05 Stable deep learning for time-series data

- Preventing gradient explosions in gated recurrent units -

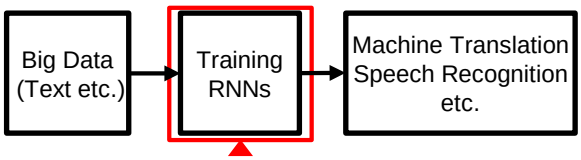
Abstract

We propose a method to stabilize training of Recurrent Neural Networks (RNNs). The RNN is one of the most successful models to handle the time-series data in many applications such as speech recognition or machine translation. However, training of RNNs requires trial and error, and expertise since training of RNNs is difficult due to the gradient exploding problem. In this study, we focus on the Gated Recurrent Unit (GRU), which is one of the modern RNN models. We reveal the parameter point at which training of GRUs is disrupted by the gradient exploding problem and propose an algorithm to prevent the gradient from exploding. Our method can reduce time for trial and error, and does not require in-depth expertise to tune the hyper-parameters for training of GRU.

Back ground

Recurrent Neural Networks (RNNs)

Models for the time-series data
1. Training RNNs
2. Prediction by using RNNs



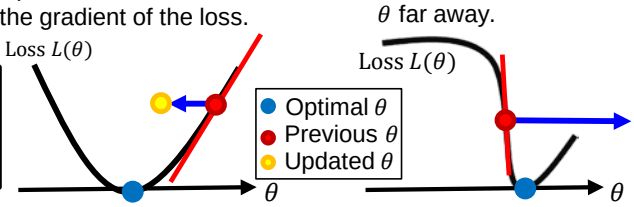
Updating parameters θ to minimize loss iteratively

Problem

Failure to train due to the extremely large gradient

Update θ based on the gradient of the loss.

A large gradient moves θ far away.



Existing method clips the gradient by the threshold that is tuned through trial and error.

Proposed method

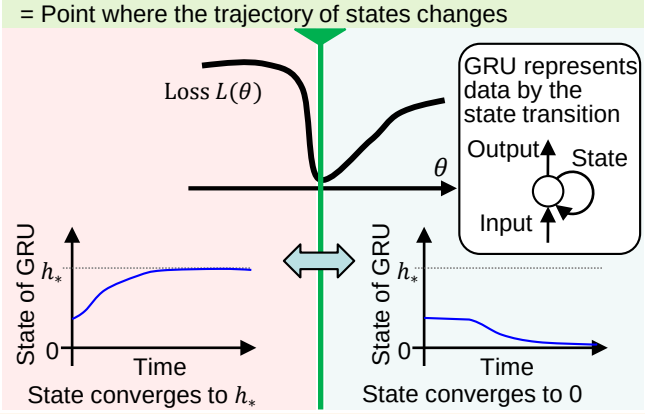
Training while avoiding the point at which gradients explode

(1) Reveal the point at which gradients explode

Gradients explode where the dynamics of RNNs changes.

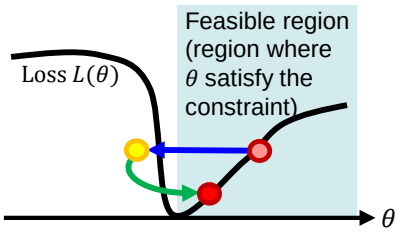
Analyze the dynamics of GRUs (modern RNN models).

Point where gradients explode
= Point where the trajectory of states changes



(2) Constrain θ not to reach the point revealed by (1)

θ is constrained where gradients do not explode.



Bring back θ into the feasible region when θ go out the feasible region

Prevent the gradient exploding problems

Reduce time for trial and error

In-depth expertise is not required

Reference

[1] Sekitoshi Kanai, Yasuhiro Fujiwara, Sotetsu Iwamura, "GRU学習時の勾配爆発の抑制方法の提案," *The 14th Information-Based Induction Sciences Workshop (IBIS2016)*, 2016. (In Japanese)

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