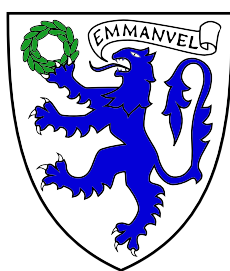


Unifying Transformers and Convolutional Neural Processes

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Contents

1 Transformers

1.1 Introduction

The Transformer is a deep learning architecture introduced in [?]. It is a sequence-to-sequence model that uses attention to learn the relationships between the input and output sequences.

In this report we will follow the notation that is used in [?] where embeddings are represented as rows $\in \mathbb{R}^{1 \times d}$ and all matrix multiplications are right multiplications.

1.2 Embedding

A machine is not capable of understand wordings, hence we need to transform it into a vector representation called an *embedding*. Let us denote the embedding of the i -th word in the input sequence as $\mathbf{x}^{(i)} \in \mathbb{R}^{1 \times d}$, where d is the feature dimension. The transformer is able to process these embeddings in **parallel** so we need a way to encode the position of the word in the sequence. We do this by adding a positional encoding $\mathbf{p}^{(i)} \in \mathbb{R}^{1 \times d}$ to the embedding \mathbf{x}_i . The positional encoding is a vector that is unique to the position of the word in the sequence. The positional encoding that is used in [?] is given by:

$$\mathbf{p}_j^{(i)} = \begin{cases} \sin\left(\frac{j}{10000^{2i/d}}\right) & \text{if } i \text{ is even} \\ \cos\left(\frac{j}{10000^{2i/d}}\right) & \text{if } i \text{ is odd} \end{cases} \quad (1)$$

where j is the dimension of the positional encoding. The positional encoding is added to the embedding as follows:

$$\mathbf{x}_i = \mathbf{x}_i + \mathbf{p}^{(i)} \in \mathbb{R}^{1 \times d} \quad (2)$$

These are all stacked together to form the input matrix $\mathbf{X} \in \mathbb{R}^{N \times d}$, where $\mathbf{X}_i = \mathbf{x}^{(i)}$ where N is the number of words in the input sequence.

[Alternative Positional Encoding] There are many ways to go about positional encoding. Another way is to use a learned positional encoding. This is done by adding a learnable vector $\mathbf{p}^{(i)} \in \mathbb{R}^{1 \times d}$ to the embedding. Alternatively to achieve translation equivariance, we can use *Relative Positional Encoding* [?, ?]. These positional encodings schemes will be useful when trying to build in equivariance into the Transformer model.

1.3 Attention

The attention mechanism is a way to learn the relationships between the input and output sequences.

2 Neural Processes

Neural Processes are an expansion of Gaussian Processes using Neural Networks introduced in [?]

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