$$\frac{dE}{dv} = \frac{dE}{dy^t} \cdot \frac{dy^t}{dv}$$

$$\frac{dE}{dy^t} = -\sum_{t=1}^{N} \frac{r^t}{y^t} + \frac{(1-r^t)}{(1-y^t)} = -\sum_{t=1}^{N} \frac{r^t - y^t}{y^t(1-y^t)}$$

$$y = \frac{1}{1 + \exp(-\sum_{h=1}^{H+1} v_h z_h^t + v_0)}$$

$$\frac{dy^t}{dv} = y^t(1-y^t) \cdot \sum_{h=1}^{H+1} z_h^t$$

$$\Delta v = -\eta \frac{dE}{dv} = -\eta \frac{dE}{dy^t} \cdot \frac{dy^t}{dv} = \eta \sum_{t=1}^{N} \frac{r^t - y^t}{y^t(1-y^t)} \cdot y^t(1-y^t) \cdot \sum_{h=1}^{H+1} z_h^t$$

$$\frac{dE}{dw_{hj}} = \frac{dE}{dy^t} \cdot \frac{dy^t}{dz^t} \cdot \frac{dz^t}{dw_{hj}}$$

$$\frac{dE}{dy^t} = -\sum_{t=1}^{N} \frac{r^t - y^t}{y^t(1-y^t)}$$

$$\frac{dy^t}{dz^t} = y^t(1-y^t) \cdot \sum_{h=1}^{H+1} v_h$$

$$\frac{dz^t}{dw_h} = \begin{cases} w_h^T x^t + w_{h0} & \text{if } w_h^T x^t + w_{h0} > 0 \\ 0 & \text{otherwise} \end{cases} =$$

$$= \frac{\max(0, w_h^t x^t)}{w_h^t}$$

$$\Delta w_h = -\eta \sum_{t=1}^{N} \frac{r^t - y^t}{y^t(1-y^t)} \cdot y^{t} \cdot \sum_{h=1}^{H} t_h \cdot \frac{\max(0, w_h^t x^t)}{w_h^t}$$

$\sqrt{2}$

a) Figure 2:

$x_0 = -1$

$x_1 + 1 = 0$ $\quad y = S(x+1)$

$w_0 = 1, w_1 = 1, w_2 = 0$

Figure 3:

