
Pixyz Documentation

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Pixyz is a library for developing deep generative models in a more concise, intuitive and extendable way!

pixyz.distributions (Distribution API)

1.1 Distribution

```
class pixyz.distributions.distributions.Distribution (cond_var=[], var=['x'],
                                                name='p', dim=1)
```

Bases: torch.nn.modules.module.Module

Distribution class. In pixyz, all distributions are required to inherit this class.

var [list] Variables of this distribution.

cond_var [list] Conditional variables of this distribution. In case that *cond_var* is not empty, we must set the corresponding inputs in order to sample variables or estimate the log likelihood.

dim [int] Number of dimensions of this distribution. This might be ignored depending on the shape which is set in the sample method and on its parent distribution. Moreover, this is not consider when this class is inherited by DNNs. This is set to 1 by default.

name [str] Name of this distribution. This name is displayed in *prob_text* and *prob_factorized_text*. This is set to “p” by default.

distribution_name

name

var

cond_var

input_var

Normally, *input_var* has same values as *cond_var*.

prob_text

prob_factorized_text

get_params (*params_dict={}*)

This method aims to get parameters of this distributions from constant parameters set in initialization and outputs of DNNs.

params_dict [dict] Input parameters.

output_dict [dict] Output parameters

```
>>> print(dist_1.prob_text, dist_1.distribution_name)
p(x) Normal
>>> dist_1.get_params()
{"loc": 0, "scale": 1}
>>> print(dist_2.prob_text, dist_2.distribution_name)
p(x|z) Normal
>>> dist_1.get_params({"z": 1})
{"loc": 0, "scale": 1}
```

sample (*x={}*, *shape=None*, *batch_size=1*, *return_all=True*, *reparam=False*)

Sample variables of this distribution. If *cond_var* is not empty, we should set inputs as a dictionary format.

x [torch.Tensor, list, or dict] Input variables.

shape [tuple] Shape of samples. If set, *batch_size* and *dim* are ignored.

batch_size [int] Batch size of samples. This is set to 1 by default.

return_all [bool] Choose whether the output contains input variables.

reparam [bool] Choose whether we sample variables with reparameterized trick.

output [dict] Samples of this distribution.

log_likelihood (*x_dict*)

Estimate the log likelihood of this distribution from inputs formatted by a dictionary.

x_dict [dict] Input samples.

log_like [torch.Tensor] Log-likelihood.

forward (**args*, ***kwargs*)

When this class is inherited by DNNs, it is also intended that this method is overridden.

sample_mean (*x*)

replace_var (***replace_dict*)

marginalize_var (*marginalize_list*)

1.2 Exponential families

1.2.1 Normal

class pixyz.distributions.**Normal** (*cond_var=[]*, *var=['x']*, *name='p'*, *dim=None*, ***kwargs*)

Bases: pixyz.distributions.distributions.DistributionBase

distribution_name

sample_mean (*x*)

1.2.2 Bernoulli

```
class pixyz.distributions.Bernoulli (cond_var=[], var=['x'], name='p', dim=None,
                                     **kwargs)
    Bases: pixyz.distributions.distributions.DistributionBase
    distribution_name
    sample_mean (x)
```

1.2.3 RelaxedBernoulli

```
class pixyz.distributions.RelaxedBernoulli (temperature, cond_var=[], var=['x'],
                                             name='p', dim=None, **kwargs)
    Bases: pixyz.distributions.distributions.DistributionBase
    distribution_name
    log_likelihood (x)
        Estimate the log likelihood of this distribution from inputs formatted by a dictionary.
    x_dict [dict] Input samples.
    log_like [torch.Tensor] Log-likelihood.
    sample_mean (x)
```

1.2.4 FactorizedBernoulli

```
class pixyz.distributions.FactorizedBernoulli (cond_var=[], var=['x'], name='p',
                                                dim=None, **kwargs)
    Bases: pixyz.distributions.exponential_distributions.Bernoulli
    Generative Models of Visually Grounded Imagination
    distribution_name
```

1.2.5 Categorical

```
class pixyz.distributions.Categorical (cond_var=[], var=['x'], name='p', dim=None,
                                       **kwargs)
    Bases: pixyz.distributions.distributions.DistributionBase
    distribution_name
    sample_mean (x)
```

1.2.6 RelaxedCategorical

```
class pixyz.distributions.RelaxedCategorical (temperature, cond_var=[], var=['x'],
                                              name='p', dim=None, **kwargs)
    Bases: pixyz.distributions.distributions.DistributionBase
    distribution_name
    log_likelihood (x)
        Estimate the log likelihood of this distribution from inputs formatted by a dictionary.
```

x_dict [dict] Input samples.

log_like [torch.Tensor] Log-likelihood.

