

Assignment 2 + Entropy, KL Divergence (SNLP Tutorial 3)

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Assignment 2

- Exercise 1: Perplexity Calculation
- Exercise 2: Formulating n-gram models
- Exercise 3: Perplexity Calculation for n-grams
- Bonus: Alternative metric to perplexity

Overview of Formulas

Concepts and formulations. (Express also as expectation values.)

- Information Content
 - $I(x) = -\log p(x)$
- Entropy
 - $H(X) = -\sum_{x \in X} p(x) \cdot \log p(x)$
- Joint entropy
 - $H(X, Y) = -\sum_{x \in X} \sum_{y \in Y} p(x, y) \cdot \log p(x, y)$
- Conditional entropy
 - $H(X, Y) = -\sum_{x \in X} \sum_{y \in Y} p(x, y) \cdot \log p(y | x)$
- Mutual Information
 - $I(X; Y) = -\sum_{x, y} p(x, y) \cdot \log \frac{p(x, y)}{p(x) \cdot p(y)}$
- Cross-entropy
 - $H(p, q) = -\sum_x p(x) \cdot \log q(x)$
- KL-Divergence
 - $D(p||q) = -\sum_{x \in X} p(x) \cdot \log \frac{p(x)}{q(x)}$

How do they relate to each other?

- Chain Rule:

$$H(X, Y) = H(X) + H(Y|X)$$

$$H(X_1 \dots X_n) = H(X_1) + H(X_2 | X_1) + \dots + H(X_n | X_1, \dots, X_{n-1})$$

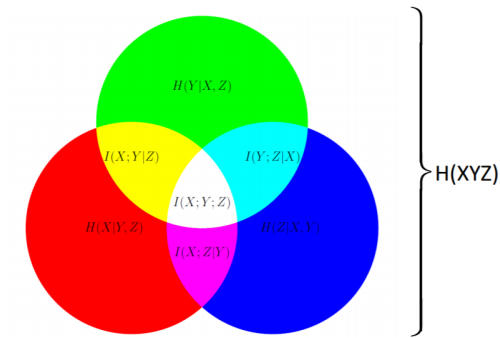
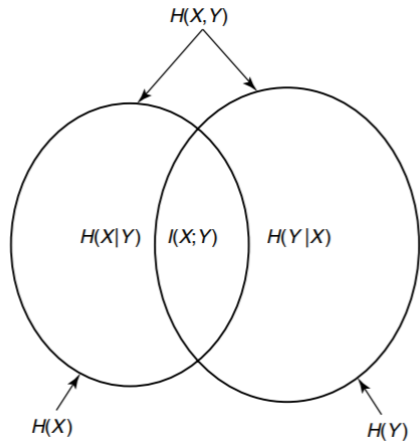
- Mutual Information and Entropy

$$I(X; Y) = H(X) - H(X | Y) = H(X) + H(Y) - H(X, Y)$$

- Apply to 3 variables

$$I(X; Y | Z) = I((X; Y)|Z) = H(X | Z) - H(X | Y, Z)$$

How do they relate to each other?



Examples - Entropy calculation

$X \setminus Y$	0	1
0	$1/2$	$1/5$
1	$1/3$	0

Find

- $H(X), H(Y)$
- $H(X, Y)$
- $H(X|Y), H(Y|X)$
- $I(X; Y)$
- $H(Y) - H(Y|X)$

Examples - Entropy of functions

What is the (in)equality relationship between $H(X)$ and $H(Y)$ when

- $y = f(x)$ # general case
- $y = 2^x$
- $y = \sin(x)$

KL-divergence

TODO, examples, exercises, questions

Resources

1 TODO