$x_1 + x_2 = -1$

$x_1 + x_2 + 1 = 0$

$y = S(-x_1 - x_2 - 1)$

$w_0 = -1 \quad w_1 = -1 \quad w_2 = -1$

b) $z_1 = S(-x_1 - x_2 - 1)$

$z_2 = S(x+1)$

AND $y = S(z_1 + z_2 - 1.5)$

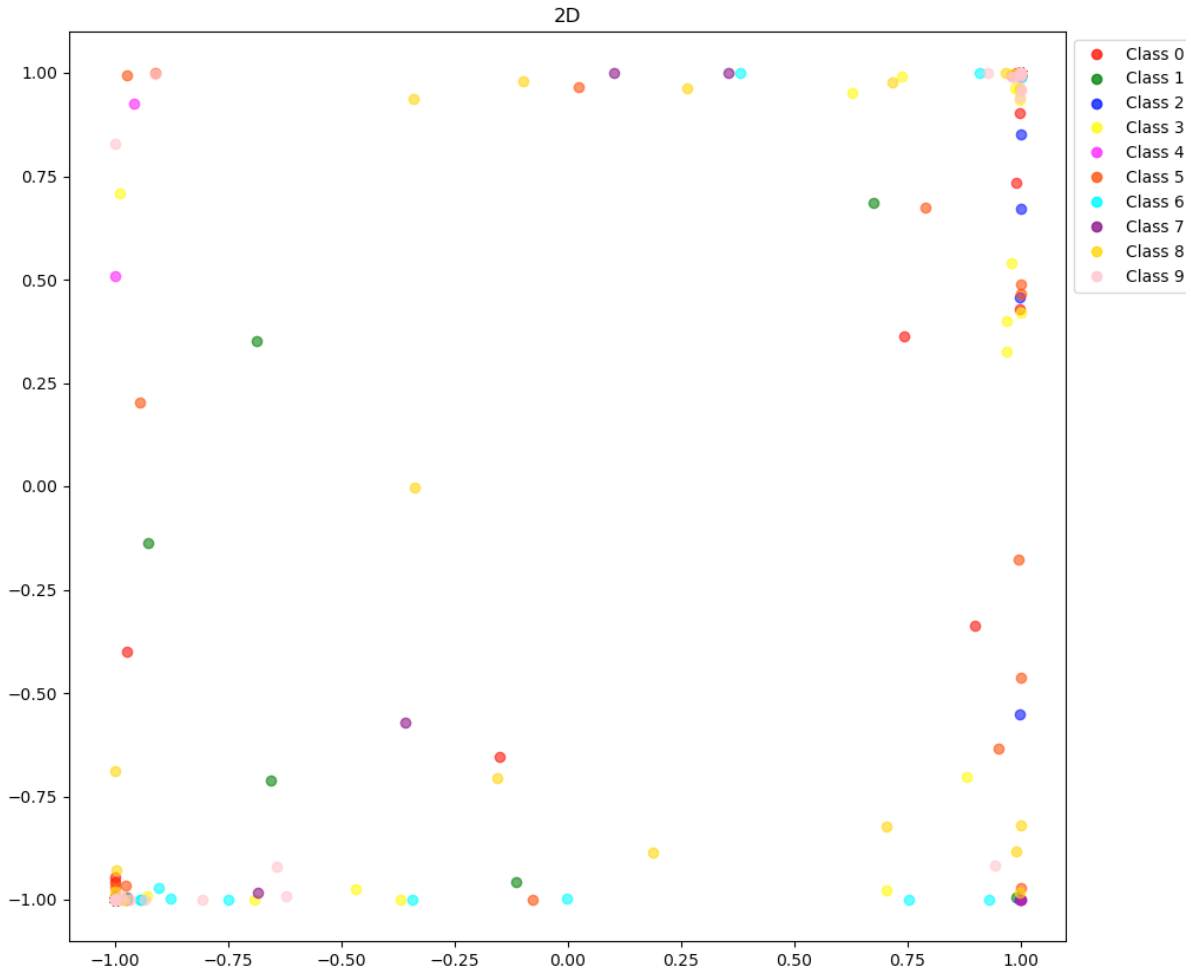
$v_0 = -1.5 \quad v_1 = 1 \quad v_2 = 1$

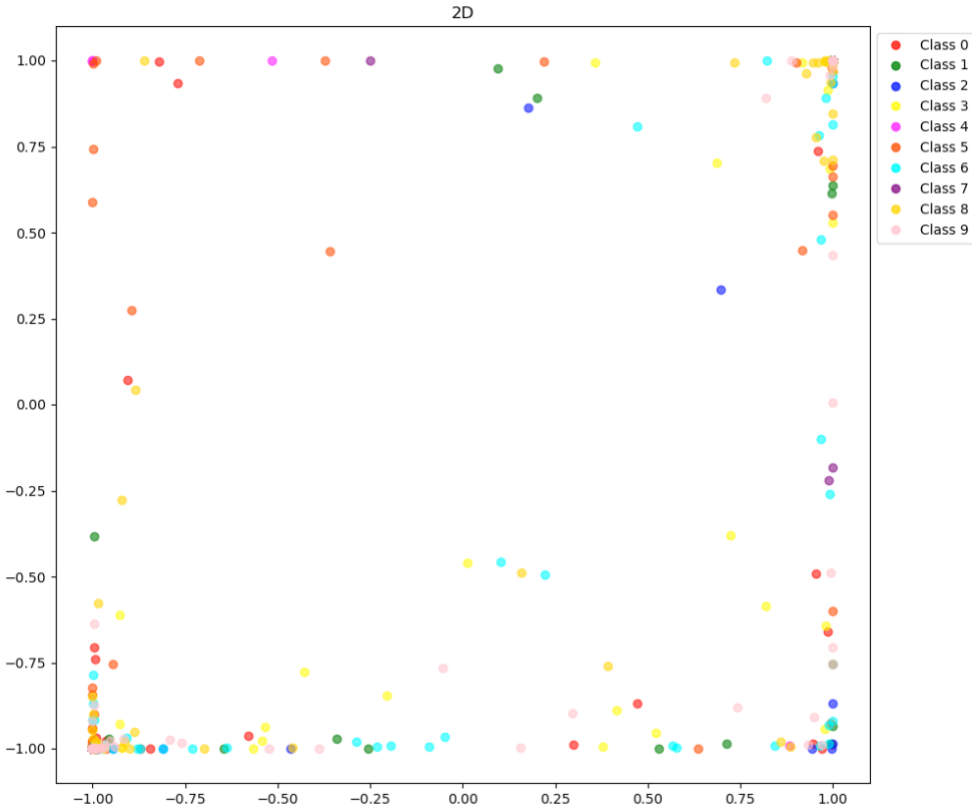
$W = \begin{bmatrix} -1 & -1 & -1 \\ 1 & 1 & 0 \end{bmatrix}^T$

