Master thesis in Computer Science, Spring 2021
Credits: 30
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Title: Investigating the latency cost of statistical learning of a Gaussian mixture simulating on a convolutional density network with adaptive batch size technique for background modeling

Description

Recent years have witnessed the proliferation of convolutional neural networks via effective learning-based approaches in change detection. However, these techniques only provide a limited description and the observed scenes' insufficient properties, where the single-valued mapping is learned to approximate the conditional averages of the target background conditioned on color and motion features of each image batch. On the other hand, statistical learning in imagery domains has become one of the most popular approaches with high adaptation to dynamic context transformation, especially the Gaussian Mixture Model. Simulating the statistical learning of a Gaussian mixture on a convolutional neural network exploits a statistical inference on scene analysis with only about a few hundreds of parameters while still maintaining rapid convergence to complex motion patterns. Besides modeling the underlying generator of the data as a non-convex optimization problem, we investigate the cost of communication when training the network with an adaptive batch size technique.

Goal

In this work, we introduce a novel, unsupervised, convolutional neural network that presents the conditional probability distributions grounded on a Gaussian Mixture Model, called Convolutional Density Network Gaussian Mixture (CDN-GM). The trade-off between energy efficiency and accuracy in the model will be investigated with an adaptive batch size throughout network training. In summary, with an assumption that the background scene of a video sequence contains the most commonly seen intensity value at each image point, our contributions in this work are proposed towards three following research questions:

RQ #1. Representing a conditional probability density function of a Mixture of Gaussians, which models the time-related history at each pixel location on a feed-forward CNN

RQ #2. Modeling the underlying generator of the data with a trainable, unsupervised loss function for Convolutional Density Network of Gaussian Mixture

RQ #3. Investigating trade-off between energy efficiency and accuracy of the model with an adaptive batch size throughout the training of the proposed network

Method

- Surveying dynamic approximation of background modeling with the requirements of robustness to real-time processing and adaptation to scene dynamics
- Surveying the communication-avoiding mechanism in the context of accelerating the optimization method of neural network training: model parallelism and data parallelism
- Proposing and evaluating an architecture of Convolutional Density Network of Gaussian Mixture (CDN-GM) on a variety of scene dynamics. Comparing the results with state-of-the-art approaches of background modeling and change detection on publicly-available datasets.
- If time allows, investigating the model training with a technique of an adaptive batch size to analyze the trade-off between energy efficiency and accuracy of the proposed network, communication cost regarding data parallelism

Schedule/timetable:

- Jan. - Feb. 2021: Surveying dynamic approximation of background modeling with robustness requirements to real-time processing and adaptation to scene dynamics. Surveying the communication-avoiding mechanism in the context of accelerating the optimization method of neural network training
- Feb. – Apr. 2021: Proposing and evaluating an architecture of Convolutional Density Network of Gaussian Mixture (CDN-GM) on a variety of scene dynamics. Comparing the results with state-of-the-art approaches of background modeling and change detection on publicly-available datasets. If time allows, investigating the model training with an adaptive batch size technique to analyze the trade-off between energy efficiency and accuracy of the proposed network, communication cost regarding data parallelism.
- May 2021: Finishing MSc thesis

Deliverables:

- Report
- Code for experimental evaluation and possible improvement.

Equipment: HPC in the AGC Lab.

Literature: Multiple papers will be recommended to the student.