TTIC 31230, Fundamentals of Deep Learning

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Language Modeling

Language Modeling

The recent progress on NLP benchmarks is due to pretraining on language modeling.

Langauge modeling is based on unconditional cross-entropy minimiztion.

$$\Phi^* = \operatorname*{argmin}_{\Phi} \; E_{y \sim \text{Pop}} \; - \ln P_\Phi(y)$$

In language modeling y is a sentence (or fixed length block of text).

Language Modeling

Let W be some finite vocabulary of tokens (words).

Let Pop be a population distribution over W^* (sentences).

We want to train a model $P_\Phi(y)$ for sentences y

$$\Phi^* = \operatorname*{argmin}_\Phi \; E_{y \sim \text{Pop}} \; -\ln P_\Phi(y)$$

Autoregressive Models

A structured object, such as a sentence or an image, has an exponentially small probability.

An autoregressive model computes conditional probability for each part given "earlier" parts.

$$P_\Phi(w_0, w_1, \cdots, w_T) = \prod_{t=0}^{T} P_\Phi(w_t \mid w_1, \ldots, w_{t-1})$$

The End of Sequence Token <EOS>

We want to define a probability distribution over sentence of different length.

For this we require that each sentence is "terminated" with an end of sequence token <EOS>.

We requite $w_T =$ <EOS> and $w[t] \neq$ <EOS> for $t < T$.

This allows

$$P_\Phi(w_0, w_1, \cdots, w_T) = \prod_{t=0}^{T} P_\Phi(w_t \mid w_1, \ldots, w_{t-1})$$

To handle sequences of different length.

Standard Measures of Performance

Bits per Character: For character language models performance is measured in bits per character. Typical numbers are slightly over one bit per character.

Perplexity: It would be natural to measure word language models in bits per word. However, it is traditional to measure them in perplexity which is defined to be 2^b where b is bits per word. Perplexities of about 60 were typical until 2017.

According to Quora there are 4.79 letters per word. 1 bit per character (including space characters) gives a perplexity of $2^{5.79}$ or 55.3.

The State of the Art (SOTA)

As of March 2020 the state of the art neural language models yield perplexities of about 10.

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