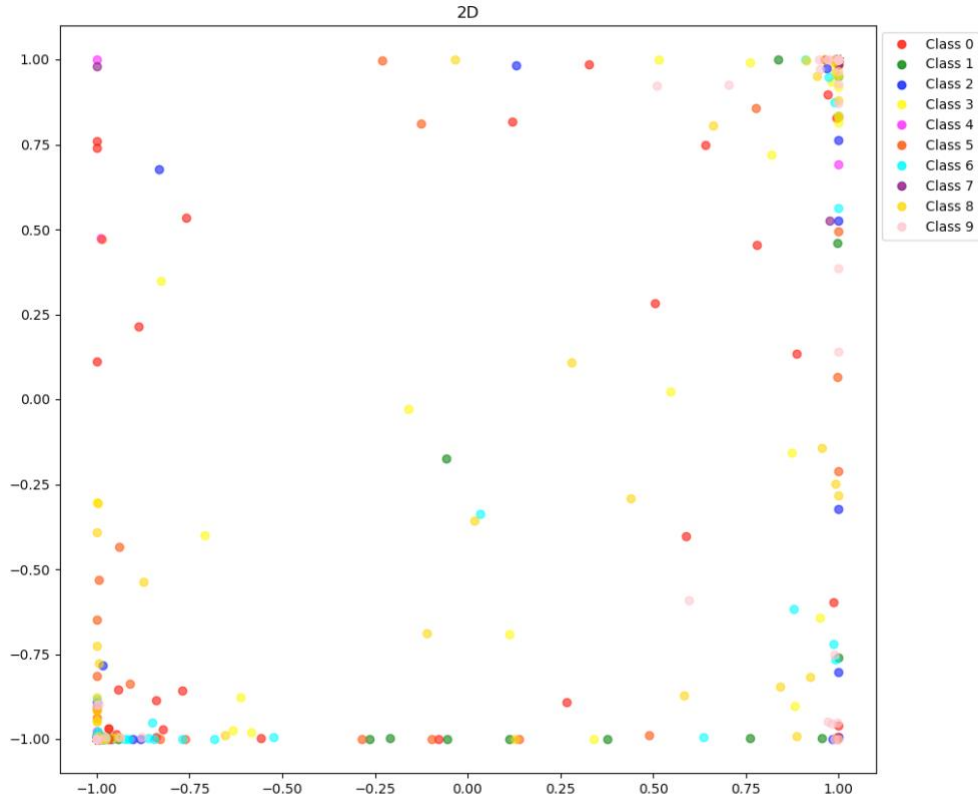
A

```
Validation accuracy for 4 hidden units is 0.174
Validation accuracy for 8 hidden units is 0.244
Validation accuracy for 16 hidden units is 0.301
Validation accuracy for 20 hidden units is 0.322
Validation accuracy for 24 hidden units is 0.278
Test accuracy with 20 hidden units is 0.109
```

