Topological Data Analysis of Decision Boundaries with Application to Model Selection Supplemental Material

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In this supplementary material, the references to the main paper are suffixed by "-M".

1. Proof of Theorem 1

Proof. Let us assume that among the n samples $\overline{z}$ drawn, $|\overline{x}| = n_x$ and $|\overline{y}| = n_y$, so that $n = n_x + n_y$. Let us denote the event $x \notin A_i$ for any i as E_i^a and the event $y \notin B_j$ for any j as E_j^b. The probability of these events are

$$P(E_i^a||\overline{x}| = n_x) = (1 - \mu_x(A_i))^{n_x} \leq (1 - \alpha_x)^{n_x} \text{ and} \tag{1}$$

$$P(E_j^b||\overline{y}| = n_y) = (1 - \mu_y(B_i))^{n_y} \leq (1 - \alpha_y)^{n_y}. \tag{2}$$

The probability bound on the composite event (4-M) is expressed as

$$P\left(\left(\cap_i \overline{E_i^a}\right) \cap \left(\cap_j \overline{E_j^b}\right)\right) > 1 - \delta, \tag{3}$$

which simplifies to

$$P\left(\overline{\left(\cup_i E_i^a\right) \cup \left(\cup_j E_j^b\right)}\right) > 1 - \delta. \tag{4}$$

This implies that

$$P(\cup_i E_i^a) + P(\cup_i E_j^b) \tag{5}$$

should be bounded from above by δ. The individual conditional probabilities can be union-bounded as $P(\cup_i E_i^a||\overline{x}| = n_x) \leq l_a(1-\alpha_x)^{n_x}$ and $P(\cup_i E_j^b||\overline{y}| = n_y) \leq l_b(1-\alpha_y)^{n_y}$. Hence, the upper bound on (5) is

$$\sum_{n_x=0}^{n} P(\cup_i E_i^a||\overline{x}| = n_x)p(|\overline{x}| = n_x) + P(\cup_i E_j^b||\overline{y}| = n - n_x)p(|\overline{y}| = n - n_x), \tag{6}$$

which, after some algebra, simplifies to

$$l_a(1 - q\alpha_x)^n + l_b(1 - (1 - q)\alpha_y)^n. \tag{7}$$

We need to find an n such that the expression in (7) is bounded above by δ.

Since we know $1 - \alpha q \leq \exp(-\alpha q)$ using Taylor approximation, when $n > \frac{1}{\alpha q}(\log 2l + \log(\frac{1}{\delta}))$, $l\exp(-\alpha q n) \leq \delta/2$. Hence if we pick n according to (3-M), (5) will be $\leq \delta$, and with probability greater than $1 - \delta$, we can ensure (4-M). □

2. Necessity of Decision Boundary Topology

When understanding the decision surfaces of labeled data, using the approach presented in our paper is more accurate than using the unlabeled data topology for either of the classes as pursued in Bianchini & Scarselli (2014) and Guss & Salakhutdinov (2018). We use a simple counter-example in Figure 1 to demonstrate this. Clearly, neither of the classes reflect the true topology of the decision boundary.

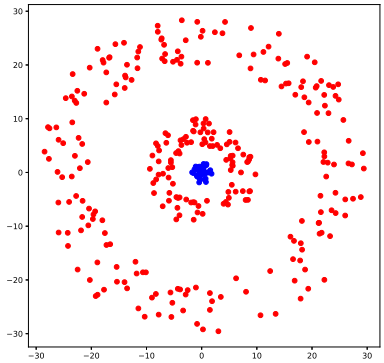

Figure 1. The *blue* class has Betti numbers $\beta_0 = 1, \beta_1 = 0$. The *red* class has Betti numbers $\beta_0 = 2, \beta_1 = 2$. Neither of them reflect the true topology of the decision boundary which has Betti numbers $\beta_0 = 1, \beta_1 = 1$

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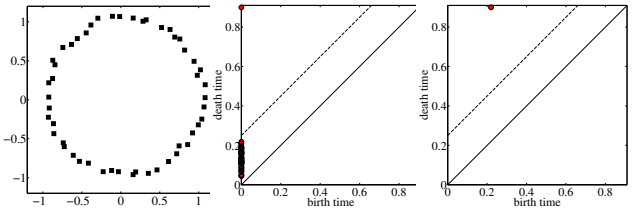
3. Background on Persistent Homology for Unlabeled Data

Consider a set of n data points in $\mathbb{R}^d$: $\mathcal{Z} = \{\mathbf{z}_1, \ldots, \mathbf{z}_n\}$. A set of points by itself has no shape per se, but if the points are viewed as samples from some shape, then the set of points reveals the underlying shape. We would like to estimate and approximate the topology of that shape by constructing a simplicial complex from the points and examining the topology of the simplicial complex. A zero-dimensional simplex is a point, a one-dimensional simplex is a line segment, a two-dimensional simplex is a triangle, a three-dimensional simplex is a tetrahedron, and so on; a simplicial complex is a set of simplices glued together in a particular way. Specifically, a simplicial complex $\mathcal{S}$ = $(\mathcal{Z}, \Sigma)$, where Σ is a family of non-empty subsets of $\mathcal{Z}$ such that each subset $\sigma \in \Sigma$ is a simplex. Furthermore, the following condition must also hold: $\sigma \in \Sigma$ and $\tau \subseteq \sigma$ implies that $\tau \in \Sigma$. In forming these non-empty subsets of points that form a simplex, we only consider subsets of points that are close to each other. There are various notions of closeness that we come back to later in this section.

Topology, being the study of shape, is primarily concerned with the number of connected components and the number and dimension of holes that an object has. The Betti numbers characterize the connectivity as follows. The zeroth Betti number β_0 is the number of connected components, the first Betti number β_1 is the number of one-dimensional holes or circles, the second Betti number β_2 is the number of two-dimensional voids or cavities, and so on. For example, a torus or inner tube has $\beta_0 = 1$ because it is just one component, $\beta_1 = 2$ because of the main hole through the middle and the hole formed when looking at a cross-section, and $\beta_2 = 1$ because of the cavity of the inner tube. Betti numbers for simplicial complexes are defined in the same way. Formally, $\beta_k(\mathcal{S})$ is the dimension of the kth homology group of the complex $H_k(\mathcal{S})$ (Carlsson, 2009).

Various approaches exist for constructing simplicial complexes from $\mathcal{Z}$. All of these depend on a scale parameter ϵ (also referred to as *time*) which specifies the extent of closeness of points. In the Čech complex Čech$(\mathcal{Z}, \epsilon)$, a simplex is created between a set of points $\mathcal{G}$ if and only if there is a non-empty intersection of the closed Euclidean balls $B(\mathbf{z}_i, \epsilon/2)$, $\forall i \in \mathcal{G}$. In the Vietoris-Rips (VR) complex, VR$(\mathcal{Z}, \epsilon)$, a simplex is created if and only if the Euclidean distance between every pair of points is less than ϵ. Efficient construction of the VR complex can proceed by creating an $\epsilon-$neighborhood graph, also referred to as the *one-skeleton* of $\mathcal{S}$. Then inductively, triplets of edges that form a triangle are taken as two-dimensional simplices, sets of four two-dimensional simplices that form a tetrahedron are taken as three-dimensional simplices, and so on.

Homological inference depends on the scale parameter (time) at which the complexes are constructed. The topological features of the simplicial complex $\mathcal{S}$ constructed from the data points $\mathcal{Z}$ that are stable across scales, i.e. that are *persistent*, are the ones that provide information about the underlying shape. Topological features that do not persist are noise. *Persistence diagrams* are representations of the birth and death times of each homology cycle corresponding to each homology group H_k, $k = 0, 1, \ldots$, i.e. for increasing values of the scale parameter, the ϵ value at which a topological feature begins to exist and ceases to exist.



(a) (b) (c)

Figure 2. (a) Noisy data samples from an underlying circle in 2-dimensional space, (b) persistence diagram for H_0, (c) persistence diagram for H_1.

As an example, let us consider the point cloud $\mathcal{Z}$ shown in Figure 2(a), with noisy samples drawn from a circle, which has Betti numbers $\beta_0 = 1$, $\beta_1 = 1$, and $\beta_k = 0$ for $k > 1$. At the value $\epsilon = 0$, the simplicial complex that is formed from $\mathcal{Z}$ is a collection of all the individual points not connected to any other point, resulting in the birth of n topological features in the H_0 persistence diagram shown in Figure 2(b). As the scale increases, all of these little features die and only one persists until the largest scale under consideration; thus the persistent $\beta_0 = 1$. Looking at the H_1 persistence diagram in Figure 2(c), we see that the only feature that is born persists until the largest scale and thus the persistent $\beta_1 = 1$. It is born at approximately a scale parameter of 0.2, which is when all of the points have been connected into a ring in the simplicial complex.

This section and Figure 2 (©2015 IEEE) are reprinted with permission, from Varshney & Ramamurthy (2015).

4. Decision Boundary Complexes for Demonstration in Section 3.3-M

We will display the decision boundary complexes corresponding to the demonstration in Section 3.3-M. The local scale multipliers for the LS-LVR filtration in Figure 3 are varied between 0.5 and 1.5 in 100 increments. The scale parameters for the P-LVR filtration in Figure 4 are varied between 0 and 10 in 100 increments. We only show 20 complexes for each filtration in evenly spaced increments.

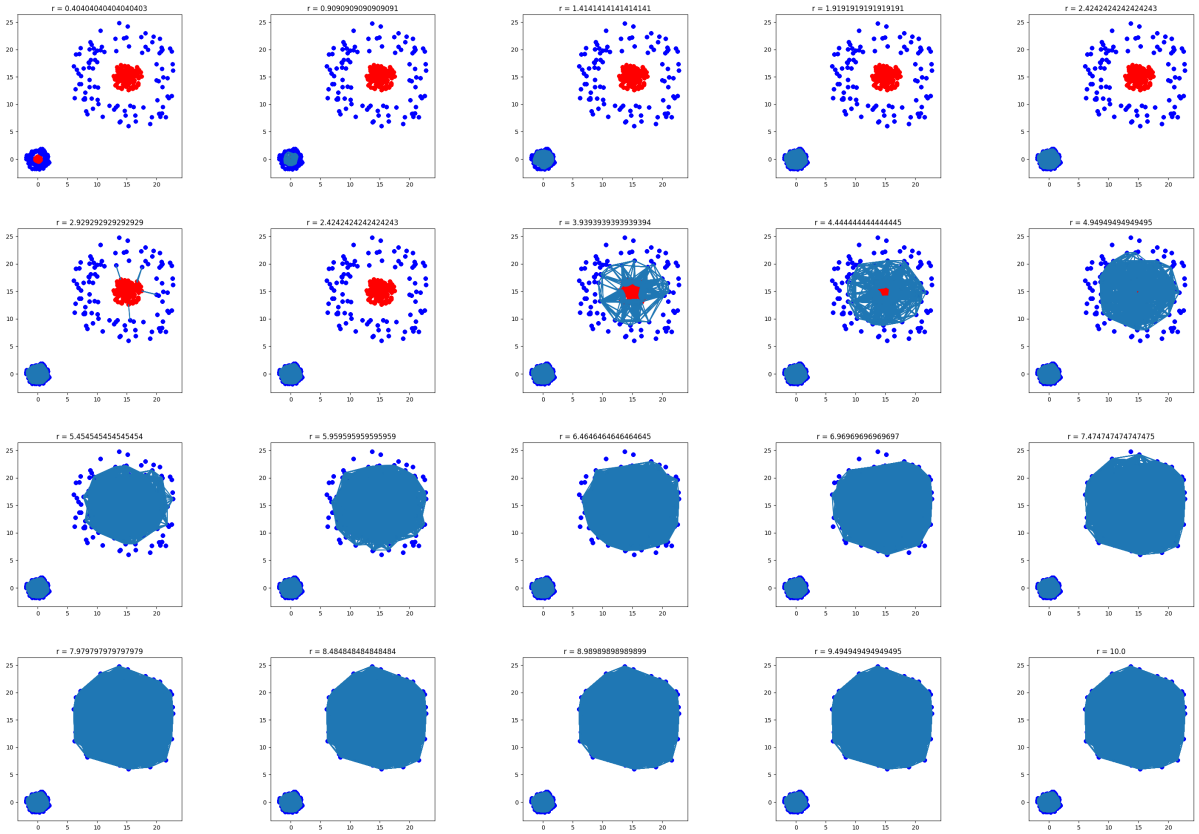


Figure 3. P-LVR complexes - the scales are given in the title of each image.

