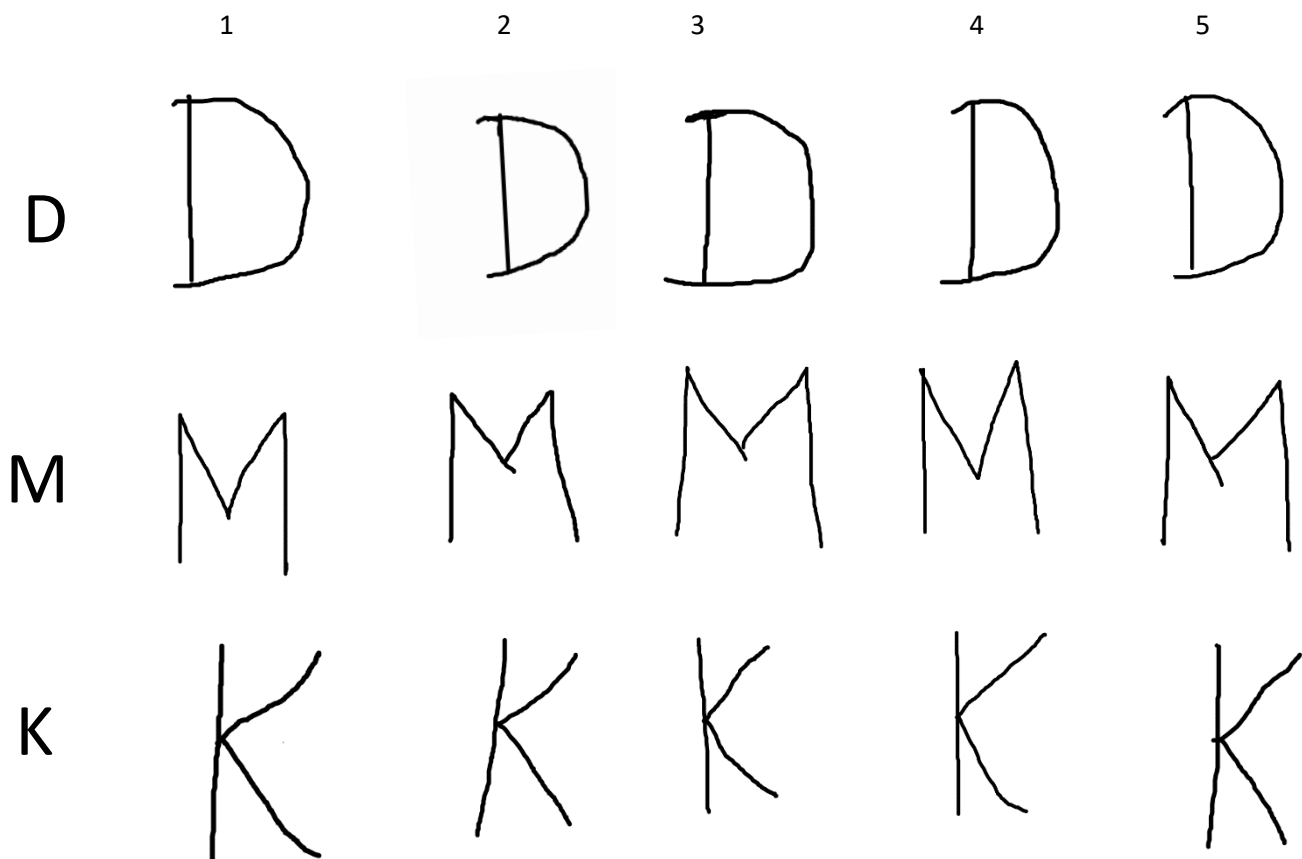# NFT ASSIGNMENT

Name : Kunal Moharkar
Roll no : BT18CSE018

1.Training Images

2. Input Feature Vectors

Dataset[0,3,6,9,12] – Kimg1, Kimg2, Kimg3, Kimg4, Kimg5.

Dataset[1,4,7,10,13] – Dimg1, Dimg2, Dimg3, Dimg4, Dimg5.

