AnalogVNN

Release 1.0.8

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CONTENTS

GitHub: https://github.com/Vivswan/AnalogVNN

AnalogVNN is a simulation framework built on PyTorch which can simulate the effects of analog components like optoelectronic noise, limited precision, and signal normalization present in photonics neural network accelerators. By following the same layer structure design present in PyTorch, the AnalogVNN framework allows users to convert most digital neural network models to their analog counterparts with just a few lines of code, taking full advantage of the open-source optimization, deep learning, and GPU acceleration libraries available through PyTorch.

CHAPTER

ONE

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1.1 Install AnalogVNN

AnalogVNN is tested and supported on the following 64-bit systems:

- Python 3.7, 3.8, 3.9, 3.10, 3.11
- Windows 7 and later
- Ubuntu 16.04 and later, including WSL
- Red Hat Enterprise Linux 7 and later
- OpenSUSE 15.2 and later
- macOS 10.12 and later

1.1.1 Installation

Install PyTorch then:

- Pip:

```
# Current stable release for CPU and GPU
pip install analogvnn

# For additional optional features
pip install analogvnn[full]
```

OR

- AnalogVNN can be downloaded at (GitHub) or creating a fork of it.

1.1.2 Dependencies

Install the required dependencies:

- PyTorch
  - Manual installation required: https://pytorch.org/
- dataclasses
- scipy
- numpy

- networkx
- (optional) tensorboard
  - For using tensorboard to visualize the network, with class *analogvnn.utils.TensorboardModelLog.TensorboardModelLog*
- (optional) torchinfo
  - For adding summary to tensorboard by using *analogvnn.utils.TensorboardModelLog.TensorboardModelLog.add_summary()*
- (optional) graphviz
  - For saving and rendering forward and backward graphs using *analogvnn.graph.AcyclicDirectedGraph.AcyclicDirectedGraph.render()*
- (optional) python-graphviz
  - For saving and rendering forward and backward graphs using *analogvnn.graph.AcyclicDirectedGraph.AcyclicDirectedGraph.render()*

That's it, you are all set to simulate analog neural networks.

Head over to the *Tutorial* and look over the *Sample code*.

1.2 Cite AnalogVNN

We would appreciate if you cite the following paper in your publications for which you used AnalogVNN:

DOI: 10.48550/arXiv.2210.10048

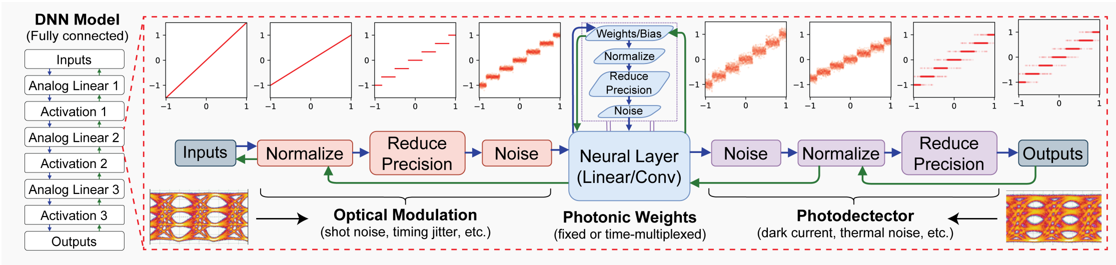
1.2.1 In BibTeX format

```
@article{shah2022analogvnn,
  title={AnalogVNN: A fully modular framework for modeling and optimizing photonic␣
↪neural networks},
  author={Shah, Vivswan and Youngblood, Nathan},
  journal={arXiv preprint arXiv:2210.10048},
  year={2022}
}
```

1.2.2 In textual form

```
Vivswan Shah, and Nathan Youngblood. "AnalogVNN: A fully modular framework for modeling
and optimizing photonic neural networks." arXiv preprint arXiv:2210.10048 (2022).
```

1.3 Sample code



Sample code and Sample code with logs for 3 layered linear photonic analog neural network with 4-bit precision, 0.5 *Leakage* and *Clamp* normalization:

```
import torch.backends.cudnn
import torchvision
from torch import optim, nn
from torch.utils.data import DataLoader
from torchvision.transforms import transforms

from analogvnn.nn.Linear import Linear
from analogvnn.nn.activation.Gaussian import GeLU
from analogvnn.nn.module.FullSequential import FullSequential
from analogvnn.nn.noise.GaussianNoise import GaussianNoise
from analogvnn.nn.normalize.Clamp import Clamp
from analogvnn.nn.precision.ReducePrecision import ReducePrecision
from analogvnn.parameter.PseudoParameter import PseudoParameter
from analogvnn.utils.is_cpu_cuda import is_cpu_cuda


def load_vision_dataset(dataset, path, batch_size, is_cuda=False, grayscale=True):
    """

    Loads a vision dataset with optional grayscale conversion and CUDA support.

    Args:
        dataset (Type[torchvision.datasets.VisionDataset]): the dataset class to use (e.
↪g. torchvision.datasets.MNIST)
        path (str): the path to the dataset files
        batch_size (int): the batch size to use for the data loader
        is_cuda (bool): a flag indicating whether to use CUDA support (defaults to False)
        grayscale (bool): a flag indicating whether to convert the images to grayscale␣
↪(defaults to True)

    Returns:
        A tuple containing the train and test data loaders, the input shape, and a tuple␣
↪of class labels.
    """

    dataset_kwargs = {
        'batch_size': batch_size,
        'shuffle': True
```

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```
    }

    if is_cuda:
        cuda_kwargs = {
            'num_workers': 1,
            'pin_memory': True,
        }
        dataset_kwargs.update(cuda_kwargs)

    if grayscale:
        use_transform = transforms.Compose([
            transforms.Grayscale(),
            transforms.ToTensor(),
        ])
    else:
        use_transform = transforms.Compose([transforms.ToTensor()])

    train_set = dataset(root=path, train=True, download=True, transform=use_transform)
    test_set = dataset(root=path, train=False, download=True, transform=use_transform)
    train_loader = DataLoader(train_set, **dataset_kwargs)
    test_loader = DataLoader(test_set, **dataset_kwargs)

    zeroth_element = next(iter(test_loader))[0]
    input_shape = list(zeroth_element.shape)

    return train_loader, test_loader, input_shape, tuple(train_set.classes)


def cross_entropy_accuracy(output, target) -> float:
    """Cross Entropy accuracy function.

    Args:
        output (torch.Tensor): output of the model from passing inputs
        target (torch.Tensor): correct labels for the inputs

    Returns:
        float: accuracy from 0 to 1
    """

    _, preds = torch.max(output.data, 1)
    correct = (preds == target).sum().item()
    return correct / len(output)


class LinearModel(FullSequential):
    def __init__(self, activation_class, norm_class, precision_class, precision, noise_
↪class, leakage):
        """Initialise LinearModel with 3 Dense layers.

        Args:
            activation_class: Activation Class
            norm_class: Normalization Class
```

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```
            precision_class: Precision Class (ReducePrecision or␣
↪StochasticReducePrecision)
            precision (int): precision of the weights and biases
            noise_class: Noise Class
            leakage (float): leakage is the probability that a reduced precision digital␣
↪value (e.g., “1011”) will
            acquire a different digital value (e.g., “1010” or “1100”) after passing␣
↪through the noise layer
            (i.e., the probability that the digital values transmitted and detected are␣
↪different after passing through
            the analog channel).
        """

        super().__init__()

        self.activation_class = activation_class
        self.norm_class = norm_class
        self.precision_class = precision_class
        self.precision = precision
        self.noise_class = noise_class
        self.leakage = leakage

        self.all_layers = []
        self.all_layers.append(nn.Flatten(start_dim=1))
        self.add_layer(Linear(in_features=28 * 28, out_features=256))
        self.add_layer(Linear(in_features=256, out_features=128))
        self.add_layer(Linear(in_features=128, out_features=10))

        self.add_sequence(*self.all_layers)

    def add_layer(self, layer):
        """To add the analog layer.

        Args:
            layer (BaseLayer): digital layer module
        """

        self.all_layers.append(self.norm_class())
        self.all_layers.append(self.precision_class(precision=self.precision))
        self.all_layers.append(self.noise_class(leakage=self.leakage, precision=self.
↪precision))
        self.all_layers.append(layer)
        self.all_layers.append(self.noise_class(leakage=self.leakage, precision=self.
↪precision))
        self.all_layers.append(self.norm_class())
        self.all_layers.append(self.precision_class(precision=self.precision))
        self.all_layers.append(self.activation_class())
        self.activation_class.initialise_(layer.weight)


class WeightModel(FullSequential):
    def __init__(self, norm_class, precision_class, precision, noise_class, leakage):
```

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```
        """Initialize the WeightModel.

        Args:
            norm_class: Normalization Class
            precision_class: Precision Class (ReducePrecision or␣
↪StochasticReducePrecision)
            precision (int): precision of the weights and biases
            noise_class: Noise Class
            leakage (float): leakage is the probability that a reduced precision digital␣
↪value (e.g., “1011”) will
            acquire a different digital value (e.g., “1010” or “1100”) after passing␣
↪through the noise layer
            (i.e., the probability that the digital values transmitted and detected are␣
↪different after passing through
            the analog channel).
        """

        super().__init__()
        self.all_layers = []

        self.all_layers.append(norm_class())
        self.all_layers.append(precision_class(precision=precision))
        self.all_layers.append(noise_class(leakage=leakage, precision=precision))

        self.eval()
        self.add_sequence(*self.all_layers)


def run_linear3_model():
    """The main function to train photonics image classifier with 3 linear/dense nn for␣
↪MNIST dataset."""

    is_cpu_cuda.use_cuda_if_available()
    torch.backends.cudnn.benchmark = True
    torch.manual_seed(0)
    device, is_cuda = is_cpu_cuda.is_using_cuda
    print(f'Device: {device}')
    print()

    # Loading Data
    print('Loading Data...')
    train_loader, test_loader, input_shape, classes = load_vision_dataset(
        dataset=torchvision.datasets.MNIST,
        path='_data/',
        batch_size=128,
        is_cuda=is_cuda
    )

    # Creating Models
    print('Creating Models...')
    nn_model = LinearModel(
        activation_class=GeLU,
```

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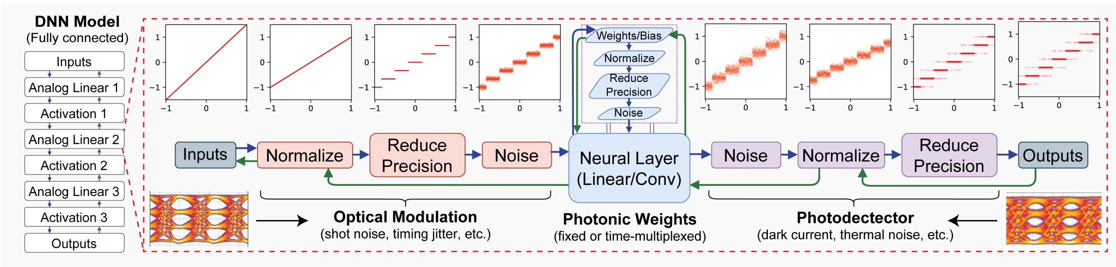
```
        norm_class=Clamp,
        precision_class=ReducePrecision,
        precision=2 ** 4,
        noise_class=GaussianNoise,
        leakage=0.5
    )
    weight_model = WeightModel(
        norm_class=Clamp,
        precision_class=ReducePrecision,
        precision=2 ** 4,
        noise_class=GaussianNoise,
        leakage=0.5
    )

    # Parametrizing Parameters of the Models
    PseudoParameter.parametrize_module(nn_model, transformation=weight_model)

    # Setting Model Parameters
    nn_model.loss_function = nn.CrossEntropyLoss()
    nn_model.accuracy_function = cross_entropy_accuracy
    nn_model.optimizer = optim.Adam(params=nn_model.parameters())

    # Compile Model
    nn_model.compile(device=device)
    weight_model.compile(device=device)

    # Training
    print('Starting Training...')
    for epoch in range(10):
        train_loss, train_accuracy = nn_model.train_on(train_loader, epoch=epoch)
        test_loss, test_accuracy = nn_model.test_on(test_loader, epoch=epoch)

        str_epoch = str(epoch + 1).zfill(1)
        print_str = f'({str_epoch})' \
                    f' Training Loss: {train_loss:.4f},' \
                    f' Training Accuracy: {100. * train_accuracy:.0f}%,' \
                    f' Testing Loss: {test_loss:.4f},' \
                    f' Testing Accuracy: {100. * test_accuracy:.0f}%\n'
        print(print_str)
    print('Run Completed Successfully...')


if __name__ == '__main__':
    run_linear3_model()
```

1.4 Tutorial



To convert a digital model to its analog counterpart the following steps needs to be followed:

1. Adding the analog layers to the digital model. For example, to create the Photonic Linear Layer with *Reduce Precision*, *Normalization* and *Noise*:

   1. Create the model similar to how you would create a digital model but using *analogvnn.nn.module.FullSequential.FullSequential* as superclass

```
class LinearModel(FullSequential):
    def __init__(self, activation_class, norm_class, precision_class, precision,
↪ noise_class, leakage):
        super().__init__()

        self.activation_class = activation_class
        self.norm_class = norm_class
        self.precision_class = precision_class
        self.precision = precision
        self.noise_class = noise_class
        self.leakage = leakage

        self.all_layers = []
        self.all_layers.append(nn.Flatten(start_dim=1))
        self.add_layer(Linear(in_features=28 * 28, out_features=256))
        self.add_layer(Linear(in_features=256, out_features=128))
        self.add_layer(Linear(in_features=128, out_features=10))

        self.add_sequence(*self.all_layers)
```

   Note: *analogvnn.nn.module.Sequential.Sequential.add_sequence()* is used to create and set forward and backward graphs in AnalogVNN, more information in *Inner Workings*

   2. To add the Reduce Precision, Normalization, and Noise before and after the main Linear layer, `add_layer` function is used.

```
def add_layer(self, layer):
    self.all_layers.append(self.norm_class())
    self.all_layers.append(self.precision_class(precision=self.precision))
    self.all_layers.append(self.noise_class(leakage=self.leakage,␣
↪precision=self.precision))
    self.all_layers.append(layer)
    self.all_layers.append(self.noise_class(leakage=self.leakage,␣
↪precision=self.precision))
    self.all_layers.append(self.norm_class())
```

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```
        self.all_layers.append(self.precision_class(precision=self.precision))
        self.all_layers.append(self.activation_class())
        self.activation_class.initialise_(layer.weight)
```

2. Creating an Analog Parameters Model for analog parameters (analog weights and biases)

```
class WeightModel(FullSequential):
    def __init__(self, norm_class, precision_class, precision, noise_class,␣
↪leakage):
        super().__init__()
        self.all_layers = []

        self.all_layers.append(norm_class())
        self.all_layers.append(precision_class(precision=precision))
        self.all_layers.append(noise_class(leakage=leakage, precision=precision))

        self.eval()
        self.add_sequence(*self.all_layers)
```

Note: Since the `WeightModel` will only be used for converting the data to analog data to be used in the main `LinearModel`, we can use `eval()` to make sure the `WeightModel` is never been trained

3. Simply getting data and setting up the model as we will normally do in PyTorch with some minor changes for automatic evaluations

```
torch.backends.cudnn.benchmark = True
device, is_cuda = is_cpu_cuda.is_using_cuda
print(f"Device: {device}")
print()

# Loading Data
print(f"Loading Data...")
train_loader, test_loader, input_shape, classes = load_vision_dataset(
    dataset=torchvision.datasets.MNIST,
    path="_data/",
    batch_size=128,
    is_cuda=is_cuda
)

# Creating Models
print(f"Creating Models...")
nn_model = LinearModel(
    activation_class=GeLU,
    norm_class=Clamp,
    precision_class=ReducePrecision,
    precision=2 ** 4,
    noise_class=GaussianNoise,
    leakage=0.5
)
weight_model = WeightModel(
    norm_class=Clamp,
    precision_class=ReducePrecision,
    precision=2 ** 4,
```

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```
    noise_class=GaussianNoise,
    leakage=0.5
)

# Setting Model Parameters
nn_model.loss_function = nn.CrossEntropyLoss()
nn_model.accuracy_function = cross_entropy_accuracy
nn_model.compile(device=device)
weight_model.compile(device=device)
```

4. Using Analog Parameters Model to convert digital parameters to analog parameters using *analogvnn.parameter.PseudoParameter.PseudoParameter.parametrize_module()*

```
PseudoParameter.parametrize_module(nn_model, transformation=weight_model)
```

5. Adding optimizer

