Normalized and Geometry-Aware Self-Attention Network for Image Captioning

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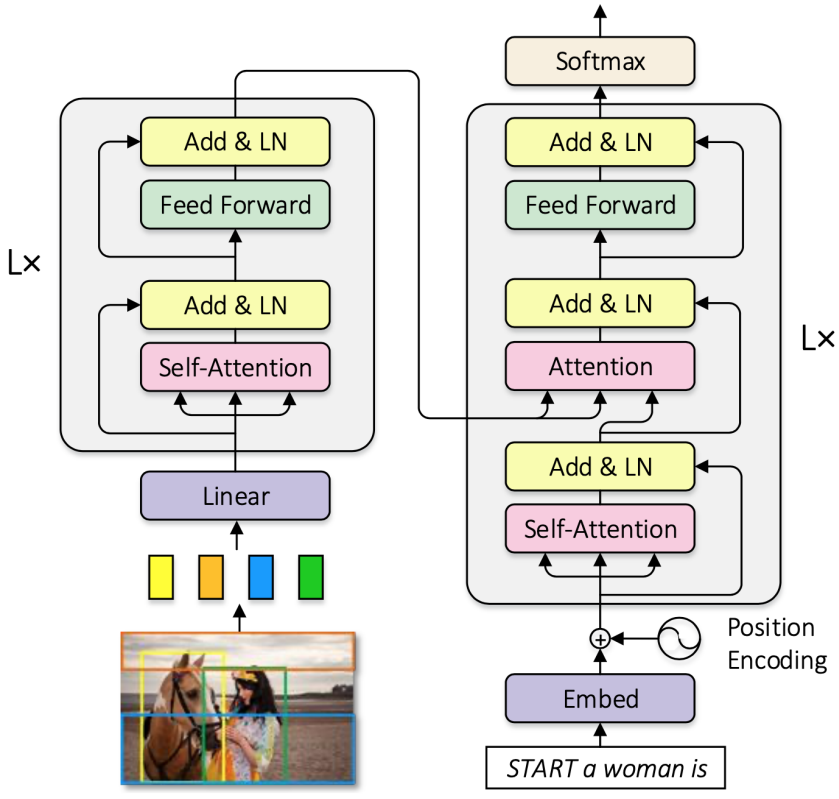
Self-Attention Networks for Image Captioning

- Take a usual Transformer model for machine translation;
- Use a pretrained Faster-RCNN model to extract objects and pass objects' features as an input to the encoder.
- Do not use positional embeddings for encoder



Normalization for an attention mechanism (N-SAN)

- Attention weights are calculated as:

$$\begin{aligned} S &= \text{Softmax}\left(QK^{\top}\right) \\ &= \text{Softmax}\left((XW_Q)\cdot\left(W_K^{\top}X^{\top}\right)\right) \end{aligned} \tag{1}$$

- The paper shows that it is beneficial to apply Instance Normalization to matrix Q:

$$\hat{x}_{btc} = \frac{x_{btc} - \mu_{bc}}{\sqrt{\sigma_{bc}^2 + \epsilon}}$$
$$\mu_{bc} = \frac{1}{T}\sum_{t=1}^{T} x_{btc}, \sigma_{bc}^2 = \frac{1}{T}\sum_{t=1}^{T}\left(x_{btc} - \mu_{bc}\right)^2 \tag{2}$$

- i.e. we normalize each sample independently across time dimension;

Incorporating geometry information (G-SAN)

- What if we mix positional information into attention calculation?

$$S = \text{Softmax}\left(QK^\top + \phi(Q', K', G)\right) \tag{3}$$

- Matrix G carries some non-trivial information about objects geometry.
- Here ϕ is a matrix of $\phi_{ij}(Q'_i, K'_j, G_{ij})$
- ϕ_{ij} is a one-layer NN on top of combinations of Q'_i, K'_j and G_{ij}.
- Authors consider different variants to combine three ingredients together.
- We compute $G_{ij} = \text{ReLU}\left(\text{FC}\left(\mathbf{f}^g_{ij}\right)\right)$ from $\mathbf{f}^g_{ij}$ which is a 4-dimensional vector of:

$$\mathbf{f}^g_{ij} = \left(\log\left(\frac{|x_i - x_j|}{w_i}\right), \log\left(\frac{|y_i - y_j|}{h_i}\right), \log\left(\frac{w_i}{w_j}\right), \log\left(\frac{h_i}{h_j}\right)\right)^{T-} \tag{4}$$

Some results and considerations

- Authors test an NG-SAN model on 2 tasks: image captioning, video question answering;
- Authors additionally test an N-SAN model on 2 tasks: video captioning, machine translation.
- Almost all the scores are improved somewhat marginally: $+0.1$-0.3 absolute points (0.2-0.7% of relative improvement). But seems like it is a lot for image captioning.
- Authors do not provide stds of the runs which would be very helpful.