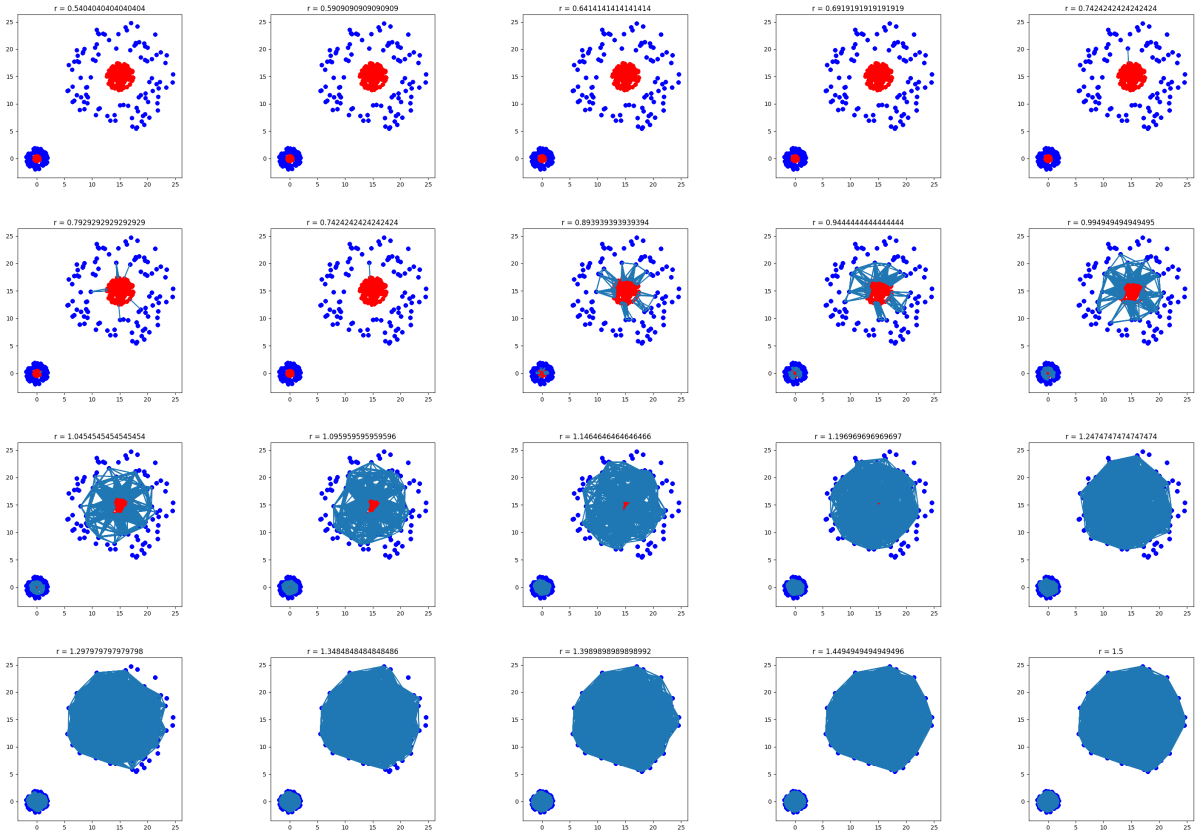


Figure 4. LS-LVR complexes - the local scale multipliers are given in the title of each image.

5. Data and Model Complexities - Total Lifetimes of Homology Groups

We provide the data model complexities for all binary datasets and trained classifiers for the three applications in the following tables.

Table 1. Data complexity for MNIST: Total life of H0 groups

	0	1	2	3	4	5	6	7	8	9
0		153.0	543.0	607.0	388.0	758.0	734.0	271.0	634.0	413.0
1			342.0	262.0	287.0	212.0	241.0	340.0	317.0	219.0
2				951.0	564.0	490.0	532.0	672.0	805.0	549.0
3					381.0	1292.0	454.0	493.0	1111.0	553.0
4						488.0	582.0	917.0	594.0	1682.0
5							548.0	419.0	1248.0	650.0
6								242.0	555.0	388.0
7									522.0	1283.0
8										731.0
9										

Table 2. Data complexity for MNIST: Total life of H1 groups

	0	1	2	3	4	5	6	7	8	9
0		9.0	205.0	202.0	91.0	300.0	229.0	78.0	211.0	112.0
1			72.0	40.0	73.0	24.0	79.0	60.0	78.0	37.0
2				400.0	211.0	183.0	216.0	228.0	350.0	178.0
3					178.0	542.0	135.0	164.0	480.0	203.0
4						192.0	166.0	350.0	263.0	714.0
5							195.0	143.0	536.0	237.0
6								60.0	210.0	121.0
7									204.0	459.0
8										297.0
9										

Table 3. Model complexity for MNIST: Total life of H0 groups

	0	1	2	3	4	5	6	7	8	9
0		153.0	543.0	607.0	388.0	758.0	734.0	271.0	634.0	413.0
1			342.0	262.0	287.0	212.0	241.0	340.0	317.0	219.0
2				951.0	564.0	490.0	532.0	672.0	805.0	549.0
3					381.0	1292.0	454.0	493.0	1111.0	553.0
4						488.0	582.0	917.0	594.0	1682.0
5							548.0	419.0	1248.0	650.0
6								242.0	555.0	388.0
7									522.0	1283.0
8										731.0
9										

Table 4. Model complexity for MNIST: Total life of H1 groups

	0	1	2	3	4	5	6	7	8	9
0		9.0	205.0	202.0	91.0	300.0	229.0	78.0	211.0	112.0
1			72.0	40.0	73.0	24.0	79.0	60.0	78.0	37.0
2				400.0	211.0	183.0	216.0	228.0	350.0	178.0
3					178.0	542.0	135.0	164.0	480.0	203.0
4						192.0	166.0	350.0	263.0	714.0
5							195.0	143.0	536.0	237.0
6								60.0	210.0	121.0
7									204.0	459.0
8										297.0
9										

Table 5. Data complexity for FashionMNIST: Total life of H0 groups

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		426.0	698.0	975.0	539.0	206.0	1946.0	122.0	465.0	173.0
Trouser			273.0	668.0	300.0	96.0	410.0	79.0	181.0	88.0
Pullover				488.0	2497.0	138.0	2108.0	98.0	390.0	126.0
Dress					775.0	125.0	980.0	92.0	310.0	128.0
Coat						124.0	1792.0	108.0	434.0	121.0
Sandal							149.0	724.0	314.0	554.0
Shirt								100.0	500.0	151.0
Sneaker									272.0	735.0
Bag										287.0
Ankle boot										

Table 6. Data complexity for FashionMNIST: Total life of H1 groups

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.0	105.0	177.0	81.0	34.0	445.0	14.0	51.0	23.0
Trouser			22.0	100.0	31.0	9.0	44.0		8.0	5.0
Pullover				99.0	692.0	20.0	592.0	2.0	75.0	13.0
Dress					134.0	35.0	148.0	13.0	41.0	7.0
Coat						16.0	561.0	6.0	70.0	11.0
Sandal							23.0	156.0	30.0	92.0
Shirt								4.0	92.0	16.0
Sneaker									30.0	154.0
Bag										37.0
Ankle boot										

Table 7. Model complexity for FashionMNIST: Total life of H0 groups

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		426.0	698.0	975.0	539.0	206.0	1946.0	122.0	465.0	173.0
Trouser			273.0	668.0	300.0	96.0	410.0	79.0	181.0	88.0
Pullover				488.0	2497.0	138.0	2108.0	98.0	390.0	126.0
Dress					775.0	125.0	980.0	92.0	310.0	128.0
Coat						124.0	1792.0	108.0	434.0	121.0
Sandal							149.0	724.0	314.0	554.0
Shirt								100.0	500.0	151.0
Sneaker									272.0	735.0
Bag										287.0
Ankle boot										

Table 8. Model complexity for FashionMNIST: Total life of H1 groups

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.0	105.0	177.0	81.0	34.0	445.0	14.0	51.0	23.0
Trouser			22.0	100.0	31.0	9.0	44.0		8.0	5.0
Pullover				99.0	692.0	20.0	592.0	2.0	75.0	13.0
Dress					134.0	35.0	148.0	13.0	41.0	7.0
Coat						16.0	561.0	6.0	70.0	11.0
Sandal							23.0	156.0	30.0	92.0
Shirt								4.0	92.0	16.0
Sneaker									30.0	154.0
Bag										37.0
Ankle boot										

Table 9. Data complexity for CIFAR10: Total life of H0 groups

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		990.0	1384.0	1019.0	1004.0	890.0	766.0	1097.0	1287.0	1048.0
automobile			1009.0	1111.0	1011.0	888.0	956.0	1008.0	1129.0	1328.0
bird				1417.0	1431.0	1341.0	1144.0	1336.0	1090.0	973.0
cat					1307.0	1562.0	1281.0	1255.0	1069.0	1058.0
deer						1132.0	1101.0	1154.0	962.0	887.0
dog							1157.0	1383.0	987.0	852.0
frog								865.0	783.0	819.0
horse									1085.0	1132.0
ship										1201.0
truck										

Table 10. Data complexity for CIFAR10: Total life of H1 groups

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		267.0	339.0	216.0	221.0	223.0	158.0	259.0	415.0	239.0
automobile			266.0	322.0	239.0	266.0	254.0	324.0	353.0	460.0
bird				544.0	434.0	490.0	294.0	377.0	242.0	259.0
cat					389.0	480.0	289.0	399.0	302.0	305.0
deer						338.0	280.0	282.0	279.0	197.0
dog							259.0	390.0	288.0	239.0
frog								251.0	175.0	149.0
horse									303.0	301.0
ship										373.0
truck										

Table 11. Model complexity for CIFAR10: Total life of H0 groups

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		990.0	1384.0	1019.0	1004.0	890.0	766.0	1097.0	1287.0	1048.0
automobile			1009.0	1111.0	1011.0	888.0	956.0	1008.0	1129.0	1328.0
bird				1417.0	1431.0	1341.0	1144.0	1336.0	1090.0	973.0
cat					1307.0	1562.0	1281.0	1255.0	1069.0	1058.0
deer						1132.0	1101.0	1154.0	962.0	887.0
dog							1157.0	1383.0	987.0	852.0
frog								865.0	783.0	819.0
horse									1085.0	1132.0
ship										1201.0
truck										

Table 12. Model complexity for CIFAR10: Total life of H1 groups

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		267.0	339.0	216.0	221.0	223.0	158.0	259.0	415.0	239.0
automobile			266.0	322.0	239.0	266.0	254.0	324.0	353.0	460.0
bird				544.0	434.0	490.0	294.0	377.0	242.0	259.0
cat					389.0	480.0	289.0	399.0	302.0	305.0
deer						338.0	280.0	282.0	279.0	197.0
dog							259.0	390.0	288.0	239.0
frog								251.0	175.0	149.0
horse									303.0	301.0
ship										373.0
truck										

6. Performance of Task Classifier on Other Tasks

We provide the classifier accuracies for the three applications in the following tables.

Table 13. MNIST Dataset - Performance classifier for task (0, 1)

	0	1	2	3	4	5	6	7	8	9
0		99.95	74.25	69.45	58.05	61.97	53.66	77.14	73.08	61.69
1			76.23	81.21	92.44	91.07	97.09	73.65	78.71	88.43
2				54.95	66.39	63.72	70.95	52.77	51.84	62.52
3					61.5	58.57	66.06	57.75	53.23	57.65
4						53.52	54.48	69.25	64.98	53.74
5							58.27	66.72	62.17	50.45
6								73.87	69.67	58.21
7									54.7	65.34
8										61.02
9										

Table 14. MNIST Dataset - Performance classifier for task (0, 2)

	0	1	2	3	4	5	6	7	8	9
0		99.81	99.55	95.03	85.47	69.12	79.51	80.73	89.46	75.92
1			52.61	57.34	66.89	84.31	73.01	70.18	63.39	75.09
2				54.95	64.95	83.21	71.36	68.45	61.27	73.59
3					60.04	78.29	66.46	63.69	56.3	68.85
4						68.04	56.39	53.93	53.83	59.07
5							61.57	63.49	72.13	58.29
6								52.27	60.3	52.87
7									57.69	54.98
8										62.88
9										

Table 15. MNIST Dataset - Performance classifier for task (0, 3)

	0	1	2	3	4	5	6	7	8	9
0		99.57	95.97	99.95	86.65	85.84	57.84	93.33	90.74	92.51
1			55.7	52.54	65.56	68.62	92.83	58.25	61.97	59.47
2				53.38	60.23	63.2	88.84	52.67	56.43	53.9
3					63.81	66.98	92.78	56.08	59.98	57.36
4						52.56	79.23	57.51	53.94	56.35
5							78.05	60.36	56.7	59.18
6								86.15	83.33	85.26
7									53.7	51.2
8										52.5
9										

Table 16. MNIST Dataset - Performance classifier for task (0, 4)

	0	1	2	3	4	5	6	7	8	9
0		83.5	67.79	60.5	99.95	63.41	84.73	56.67	69.14	96.08
1			66.17	73.29	62.82	72.57	51.7	76.56	65.86	59.7
2				57.3	80.88	55.56	65.83	60.87	50.8	77.36
3					88.7	52.21	73.58	53.68	58.32	85.04
4						88.9	65.82	92.09	80.98	53.19
5							72.81	56.09	56.59	85.01
6								77.14	65.48	62.38
7									61.99	88.41
8										77.36
9										

Table 17. MNIST Dataset - Performance classifier for task (0, 5)

	0	1	2	3	4	5	6	7	8	9
0		98.2	57.16	97.49	92.41	99.52	80.8	77.99	96.52	88.59
1			90.4	53.47	58.86	54.56	70.19	71.15	55.24	61.75
2				89.23	84.16	90.7	72.76	70.29	88.14	80.55
3					55.67	50.95	67.68	68.79	51.81	58.79
4						55.07	62.11	63.43	53.94	53.24
5							67.84	69.01	50.96	58.39
6								51.76	66.15	58.67
7									67.33	60.09
8										57.14
9										

Table 18. MNIST Dataset - Performance classifier for task (0, 6)