```
nn_model.optimizer = optim.Adam(params=nn_model.parameters())
```

6. Then you are good to go to train and test the model

```
# Training
print(f"Starting Training...")
for epoch in range(10):
    train_loss, train_accuracy = nn_model.train_on(train_loader, epoch=epoch)
    test_loss, test_accuracy = nn_model.test_on(test_loader, epoch=epoch)

    str_epoch = str(epoch + 1).zfill(1)
    print_str = f'({str_epoch})' \
                f' Training Loss: {train_loss:.4f},' \
                f' Training Accuracy: {100. * train_accuracy:.0f}%,' \
                f' Testing Loss: {test_loss:.4f},' \
                f' Testing Accuracy: {100. * test_accuracy:.0f}%\n'
    print(print_str)
print("Run Completed Successfully...")
```

Full Sample code for this process can be found at *Sample code*

1.5 Inner Workings

There are three major new classes in AnalogVNN, which are as follows

1.5.1 PseudoParameters

class:*analogvnn.parameter.PseudoParameter.PseudoParameter()*

`PseudoParameters` is a subclass of `Parameter` class of PyTorch.

`PseudoParameters` class lets you convent a digital parameter to analog parameter by converting the parameter of layer of `Parameter` class to `PseudoParameters`.

`PseudoParameters` requires a ParameterizingModel to parameterize the parameters (weights and biases) of the layer to get parameterized data

PyTorch's ParameterizedParameters vs AnalogVNN's PseudoParameters:

- Similarity (Forward or Parameterizing the data):

  Data → ParameterizingModel → Parameterized Data

- Difference (Backward or Gradient Calculations):
  - ParameterizedParameters

    Parameterized Data → ParameterizingModel → Data

  - PseudoParameters

    Parameterized Data → Data

So, by using `PseudoParameters` class the gradients of the parameter are calculated in such a way that the ParameterizingModel was never present.

To convert parameters of a layer or model to use PseudoParameters, then use:

```
PseudoParameters.parameterize(Model, "parameter_name",␣
↪transformation=ParameterizingModel)
```

OR

