Converting ANN architectures to SNN with GeNN

Jorge Felipe Gaviria Fierro, Laura Isabella Forero Camacho

UNIVERSITY OF SUSSEX

Universidad de los Andes

Introduction

Neural Networks are a series of neurons connected and used for predictive modeling, adaptative control and applications where they can be trained via a dataset.

Spiking neural networks (SNNs) are artificial neural networks that more closely mimic natural neural networks. SNNs operate based on dynamic binary spiking inputs as a function of time.

Objectives

The objective was to create Artificial Neural Networks architectures and transform them into Spiking Neural Networks following the next constraints:

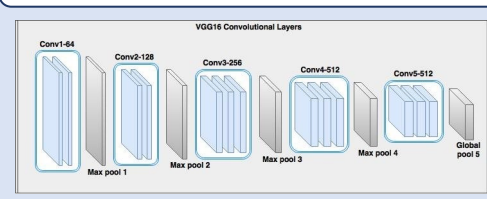
1. The TF model most consist of ReLU layers.
2. No bias tensor most be included in the layers.
3. Average Pooling Layers most be used. This is because the concept of maximum output is less meaningful when the only values it can take are zero for n = 0 spikes, or one for n > 0 spikes.
4. The padding can only be of type valid or same.

Data-set used: **CIFAR-10.**

Sequential

A Sequential model is appropriate for a plain stack of layers where each layer has exactly one input tensor and one output tensor.

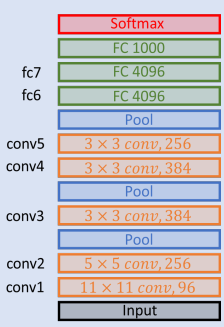
VGG13



VGG-13 is a CNN architecture . It contains 13 convolutional layers and 4 max-pooling layers.

VGG-13 Model Conversion Reults (89.5% acc)			
Type Converter	Input Type	Time (ms)	SNN accuracy
data-norm	poisson	2500	79.17%
data-norm	poisson signed	2500	78.51%
data-norm	if	2500	75.28%
spike-norm	spike	2500	9.50%
spike-norm	poisson signed	2500	57.08%
FS	-	10	89.19%

AlexNet



AlexNet

AlexNet is a CNN architecture, designed by Alex Krizhevsky. It consists of 5 convolutional layers and 3 max-pooling layers.

AlexNet Model Conversion Results (80% acc)			
Type Converter	Input Type	Time (ms)	SNN accuracy
data-norm	poisson	500	72.02%
data-norm	poisson signed	500	71.44%
data-norm	if	500	67.2%
spike-norm	spike	500	10.22%
spike-norm	poisson signed	500	69.52%
FS	-	10	24.23%

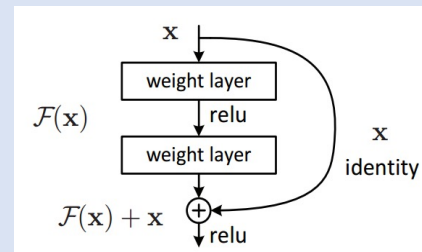
Other architectures implemented: MobileNet V1.

Functional API

The functional API can handle models with non-linear topology, shared layers, and multiple inputs or outputs.

ResNet

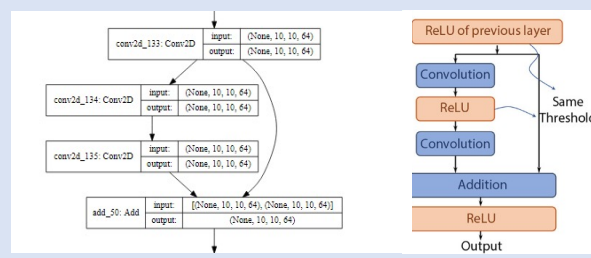
ResNet was proposed in 2015 by researchers at Microsoft. This architecture introduced the concept called Residual Network.



Residual Block: Solve the problem of the vanishing/exploding gradient.

Sengupta corrections:

We added an identity convolutional layer at the beginning of the block for adding the same threshold since activation layers are not yet supported by mlgenn.



ANN accuracy : 81.3%
SNN (data-norm): 33%
SNN (data-norm with Sengupta corrections): 13.2%

Discussion

The conversion of sequential architectures obtained a minimum difference of 9% between the accuracy of the ANN and the SNN. The architecture with the best results was VGG-13. In addition, the best performing conversion was data-norm. Further adjustments should be done in order to obtain better results when converting Functional API networks.

Code repository:
https://github.com/jfgf11/ml_genn_examples_ssh

References

Sengupta, A. (2019). Going Deeper in Spiking Neural Networks: VGG and Residual Architectures. Frontiers.

Stöckl, C. (2021). Optimized spiking neurons can classify images with high accuracy through temporal coding with two spikes. Nature Machine Intelligence.

https://www.tensorflow.org/datasets/catalog/cifar10