Dataset[2,5,8,11,14] – Mimg1, Mimg2, Mimg3, Mimg4, Mimg5.

```
Dataset = [

[1,1,1,0,1,1,1,1,1,0,1,1,0,0,1,1,0,0,1,0,1,1,0,0,0,0,0,0,1,0,1,1,0,0,0,0,0,1,1
,0,1,1,0,0,0,1,1,1,1,0,1,1,0,0,0,1,1,1,1,0,1,1,0,0,0,0,1,1,1,0,1,1,0,0,0,0,0,1
,1,0,1,1,0,0,1,0,0,0,1,0,0,0,0,0,0,0,0,0,0],

[1,0,0,0,0,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,1,0,0,0,1,1,1,1,0,0,1,1,0,0,0,1
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,1,1,1,0,0,0,0,0,0,1,1,1,1,0,0,0,1,1,1,1,1,1],

[1,1,1,1,1,1,1,1,1,1,1,0,0,1,1,0,0,0,1,1,1,0,0,0,1,0,0,0,1,1,1,0,0,0,0,0,0,0,1
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,1,1,1,0,0,1,1,1,0,0,1,1,1,1,1,1,1,1,0,0,1,1],

[1,1,1,0,0,1,1,1,1,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1
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[1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,1
,1,1,1,0,0,0,1,0,0,1,1,1,1,0,0,0,0,0,0,0,1,1,1,1,0,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,0,1
,1,1,1,1,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1],

[1,1,1,1,1,1,1,1,1,1,1,0,0,1,1,0,0,1,1,1,1,0,0,1,0,0,0,1,1,1,1,0,0,0,0,0,0,1,1
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,1,1,1,0,0,1,1,1,0,0,1,1,1,1,1,1,1,1,1,1,1,1],

[1,1,0,0,1,1,1,1,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1,1
,1,1,1,0,0,0,1,1,1,1,1,1,1,0,0,0,1,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,0
,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,1,1,1,1,1,1],

[1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,1,0,0,0,0,0,0,0,1,1,1,1,0,0,1,0,0,0,1
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,1,1,1,0,0,0,0,0,0,0,1,1,1,0,0,0,0,0,1,1,1,1],

[1,1,0,1,1,1,1,0,1,1,1,0,0,0,1,1,0,0,1,1,1,0,0,0,1,0,0,0,0,1,1,0,0,0,0,0,0,0,0
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[1,1,1,0,0,1,1,0,0,1,1,1,1,0,0,1,0,0,0,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1
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,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,1,1],

[1,1,1,0,0,0,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,1,0,0,0,0,0,1
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,1,1,1,1,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1],
```

```
[1,1,1,1,1,0,0,1,1,1,1,0,0,1,1,0,0,0,1,1,1,0,0,0,1,0,0,0,1,1,1,0,0,0,0,0,0,0,1
,1,1,0,0,0,0,0,0,1,1,1,0,0,0,0,0,0,0,1,1,1,0,0,1,0,0,0,0,1,1,1,0,0,1,1,1,0,0
,1,1,1,0,0,1,1,1,0,0,1,1,1,1,0,1,1,1,1,0,1,1],

[1,1,1,0,1,1,1,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1,1
,1,1,1,1,0,0,1,1,1,1,1,1,1,1,1,0,0,0,1,1,1,1,1,1,0,0,0,0,1,1,1,1,1,1,0,0,0,0,1
,1,1,1,1,0,0,1,0,0,1,1,1,1,0,0,1,0,0,1,1,1],

[1,1,0,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,1,0,0,0,1
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,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1,1,1],

[1,1,1,1,1,1,1,1,1,1,1,0,0,1,1,1,0,0,1,1,1,0,0,0,1,0,0,0,1,1,1,0,0,0,0,0,0,0,1
,1,1,0,0,0,0,0,0,1,1,1,0,0,0,0,1,0,0,1,1,1,0,0,0,0,1,0,0,1,1,1,0,0,1,1,1,0,0
,1,1,1,0,0,1,1,1,0,0,1,1,1,1,1,1,1,1,0,0,1,1]

]
```
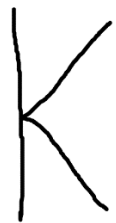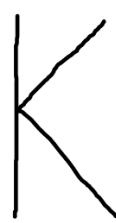
3. Architecture of Neural Network

Single Hidden Layer	Two Hidden Layers
Number of input layer nodes: 100 Number of hidden layer nodes: 80 Number of output layer nodes: 3 Activation function: sigmoid	Number of input nodes: 100 Number of hidden layer 1 nodes: 80 Number of hidden layer 2 nodes: 30 Number of output nodes: 3 Activation function: sigmoid

4. Training Results

Hidden Layers	Learning rate	0.01	0.05	0.1	0.2	0.4	0.8
	Epochs	7017	1382	700	360	183	103
1	Error Threshold	0.01	0.01	0.01	0.01	0.01	0.01
	Epochs	>10000 (no converge)	6515	3152	1568	809	413
2	Error Threshold	0.01	0.01	0.01	0.01	0.01	0.01

5. Testing images

K

D

M

Unseen

6. Input Feature Vectors

Testset[0,1] – Kimg1, Kimg2.