```
PseudoParameters.parametrize_module(Model, transformation=ParameterizingModel)
```

1.5.2 Forward and Backward Graphs

Graph class:*analogvnn.graph.ModelGraph.ModelGraph()*

Forward Graph class:*analogvnn.graph.ForwardGraph.ForwardGraph()*

Backward Graph class:*analogvnn.graph.BackwardGraph.BackwardGraph()*

Documentation Coming Soon…

1.6 Extra Analog Classes

Some extra layers which can be found in AnalogVNN are as follows:

1.6.1 Reduce Precision

Reduce Precision classes are used to reduce precision of an input to some given precision level

ReducePrecision

class: *analogvnn.nn.precision.ReducePrecision.ReducePrecision*

Reduce Precision uses the following function to reduce precision of the input value

$$RP(x) = sign(x * p) * max(\left\lfloor \left| x * p \right| \right\rfloor, \left\lceil \left| x * p \right| - d \right\rceil) * \frac{1}{p}$$

where:

- x is the original number in full precision
- p is the analog precision of the input signal, output signal, or weights (p Natural Numbers, $Bit\ Precision = log_2(p+1)$)
- d is the divide parameter (0 d 1, default value = 0.5) which determines whether x is rounded to a discrete level higher or lower than the original value

StochasticReducePrecision

class: *analogvnn.nn.precision.StochasticReducePrecision.StochasticReducePrecision*

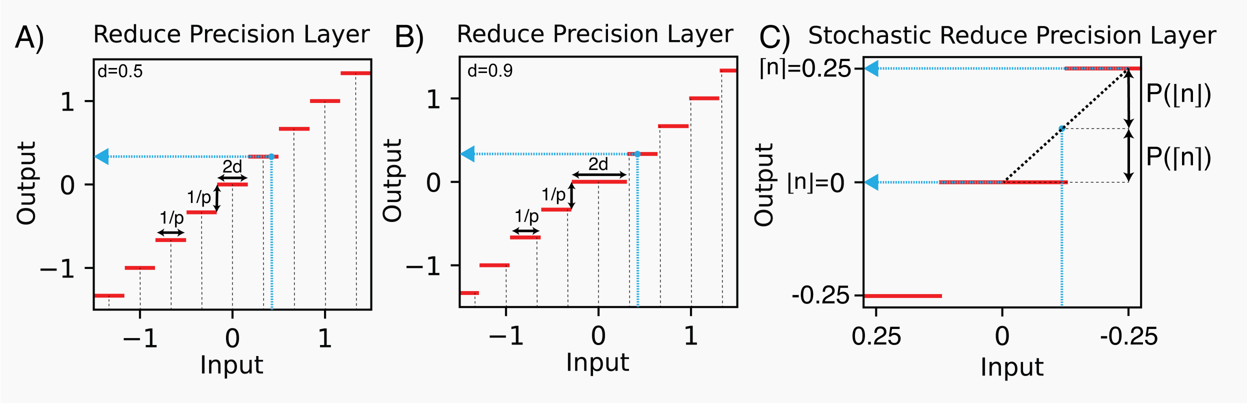
Reduce Precision uses the following probabilistic function to reduce precision of the input value

$$SRP(x) = sign(x * p) * f(\left| x * p \right|) * \frac{1}{p}$$

$$f(x) = \begin{cases} \lfloor x \rfloor & : r \leq 1 - \left| \lfloor x \rfloor - x \right| \\ \lceil x \rceil & : otherwise \end{cases}$$

where:

- r is a uniformly distributed random number between 0 and 1
- p is the analog precision (p Natural Numbers, $Bit\ Precision = log_2(p+1)$)
- f(x) is the stochastic rounding function



1.6.2 Normalization

LPNorm

class: *analogvnn.nn.normalize.LPNorm.LPNorm*

$$L^pNorm(x) = \left[x_{ij..k} \rightarrow \frac{x_{ij..k}}{\sqrt[p]{\sum_{j..k} |x_{ij..k}|^p}} \right]$$

$$L^pNormM(x) = \frac{L^pNorm(x)}{max(|L^pNorm(x)|)}$$

where:

- x is the input weight matrix,
- i, j … k are indexes of the matrix,
- p is a positive integer.

LPNormW

class: *analogvnn.nn.normalize.LPNorm.LPNormW*

$$L^pNormW(x) = \frac{x}{\|x\|_p} = \frac{x}{\sqrt[p]{\sum |x|^p}}$$

$$L^pNormWM(x) = \frac{L^pNormW(x)}{max(|L^pNormW(x)|)}$$

where:

- x is the input weight matrix,
- p is a positive integer.

Clamp

class: `analogvnn.nn.normalize.Clamp.Clamp`

$$Clamp_{pq}(x) = \begin{cases} q & : qx \\ x & : p \leq x \leq q \\ p & : px \end{cases}$$

where:

- p, q   (p q, Default value for photonics p = 1 and q = 1)

1.6.3 Noise

Leakage

We have defined an information loss parameter, "Error Probability" or "EP" or "Leakage", as the probability that a reduced precision digital value (e.g., "1011") will acquire a different digital value (e.g., "1010" or "1100") after passing through the noise layer (i.e., the probability that the digital values transmitted and detected are different after passing through the analog channel). This is a similar concept to the bit error ratio (BER) used in digital communications, but for numbers with multiple bits of resolution. While SNR (signal-to-noise ratio) is inversely proportional to sigma, the standard deviation of the signal noise, EP is indirectly proportional to . However, we choose EP since it provides a more intuitive understanding of the effect of noise in an analog system from a digital perspective. It is also similar to the rate parameter used in PyTorch's Dropout Layer [23], though different in function. EP is defined as follows:

$$leakage = 1 - \frac{\int_{q=a}^{b} \int_{p=-\infty}^{\infty} sign\left(\delta\left(RP\left(p\right) - RP\left(q\right)\right)\right) * PDF_{N_{RP(q)}}(p)\ dp\ dq}{|b-a|}$$

$$leakage = 1 - \frac{\int_{q=a}^{b} \int_{p=max\left(RP(q)-\frac{s}{2},a\right)}^{min\left(RP(q)+\frac{s}{2},b\right)} PDF_{N_{RP(q)}}(p)\ dp\ dq}{|b-a|}$$

$$leakage = 1 - \frac{1}{size(R_{RP}(a,b)) - 1} * \sum_{q \in S_{RP}(s,b)} \int_{p=max\left(p-\frac{s}{2},a\right)}^{min\left(q+\frac{s}{2},b\right)} PDF_{N_{RP(q)}}(p)\ dp$$

$$leakage = 1 - \frac{1}{size(R_{RP}(a,b)) - 1} * \sum_{q \in S_{RP}(s,b)} \left[CDF_{N_q}(p)\right]_{max\left(p-\frac{s}{2},a\right)}^{min\left(q+\frac{s}{2},b\right)}$$

For noise distributions invariant to linear transformations (e.g., Uniform, Normal, Laplace, etc.), the EP equation is as follows:

$$leakage = 2 * CDF_{N_0}\left(-\frac{1}{2*p}\right)$$

where:

- leakage is in the range [0, 1]
- δ is the Dirac Delta function
- RP is the Reduce Precision function (for the above equation, d=0.5)
- s is the step width of reduce precision function
- $R_{RP}(a,b)$ is $\{x[a,b]|RP(x) = x\}$
- PDF_x is the probability density function for the noise distribution, x
- CDF_x is the cumulative density function for the noise distribution, x

- N_x is the noise function around point x. (for Gaussian Noise, x = mean and for Poisson Noise, x = rate)
- a, b are the limits of the analog signal domain (for photonics a = 1 and b = 1)

GaussianNoise

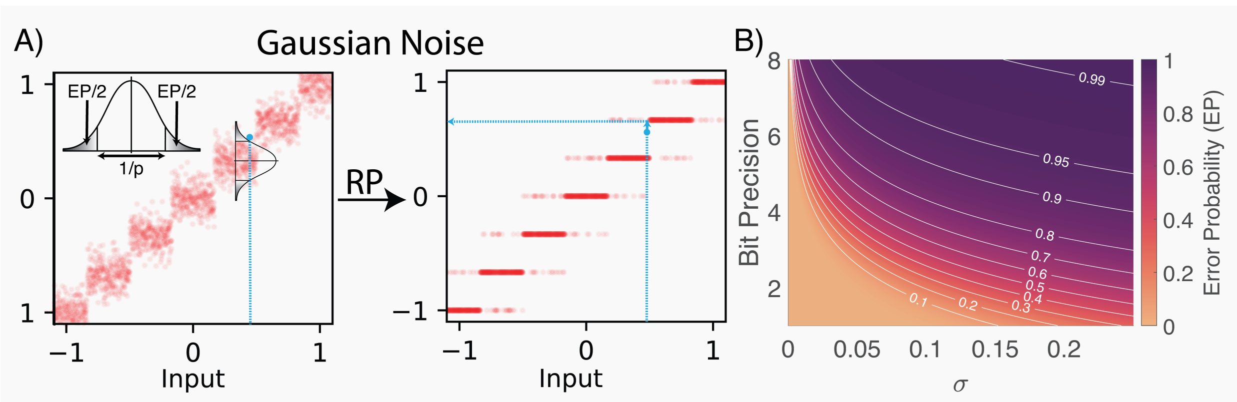
class: `analogvnn.nn.noise.GaussianNoise.GaussianNoise`

$$leakage = 1 - erf\left(\frac{1}{2\sqrt{2} * \sigma * p}\right)$$

$$\sigma = \frac{1}{2\sqrt{2} * p * erf^{-1}(1 - leakage)}$$

where:

- σ is the standard deviation of Gaussian Noise
- leakage is the error probability (0 > leakage > 1)
- erf is the Gauss Error Function
- p is precision



1.7 API Reference

This page contains auto-generated API reference documentation[1].

1.7.1 analogvnn

AnalogVNN: A fully modular framework for modeling and optimizing analog/photonic neural networks.

[1] Created with sphinx-autoapi

Subpackages

`analogvnn.backward`

Submodules

`analogvnn.backward.BackwardFunction`

Module Contents

Classes

BackwardFunction	The backward module that uses a function to compute the backward gradient.

class analogvnn.backward.BackwardFunction.**BackwardFunction**(*backward_function: analogvnn.utils.common_types.TENSOR_CALLABLE, layer: torch.nn.Module = None*)

Bases: *analogvnn.backward.BackwardModule.BackwardModule*, abc.ABC

The backward module that uses a function to compute the backward gradient.

Variables

_backward_function (*TENSOR_CALLABLE*) – The function used to compute the backward gradient.

property backward_function: analogvnn.utils.common_types.TENSOR_CALLABLE

The function used to compute the backward gradient.

Returns

The function used to compute the backward gradient.

Return type

TENSOR_CALLABLE

_backward_function: analogvnn.utils.common_types.TENSOR_CALLABLE

set_backward_function(*backward_function: analogvnn.utils.common_types.TENSOR_CALLABLE*) → *BackwardFunction*

Sets the function used to compute the backward gradient with.

Parameters

backward_function (*TENSOR_CALLABLE*) – The function used to compute the backward gradient with.

Returns

self.

Return type

BackwardFunction

backward(**grad_output: torch.Tensor, **grad_output_kwarg: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Computes the backward gradient of inputs with respect to outputs using the backward function.

Parameters

- ***grad_output** (*Tensor*) – The gradients of the output of the layer.
- ****grad_output_kwarg** (*Tensor*) – The gradients of the output of the layer.

Returns
The gradients of the input of the layer.

Return type
TENSORS

Raises
NotImplementedError – If the backward function is not set.

analogvnn.backward.BackwardIdentity

Module Contents

Classes

BackwardIdentity	The backward module that returns the output gradients as the input gradients.

class analogvnn.backward.BackwardIdentity.**BackwardIdentity**(*layer: torch.nn.Module = None*)

Bases: *analogvnn.backward.BackwardModule.BackwardModule*, abc.ABC

The backward module that returns the output gradients as the input gradients.

backward(**grad_output: torch.Tensor*, ***grad_output_kwarg: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Returns the output gradients as the input gradients.

Parameters

- ***grad_output** (*Tensor*) – The gradients of the output of the layer.
- ****grad_output_kwarg** (*Tensor*) – The gradients of the output of the layer.

Returns
The gradients of the input of the layer.

Return type
TENSORS

analogvnn.backward.BackwardModule

Module Contents

Classes

BackwardModule	Base class for all backward modules.

`class analogvnn.backward.BackwardModule.BackwardModule(layer: torch.nn.Module = None)`

Bases: `abc.ABC`

Base class for all backward modules.

A backward module is a module that can be used to compute the backward gradient of a given function. It is used to compute the gradient of the input of a function with respect to the output of the function.

Variables

- **_layer** (*Optional[nn.Module]*) – The layer for which the backward gradient is computed.
- **_empty_holder_tensor** (*Tensor*) – A placeholder tensor which always requires gradient for backward gradient computation.
- **_autograd_backward** (*Type[AutogradBackward]*) – The autograd backward function.
- **_disable_autograd_backward** (*bool*) – If True the autograd backward function is disabled.

`class AutogradBackward`

Bases: `torch.autograd.Function`

Optimization and proper calculation of gradients when using the autograd engine.

`static forward(ctx: Any, backward_module: BackwardModule, _: torch.Tensor, *args: torch.Tensor, **kwargs: torch.Tensor) → analogvnn.utils.common_types.TENSORS`

Forward pass of the autograd function.

Parameters

- **ctx** – The context of the autograd function.
- **backward_module** (*BackwardModule*) – The backward module.
- **_** (*Tensor*) – placeholder tensor which always requires grad.
- ***args** (*Tensor*) – The arguments of the function.
- ****kwargs** (*Tensor*) – The keyword arguments of the function.

Returns

The output of the function.

Return type

TENSORS

`static backward(ctx: Any, *grad_outputs: torch.Tensor) → Tuple[None, None, analogvnn.utils.common_types.TENSORS]`

Backward pass of the autograd function.

Parameters

- **ctx** – The context of the autograd function.
- ***grad_outputs** (*Tensor*) – The gradients of the output of the function.

Returns

The gradients of the input of the function.

Return type

TENSORS

`property layer: Optional[torch.nn.Module]`

Gets the layer for which the backward gradient is computed.

Returns

layer

Return type

Optional[nn.Module]

_layer: Optional[torch.nn.Module]

_empty_holder_tensor: torch.Tensor

_autograd_backward: Type[*AutogradBackward*]

_disable_autograd_backward: bool = False

__call__: Callable[Ellipsis, Any]

abstract **forward**(**inputs: torch.Tensor*, ***inputs_kwarg: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Forward pass of the layer.

Parameters

- ***inputs** (*Tensor*) – The inputs of the layer.
- ****inputs_kwarg** (*Tensor*) – The keyword inputs of the layer.

Returns
The output of the layer.

Return type
TENSORS

Raises
NotImplementedError – If the forward pass is not implemented.

abstract **backward**(**grad_outputs: torch.Tensor*, ***grad_output_kwarg: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Backward pass of the layer.

Parameters

- ***grad_outputs** (*Tensor*) – The gradients of the output of the layer.
- ****grad_output_kwarg** (*Tensor*) – The keyword gradients of the output of the layer.

Returns
The gradients of the input of the layer.

Return type
TENSORS

Raises
NotImplementedError – If the backward pass is not implemented.

_call_impl_forward(**args: torch.Tensor*, ***kwarg: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Calls Forward pass of the layer.

Parameters

- ***inputs** (*Tensor*) – The inputs of the layer.
- ****inputs_kwarg** (*Tensor*) – The keyword inputs of the layer.

Returns
The output of the layer.

Return type
TENSORS

_call_impl_backward(**grad_output: torch.Tensor*, ***grad_output_kwarg: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Calls Backward pass of the layer.

Parameters

- ***grad_outputs** (*Tensor*) – The gradients of the output of the layer.
- ****grad_output_kwarg** (*Tensor*) – The keyword gradients of the output of the layer.

Returns
The gradients of the input of the layer.

Return type
TENSORS

auto_apply(**args: torch.Tensor*, *to_apply=True*, ***kwargs: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Applies the backward module to the given layer using the proper method.

Parameters

- ***args** (*Tensor*) – The inputs of the layer.
- **to_apply** (*bool*) – if True and is training then the AutogradBackward is applied,
- **applied.** (*otherwise the backward module is*) –
- ****kwargs** (*Tensor*) – The keyword inputs of the layer.

Returns
The output of the layer.

Return type
TENSORS

has_forward() → bool

Checks if the forward pass is implemented.

Returns
True if the forward pass is implemented, False otherwise.

Return type
bool

get_layer() → Optional[torch.nn.Module]

Gets the layer for which the backward gradient is computed.

Returns
layer

Return type
Optional[nn.Module]

set_layer(*layer: Optional[torch.nn.Module]*) → BackwardModule

Sets the layer for which the backward gradient is computed.

Parameters
layer (*nn.Module*) – The layer for which the backward gradient is computed.

Returns
self

Return type
BackwardModule

Raises

- `ValueError` – If self is a subclass of nn.Module.
- `ValueError` – If the layer is already set.
- `ValueError` – If the layer is not an instance of nn.Module.

`_set_autograd_backward()`

static **`set_grad_of`**(*tensor: torch.Tensor*, *grad: torch.Tensor*) → Optional[torch.Tensor]

Sets the gradient of the given tensor.

Parameters

- **tensor** (*Tensor*) – The tensor.
- **grad** (*Tensor*) – The gradient.

Returns
the gradient of the tensor.

Return type
Optional[Tensor]

`__getattr__`(*name: str*) → Any

Gets the attribute of the layer.

Parameters
name (*str*) – The name of the attribute.

Returns
The attribute of the layer.

Return type
Any

Raises
`AttributeError` – If the attribute is not found.

analogvnn.backward.BackwardUsingForward

Module Contents

Classes

BackwardUsingForward	The backward module that uses the forward function to compute the backward gradient.

class analogvnn.backward.BackwardUsingForward.**BackwardUsingForward**(*layer: torch.nn.Module = None*)

Bases: *analogvnn.backward.BackwardModule.BackwardModule*, `abc.ABC`

The backward module that uses the forward function to compute the backward gradient.

backward(**grad_output: torch.Tensor*, ***grad_output_kwarg: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Computes the backward gradient of inputs with respect to outputs using the forward function.

Parameters

- ***grad_output** (*Tensor*) – The gradients of the output of the layer.
- ****grad_output_kwarg** (*Tensor*) – The gradients of the output of the layer.

Returns

The gradients of the input of the layer.

Return type

TENSORS

analogvnn.fn

Additional functions for analogvnn.

Submodules

analogvnn.fn.dirac_delta

Module Contents

Functions

gaussian_dirac_delta(...)	Gaussian Dirac Delta function with standard deviation *std*.

analogvnn.fn.dirac_delta.**gaussian_dirac_delta**(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *std: analogvnn.utils.common_types.TENSOR_OPERABLE = 0.001*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Gaussian Dirac Delta function with standard deviation *std*.

Parameters

- **x** (*TENSOR_OPERABLE*) – Tensor
- **std** (*TENSOR_OPERABLE*) – standard deviation.

Returns

TENSOR_OPERABLE with the same shape as x, with values of the Gaussian Dirac Delta function.

Return type

TENSOR_OPERABLE

analogvnn.fn.reduce_precision

Module Contents

Functions

reduce_precision(...)	Takes *x* and reduces its precision to *precision* by rounding to the nearest multiple of *precision*.
stochastic_reduce_precision(...)	Takes *x* and reduces its precision by rounding to the nearest multiple of *precision* with stochastic scheme.

analogvnn.fn.reduce_precision.**reduce_precision**(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*, *divide: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Takes *x* and reduces its precision to *precision* by rounding to the nearest multiple of *precision*.

Parameters

- **x** (*TENSOR_OPERABLE*) – Tensor
- **precision** (*TENSOR_OPERABLE*) – the precision of the quantization.
- **divide** (*TENSOR_OPERABLE*) – the rounding value that is if divide is 0.5, then 0.6 will be rounded to 1.0 and 0.4 will be rounded to 0.0.

Returns

TENSOR_OPERABLE with the same shape as x, but with values rounded to the nearest multiple of precision.

Return type

TENSOR_OPERABLE

analogvnn.fn.reduce_precision.**stochastic_reduce_precision**(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Takes *x* and reduces its precision by rounding to the nearest multiple of *precision* with stochastic scheme.

Parameters

- **x** (*TENSOR_OPERABLE*) – Tensor
- **precision** (*TENSOR_OPERABLE*) – the precision of the quantization.

Returns

TENSOR_OPERABLE with the same shape as x, but with values rounded to the nearest multiple of precision.

Return type

TENSOR_OPERABLE

`analogvnn.fn.test`

Module Contents

Functions

`test`(→ Tuple[float, float])	Test the model on the test set.

`analogvnn.fn.test.test`(*model: torch.nn.Module*, *test_loader: torch.utils.data.DataLoader*, *test_run: bool = False*) → Tuple[float, float]

Test the model on the test set.

Parameters

- **model** (`torch.nn.Module`) – the model to test.
- **test_loader** (`DataLoader`) – the test set.
- **test_run** (`bool`) – is it a test run.

Returns
the loss and accuracy of the model on the test set.

Return type
tuple

`analogvnn.fn.to_matrix`

Module Contents

Functions

`to_matrix`(→ torch.Tensor)	*to_matrix* takes a tensor and returns a matrix with the same values as the tensor.

`analogvnn.fn.to_matrix.to_matrix`(*tensor: torch.Tensor*) → torch.Tensor

to_matrix takes a tensor and returns a matrix with the same values as the tensor.

Parameters
tensor (`Tensor`) – Tensor

Returns
Tensor with the same values as the tensor, but with shape (1, -1).

Return type
Tensor

analogvnn.fn.train

Module Contents

Functions

train(→ Tuple[float, float])	Train the model on the train set.

analogvnn.fn.train.**train**(*model: torch.nn.Module*, *train_loader: torch.utils.data.DataLoader*, *epoch: Optional[int] = None*, *test_run: bool = False*) → Tuple[float, float]

Train the model on the train set.

