Parallelizing Linear Recurrent Neural Nets Over Sequence Length

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Abstract

RNN training and inference generally takes time linear in the sequence length because of non-linear sequential dependencies. We show the training and inference of RNNs with only linear sequential dependencies can be parallelized over the sequence length using the parallel scan algorithm, leading to rapid training on long sequences even with small minibatch size. We use this insight and a parallel linear recurrence CUDA kernel to accelerate several state of the art RNN architectures by up to 9x and to solve a synthetic sequence classification task with a one million timestep dependency.

Background

Large minibatches are necessary for computational performance but create large memory requirements and may damage model generalization ability.

Linear RNNs and convolutional models such as strongly typed RNNs, Wavenet, Bytenet, quasi-RNNs, and simple recurrent units have achieved state of the art results on many sequential tasks with rapid training times.

Given x_t, λ_t can compute $h_t = \lambda_t h_{t-1} + x_t$ for $t = 1 \dots T$ on p processors in $O(T/p + \log(p))$ with the classic parallel scan algorithm.

This statement requires citation [**?**].

3	1	5	0	2	4	2	6	1
3	4	**9**	0	2	**6**	2	8	9
			+9			**+9+6**		
3	4	9	9	11	15	17	23	24

Figure 1: Parallel cumulative sum example

Materials

The following materials were required to complete the research:

- Curabitur pellentesque dignissim
- Eu facilisis est tempus quis
- Duis porta consequat lorem
- Eu facilisis est tempus quis

The materials were prepared according to the steps outlined below:

1. Curabitur pellentesque dignissim
2. Eu facilisis est tempus quis
3. Duis porta consequat lorem
4. Curabitur pellentesque dignissim

Important Result

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Mathematical Section

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$$E = mc^2 \tag{1}$$

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$$\cos^3\theta = \frac{1}{4}\cos\theta + \frac{3}{4}\cos 3\theta \tag{2}$$

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$$\kappa = \frac{\xi}{E_{\max}} \tag{3}$$

Methods

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Results

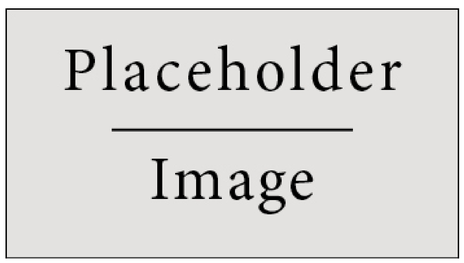

Figure 2: Figure caption

Nunc tempus venenatis facilisis. Curabitur suscipit consequat eros non porttitor. Sed a massa dolor, id ornare enim:

Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table 1: Table caption

Conclusion

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Additional Information

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- Curabitur pellentesque dignissim
- Eu facilisis est tempus quis
- Duis porta consequat lorem

References

Acknowledgements

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