Testset[2,3] – Dimg1, Dimg2.

Testset[4,5] – Mimg1, Mimg2.

Testset[6,7] – Simg1, Aimg1.

```
Testset = [

[1,1,0,0,1,1,1,1,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1,1
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,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,1,1,1,1,1,1],

[1,1,0,0,1,1,1,1,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,1,1,1
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,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,1,1,1,1,1,1],

[1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,1,1,1,1,0,0,0,0,0,0,1,1,1,1,0,0,0,1,0,0,0,1
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,1,1,1,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1],

[1,1,1,0,0,1,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,0,0,0,1,1,1,1,0,0,1,1,0,0,1
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[1,1,1,1,1,1,1,1,1,1,1,1,0,0,1,0,0,1,1,1,1,0,0,0,0,0,0,0,1,1,1,0,0,0,0,0,0,0,1
,1,1,0,0,0,0,0,0,1,1,1,0,0,0,0,0,0,0,1,1,1,0,0,0,1,0,0,1,1,1,0,0,1,1,1,0,0,1,1,1,0,0
,1,1,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1,1,1,1,1,1],

[1,1,1,1,1,1,1,1,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,1,0,0,1,1,1,1,1,0,0,0,0,0,0,1
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[1,1,1,1,1,0,0,1,1,1,1,1,1,0,0,0,0,0,1,1,1,1,0,0,0,0,0,1,1,1,1,1,0,0,1,1,1,1
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[1,1,1,0,0,1,1,1,1,1,1,1,1,0,0,1,1,1,1,1,1,1,1,1,0,0,0,1,1,1,1,1,1,0,0,0,0,1,1,1
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,1,1,1,1,0,1,1,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1]

]
```