Parameters

- **model** (*torch.nn.Module*) – the model to train.
- **train_loader** (*DataLoader*) – the train set.
- **epoch** (*int*) – the current epoch.
- **test_run** (*bool*) – is it a test run.

Returns
the loss and accuracy of the model on the train set.

Return type
tuple

analogvnn.graph

Submodules

analogvnn.graph.AccumulateGrad

Module Contents

Classes

AccumulateGrad	AccumulateGrad is a module that accumulates the gradients of the outputs of the module it is attached to.

class analogvnn.graph.AccumulateGrad.**AccumulateGrad**(*module: Union[torch.nn.Module, Callable]*)

AccumulateGrad is a module that accumulates the gradients of the outputs of the module it is attached to.

It has no parameters of its own.

Variables

- **module** (*nn.Module*) – Module to accumulate gradients for.
- **input_output_connections** (*Dict[str, Dict[str, Union[None, bool, int, str, GRAPH_NODE_TYPE]]]*) – input/output
- **connections.** –

input_output_connections: Dict[str, Dict[str, Union[None, bool, int, str, analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE]]]

module: Union[torch.nn.Module, Callable]

grad

Alias for __call__.

__repr__()

Return a string representation of the module.

Returns
String representation of the module.

Return type
str

__call__(*grad_outputs_args_kwargs:* analogvnn.graph.ArgsKwargs.ArgsKwargs, *forward_input_output_graph: Dict[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE,* analogvnn.graph.ArgsKwargs.InputOutput*]*) → *analogvnn.graph.ArgsKwargs.ArgsKwargs*

Calculate and Accumulate the output gradients of the module.

Parameters

- **grad_outputs_args_kwargs** (ArgsKwargs) – The output gradients from previous modules (predecessors).
- **forward_input_output_graph** (*Dict[GRAPH_NODE_TYPE,* InputOutput*]*) – The input and output from forward pass.

Returns
The output gradients.

Return type
ArgsKwargs

analogvnn.graph.AcyclicDirectedGraph

Module Contents

Classes

AcyclicDirectedGraph	The base class for all acyclic directed graphs.

class analogvnn.graph.AcyclicDirectedGraph.**AcyclicDirectedGraph**(*graph_state:* analogvnn.graph.ModelGraphState.ModelGraphSta *= None*)

Bases: abc.ABC

The base class for all acyclic directed graphs.

Variables

- **graph** (*nx.MultiDiGraph*) – The graph.
- **graph_state** (ModelGraphState) – The graph state.
- **_is_static** (*bool*) – If True, the graph is not changing during runtime and will be cached.

- **_static_graphs** (*Dict[GRAPH_NODE_TYPE, List[Tuple[GRAPH_NODE_TYPE, List[GRAPH_NODE_TYPE]]]]*) – The static graphs.
- **INPUT** (GraphEnum) – GraphEnum.INPUT
- **OUTPUT** (GraphEnum) – GraphEnum.OUTPUT
- **STOP** (GraphEnum) – GraphEnum.STOP

graph: networkx.MultiDiGraph

graph_state: *analogvnn.graph.ModelGraphState.ModelGraphState*

_is_static: bool

_static_graphs: Dict[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE, List[Tuple[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE, List[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE]]]]

INPUT

OUTPUT

STOP

save

Alias for render.

abstract __call__(**args*, ***kwargs*)

Performs pass through the graph.

Parameters

- ***args** – Arguments
- ****kwargs** – Keyword arguments

Raises

NotImplementedError – since method is abstract

add_connection(**args: analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE*)

Add a connection between nodes.

Parameters

***args** – The nodes.

Returns

self.

Return type

AcyclicDirectedGraph

add_edge(*u_of_edge: analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE*, *v_of_edge: analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE*, *in_arg: Union[None, int, bool] = None*, *in_kwarg: Union[None, str, bool] = None*, *out_arg: Union[None, int, bool] = None*, *out_kwarg: Union[None, str, bool] = None*)

Add an edge to the graph.

Parameters

- **u_of_edge** (*GRAPH_NODE_TYPE*) – The source node.
- **v_of_edge** (*GRAPH_NODE_TYPE*) – The target node.

- **in_arg** (*Union[None, int, bool]*) – The input argument.
- **in_kwarg** (*Union[None, str, bool]*) – The input keyword argument.
- **out_arg** (*Union[None, int, bool]*) – The output argument.
- **out_kwarg** (*Union[None, str, bool]*) – The output keyword argument.

Returns
self.

Return type
AcyclicDirectedGraph

`static check_edge_parameters`(*in_arg: Union[None, int, bool], in_kwarg: Union[None, str, bool], out_arg: Union[None, int, bool], out_kwarg: Union[None, str, bool]*) → Dict[str, Union[None, int, str, bool]]

Check the edge's in and out parameters.

Parameters

- **in_arg** (*Union[None, int, bool]*) – The input argument.
- **in_kwarg** (*Union[None, str, bool]*) – The input keyword argument.
- **out_arg** (*Union[None, int, bool]*) – The output argument.
- **out_kwarg** (*Union[None, str, bool]*) – The output keyword argument.

Returns
Dict of valid edge's in and out parameters.

Return type
Dict[str, Union[None, int, str, bool]]

Raises
`ValueError` – If in and out parameters are invalid.

`static _create_edge_label`(*in_arg: Union[None, int, bool] = None, in_kwarg: Union[None, str, bool] = None, out_arg: Union[None, int, bool] = None, out_kwarg: Union[None, str, bool] = None, **kwargs*) → str

Create the edge's label.

Parameters

- **in_arg** (*Union[None, int, bool]*) – The input argument.
- **in_kwarg** (*Union[None, str, bool]*) – The input keyword argument.
- **out_arg** (*Union[None, int, bool]*) – The output argument.
- **out_kwarg** (*Union[None, str, bool]*) – The output keyword argument.

Returns
The edge's label.

Return type
str

`compile`(*is_static: bool = True*)

Compile the graph.

Parameters
is_static (*bool*) – If True, the graph will be compiled as a static graph.

Returns
The compiled graph.

Return type
AcyclicDirectedGraph

Raises
`ValueError` – If the graph is not acyclic.

static _reindex_out_args(*graph: networkx.MultiDiGraph*) → networkx.MultiDiGraph

Reindex the output arguments.

Parameters
graph (*nx.MultiDiGraph*) – The graph.

Returns
The graph with re-indexed output arguments.

Return type
nx.MultiDiGraph

_create_static_sub_graph(*from_node: analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE*) → List[Tuple[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE, List[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE]]]

Create a static sub graph connected to the given node.

Parameters
from_node (*GRAPH_NODE_TYPE*) – The node.

Returns
The static sub graph.

Return type
List[Tuple[GRAPH_NODE_TYPE, List[GRAPH_NODE_TYPE]]]

parse_args_kwargs(*input_output_graph: Dict[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE, analogvnn.graph.ArgsKwargs.InputOutput], module: analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE, predecessors: List[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE]*) → *analogvnn.graph.ArgsKwargs.ArgsKwargs*

Parse the arguments and keyword arguments.

Parameters

- **input_output_graph** (*Dict[GRAPH_NODE_TYPE, InputOutput]*) – The input output graph.
- **module** (*GRAPH_NODE_TYPE*) – The module.
- **predecessors** (*List[GRAPH_NODE_TYPE]*) – The predecessors.

Returns
The arguments and keyword arguments.

Return type
ArgsKwargs

render(**args, real_label: bool = False, **kwargs*) → str

Save the source to file and render with the Graphviz engine.

Parameters

- ***args** – Arguments to pass to graphviz render function.

- **real_label** – If True, the real label will be used instead of the label.
- ****kwargs** – Keyword arguments to pass to graphviz render function.

Returns
The (possibly relative) path of the rendered file.

Return type
str

analogvnn.graph.ArgsKwargs

Module Contents

Classes

InputOutput	Inputs and outputs of a module.
ArgsKwargs	The arguments.

Attributes

ArgsKwargsInput	ArgsKwargsInput is the input type for ArgsKwargs
ArgsKwargsOutput	ArgsKwargsOutput is the output type for ArgsKwargs

class analogvnn.graph.ArgsKwargs.**InputOutput**

Inputs and outputs of a module.

Variables

- **inputs** (*Optional[ArgsKwargs]*) – Inputs of a module.
- **outputs** (*Optional[ArgsKwargs]*) – Outputs of a module.

inputs: Optional[*ArgsKwargs*]

outputs: Optional[*ArgsKwargs*]

class analogvnn.graph.ArgsKwargs.**ArgsKwargs**(*args=None*, *kwargs=None*)

The arguments.

Variables

- **args** (*List*) – The arguments.
- **kwargs** (*Dict*) – The keyword arguments.

args: List

kwargs: Dict

is_empty()

Returns whether the ArgsKwargs object is empty.

__repr__()

Returns a string representation of the parameter.

classmethod to_args_kwargs_object(*outputs: ArgsKwargsInput*) → *ArgsKwargs*

Convert the output of a module to ArgsKwargs object.

Parameters
`outputs` – The output of a module

Returns
The ArgsKwargs object

Return type
ArgsKwargs

static from_args_kwargs_object(*outputs:* ArgsKwargs) → ArgsKwargsOutput

Convert ArgsKwargs to object or tuple or dict.

Parameters
`outputs` (ArgsKwargs) – ArgsKwargs object

Returns
object or tuple or dict

Return type
ArgsKwargsOutput

analogvnn.graph.ArgsKwargs.**ArgsKwargsInput**

ArgsKwargsInput is the input type for ArgsKwargs

analogvnn.graph.ArgsKwargs.**ArgsKwargsOutput**

ArgsKwargsOutput is the output type for ArgsKwargs

analogvnn.graph.BackwardGraph

Module Contents

Classes

BackwardGraph	The backward graph.

class analogvnn.graph.BackwardGraph.**BackwardGraph**(*graph_state:* analogvnn.graph.ModelGraphState.ModelGraphState *= None*)

Bases: *analogvnn.graph.AcyclicDirectedGraph.AcyclicDirectedGraph*

The backward graph.

__call__(*gradient: analogvnn.utils.common_types.TENSORS = None*) → analogvnn.graph.ArgsKwargs.ArgsKwargsOutput

Backward pass through the backward graph.

Parameters
`gradient` (*TENSORS*) – gradient of the loss function w.r.t. the output of the forward graph

Returns
gradient of the inputs function w.r.t. loss

Return type
ArgsKwargsOutput

compile(*is_static=True*)

Compile the graph.

Parameters
is_static (*bool*) – If True, the graph is not changing during runtime and will be cached.

Returns
self.

Return type
BackwardGraph

Raises
ValueError – If no forward pass has been performed yet.

from_forward(*forward_graph: Union[analogvnn.graph.AcyclicDirectedGraph.AcyclicDirectedGraph, networkx.DiGraph]*) → *BackwardGraph*

Create a backward graph from inverting forward graph.

Parameters
forward_graph (*Union[AcyclicDirectedGraph, nx.DiGraph]*) – The forward graph.

Returns
self.

Return type
BackwardGraph

calculate(**args*, ***kwargs*) → analogvnn.graph.ArgsKwargs.ArgsKwargsOutput

Calculate the gradient of the whole graph w.r.t. loss.

Parameters

- ***args** – The gradients args of outputs.
- ****kwargs** – The gradients kwargs of outputs.

Returns
The gradient of the inputs function w.r.t. loss.

Return type
ArgsKwargsOutput

Raises
ValueError – If no forward pass has been performed yet.

_pass(*from_node: analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE*, **args*, ***kwargs*) → Dict[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE, *analogvnn.graph.ArgsKwargs.InputOutput*]

Perform the backward pass through the graph.

Parameters

- **from_node** (*GRAPH_NODE_TYPE*) – The node to start the backward pass from.
- ***args** – The gradients args of outputs.
- ****kwargs** – The gradients kwargs of outputs.

Returns
The input and output gradients of each node.

Return type
Dict[GRAPH_NODE_TYPE, *InputOutput*]

_calculate_gradients(*module: Union[*analogvnn.graph.AccumulateGrad.AccumulateGrad*,* analogvnn.nn.module.Layer.Layer*,* analogvnn.backward.BackwardModule.BackwardModule*, Callable]*, *grad_outputs:* analogvnn.graph.ArgsKwargs.InputOutput) → *analogvnn.graph.ArgsKwargs.ArgsKwargs*

Calculate the gradient of a module w.r.t. outputs of the module using the output's gradients.

Parameters

- **module** (*Union[*`AccumulateGrad`, `Layer`, `BackwardModule`, *Callable]*) – The module to calculate the gradient of.
- **grad_outputs** (`InputOutput`) – The gradients of the output of the module.

Returns
The input gradients of the module.

Return type
ArgsKwargs

`analogvnn.graph.ForwardGraph`

Module Contents

Classes

ForwardGraph	The forward graph.

class analogvnn.graph.ForwardGraph.**ForwardGraph**(*graph_state:* analogvnn.graph.ModelGraphState.ModelGraphState *= None*)

Bases: *analogvnn.graph.AcyclicDirectedGraph.AcyclicDirectedGraph*

The forward graph.

__call__(*inputs: analogvnn.utils.common_types.TENSORS*, *is_training: bool*) → analogvnn.graph.ArgsKwargs.ArgsKwargsOutput

Forward pass through the forward graph.

Parameters

- **inputs** (*TENSORS*) – Input to the graph
- **is_training** (*bool*) – Is training or not

Returns
Output of the graph

Return type
ArgsKwargsOutput

compile(*is_static: bool = True*)

Compile the graph.

Parameters
is_static (*bool*) – If True, the graph is not changing during runtime and will be cached.

Returns
self.

Return type
ForwardGraph

Raises
`ValueError` – If no forward pass has been performed yet.

`calculate`(*inputs: analogvnn.utils.common_types.TENSORS*, *is_training: bool = True*, ***kwargs*) → analogvnn.graph.ArgsKwargs.ArgsKwargsOutput

Calculate the output of the graph.

Parameters

- **inputs** (*TENSORS*) – Input to the graph
- **is_training** (*bool*) – Is training or not
- ****kwargs** – Additional arguments

Returns
Output of the graph

Return type
ArgsKwargsOutput

`_pass`(*from_node: analogvnn.graph.GraphEnum.GraphEnum*, **inputs: torch.Tensor*) → Dict[*analogvnn.graph.GraphEnum.GraphEnum*, *analogvnn.graph.ArgsKwargs.InputOutput*]

Perform the forward pass through the graph.

Parameters

- **from_node** (`GraphEnum`) – The node to start the forward pass from
- ***inputs** (*Tensor*) – Input to the graph

Returns
The input and output of each node

Return type
Dict[*GraphEnum*, *InputOutput*]

`static _detach_tensor`(*tensor: torch.Tensor*) → torch.Tensor

Detach the tensor from the autograd graph.

Parameters
tensor (*torch.Tensor*) – Tensor to detach

Returns
Detached tensor

Return type
torch.Tensor

analogvnn.graph.GraphEnum

Module Contents

Classes

GraphEnum	The graph enum for indicating input, output and stop.

Attributes

GRAPH_NODE_TYPE

class analogvnn.graph.GraphEnum.**GraphEnum**

Bases: enum.Enum

The graph enum for indicating input, output and stop.

Variables

- **INPUT** (GraphEnum) – GraphEnum.INPUT
- **OUTPUT** (GraphEnum) – GraphEnum.OUTPUT
- **STOP** (GraphEnum) – GraphEnum.STOP

INPUT = 'INPUT'

OUTPUT = 'OUTPUT'

STOP = 'STOP'

analogvnn.graph.GraphEnum.**GRAPH_NODE_TYPE**

analogvnn.graph.ModelGraph

Module Contents

Classes

ModelGraph	Store model's graph.

class analogvnn.graph.ModelGraph.**ModelGraph**(*use_autograd_graph: bool = False, allow_loops: bool = False*)

Bases: *analogvnn.graph.ModelGraphState.ModelGraphState*

Store model's graph.

Variables

- **forward_graph** (ForwardGraph) – store model's forward graph.

- **backward_graph** (BackwardGraph) – store model's backward graph.

forward_graph: *analogvnn.graph.ForwardGraph.ForwardGraph*

backward_graph: *analogvnn.graph.BackwardGraph.BackwardGraph*

compile(*is_static: bool = True*, *auto_backward_graph: bool = False*) → *ModelGraph*

Compile the model graph.

Parameters

- **is_static** (*bool*) – If True, the model graph is static.
- **auto_backward_graph** (*bool*) – If True, the backward graph is automatically created.

Returns
self.

Return type
ModelGraph

analogvnn.graph.ModelGraphState

Module Contents

Classes

ModelGraphState	The state of a model graph.

class analogvnn.graph.ModelGraphState.**ModelGraphState**(*use_autograd_graph: bool = False*, *allow_loops=False*)

The state of a model graph.

Variables

- **allow_loops** (*bool*) – if True, the graph is allowed to contain loops.
- **forward_input_output_graph** (*Optional[Dict[GRAPH_NODE_TYPE, InputOutput]]*) – the input and output of the
- **pass.** (*forward*) –
- **use_autograd_graph** (*bool*) – if True, the autograd graph is used to calculate the gradients.
- **_loss** (*Tensor*) – the loss.
- **INPUT** (GraphEnum) – GraphEnum.INPUT
- **OUTPUT** (GraphEnum) – GraphEnum.OUTPUT
- **STOP** (GraphEnum) – GraphEnum.STOP

Properties:
input (Tensor): the input of the forward pass. output (Tensor): the output of the forward pass. loss (Tensor): the loss.

property inputs: Optional[*analogvnn.graph.ArgsKwargs.ArgsKwargs*]

Get the inputs.

Returns
the inputs.

Return type
ArgsKwargs

property outputs: Optional[*analogvnn.graph.ArgsKwargs.ArgsKwargs*]

Get the output.

Returns
the output.

Return type
ArgsKwargs

property loss

Get the loss.

Returns
the loss.

Return type
Tensor

allow_loops: bool

use_autograd_graph: bool

forward_input_output_graph: Optional[Dict[analogvnn.graph.GraphEnum.GRAPH_NODE_TYPE, *analogvnn.graph.ArgsKwargs.InputOutput*]]

_loss: Optional[torch.Tensor]

INPUT

OUTPUT

STOP

ready_for_forward(*exception: bool = False*) → bool

Check if the state is ready for forward pass.

Parameters
exception (*bool*) – If True, an exception is raised if the state is not ready for forward pass.

Returns
True if the state is ready for forward pass.

Return type
bool

Raises
RuntimeError – If the state is not ready for forward pass and exception is True.

ready_for_backward(*exception: bool = False*) → bool

Check if the state is ready for backward pass.

Parameters
`exception` (*bool*) – if True, raise an exception if the state is not ready for backward pass.

Returns
True if the state is ready for backward pass.

Return type
bool

Raises
`RuntimeError` – if the state is not ready for backward pass and exception is True.

`set_loss`(*loss: Union[torch.Tensor, None]*) → *ModelGraphState*

Set the loss.

Parameters
`loss` (*Tensor*) – the loss.

Returns
self.

Return type
ModelGraphState

`analogvnn.graph.to_graph_viz_digraph`

Module Contents

Functions

to_graphviz_digraph(→ graphviz.Digraph)	Returns a pygraphviz graph from a NetworkX graph N.

`analogvnn.graph.to_graph_viz_digraph.to_graphviz_digraph`(*from_graph: networkx.DiGraph, real_label: bool = False*) → graphviz.Digraph

Returns a pygraphviz graph from a NetworkX graph N.

Parameters

- `from_graph` (*networkx.DiGraph*) – the graph to convert.
- `real_label` (*bool*) – True to use the real label.

Returns
the converted graph.

Return type
graphviz.Digraph

Raises
`ImportError` – if graphviz (https://pygraphviz.github.io/) is not available.

analogvnn.nn

Subpackages

analogvnn.nn.activation

Submodules

analogvnn.nn.activation.Activation

Module Contents

Classes

InitImplement	Implements the initialisation of parameters using the activation function.