sample_mean (x)

1.3 Complex distributions

1.3.1 MixtureModel

class pixyz.distributions.**MixtureModel** (*distributions, prior, name='p'*)

Bases: *pixyz.distributions.distributions.Distribution*

Mixture models. $p(x) = \sum_i p(x|z = i)p(z = i)$

distributions [list] List of distributions.

prior [pixyz.Distribution.Categorical] Prior distribution of latent variable (i.e., the contribution rate). This should be a categorical distribution and the number of its category should be the same as the length of the distribution list.

```
>>> from pixyz.distributions import Normal, Categorical
>>> from pixyz.distributions.mixture_distributions import MixtureModel
>>>
>>> z_dim = 3 # the number of mixture
>>> x_dim = 2 # the input dimension.
>>>
>>> distributions = [] # the list of distributions
>>> for i in range(z_dim):
>>>     loc = torch.randn(x_dim) # initialize the value of location (mean)
>>>     scale = torch.empty(x_dim).fill_(1.) # initialize the value of scale_
↪ (variance)
>>>     distributions.append(Normal(loc=loc, scale=scale, var=["x"], name="p_%d"
↪ %i))
>>>
>>> probs = torch.empty(z_dim).fill_(1. / z_dim) # initialize the value of_
↪ probabilities
>>> prior = Categorical(probs=probs, var=["z"], name="prior")
>>>
>>> p = MixtureModel(distributions=distributions, prior=prior)
```

prob_text

prob_factorized_text

distribution_name

get_posterior_probs (x_dict)

sample (*batch_size=1, return_hidden=False, **kwargs*)

Sample variables of this distribution. If *cond_var* is not empty, we should set inputs as a dictionary format.

x [torch.Tensor, list, or dict] Input variables.

shape [tuple] Shape of samples. If set, *batch_size* and *dim* are ignored.

batch_size [int] Batch size of samples. This is set to 1 by default.

return_all [bool] Choose whether the output contains input variables.

reparam [bool] Choose whether we sample variables with reparameterized trick.

output [dict] Samples of this distribution.

log_likelihood_all_hidden (*x_dict*)

Estimate joint log-likelihood, $\log p(x, z)$, where input is *x*.

x_dict [dict] Input variables (including *var*).

loglike [torch.Tensor] dim=0 : the number of mixture dim=1 : the size of batch

log_likelihood (*x_dict*)

Estimate log-likelihood, $\log p(x)$.

x_dict [dict] Input variables (including *var*).

loglike [torch.Tensor] The log-likelihood value of *x*.

1.3.2 NormalPoE

class pixyz.distributions.**NormalPoE** (*prior*, *dists*=[], ***kwargs*)

Bases: torch.nn.modules.module.Module

$p(z|x, y) \propto p(z)p(z|x)p(z|y)$

dists [list] Other distributions.

prior [Distribution] Prior distribution.

```
>>> poe = NormalPoE(c, [a, b])
```

get_params (*params*, ***kwargs*)

experts (*loc*, *scale*, *eps*=1e-08)

sample (*x*=None, *return_all*=True, ***kwargs*)

log_likelihood (*x*)

sample_mean (*x*, ***kwargs*)

1.4 Special distributions

1.4.1 Deterministic

class pixyz.distributions.**Deterministic** (***kwargs*)

Bases: *pixyz.distributions.distributions.Distribution*

Deterministic distribution (or degeneration distribution)

distribution_name

sample (*x*={}, *return_all*=True, ***kwargs*)

Sample variables of this distribution. If *cond_var* is not empty, we should set inputs as a dictionary format.

x [torch.Tensor, list, or dict] Input variables.

shape [tuple] Shape of samples. If set, *batch_size* and *dim* are ignored.

batch_size [int] Batch size of samples. This is set to 1 by default.

return_all [bool] Choose whether the output contains input variables.

reparam [bool] Choose whether we sample variables with reparameterized trick.

output [dict] Samples of this distribution.

1.4.2 DataDistribution

```
class pixyz.distributions.DataDistribution (var, name='p_data')
    Bases: pixyz.distributions.distributions.Distribution
    Data distribution. TODO: Fix this behavior if multiplied with other distributions
    distribution_name
    sample (x={}, **kwargs)
        Sample variables of this distribution. If cond_var is not empty, we should set inputs as a dictionary format.
    x [torch.Tensor, list, or dict] Input variables.
    shape [tuple] Shape of samples. If set, batch_size and dim are ignored.
    batch_size [int] Batch size of samples. This is set to 1 by default.
    return_all [bool] Choose whether the output contains input variables.
    reparam [bool] Choose whether we sample variables with reparameterized trick.
    output [dict] Samples of this distribution.

    input_var
        In DataDistribution, input_var is same as var.
```

