

COMS W4705: Natural Language Processing

Written Homework 4

Sample Solutions

December 17, 2018

Problem 1

Euclidean distance:

$$\text{dist}_{\text{eucl}}(\text{animal}, \text{dog}) = 3.3166$$

$$\text{dist}_{\text{eucl}}(\text{animal}, \text{cat}) = 8.4261$$

$$\text{dist}_{\text{eucl}}(\text{animal}, \text{computer}) = 4.5826$$

$$\text{dist}_{\text{eucl}}(\text{animal}, \text{run}) = 6.9282$$

$$\text{dist}_{\text{eucl}}(\text{animal}, \text{mouse}) = 9.6437$$

Therefore *dog* is the most similar word to *animal*.

Cosine similarity:

$$\text{sim}_{\text{cos}}(\text{animal}, \text{dog}) = 0.8519$$

$$\text{sim}_{\text{cos}}(\text{animal}, \text{cat}) = 0.7292$$

$$\text{sim}_{\text{cos}}(\text{animal}, \text{computer}) = 0.7620$$

$$\text{sim}_{\text{cos}}(\text{animal}, \text{run}) = 0.6014$$

$$\text{sim}_{\text{cos}}(\text{animal}, \text{mouse}) = 0.6658$$

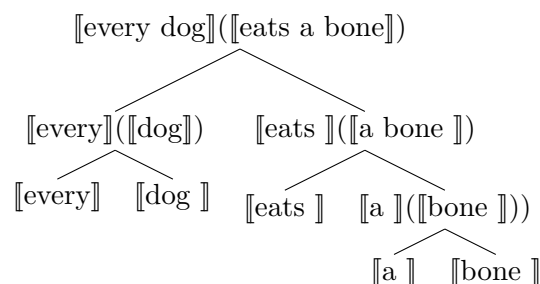
dog is still the most similar word to *animal*.

Problem 2

There are multiple possible solutions to this problem. Here is one: We assume the two senses a and b are given as WordNet synsets. The lexical relations in WordNet (hypernyms, meronyms, etc.) form a graph. We can compute the shortest path between a and b in the graph, i.e. the shortest number of lexical-relations one needs to follow to go from a to b. Polysemes will have a relatively short distance to each other, while homonyms (that are mostly unrelated) will have a large distance.

Problem 3

a)



$$\llbracket \text{a bone} \rrbracket = \llbracket \text{a} \rrbracket (\llbracket \text{bone} \rrbracket) =$$

$$\begin{aligned} & (\lambda R. \lambda S. \exists y R(y) \wedge S(y)) (\lambda y. \text{bone}(y)) = \\ & \lambda S. \exists y (\lambda y. \text{bone}(y))(y) \wedge S(y) = \lambda S. \exists y \text{bone}(y) \wedge S(y) \end{aligned}$$

$$\llbracket \text{every dog} \rrbracket = \llbracket \text{every} \rrbracket (\llbracket \text{dog} \rrbracket) =$$

$$\begin{aligned} & (\lambda P. \lambda Q. \forall x P(X) \rightarrow Q(x)) (\lambda x. \text{dog}(x)) = \\ & \lambda Q. \forall x (\lambda x. \text{dog}(x))(x) \rightarrow Q(x) = \\ & \lambda Q. \forall x \text{dog}(x) \rightarrow Q(x) \end{aligned}$$

$$\llbracket \text{eats a bone} \rrbracket = \llbracket \text{eats} \rrbracket (\llbracket \text{a bone} \rrbracket) =$$

$$\begin{aligned} & (\lambda T. \lambda x. T(\lambda z. \text{eats}(x, z))) (\lambda S. \exists y \text{bone}(y) \wedge S(y)) \\ & \lambda x. (\lambda S. \exists y \text{bone}(y) \wedge S(y)) (\lambda z. \text{eats}(x, z)) = \\ & \lambda x. \exists y \text{bone}(y) \wedge (\lambda z. \text{eats}(x, z))(y) = \\ & \lambda x. \exists y \text{bone}(y) \wedge \text{eats}(x, y) \end{aligned}$$

$$\llbracket \text{every dog eats a bone} \rrbracket = \llbracket \text{every dog} \rrbracket (\llbracket \text{eats a bone} \rrbracket) =$$

$$\begin{aligned} & (\lambda Q. \forall x \text{dog}(x) \rightarrow Q(x)) (\lambda x. \exists y \text{bone}(y) \wedge \text{eats}(x, y)) \\ & \forall x \text{dog}(x) \rightarrow (\lambda x. \exists y \text{bone}(y) \wedge \text{eats}(x, y))(x) = \\ & \forall x \text{dog}(x) \rightarrow \exists y \text{bone}(y) \wedge \text{eats}(y, x) \end{aligned}$$

b)

$$\begin{aligned} & \forall x \text{dog}(x) \rightarrow \exists y \text{bone}(y) \wedge \text{eats}(y, x) \\ & \exists y \text{bone}(y) \wedge \forall x \text{dog}(x) \rightarrow \text{eats}(y, x) \end{aligned}$$

- c) While one could represent quantifiers in AMR, for example using a ”:mod every” edge, AMR cannot represent quantifier scope. The reason for this is that the edges only express local semantic roles for individual concepts, not for entire phrases. As a result, there is no way to distinguish between the two readings from part b). Both interpretations would have the same graph representation.