Outlining Probability Distributions Using the Givenness Hierarchy

Alex LaGrassa

November 20, 2015

1 Problem

Given a sentence with modifier m, determiner d, set of features F, return the most probable object in a robot's memory.

Model the robots memory as a set of $n_i \in M$, or long term memory. A subset of those objects are in set A of activated object (objects the robot is actively working with). Call that set A and $A \subset M$. The robot has a function that maps the number(n_i) of objects present to a discrete probability function

$$F(n_i, o) = P(n_i = o)$$

. This is based on an internal distribution function with a probability $\forall o_i \in O$.

2 Defining the Most Probable Object

The most probable object n is the most likely object the sentence is referring to. That means it has the highest probability of being the object α such that $/m, d/ \in F_\alpha$

Defined more rigorously, we are finding

$$n.P(n = \alpha) = max(F(n, \alpha))$$

3 Updating the Probabilities if $\alpha \in A$

If the human and robot were working with objects on the table, it would be much more probable that the n_i where $n_i = \alpha$ was in the set of objects on tha table. The set of objects on the table would then be in the activated set, A. Thus,

$$\forall n_i, P(n_i | n_i \in A) >> P(n_i | n_i \notin A)$$

As an example, a determiner like "that" would indicate that $\alpha \in A$. It's still worthwhile to check the probabilities $\forall n_i \in M$, but if the object were found with reasonably high probability in A, checking M might not be necessary.

This way of updating the model is adapted from using the Givenness Hierarchy, (Gundel, Hedberg, and Zacharski 1993), which associates referential expresions with a "cognitive status." For example, if an object is referred to as "this", then it is in activated memory, while "that" usually refers to a familar object that is not necessarily in activated memory.

A probability update given that $n_i \in A$ would reweight with some $w > 0.5$ so $\forall n_i \in A, n_i' = w * n_i$ and $\forall n_i \ni A, n_i' = (1 - w) * n_i$

4 Updating Probability if $\exists_{=1}\alpha \in M$

Similarly, the Givennness Hierarchy would declare an object modified with "the" as uniquely identifiable. That means the probability function F now must take into account that all $\forall n_j.i \neq j$, $F(n_i, o) = \prod_{n_j \in M. j \neq i} P(n_i = o | n_j \neq o)$, which computationally becomes a much harder problem if there is conditional dependence on the other objects being α. Intuitively, it should be true that $P(n_i = o | \exists_{=1}\alpha \in M, n_{j \neq i \in M} != o) = 1$. Thus, the problem reducesto a joint probability distribution. The next question is whether to treat all other probabilities independently. If their probability of not being α depended on all other $n_j \in M$, then the joint probability would be very difficult if not impossible to compute, since it must account for dependencies on all objects.

Alternatively, this could change the algorithm by finding the n_i with the highest $P(n_i = \alpha)$ because finding "a" n_i would be less correct than finding the most probable $n_i \in M$