CSE 250A HW5

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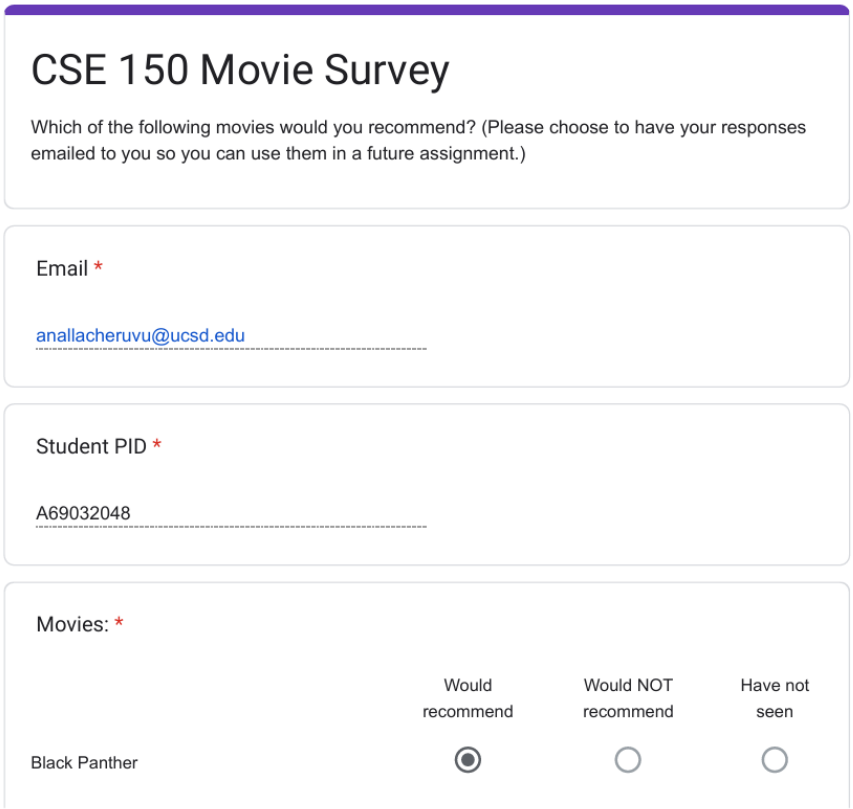
5.1 Survey



CSE 150 Movie Survey

Which of the following movies would you recommend? (Please choose to have your responses emailed to you so you can use them in a future assignment.)

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Movies: *

	Would recommend	Would NOT recommend	Have not seen
Black Panther	◉	○	○

Inception	◉	○	○
The Last Airbender	○	◉	○
The Hunger Games	◉	○	○
The Wolf of Wall Street	◉	○	○
World War Z	○	◉	○
Interstellar	○	◉	○
The Martian	◉	○	○
Iron Man 3	○	◉	○
La La Land	○	◉	○
Star Wars: The Last Jedi	○	◉	○
WALL-E	◉	○	○
The Dark Knight	◉	○	○
The Lord of the Rings: The Fellowship of the Ring	○	○	◉
The Matrix	◉	○	○
Star Trek Beyond	○	◉	○
Jurassic World	○	◉	○
Jurassic Park (1993)	◉	○	○
Deadpool 2	○	◉	○
Guardians of the Galaxy	○	◉	○
Mission: Impossible - Fallout	◉	○	○
Guardians of the Galaxy Vol. 2	○	◉	○

Zootopia	◉	○	○
Tron	◉	○	○
Star Wars: The Phantom Menace	○	○	◉
Moana	◉	○	○
Man of Steel	◉	○	○
Get Out	◉	○	○
Suicide Squad	◉	○	○
The Shape of Water	○	◉	○
The Avengers	◉	○	○
Mad Max: Fury Road	○	◉	○
Frozen	◉	○	○
The Imitation Game	◉	○	○
Ex Machina	○	○	◉
2001: A Space Odyssey	◉	○	○
Blade Runner 2049	○	○	◉
Terminator Genisys	○	○	◉
Terminator 2	○	○	◉
Avengers: Infinity War	◉	○	○
Coco	◉	○	○
Ant-Man and the Wasp	◉	○	○
Venom	◉	○	○

