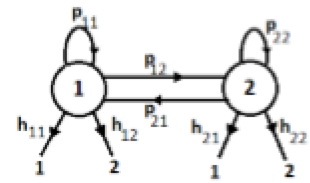
Assignment-3 (HMM, SVM and ANN)

HMM



Model 1		Model 2	
$p_{11} = 0.8$	$p_{21} = 0.3$	$p_{11} = 0.2$	$p_{21} = 0.7$
$h_{11} = 0.9$	$h_{21} = 0.2$	$h_{11} = 0.1$	$h_{21} = 0.8$

Identify the model from which the following data has been generated.

DATA 1: [1 1 1 1 1 | 2 1 1 1 2 |2 1 1 1 2 |…

…2 2 1 1 1 | 1 1 1 2 2 |1 1 2 2 2 | 2 1 1 1 1|…

…1 1 1 1 1 | 1 2 1 1 1 |2 1 1 2 2 | 2 1 1 1 1|…

…1 1 1 2 1 | 1 2 1 2 2 |2 2 2 2 2 | 2 2 1 2 2|…

…2 1 1 2 1 | 1 1 1 1 2 |1 2 1 2 1 | 1 2 2 2 2|…

…2 2 2 1 1]

DATA 2: [1 1 1 1 1 | 1 1 1 2 1 |1 2 2 1 1 |…

…2 1 2 1 2 | 2 2 1 1 1 |2 2 1 1 1 | 1 2 2 1 2|…

…1 2 1 1 1 | 1 2 1 1 1 |1 2 2 1 2 | 1 2 1 1 1|…

…2 2 1 2 1 | 1 1 1 1 1 |2 1 1 1 2 | 2 1 1 1 2|…

…1 2 1 1 1 | 1 2 1 1 1 |1 1 1 1 1 | 2 1 1 1 2|…

…1 1 2 1 1]

with and without state sequence.

STATE 1: [1 1 1 1 2 | 2 1 1 1 1 |2 1 1 1 2 |…

…2 2 1 1 1 | 1 1 2 2 1 |1 1 1 1 2 | 2 1 1 1 1|…

…1 1 1 1 1 | 1 1 1 1 1 |1 1 1 1 1 | 2 1 1 2 2|…

…2 1 1 1 1 | 1 1 1 1 1 |1 2 2 2 2 | 2 2 2 2 2|…

…2 2 2 2 2 | 2 2 2 2 1 |1 1 1 1 2 | 1 2 2 2 2|…

…2 2 2 1 1]

STATE 2: [1 2 2 2 2 | 2 1 2 2 2 |2 2 1 2 1 |…

…2 2 1 2 2 | 1 1 2 2 2 |1 2 2 2 2 | 2 2 1 2 1|…

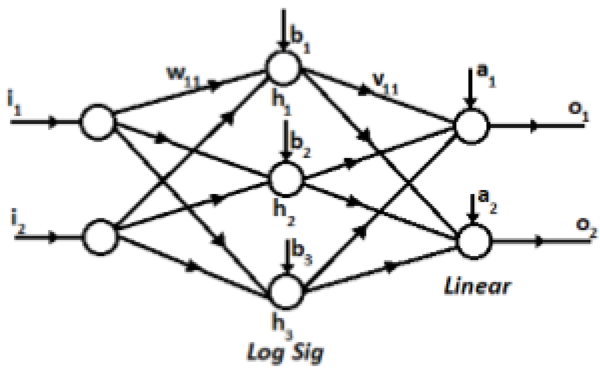
…2 1 2 2 2 | 2 1 2 2 1 |2 1 1 2 1 | 2 1 1 2 2|…

…2 2 2 1 2 | 1 2 2 2 2 |1 2 2 2 2 | 1 2 2 2 1|…

…2 1 2 2 2 | 2 1 1 2 2 |2 1 2 2 2 | 2 2 2 2 2|…

…2 2 1 2 1]

PART-1 ANN



TRAINING:

$$DATA_1 = \begin{bmatrix} 1.08 & 0.75 & 0.85 & 0.94 & 0.40 \\ 0.08 & -0.19 & -0.11 & 0.01 & -0.09 \end{bmatrix}$$

$$DATA_2 = \begin{bmatrix} 0.01 & -0.01 & 0.09 & -0.05 & -0.45 \\ 0.85 & 1.05 & 0.93 & 1.41 & 1.45 \end{bmatrix}$$

VALIDATION:

$$DATA_1 = \begin{bmatrix} 1.25 & 1.19 & 0.99 & 0.69 & 1.32 \\ -0.21 & 0.07 & 0.04 & -0.02 & 0.02 \end{bmatrix}$$

$$DATA_2 = \begin{bmatrix} 0.07 & -0.33 & -0.06 & -0.33 & -0.24 \\ 1.20 & 0.88 & 1.08 & 1.10 & 1.01 \end{bmatrix}$$