	0	1	2	3	4	5	6	7	8	9
0		91.87	67.05	67.74	98.73	90.54	99.02	53.04	81.47	77.02
1			75.03	74.83	53.33	56.24	53.08	88.12	62.83	66.23
2				50.49	80.44	71.62	80.5	63.69	63.56	59.53
3					80.27	71.35	80.34	64.33	63.21	59.14
4						60.51	50.31	94.53	67.43	71.02
5							60.32	86.35	57.72	61.65
6								94.76	67.34	70.97
7									77.67	73.39
8										53.91
9										

Table 19. MNIST Dataset - Performance classifier for task (0, 7)

	0	1	2	3	4	5	6	7	8	9
0		95.7	72.37	77.99	97.2	69.28	52.73	99.8	79.73	98.89
1			73.83	69.09	51.91	79.87	93.65	51.55	68.28	50.28
2				55.24	73.63	54.63	69.95	76.7	56.53	75.6
3					68.52	60.3	75.61	71.74	51.21	70.58
4						80.15	95.0	53.68	67.64	52.34
5							66.65	83.28	61.79	82.17
6								97.68	77.33	96.75
7									70.93	51.35
8										69.74
9										

Table 20. MNIST Dataset - Performance classifier for task (0, 8)

	0	1	2	3	4	5	6	7	8	9
0		99.76	90.85	92.06	97.45	93.8	79.93	86.7	99.54	97.74
1			60.64	60.05	55.74	61.47	72.58	64.59	54.01	54.8
2				50.73	55.41	50.1	62.16	54.13	57.28	56.25
3					54.72	50.89	63.06	54.91	56.6	55.57
4						55.92	68.09	59.65	51.89	50.93
5							62.97	54.32	57.93	56.81
6								57.91	70.08	68.78
7									61.54	60.43
8										50.93
9										

Table 21. MNIST Dataset - Performance classifier for task (0, 9)

	0	1	2	3	4	5	6	7	8	9
0		89.31	71.82	83.47	99.18	80.4	61.87	99.6	85.16	99.65
1			68.11	57.72	56.31	62.95	78.74	57.61	56.85	57.28
2				61.12	76.12	56.76	60.5	77.04	62.36	76.87
3					65.01	55.1	72.15	66.19	51.06	65.92
4						71.13	87.89	51.54	64.21	51.13
5							68.32	72.24	56.32	72.01
6								88.57	73.65	88.51
7									65.43	50.42
8										65.15
9										

Table 22. MNIST Dataset - Performance classifier for task (1, 2)

	0	1	2	3	4	5	6	7	8	9
0		46.43	99.65	91.36	93.37	77.3	97.52	86.01	88.13	87.53
1			99.58	91.89	93.76	78.93	97.61	86.92	88.9	88.34
2				58.62	57.35	75.36	53.92	63.4	62.66	62.37
3					51.41	66.4	54.98	54.91	53.93	53.79
4						68.14	53.61	56.37	55.42	55.25
5							72.16	61.04	62.54	62.39
6								59.97	59.11	58.87
7									51.1	51.15
8										50.08
9										

Table 23. MNIST Dataset - Performance classifier for task (1, 3)

	0	1	2	3	4	5	6	7	8	9
0		46.34	88.17	99.85	92.81	96.96	89.53	95.02	95.39	97.99
1			89.02	99.86	93.34	97.19	90.3	95.38	95.73	98.13
2				60.97	53.57	55.77	50.1	56.6	55.93	59.14
3					57.63	55.94	61.48	54.32	55.29	51.86
4						52.08	53.81	53.18	52.4	55.75
5							56.11	51.3	50.43	53.97
6								56.95	56.26	59.58
7									50.85	52.48
8										53.4
9										

Table 24. MNIST Dataset - Performance classifier for task (1, 4)

	0	1	2	3	4	5	6	7	8	9
0		38.49	58.2	49.7	91.49	72.28	88.44	68.82	71.19	89.94
1			68.85	61.07	99.95	82.59	97.23	78.73	81.18	98.41
2				58.37	82.22	63.1	79.15	60.34	62.41	80.84
3					91.16	72.24	88.16	68.84	71.17	89.65
4						71.18	53.56	71.69	70.45	50.98
5							67.73	52.03	50.16	69.86
6								68.48	67.13	52.52
7									51.8	70.45
8										69.19
9										

Table 25. MNIST Dataset - Performance classifier for task (1, 5)

	0	1	2	3	4	5	6	7	8	9
0		46.38	66.2	94.27	93.48	99.84	96.13	67.63	87.0	96.28
1			68.57	94.64	93.91	99.8	96.37	69.9	87.91	96.5
2				77.18	76.17	81.55	78.54	51.36	69.79	79.13
3					51.41	52.73	50.66	75.86	57.96	51.96
4						54.27	52.11	74.83	56.65	53.39
5							52.11	80.16	61.25	50.66
6								77.19	58.85	51.35
7									68.43	77.81
8										59.96
9										

Table 26. MNIST Dataset - Performance classifier for task (1, 6)

	0	1	2	3	4	5	6	7	8	9
0		45.77	79.08	55.03	96.02	84.72	99.02	55.13	80.19	82.4
1			81.13	58.83	96.88	86.48	99.67	58.9	82.22	84.24
2				73.75	65.79	53.38	68.34	73.4	50.25	52.92
3					90.31	78.92	93.19	50.15	74.7	76.97
4						63.5	52.42	89.8	66.0	62.98
5							66.22	78.49	53.22	50.29
6								92.65	68.63	65.53
7									74.33	76.58
8										52.75
9										

Table 27. MNIST Dataset - Performance classifier for task (1, 7)

	0	1	2	3	4	5	6	7	8	9
0		37.26	64.07	62.26	87.26	64.53	54.44	89.89	71.29	88.99
1			75.5	73.94	97.26	76.71	66.99	99.49	82.5	98.74
2				51.91	72.24	50.57	59.9	75.15	56.63	74.13
3					74.45	51.47	58.03	77.33	58.67	76.32
4						74.49	83.25	53.48	66.1	52.24
5							60.05	77.55	57.72	76.49
6								86.0	67.08	85.05
7									69.23	51.25
8										68.13
9										

Table 28. MNIST Dataset - Performance classifier for task (1, 8)

	0	1	2	3	4	5	6	7	8	9
0		46.48	90.21	96.53	98.88	98.61	99.59	89.19	99.95	98.69
1			90.77	96.64	98.82	98.57	99.47	89.83	99.81	98.65
2				55.73	57.45	55.25	57.64	51.07	58.33	57.81
3					51.66	50.84	51.78	56.82	52.52	52.11
4						52.61	50.1	58.56	50.87	50.48
5							52.76	56.41	53.54	53.08
6								58.76	50.78	50.38
7									59.44	58.91
8										50.38
9										

Table 29. MNIST Dataset - Performance classifier for task (1, 9)

	0	1	2	3	4	5	6	7	8	9
0		44.92	59.54	77.04	97.96	89.37	85.29	94.92	87.1	98.24
1			63.82	80.09	99.53	91.66	87.82	96.67	89.47	99.77
2				66.94	87.19	78.33	74.72	84.47	76.57	87.6
3					70.23	60.46	57.42	67.86	59.43	70.88
4						60.89	63.25	51.94	61.04	50.93
5							52.86	58.59	50.64	61.7
6								60.98	52.12	64.01
7									58.84	52.82
8										61.83
9										

Table 30. MNIST Dataset - Performance classifier for task (2, 3)

	0	1	2	3	4	5	6	7	8	9
0		74.04	45.73	96.43	72.02	92.25	52.63	76.25	83.21	86.58
1			77.43	69.37	53.61	63.94	71.86	50.86	56.66	60.21
2				99.46	75.72	95.58	56.88	79.76	86.64	89.86
3					74.7	56.99	94.36	69.48	63.86	59.73
4						69.16	69.64	54.73	61.09	64.84
5							90.0	63.75	57.61	53.34
6								73.97	80.95	84.39
7									56.09	59.84
8										53.96
9										

Table 31. MNIST Dataset - Performance classifier for task (2, 4)

	0	1	2	3	4	5	6	7	8	9
0		38.39	40.26	47.24	90.67	73.24	74.97	58.67	59.21	89.74
1			52.28	58.88	99.29	83.57	84.85	69.39	70.18	98.32
2				56.9	99.35	82.8	84.17	67.96	68.74	98.33
3					92.82	75.76	77.39	61.24	61.84	91.88
4						69.37	66.19	81.04	81.6	50.38
5							52.65	63.59	63.67	68.7
6								65.61	65.73	65.58
7									50.3	80.27
8										80.79
9										

Table 32. MNIST Dataset - Performance classifier for task (2, 5)

	0	1	2	3	4	5	6	7	8	9
0		42.41	25.1	63.52	56.63	74.63	52.37	37.75	51.02	58.17
1			65.71	70.02	63.72	80.66	59.87	53.95	58.56	65.07
2				87.71	81.33	100.0	77.49	62.38	75.97	82.51
3					56.98	60.09	61.33	75.27	62.55	55.27
4						67.66	54.33	68.71	55.62	51.63
5							72.43	86.82	73.63	65.7
6								64.7	51.35	55.92
7									63.29	70.05
8										57.19
9										

Table 33. MNIST Dataset - Performance classifier for task (2, 6)

	0	1	2	3	4	5	6	7	8	9
0		30.69	31.36	35.63	71.3	74.36	81.84	32.82	43.4	45.8
1			51.55	55.71	89.04	92.65	99.0	52.94	63.25	65.16
2				54.36	89.37	93.19	99.85	51.46	62.26	64.28
3					85.34	89.01	95.88	52.89	57.91	60.03
4						52.03	60.26	87.96	77.97	75.19
5							58.7	91.72	81.35	78.38
6								98.44	88.61	85.61
7									60.79	62.84
8										52.29
9										

Table 34. MNIST Dataset - Performance classifier for task (2, 7)

	0	1	2	3	4	5	6	7	8	9
0		54.18	48.61	52.41	66.26	58.6	50.31	98.46	54.91	93.97
1			55.38	51.89	60.89	53.58	53.94	90.89	50.36	86.66
2				53.72	67.23	59.82	51.71	98.59	56.18	94.22
3					63.6	55.94	52.13	95.39	52.42	90.94
4						58.43	66.13	82.54	61.4	77.9
5							58.38	92.29	53.48	87.53
6								98.69	54.66	94.15
7									93.81	54.84
8										89.26
9										

Table 35. MNIST Dataset - Performance classifier for task (2, 8)

	0	1	2	3	4	5	6	7	8	9
0		90.73	40.76	80.0	78.08	89.53	59.6	61.45	91.56	86.27
1			98.34	62.33	64.67	55.99	82.27	79.2	52.35	56.53
2				88.34	86.59	98.13	68.69	70.19	99.75	94.46
3					52.31	57.52	70.88	68.01	60.84	56.17
4						60.09	68.81	65.97	63.34	58.56
5							79.95	76.56	53.86	50.97
6								52.22	82.4	77.22
7									79.07	74.13
8										54.56
9										

Table 36. MNIST Dataset - Performance classifier for task (2, 9)

	0	1	2	3	4	5	6	7	8	9
0		28.13	28.18	51.96	74.72	68.91	30.5	68.43	54.04	78.83
1			51.08	73.38	94.76	90.28	54.04	88.49	75.68	98.32
2				73.41	95.88	91.22	53.07	89.27	75.82	99.61
3					72.39	66.56	71.19	66.24	52.02	76.47
4						56.99	94.48	55.72	70.76	54.45
5							89.57	50.83	64.74	61.55
6								87.66	73.65	98.37
7									64.54	59.99
8										74.94
9										

Table 37. MNIST Dataset - Performance classifier for task (3, 4)

	0	1	2	3	4	5	6	7	8	9
0		45.39	51.69	47.39	97.86	55.13	81.17	52.29	50.97	86.93
1			56.07	52.12	98.96	59.55	83.52	56.63	55.52	88.81
2				54.21	94.94	53.22	78.64	50.58	50.75	84.32
3					99.75	57.78	83.33	54.81	53.58	88.95
4						94.98	67.27	94.43	97.03	60.27
5							77.46	52.6	54.13	83.59
6								78.1	80.28	56.63
7									51.35	83.8
8										86.08
9										

Table 38. MNIST Dataset - Performance classifier for task (3, 5)

	0	1	2	3	4	5	6	7	8	9
0		45.63	48.21	47.19	80.68	97.33	96.28	56.72	69.19	63.3
1			52.61	51.7	82.81	98.27	97.28	60.52	72.17	66.65
2				50.98	81.68	97.92	96.88	58.3	70.49	64.72
3					83.03	99.53	98.42	59.37	71.72	65.87
4						65.15	65.21	73.23	61.61	66.95
5							50.59	89.11	77.38	82.69
6								88.37	77.02	82.16
7									61.99	56.36
8										55.57
9										

Table 39. MNIST Dataset - Performance classifier for task (3, 6)

	0	1	2	3	4	5	6	7	8	9
0		32.25	32.65	25.78	56.83	41.99	75.7	25.8	39.56	32.53
1			51.22	54.97	74.07	61.12	91.73	55.11	58.13	51.31
2				56.51	73.98	60.34	92.56	56.65	57.23	50.07
3					80.92	67.46	99.8	50.2	64.01	56.66
4						65.15	68.76	80.85	67.28	74.18
5							85.03	67.5	52.89	60.39
6								99.55	86.34	92.98
7									64.09	56.8
8										57.24
9										

Table 40. MNIST Dataset - Performance classifier for task (3, 7)