B




2D
Class 0
Class 1
Class 2
Class 3
Class 4
Class 5
Class 6
Class 7
Class 8
Class 9
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00


2D
Class 0
Class 1
Class 2
Class 3
Class 4
Class 5
Class 6
Class 7
Class 8
Class 9
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.00
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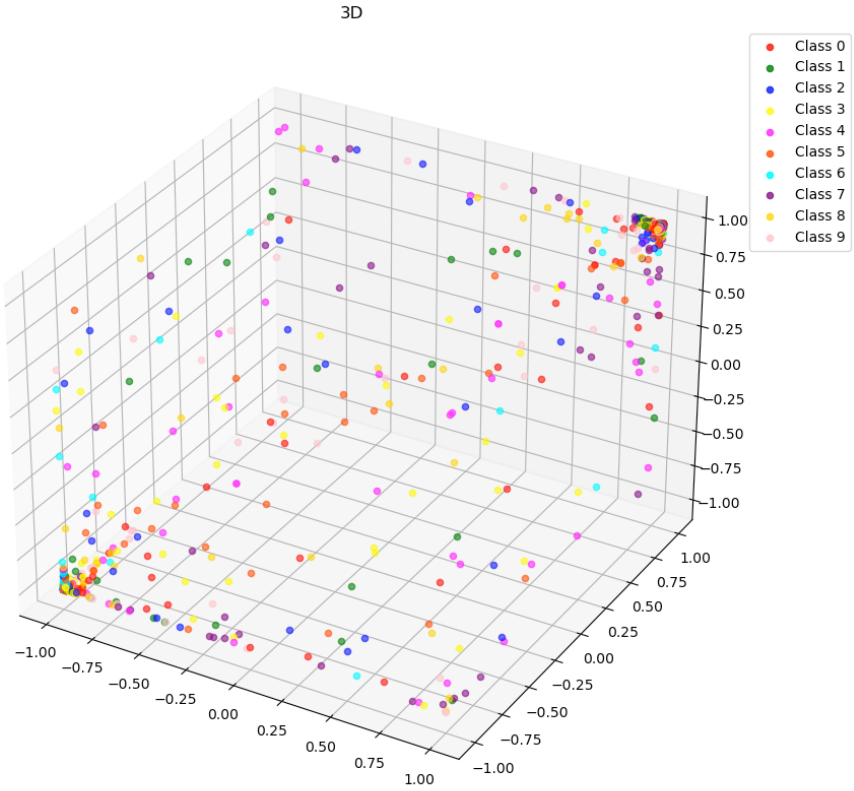
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00

C


3D
Class 0
Class 1
Class 2
Class 3
Class 4
Class 5
Class 6
Class 7
Class 8
Class 9
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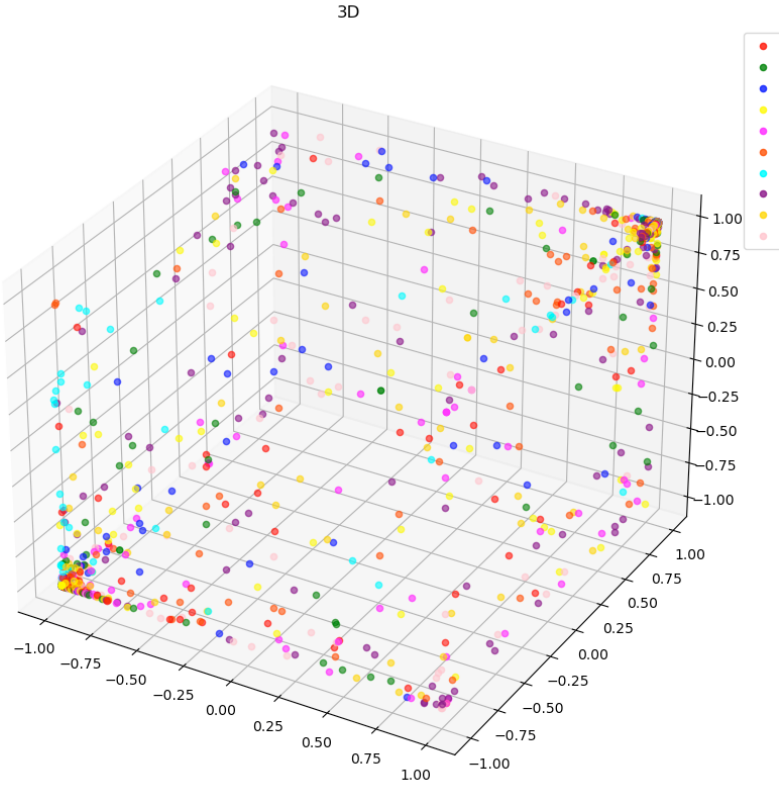
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00


