SNN Meets ANN: Combining Spiking Neural Network (SNN) and Artificial Neural Network (ANN) for Image Classification
SNN・ミーツ・ANN
―スパイキングニューラルネットワークと人工ニューラルネットワークの組み合わせによる画像分類―

Student No.: 201821636
氏名: 村松　直哉
Name: Muramatsu Naoya

In recent years, deep learning has achieved breakthrough successes in various fields, such as image recognition, natural language processing, playing perfect-information game and so on. Unfortunately, the traditional deep neural networks, referred to as artificial neural networks (ANNs), suffer from high energy consumption. Therefore, spiking neural networks (SNNs) have been proposed, which can dramatically decrease the computational power during training and inference of machine learning models. However, SNNs are inferior to conventional neural networks in terms of performance even for the simplest task, image classification. The reason is that data handled in the real world often have been normalized into the range of $[0, 1]$, which is not appropriate for SNNs processing spikes, sparse and binary signals.

To cope with the aforementioned issues, we appeal to combine SNN and ANN, and propose hybrid neural networks (HNNs). An HNN consists of spiking layers (SLs, i.e., the neural layers of an SNN) and artificial layers (ALs, i.e., the neural layers of an ANN). Thanks to the coding methods, such as the existing ones (duplicate coding and Poisson coding) and our proposed differentiable Gaussian coding, we can bridge the two kinds of neural layers by converting the real-valued data into binary spike trains. Furthermore, we introduce two learning methods, which enables us to train SLs and ALs either separately or simultaneously.

To demonstrate the effectiveness of the proposed framework, we conducted a series of experiments based on the widely used datasets, MNIST and CIFAR-10. The experimental results show that: (1) The performance of a network can generally be improved by increasing the ratio of ALs, which can surpass that of pure SNNs. (2) Gaussian coding is capable of achieving higher accuracy for complex datasets even when the percentage of ALs is small. The proposed HNNs can bridge the gap between the traits of ANNs and SNNs, which provides insights on well understanding the potential of SNN.

Principal Academic Advisor: Tetsuji SATOH
Secondary Academic Advisor: Hai-Tao YU