TUTORIAL OF WEEK 11

INT301 Bio-computation, Week 11, 2025

Example of Simple Competitive Learning

- **We are given 6 data samples:**

```
[0 1 1]       [1 1 0.5]       [0.2 0.2 0.2]
[0.5 0.5 0.5] [0.4 0.6 0.5]   [0 0 0]
```

- **3 ouput units each associated with a prototype vector.**
- **Learning rate: 0.5**
- **You are required to update the prototype vectors using Simple Competitive Learning (SCL) according to such upadating rule:**

$$\Delta w_{ji} = \eta y_j \left(x_i - w_{ji} \right)$$

$$\begin{cases} y_{j^*} = 1 \\ y_j = 0 \qquad if \qquad j \neq j^* \end{cases}$$

Example of Simple Competitive Learning

- **Question 1: The 3 prototype vectors are randomly initialized as:**

[0.14 0.75 0.71] [0.99 0.51 0.37] [0.73 0.81 0.87]

and the winner units are determined by minimizing the Euclidean distance. Please upadate the vectors one epoch and list the clustering result.

$$\Delta w_{ji} = \eta y_j \left(x_i - w_{ji} \right)$$

$$\begin{cases} y_{j^*} = 1 \\ y_j = 0 \quad if \quad j \neq j^* \end{cases}$$

Training on Input Vectors

Input vector # 1: [0.00 1.00 1.00]

Computing the distance beween Input vector to each prototype vector:

[0.14 0.75 0.71] [0.99 0.51 0.37] [0.73 0.81 0.87]

↓ 0.1662 ↓ 1.6171 ↓ 0.5859

Winning weight vector # 1: [0.14 0.75 0.71]

Updated winning weight vector:

[0.14 0.75 0.71]+0.5*([0.00 1.00 1.00]-[0.14 0.75 0.71])

[0.07 0.87 0.85][0.99 0.51 0.37] [0.73 0.81 0.87]

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 2: [1.00 1.00 0.5]

Computing the distance beween Input vector to each prototype vector:

[0.07 0.87 0.85] [0.99 0.51 0.37] [0.73 0.81 0.87]

↓ ↓ ↓

1.0043 0.2571 0.2459

Winning weight vector # 3: [0.73 0.81 0.87]

Updated winning weight vector:

[0.73 0.81 0.87]+0.5*([1.00 1.00 0.5]-[0.73 0.81 0.87])

[0.07 0.87 0.85][0.99 0.51 0.37] **[0.87 0.90 0.69]**

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 3: [0.2 0.2 0.2]

Computing the distance beween Input vector to each prototype vector:

[0.07 0.87 0.85] [0.99 0.51 0.37] [0.87 0.90 0.69]

↓ ↓ ↓

0.8883 0.7491 1.1790

Winning weight vector # 2: [0.99 0.51 0.37]

Updated winning weight vector:

[0.99 0.51 0.37]+0.5*([0.2 0.2 0.2]-[0.99 0.51 0.37])

[0.07 0.87 0.85]**[0.59 0.36 0.29]** [0.87 0.90 0.69]

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 4: [0.5 0.5 0.5]

Computing the distance beween Input vector to each prototype vector:

[0.07 0.87 0.85] [0.59 0.36 0.29] [0.87 0.90 0.69]

↓ ↓ ↓

0.4443 0.0718 0.3330

Winning weight vector # 2: [0.59 0.36 0.29]

Updated winning weight vector:

[0.59 0.36 0.29]+0.5*([0.5 0.5 0.5]-[0.59 0.36 0.29])

[0.07 0.87 0.85]**[0.55 0.43 0.39]** [0.87 0.90 0.69]

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 5: [0.4 0.6 0.5]

Computing the distance beween Input vector to each prototype vector:

[0.07 0.87 0.85] [0.55 0.43 0.39] [0.87 0.90 0.69]

↓ ↓ ↓

0.3043 0.0635 0.3470

Winning weight vector # 2: [0.59 0.36 0.29]

Updated winning weight vector:

[0.55 0.43 0.39]+0.5*([0.4 0.6 0.5]-[0.55 0.43 0.39])

[0.07 0.87 0.85]**[0.47 0.51 0.45]** [0.87 0.90 0.69]

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 6: [0.0 0.0 0.0]

Computing the distance beween Input vector to each prototype vector:

[0.07 0.87 0.85] [0.47 0.51 0.45] [0.87 0.90 0.69]