1.4.3 CustomLikelihoodDistribution

```
class pixyz.distributions.CustomLikelihoodDistribution (var=['x'], likelihood=None, **kwargs)
    Bases: pixyz.distributions.distributions.Distribution
    input_var
        In CustomLikelihoodDistribution, input_var is same as var.
    distribution_name
    log_likelihood (x_dict)
        Estimate the log likelihood of this distribution from inputs formatted by a dictionary.
    x_dict [dict] Input samples.
    log_like [torch.Tensor] Log-likelihood.
```

1.5 Flow-based

1.5.1 PlanarFlow

class pixyz.distributions.**PlanarFlow** (*prior, dim, num_layers=1, var=[], **kwargs*)
 Bases: pixyz.distributions.flows.Flow

1.5.2 RealNVP

class pixyz.distributions.**RealNVP** (*prior, dim, num_multiscale_layers=2, var=[], image=False, name='p', **kwargs*)
 Bases: *pixyz.distributions.distributions.Distribution*

prob_text

forward (*x, inverse=False, jacobian=False*)

When this class is inherited by DNNs, it is also intended that this method is overridden.

sample (*x={}, only_flow=False, return_all=True, **kwargs*)

Sample variables of this distribution. If *cond_var* is not empty, we should set inputs as a dictionary format.

x [torch.Tensor, list, or dict] Input variables.

shape [tuple] Shape of samples. If set, *batch_size* and *dim* are ignored.

batch_size [int] Batch size of samples. This is set to 1 by default.

return_all [bool] Choose whether the output contains input variables.

reparam [bool] Choose whether we sample variables with reparameterized trick.

output [dict] Samples of this distribution.

sample_inv (*x, return_all=True, **kwargs*)

log_likelihood (*x*)

Estimate the log likelihood of this distribution from inputs formatted by a dictionary.

x_dict [dict] Input samples.

log_like [torch.Tensor] Log-likelihood.

1.6 Operators

1.6.1 ReplaceVarDistribution

class pixyz.distributions.distributions.**ReplaceVarDistribution** (*a, replace_dict*)
 Bases: *pixyz.distributions.distributions.Distribution*

Replace names of variables in Distribution.

a [pixyz.Distribution (not pixyz.MultiplyDistribution)] Distribution.

replace_dict [dict] Dictionary.

forward (**args, **kwargs*)

When this class is inherited by DNNs, it is also intended that this method is overridden.

get_params (*params_dict*)

This method aims to get parameters of this distributions from constant parameters set in initialization and outputs of DNNs.

params_dict [dict] Input parameters.

output_dict [dict] Output parameters

```
>>> print(dist_1.prob_text, dist_1.distribution_name)
p(x) Normal
>>> dist_1.get_params()
{"loc": 0, "scale": 1}
>>> print(dist_2.prob_text, dist_2.distribution_name)
p(x|z) Normal
>>> dist_1.get_params({"z": 1})
{"loc": 0, "scale": 1}
```

sample (*x={}, shape=None, batch_size=1, return_all=True, reparam=False*)

Sample variables of this distribution. If *cond_var* is not empty, we should set inputs as a dictionary format.

x [torch.Tensor, list, or dict] Input variables.

shape [tuple] Shape of samples. If set, *batch_size* and *dim* are ignored.

batch_size [int] Batch size of samples. This is set to 1 by default.

return_all [bool] Choose whether the output contains input variables.

reparam [bool] Choose whether we sample variables with reparameterized trick.

output [dict] Samples of this distribution.

log_likelihood (*x*)

Estimate the log likelihood of this distribution from inputs formatted by a dictionary.

x_dict [dict] Input samples.

log_like [torch.Tensor] Log-likelihood.

sample_mean (*x*)

input_var

Normally, *input_var* has same values as *cond_var*.

distribution_name

1.6.2 MarginalizeVarDistribution

class pixyz.distributions.distributions.**MarginalizeVarDistribution** (*a*,
*marginal-
ize_list*)

Bases: *pixyz.distributions.distributions.Distribution*

Marginalize variables in Distribution. $p(x) = \int p(x, z) dz$

a [pixyz.Distribution (not pixyz.DistributionBase)] Distribution.

marginalize_list [list] Variables to marginalize.

forward (*args, **kwargs)

When this class is inherited by DNNs, it is also intended that this method is overridden.

get_params (params_dict)

This method aims to get parameters of this distributions from constant parameters set in initialization and outputs of DNNs.

params_dict [dict] Input parameters.

output_dict [dict] Output parameters

```
>>> print(dist_1.prob_text, dist_1.distribution_name)
p(x) Normal
>>> dist_1.get_params()
{"loc": 0, "scale": 1}
>>> print(dist_2.prob_text, dist_2.distribution_name)
p(x|z) Normal
>>> dist_1.get_params({"z": 1})
{"loc": 0, "scale": 1}
```

sample (x={}, shape=None, batch_size=1, return_all=True, reparam=False)