Activation	This class is base class for all activation functions.

class analogvnn.nn.activation.Activation.**InitImplement**

Implements the initialisation of parameters using the activation function.

static initialise(*tensor: torch.Tensor*) → torch.Tensor

Initialisation of tensor using xavier uniform initialisation.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

static initialise_(*tensor: torch.Tensor*) → torch.Tensor

In-place initialisation of tensor using xavier uniform initialisation.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

class analogvnn.nn.activation.Activation.**Activation**

Bases: *analogvnn.nn.module.Layer.Layer*, *analogvnn.backward.BackwardModule.BackwardModule*, *InitImplement*, abc.ABC

This class is base class for all activation functions.

analogvnn.nn.activation.BinaryStep

Module Contents

Classes

BinaryStep	Implements the binary step activation function.

class analogvnn.nn.activation.BinaryStep.**BinaryStep**

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the binary step activation function.

static forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of the binary step activation function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the binary step activation function.

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

analogvnn.nn.activation.ELU

Module Contents

Classes

SELU	Implements the scaled exponential linear unit (SELU) activation function.
ELU	Implements the exponential linear unit (ELU) activation function.

class analogvnn.nn.activation.ELU.**SELU**(*alpha: float = 1.0507*, *scale_factor: float = 1.0*)

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the scaled exponential linear unit (SELU) activation function.

Variables

- **alpha** (*nn.Parameter*) – the alpha parameter.
- **scale_factor** (*nn.Parameter*) – the scale factor parameter.

__constants__ = ['alpha', 'scale_factor']

alpha: torch.nn.Parameter

scale_factor: torch.nn.Parameter

forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of the scaled exponential linear unit (SELU) activation function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the scaled exponential linear unit (SELU) activation function.

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

static initialise(*tensor: torch.Tensor*) → torch.Tensor

Initialisation of tensor using xavier uniform, gain associated with SELU activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

static initialise_(*tensor: torch.Tensor*) → torch.Tensor

In-place initialisation of tensor using xavier uniform, gain associated with SELU activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

class analogvnn.nn.activation.ELU.**ELU**(*alpha: float = 1.0507*)

Bases: *SELU*

Implements the exponential linear unit (ELU) activation function.

Variables

- **alpha** (*nn.Parameter*) – 1.0507
- **scale_factor** (*nn.Parameter*) –

  1.

analogvnn.nn.activation.Gaussian

Module Contents

Classes

Gaussian	Implements the Gaussian activation function.
GeLU	Implements the Gaussian error linear unit (GeLU) activation function.

class analogvnn.nn.activation.Gaussian.**Gaussian**

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the Gaussian activation function.

static **forward**(*x: torch.Tensor*) → torch.Tensor

Forward pass of the Gaussian activation function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the Gaussian activation function.

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

class analogvnn.nn.activation.Gaussian.**GeLU**

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the Gaussian error linear unit (GeLU) activation function.

static **forward**(*x: torch.Tensor*) → torch.Tensor

Forward pass of the Gaussian error linear unit (GeLU) activation function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the Gaussian error linear unit (GeLU) activation function.

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

analogvnn.nn.activation.Identity

Module Contents

Classes

Identity	Implements the identity activation function.

class analogvnn.nn.activation.Identity.**Identity**(*name=None*)

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the identity activation function.

Variables
name (*str*) – the name of the activation function.

name: Optional[str]

extra_repr() → str

Extra __repr__ of the identity activation function.

Returns
the extra representation of the identity activation function.

Return type
str

static forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of the identity activation function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor same as the input tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the identity activation function.

Parameters
: **grad_output** (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
: the gradient of the input tensor same as the gradient of the output tensor.

Return type
: Optional[Tensor]

analogvnn.nn.activation.ReLU

Module Contents

Classes

PReLU	Implements the parametric rectified linear unit (PReLU) activation function.
ReLU	Implements the rectified linear unit (ReLU) activation function.
LeakyReLU	Implements the leaky rectified linear unit (LeakyReLU) activation function.

class analogvnn.nn.activation.ReLU.**PReLU**(*alpha: float*)

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the parametric rectified linear unit (PReLU) activation function.

Variables

- **alpha** (*float*) – the slope of the negative part of the activation function.
- **_zero** (*Tensor*) – placeholder tensor of zero.

__constants__ = ['alpha', '_zero']

alpha: torch.nn.Parameter

_zero: torch.nn.Parameter

forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of the parametric rectified linear unit (PReLU) activation function.

Parameters
: **x** (*Tensor*) – the input tensor.

Returns
: the output tensor.

Return type
: Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the parametric rectified linear unit (PReLU) activation function.

Parameters
: **grad_output** (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

static initialise(*tensor: torch.Tensor*) → torch.Tensor

Initialisation of tensor using kaiming uniform, gain associated with PReLU activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

static initialise_(*tensor: torch.Tensor*) → torch.Tensor

In-place initialisation of tensor using kaiming uniform, gain associated with PReLU activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

class analogvnn.nn.activation.ReLU.**ReLU**

Bases: *PReLU*

Implements the rectified linear unit (ReLU) activation function.

Variables
alpha (*float*) – 0

static initialise(*tensor: torch.Tensor*) → torch.Tensor

Initialisation of tensor using kaiming uniform, gain associated with ReLU activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

static initialise_(*tensor: torch.Tensor*) → torch.Tensor

In-place initialisation of tensor using kaiming uniform, gain associated with ReLU activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

class analogvnn.nn.activation.ReLU.**LeakyReLU**

Bases: *PReLU*

Implements the leaky rectified linear unit (LeakyReLU) activation function.

Variables

alpha (*float*) – 0.01

analogvnn.nn.activation.SiLU

Module Contents

Classes

SiLU	Implements the SiLU activation function.

class analogvnn.nn.activation.SiLU.**SiLU**

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the SiLU activation function.

static forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of the SiLU.

Parameters

x (*Tensor*) – the input tensor.

Returns

the output tensor.

Return type

Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the SiLU.

Parameters

grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns

the gradient of the input tensor.

Return type

Optional[Tensor]

analogvnn.nn.activation.Sigmoid

Module Contents

Classes

Logistic	Implements the logistic activation function.
Sigmoid	Implements the sigmoid activation function.

class analogvnn.nn.activation.Sigmoid.**Logistic**

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the logistic activation function.

static forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of the logistic activation function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the logistic activation function.

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

static initialise(*tensor: torch.Tensor*) → torch.Tensor

Initialisation of tensor using xavier uniform, gain associated with logistic activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

static initialise_(*tensor: torch.Tensor*) → torch.Tensor

In-place initialisation of tensor using xavier uniform, gain associated with logistic activation function.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

class analogvnn.nn.activation.Sigmoid.**Sigmoid**

Bases: *Logistic*

Implements the sigmoid activation function.

analogvnn.nn.activation.Tanh

Module Contents

Classes

Tanh	Implements the tanh activation function.

class analogvnn.nn.activation.Tanh.**Tanh**

Bases: *analogvnn.nn.activation.Activation.Activation*

Implements the tanh activation function.

static forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of the tanh activation function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the tanh activation function.

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

static initialise(*tensor: torch.Tensor*) → torch.Tensor

Initialisation of tensor using xavier uniform, gain associated with tanh.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

static initialise_(*tensor: torch.Tensor*) → torch.Tensor

In-place initialisation of tensor using xavier uniform, gain associated with tanh.

Parameters
tensor (*Tensor*) – the tensor to be initialized.

Returns
the initialized tensor.

Return type
Tensor

analogvnn.nn.module

Submodules

analogvnn.nn.module.FullSequential

Module Contents

Classes

FullSequential	A sequential model where backward graph is the reverse of forward graph.

class analogvnn.nn.module.FullSequential.**FullSequential**(*tensorboard_log_dir=None*, *device=is_cpu_cuda.device*)

Bases: *analogvnn.nn.module.Sequential.Sequential*

A sequential model where backward graph is the reverse of forward graph.

compile(*device: Optional[torch.device] = None*, *layer_data: bool = True*)

Compile the model and add forward and backward graph.

Parameters

- **device** (*torch.device*) – The device to run the model on.
- **layer_data** (*bool*) – True if the data of the layers should be compiled.

Returns

self

Return type

FullSequential

analogvnn.nn.module.Layer

Module Contents

Classes

Layer	Base class for analog neural network modules.

class analogvnn.nn.module.Layer.**Layer**

Bases: torch.nn.Module

Base class for analog neural network modules.

Variables

- **_inputs** (*Union[None, ArgsKwargs]*) – Inputs of the layer.
- **_outputs** (*Union[None, Tensor, Sequence[Tensor]]*) – Outputs of the layer.
- **_backward_module** (*Optional[BackwardModule]*) – Backward module of the layer.

- **_use_autograd_graph** (*bool*) – If True, the autograd graph is used to calculate the gradients.
- **call_super_init** (*bool*) – If True, the super class __init__ of nn.Module is called
- **https** – //github.com/pytorch/pytorch/pull/91819

property use_autograd_graph: bool

If True, the autograd graph is used to calculate the gradients.

Returns
use_autograd_graph.

Return type
bool

property inputs: analogvnn.graph.ArgsKwargs.ArgsKwargsOutput

Inputs of the layer.

Returns
inputs.

Return type
ArgsKwargsOutput

property outputs: Union[None, torch.Tensor, Sequence[torch.Tensor]]

Outputs of the layer.

Returns
outputs.

Return type
Union[None, Tensor, Sequence[Tensor]]

property backward_function: Union[None, Callable, *analogvnn.backward.BackwardModule.BackwardModule*]

Backward module of the layer.

Returns
backward_function.

Return type
Union[None, Callable, *BackwardModule*]

_inputs: Union[None, *analogvnn.graph.ArgsKwargs.ArgsKwargs*]

_outputs: Union[None, torch.Tensor, Sequence[torch.Tensor]]

_backward_module: Optional[*analogvnn.backward.BackwardModule.BackwardModule*]

_use_autograd_graph: bool

call_super_init: bool = True

__call__(**inputs*, ***kwargs*)

Calls the forward pass of neural network layer.

Parameters

- ***inputs** – Inputs of the forward pass.
- ****kwargs** – Keyword arguments of the forward pass.

`set_backward_function`(*backward_class: Union[Callable, analogvnn.backward.BackwardModule.BackwardModule, Type[analogvnn.backward.BackwardModule.BackwardModule]]*) → *Layer*

Sets the backward_function attribute.

Parameters
`backward_class` (*Union[Callable, BackwardModule, Type[BackwardModule]]*) – backward_function.

Returns
self.

Return type
Layer

Raises
`TypeError` – If backward_class is not a callable or BackwardModule.

`named_registered_children`(*memo: Optional[Set[torch.nn.Module]] = None*) → Iterator[Tuple[str, torch.nn.Module]]

Returns an iterator over immediate registered children modules.

Parameters
`memo` – a memo to store the set of modules already added to the result

Yields
(str, Module) – Tuple containing a name and child module

Note: Duplicate modules are returned only once. In the following example, `l` will be returned only once.

`registered_children`() → Iterator[torch.nn.Module]

Returns an iterator over immediate registered children modules.

Yields
nn.Module – a module in the network

Note: Duplicate modules are returned only once. In the following example, `l` will be returned only once.

`_forward_wrapper`(*function: Callable*) → Callable

Wrapper for the forward function.

Parameters
`function` (*Callable*) – Forward function.

Returns
Wrapped function.

Return type
Callable

`_call_impl_forward`(**args: torch.Tensor*, ***kwargs: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Calls the forward pass of the layer.

Parameters

- `*args` – Inputs of the forward pass.

- **kwargs – Keyword arguments of the forward pass.

Returns
Outputs of the forward pass.

Return type
TENSORS

`analogvnn.nn.module.Model`

Module Contents

Classes

Model	Base class for analog neural network models.

class analogvnn.nn.module.Model.**Model**(*tensorboard_log_dir=None*, *device=is_cpu_cuda.device*)

Bases: *analogvnn.nn.module.Layer.Layer*, *analogvnn.backward.BackwardModule.BackwardModule*

Base class for analog neural network models.

Variables

- **_compiled** (*bool*) – True if the model is compiled.
- **tensorboard** (TensorboardModelLog) – The tensorboard logger of the model.
- **graphs** (ModelGraph) – The graph of the model.
- **forward_graph** (ForwardGraph) – The forward graph of the model.
- **backward_graph** (BackwardGraph) – The backward graph of the model.
- **optimizer** (*optim.Optimizer*) – The optimizer of the model.
- **loss_function** (*Optional[TENSOR_CALLABLE]*) – The loss function of the model.
- **accuracy_function** (*Optional[TENSOR_CALLABLE]*) – The accuracy function of the model.
- **device** (*torch.device*) – The device of the model.

property **use_autograd_graph**

Is the autograd graph used for the model.

Returns
If True, the autograd graph is used to calculate the gradients.

Return type
bool

__constants__ = ['device']

_compiled: bool

tensorboard: Optional[*analogvnn.utils.TensorboardModelLog.TensorboardModelLog*]

graphs: *analogvnn.graph.ModelGraph.ModelGraph*

forward_graph: *analogvnn.graph.ForwardGraph.ForwardGraph*

backward_graph: *analogvnn.graph.BackwardGraph.BackwardGraph*

optimizer: Optional[torch.optim.Optimizer]

loss_function: Optional[analogvnn.utils.common_types.TENSOR_CALLABLE]

accuracy_function: Optional[analogvnn.utils.common_types.TENSOR_CALLABLE]

device: torch.device

__call__(**args*, ***kwargs*)

Call the model.

Parameters

- ***args** – The arguments of the model.
- ****kwargs** – The keyword arguments of the model.

Returns
The output of the model.

Return type
TENSORS

Raises
RuntimeError – if the model is not compiled.

named_registered_children(*memo: Optional[Set[torch.nn.Module]] = None*) → Iterator[Tuple[str, torch.nn.Module]]

Returns an iterator over registered modules under self.

Parameters
memo – a memo to store the set of modules already added to the result

Yields
(str, nn.Module) – Tuple of name and module

Note: Duplicate modules are returned only once. In the following example, l will be returned only once.

compile(*device: Optional[torch.device] = None*, *layer_data: bool = True*)

Compile the model.

Parameters

- **device** (*torch.device*) – The device to run the model on.
- **layer_data** (*bool*) – If True, the layer data is logged.

Returns
The compiled model.

Return type
Model

forward(**inputs: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Forward pass of the model.

Parameters
***inputs** (*Tensor*) – The inputs of the model.

Returns
The output of the model.

Return type
TENSORS

backward(**inputs: torch.Tensor*) → analogvnn.utils.common_types.TENSORS

Backward pass of the model.

Parameters
***inputs** (*Tensor*) – The inputs of the model.

Returns
The output of the model.

Return type
TENSORS

loss(*output: torch.Tensor*, *target: torch.Tensor*) → Tuple[torch.Tensor, torch.Tensor]

Calculate the loss of the model.

Parameters

- **output** (*Tensor*) – The output of the model.
- **target** (*Tensor*) – The target of the model.

Returns
The loss and the accuracy of the model.

Return type
Tuple[Tensor, Tensor]

Raises
ValueError – if loss_function is None.

train_on(*train_loader: torch.utils.data.DataLoader*, *epoch: int = None*, **args*, ***kwargs*) → Tuple[float, float]

Train the model on the train_loader.

Parameters

- **train_loader** (*DataLoader*) – The train loader of the model.
- **epoch** (*int*) – The epoch of the model.
- ***args** – The arguments of the train function.
- ****kwargs** – The keyword arguments of the train function.

Returns
The loss and the accuracy of the model.

Return type
Tuple[float, float]

Raises
RuntimeError – if model is not compiled.

test_on(*test_loader: torch.utils.data.DataLoader*, *epoch: int = None*, **args*, ***kwargs*) → Tuple[float, float]

Test the model on the test_loader.

Parameters

- **test_loader** (*DataLoader*) – The test loader of the model.

- **epoch** (*int*) – The epoch of the model.
- ***args** – The arguments of the test function.
- ****kwargs** – The keyword arguments of the test function.

Returns
The loss and the accuracy of the model.

Return type
Tuple[float, float]

Raises
RuntimeError – if model is not compiled.

