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Task 1

1.1

X={color, shape, texture}

Y={banana, grapes, apple, orange}

D={**banana**:[yellow, curved, smooth]; **apple**:[red, round, smooth]; **orange**:[orange, round, rough]; **banana**:[brown, curved, smooth]; **grapes**:[green, oval, smooth]; **apple**:[green, round, smooth]}

1.2

Distance between l0, l1 is |0-1|=1
Distance between l0, l2 is |0-2|=2
Distance between l0, l3 is |0-3|=3
Distance between l1, l2 is |1-2|=1
Distance between l1, l3 is |1-3|=2
Distance between l2, l3 is |2-3|=1
Problem: distance not evenly distributed. Mis-classify l1 to l3 should not be more wrong than classify l1 to l2.

1.3

True labels y={0,2,3,0,1,2}

Predict labels by classifier $\hat{y}$={0,2,3,3,1,1}

Loss = 0+0+0+3+0+1 = 4

*** Q: what should the loss function be like?*

1.4

To be uniform means to have equal distance between each pair of labels. Since in two-dimension coordinate system, the max number of uniformed labels is 3, we need three dimension.

L0 = (1,1,1)
L1 = (1,-1,-1)
L2 = (-1,1,-1)
L3 = (-1,-1,1)
Distance = 8**0.5

Normalization:

L0 = $(\frac{\sqrt{2}}{2},\frac{\sqrt{2}}{2},\frac{\sqrt{2}}{2})$
L1 = $(\frac{\sqrt{2}}{2},\frac{-\sqrt{2}}{2},\frac{-\sqrt{2}}{2})$
L2 = $(\frac{-\sqrt{2}}{2},\frac{\sqrt{2}}{2},\frac{-\sqrt{2}}{2})$
L3 = $(\frac{-\sqrt{2}}{2},\frac{-\sqrt{2}}{2},\frac{\sqrt{2}}{2})$

1.5

Distance = 1
Loss = 0+0+0+1+0+1=2

1.6

To encode all the features, for each feature, the distance should be the same, so:
Color: [yellow, red, orange, brown, green]

Yellow=(1,1,1,1)
Red=(1,-1,-1,-1)
Orange=(-1,1,-1,-1)
Brown=(-1,-1,1,-1)

Green=(-1,-1,-1,1)
Shape: [curved, round, oval]
Curved=(1,1)
Round=(1,-1)
Oval=(-1,1)
Texture: [smooth, rough]
Smooth=(1)
Rough=(-1)

*** Q: do we need normalize all these values?*

Task2

2.1.1
F1-score is harmonic mean of recall and precious.
Precious: in true class i, how many samples are successfully counted.
Precious = *T_positive / (T_positive + T_negative)*
Recall: in predicted class i, how many prediction is right.
Recall = *T_positive / (T_positive + F_positive)*
F1-score = *2 * precious * recall / (precious + recall)*
So:
Minimal F1-score = 0
When a classifier predict all instance as negative, but there is actually instance positive.

Maximal F1-score = 1
When the classifier perfectly predict all instance.

2.1.2
Pre = Recall = 0 means the classifier predict all instance in True_class1 as class2, and all instance in True_class2 as class1.

2.1.3
In data set D with n samples, the number of positive sample is m, negative sample is $n-m$.
If classifier pick class randomly:
True_Positive = $m/2$, True_Negative = $(n-m)/2$
False_positive = $m/2$, False_negative = $(n-m)/2$

Precious = $0.5m / 0.5n = m/n$
Recall = $0.5m / m = 0.5$
F1 = $2m/(2m+n)$

If n-m = m:
Precious = 0.5
Recall = 0.5
F1 = 0.5

2.2.1
For C1: P1=250/250=1, P2=250/250=1; R1=250/250=1, R2=250/250=1 -> F=1
For C2: P1=125/250=0,5; P2=125/250=0,5; R1=125/250=0,5; R2=125/250=0,5 -> F=0,5
Choose C1

2.2.2
For C1: P1=0, P2=0; R1=0, R2=0 -> F=0
For C2: P1=125/250=0,5; P2=125/250=0,5; R1=125/250=0,5; R2=125/250=0,5 -> F=0,5
Choose C2

2.2.3
For C1: P1=200/225=0,89, P2=200/275=0,73; R1=200/275=0,73, R2=200/225=0,89 -> F=0,8
For C2: P1=200/275=0,73; P2=200/225=0,89; R1=200/225=0,89; R2=200/275=0,73 -> F=0,8
Choose C2, because higher true positive prediction matters more.

2.2.4
Choose C1, because lower false positive prediction matters.

Task3

3.1

		Predict		
	Apple	Grapes	Orange	Total
Apple	**5**	1	2	8
Grapes	1	**7**	1	9
Orange	1	1	**6**	8
Total	7	9	9	25

3.2

	Precious	Recall	F1
Apple	5/7=0,71	5/8=0,625	0,8875/1,335≈0.665
Grapes	7/9=0,78	7/9=0,78	1,2168/1,56≈0.78
Orange	6/9=0,67	6/8=0,75	1,005/1,42≈0.708

3.3
All Precious = 18/25 = 0,72
All Recall = 18/25 = 0.72
Micro F1-score = 0.72

3.4
Macro F1-score ≈ 0.718

3.5
Small number of samples.
Many samples in data set belong to a certain class, not evenly distributed.
Classifier has different performance with different class.