3D
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−0.75
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−0.25
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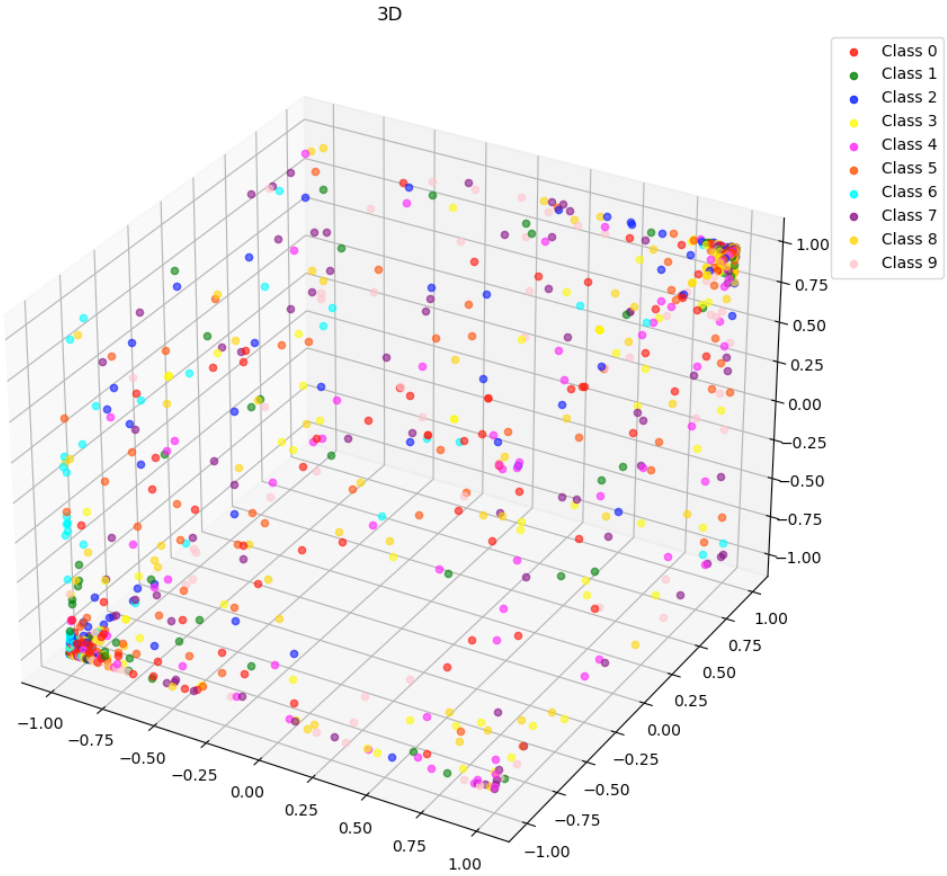
0.25
0.50
0.75
1.00


3D
Class 0
Class 1
Class 2
Class 3
Class 4
Class 5
Class 6
Class 7
Class 8
Class 9
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00