fit(*train_loader: torch.utils.data.DataLoader*, *test_loader: torch.utils.data.DataLoader*, *epoch: int = None*) → Tuple[float, float, float, float]

Fit the model on the train_loader and test the model on the test_loader.

Parameters

- **train_loader** (*DataLoader*) – The train loader of the model.
- **test_loader** (*DataLoader*) – The test loader of the model.
- **epoch** (*int*) – The epoch of the model.

Returns
The train loss, the train accuracy, the test loss and the test accuracy of the model.

Return type
Tuple[float, float, float, float]

create_tensorboard(*log_dir: str*) → *analogvnn.utils.TensorboardModelLog.TensorboardModelLog*

Create a tensorboard.

Parameters
log_dir (*str*) – The log directory of the tensorboard.

Raises
ImportError – if tensorboard (https://www.tensorflow.org/) is not installed.

subscribe_tensorboard(*tensorboard:* analogvnn.utils.TensorboardModelLog.TensorboardModelLog)

Subscribe the model to the tensorboard.

Parameters
tensorboard (TensorboardModelLog) – The tensorboard of the model.

Returns
self.

Return type
Model

analogvnn.nn.module.Sequential

Module Contents

Classes

Sequential	Base class for all sequential models.

class analogvnn.nn.module.Sequential.**Sequential**(*tensorboard_log_dir=None*, *device=is_cpu_cuda.device*)

Bases: *analogvnn.nn.module.Model.Model*, torch.nn.Sequential

Base class for all sequential models.

__call__(**args*, ***kwargs*)

Call the model.

Parameters

- ***args** – The input.
- ****kwargs** – The input.

Returns
The output of the model.

Return type
torch.Tensor

compile(*device: Optional[torch.device] = None*, *layer_data: bool = True*)

Compile the model and add forward graph.

Parameters

- **device** (*torch.device*) – The device to run the model on.
- **layer_data** (*bool*) – True if the data of the layers should be compiled.

Returns
self

Return type
Sequential

add_sequence(**args*)

Add a sequence of modules to the forward graph of model.

Parameters
***args** (*nn.Module*) – The modules to add.

analogvnn.nn.noise

Submodules

analogvnn.nn.noise.GaussianNoise

Module Contents

Classes

GaussianNoise	Implements the Gaussian noise function.

class analogvnn.nn.noise.GaussianNoise.**GaussianNoise**(*std: Optional[float] = None, leakage: Optional[float] = None, precision: Optional[int] = None*)

Bases: *analogvnn.nn.noise.Noise.Noise*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the Gaussian noise function.

Variables

- **std** (*nn.Parameter*) – the standard deviation of the Gaussian noise.
- **leakage** (*nn.Parameter*) – the leakage of the Gaussian noise.
- **precision** (*nn.Parameter*) – the precision of the Gaussian noise.

property stddev: torch.Tensor

The standard deviation of the Gaussian noise.

Returns
the standard deviation of the Gaussian noise.

Return type
Tensor

property variance: torch.Tensor

The variance of the Gaussian noise.

Returns
the variance of the Gaussian noise.

Return type
Tensor

__constants__ = ['std', 'leakage', 'precision']

std: torch.nn.Parameter

leakage: torch.nn.Parameter

precision: torch.nn.Parameter

static calc_std(*leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the standard deviation of the Gaussian noise.

Parameters

- **leakage** (*float*) – the leakage of the Gaussian noise.
- **precision** (*int*) – the precision of the Gaussian noise.

Returns

the standard deviation of the Gaussian noise.

Return type

float

static calc_precision(*std: analogvnn.utils.common_types.TENSOR_OPERABLE*, *leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the precision of the Gaussian noise.

Parameters

- **std** (*float*) – the standard deviation of the Gaussian noise.
- **leakage** (*float*) – the leakage of the Gaussian noise.

Returns

the precision of the Gaussian noise.

Return type

int

static calc_leakage(*std: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the leakage of the Gaussian noise.

Parameters

- **std** (*float*) – the standard deviation of the Gaussian noise.
- **precision** (*int*) – the precision of the Gaussian noise.

Returns

the leakage of the Gaussian noise.

Return type

float

pdf(*x: torch.Tensor*, *mean: torch.Tensor = 0*) → torch.Tensor

Calculate the probability density function of the Gaussian noise.

Parameters

- **x** (*Tensor*) – the input tensor.
- **mean** (*Tensor*) – the mean of the Gaussian noise.

Returns

the probability density function of the Gaussian noise.

Return type
Tensor

log_prob(*x: torch.Tensor*, *mean: torch.Tensor = 0*) → torch.Tensor

Calculate the log probability density function of the Gaussian noise.

Parameters

- **x** (*Tensor*) – the input tensor.
- **mean** (*Tensor*) – the mean of the Gaussian noise.

Returns
the log probability density function of the Gaussian noise.

Return type
Tensor

static static_cdf(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *std: analogvnn.utils.common_types.TENSOR_OPERABLE*, *mean: analogvnn.utils.common_types.TENSOR_OPERABLE = 0.0*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the cumulative distribution function of the Gaussian noise.

Parameters

- **x** (*TENSOR_OPERABLE*) – the input tensor.
- **std** (*TENSOR_OPERABLE*) – the standard deviation of the Gaussian noise.
- **mean** (*TENSOR_OPERABLE*) – the mean of the Gaussian noise.

Returns
the cumulative distribution function of the Gaussian noise.

Return type
TENSOR_OPERABLE

cdf(*x: torch.Tensor*, *mean: torch.Tensor = 0*) → torch.Tensor

Calculate the cumulative distribution function of the Gaussian noise.

Parameters

- **x** (*Tensor*) – the input tensor.
- **mean** (*Tensor*) – the mean of the Gaussian noise.

Returns
the cumulative distribution function of the Gaussian noise.

Return type
Tensor

forward(*x: torch.Tensor*) → torch.Tensor

Add the Gaussian noise to the input tensor.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

extra_repr() → str

The extra representation of the Gaussian noise.

Returns
the extra representation of the Gaussian noise.

Return type
str

analogvnn.nn.noise.LaplacianNoise

Module Contents

Classes

LaplacianNoise	Implements the Laplacian noise function.

class analogvnn.nn.noise.LaplacianNoise.**LaplacianNoise**(*scale: Optional[float] = None*, *leakage: Optional[float] = None*, *precision: Optional[int] = None*)

Bases: *analogvnn.nn.noise.Noise.Noise*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the Laplacian noise function.

Variables

- **scale** (*nn.Parameter*) – the scale of the Laplacian noise.
- **leakage** (*nn.Parameter*) – the leakage of the Laplacian noise.
- **precision** (*nn.Parameter*) – the precision of the Laplacian noise.

property stddev: torch.Tensor

The standard deviation of the Laplacian noise.

Returns
the standard deviation of the Laplacian noise.

Return type
Tensor

property variance: torch.Tensor

The variance of the Laplacian noise.

Returns
the variance of the Laplacian noise.

Return type
Tensor

__constants__ = ['scale', 'leakage', 'precision']

scale: torch.nn.Parameter

leakage: torch.nn.Parameter

precision: torch.nn.Parameter

static calc_scale(*leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the scale of the Laplacian noise.

Parameters

- **leakage** (*float*) – the leakage of the Laplacian noise.
- **precision** (*int*) – the precision of the Laplacian noise.

Returns
the scale of the Laplacian noise.

Return type
float

static calc_precision(*scale: analogvnn.utils.common_types.TENSOR_OPERABLE*, *leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the precision of the Laplacian noise.

Parameters

- **scale** (*float*) – the scale of the Laplacian noise.
- **leakage** (*float*) – the leakage of the Laplacian noise.

Returns
the precision of the Laplacian noise.

Return type
int

static calc_leakage(*scale: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → torch.Tensor

Calculate the leakage of the Laplacian noise.

Parameters

- **scale** (*float*) – the scale of the Laplacian noise.
- **precision** (*int*) – the precision of the Laplacian noise.

Returns
the leakage of the Laplacian noise.

Return type
float

pdf(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *loc: analogvnn.utils.common_types.TENSOR_OPERABLE = 0*) → torch.Tensor

The probability density function of the Laplacian noise.

Parameters

- **x** (*TENSOR_OPERABLE*) – the input tensor.
- **loc** (*TENSOR_OPERABLE*) – the mean of the Laplacian noise.

Returns
the probability density function of the Laplacian noise.

Return type
Tensor

log_prob(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *loc: analogvnn.utils.common_types.TENSOR_OPERABLE = 0*) → torch.Tensor

The log probability density function of the Laplacian noise.

Parameters

- **x** (*TENSOR_OPERABLE*) – the input tensor.
- **loc** (*TENSOR_OPERABLE*) – the mean of the Laplacian noise.

Returns
the log probability density function of the Laplacian noise.

Return type
Tensor

static static_cdf(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *scale: analogvnn.utils.common_types.TENSOR_OPERABLE*, *loc: analogvnn.utils.common_types.TENSOR_OPERABLE = 0.0*) → analogvnn.utils.common_types.TENSOR_OPERABLE

The cumulative distribution function of the Laplacian noise.

Parameters

- **x** (*TENSOR_OPERABLE*) – the input tensor.
- **scale** (*TENSOR_OPERABLE*) – the scale of the Laplacian noise.
- **loc** (*TENSOR_OPERABLE*) – the mean of the Laplacian noise.

Returns
the cumulative distribution function of the Laplacian noise.

Return type
TENSOR_OPERABLE

cdf(*x: torch.Tensor*, *loc: torch.Tensor = 0*) → torch.Tensor

The cumulative distribution function of the Laplacian noise.

Parameters

- **x** (*Tensor*) – the input tensor.
- **loc** (*Tensor*) – the mean of the Laplacian noise.

Returns
the cumulative distribution function of the Laplacian noise.

Return type
Tensor

forward(*x: torch.Tensor*) → torch.Tensor

Add Laplacian noise to the input tensor.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor with Laplacian noise.

Return type
Tensor

extra_repr() → str

The extra representation of the Laplacian noise.

Returns
the extra representation of the Laplacian noise.

Return type
str

analogvnn.nn.noise.Noise

Module Contents

Classes

Noise	This class is base class for all noise functions.

class analogvnn.nn.noise.Noise.**Noise**

Bases: *analogvnn.nn.module.Layer.Layer*

This class is base class for all noise functions.

analogvnn.nn.noise.PoissonNoise

Module Contents

Classes

PoissonNoise	Implements the Poisson noise function.

class analogvnn.nn.noise.PoissonNoise.**PoissonNoise**(*scale: Optional[float] = None*, *max_leakage: Optional[float] = None*, *precision: Optional[int] = None*)

Bases: *analogvnn.nn.noise.Noise.Noise*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the Poisson noise function.

Variables

- **scale** (*nn.Parameter*) – the scale of the Poisson noise function.
- **max_leakage** (*nn.Parameter*) – the maximum leakage of the Poisson noise.
- **precision** (*nn.Parameter*) – the precision of the Poisson noise.

property leakage: float

The leakage of the Poisson noise.

Returns
the leakage of the Poisson noise.

Return type
float

`property rate_factor: torch.Tensor`

The rate factor of the Poisson noise.

Returns
the rate factor of the Poisson noise.

Return type
Tensor

`__constants__ = ['scale', 'max_leakage', 'precision']`

`scale: torch.nn.Parameter`

`max_leakage: torch.nn.Parameter`

`precision: torch.nn.Parameter`

`static calc_scale`(*max_leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*, *max_check=10000*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculates the scale using the maximum leakage and the precision.

Parameters

- **max_leakage** (*TENSOR_OPERABLE*) – the maximum leakage of the Poisson noise.
- **precision** (*TENSOR_OPERABLE*) – the precision of the Poisson noise.
- **max_check** (*int*) – the maximum value to check for the scale.

Returns
the scale of the Poisson noise function.

Return type
TENSOR_OPERABLE

`static calc_precision`(*scale: analogvnn.utils.common_types.TENSOR_OPERABLE*, *max_leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*, *max_check=2**16*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculates the precision using the scale and the maximum leakage.

Parameters

- **scale** (*TENSOR_OPERABLE*) – the scale of the Poisson noise function.
- **max_leakage** (*TENSOR_OPERABLE*) – the maximum leakage of the Poisson noise.
- **max_check** (*int*) – the maximum value to check for the precision.

Returns
the precision of the Poisson noise.

Return type
TENSOR_OPERABLE

static calc_max_leakage(*scale: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculates the maximum leakage using the scale and the precision.

Parameters

- **scale** (*TENSOR_OPERABLE*) – the scale of the Poisson noise function.
- **precision** (*TENSOR_OPERABLE*) – the precision of the Poisson noise.

Returns
the maximum leakage of the Poisson noise.

Return type
TENSOR_OPERABLE

static static_cdf(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*, *rate: analogvnn.utils.common_types.TENSOR_OPERABLE*, *scale_factor: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculates the cumulative distribution function of the Poisson noise.

Parameters

- **x** (*TENSOR_OPERABLE*) – the input of the Poisson noise.
- **rate** (*TENSOR_OPERABLE*) – the rate of the Poisson noise.
- **scale_factor** (*TENSOR_OPERABLE*) – the scale factor of the Poisson noise.

Returns
the cumulative distribution function of the Poisson noise.

Return type
TENSOR_OPERABLE

static staticmethod_leakage(*scale: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculates the leakage of the Poisson noise using the scale and the precision.

Parameters

- **scale** (*TENSOR_OPERABLE*) – the scale of the Poisson noise function.
- **precision** (*TENSOR_OPERABLE*) – the precision of the Poisson noise.

Returns
the leakage of the Poisson noise.

Return type
TENSOR_OPERABLE

pdf(*x: torch.Tensor*, *rate: torch.Tensor*) → torch.Tensor

Calculates the probability density function of the Poisson noise.

Parameters

- **x** (*Tensor*) – the input of the Poisson noise.
- **rate** (*Tensor*) – the rate of the Poisson noise.

Returns
the probability density function of the Poisson noise.

Return type
Tensor

log_prob(*x: torch.Tensor*, *rate: torch.Tensor*) → torch.Tensor

Calculates the log probability of the Poisson noise.

Parameters

- **x** (*Tensor*) – the input of the Poisson noise.
- **rate** (*Tensor*) – the rate of the Poisson noise.

Returns
the log probability of the Poisson noise.

Return type
Tensor

cdf(*x: torch.Tensor*, *rate: torch.Tensor*) → torch.Tensor

Calculates the cumulative distribution function of the Poisson noise.

Parameters

- **x** (*Tensor*) – the input of the Poisson noise.
- **rate** (*Tensor*) – the rate of the Poisson noise.

Returns
the cumulative distribution function of the Poisson noise.

Return type
Tensor

forward(*x: torch.Tensor*) → torch.Tensor

Adds the Poisson noise to the input.

Parameters
x (*Tensor*) – the input of the Poisson noise.

Returns
the output of the Poisson noise.

Return type
Tensor

extra_repr() → str

Returns the extra representation of the Poisson noise.

Returns
the extra representation of the Poisson noise.

Return type
str

analogvnn.nn.noise.UniformNoise

Module Contents

Classes

UniformNoise	Implements the uniform noise function.

class analogvnn.nn.noise.UniformNoise.**UniformNoise**(*low: Optional[float] = None*, *high: Optional[float] = None*, *leakage: Optional[float] = None*, *precision: Optional[int] = None*)

Bases: *analogvnn.nn.noise.Noise.Noise*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the uniform noise function.

Variables

- **low** (*nn.Parameter*) – the lower bound of the uniform noise.
- **high** (*nn.Parameter*) – the upper bound of the uniform noise.
- **leakage** (*nn.Parameter*) – the leakage of the uniform noise.
- **precision** (*nn.Parameter*) – the precision of the uniform noise.

property mean: torch.Tensor

The mean of the uniform noise.

Returns
the mean of the uniform noise.

Return type
Tensor

property stddev: torch.Tensor

The standard deviation of the uniform noise.

Returns
the standard deviation of the uniform noise.

Return type
Tensor

property variance: torch.Tensor

The variance of the uniform noise.

Returns
the variance of the uniform noise.

Return type
Tensor

__constants__ = ['low', 'high', 'leakage', 'precision']

low: torch.nn.Parameter

high: torch.nn.Parameter

`leakage: torch.nn.Parameter`

`precision: torch.nn.Parameter`

static calc_high_low(*leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → Tuple[analogvnn.utils.common_types.TENSOR_OPERABLE, analogvnn.utils.common_types.TENSOR_OPERABLE]

Calculate the high and low from leakage and precision.

Parameters

- **leakage** (*TENSOR_OPERABLE*) – the leakage of the uniform noise.
- **precision** (*TENSOR_OPERABLE*) – the precision of the uniform noise.

Returns

the high and low of the uniform noise.

Return type

Tuple[TENSOR_OPERABLE, TENSOR_OPERABLE]

static calc_leakage(*low: analogvnn.utils.common_types.TENSOR_OPERABLE*, *high: analogvnn.utils.common_types.TENSOR_OPERABLE*, *precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the leakage from low, high and precision.

Parameters

- **low** (*TENSOR_OPERABLE*) – the lower bound of the uniform noise.
- **high** (*TENSOR_OPERABLE*) – the upper bound of the uniform noise.
- **precision** (*TENSOR_OPERABLE*) – the precision of the uniform noise.

Returns

the leakage of the uniform noise.

Return type

TENSOR_OPERABLE

static calc_precision(*low: analogvnn.utils.common_types.TENSOR_OPERABLE*, *high: analogvnn.utils.common_types.TENSOR_OPERABLE*, *leakage: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Calculate the precision from low, high and leakage.

Parameters

- **low** (*TENSOR_OPERABLE*) – the lower bound of the uniform noise.
- **high** (*TENSOR_OPERABLE*) – the upper bound of the uniform noise.
- **leakage** (*TENSOR_OPERABLE*) – the leakage of the uniform noise.

Returns

the precision of the uniform noise.

Return type

TENSOR_OPERABLE

pdf(*x: torch.Tensor*) → torch.Tensor

The probability density function of the uniform noise.

Parameters
x (*Tensor*) – the input tensor.

Returns
the probability density function of the uniform noise.

Return type
Tensor

log_prob(*x: torch.Tensor*) → torch.Tensor

The log probability density function of the uniform noise.

