	20.64 \pm 0.41	22.16 \pm 0.51	20.79 \pm 0.29	21.28 \pm 0.38	35.36 \pm 9.87	32.95 \pm 2.88	51.79 \pm 1.97
	3	20.00 \pm 0.19	20.75 \pm 0.34	19.59 \pm 0.13	20.18 \pm 0.17	33.42 \pm 7.00	27.36 \pm 0.60	46.89 \pm 0.88
	4	21.52 \pm 0.45	23.06 \pm 0.40	21.38 \pm 0.47	22.21 \pm 0.44	26.43 \pm 3.86	28.22 \pm 1.60	54.93 \pm 0.93
	5	19.52 \pm 0.48	21.04 \pm 0.26	19.39 \pm 0.28	20.00 \pm 0.39	28.82 \pm 6.88	30.49 \pm 3.15	55.75 \pm 0.81
	6	19.57 \pm 0.62	20.28 \pm 0.34	18.81 \pm 0.49	19.73 \pm 0.36	30.68 \pm 8.93	34.32 \pm 1.32	50.58 \pm 1.54
	7	22.19 \pm 0.56	23.73 \pm 0.57	22.15 \pm 0.37	22.27 \pm 1.12	32.77 \pm 7.82	38.24 \pm 3.78	60.84 \pm 1.01
	8	19.76 \pm 0.46	21.12 \pm 0.43	19.25 \pm 0.21	20.06 \pm 0.33	26.54 \pm 6.64	35.86 \pm 3.21	33.97 \pm 0.91
	9	19.98 \pm 0.71	22.42 \pm 0.39	20.14 \pm 0.31	20.76 \pm 0.65	26.65 \pm 7.12	35.45 \pm 1.65	50.85 \pm 1.01
	<i>average</i>	20.71 \pm 0.14	22.39 \pm 0.11	20.54 \pm 0.18	21.12 \pm 0.19	29.63 \pm 1.91	33.74 \pm 0.68	46.97 \pm 0.47

Table 15: AUPR-out (%) (outliers as positive class) when $\rho = 0.25$

Dataset	Class name	CAE	CAE-IF	DRAE	RDAE	DAGMM	SSD-IF	E^3 Outlier
MNIST	0	26.69 \pm 2.62	61.98 \pm 3.88	40.68 \pm 6.14	28.46 \pm 3.48	45.38 \pm 22.35	60.50 \pm 3.40	68.47 \pm 3.22
	1	94.06 \pm 3.44	94.00 \pm 1.46	90.14 \pm 1.79	93.20 \pm 2.68	70.89 \pm 26.56	82.89 \pm 1.59	65.56 \pm 0.89
	2	26.39 \pm 1.73	40.16 \pm 2.33	34.85 \pm 3.59	31.38 \pm 2.83	25.39 \pm 4.49	62.53 \pm 1.94	69.14 \pm 0.97
	3	31.81 \pm 2.64	51.47 \pm 1.95	35.32 \pm 13.26	35.15 \pm 3.33	35.09 \pm 10.86	71.62 \pm 1.94	86.50 \pm 1.27
	4	43.44 \pm 6.28	59.23 \pm 2.21	42.84 \pm 3.19	50.36 \pm 5.38	47.61 \pm 23.44	79.42 \pm 0.99	77.31 \pm 1.09
	5	32.41 \pm 1.86	44.70 \pm 2.81	38.17 \pm 12.58	40.02 \pm 3.50	25.95 \pm 2.35	67.59 \pm 2.17	65.84 \pm 1.36
	6	36.60 \pm 4.95	62.75 \pm 2.00	37.44 \pm 8.17	46.62 \pm 4.35	38.33 \pm 23.37	77.45 \pm 2.75	80.22 \pm 0.96
	7	62.03 \pm 4.27	74.01 \pm 3.36	55.28 \pm 4.22	65.42 \pm 3.90	52.38 \pm 17.20	76.34 \pm 2.20	74.78 \pm 0.63
	8	22.26 \pm 2.33	41.25 \pm 2.81	25.36 \pm 2.37	23.14 \pm 0.73	30.70 \pm 8.07	59.19 \pm 2.95	68.80 \pm 0.65
	9	51.43 \pm 3.32	67.11 \pm 1.99	48.58 \pm 7.40	56.62 \pm 2.20	37.12 \pm 9.85	81.94 \pm 1.58	80.65 \pm 0.60