7. Testing Results

1.single layer

The network converges for all learning rates and provides correct output for **5/6** seen image sets (cannot identify one M) . However, it fails to classify unseen images. It Identifies S as D and A as K. Accuracy for all the learning rate values is **62.5% (5/8)**

```
the learning rate is 0.01

Decimal output:[0.006301471409026821, 0.0421912162464689, 0.963141372376954]
output is: K
Output should be: [0, 0, 1](K)
Decimal output:[0.006301471409026821, 0.0421912162464689, 0.963141372376954]
output is: K
Output should be: [0, 0, 1](K)
Decimal output:[0.1329487915182777, 0.955015228185456, 0.0030741347098536052]
output is: D  Output should be: [0, 1, 0](D)
Decimal output:[0.005672528204053991,0.9871826621777731, 0.023934998830728235]
output is: D
Output should be: [0, 1, 0](D)
Decimal output:[0.9339193722802882, 0.10220920956857357, 0.004440015238625721]
output is: M
Output should be: [1, 0, 0](M)
Decimal output:[0.3636733034618726, 0.43458979497859956, 0.018349948834361553]
output is: Cannot Identify
Output should be: [1, 0, 0](M)
Decimal output:[0.027984242984131106, 0.7796432589286224, 0.08071772689392613]
output is: D
Output should be: cannot identify
Decimal output:[0.02911761127795307, 0.07178432326868739, 0.7531738568767947]
output is: K
Output should be: cannot identify
```

```
the learning rate is 0.05

Decimal output:[0.0062961332654005615, 0.0423041878577916, 0.9633291888676435]
   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0062961332654005615, 0.0423041878577916, 0.9633291888676435]
   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.13423550169000664, 0.9564547813152195, 0.002986973227645168]
   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.006027033002711765, 0.9870788565972607, 0.0237001811743162]
   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9360336494403453, 0.10580163766794727, 0.0041026017224879505
]   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.36189767696796493, 0.4419151208817572, 0.01829991322587896]
  and output is: Cannot Identify  Output should be: [1, 0, 0]
Decimal output:[0.028352075976141797, 0.7764262929937438, 0.08264050226257129]
   and output is: D  Output should be: Not able to identify
Decimal output:[0.02832361356177805, 0.0728446233907426, 0.7564525672635978]
 and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.1

Decimal output:[0.0052851048021296115, 0.04216642715909735, 0.9646444012763297
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0052851048021296115, 0.04216642715909735, 0.9646444012763297
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.13566202431098506, 0.9550196952900569, 0.0032770268149188747
]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.006341638446574776, 0.9868053288961781, 0.02421645772310405]
    and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9379242683841371, 0.1049545819219809, 0.00394122165885917]
 and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.3683487411346402, 0.45123429466364984, 0.0177143608234867]
 and output is: Cannot Identify  Output should be: [1, 0, 0]
Decimal output:[0.02870123005512193, 0.7802520043474974, 0.08075675698383908]
   and output is: D  Output should be: Not able to identify
Decimal output:[0.026020792690865335, 0.07435528574922035, 0.7558446153170563]
    and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.2

Decimal output:[0.005935256833886406, 0.0419543614099485, 0.9650974173929865]
   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.005935256833886406, 0.0419543614099485, 0.9650974173929865]
   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.13303189446068914, 0.9563521496374232, 0.0030559007967687606
]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.006209959696967433, 0.9865882190407844, 0.0240934880244885]
  and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9385743136571939, 0.10243296700854344, 0.004244653179434573]
   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.3800213037686693, 0.44588446400737736, 0.017854439567132528]
   and output is: Cannot Identify  Output should be: [1, 0, 0]
Decimal output:[0.02892301552338971, 0.7801459981940474, 0.07940284266898653]
  and output is: D  Output should be: Not able to identify
Decimal output:[0.02891988654563772, 0.07288208198962526, 0.7587607767596946]
  and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.4

Decimal output:[0.005227419780821437, 0.04129025033424902, 0.9672465069345213]
    and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.005227419780821437, 0.04129025033424902, 0.9672465069345213]
    and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.1306786072843309, 0.9497949611552738, 0.003581536548972321]
   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.006341638446574776, 0.9868053288961781, 0.02421645772310405]
    and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9379242683841371, 0.1049545819219809, 0.00394122165885917]
 and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.37821501169225025, 0.46258659171418803, 0.017342351010532858
] and output is: Cannot Identify  Output should be: [1, 0, 0]
Decimal output:[0.029299293413863454, 0.7919326214184389, 0.07610944422840678]
and output is: D  Output should be: Not able to identify
Decimal output:[0.02580742095784445, 0.0733264982232018, 0.7727688891824116]
and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.8

Decimal output:[0.0020663257347028653, 0.03885455453728006, 0.9708111426680529
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0020663257347028653, 0.03885455453728006, 0.9708111426680529
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.12334804433945216, 0.9488887103693002, 0.0043223571496366665
]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.008443129662787945, 0.9847639015599484, 0.022997041742260204
]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9503101272178135, 0.08344306177892429, 0.002615564816367841]
   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.37509756377422976, 0.4964130917461141, 0.014075686094833223]
   and output is: Cannot Identify  Output should be: [1, 0, 0]
Decimal output:[0.024416151830789323, 0.8129305488977503, 0.07090848040480481]
   and output is: D  Output should be: Not able to identify
Decimal output:[0.012491256554502138, 0.08246977100593123, 0.7743351030136858]
   and output is: K  Output should be: Not able to identify
```