Parameters
x (*Tensor*) – the input tensor.

Returns
the log probability density function of the uniform noise.

Return type
Tensor

cdf(*x: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

The cumulative distribution function of the uniform noise.

Parameters
x (*TENSOR_OPERABLE*) – the input tensor.

Returns
the cumulative distribution function of the uniform noise.

Return type
TENSOR_OPERABLE

forward(*x: torch.Tensor*) → torch.Tensor

Add the uniform noise to the input tensor.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

extra_repr() → str

The extra representation of the uniform noise.

Returns
the extra representation of the uniform noise.

Return type
str

analogvnn.nn.normalize

Submodules

analogvnn.nn.normalize.Clamp

Module Contents

Classes

Clamp	Implements the clamp normalization function with range [-1, 1].
Clamp01	Implements the clamp normalization function with range [0, 1].

class analogvnn.nn.normalize.Clamp.**Clamp**

Bases: *analogvnn.nn.normalize.Normalize.Normalize*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the clamp normalization function with range [-1, 1].

static forward(*x: torch.Tensor*)

Forward pass of the clamp normalization function with range [-1, 1].

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the clamp normalization function with range [-1, 1].

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

class analogvnn.nn.normalize.Clamp.**Clamp01**

Bases: *analogvnn.nn.normalize.Normalize.Normalize*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the clamp normalization function with range [0, 1].

static forward(*x: torch.Tensor*)

Forward pass of the clamp normalization function with range [0, 1].

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the clamp normalization function with range [0, 1].

Parameters
grad_output (*Optional[Tensor]*) – the gradient of the output tensor.

Returns
the gradient of the input tensor.

Return type
Optional[Tensor]

analogvnn.nn.normalize.LPNorm

Module Contents

Classes

LPNorm	Implements the row-wise Lp normalization function.
LPNormW	Implements the whole matrix Lp normalization function.
L1Norm	Implements the row-wise L1 normalization function.
L2Norm	Implements the row-wise L2 normalization function.
L1NormW	Implements the whole matrix L1 normalization function.
L2NormW	Implements the whole matrix L2 normalization function.
L1NormM	Implements the row-wise L1 normalization function with maximum absolute value of 1.
L2NormM	Implements the row-wise L2 normalization function with maximum absolute value of 1.
L1NormWM	Implements the whole matrix L1 normalization function with maximum absolute value of 1.
L2NormWM	Implements the whole matrix L2 normalization function with maximum absolute value of 1.

class analogvnn.nn.normalize.LPNorm.**LPNorm**(*p: int*, *make_max_1=False*)

Bases: *analogvnn.nn.normalize.Normalize.Normalize*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the row-wise Lp normalization function.

Variables

- **p** (*int*) – the pth power of the Lp norm.
- **make_max_1** (*bool*) – if True, the maximum absolute value of the output tensor will be 1.

__constants__ = ['p', 'make_max_1']

p: torch.nn.Parameter

make_max_1: torch.nn.Parameter

forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of row-wise Lp normalization function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

class analogvnn.nn.normalize.LPNorm.**LPNormW**(*p: int*, *make_max_1=False*)

Bases: *LPNorm*

Implements the whole matrix Lp normalization function.

forward(*x: torch.Tensor*) → torch.Tensor

Forward pass of whole matrix Lp normalization function.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

class analogvnn.nn.normalize.LPNorm.**L1Norm**

Bases: *LPNorm*

Implements the row-wise L1 normalization function.

class analogvnn.nn.normalize.LPNorm.**L2Norm**

Bases: *LPNorm*

Implements the row-wise L2 normalization function.

class analogvnn.nn.normalize.LPNorm.**L1NormW**

Bases: *LPNormW*

Implements the whole matrix L1 normalization function.

class analogvnn.nn.normalize.LPNorm.**L2NormW**

Bases: *LPNormW*

Implements the whole matrix L2 normalization function.

class analogvnn.nn.normalize.LPNorm.**L1NormM**

Bases: *LPNorm*

Implements the row-wise L1 normalization function with maximum absolute value of 1.

class analogvnn.nn.normalize.LPNorm.**L2NormM**

Bases: *LPNorm*

Implements the row-wise L2 normalization function with maximum absolute value of 1.

class analogvnn.nn.normalize.LPNorm.**L1NormWM**

Bases: *LPNormW*

Implements the whole matrix L1 normalization function with maximum absolute value of 1.

class analogvnn.nn.normalize.LPNorm.**L2NormWM**

Bases: *LPNormW*

Implements the whole matrix L2 normalization function with maximum absolute value of 1.

analogvnn.nn.normalize.Normalize

Module Contents

Classes

Normalize	This class is base class for all normalization functions.

class analogvnn.nn.normalize.Normalize.**Normalize**

Bases: *analogvnn.nn.module.Layer.Layer*

This class is base class for all normalization functions.

analogvnn.nn.precision

Submodules

analogvnn.nn.precision.Precision

Module Contents

Classes

Precision	This class is base class for all precision functions.

class analogvnn.nn.precision.Precision.**Precision**

Bases: *analogvnn.nn.module.Layer.Layer*

This class is base class for all precision functions.

`analogvnn.nn.precision.ReducePrecision`

Module Contents

Classes

ReducePrecision	Implements the reduce precision function.

class analogvnn.nn.precision.ReducePrecision.**ReducePrecision**(*precision: int = None*, *divide: float = 0.5*)

Bases: *analogvnn.nn.precision.Precision.Precision*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the reduce precision function.

Variables

- **precision** (*nn.Parameter*) – the precision of the output tensor.
- **divide** (*nn.Parameter*) – the rounding value that is if divide is 0.5, then 0.6 will be rounded to 1.0 and 0.4 will be rounded to 0.0.

property precision_width: torch.Tensor

The precision width.

Returns
the precision width

Return type
Tensor

property bit_precision: torch.Tensor

The bit precision of the ReducePrecision module.

Returns
the bit precision of the ReducePrecision module.

Return type
Tensor

__constants__ = ['precision', 'divide']

precision: torch.nn.Parameter

divide: torch.nn.Parameter

static convert_to_precision(*bit_precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Convert the bit precision to the precision.

Parameters
bit_precision (*TENSOR_OPERABLE*) – the bit precision.

Returns
the precision.

Return type
TENSOR_OPERABLE

extra_repr() → str

The extra __repr__ string of the ReducePrecision module.

Returns
string

Return type
str

forward(*x: torch.Tensor*) → torch.Tensor

Forward function of the ReducePrecision module.

Parameters
x (*Tensor*) – the input tensor.

Returns
the output tensor.

Return type
Tensor

analogvnn.nn.precision.StochasticReducePrecision

Module Contents

Classes

StochasticReducePrecision	Implements the stochastic reduce precision function.

class analogvnn.nn.precision.StochasticReducePrecision.**StochasticReducePrecision**(*precision: int = 8*)

Bases: *analogvnn.nn.precision.Precision.Precision*, *analogvnn.backward.BackwardIdentity.BackwardIdentity*

Implements the stochastic reduce precision function.

Variables
precision (*nn.Parameter*) – the precision of the output tensor.

property precision_width: torch.Tensor

The precision width.

Returns
the precision width

Return type
Tensor

property bit_precision: torch.Tensor

The bit precision of the ReducePrecision module.

Returns
the bit precision of the ReducePrecision module.

Return type
Tensor

`__constants__ = ['precision']`

`precision: torch.nn.Parameter`

`static convert_to_precision`(*bit_precision: analogvnn.utils.common_types.TENSOR_OPERABLE*) → analogvnn.utils.common_types.TENSOR_OPERABLE

Convert the bit precision to the precision.

Parameters
`bit_precision` (*TENSOR_OPERABLE*) – the bit precision.

Returns
the precision.

Return type
TENSOR_OPERABLE

`extra_repr()` → str

The extra __repr__ string of the StochasticReducePrecision module.

Returns
string

Return type
str

`forward`(*x: torch.Tensor*) → torch.Tensor

Forward function of the StochasticReducePrecision module.

Parameters
`x` (*Tensor*) – input tensor.

Returns
output tensor.

Return type
Tensor

Submodules

`analogvnn.nn.Linear`

Module Contents

Classes

LinearBackpropagation	The backpropagation module of a linear layer.
Linear	A linear layer.

`class analogvnn.nn.Linear.LinearBackpropagation`(*layer: torch.nn.Module = None*)

Bases: *analogvnn.backward.BackwardModule.BackwardModule*

The backpropagation module of a linear layer.

forward(*x: torch.Tensor*)

Forward pass of the linear layer.

Parameters
x (*Tensor*) – The input of the linear layer.

Returns
The output of the linear layer.

Return type
Tensor

backward(*grad_output: Optional[torch.Tensor]*) → Optional[torch.Tensor]

Backward pass of the linear layer.

Parameters
grad_output (*Optional[Tensor]*) – The gradient of the output.

Returns
The gradient of the input.

Return type
Optional[Tensor]

class analogvnn.nn.Linear.**Linear**(*in_features: int*, *out_features: int*, *bias: bool = True*)

Bases: *analogvnn.nn.module.Layer.Layer*

A linear layer.

Variables

- **in_features** (*int*) – The number of input features.
- **out_features** (*int*) – The number of output features.
- **weight** (*nn.Parameter*) – The weight of the layer.
- **bias** (*nn.Parameter*) – The bias of the layer.

__constants__ = ['in_features', 'out_features']

in_features: int

out_features: int

weight: torch.nn.Parameter

bias: Optional[torch.nn.Parameter]

reset_parameters()

Reset the parameters of the layer.

extra_repr() → str

Extra representation of the linear layer.

Returns
The extra representation of the linear layer.

Return type
str

analogvnn.parameter

Submodules

analogvnn.parameter.PseudoParameter

Module Contents

Classes

PseudoParameter	A parameterized parameter which acts like a normal parameter during gradient updates.

class analogvnn.parameter.PseudoParameter.**PseudoParameter**(*data=None*, *requires_grad=True*, *transformation=None*)

Bases: `torch.nn.Module`

A parameterized parameter which acts like a normal parameter during gradient updates.

PyTorch's ParameterizedParameters vs AnalogVNN's PseudoParameters:

- **Similarity (Forward or Parameterizing the data):**
  > Data -> ParameterizingModel -> Parameterized Data
- Difference (Backward or Gradient Calculations): - ParameterizedParameters

  > Parameterized Data -> ParameterizingModel -> Data

  – PseudoParameters > Parameterized Data -> Data

Variables

- **_transformation** (*Callable*) – the transformation.
- **_transformed** (*nn.Parameter*) – the transformed parameter.

Properties:
grad (Tensor): the gradient of the parameter. module (PseudoParameterModule): the module that wraps the parameter and the transformation. transformation (Callable): the transformation.

property transformation

Returns the transformation.

Returns
the transformation.

Return type
Callable

_transformation: Callable

_transformed: torch.nn.Parameter

forward

Alias for __call__

_call_impl

Alias for __call__

right_inverse

Alias for set_original_data.

static identity(*x: Any*) → Any

The identity function.

Parameters
`x` (*Any*) – the input tensor.

Returns
the input tensor.

Return type
Any

__call__(**args*, ***kwargs*)

Transforms the parameter.

Parameters

- ***args** – additional arguments.
- ****kwargs** – additional keyword arguments.

Returns
the transformed parameter.

Return type
nn.Parameter

Raises
`RuntimeError` – if the transformation callable fails.

set_original_data(*data: torch.Tensor*) → *PseudoParameter*

Set data to the original parameter.

Parameters
`data` (*Tensor*) – the data to set.

Returns
self.

Return type
PseudoParameter

__repr__()

Returns a string representation of the parameter.

Returns
the string representation.

Return type
str

set_transformation(*transformation*) → *PseudoParameter*

Sets the transformation.

Parameters
`transformation` (*Callable*) – the transformation.

Returns
self.

Return type
PseudoParameter

static substitute_member(*tensor_from: Any, tensor_to: Any, property_name: str, setter: bool = True*)

Substitutes a member of a tensor as property of another tensor.

Parameters

- **tensor_from** (*Any*) – the tensor property to substitute.
- **tensor_to** (*Any*) – the tensor property to substitute to.
- **property_name** (*str*) – the name of the property.
- **setter** (*bool*) – whether to substitute the setter.

classmethod parameterize(*module: torch.nn.Module, param_name: str, transformation: Callable*) → *PseudoParameter*

Parameterizes a parameter.

Parameters

- **module** (*nn.Module*) – the module.
- **param_name** (*str*) – the name of the parameter.
- **transformation** (*Callable*) – the transformation to apply.

Returns
the parameterized parameter.

Return type
PseudoParameter

classmethod parametrize_module(*module: torch.nn.Module, transformation: Callable, requires_grad: bool = True, types: Optional[Union[type, Tuple[type]]] = None*)

Parametrize all parameters of a module.

Parameters

- **module** (*nn.Module*) – the module parameters to parametrize.
- **transformation** (*Callable*) – the transformation.
- **requires_grad** (*bool*) – if True, only parametrized parameters that require gradients.
- **types** (*Union[type, Tuple[type]]*) – the type or tuple of types to parametrize.

analogvnn.utils

Submodules

analogvnn.utils.TensorboardModelLog

Module Contents

Classes

TensorboardModelLog	Tensorboard model log.

class analogvnn.utils.TensorboardModelLog.**TensorboardModelLog**(*model: analogvnn.nn.module.Model.Model, log_dir: str*)

Tensorboard model log.

Variables

- **model** (*nn.Module*) – the model to log.
- **tensorboard** (*SummaryWriter*) – the tensorboard.
- **layer_data** (*bool*) – whether to log the layer data.
- **_log_record** (*Dict[str, bool]*) – the log record.

model: torch.nn.Module

tensorboard: Optional[torch.utils.tensorboard.SummaryWriter]

layer_data: bool

_log_record: Dict[str, bool]

__exit__

Close the tensorboard.

set_log_dir(*log_dir: str*) → *TensorboardModelLog*

Set the log directory.

Parameters
log_dir (*str*) – the log directory.

Returns
self.

Return type
TensorboardModelLog

Raises
ValueError – if the log directory is invalid.

_add_layer_data(*epoch: int = None*)

Add the layer data to the tensorboard.

Parameters
epoch (*int*) – the epoch to add the data for.

on_compile(*layer_data: bool = True*)

Called when the model is compiled.

Parameters
layer_data (*bool*) – whether to log the layer data.

add_graph(*train_loader: torch.utils.data.DataLoader*, *model: Optional[torch.nn.Module] = None*, *input_size: Optional[Sequence[int]] = None*) → *TensorboardModelLog*

Add the model graph to the tensorboard.

Parameters

- **train_loader** (*DataLoader*) – the train loader.
- **model** (*Optional[nn.Module]*) – the model to log.
- **input_size** (*Optional[Sequence[int]]*) – the input size.

Returns
self.

Return type
TensorboardModelLog

add_summary(*input_size: Optional[Sequence[int]] = None*, *train_loader: Optional[torch.utils.data.DataLoader] = None*, *model: Optional[torch.nn.Module] = None*, **args*, ***kwargs*) → Tuple[str, str]

Add the model summary to the tensorboard.

Parameters

- **input_size** (*Optional[Sequence[int]]*) – the input size.
- **train_loader** (*Optional[DataLoader]*) – the train loader.
- **model** (*nn.Module*) – the model to log.
- ***args** – the arguments to torchinfo.summary.
- ****kwargs** – the keyword arguments to torchinfo.summary.

Returns
the model __repr__ and the model summary.

Return type
Tuple[str, str]

register_training(*epoch: int*, *train_loss: float*, *train_accuracy: float*) → *TensorboardModelLog*

Register the training data.

Parameters

- **epoch** (*int*) – the epoch.
- **train_loss** (*float*) – the training loss.
- **train_accuracy** (*float*) – the training accuracy.

Returns
self.

Return type
TensorboardModelLog

register_testing(*epoch: int*, *test_loss: float*, *test_accuracy: float*) → *TensorboardModelLog*

Register the testing data.

Parameters

- **epoch** (*int*) – the epoch.
- **test_loss** (*float*) – the test loss.

- **test_accuracy** (*float*) – the test accuracy.

Returns
self.

Return type
TensorboardModelLog

close(**args*, ***kwargs*)

Close the tensorboard.

Parameters

- ***args** – ignored.
- ****kwargs** – ignored.

__enter__()

Enter the TensorboardModelLog context.

Returns
self.

Return type
TensorboardModelLog

analogvnn.utils.common_types

Module Contents

analogvnn.utils.common_types.**TENSORS**

TENSORS is a type alias for a tensor or a sequence of tensors.

analogvnn.utils.common_types.**TENSOR_OPERABLE**

TENSOR_OPERABLE is a type alias for types that can be operated on by a tensor.

analogvnn.utils.common_types.**TENSOR_CALLABLE**

TENSOR_CALLABLE is a type alias for a function that takes a *TENSOR_OPERABLE* and returns a *TENSOR_OPERABLE*.

analogvnn.utils.get_model_summaries

Module Contents

Functions

get_model_summaries(→ Tuple[str, str])	Creates the model summaries.

analogvnn.utils.get_model_summaries.**get_model_summaries**(*model: Optional[torch.nn.Module], input_size: Optional[Sequence[int]] = None, train_loader: torch.utils.data.DataLoader = None, *args, **kwargs*) → Tuple[str, str]

Creates the model summaries.

Parameters

- **train_loader** (*DataLoader*) – the train loader.
- **model** (*nn.Module*) – the model to log.
- **input_size** (*Optional[Sequence[int]]*) – the input size.
- ***args** – the arguments to torchinfo.summary.
- ****kwargs** – the keyword arguments to torchinfo.summary.

Returns
the model __repr__ and the model summary.

Return type
Tuple[str, str]

Raises

- **ImportError** – if torchinfo (https://github.com/tyleryep/torchinfo) is not installed.
- **ValueError** – if the input_size and train_loader are None.

analogvnn.utils.is_cpu_cuda

Module Contents

Classes

CPUCuda	CPUCuda is a class that can be used to get, check and set the device.

Attributes

is_cpu_cuda	The CPUCuda instance.

`class analogvnn.utils.is_cpu_cuda.CPUCuda`

CPUCuda is a class that can be used to get, check and set the device.

Variables

- **_device** (*torch.device*) – The device.
- **device_name** (*str*) – The name of the device.