	<i>average</i>	42.71 \pm 1.24	59.67 \pm 0.84	44.87 \pm 2.48	47.04 \pm 0.55	40.88 \pm 3.97	71.95 \pm 0.61	73.73 \pm 0.43
Fashion-MNIST	t-shirt	27.79 \pm 3.40	53.62 \pm 1.60	32.42 \pm 4.37	35.58 \pm 2.88	43.22 \pm 15.34	68.48 \pm 1.48	75.03 \pm 1.20
	trouser	79.63 \pm 1.17	80.78 \pm 1.23	70.34 \pm 8.39	81.79 \pm 2.14	56.03 \pm 7.78	84.23 \pm 1.43	84.96 \pm 0.99
	pullover	27.88 \pm 1.39	51.84 \pm 1.78	31.52 \pm 1.33	38.05 \pm 1.43	25.99 \pm 5.43	76.97 \pm 1.06	84.77 \pm 0.51
	dress	40.74 \pm 2.45	56.84 \pm 2.57	43.36 \pm 1.86	42.67 \pm 2.05	44.94 \pm 15.89	69.80 \pm 2.91	68.50 \pm 1.00
	coat	37.53 \pm 4.41	57.29 \pm 0.66	34.09 \pm 1.08	43.48 \pm 1.83	29.01 \pm 6.65	79.60 \pm 1.52	82.75 \pm 0.38
	sandal	38.60 \pm 5.78	29.14 \pm 1.53	40.25 \pm 1.50	35.98 \pm 4.69	61.05 \pm 18.57	60.85 \pm 5.39	73.96 \pm 6.75
	shirt	23.85 \pm 1.08	42.73 \pm 0.84	24.60 \pm 0.83	30.69 \pm 1.80	29.42 \pm 3.78	64.51 \pm 1.72	66.43 \pm 0.39
	sneaker	67.30 \pm 3.20	70.95 \pm 1.11	71.05 \pm 5.14	68.38 \pm 2.82	68.99 \pm 21.31	91.21 \pm 1.70	96.67 \pm 0.37
	bag	20.41 \pm 2.31	30.39 \pm 0.99	21.55 \pm 0.79	21.53 \pm 2.04	29.38 \pm 5.81	37.12 \pm 4.00	56.80 \pm 1.88
	ankle-boot	48.66 \pm 5.26	56.81 \pm 3.54	44.80 \pm 1.86	53.07 \pm 3.63	45.05 \pm 20.44	88.68 \pm 1.62	97.13 \pm 0.14
	<i>average</i>	41.24 \pm 0.92	53.04 \pm 0.64	41.40 \pm 0.89	45.12 \pm 0.99	43.31 \pm 5.88	72.14 \pm 1.17	78.70 \pm 0.36
CIFAR10	airplane	38.96 \pm 3.07	33.38 \pm 0.85	41.42 \pm 1.00	34.78 \pm 3.14	23.97 \pm 5.71	24.56 \pm 0.85	44.14 \pm 1.63
	automobile	19.54 \pm 0.71	18.82 \pm 0.16	19.69 \pm 0.34	17.90 \pm 0.21	39.18 \pm 5.95	38.53 \pm 3.50	80.42 \pm 2.32
	bird	34.55 \pm 0.55	37.27 \pm 0.44	37.00 \pm 0.36	37.87 \pm 0.61	23.04 \pm 1.53	26.59 \pm 1.26	34.57 \pm 1.27
	cat	31.41 \pm 0.64	27.32 \pm 0.40	32.59 \pm 0.46	29.90 \pm 1.47	27.39 \pm 3.23	28.18 \pm 0.57	30.73 \pm 0.49
	deer	37.47 \pm 2.32	44.59 \pm 0.28	39.53 \pm 0.92	42.77 \pm 0.85	28.76 \pm 4.05	33.95 \pm 1.32	52.42 \pm 1.41
	dog	31.17 \pm 0.87	26.41 \pm 0.35	33.82 \pm 0.33	30.68 \pm 1.21	31.95 \pm 2.78	33.73 \pm 3.15	52.31 \pm 2.20