5.2 EM algorithm

a)

$$P(B=b|A=a) = \frac{\sum_{t=1}^{T} I(a,a_t) I(b,b_t)}{\sum_{t=1}^{T} I(a,a_t)}$$

$$P(C=c|A=a,B=b) = \frac{\sum_{t=1}^{T} I(a,a_t) I(b,b_t) I(c,c_t)}{\sum_{t=1}^{T} I(a,a_t) I(b,b_t)}$$

$$P(D=d|A=a,C=c) = \frac{\sum_{t=1}^{T} I(a,a_t) I(c,c_t) I(d,d_t)}{\sum_{t=1}^{T} I(a,a_t) I(c,c_t)}$$

b) $P(A=a,B=b|C=c,D=d) = \frac{P(A=a,B=b,C=c,D=d)}{P(C=c,D=d)}$

$= \frac{P(A=a)P(B=b|A=a)P(C=c|B=b,A=a)P(D=d|C=c,B=b,A=a)}{P(C=c)P(D=d|C=c)}$

$= \boxed{\frac{P(A=a)P(B=b|A=a)P(C=c|B=b,A=a)P(D=d|C=c,B=b)}{\Sigma_{A=a,B=b}P(A=a)P(B=b|A=a)P(C=c|B=b,A=a)P(D=d|C=c,B=b)}}$

c) $\boxed{P(a|c,d) = \Sigma_{B=b}P(A=a,B=b|C=c,D=d)}$

$\boxed{P(b|c,d) = \Sigma_{A=a}P(B=b,A=a|C=c,D=d)}$

d) $\mathrm{P(C=c}_t, D=d_t) = P(C=c_t)P(D=d_t|C=c_t) =$
$\Sigma_{A=a,B=b}P(A=a)P(B=b|A=a)P(C=c_t|B=b,A=a)P(D=d_t|C=c_t,B=b)$

$\boxed{\mathrm{L=}\Sigma_t log \Sigma_{A=a,B=b}P(A=a)P(B=b|A=a)P(C=c_t|B=b,A=a)P(D=d_t|C=c_t,B=b)}$

e)

$$P(A=a) \leftarrow \frac{\sum_{t=1}^{T} P(A=a|C=c_t, D=d_t)}{T}$$

$$P(B=b|A=a) \leftarrow \frac{\sum_{t=1}^{T} P(B=b, A=a|C=c_t, D=d_t)}{\sum_{t=1}^{T} P(A=a|C=c_t, D=d_t)}$$

$$P(C=c|A=a, B=b) \leftarrow \frac{\sum_{t=1}^{T} I(c, c_t) P(A=a, B=b|C=c_t, D=d_t)}{\sum_{t=1}^{T} P(A=a, B=b|C=c_t, D=d_t)}$$

$$P(D=d|B=b, C=c) \leftarrow \frac{\sum_{t=1}^{T} I(c, c_t) I(d, d_t) P(B=b|C=c_t, D=d_t)}{\sum_{t=1}^{T} I(c, c_t) P(B=b|C=c_t, D=d_t)}$$

5.3 EM algorithm for noisy-OR

a) P(Y=1—X) $= \Sigma_{Z \epsilon \{0,1\}^n} P(Y=1, Z|X) =$
$\Sigma_{Z \epsilon \{0,1\}^n} P(Y=1|Z, X) P(Z|X) = \Sigma_{Z \epsilon \{0,1\}^n} P(Y=1|Z) P(Z|X) =$
$\Sigma_{Z \epsilon \{0,1\}^n} \Pi_i^n P(Z_i|X_i) = 1 - \Pi_i^n P(Z_i=0|X_i) =$ $\boxed{\text{1-}\Pi_i^n (1-p_i)^{X_i}}$

$b) P(Z_i=1, X_i=1|X=x, Y=y) = \frac{\Sigma_{Z=\{0,1\}^n} P(Z_i=1, X_i=1, X=x, Z=z, Y=1)}{P(X=x, Y=y)} =$
$\frac{P(Z_i=1, X_i=1) P(X_i=1) \Sigma_{z_j} \Pi_j P(Z_j=z_j, X_j=x_j) P(Y=1|Z=z)}{P(Y=1|X=x)} =$ $\boxed{\frac{y x_i p_i}{1-\Pi_j (1-p_j)^{X_j}}}$