2.Multiple layers

The network fails to converge for learning rate **0.01** and fails to classify any of the given test inputs. It converges for all other learning rates and provides correct output for **5/6** seen image sets (identifies one M as D). However, it fails to classify unseen images. It Identifies S as D and A as K. Accuracy for all the learning rate values is **62.5%(5/8)**

```
the learning rate is 0.01

Decimal output:[0.3358447238103626, 0.33390060430538243, 0.3324764981546395]
 and output is: Cannot Identify  Output should be: [0, 0, 1]
Decimal output:[0.3358447238103626, 0.33390060430538243, 0.3324764981546395]
 and output is: Cannot Identify  Output should be: [0, 0, 1]
Decimal output:[0.3347509185306144, 0.33257928935569664, 0.3310132316715015]
 and output is: Cannot Identify  Output should be: [0, 1, 0]
Decimal output:[0.33509893627705123, 0.33300129955409685, 0.3314802463339482]
  and output is: Cannot Identify  Output should be: [0, 1, 0]
Decimal output:[0.3348632500627955, 0.33271191178420506, 0.33116004347679173]
  and output is: Cannot Identify  Output should be: [1, 0, 0]
Decimal output:[0.33528043288645665, 0.3332171513898165, 0.33171942831471485]
  and output is: Cannot Identify  Output should be: [1, 0, 0]
Decimal output:[0.3353114994505378, 0.333256710081073, 0.33176328897563534]
and output is: Cannot Identify  Output should be: Not able to identify
Decimal output:[0.3360266073289294, 0.33411922099824753, 0.3327183715494577]
 and output is: Cannot Identify  Output should be: Not able to identify
```

```
the learning rate is 0.05

Decimal output:[0.0037396408405203103, 0.03263896221775101, 0.9732478928826258
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0037396408405203103, 0.03263896221775101, 0.9732478928826258
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.1554875057507413, 0.9413658770712393, 0.00022559210581629075
]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.011121257672784223, 0.9744059736591831, 0.027935655758979577
]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9733593273595991, 0.025105588572832026, 5.732001321951162e-
07]   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.2698035532776139, 0.8101508628357805, 0.00014545717469143925
]   and output is: D  Output should be: [1, 0, 0]
Decimal output:[0.012126555460297927, 0.9400388407330744, 0.04408065977448255]
   and output is: D  Output should be: Not able to identify
Decimal output:[0.00541625231442304, 0.269373625460732, 0.7631848670514302]
and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.1

Decimal output:[0.0035770705901200742, 0.0325620879607037, 0.9733817618234661]
   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0035770705901200742, 0.0325620879607037, 0.9733817618234661]
   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.16813523122969984, 0.9389982625368527, 0.0001674415707372609
4]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.01097891654512618, 0.9725923456849028, 0.031024535748120693]
   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9739507590055999, 0.024705285531047706, 3.213600245658516e-
07]   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.2810327948540038, 0.8144702226784233, 0.00010385133350426654
]   and output is: D  Output should be: [1, 0, 0]
Decimal output:[0.012015963445192497, 0.942350825038786, 0.04381246781132864]
  and output is: D  Output should be: Not able to identify
Decimal output:[0.005213524681096408, 0.2764336338174899, 0.7642630623219893]
  and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.2

Decimal output:[0.0032826666273038847, 0.032670106276941537, 0.974372221855489
4]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0032826666273038847, 0.032670106276941537, 0.974372221855489
4]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.17532989818924288, 0.9448763806651965, 0.0001295590708105084
3]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.01108733584206071, 0.9678997724691004, 0.03169087657034276]
  and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9740825655602101, 0.02441934097471254, 2.754695334181298e-
07]   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.2823199266701667, 0.8363984659209225, 8.369437141469036e-
05]   and output is: D  Output should be: [1, 0, 0]
Decimal output:[0.01198781091659454, 0.9413280873695982, 0.0413902856618508]
 and output is: D  Output should be: Not able to identify
Decimal output:[0.004984915258886708, 0.28885455136032795, 0.7528888712735784]
   and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.4

Decimal output:[0.0031688634168620415, 0.032327418248798014, 0.974612260775524
1]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0031688634168620415, 0.032327418248798014, 0.974612260775524
1]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.18869548281581688, 0.943277081879343, 9.507592290842165e-
05]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.010769580460615007, 0.9672270740296739, 0.03476910366634216]
   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9754759855392279, 0.023467292153629013, 1.4260080699569901e-
07]   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.30538848628839055, 0.8333284704576163, 5.508420122801446e-
05]   and output is: D  Output should be: [1, 0, 0]
Decimal output:[0.011873574401326257, 0.9456199309534115, 0.040258871933730754
]   and output is: D  Output should be: Not able to identify
Decimal output:[0.004836263617209603, 0.30126559640945505, 0.7506497008245492]
   and output is: K  Output should be: Not able to identify
```

```
the learning rate is 0.8

Decimal output:[0.0031644524948973764, 0.03215822525081707, 0.9746187991609365
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.0031644524948973764, 0.03215822525081707, 0.9746187991609365
]   and output is: K  Output should be: [0, 0, 1]
Decimal output:[0.18557928769230092, 0.9419355340112939, 8.44360626887313e-
05]   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.010652780856198888, 0.9691256105782315, 0.03605408558126936]
   and output is: D  Output should be: [0, 1, 0]
Decimal output:[0.9759521815788376, 0.022662465242409446, 6.314697530163787e-
08]   and output is: M  Output should be: [1, 0, 0]
Decimal output:[0.303185106002321, 0.8384620621087533, 4.254992495019732e-
05]   and output is: D  Output should be: [1, 0, 0]
Decimal output:[0.011919159672200252, 0.9491040801544577, 0.03981095022948533]
   and output is: D  Output should be: Not able to identify
Decimal output:[0.0048486305340927315, 0.31886316829056055, 0.7435404978366142
]   and output is: K  Output should be: Not able to identify
```