	frog	24.56 \pm 1.26	35.89 \pm 0.59	23.40 \pm 0.73	29.77 \pm 1.60	32.87 \pm 4.82	34.05 \pm 2.64	48.20 \pm 1.59
	horse	24.79 \pm 0.83	23.87 \pm 0.63	26.91 \pm 0.62	25.06 \pm 0.81	32.53 \pm 4.39	38.86 \pm 3.58	68.17 \pm 2.60
	ship	43.19 \pm 4.65	39.69 \pm 0.80	46.05 \pm 0.57	43.47 \pm 2.32	30.15 \pm 9.33	35.85 \pm 4.28	74.13 \pm 1.86
	truck	19.79 \pm 0.35	18.22 \pm 0.27	19.71 \pm 0.22	17.96 \pm 0.54	40.91 \pm 7.75	34.47 \pm 2.65	72.34 \pm 0.73
	<i>average</i>	30.54 \pm 0.71	30.55 \pm 0.11	32.01 \pm 0.19	31.02 \pm 0.25	31.08 \pm 1.81	32.88 \pm 0.73	55.74 \pm 0.51
CIFAR100	aquatic mammals	42.17 \pm 2.54	35.40 \pm 1.19	42.88 \pm 1.78	39.01 \pm 2.62	25.57 \pm 2.12	29.01 \pm 1.25	47.31 \pm 1.54
	fish	37.83 \pm 1.98	32.10 \pm 1.51	36.94 \pm 0.60	35.71 \pm 1.91	21.97 \pm 2.39	30.98 \pm 2.79	39.58 \pm 1.19
	flowers	18.09 \pm 0.50	19.17 \pm 0.42	18.64 \pm 0.40	20.22 \pm 1.49	30.54 \pm 6.71	29.80 \pm 3.09	48.77 \pm 1.79
	food containers	31.34 \pm 1.00	30.94 \pm 0.93	30.70 \pm 0.58	27.36 \pm 2.04	23.19 \pm 1.65	23.87 \pm 1.13	42.69 \pm 1.76
	fruit and vegetables	25.70 \pm 2.10	22.75 \pm 0.46	25.88 \pm 0.31	24.81 \pm 1.18	35.12 \pm 4.33	26.15 \pm 1.34	44.05 \pm 1.02
	household electrical devices	26.00 \pm 1.10	20.91 \pm 0.35	27.27 \pm 0.52	22.36 \pm 1.12	25.54 \pm 3.74	23.93 \pm 0.83	29.21 \pm 0.75
	household furniture	33.97 \pm 0.47	26.97 \pm 0.71	34.26 \pm 0.62	28.66 \pm 4.48	26.80 \pm 5.16	22.29 \pm 0.35	47.64 \pm 1.37
	inserts	22.91 \pm 0.96	25.33 \pm 0.84	23.58 \pm 0.51	24.33 \pm 1.07	23.34 \pm 2.39	28.23 \pm 0.83	40.23 \pm 0.66
	large carnivores	26.33 \pm 1.05	29.78 \pm 1.32	28.75 \pm 0.57	30.54 \pm 1.06	36.38 \pm 1.68	32.37 \pm 2.48	60.85 \pm 2.53
	large man-made outdoor things	40.66 \pm 4.33	37.86 \pm 1.32	45.53 \pm 1.06	43.49 \pm 3.14	39.77 \pm 5.00	30.71 \pm 1.07	70.37 \pm 1.41
	large natural outdoor scenes	58.07 \pm 0.69	60.32 \pm 0.90	56.01 \pm 0.51	59.39 \pm 2.45	27.85 \pm 3.17	32.72 \pm 2.16	56.96 \pm 1.66
	large omnivores and herbivores	31.52 \pm 0.76	28.80 \pm 0.46	34.34 \pm 0.82	33.78 \pm 0.95	33.20 \pm 3.81	29.08 \pm 1.35	57.69 \pm 1.40
	medium-sized mammals	33.18 \pm 0.43	29.39 \pm 0.78	32.86 \pm 1.30	34.31 \pm 0.84	37.37 \pm 2.60	30.85 \pm 1.56	56.59 \pm 1.56