1. Initialize the weights:

$w_{11} = 0.85$	$w_{12} = 0.90$	$w_{13} = 0.12$	$w_{21} = 0.91$	$w_{22} = 0.63$	$w_{23} = 0.09$
$v_{11} = 0.28$	$v_{12} = 0.55$	$v_{21} = 0.96$	$v_{22} = 0.96$	$v_{31} = 0.16$	$v_{32} = 0.97$

$b_1 = 0.96$	$b_2 = 0.49$	$b_3 = 0.80$	$a_1 = 0.14$	$a_2 = 0.42$

2. For the Input $DATA_1$, $DATA_2$, Obtain the hidden layer output and output layer output and error vectors $e_1 = t_1 - o_1$, $e_2 = t_2 - o_2$.

Data Index	h_1	h_2	h_3	o_1	o_2	t_1	t_2	e_1	e_2
1						1	0		
2						1	0		
3						1	0		
4						1	0		
5						1	0		
6						0	1		
7						0	1		
8						0	1		
9						0	1		
10						0	1		

$\boxed{SSE =\qquad}$

3. Update the weights using the following:
$w_{11}(t+1) = w_{11}(t)_{+}\eta h_1(1-h_1)i_1[e_1v_{11} + e_2v_{12}]$
$w_{12}(t+1) = w_{12}(t)_{+}\eta h_2(1-h_2)i_1[e_1v_{21} + e_2v_{22}]$
$w_{13}(t+1) = w_{13}(t)_{+}\eta h_3(1-h_3)i_1[e_1v_{31} + e_2v_{32}]$
$w_{21}(t+1) = w_{21}(t)_{+}\eta h_1(1-h_1)i_2[e_2v_{11} + e_2v_{12}]$
$w_{22}(t+1) = w_{22}(t)_{+}\eta h_2(1-h_2)i_2[e_2v_{21} + e_2v_{22}]$
$w_{23}(t+1) = w_{23}(t)_{+}\eta h_3(1-h_3)i_2[e_2v_{31} + e_2v_{32}]$
$v_{11}(t+1) = v_{11}(t)_{+}\eta h_1e_1$ $\quad$ $v_{12}(t+1) = v_{12}(t)_{+}\eta h_1e_2$
$v_{21}(t+1) = v_{21}(t)_{+}\eta h_2e_1$ $\quad$ $v_{22}(t+1) = v_{22}(t)_{+}\eta h_2e_2$
$v_{31}(t+1) = v_{31}(t)_{+}\eta h_3e_1$ $\quad$ $v_{32}(t+1) = v_{32}(t)_{+}\eta h_3e_2$
$a_1(t+1) = a_1(t) + \eta e_1$ $\quad$ $a_2(t+1) = a_2(t) + \eta e_2$
$b_1(t+1) = b_1(t) + \eta h_1(1-h_1)[e_1v_{11} + e_2v_{12}]$
$b_2(t+1) = b_2(t) + \eta h_2(1-h_2)[e_1v_{21} + e_2v_{22}]$
$b_3(t+1) = b_3(t) + \eta h_3(1-h_3)[e_1v_{31} + e_2v_{32}]$

4. Repeat steps 2 and 3 to obtain the following for 5 epochs.
EPOCH 2:

Data Index	h_1	h_2	h_3	o_1	o_2	t_1	t_2	e_1	e_2
1						1	0		
2						1	0		
3						1	0		
4						1	0		
5						1	0		
6						0	1		
7						0	1		
8						0	1		
9						0	1		
10						0	1		

$SSE =$

EPOCH 3:

Data Index	h_1	h_2	h_3	o_1	o_2	t_1	t_2	e_1	e_2
1						1	0		
2						1	0		
3						1	0		
4						1	0		
5						1	0		
6						0	1		
7						0	1		
8						0	1		
9						0	1		
10						0	1		

$SSE =$

EPOCH 4:

Data Index	h_1	h_2	h_3	o_1	o_2	t_1	t_2	e_1	e_2
1						1	0		
2						1	0		
3						1	0		
4						1	0		
5						1	0		
6						0	1		
7						0	1		
8						0	1		
9						0	1		
10						0	1		

$\boxed{SSE = \quad\quad\quad}$

EPOCH 5:

Data Index	h_1	h_2	h_3	o_1	o_2	t_1	t_2	e_1	e_2
1						1	0		
2						1	0		
3						1	0		
4						1	0		
5						1	0		
6						0	1		
7						0	1		
8						0	1		
9						0	1		
10						0	1		