↓ ↓ ↓

1.4843 0.6835 2.0430

Winning weight vector # 2: [0.47 0.51 0.45]

Updated winning weight vector:

[0.47 0.51 0.45]+0.5*([0.0 0.0 0.0]-[0.47 0.51 0.45])

[0.07 0.87 0.85]**[0.24 0.26 0.22]** [0.87 0.90 0.69]

Finish of Epoch 1

Example of Simple Competitive Learning

```
Clusters after epoch 1:
 Weight vector # 1: [ 0.07  0.87  0.85 ]
    Input vector # 1:   [ 0.00  1.00  1.00 ]
 Weight vector # 2: [ 0.24  0.26  0.22 ]
    Input vector # 3:   [ 0.20  0.20  0.20 ]
    Input vector # 4:   [ 0.50  0.50  0.50 ]
    Input vector # 5:   [ 0.40  0.60  0.50 ]
    Input vector # 6:   [ 0.00  0.00  0.00 ]
 Weight vector # 3: [ 0.87  0.90  0.69 ]
    Input vector # 2:   [ 1.00  1.00  0.50 ]
```

Example of Simple Competitive Learning

- **Question 2: Based on the 3 prototype vectors initialized in question 1 and the winner units are determined by maximizing inner product. Please upadate the vectors one epoch and list the clustering result again.**

Training on Input Vectors

Input vector # 1: [0.00 1.00 1.00]

Computing the distance beween Input vector to each prototype vector:

[0.14 0.75 0.71] [0.99 0.51 0.37] [0.73 0.81 0.87]

↓ ↓ ↓

1.4600 0.8800 1.6800

Winning weight vector # 3: [0.73 0.81 0.87]

Updated winning weight vector:

[0.73 0.81 0.87]+0.5*([0.00 1.00 1.00]-[0.73 0.81 0.87])

[0.14 0.75 0.71][0.99 0.51 0.37] **[0.37 0.91 0.94]**

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 2: [1.00 1.00 0.5]

Computing the distance beween Input vector to each prototype vector:

[0.14 0.75 0.71] [0.99 0.51 0.37] [0.37 0.91 0.94]

↓ ↓ ↓

1.2450 1.6850 1.7500

Winning weight vector # 3: [0.37 0.91 0.94]

Updated winning weight vector:

[0.37 0.91 0.94]+0.5*([1.00 1.00 0.5]-[0.37 0.91 0.94])

[0.14 0.75 0.71][0.99 0.51 0.37] **[0.69 0.96 0.72]**

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 3: [0.2 0.2 0.2]

Computing the distance beween Input vector to each prototype vector:

[0.14 0.75 0.71] [0.99 0.51 0.37] [0.69 0.96 0.72]

↓ ↓ ↓

0.3200 0.3740 0.4740

Winning weight vector # 3: [0.69 0.96 0.72]

Updated winning weight vector:

[0.69 0.96 0.72]+0.5*([0.2 0.2 0.2]-[0.69 0.96 0.72])

[0.14 0.75 0.71][0.99 0.51 0.37] **[0.45 0.58 0.46]**

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 4: [0.5 0.5 0.5]

Computing the distance beween Input vector to each prototype vector:

[0.14 0.75 0.71] [0.99 0.51 0.37] [0.45 0.58 0.46]

↓ ↓ ↓

0.8000 0.9350 0.7450

Winning weight vector # 2: [0.99 0.51 0.37]

Updated winning weight vector:

[0.99 0.51 0.37]+0.5*([0.5 0.5 0.5]-[0.99 0.51 0.37])

[0.14 0.75 0.71]**[0.71 0.51 0.44]** [0.45 0.58 0.46]

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 5: [0.4 0.6 0.5]

Computing the distance beween Input vector to each prototype vector:

[0.14 0.75 0.71] [0.71 0.51 0.44] [0.45 0.58 0.46]

↓ ↓ ↓

0.8610 0.8100 0.7580

Winning weight vector # 1: [0.14 0.75 0.71]

Updated winning weight vector:

[0.14 0.75 0.71]+0.5*([0.4 0.6 0.5]-[0.14 0.75 0.71])

[0.27 0.68 0.61][0.71 0.51 0.44] [0.45 0.58 0.46]

Example of Simple Competitive Learning

Training on Input Vectors

Input vector # 6: [0.0 0.0 0.0]

Computing the distance beween Input vector to each prototype vector:

[0.27 0.68 0.61] [0.71 0.51 0.44] [0.45 0.58 0.46]