	0	1	2	3	4	5	6	7	8	9
0		72.43	54.22	44.27	88.43	49.09	56.35	94.42	50.82	89.44
1			67.97	77.44	63.2	74.25	66.79	69.3	71.74	64.46
2				59.75	83.22	55.3	51.91	89.17	53.44	84.27
3					93.57	55.1	62.04	99.36	56.55	94.5
4						91.14	82.53	56.87	87.73	51.53
5							57.57	97.34	51.77	92.16
6								88.72	55.54	83.63
7									93.76	55.28
8										88.75
9										

Table 41. MNIST Dataset - Performance classifier for task (3, 8)

	0	1	2	3	4	5	6	7	8	9
0		91.63	71.32	46.18	87.87	77.99	95.72	62.8	96.47	78.18
1			70.84	94.59	56.5	67.59	50.26	78.83	51.3	64.93
2				74.73	65.59	54.94	72.96	58.35	73.88	56.44
3					91.11	81.55	98.88	66.34	99.6	81.53
4						61.69	57.37	74.18	58.44	59.17
5							69.57	63.91	70.58	51.92
6								81.67	51.14	66.55
7									82.52	64.9
8										67.52
9										

Table 42. MNIST Dataset - Performance classifier for task (3, 9)

	0	1	2	3	4	5	6	7	8	9
0		26.81	29.47	28.94	77.27	44.12	49.43	61.6	46.26	78.88
1			53.58	53.33	98.44	68.77	72.91	83.45	69.8	99.67
2				50.29	97.07	65.75	70.2	81.36	66.95	98.38
3					97.89	66.25	70.73	81.99	67.44	99.21
4						84.42	78.14	65.02	81.08	51.98
5							55.35	67.86	51.98	86.01
6								62.29	53.21	79.77
7									65.28	66.76
8										82.65
9										

Table 43. MNIST Dataset - Performance classifier for task (4, 5)

	0	1	2	3	4	5	6	7	8	9
0		64.07	74.6	98.34	49.34	99.31	80.08	62.35	90.99	53.54
1			59.11	80.98	64.67	80.86	63.64	52.29	73.87	60.59
2				72.87	75.22	72.25	54.42	61.99	65.25	70.8
3					98.95	52.05	69.26	85.03	58.11	94.16
4						99.95	80.72	62.99	91.62	54.19
5							68.38	85.16	56.54	94.84
6								66.87	61.28	76.05
7									77.62	58.71
8										86.84
9										

Table 44. MNIST Dataset - Performance classifier for task (4, 6)

	0	1	2	3	4	5	6	7	8	9
0		69.98	68.39	72.76	44.24	75.37	93.7	43.08	63.87	43.54
1			52.42	51.42	75.3	52.59	70.28	75.96	57.18	75.7
2				54.06	73.98	55.46	73.97	74.71	54.94	74.42
3					78.41	51.16	70.02	79.05	59.17	78.8
4						81.38	99.48	51.29	69.63	50.78
5							70.11	81.98	60.93	81.75
6								99.65	79.81	99.59
7									70.48	50.52
8										70.15
9										

Table 45. MNIST Dataset - Performance classifier for task (4, 7)

	0	1	2	3	4	5	6	7	8	9
0		70.35	81.96	86.33	45.46	70.73	46.59	95.37	74.77	63.45
1			59.81	63.64	74.54	52.1	73.72	72.21	52.54	57.6
2				53.92	86.35	63.25	85.63	63.01	57.93	68.4
3					90.76	67.61	90.09	59.22	62.05	72.56
4						75.45	51.19	99.75	79.29	67.91
5							74.54	77.24	55.14	56.34
6								99.19	78.47	66.95
7									71.33	81.59
8										60.92
9										

Table 46. MNIST Dataset - Performance classifier for task (4, 8)

	0	1	2	3	4	5	6	7	8	9
0		97.64	91.85	97.44	47.91	95.94	71.57	92.73	97.65	64.35
1			57.64	52.96	99.53	57.28	78.17	56.91	53.63	83.68
2				55.0	93.84	50.94	71.31	50.78	54.44	77.27
3					99.45	54.42	76.73	54.22	50.66	82.62
4						98.08	73.66	94.73	99.69	66.4
5							73.89	50.1	53.8	80.22
6								72.16	76.55	56.74
7									53.65	78.11
8										82.55
9										

Table 47. MNIST Dataset - Performance classifier for task (4, 9)

	0	1	2	3	4	5	6	7	8	9
0		55.65	80.42	94.37	46.89	92.47	50.93	95.52	93.96	96.43
1			72.73	85.59	58.53	83.33	54.85	86.73	85.06	87.5
2				63.27	83.42	59.51	79.85	64.66	62.31	65.26
3					97.39	54.63	93.95	51.52	51.21	52.01
4						95.68	54.07	98.51	97.03	99.45
5							92.0	56.2	53.43	56.76
6								95.12	93.53	96.03
7									52.75	50.47
8										53.25
9										

Table 48. MNIST Dataset - Performance classifier for task (5, 6)

	0	1	2	3	4	5	6	7	8	9
0		49.13	49.4	25.73	44.44	27.51	75.49	25.45	30.25	27.15
1			50.3	71.66	54.27	69.86	74.49	71.94	67.43	70.34
2				73.07	54.82	71.26	75.43	73.35	68.64	71.68
3					68.78	53.26	99.64	50.49	54.89	51.41
4						66.65	81.08	69.1	64.16	67.35
5							99.46	53.75	51.88	51.76
6								99.7	95.55	98.22
7									55.34	51.89
8										53.45
9										

Table 49. MNIST Dataset - Performance classifier for task (5, 7)

	0	1	2	3	4	5	6	7	8	9
0		92.81	72.47	52.16	86.49	52.08	54.02	99.6	57.27	92.16
1			70.93	90.21	58.95	92.75	89.54	54.18	86.2	53.12
2				70.03	63.11	71.47	68.79	76.41	65.45	68.94
3					83.79	50.21	51.78	96.76	54.99	89.4
4						86.13	82.89	63.93	79.35	56.15
5							52.11	99.84	55.52	92.06
6								96.22	53.31	88.66
7									92.66	57.73
8										85.12
9										

Table 50. MNIST Dataset - Performance classifier for task (5, 8)

	0	1	2	3	4	5	6	7	8	9
0		88.13	87.97	66.48	86.54	41.29	66.05	80.43	88.89	85.47
1			51.96	72.31	54.23	97.83	73.67	59.04	52.2	54.71
2				71.35	52.33	98.18	72.76	57.43	50.2	52.87
3					69.53	75.81	50.86	63.89	71.77	68.7
4						96.96	70.93	55.27	52.2	50.58
5							75.62	90.31	99.46	95.69
6								65.11	73.24	70.06
7									57.44	54.64
8										52.75
9										

Table 51. MNIST Dataset - Performance classifier for task (5, 9)

	0	1	2	3	4	5	6	7	8	9
0		79.05	83.0	61.71	94.04	47.12	56.86	94.67	77.02	94.62
1			52.28	67.79	61.79	82.98	73.01	63.06	54.1	62.73
2				71.11	59.93	87.32	76.68	61.31	56.78	60.95
3					81.68	65.09	55.08	82.58	64.87	82.42
4						98.99	87.68	51.64	67.18	51.18
5							60.11	99.53	81.19	99.53
6								88.47	70.45	88.36
7									68.43	50.47
8										68.13
9										

Table 52. MNIST Dataset - Performance classifier for task (6, 7)

	0	1	2	3	4	5	6	7	8	9
0		82.65	58.1	72.51	76.91	64.69	37.1	86.8	70.83	86.02
1			74.34	61.31	57.68	70.5	94.94	52.24	63.44	51.21
2				63.96	68.12	55.82	70.75	77.96	62.16	77.12
3					54.02	59.1	85.47	64.28	52.07	63.3
4						63.5	90.1	60.5	56.19	59.47
5							78.38	74.17	57.07	73.22
6								99.8	84.01	99.14
7									66.58	51.1
8										65.61
9										

Table 53. MNIST Dataset - Performance classifier for task (6, 8)

	0	1	2	3	4	5	6	7	8	9
0		81.7	73.11	79.85	69.93	74.89	31.32	81.18	80.66	80.14
1			59.48	53.57	63.2	60.09	99.33	52.06	53.39	53.31
2				56.32	53.67	50.05	91.56	57.82	56.68	56.59
3					60.19	56.73	98.58	51.57	50.25	50.27
4						54.0	88.81	61.69	60.63	60.47
5							94.76	58.33	57.13	57.02
6								99.75	99.74	98.88
7									51.35	51.3
8										50.03
9										

Table 54. MNIST Dataset - Performance classifier for task (6, 9)

	0	1	2	3	4	5	6	7	8	9
0		40.9	49.11	69.7	75.64	63.41	29.98	79.88	68.53	79.74
1			58.05	77.25	82.85	71.88	59.34	86.64	76.29	86.57
2				70.08	75.87	63.98	68.59	80.0	68.94	79.86
3					55.57	57.41	89.63	60.21	51.51	59.88
4						63.45	95.93	54.83	57.21	54.45
5							84.54	68.18	55.95	67.91
6								99.75	88.82	99.8
7									61.89	50.42
8										61.57
9										

Table 55. MNIST Dataset - Performance classifier for task (7, 8)

	0	1	2	3	4	5	6	7	8	9
0		76.5	86.53	92.26	77.32	96.63	97.06	46.56	97.08	62.64
1			58.05	63.08	51.16	65.42	66.79	79.1	67.05	64.41
2				55.19	59.88	57.17	58.89	89.03	59.22	73.69
3					65.31	51.68	53.61	94.65	53.98	79.2
4						67.98	69.38	80.1	69.63	64.29
5							52.11	99.06	52.52	82.69
6								99.4	50.41	83.58
7									99.4	65.73
8										83.71
9										

Table 56. MNIST Dataset - Performance classifier for task (7, 9)

	0	1	2	3	4	5	6	7	8	9
0		45.67	60.39	77.99	92.3	92.41	89.42	43.28	86.95	93.82
1			63.87	80.23	93.53	93.69	90.87	52.01	88.57	94.92
2				67.04	80.83	80.41	77.89	66.7	75.57	82.46
3					63.7	62.46	60.52	83.95	58.32	65.58
4						51.92	53.4	98.01	55.52	52.08
5							51.62	98.39	53.86	54.08
6								95.27	52.17	55.47
7									92.81	99.41
8										57.54
9										

Table 57. MNIST Dataset - Performance classifier for task (8, 9)

	0	1	2	3	4	5	6	7	8	9
0		40.0	44.28	54.62	89.45	56.57	50.57	87.0	42.22	91.45
1			54.45	64.15	96.55	66.5	60.63	94.13	52.82	98.32
2				60.14	94.14	62.37	56.33	91.65	51.84	96.03
3					84.24	51.63	54.12	81.94	62.3	86.28
4						84.74	89.33	51.54	97.34	52.54
5							56.05	82.29	64.74	86.9
6								86.86	58.44	91.36
7									94.71	54.0
8										99.24
9										

Table 58. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Trouser)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		99.2	50.45	59.8	54.8	50.55	50.35	49.85	51.55	49.8
Trouser			98.75	89.4	94.4	98.65	98.85	99.35	97.65	99.4
Pullover				59.35	54.35	50.1	50.1	50.6	51.1	50.65
Dress					55.0	59.25	59.45	59.95	58.25	60.0
Coat						54.25	54.45	54.95	53.25	55.0
Sandal							50.2	50.7	51.0	50.75
Shirt								50.5	51.2	50.55
Sneaker									51.7	50.05
Bag										51.75
Ankle boot										

Table 59. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Pullover)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		48.8	96.8	55.45	95.75	80.2	79.0	76.8	87.35	86.9
Trouser			98.0	56.65	96.95	81.4	80.2	78.0	88.55	88.1
Pullover				91.35	51.05	66.6	67.8	70.0	59.45	59.9
Dress					90.3	74.75	73.55	71.35	81.9	81.45
Coat						65.55	66.75	68.95	58.4	58.85
Sandal							51.2	53.4	57.15	56.7
Shirt								52.2	58.35	57.9
Sneaker									60.55	60.1
Bag										50.45
Ankle boot										

Table 60. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Dress)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		92.75	56.2	96.85	69.6	57.5	56.85	64.25	64.45	52.1
Trouser			86.55	54.1	73.15	85.25	85.9	78.5	78.3	90.65
Pullover				90.65	63.4	51.3	50.65	58.05	58.25	54.1
Dress					77.25	89.35	90.0	82.6	82.4	94.75
Coat						62.1	62.75	55.35	55.15	67.5
Sandal							50.65	56.75	56.95	55.4
Shirt								57.4	57.6	54.75
Sneaker									50.2	62.15
Bag										62.35
Ankle boot										

Table 61. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Coat)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		52.95	87.25	60.7	98.9	57.2	77.1	63.2	74.4	59.05
Trouser			84.3	57.75	95.95	54.25	74.15	60.25	71.45	56.1
Pullover				76.55	61.65	80.05	60.15	74.05	62.85	78.2
Dress					88.2	53.5	66.4	52.5	63.7	51.65
Coat						91.7	71.8	85.7	74.5	89.85
Sandal							69.9	56.0	67.2	51.85
Shirt								63.9	52.7	68.05
Sneaker									61.2	54.15
Bag										65.35
Ankle boot										