$c) p_i = P(Z_i=1|X_i=1)$
$P(Z_i=1|X_i=1) \leftarrow \frac{\Sigma_{t=1}^{T} P(Z_i=1, X_i=1|X=x^{(t)}, Y=y^{(t)})}{\Sigma_{t=1}^{T} P(X_i=1|X=x^{(t)}, Y=y^{(t)})} =$
$\frac{\Sigma_{t=1}^{T} P(Z_i=1, X_i=1|X=x^{(t)}, Y=y^{(t)})}{T_i}$

$\boxed{\text{p}_i \leftarrow \frac{\Sigma_{t=1}^{T} P(Z_i=1, X_i=1|X=x^{(t)}, Y=y^{(t)})}{T_i}}$

HW5

November 11, 2024

[1]:
```
import math
```

[3]:
```
with open('spectX-1.txt', 'r') as f:
    features = [list(map(int, line.rstrip(' \n').split(' '))) for line in f]

with open('spectY-1.txt', 'r') as f:
    labels = [int(line.rstrip("\n")) for line in f]
```

[5]:
```
num_samples = len(features)
iterations = 256
num_features = 23
probabilities = [0.05] * num_features
feature_counts = [0] * num_features
```

[7]:
```
for i in range(num_samples):
    for j in range(num_features):
        if features[i][j] == 1:
            feature_counts[j] += 1
```

[9]:
```
log_likelihood = [0] * (iterations + 1)
mistakes = [0] * (iterations + 1)
```

[11]:
```
for iteration in range(iterations + 1):
    for sample in range(num_samples):
        term_1 = 0
        term_2 = 1
        for feature in range(num_features):
            if features[sample][feature] == 1:
                term_1 += features[sample][feature] * (0 if␣
↪probabilities[feature] == 0 else math.log(1 - probabilities[feature]))
            term_2 *= (1 - probabilities[feature]) ** features[sample][feature]
        log_likelihood[iteration] += (1 - labels[sample]) * term_1 +␣
↪labels[sample] * math.log(1 - term_2)

    log_likelihood[iteration] /= num_samples
    mistakes[iteration] = 0
    for sample in range(num_samples):
        probability = 1
```

```
        for feature in range(num_features):
            probability *= (1 - probabilities[feature]) **␣
↪features[sample][feature]
        prob_of_1 = 1 - probability
        if (labels[sample] == 1 and prob_of_1 <= 0.5) or (labels[sample] == 0␣
↪and prob_of_1 >= 0.5):
            mistakes[iteration] += 1

    posteriors = []
    for sample in range(num_samples):
        denominator = 1
        for feature in range(num_features):
            denominator *= (1 - probabilities[feature]) **␣
↪features[sample][feature]
        posteriors.append([labels[sample] * features[sample][feature] *␣
↪probabilities[feature] / (1 - denominator) for feature in range(num_features)])

    for feature in range(num_features):
        probabilities[feature] = sum(posteriors[sample][feature] for sample in␣
↪range(num_samples)) / feature_counts[feature]
```

[12]:
```
for iteration in [0, 1, 2, 4, 8, 16, 32, 64, 128, 256]:
    print(f"Iteration: {iteration} \t Mistakes: {mistakes[iteration]} \t Log␣
↪Likelihood: {round(log_likelihood[iteration], 5)}")
```

```
Iteration: 0     Mistakes: 175   Log Likelihood: -0.95809
Iteration: 1     Mistakes: 56    Log Likelihood: -0.49592
Iteration: 2     Mistakes: 43    Log Likelihood: -0.40822
Iteration: 4     Mistakes: 42    Log Likelihood: -0.36461
Iteration: 8     Mistakes: 44    Log Likelihood: -0.3475
Iteration: 16    Mistakes: 40    Log Likelihood: -0.33462
Iteration: 32    Mistakes: 37    Log Likelihood: -0.32258
Iteration: 64    Mistakes: 37    Log Likelihood: -0.31483
Iteration: 128   Mistakes: 36    Log Likelihood: -0.31116
Iteration: 256   Mistakes: 36    Log Likelihood: -0.31016
```