↓ ↓ ↓

0.0000 0.0000 0.0000

Winning weight vector # 1: [0.27 0.61 0.61]

Updated winning weight vector:

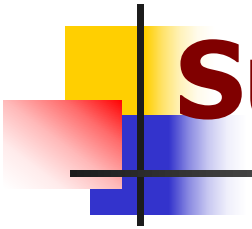
[0.27 0.68 0.61]+0.5*([0.0 0.0 0.0]-[0.27 0.68 0.61])

[0.14 0.34 0.31][0.71 0.51 0.44] [0.45 0.58 0.46]

Finish of Epoch 1

Example of Simple Competitive Learning

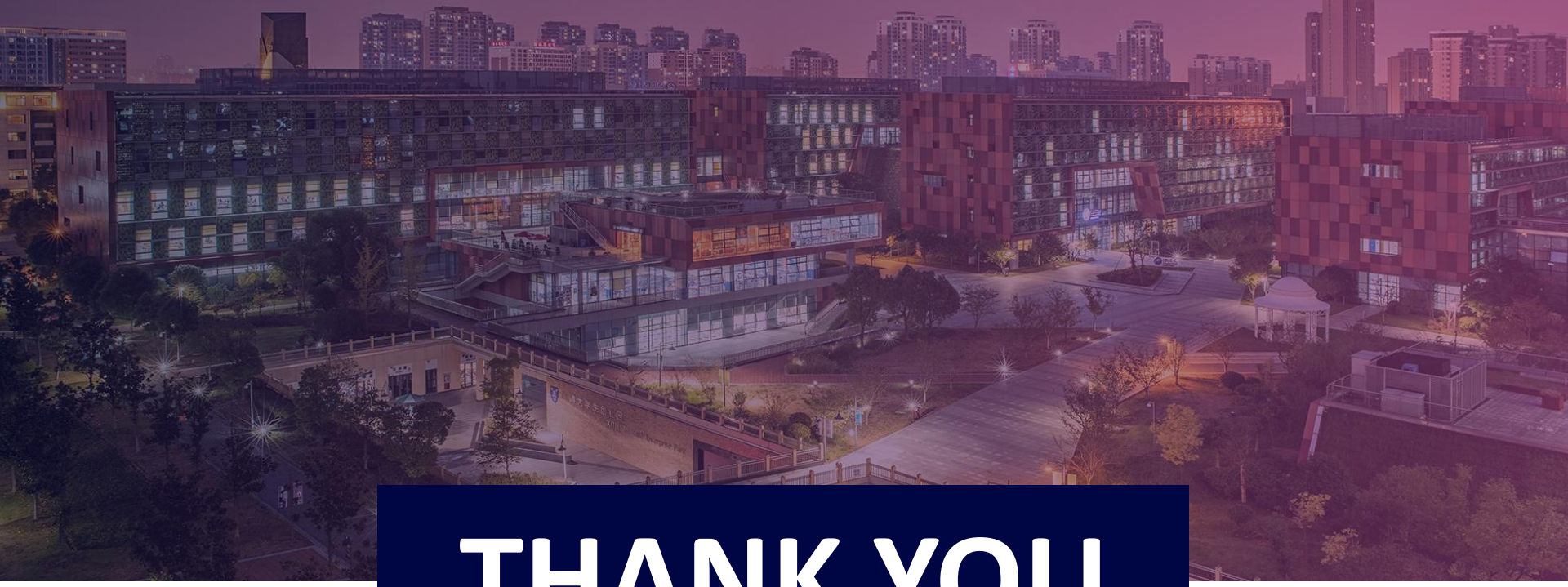
```
Clusters after epoch 1:
 Weight vector # 1: [ 0.14  0.34  0.31 ]
    Input vector # 5:   [ 0.40  0.60  0.50 ]
    Input vector # 6:   [ 0.00  0.00  0.00 ]
 Weight vector # 2: [ 0.71  0.51  0.44]
    Input vector # 4:   [ 0.50  0.50  0.50 ]
 Weight vector # 3: [ 0.45  0.58  0.46 ]
    Input vector # 1:   [ 0.00  1.00  1.00 ]
    Input vector # 2:   [ 1.00  1.00  0.50 ]
    Input vector # 3:   [ 0.20  0.20  0.20 ]
```



Summary

- SCL is sensitive to the choice of winning unit criterion
- Different similarity measures lead to different final prototypes

Will altering the presentation order of the training samples produce different update trajectories and hence different converged vectors?



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