$\boxed{SSE = \quad\quad\quad}$

5. Plot SSE versus umber of epochs.

6. Use the latest weights to obtain the output of the following vectors

$Vector$	o_1	o_2	Class Index
$\begin{bmatrix} 1.25 \\ -0.21 \end{bmatrix}$			
$\begin{bmatrix} 1.19 \\ 0.07 \end{bmatrix}$			
$\begin{bmatrix} 0.99 \\ 0.04 \end{bmatrix}$			
$\begin{bmatrix} 0.69 \\ -0.02 \end{bmatrix}$			
$\begin{bmatrix} 1.32 \\ 0.02 \end{bmatrix}$			
$\begin{bmatrix} 0.07 \\ 1.20 \end{bmatrix}$			
$\begin{bmatrix} -0.33 \\ 0.88 \end{bmatrix}$			
$\begin{bmatrix} -0.06 \\ 1.08 \end{bmatrix}$			
$\begin{bmatrix} -0.33 \\ 1.10 \end{bmatrix}$			
$\begin{bmatrix} -0.24 \\ 1.01 \end{bmatrix}$			

SVM

Given the data $DATA_1 = [X_1\ X_2\ ...\ X_{10}]$ and $DATA_2 = [X_{11}\ X_{12}\ ...\ X_{20}]$

$$DATA_1 = \begin{bmatrix} 1.08 & 0.75 & 0.85 & 0.94 & 0.40 & 1.25 & 1.19 & 0.99 & 0.69 & 1.32 \\ 0.08 & -0.19 & -0.11 & 0.01 & -0.09 & -0.21 & 0.07 & 0.04 & -0.02 & 0.02 \end{bmatrix}$$

$$DATA_2 = \begin{bmatrix} 0.01 & -0.01 & 0.09 & -0.05 & -0.45 & 0.07 & -0.33 & -0.06 & -0.33 & -0.24 \\ 0.85 & 1.05 & 0.93 & 1.41 & 1.45 & 1.20 & 0.88 & 1.08 & 1.10 & 1.01 \end{bmatrix}$$

1. Assign $t_i = 1 \,\forall\, i = 1, \ldots, 10$, $t_i = -1 \,\forall\, i = 11, \ldots, 20$

2. Construct the linear equation

$$\begin{bmatrix} K(X_1,X_1)t_1^2 & K(X_1,X_2)t_1t_2 & \ldots & K(X_1,X_{20})t_1t_{20} \\ K(X_2,X_1)t_2t_1 & K(X_2,X_2)t_2^2 & \ldots & K(X_2,X_{20})t_2t_{20} \\ \vdots & \vdots & \ddots & \vdots \\ K(X_{20},X_1)t_{20}t_1 & K(X_{20},X_2)t_{20}t_2 & \ldots & K(X_{20},X_{20})t_{20}^2 \\ t_1 & t_2 & \ldots & t_{20} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_{20} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \\ 0 \end{bmatrix}$$

where $K(X_i, X_j) = X_i^T.X_j$ with $\sigma^2 = 1$

3. Solve for $a_1, \ldots, a_{20}$.

4. Choose the values $0 \leq a_i \leq C$. C is the box variable. Choose it as 10. Let $n(M_1) = N_1$. Let the set be M_1.

5. Choose the values $0 \leq a_i \leq C$. Let $n(M_2) = N_2$. Let the set be M_2.

6. Compute $\mathbf{W}$ matrix as follows

$$\mathbf{W} = \sum_{n=1, n \in M_2}^{20} a_n t_n \underline{x}_n$$

$\mathbf{W} =$

7. Obtain $\mathbf{b}$ using the following:

$$\mathbf{b} = \frac{1}{N_1} \sum_{m \in M_1} \left[t_m - \sum_{n \in M_2} a_n t_n K(X_n, X_m) \right]$$

$\underline{\mathbf{b}} =$

8. Plot the data.
Plot the line $\mathbf{W}^T.\underline{X} + \mathbf{b}$
Inference: See that the obtained line partitions $DATA_1$ and $DATA_2$
Use the kernel function $K(X_i, X_j) = exp\left(-\frac{(X_i - X_j)^T (X_i - X_j)}{2\sigma^2}\right)$, with $\sigma^2 = 1$.
Obtain the expression for the linear separation line/plane/hyperplane

that partitions the classes.

Obtain the index obtained for the following test data using the trained SVM.

Data	$\begin{bmatrix} 0.0083 \\ 0.85 \end{bmatrix}$	$\begin{bmatrix} 0.08 \\ 0.93 \end{bmatrix}$	$\begin{bmatrix} 0.06 \\ 1.2 \end{bmatrix}$	$\begin{bmatrix} 1.13 \\ 0.07 \end{bmatrix}$	$\begin{bmatrix} 1.21 \\ 0.20 \end{bmatrix}$
Index					

(OR) Demonstrate soft-margin SVM classifier using Image.mat (dataset).