Table 62. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Sandal)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.9	49.8	49.8	49.8	99.8	49.8	99.8	58.75	99.7
Trouser			50.1	50.1	50.1	99.9	50.1	99.9	58.85	99.8
Pullover				50.0	50.0	100.0	50.0	100.0	58.95	99.9
Dress					50.0	100.0	50.0	100.0	58.95	99.9
Coat						100.0	50.0	100.0	58.95	99.9
Sandal							100.0	50.0	91.05	50.1
Shirt								100.0	58.95	99.9
Sneaker									91.05	50.1
Bag										90.95
Ankle boot										

Table 63. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Shirt)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.15	90.6	57.75	93.05	74.55	86.6	87.95	78.6	93.9
Trouser			91.45	58.6	93.9	75.4	87.45	88.8	79.45	94.75
Pullover				82.85	52.45	66.05	54.0	52.65	62.0	53.3
Dress					85.3	66.8	78.85	80.2	70.85	86.15
Coat						68.5	56.45	55.1	64.45	50.85
Sandal							62.05	63.4	54.05	69.35
Shirt								51.35	58.0	57.3
Sneaker									59.35	55.95
Bag										65.3
Ankle boot										

Table 64. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Sneaker)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.85	49.85	49.85	49.85	98.8	49.85	99.85	55.35	99.0
Trouser			50.0	50.0	50.0	98.95	50.0	100.0	55.5	99.15
Pullover				50.0	50.0	98.95	50.0	100.0	55.5	99.15
Dress					50.0	98.95	50.0	100.0	55.5	99.15
Coat						98.95	50.0	100.0	55.5	99.15
Sandal							98.95	51.05	93.45	50.2
Shirt								100.0	55.5	99.15
Sneaker									94.5	50.85
Bag										93.65
Ankle boot										

Table 65. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		52.95	56.45	55.1	74.5	96.9	56.75	99.0	98.65	98.8
Trouser			53.5	52.15	71.55	93.95	53.8	96.05	95.7	95.85
Pullover				51.35	68.05	90.45	50.3	92.55	92.2	92.35
Dress					69.4	91.8	51.65	93.9	93.55	93.7
Coat						72.4	67.75	74.5	74.15	74.3
Sandal							90.15	52.1	51.75	51.9
Shirt								92.25	91.9	92.05
Sneaker									50.35	50.2
Bag										50.15
Ankle boot										

Table 66. FashionMNIST Dataset - Performance classifier for task (T-shirt/top, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.95	49.95	50.0	49.95	90.75	49.95	98.45	52.2	99.9
Trouser			50.0	50.05	50.0	90.8	50.0	98.5	52.25	99.95
Pullover				50.05	50.0	90.8	50.0	98.5	52.25	99.95
Dress					50.05	90.75	50.05	98.45	52.2	99.9
Coat						90.8	50.0	98.5	52.25	99.95
Sandal							90.8	57.7	88.55	59.15
Shirt								98.5	52.25	99.95
Sneaker									96.25	51.45
Bag										97.7
Ankle boot										

Table 67. FashionMNIST Dataset - Performance classifier for task (Trouser, Pullover)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		46.0	95.6	64.95	94.5	87.55	93.15	95.55	93.8	78.75
Trouser			99.6	68.95	98.5	91.55	97.15	99.55	97.8	82.75
Pullover				80.65	51.1	58.05	52.45	50.05	51.8	66.85
Dress					79.55	72.6	78.2	80.6	78.85	63.8
Coat						56.95	51.35	51.05	50.7	65.75
Sandal							55.6	58.0	56.25	58.8
Shirt								52.4	50.65	64.4
Sneaker									51.75	66.8
Bag										65.05
Ankle boot										

Table 68. FashionMNIST Dataset - Performance classifier for task (Trouser, Dress)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		50.2	99.0	99.0	97.75	91.0	98.65	92.8	86.7	66.85
Trouser			98.8	98.8	97.55	90.8	98.45	92.6	86.5	66.65
Pullover				50.0	51.25	58.0	50.35	56.2	62.3	82.15
Dress					51.25	58.0	50.35	56.2	62.3	82.15
Coat						56.75	50.9	54.95	61.05	80.9
Sandal							57.65	51.8	54.3	74.15
Shirt								55.85	61.95	81.8
Sneaker									56.1	75.95
Bag										69.85
Ankle boot										

Table 69. FashionMNIST Dataset - Performance classifier for task (Trouser, Coat)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		41.05	90.55	61.05	90.5	85.4	87.3	90.7	89.55	89.95
Trouser			99.5	70.0	99.45	94.35	96.25	99.65	98.5	98.9
Pullover				79.5	50.05	55.15	53.25	50.15	51.0	50.6
Dress					79.45	74.35	76.25	79.65	78.5	78.9
Coat						55.1	53.2	50.2	50.95	50.55
Sandal							51.9	55.3	54.15	54.55
Shirt								53.4	52.25	52.65
Sneaker									51.15	50.75
Bag										50.4
Ankle boot										

Table 70. FashionMNIST Dataset - Performance classifier for task (Trouser, Sandal)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.1	50.65	49.25	50.0	99.05	51.55	99.05	90.35	99.05
Trouser			51.55	50.15	50.9	99.95	52.45	99.95	91.25	99.95
Pullover				51.4	50.65	98.4	50.9	98.4	89.7	98.4
Dress					50.75	99.8	52.3	99.8	91.1	99.8
Coat						99.05	51.55	99.05	90.35	99.05
Sandal							97.5	50.0	58.7	50.0
Shirt								97.5	88.8	97.5
Sneaker									58.7	50.0
Bag										58.7
Ankle boot										

Table 71. FashionMNIST Dataset - Performance classifier for task (Trouser, Shirt)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		50.2	99.4	83.55	99.15	97.85	99.3	99.65	99.3	98.95
Trouser			99.2	83.35	98.95	97.65	99.1	99.45	99.1	98.75
Pullover				65.85	50.25	51.55	50.1	50.25	50.1	50.45
Dress					65.6	64.3	65.75	66.1	65.75	65.4
Coat						51.3	50.15	50.5	50.15	50.2
Sandal							51.45	51.8	51.45	51.1
Shirt								50.35	50.0	50.35
Sneaker									50.35	50.7
Bag										50.35
Ankle boot										

Table 72. FashionMNIST Dataset - Performance classifier for task (Trouser, Sneaker)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.35	50.45	49.6	50.1	98.5	51.3	99.3	90.8	98.5
Trouser			51.1	50.25	50.75	99.15	51.95	99.95	91.45	99.15
Pullover				50.85	50.35	98.05	50.85	98.85	90.35	98.05
Dress					50.5	98.9	51.7	99.7	91.2	98.9
Coat						98.4	51.2	99.2	90.7	98.4
Sandal							97.2	50.8	57.7	50.0
Shirt								98.0	89.5	97.2
Sneaker									58.5	50.8
Bag										57.7
Ankle boot										

Table 73. FashionMNIST Dataset - Performance classifier for task (Trouser, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		29.85	74.05	38.15	69.2	79.3	66.6	79.7	79.55	79.2
Trouser			94.2	58.3	89.35	99.45	86.75	99.85	99.7	99.35
Pullover				85.9	54.85	55.25	57.45	55.65	55.5	55.15
Dress					81.05	91.15	78.45	91.55	91.4	91.05
Coat						60.1	52.6	60.5	60.35	60.0
Sandal							62.7	50.4	50.25	50.1
Shirt								63.1	62.95	62.6
Sneaker									50.15	50.5
Bag										50.35
Ankle boot										

Table 74. FashionMNIST Dataset - Performance classifier for task (Trouser, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.5	49.9	49.65	49.75	96.35	50.3	99.45	84.8	99.5
Trouser			50.4	50.15	50.25	96.85	50.8	99.95	85.3	100.0
Pullover				50.25	50.15	96.45	50.4	99.55	84.9	99.6
Dress					50.1	96.7	50.65	99.8	85.15	99.85
Coat						96.6	50.55	99.7	85.05	99.75
Sandal							96.05	53.1	61.55	53.15
Shirt								99.15	84.5	99.2
Sneaker									64.65	50.05
Bag										64.7
Ankle boot										

Table 75. FashionMNIST Dataset - Performance classifier for task (Pullover, Dress)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		74.35	26.2	74.05	33.6	25.6	37.8	25.2	31.65	27.5
Trouser			98.15	50.3	90.75	98.75	86.55	99.15	92.7	96.85
Pullover				97.85	57.4	50.6	61.6	51.0	55.45	51.3
Dress					90.45	98.45	86.25	98.85	92.4	96.55
Coat						58.0	54.2	58.4	51.95	56.1
Sandal							62.2	50.4	56.05	51.9
Shirt								62.6	56.15	60.3
Sneaker									56.45	52.3
Bag										54.15
Ankle boot										

Table 76. FashionMNIST Dataset - Performance classifier for task (Pullover, Coat)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		88.15	43.3	77.7	85.75	40.25	67.6	39.55	52.15	45.25
Trouser			94.85	60.45	52.4	97.9	70.55	98.6	86.0	92.9
Pullover				84.4	92.45	53.05	74.3	53.75	58.85	51.95
Dress					58.05	87.45	60.1	88.15	75.55	82.45
Coat						95.5	68.15	96.2	83.6	90.5
Sandal							77.35	50.7	61.9	55.0
Shirt								78.05	65.45	72.35
Sneaker									62.6	55.7
Bag										56.9
Ankle boot										

Table 77. FashionMNIST Dataset - Performance classifier for task (Pullover, Sandal)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.95	49.6	51.1	49.6	99.55	49.6	99.6	65.9	99.6
Trouser			50.35	51.15	50.35	99.6	50.35	99.65	65.95	99.65
Pullover				51.5	50.0	99.95	50.0	100.0	66.3	100.0
Dress					51.5	98.45	51.5	98.5	64.8	98.5
Coat						99.95	50.0	100.0	66.3	100.0
Sandal							99.95	50.05	83.65	50.05
Shirt								100.0	66.3	100.0
Sneaker									83.7	50.0
Bag										83.7
Ankle boot										

Table 78. FashionMNIST Dataset - Performance classifier for task (Pullover, Shirt)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		96.9	52.05	93.15	74.0	88.5	93.25	78.7	77.75	96.5
Trouser			94.85	53.75	72.9	58.4	53.65	68.2	69.15	50.4
Pullover				91.1	71.95	86.45	91.2	76.65	75.7	94.45
Dress					69.15	54.65	50.1	64.45	65.4	53.35
Coat						64.5	69.25	54.7	53.75	72.5
Sandal							54.75	59.8	60.75	58.0
Shirt								64.55	65.5	53.25
Sneaker									50.95	67.8
Bag										68.75
Ankle boot										

Table 79. FashionMNIST Dataset - Performance classifier for task (Pullover, Sneaker)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.85	49.8	49.9	49.8	98.8	49.9	99.8	66.95	99.2
Trouser			50.05	50.05	50.05	98.95	50.05	99.95	67.1	99.35
Pullover				50.1	50.0	99.0	50.1	100.0	67.15	99.4
Dress					50.1	98.9	50.0	99.9	67.05	99.3
Coat						99.0	50.1	100.0	67.15	99.4
Sandal							98.9	51.0	81.85	50.4
Shirt								99.9	67.05	99.3
Sneaker									82.85	50.6
Bag										82.25
Ankle boot										

Table 80. FashionMNIST Dataset - Performance classifier for task (Pullover, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		62.25	47.05	53.9	47.8	95.5	50.6	96.8	96.25	96.1
Trouser			65.2	58.35	64.45	83.25	61.65	84.55	84.0	83.85
Pullover				56.85	50.75	98.45	53.55	99.75	99.2	99.05
Dress					56.1	91.6	53.3	92.9	92.35	92.2
Coat						97.7	52.8	99.0	98.45	98.3
Sandal							94.9	51.3	50.75	50.6
Shirt								96.2	95.65	95.5
Sneaker									50.55	50.7
Bag										50.15
Ankle boot										

Table 81. FashionMNIST Dataset - Performance classifier for task (Pullover, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		50.25	49.75	54.5	49.8	94.05	49.8	99.45	53.15	99.7
Trouser			50.5	54.25	50.45	93.8	50.45	99.2	52.9	99.45
Pullover				54.75	50.05	94.3	50.05	99.7	53.4	99.95
Dress					54.7	89.55	54.7	94.95	51.35	95.2
Coat						94.25	50.0	99.65	53.35	99.9
Sandal							94.25	55.4	90.9	55.65
Shirt								99.65	53.35	99.9
Sneaker									96.3	50.25
Bag										96.55
Ankle boot										

Table 82. FashionMNIST Dataset - Performance classifier for task (Dress, Coat)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		42.7	88.05	43.6	89.9	65.05	75.85	53.5	86.15	78.15
Trouser			95.35	50.9	97.2	72.35	83.15	60.8	93.45	85.45
Pullover				94.45	51.85	73.0	62.2	84.55	51.9	59.9
Dress					96.3	71.45	82.25	59.9	92.55	84.55
Coat						74.85	64.05	86.4	53.75	61.75
Sandal							60.8	61.55	71.1	63.1
Shirt								72.35	60.3	52.3
Sneaker									82.65	74.65
Bag										58.0
Ankle boot										