	non-insert invertebrates	25.24 \pm 0.42	27.58 \pm 0.47	24.60 \pm 0.50	25.73 \pm 0.98	23.03 \pm 1.20	24.53 \pm 1.11	28.13 \pm 0.66
	people	24.36 \pm 0.66	20.83 \pm 0.47	25.00 \pm 0.87	23.41 \pm 1.28	31.73 \pm 2.29	26.46 \pm 1.14	63.12 \pm 1.63
	reptiles	28.78 \pm 1.46	30.05 \pm 0.15	30.14 \pm 0.97	30.74 \pm 1.31	25.00 \pm 2.41	27.32 \pm 1.12	41.48 \pm 0.40
	small mammals	35.88 \pm 1.50	39.24 \pm 0.80	37.20 \pm 1.34	41.20 \pm 0.60	29.51 \pm 1.53	28.89 \pm 1.85	46.62 \pm 1.06
	trees	37.26 \pm 2.71	39.51 \pm 1.26	38.63 \pm 1.24	41.60 \pm 1.76	35.39 \pm 0.81	36.33 \pm 1.39	73.18 \pm 1.49
	vehicles 1	18.98 \pm 0.41	19.72 \pm 0.57	19.68 \pm 0.68	20.68 \pm 0.96	31.55 \pm 2.30	27.76 \pm 1.88	74.05 \pm 1.63
	vehicles 2	24.53 \pm 1.52	24.37 \pm 0.63	27.32 \pm 0.97	25.49 \pm 2.01	25.14 \pm 1.66	24.68 \pm 1.48	58.09 \pm 1.83
	<i>average</i>	31.14 \pm 0.45	30.05 \pm 0.38	32.01 \pm 0.30	31.64 \pm 0.34	29.40 \pm 0.92	28.30 \pm 0.65	51.33 \pm 0.45
SVHN	0	25.65 \pm 0.15	28.93 \pm 0.55	25.43 \pm 0.45	26.37 \pm 0.23	31.04 \pm 4.68	48.86 \pm 1.17	34.80 \pm 1.07
	1	29.07 \pm 0.94	31.72 \pm 0.71	28.75 \pm 0.34	29.29 \pm 1.06	38.81 \pm 14.53	36.22 \pm 2.46	35.50 \pm 0.44
	2	26.06 \pm 0.49	27.01 \pm 0.55	25.90 \pm 0.49	26.54 \pm 0.40	38.99 \pm 8.09	35.80 \pm 1.11	56.45 \pm 1.68
	3	24.73 \pm 0.29	25.29 \pm 0.33	24.52 \pm 0.56	24.98 \pm 0.35	37.41 \pm 7.81	30.83 \pm 2.58	51.16 \pm 0.91
	4	26.48 \pm 0.51	28.32 \pm 0.53	26.63 \pm 0.32	27.23 \pm 0.25	41.05 \pm 8.46	33.94 \pm 2.11	59.22 \pm 1.78
	5	24.12 \pm 0.23	25.90 \pm 0.44	24.33 \pm 0.41	24.71 \pm 0.50	29.96 \pm 5.51	34.70 \pm 1.81	60.51 \pm 0.63
	6	24.12 \pm 0.37	25.18 \pm 0.49	23.63 \pm 0.56	24.25 \pm 0.27	32.34 \pm 5.84	37.64 \pm 2.15	54.78 \pm 0.90
	7	27.85 \pm 0.56	29.40 \pm 0.63	26.88 \pm 1.01	28.12 \pm 0.57	39.21 \pm 14.43	44.16 \pm 2.30	64.05 \pm 0.94
	8	24.49 \pm 0.40	26.45 \pm 0.46	24.47 \pm 0.35	25.11 \pm 0.42	31.96 \pm 5.79	39.07 \pm 2.67	37.75 \pm 1.14
	9	24.79 \pm 0.57	26.72 \pm 0.67	24.79 \pm 0.23	25.23 \pm 0.56	39.40 \pm 11.69	38.84 \pm 2.13	55.71 \pm 1.42
	<i>average</i>	25.74 \pm 0.13	27.49 \pm 0.16	25.53 \pm 0.25	26.18 \pm 0.18	36.02 \pm 5.04	38.01 \pm 0.69	50.99 \pm 0.40