`property device: torch.device`

Get the device.

Returns
the device.

Return type
torch.device

property is_cpu: bool

Check if the device is cpu.

Returns
True if the device is cpu, False otherwise.

Return type
bool

property is_cuda: bool

Check if the device is cuda.

Returns
True if the device is cuda, False otherwise.

Return type
bool

property is_using_cuda: Tuple[torch.device, bool]

Check if the device is cuda.

Returns
the device and True if the device is cuda, False otherwise.

Return type
tuple

_device: torch.device

device_name: str

use_cpu() → *CPUCuda*

Use cpu.

Returns
self

Return type
CPUCuda

use_cuda_if_available() → *CPUCuda*

Use cuda if available.

Returns
self

Return type
CPUCuda

set_device(*device_name: Union[str, torch.device]*) → *CPUCuda*

Set the device to the given device name.

Parameters
device_name (*Union[str, torch.device]*) – the device name.

Returns
self

Return type
CPUCuda

get_module_device(*module*) → torch.device

Get the device of the given module.

Parameters
module (*torch.nn.Module*) – the module.

Returns
the device of the module.

Return type
torch.device

analogvnn.utils.is_cpu_cuda.**is_cpu_cuda**: *CPUCuda*

The CPUCuda instance.

Type
CPUCuda

analogvnn.utils.render_autograd_graph

Module Contents

Classes

AutoGradDot	Stores and manages Graphviz representation of PyTorch autograd graph.

Functions

size_to_str(size)	Convert a tensor size to a string.
make_autograd_obj_from_outputs(→ AutoGradDot)	Compile Graphviz representation of PyTorch autograd graph from output tensors.
make_autograd_obj_from_module(→ AutoGradDot)	Compile Graphviz representation of PyTorch autograd graph from forward pass.
get_autograd_dot_from_trace(→ graphviz.Digraph)	Produces graphs of torch.jit.trace outputs.
get_autograd_dot_from_outputs(→ graphviz.Digraph)	Runs and make Graphviz representation of PyTorch autograd graph from output tensors.
get_autograd_dot_from_module(→ graphviz.Digraph)	Runs and make Graphviz representation of PyTorch autograd graph from forward pass.
save_autograd_graph_from_outputs(→ str)	Save Graphviz representation of PyTorch autograd graph from output tensors.
save_autograd_graph_from_module(→ str)	Save Graphviz representation of PyTorch autograd graph from forward pass.
save_autograd_graph_from_trace(→ str)	Save Graphviz representation of PyTorch autograd graph from trace.

analogvnn.utils.render_autograd_graph.**size_to_str**(*size*)

Convert a tensor size to a string.

Parameters
size (*torch.Size*) – the size to convert.

Returns
the string representation of the size.

Return type
str

`class analogvnn.utils.render_autograd_graph.AutoGradDot`

Stores and manages Graphviz representation of PyTorch autograd graph.

Variables

- **dot** (*graphviz.Digraph*) – Graphviz representation of the autograd graph.
- **_module** (*nn.Module*) – The module to be traced.
- **_inputs** (*List[Tensor]*) – The inputs to the module.
- **_inputs_kwargs** (*Dict[str, Tensor]*) – The keyword arguments to the module.
- **_outputs** (*Sequence[Tensor]*) – The outputs of the module.
- **param_map** (*Dict[int, str]*) – A map from parameter values to their names.
- **_seen** (*set*) – A set of nodes that have already been added to the graph.
- **show_attrs** (*bool*) – whether to display non-tensor attributes of backward nodes (Requires PyTorch version >= 1.9)
- **show_saved** (*bool*) – whether to display saved tensor nodes that are not by custom autograd functions. Saved tensor nodes for custom functions, if present, are always displayed. (Requires PyTorch version >= 1.9)
- **max_attr_chars** (*int*) – if show_attrs is *True*, sets max number of characters to display for any given attribute.
- **_called** (*bool*) – the module has been called.

`property inputs: Sequence[torch.Tensor]`

The arg inputs to the module.

Returns
the arg inputs to the module.

Return type
Sequence[Tensor]

`property inputs_kwargs: Dict[str, torch.Tensor]`

The keyword inputs to the module.

Parameters

- **Dict[str** – the keyword inputs to the module.
- **Tensor]** – the keyword inputs to the module.

`property outputs: Optional[Sequence[torch.Tensor]]`

The outputs of the module.

Returns
the outputs of the module.

Return type
Optional[Sequence[Tensor]]

property module: torch.nn.Module

The module.

Returns
the module to be traced.

Return type
nn.Module

property ignore_tensor: Dict[int, bool]

The tensor ignored from the dot graphs.

Returns
the ignore tensor dict.

Return type
Dict[int, bool]

dot: graphviz.Digraph

_module: torch.nn.Module

_inputs: Sequence[torch.Tensor]

_inputs_kwargs: Dict[str, torch.Tensor]

_outputs: Sequence[torch.Tensor]

param_map: dict

_seen: set

show_attrs: bool

show_saved: bool

max_attr_chars: int

_called: bool = False

_ignore_tensor: Dict[int, bool]

__post_init__()

Create the graphviz graph.

Raises
ImportError – if graphviz (https://pygraphviz.github.io/) is not available.

reset_params()

Reset the param_map and _seen.

Returns
self.

Return type
AutoGradDot

add_ignore_tensor(*tensor: torch.Tensor*)

Add a tensor to the ignore tensor dict.

Parameters
tensor (*Tensor*) – the tensor to ignore.

Returns
self.

Return type
AutoGradDot

del_ignore_tensor(*tensor: torch.Tensor*)

Delete a tensor from the ignore tensor dict.

Parameters
tensor (*Tensor*) – the tensor to delete.

Returns
self.

Return type
AutoGradDot

get_tensor_name(*tensor: torch.Tensor*, *name: Optional[str] = None*) → Tuple[str, str]

Get the name of the tensor.

Parameters

- **tensor** (*Tensor*) – the tensor.
- **name** (*Optional[str]*) – the name of the tensor. Defaults to None.

Returns
the name and size of the tensor.

Return type
Tuple[str, str]

add_tensor(*tensor: torch.Tensor*, *name: Optional[str] = None*, *_attributes=None*, ***kwargs*)

Add a tensor to the graph.

Parameters

- **tensor** (*Tensor*) – the tensor.
- **name** (*Optional[str]*) – the name of the tensor. Defaults to None.
- **_attributes** (*Optional[Dict[str, str]]*) – the attributes of the tensor. Defaults to None.
- ****kwargs** – the attributes of the dot.node function.

Returns
self.

Return type
AutoGradDot

add_fn(*fn: Any*, *_attributes=None*, ***kwargs*)

Add a function to the graph.

Parameters

- **fn** (*Any*) – the function.
- **_attributes** (*Optional[Dict[str, str]]*) – the attributes of the function. Defaults to None.
- ****kwargs** – the attributes of the dot.node function.

Returns
self.

Return type
AutoGradDot

add_edge(*u: Any*, *v: Any*, *label: Optional[str] = None*, *_attributes=None*, ***kwargs*)

Add an edge to the graph.

Parameters

- **u** (*Any*) – tail node.
- **v** (*Any*) – head node.
- **label** (*Optional[str]*) – the label of the edge. Defaults to None.
- **_attributes** (*Optional[Dict[str, str]]*) – the attributes of the edge. Defaults to None.
- ****kwargs** – the attributes of the dot.edge function.

Returns
self.

Return type
AutoGradDot

add_seen(*item: Any*)

Add an item to the seen set.

Parameters
item (*Any*) – the item.

Returns
self.

Return type
AutoGradDot

is_seen(*item: Any*) → bool

Check if the item is in the seen set.

Parameters
item (*Any*) – the item.

Returns
True if the item is in the seen set.

Return type
bool

`analogvnn.utils.render_autograd_graph.`**`make_autograd_obj_from_outputs`**(*outputs: Union[torch.Tensor, Sequence[torch.Tensor]], named_params: Union[Dict[str, Any], Iterator[Tuple[str, torch.nn.Parameter]]], additional_params: Optional[dict] = None, show_attrs: bool = True, show_saved: bool = True, max_attr_chars: int = 50*) → *AutoGradDot*

Compile Graphviz representation of PyTorch autograd graph from output tensors.

Parameters

- **outputs** (*Union[Tensor, Sequence[Tensor]]*) – output tensor(s) of forward pass
- **named_params** (*Union[Dict[str, Any], Iterator[Tuple[str, Parameter]]]*) – dict of params to label nodes with
- **additional_params** (*dict*) – dict of additional params to label nodes with
- **show_attrs** (*bool*) – whether to display non-tensor attributes of backward nodes (Requires PyTorch version >= 1.9)
- **show_saved** (*bool*) – whether to display saved tensor nodes that are not by custom autograd functions. Saved tensor nodes for custom functions, if present, are always displayed. (Requires PyTorch version >= 1.9)
- **max_attr_chars** (*int*) – if show_attrs is *True*, sets max number of characters to display for any given attribute.

Returns

graphviz representation of autograd graph

Return type

AutoGradDot

`analogvnn.utils.render_autograd_graph.`**`make_autograd_obj_from_module`**(*module: torch.nn.Module, *args: torch.Tensor, additional_params: Optional[dict] = None, show_attrs: bool = True, show_saved: bool = True, max_attr_chars: int = 50, from_forward: bool = False, **kwargs: torch.Tensor*) → *AutoGradDot*

Compile Graphviz representation of PyTorch autograd graph from forward pass.

Parameters

- **module** (*nn.Module*) – PyTorch model
- ***args** (*Tensor*) – input to the model
- **additional_params** (*dict*) – dict of additional params to label nodes with

- **show_attrs** (*bool*) – whether to display non-tensor attributes of backward nodes (Requires PyTorch version >= 1.9)
- **show_saved** (*bool*) – whether to display saved tensor nodes that are not by custom autograd functions. Saved tensor nodes for custom functions, if present, are always displayed. (Requires PyTorch version >= 1.9)
- **max_attr_chars** (*int*) – if show_attrs is *True*, sets max number of characters to display for any given attribute.
- **from_forward** (*bool*) – if True then use autograd graph otherwise analogvvn graph
- ****kwargs** (*Tensor*) – input to the model

Returns
graphviz representation of autograd graph

Return type
AutoGradDot

`analogvnn.utils.render_autograd_graph.get_autograd_dot_from_trace(trace) → graphviz.Digraph`

Produces graphs of torch.jit.trace outputs.

Example: >>> trace, = torch.jit.trace(model, args=(x,)) >>> dot = get_autograd_dot_from_trace(trace)

Parameters
trace (*torch.jit.trace*) – the trace object to visualize.

Returns
the resulting graph.

Return type
graphviz.Digraph

`analogvnn.utils.render_autograd_graph.get_autograd_dot_from_outputs(outputs: Union[torch.Tensor, Sequence[torch.Tensor]], named_params: Union[Dict[str, Any], Iterator[Tuple[str, torch.nn.Parameter]]], additional_params: Optional[dict] = None, show_attrs: bool = True, show_saved: bool = True, max_attr_chars: int = 50) → graphviz.Digraph`

Runs and make Graphviz representation of PyTorch autograd graph from output tensors.

Parameters

- **outputs** (*Union[Tensor, Sequence[Tensor]]*) – output tensor(s) of forward pass
- **named_params** (*Union[Dict[str, Any], Iterator[Tuple[str, Parameter]]]*) – dict of params to label nodes with
- **additional_params** (*dict*) – dict of additional params to label nodes with
- **show_attrs** (*bool*) – whether to display non-tensor attributes of backward nodes (Requires PyTorch version >= 1.9)

- **show_saved** (*bool*) – whether to display saved tensor nodes that are not by custom autograd functions. Saved tensor nodes for custom functions, if present, are always displayed. (Requires PyTorch version >= 1.9)
- **max_attr_chars** (*int*) – if show_attrs is *True*, sets max number of characters to display for any given attribute.

Returns
graphviz representation of autograd graph

Return type
Digraph

`analogvnn.utils.render_autograd_graph.`**`get_autograd_dot_from_module`**(*module: torch.nn.Module, *args: torch.Tensor, additional_params: Optional[dict] = None, show_attrs: bool = True, show_saved: bool = True, max_attr_chars: int = 50, from_forward: bool = False, **kwargs: torch.Tensor*) → graphviz.Digraph

Runs and make Graphviz representation of PyTorch autograd graph from forward pass.

Parameters

- **module** (*nn.Module*) – PyTorch model
- ***args** (*Tensor*) – input to the model
- **additional_params** (*dict*) – dict of additional params to label nodes with
- **show_attrs** (*bool*) – whether to display non-tensor attributes of backward nodes (Requires PyTorch version >= 1.9)
- **show_saved** (*bool*) – whether to display saved tensor nodes that are not by custom autograd functions. Saved tensor nodes for custom functions, if present, are always displayed. (Requires PyTorch version >= 1.9)
- **max_attr_chars** (*int*) – if show_attrs is *True*, sets max number of characters to display for any given attribute.
- **from_forward** (*bool*) – if True then use autograd graph otherwise analogvvn graph
- ****kwargs** (*Tensor*) – input to the model

Returns
graphviz representation of autograd graph

Return type
Digraph

`analogvnn.utils.render_autograd_graph.`**`save_autograd_graph_from_outputs`**(*filename: Union[str, pathlib.Path], outputs: Union[torch.Tensor, Sequence[torch.Tensor]], named_params: Union[Dict[str, Any], Iterator[Tuple[str, torch.nn.Parameter]]], additional_params: Optional[dict] = None, show_attrs: bool = True, show_saved: bool = True, max_attr_chars: int = 50*) → str

Save Graphviz representation of PyTorch autograd graph from output tensors.

Parameters

- **filename** (*Union[str, Path]*) – filename to save the graph to
- **outputs** (*Union[Tensor, Sequence[Tensor]]*) – output tensor(s) of forward pass
- **named_params** (*Union[Dict[str, Any], Iterator[Tuple[str, Parameter]]]*) – dict of params to label nodes with
- **additional_params** (*dict*) – dict of additional params to label nodes with
- **show_attrs** (*bool*) – whether to display non-tensor attributes of backward nodes (Requires PyTorch version >= 1.9)
- **show_saved** (*bool*) – whether to display saved tensor nodes that are not by custom autograd functions. Saved tensor nodes for custom functions, if present, are always displayed. (Requires PyTorch version >= 1.9)
- **max_attr_chars** (*int*) – if show_attrs is *True*, sets max number of characters to display for any given attribute.

Returns

The (possibly relative) path of the rendered file.

Return type

str

`analogvnn.utils.render_autograd_graph.`**`save_autograd_graph_from_module`**(*filename: Union[str, pathlib.Path], module: torch.nn.Module, *args: torch.Tensor, additional_params: Optional[dict] = None, show_attrs: bool = True, show_saved: bool = True, max_attr_chars: int = 50, from_forward: bool = False, **kwargs: torch.Tensor*) → str

Save Graphviz representation of PyTorch autograd graph from forward pass.

Parameters

- **filename** (*Union[str, Path]*) – filename to save the graph to
- **module** (*nn.Module*) – PyTorch model
- ***args** (*Tensor*) – input to the model
- **additional_params** (*dict*) – dict of additional params to label nodes with
- **show_attrs** (*bool*) – whether to display non-tensor attributes of backward nodes (Requires PyTorch version >= 1.9)
- **show_saved** (*bool*) – whether to display saved tensor nodes that are not by custom autograd functions. Saved tensor nodes for custom functions, if present, are always displayed. (Requires PyTorch version >= 1.9)
- **max_attr_chars** (*int*) – if show_attrs is *True*, sets max number of characters to display for any given attribute.
- **from_forward** (*bool*) – if True then use autograd graph otherwise analogvvn graph
- ****kwargs** (*Tensor*) – input to the model

Returns
The (possibly relative) path of the rendered file.

Return type
str

`analogvnn.utils.render_autograd_graph.`**`save_autograd_graph_from_trace`**(*filename: Union[str, pathlib.Path], trace*) → str

Save Graphviz representation of PyTorch autograd graph from trace.

Parameters

- **filename** (*Union[str, Path]*) – filename to save the graph to
- **trace** (*torch.jit.trace*) – the trace object to visualize.

Returns
The (possibly relative) path of the rendered file.

Return type
str

analogvnn.utils.to_tensor_parameter

Module Contents

Functions

to_float_tensor(→ Tuple[Union[torch.Tensor, None], ...)	Converts the given arguments to *torch.Tensor* of type *torch.float32*.
to_nongrad_parameter(→ Tuple[Union[torch.nn.Parameter, ...)	Converts the given arguments to *nn.Parameter* of type *torch.float32*.

`analogvnn.utils.to_tensor_parameter.`**`to_float_tensor`**(**args*) → Tuple[Union[torch.Tensor, None], Ellipsis]

Converts the given arguments to *torch.Tensor* of type *torch.float32*.

The returned tensors are not trainable.

Parameters
`*args` – the arguments to convert.

Returns
the converted arguments.

Return type
tuple

`analogvnn.utils.to_tensor_parameter.to_nongrad_parameter(*args)` → Tuple[Union[torch.nn.Parameter, None], Ellipsis]

Converts the given arguments to *nn.Parameter* of type *torch.float32*.

The returned parameters are not trainable.

Parameters
`*args` – the arguments to convert.

Returns
the converted arguments.

Return type
tuple

Package Contents

`analogvnn.__package__ = 'analogvnn'`

`analogvnn.__author__ = 'Vivswan Shah (vivswanshah@pitt.edu)'`

`analogvnn.__version__`

1.8 Changelog

1.8.1 1.0.8

- Removed redundant code from `reduce_precision`.
- Added `types` argument to `PseudoParameter.parametrize_module` for better selection for Parameterising the Layers.

1.8.2 1.0.7

- Fixed GeLU backward function equation.

1.8.3 1.0.6

- Model is subclass of BackwardModule for additional functionality.
- Using inspect.isclass to check if backward_class is a class in Linear.set_backward_function.
- Repr using self.__class__.__name__ in all classes.

1.8.4 1.0.5 (Patches for Pytorch 2.0.1)

- Removed unnecessary PseudoParameter.grad property.
- Patch for Pytorch 2.0.1, add filtering inputs in BackwardGraph._calculate_gradients.

1.8.5 1.0.4

- Combined PseudoParameter and PseudoParameterModule for better visibility.
  - BugFix: fixed save and load of state_dict of PseudoParameter and transformation module.
- Removed redundant class analogvnn.parameter.Parameter.

1.8.6 1.0.3

- Added support for no loss function in Model class.
  - If no loss function is provided, the Model object will use outputs for gradient computation.
- Added support for multiple loss outputs from loss function.

1.8.7 1.0.2

- Bugfix: removed graph from Layer class.
  - graph was causing issues with nested Model objects.
  - Now _use_autograd_graph is directly set while compiling the Model object.

1.8.8 1.0.1 (Patches for Pytorch 2.0.0)

- added grad.setter to PseudoParameterModule class.

1.8.9 1.0.0

- Public release.

CHAPTER

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PYTHON MODULE INDEX

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