Table 83. FashionMNIST Dataset - Performance classifier for task (Dress, Sandal)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.7	51.2	49.5	51.05	99.4	51.5	99.45	85.45	99.4
Trouser			51.5	50.2	51.35	99.7	51.8	99.75	85.75	99.7
Pullover				51.7	50.15	98.2	50.3	98.25	84.25	98.2
Dress					51.55	99.9	52.0	99.95	85.95	99.9
Coat						98.35	50.45	98.4	84.4	98.35
Sandal							97.9	50.05	63.95	50.0
Shirt								97.95	83.95	97.9
Sneaker									64.0	50.05
Bag										63.95
Ankle boot										

Table 84. FashionMNIST Dataset - Performance classifier for task (Dress, Shirt)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		47.8	94.9	47.9	89.2	93.9	93.75	95.2	87.0	95.6
Trouser			97.1	50.1	91.4	96.1	95.95	97.4	89.2	97.8
Pullover				97.0	55.7	51.0	51.15	50.3	57.9	50.7
Dress					91.3	96.0	95.85	97.3	89.1	97.7
Coat						54.7	54.55	56.0	52.2	56.4
Sandal							50.15	51.3	56.9	51.7
Shirt								51.45	56.75	51.85
Sneaker									58.2	50.4
Bag										58.6
Ankle boot										

Table 85. FashionMNIST Dataset - Performance classifier for task (Dress, Sneaker)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.5	50.55	49.5	50.0	98.75	51.0	99.45	82.5	98.55
Trouser			51.05	50.0	50.5	99.25	51.5	99.95	83.0	99.05
Pullover				51.05	50.55	98.2	50.45	98.9	81.95	98.0
Dress					50.5	99.25	51.5	99.95	83.0	99.05
Coat						98.75	51.0	99.45	82.5	98.55
Sandal							97.75	50.7	66.25	50.2
Shirt								98.45	81.5	97.55
Sneaker									66.95	50.9
Bag										66.05
Ankle boot										

Table 86. FashionMNIST Dataset - Performance classifier for task (Dress, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		45.55	59.75	45.2	64.05	94.65	56.7	94.8	94.45	94.7
Trouser			64.2	50.35	68.5	99.1	61.15	99.25	98.9	99.15
Pullover				64.55	54.3	84.9	53.05	85.05	84.7	84.95
Dress					68.85	99.45	61.5	99.6	99.25	99.5
Coat						80.6	57.35	80.75	80.4	80.65
Sandal							87.95	50.15	50.2	50.05
Shirt								88.1	87.75	88.0
Sneaker									50.35	50.1
Bag										50.25
Ankle boot										

Table 87. FashionMNIST Dataset - Performance classifier for task (Dress, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.6	49.8	49.65	49.8	96.2	50.2	99.55	75.05	99.6
Trouser			50.2	50.05	50.2	96.6	50.6	99.95	75.45	100.0
Pullover				50.15	50.0	96.4	50.4	99.75	75.25	99.8
Dress					50.15	96.55	50.55	99.9	75.4	99.95
Coat						96.4	50.4	99.75	75.25	99.8
Sandal							96.0	53.35	71.15	53.4
Shirt								99.35	74.85	99.4
Sneaker									74.5	50.05
Bag										74.55
Ankle boot										

Table 88. FashionMNIST Dataset - Performance classifier for task (Coat, Sandal)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		51.6	49.35	50.2	49.25	99.15	49.3	99.15	67.05	99.15
Trouser			52.25	51.4	52.35	97.55	52.3	97.55	65.45	97.55
Pullover				50.85	50.1	99.8	50.05	99.8	67.7	99.8
Dress					50.95	98.95	50.9	98.95	66.85	98.95
Coat						99.9	50.05	99.9	67.8	99.9
Sandal							99.85	50.0	82.1	50.0
Shirt								99.85	67.75	99.85
Sneaker									82.1	50.0
Bag										82.1
Ankle boot										

Table 89. FashionMNIST Dataset - Performance classifier for task (Coat, Shirt)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		91.8	84.2	90.2	55.45	99.0	96.8	99.6	83.95	99.45
Trouser			57.6	51.6	86.35	57.2	55.0	57.8	57.85	57.65
Pullover				56.0	78.75	64.8	62.6	65.4	50.25	65.25
Dress					84.75	58.8	56.6	59.4	56.25	59.25
Coat						93.55	91.35	94.15	78.5	94.0
Sandal							52.2	50.6	65.05	50.45
Shirt								52.8	62.85	52.65
Sneaker									65.65	50.15
Bag										65.5
Ankle boot										

Table 90. FashionMNIST Dataset - Performance classifier for task (Coat, Sneaker)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.7	49.65	49.75	49.7	99.15	49.65	99.65	63.5	98.95
Trouser			50.05	50.05	50.0	99.45	50.05	99.95	63.8	99.25
Pullover				50.1	50.05	99.5	50.0	100.0	63.85	99.3
Dress					50.05	99.4	50.1	99.9	63.75	99.2
Coat						99.45	50.05	99.95	63.8	99.25
Sandal							99.5	50.5	85.65	50.2
Shirt								100.0	63.85	99.3
Sneaker									86.15	50.7
Bag										85.45
Ankle boot										

Table 91. FashionMNIST Dataset - Performance classifier for task (Coat, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		29.5	30.85	37.1	28.45	77.6	37.5	78.25	77.7	77.65
Trouser			51.35	57.6	51.05	98.1	58.0	98.75	98.2	98.15
Pullover				56.25	52.4	96.75	56.65	97.4	96.85	96.8
Dress					58.65	90.5	50.4	91.15	90.6	90.55
Coat						99.15	59.05	99.8	99.25	99.2
Sandal							90.1	50.65	50.1	50.05
Shirt								90.75	90.2	90.15
Sneaker									50.55	50.6
Bag										50.05
Ankle boot										

Table 92. FashionMNIST Dataset - Performance classifier for task (Coat, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.7	49.4	51.05	49.2	95.9	49.35	99.15	62.2	99.15
Trouser			50.3	51.35	50.5	96.2	50.35	99.45	62.5	99.45
Pullover				51.65	50.2	96.5	50.05	99.75	62.8	99.75
Dress					51.85	94.85	51.7	98.1	61.15	98.1
Coat						96.7	50.15	99.95	63.0	99.95
Sandal							96.55	53.25	83.7	53.25
Shirt								99.8	62.85	99.8
Sneaker									86.95	50.0
Bag										86.95
Ankle boot										

Table 93. FashionMNIST Dataset - Performance classifier for task (Sandal, Shirt)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		99.5	99.6	99.45	99.6	49.65	99.6	49.6	82.45	49.65
Trouser			50.1	50.05	50.1	99.85	50.1	99.9	67.05	99.85
Pullover				50.15	50.0	99.95	50.0	100.0	67.15	99.95
Dress					50.15	99.8	50.15	99.85	67.0	99.8
Coat						99.95	50.0	100.0	67.15	99.95
Sandal							99.95	50.05	82.8	50.0
Shirt								100.0	67.15	99.95
Sneaker									82.85	50.05
Bag										82.8
Ankle boot										

Table 94. FashionMNIST Dataset - Performance classifier for task (Sandal, Sneaker)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.5	49.45	52.1	49.85	49.9	49.8	98.65	54.55	78.6
Trouser			50.05	52.6	50.35	50.4	50.3	99.15	55.05	79.1
Pullover				52.65	50.4	50.45	50.35	99.2	55.1	79.15
Dress					52.25	52.2	52.3	96.55	52.45	76.5
Coat						50.05	50.05	98.8	54.7	78.75
Sandal							50.1	98.75	54.65	78.7
Shirt								98.85	54.75	78.8
Sneaker									94.1	70.05
Bag										74.05
Ankle boot										

Table 95. FashionMNIST Dataset - Performance classifier for task (Sandal, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		99.65	99.65	99.7	99.8	49.85	99.75	49.8	99.35	49.95
Trouser			50.0	50.05	50.15	99.8	50.1	99.85	50.3	99.7
Pullover				50.05	50.15	99.8	50.1	99.85	50.3	99.7
Dress					50.1	99.85	50.05	99.9	50.35	99.75
Coat						99.95	50.05	100.0	50.45	99.85
Sandal							99.9	50.05	99.5	50.1
Shirt								99.95	50.4	99.8
Sneaker									99.55	50.15
Bag										99.4
Ankle boot										

Table 96. FashionMNIST Dataset - Performance classifier for task (Sandal, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		48.0	49.3	58.05	49.75	48.35	50.3	60.75	51.2	97.4
Trouser			51.3	60.05	51.75	50.35	52.3	62.75	53.2	99.4
Pullover				58.75	50.45	50.95	51.0	61.45	51.9	98.1
Dress					58.3	59.7	57.75	52.7	56.85	89.35
Coat						51.4	50.55	61.0	51.45	97.65
Sandal							51.95	62.4	52.85	99.05
Shirt								60.45	50.9	97.1
Sneaker									59.55	86.65
Bag										96.2
Ankle boot										

Table 97. FashionMNIST Dataset - Performance classifier for task (Shirt, Sneaker)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		49.85	49.7	49.85	49.7	98.8	49.7	99.7	62.35	99.2
Trouser			50.15	50.0	50.15	98.95	50.15	99.85	62.5	99.35
Pullover				50.15	50.0	99.1	50.0	100.0	62.65	99.5
Dress					50.15	98.95	50.15	99.85	62.5	99.35
Coat						99.1	50.0	100.0	62.65	99.5
Sandal							99.1	50.9	86.45	50.4
Shirt								100.0	62.65	99.5
Sneaker									87.35	50.5
Bag										86.85
Ankle boot										

Table 98. FashionMNIST Dataset - Performance classifier for task (Shirt, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		65.7	49.35	51.0	49.3	97.9	49.95	99.05	98.55	97.8
Trouser			66.35	64.7	66.4	82.2	65.75	83.35	82.85	82.1
Pullover				51.65	50.05	98.55	50.6	99.7	99.2	98.45
Dress					51.7	96.9	51.05	98.05	97.55	96.8
Coat						98.6	50.65	99.75	99.25	98.5
Sandal							97.95	51.15	50.65	50.1
Shirt								99.1	98.6	97.85
Sneaker									50.5	51.25
Bag										50.75
Ankle boot										

Table 99. FashionMNIST Dataset - Performance classifier for task (Shirt, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		50.0	50.0	49.95	49.95	95.55	49.9	99.8	51.75	99.85
Trouser			50.0	50.05	50.05	95.55	50.1	99.8	51.75	99.85
Pullover				50.05	50.05	95.55	50.1	99.8	51.75	99.85
Dress					50.0	95.6	50.05	99.85	51.8	99.9
Coat						95.6	50.05	99.85	51.8	99.9
Sandal							95.65	54.25	93.8	54.3
Shirt								99.9	51.85	99.95
Sneaker									98.05	50.05
Bag										98.1
Ankle boot										

Table 100. FashionMNIST Dataset - Performance classifier for task (Sneaker, Bag)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		99.7	99.85	99.6	99.85	59.55	99.85	49.85	99.55	51.8
Trouser			50.15	50.1	50.15	90.15	50.15	99.85	50.15	97.9
Pullover				50.25	50.0	90.3	50.0	100.0	50.3	98.05
Dress					50.25	90.05	50.25	99.75	50.05	97.8
Coat						90.3	50.0	100.0	50.3	98.05
Sandal							90.3	59.7	90.0	57.75
Shirt								100.0	50.3	98.05
Sneaker									99.7	51.95
Bag										97.75
Ankle boot										

Table 101. FashionMNIST Dataset - Performance classifier for task (Sneaker, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		39.1	77.4	45.4	68.1	56.15	62.45	39.45	48.85	86.55
Trouser			88.3	56.3	79.0	67.05	73.35	50.35	59.75	97.45
Pullover				82.0	59.3	71.25	64.95	87.95	78.55	59.15
Dress					72.7	60.75	67.05	55.95	53.45	91.15
Coat						61.95	55.65	78.65	69.25	68.45
Sandal							56.3	66.7	57.3	80.4
Shirt								73.0	63.6	74.1
Sneaker									59.4	97.1
Bag										87.7
Ankle boot										

Table 102. FashionMNIST Dataset - Performance classifier for task (Bag, Ankle boot)

	T-shirt/top	Trouser	Pullover	Dress	Coat	Sandal	Shirt	Sneaker	Bag	Ankle boot
T-shirt/top		56.3	49.95	51.5	49.9	87.7	49.85	93.8	49.95	99.65
Trouser			56.35	54.8	56.4	81.4	56.45	87.5	56.35	93.35
Pullover				51.55	50.05	87.75	50.1	93.85	50.0	99.7
Dress					51.6	86.2	51.65	92.3	51.55	98.15
Coat						87.8	50.05	93.9	50.05	99.75
Sandal							87.85	56.1	87.75	61.95
Shirt								93.95	50.1	99.8
Sneaker									93.85	55.85
Bag										99.7
Ankle boot										

Table 103. CIFAR10 Dataset - Performance classifier for task (airplane, automobile)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		99.0	53.7	59.25	53.85	59.5	64.5	53.75	57.0	85.2
automobile			95.3	89.75	95.15	89.5	84.5	95.25	92.0	63.8
bird				55.55	50.15	55.8	60.8	50.05	53.3	81.5
cat					55.4	50.25	55.25	55.5	52.25	75.95
deer						55.65	60.65	50.1	53.15	81.35
dog							55.0	55.75	52.5	75.7
frog								60.75	57.5	70.7
horse									53.25	81.45
ship										78.2
truck										

Table 104. CIFAR10 Dataset - Performance classifier for task (airplane, bird)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		56.3	94.75	86.25	91.95	89.8	92.8	83.6	52.95	55.6
automobile			88.45	79.95	85.65	83.5	86.5	77.3	53.35	50.7
bird				58.5	52.8	54.95	51.95	61.15	91.8	89.15
cat					55.7	53.55	56.55	52.65	83.3	80.65
deer						52.15	50.85	58.35	89.0	86.35
dog							53.0	56.2	86.85	84.2
frog								59.2	89.85	87.2
horse									80.65	78.0
ship										52.65
truck										

Table 105. CIFAR10 Dataset - Performance classifier for task (airplane, cat)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		56.05	84.8	96.8	90.5	96.9	94.3	83.0	55.05	60.65
automobile			78.75	90.75	84.45	90.85	88.25	76.95	51.0	54.6
bird				62.0	55.7	62.1	59.5	51.8	79.75	74.15
cat					56.3	50.1	52.5	63.8	91.75	86.15
deer						56.4	53.8	57.5	85.45	79.85
dog							52.6	63.9	91.85	86.25
frog								61.3	89.25	83.65
horse									77.95	72.35
ship										55.6
truck										

Table 106. CIFAR10 Dataset - Performance classifier for task (airplane, deer)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		54.45	77.75	82.3	97.4	83.05	88.8	86.95	52.45	56.0
automobile			73.3	77.85	92.95	78.6	84.35	82.5	52.0	51.55
bird				54.55	69.65	55.3	61.05	59.2	75.3	71.75
cat					65.1	50.75	56.5	54.65	79.85	76.3
deer						64.35	58.6	60.45	94.95	91.4
dog							55.75	53.9	80.6	77.05
frog								51.85	86.35	82.8
horse									84.5	80.95
ship										53.55
truck										

Table 107. CIFAR10 Dataset - Performance classifier for task (airplane, dog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		63.6	85.1	95.15	90.65	97.45	92.4	93.0	54.05	68.05
automobile			71.5	81.55	77.05	83.85	78.8	79.4	59.55	54.45
bird				60.05	55.55	62.35	57.3	57.9	81.05	67.05
cat					54.5	52.3	52.75	52.15	91.1	77.1
deer						56.8	51.75	52.35	86.6	72.6
dog							55.05	54.45	93.4	79.4
frog								50.6	88.35	74.35
horse									88.95	74.95
ship										64.0
truck										

Table 108. CIFAR10 Dataset - Performance classifier for task (airplane, frog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		60.4	80.65	87.7	85.1	87.85	98.4	71.7	54.5	62.45
automobile			70.25	77.3	74.7	77.45	88.0	61.3	55.9	52.05
bird				57.05	54.45	57.2	67.75	58.95	76.15	68.2
cat					52.6	50.15	60.7	66.0	83.2	75.25
deer						52.75	63.3	63.4	80.6	72.65
dog							60.55	66.15	83.35	75.4
frog								76.7	93.9	85.95
horse									67.2	59.25
ship										57.95
truck										

Table 109. CIFAR10 Dataset - Performance classifier for task (airplane, horse)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		53.8	75.9	83.95	87.35	91.65	78.7	98.05	52.6	56.6
automobile			72.1	80.15	83.55	87.85	74.9	94.25	51.2	52.8
bird				58.05	61.45	65.75	52.8	72.15	73.3	69.3
cat					53.4	57.7	55.25	64.1	81.35	77.35
deer						54.3	58.65	60.7	84.75	80.75
dog							62.95	56.4	89.05	85.05
frog								69.35	76.1	72.1
horse									95.45	91.45
ship										54.0
truck										

Table 110. CIFAR10 Dataset - Performance classifier for task (airplane, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		74.4	54.2	61.6	54.45	59.15	61.45	50.75	96.15	70.0
automobile			70.2	62.8	69.95	65.25	62.95	73.65	71.75	54.4
bird				57.4	50.25	54.95	57.25	53.45	91.95	65.8
cat					57.15	52.45	50.15	60.85	84.55	58.4
deer						54.7	57.0	53.7	91.7	65.55
dog							52.3	58.4	87.0	60.85
frog								60.7	84.7	58.55
horse									95.4	69.25
ship										76.15
truck										

Table 111. CIFAR10 Dataset - Performance classifier for task (airplane, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		91.55	53.95	62.25	56.9	64.2	69.35	61.05	60.3	97.0
automobile			87.6	79.3	84.65	77.35	72.2	80.5	81.25	55.45
bird				58.3	52.95	60.25	65.4	57.1	56.35	93.05
cat					55.35	51.95	57.1	51.2	51.95	84.75
deer						57.3	62.45	54.15	53.4	90.1
dog							55.15	53.15	53.9	82.8
frog								58.3	59.05	77.65
horse									50.75	85.95
ship										86.7
truck										

Table 112. CIFAR10 Dataset - Performance classifier for task (automobile, bird)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		37.9	87.1	84.4	86.25	86.65	85.5	82.85	64.85	42.7
automobile			99.2	96.5	98.35	98.75	97.6	94.95	76.95	54.8
bird				52.7	50.85	50.45	51.6	54.25	72.25	94.4
cat					51.85	52.25	51.1	51.55	69.55	91.7
deer						50.4	50.75	53.4	71.4	93.55
dog							51.15	53.8	71.8	93.95
frog								52.65	70.65	92.8
horse									68.0	90.15
ship										72.15
truck										

Table 113. CIFAR10 Dataset - Performance classifier for task (automobile, cat)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		27.65	74.35	76.3	74.05	76.55	74.95	69.45	47.4	33.65
automobile			96.7	98.65	96.4	98.9	97.3	91.8	69.75	56.0
bird				51.95	50.3	52.2	50.6	54.9	76.95	90.7
cat					52.25	50.25	51.35	56.85	78.9	92.65
deer						52.5	50.9	54.6	76.65	90.4
dog							51.6	57.1	79.15	92.9
frog								55.5	77.55	91.3
horse									72.05	85.8
ship										63.75
truck										

Table 114. CIFAR10 Dataset - Performance classifier for task (automobile, deer)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		36.85	84.4	83.2	86.4	83.95	83.8	85.4	59.85	42.9
automobile			97.55	96.35	99.55	97.1	96.95	98.55	73.0	56.05
bird				51.2	52.0	50.45	50.6	51.0	74.55	91.5
cat					53.2	50.75	50.6	52.2	73.35	90.3
deer						52.45	52.6	51.0	76.55	93.5
dog							50.15	51.45	74.1	91.05
frog								51.6	73.95	90.9
horse									75.55	92.5
ship										66.95
truck										

Table 115. CIFAR10 Dataset - Performance classifier for task (automobile, dog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		27.0	73.5	74.6	74.3	75.65	72.95	73.9	38.65	32.25
automobile			96.5	97.6	97.3	98.65	95.95	96.9	61.65	55.25
bird				51.1	50.8	52.15	50.55	50.4	84.85	91.25
cat					50.3	51.05	51.65	50.7	85.95	92.35
deer						51.35	51.35	50.4	85.65	92.05
dog							52.7	51.75	87.0	93.4
frog								50.95	84.3	90.7
horse									85.25	91.65
ship										56.4
truck										

Table 116. CIFAR10 Dataset - Performance classifier for task (automobile, frog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		38.9	80.75	80.3	82.2	79.3	88.3	66.7	46.3	42.05
automobile			91.85	91.4	93.3	90.4	99.4	77.8	57.4	53.15
bird				50.45	51.45	51.45	57.55	64.05	84.45	88.7
cat					51.9	51.0	58.0	63.6	84.0	88.25
deer						52.9	56.1	65.5	85.9	90.15
dog							59.0	62.6	83.0	87.25
frog								71.6	92.0	96.25
horse									70.4	74.65
ship										54.25
truck										

Table 117. CIFAR10 Dataset - Performance classifier for task (automobile, horse)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		28.75	75.15	74.5	77.15	76.55	71.05	78.0	42.75	36.45
automobile			96.4	95.75	98.4	97.8	92.3	99.25	64.0	57.7
bird				50.65	52.0	51.4	54.1	52.85	82.4	88.7
cat					52.65	52.05	53.45	53.5	81.75	88.05
deer						50.6	56.1	50.85	84.4	90.7
dog							55.5	51.45	83.8	90.1
frog								56.95	78.3	84.6
horse									85.25	91.55
ship										56.3
truck										

Table 118. CIFAR10 Dataset - Performance classifier for task (automobile, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		40.5	74.55	70.35	70.0	67.1	61.05	55.75	88.75	48.7
automobile			84.05	79.85	79.5	76.6	70.55	65.25	98.25	58.2
bird				54.2	54.55	57.45	63.5	68.8	64.2	75.85
cat					50.35	53.25	59.3	64.6	68.4	71.65
deer						52.9	58.95	64.25	68.75	71.3
dog							56.05	61.35	71.65	68.4
frog								55.3	77.7	62.35
horse									83.0	57.05
ship										90.05
truck										

Table 119. CIFAR10 Dataset - Performance classifier for task (automobile, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		42.65	78.05	78.45	78.75	79.65	74.65	80.65	74.55	88.0
automobile			85.4	85.8	86.1	87.0	82.0	88.0	81.9	95.35
bird				50.4	50.7	51.6	53.4	52.6	53.5	59.95
cat					50.3	51.2	53.8	52.2	53.9	59.55
deer						50.9	54.1	51.9	54.2	59.25
dog							55.0	51.0	55.1	58.35
frog								56.0	50.1	63.35
horse									56.1	57.35
ship										63.45
truck										

Table 120. CIFAR10 Dataset - Performance classifier for task (bird, cat)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		69.25	41.95	84.15	62.2	80.0	72.1	65.15	58.55	72.6
automobile			77.3	64.9	57.05	60.75	52.85	54.1	60.7	53.35
bird				92.2	70.25	88.05	80.15	73.2	66.6	80.65
cat					71.95	54.15	62.05	69.0	75.6	61.55
deer						67.8	59.9	52.95	53.65	60.4
dog							57.9	64.85	71.45	57.4
frog								56.95	63.55	50.5
horse									56.6	57.45
ship										64.05
truck										

Table 121. CIFAR10 Dataset - Performance classifier for task (bird, deer)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		56.65	42.0	63.4	86.05	58.25	65.85	75.25	57.4	61.4
automobile			64.65	56.75	79.4	51.6	59.2	68.6	50.75	54.75
bird				71.4	94.05	66.25	73.85	83.25	65.4	69.4
cat					72.65	55.15	52.45	61.85	56.0	52.0
deer						77.8	70.2	60.8	78.65	74.65
dog							57.6	67.0	50.85	53.15
frog								59.4	58.45	54.45
horse									67.85	63.85
ship										54.0
truck										

Table 122. CIFAR10 Dataset - Performance classifier for task (bird, dog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		57.05	48.15	75.6	60.9	92.2	52.65	77.6	50.75	64.6
automobile			58.9	68.55	53.85	85.15	54.4	70.55	56.3	57.55
bird				77.45	62.75	94.05	54.5	79.45	52.6	66.45
cat					64.7	66.6	72.95	52.0	74.85	61.0
deer						81.3	58.25	66.7	60.15	53.7
dog							89.55	64.6	91.45	77.6
frog								74.95	51.9	61.95
horse									76.85	63.0
ship										63.85
truck										

Table 123. CIFAR10 Dataset - Performance classifier for task (bird, frog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		72.95	48.65	69.45	60.05	60.35	94.25	55.2	55.6	69.4
automobile			74.3	53.5	62.9	62.6	71.3	67.75	67.35	53.55
bird				70.8	61.4	61.7	95.6	56.55	56.95	70.75
cat					59.4	59.1	74.8	64.25	63.85	50.05
deer						50.3	84.2	54.85	54.45	59.35
dog							83.9	55.15	54.75	59.05
frog								89.05	88.65	74.85
horse									50.4	64.2
ship										63.8
truck										

Table 124. CIFAR10 Dataset - Performance classifier for task (bird, horse)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		62.45	44.55	57.55	62.25	62.8	47.6	90.4	49.2	72.55
automobile			67.9	54.9	50.2	50.35	64.85	77.95	63.25	60.1
bird				63.0	67.7	68.25	53.05	95.85	54.65	78.0
cat					54.7	55.25	59.95	82.85	58.35	65.0
deer						50.55	64.65	78.15	63.05	60.3
dog							65.2	77.6	63.6	59.75
frog								92.8	51.6	74.95
horse									91.2	67.85
ship										73.35
truck										

Table 125. CIFAR10 Dataset - Performance classifier for task (bird, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		65.8	27.3	30.9	28.35	28.95	28.65	28.75	75.1	63.5
automobile			88.5	84.9	87.45	86.85	87.15	87.05	59.3	52.3
bird				53.6	51.05	51.65	51.35	51.45	97.8	86.2
cat					52.55	51.95	52.25	52.15	94.2	82.6
deer						50.6	50.3	50.4	96.75	85.15
dog							50.3	50.2	96.15	84.55
frog								50.1	96.45	84.85
horse									96.35	84.75
ship										61.6
truck										

Table 126. CIFAR10 Dataset - Performance classifier for task (bird, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		76.8	30.25	36.65	31.3	32.45	33.2	37.1	62.35	78.7
automobile			96.55	90.15	95.5	94.35	93.6	89.7	64.45	51.9
bird				56.4	51.05	52.2	52.95	56.85	82.1	98.45
cat					55.35	54.2	53.45	50.45	75.7	92.05
deer						51.15	51.9	55.8	81.05	97.4
dog							50.75	54.65	79.9	96.25
frog								53.9	79.15	95.5
horse									75.25	91.6
ship										66.35
truck										

Table 127. CIFAR10 Dataset - Performance classifier for task (cat, deer)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		50.7	56.0	35.65	78.85	37.5	52.35	67.2	52.85	48.7
automobile			55.3	65.05	78.15	63.2	51.65	66.5	52.15	52.0
bird				70.35	72.85	68.5	53.65	61.2	53.15	57.3
cat					93.2	51.85	66.7	81.55	67.2	63.05
deer						91.35	76.5	61.65	76.0	80.15
dog							64.85	79.7	65.35	61.2
frog								64.85	50.5	53.65
horse									64.35	68.5
ship										54.15
truck										

Table 128. CIFAR10 Dataset - Performance classifier for task (cat, dog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		60.35	61.6	50.7	67.7	86.6	54.4	78.95	49.9	64.9
automobile			51.25	59.65	57.35	76.25	55.95	68.6	60.45	54.55
bird				60.9	56.1	75.0	57.2	67.35	61.7	53.3
cat					67.0	85.9	53.7	78.25	50.8	64.2
deer						68.9	63.3	61.25	67.8	52.8
dog							82.2	57.65	86.7	71.7
frog								74.55	54.5	60.5
horse									79.05	64.05
ship										65.0
truck										

Table 129. CIFAR10 Dataset - Performance classifier for task (cat, frog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		66.3	60.05	42.05	51.65	42.65	87.2	44.05	54.85	54.1
automobile			56.25	74.25	64.65	73.65	70.9	72.25	61.45	62.2
bird				68.0	58.4	67.4	77.15	66.0	55.2	55.95
cat					59.6	50.6	95.15	52.0	62.8	62.05
deer						59.0	85.55	57.6	53.2	52.45
dog							94.55	51.4	62.2	61.45
frog								93.15	82.35	83.1
horse									60.8	60.05
ship										50.75
truck										

Table 130. CIFAR10 Dataset - Performance classifier for task (cat, horse)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		54.55	47.0	43.4	52.7	45.55	43.2	86.95	48.3	55.1
automobile			57.55	61.15	51.85	59.0	61.35	82.4	56.25	50.55
bird				53.6	55.7	51.45	53.8	89.95	51.3	58.1
cat					59.3	52.15	50.2	93.55	54.9	61.7
deer						57.15	59.5	84.25	54.4	52.4
dog							52.35	91.4	52.75	59.55
frog								93.75	55.1	61.9
horse									88.65	81.85
ship										56.8
truck										

Table 131. CIFAR10 Dataset - Performance classifier for task (cat, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		65.8	33.25	30.15	31.45	30.15	30.55	31.4	77.0	61.1
automobile			82.55	85.65	84.35	85.65	85.25	84.4	61.2	54.7
bird				53.1	51.8	53.1	52.7	51.85	93.75	77.85
cat					51.3	50.0	50.4	51.25	96.85	80.95
deer						51.3	50.9	50.05	95.55	79.65
dog							50.4	51.25	96.85	80.95
frog								50.85	96.45	80.55
horse									95.6	79.7
ship										65.9
truck										

Table 132. CIFAR10 Dataset - Performance classifier for task (cat, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		75.1	34.25	29.5	34.3	29.4	33.05	44.3	67.35	76.7
automobile			90.85	95.6	90.8	95.7	92.05	80.8	57.75	51.6
bird				54.75	50.05	54.85	51.2	60.05	83.1	92.45
cat					54.8	50.1	53.55	64.8	87.85	97.2
deer						54.9	51.25	60.0	83.05	92.4
dog							53.65	64.9	87.95	97.3
frog								61.25	84.3	93.65
horse									73.05	82.4
ship										59.35
truck										

Table 133. CIFAR10 Dataset - Performance classifier for task (deer, dog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		67.25	61.9	74.8	40.55	86.3	54.6	61.1	50.75	70.5
automobile			55.35	57.55	76.7	69.05	62.65	56.15	66.5	53.25
bird				62.9	71.35	74.4	57.3	50.8	61.15	58.6
cat					84.25	61.5	70.2	63.7	74.05	54.3
deer						95.75	64.05	70.55	60.2	79.95
dog							81.7	75.2	85.55	65.8
frog								56.5	53.85	65.9
horse									60.35	59.4
ship										69.75
truck										

Table 134. CIFAR10 Dataset - Performance classifier for task (deer, frog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		69.4	57.95	59.0	34.9	54.25	81.35	39.3	57.85	61.65
automobile			61.45	60.4	84.5	65.15	61.95	80.1	61.55	57.75
bird				51.05	73.05	53.7	73.4	68.65	50.1	53.7
cat					74.1	54.75	72.35	69.7	51.15	52.65
deer						69.35	96.45	54.4	72.95	76.75
dog							77.1	64.95	53.6	57.4
frog								92.05	73.5	69.7
horse									68.55	72.35
ship										53.8
truck										

Table 135. CIFAR10 Dataset - Performance classifier for task (deer, horse)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		71.35	52.7	56.25	36.1	67.2	40.7	82.1	51.6	73.65
automobile			68.65	65.1	85.25	54.15	80.65	60.75	69.75	52.3
bird				53.55	66.6	64.5	62.0	79.4	51.1	70.95
cat					70.15	60.95	65.55	75.85	54.65	67.4
deer						81.1	54.6	96.0	65.5	87.55
dog							76.5	64.9	65.6	56.45
frog								91.4	60.9	82.95
horse									80.5	58.45
ship										72.05
truck										

Table 136. CIFAR10 Dataset - Performance classifier for task (deer, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		65.95	32.95	34.25	27.15	35.3	32.4	29.05	75.5	61.95
automobile			83.0	81.7	88.8	80.65	83.55	86.9	59.55	54.0
bird				51.3	55.8	52.35	50.55	53.9	92.55	79.0
cat					57.1	51.05	51.85	55.2	91.25	77.7
deer						58.15	55.25	51.9	98.35	84.8
dog							52.9	56.25	90.2	76.65
frog								53.35	93.1	79.55
horse									96.45	82.9
ship										63.55
truck										

Table 137. CIFAR10 Dataset - Performance classifier for task (deer, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		78.95	36.1	37.3	31.65	37.65	36.9	35.15	65.45	80.85
automobile			92.85	91.65	97.3	91.3	92.05	93.8	63.5	51.9
bird				51.2	54.45	51.55	50.8	50.95	79.35	94.75
cat					55.65	50.35	50.4	52.15	78.15	93.55
deer						56.0	55.25	53.5	83.8	99.2
dog							50.75	52.5	77.8	93.2
frog								51.75	78.55	93.95
horse									80.3	95.7
ship										65.4
truck										

Table 138. CIFAR10 Dataset - Performance classifier for task (dog, frog)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		56.2	56.3	45.85	50.1	31.45	77.85	34.5	58.2	48.55
automobile			50.1	60.35	56.1	74.75	71.65	71.7	52.0	57.65
bird				60.45	56.2	74.85	71.55	71.8	51.9	57.75
cat					54.25	64.4	82.0	61.35	62.35	52.7
deer						68.65	77.75	65.6	58.1	51.55
dog							96.4	53.05	76.75	67.1
frog								93.35	69.65	79.3
horse									73.7	64.05
ship										59.65
truck										

Table 139. CIFAR10 Dataset - Performance classifier for task (dog, horse)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		52.55	42.65	33.55	50.25	28.7	38.25	73.9	50.7	59.55
automobile			59.9	69.0	52.3	73.85	64.3	71.35	51.85	57.0
bird				59.1	57.6	63.95	54.4	81.25	58.05	66.9
cat					66.7	54.85	54.7	90.35	67.15	76.0
deer						71.55	62.0	73.65	50.45	59.3
dog							59.55	95.2	72.0	80.85
frog								85.65	62.45	71.3
horse									73.2	64.35
ship										58.85
truck										

Table 140. CIFAR10 Dataset - Performance classifier for task (dog, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		87.1	49.45	46.55	47.55	42.25	48.2	45.8	90.95	85.05
automobile			87.65	90.55	89.55	94.85	88.9	91.3	53.85	52.05
bird				52.9	51.9	57.2	51.25	53.65	91.5	85.6
cat					51.0	54.3	51.65	50.75	94.4	88.5
deer						55.3	50.65	51.75	93.4	87.5
dog							55.95	53.55	98.7	92.8
frog								52.4	92.75	86.85
horse									95.15	89.25
ship										55.9
truck										

Table 141. CIFAR10 Dataset - Performance classifier for task (dog, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		81.9	41.05	39.75	40.75	35.3	45.55	46.2	79.1	83.3
automobile			90.85	92.15	91.15	96.6	86.35	85.7	52.8	51.4
bird				51.3	50.3	55.75	54.5	55.15	88.05	92.25
cat					51.0	54.45	55.8	56.45	89.35	93.55
deer						55.45	54.8	55.45	88.35	92.55
dog							60.25	60.9	93.8	98.0
frog								50.65	83.55	87.75
horse									82.9	87.1
ship										54.2
truck										

Table 142. CIFAR10 Dataset - Performance classifier for task (frog, horse)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		45.55	46.65	46.1	52.6	54.2	35.15	81.6	43.95	57.95
automobile			51.1	50.55	57.05	58.65	60.4	86.05	51.6	62.4
bird				50.55	55.95	57.55	61.5	84.95	52.7	61.3
cat					56.5	58.1	60.95	85.5	52.15	61.85
deer						51.6	67.45	79.0	58.65	55.35
dog							69.05	77.4	60.25	53.75
frog								96.45	58.8	72.8
horse									87.65	73.65
ship										64.0
truck										

Table 143. CIFAR10 Dataset - Performance classifier for task (frog, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		86.3	52.85	53.35	49.95	53.65	42.35	59.4	90.9	83.95
automobile			83.45	82.95	86.35	82.65	93.95	76.9	54.6	52.35
bird				50.5	52.9	50.8	60.5	56.55	88.05	81.1
cat					53.4	50.3	61.0	56.05	87.55	80.6
deer						53.7	57.6	59.45	90.95	84.0
dog							61.3	55.75	87.25	80.3
frog								67.05	98.55	91.6
horse									81.5	74.55
ship										56.95
truck										

Table 144. CIFAR10 Dataset - Performance classifier for task (frog, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		78.4	41.6	44.5	43.8	48.05	31.5	67.7	73.0	80.3
automobile			86.8	83.9	84.6	80.35	96.9	60.7	55.4	51.9
bird				52.9	52.2	56.45	60.1	76.1	81.4	88.7
cat					50.7	53.55	63.0	73.2	78.5	85.8
deer						54.25	62.3	73.9	79.2	86.5
dog							66.55	69.65	74.95	82.25
frog								86.2	91.5	98.8
horse									55.3	62.6
ship										57.3
truck										

Table 145. CIFAR10 Dataset - Performance classifier for task (horse, ship)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		86.6	54.4	54.0	46.25	48.1	57.5	42.05	90.25	80.25
automobile			82.2	82.6	90.35	88.5	79.1	94.55	53.65	56.35
bird				50.4	58.15	56.3	53.1	62.35	85.85	75.85
cat					57.75	55.9	53.5	61.95	86.25	76.25
deer						51.85	61.25	54.2	94.0	84.0
dog							59.4	56.05	92.15	82.15
frog								65.45	82.75	72.75
horse									98.2	88.2
ship										60.0
truck										

Table 146. CIFAR10 Dataset - Performance classifier for task (horse, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		73.05	31.85	32.4	29.7	29.4	37.95	28.1	67.3	76.3
automobile			91.2	90.65	93.35	93.65	85.1	94.95	55.75	53.25
bird				50.55	52.15	52.45	56.1	53.75	85.45	94.45
cat					52.7	53.0	55.55	54.3	84.9	93.9
deer						50.3	58.25	51.6	87.6	96.6
dog							58.55	51.3	87.9	96.9
frog								59.85	79.35	88.35
horse									89.2	98.2
ship										59.0
truck										

Table 147. CIFAR10 Dataset - Performance classifier for task (ship, truck)

	airplane	automobile	bird	cat	deer	dog	frog	horse	ship	truck
airplane		80.65	56.85	62.1	62.65	65.4	65.35	77.8	39.7	87.45
automobile			73.8	68.55	68.0	65.25	65.3	52.85	90.95	56.8
bird				55.25	55.8	58.55	58.5	70.95	67.15	80.6
cat					50.55	53.3	53.25	65.7	72.4	75.35
deer						52.75	52.7	65.15	72.95	74.8
dog							50.05	62.4	75.7	72.05
frog								62.45	75.65	72.1
horse									88.1	59.65
ship										97.75
truck										

References

Bianchini, M. and Scarselli, F. On the complexity of neural network classifiers: A comparison between shallow and deep architectures. *IEEE Trans. Neural Netw. Learn. Syst.*, 25(8):1553–1565, August 2014.

Carlsson, G. Topology and data. *Bull. Amer. Math. Soc.*, 46 (2):255–308, April 2009.

Guss, W. H. and Salakhutdinov, R. On characterizing the capacity of neural networks using algebraic topology. arXiv:1802.04443, 2018.

Varshney, K. R. and Ramamurthy, K. N. Persistent topology of decision boundaries. In *Proc. IEEE Int. Conf. Acoust. Speech Signal Process.*, pp. 3931–3935, Brisbane, Australia, April 2015.