Sample variables of this distribution. If *cond_var* is not empty, we should set inputs as a dictionary format.

x [torch.Tensor, list, or dict] Input variables.

shape [tuple] Shape of samples. If set, *batch_size* and *dim* are ignored.

batch_size [int] Batch size of samples. This is set to 1 by default.

return_all [bool] Choose whether the output contains input variables.

reparam [bool] Choose whether we sample variables with reparameterized trick.

output [dict] Samples of this distribution.

log_likelihood (x_dict)

Estimate the log likelihood of this distribution from inputs formatted by a dictionary.

x_dict [dict] Input samples.

log_like [torch.Tensor] Log-likelihood.

sample_mean (x)

input_var

Normally, *input_var* has same values as *cond_var*.

distribution_name

prob_factorized_text

1.6.3 MultiplyDistribution

class pixyz.distributions.distributions.**MultiplyDistribution** (a, b)

Bases: *pixyz.distributions.distributions.Distribution*

Multiply by given distributions, e.g, $p(x, y|z) = p(x|z, y)p(y|z)$. In this class, it is checked if two distributions can be multiplied.

$p(x|z)p(z|y)$ -> Valid

$p(x|z)p(y|z)$ -> Valid

$p(x|z)p(y|a)$ -> Valid

$p(x|z)p(z|x)$ -> Invalid (recursive)

$p(x|z)p(x|y)$ -> Invalid (conflict)

a [pixyz.Distribution] Distribution.

b [pixyz.Distribution] Distribution.

```
>>> p_multi = MultipleDistribution([a, b])
>>> p_multi = a * b
```

inh_var

input_var

Normally, *input_var* has same values as *cond_var*.

prob_factorized_text

sample (*x*={}, *shape*=None, *batch_size*=1, *return_all*=True, *reparam*=False)

Sample variables of this distribution. If *cond_var* is not empty, we should set inputs as a dictionary format.

x [torch.Tensor, list, or dict] Input variables.

shape [tuple] Shape of samples. If set, *batch_size* and *dim* are ignored.

batch_size [int] Batch size of samples. This is set to 1 by default.

return_all [bool] Choose whether the output contains input variables.

reparam [bool] Choose whether we sample variables with reparameterized trick.

output [dict] Samples of this distribution.

log_likelihood (*x*)

Estimate the log likelihood of this distribution from inputs formatted by a dictionary.

x_dict [dict] Input samples.

log_like [torch.Tensor] Log-likelihood.

1.7 Functions

`pixyz.distributions.distributions.sum_samples` (*samples*)

2.1 Loss

```
class pixyz.losses.losses.Loss (p1, p2=None, input_var=None)
    Bases: object

    input_var
    loss_text

    abs ()
    mean ()
    sum ()

    estimate (x={}, **kwargs)
    train (x={}, **kwargs)
        Train the implicit (adversarial) loss function.
    test (x={}, **kwargs)
        Test the implicit (adversarial) loss function.
```

2.2 Negative expected value of log-likelihood (entropy)

2.2.1 CrossEntropy

```
class pixyz.losses.CrossEntropy (p1, p2, input_var=None)
    Bases: pixyz.losses.losses.Loss

    Cross entropy, a.k.a., the negative expected value of log-likelihood (Monte Carlo approximation).
```

$$-\mathbb{E}_{q(x)}[\log p(x)] \approx -\frac{1}{L} \sum_{l=1}^L \log p(x_l),$$

where $x_l \sim q(x)$.

loss_text

estimate ($x=\{\}$)

2.2.2 Entropy

class pixyz.losses.**Entropy** (p_l , $input_var=None$)

Bases: [pixyz.losses.losses.Loss](#)

Entropy (Monte Carlo approximation).

$$-\mathbb{E}_{p(x)}[\log p(x)] \approx -\frac{1}{L} \sum_{l=1}^L \log p(x_l),$$

where $x_l \sim p(x)$.

Note: This class is a special case of the *CrossEntropy* class. You can get the same result with *CrossEntropy*.

loss_text

estimate ($x=\{\}$)

2.2.3 StochasticReconstructionLoss

class pixyz.losses.**StochasticReconstructionLoss** ($encoder$, $decoder$, $input_var=None$)

Bases: [pixyz.losses.losses.Loss](#)

Reconstruction Loss (Monte Carlo approximation).

$$-\mathbb{E}_{q(z|x)}[\log p(x|z)] \approx -\frac{1}{L} \sum_{l=1}^L \log p(x|z_l),$$

where $z_l \sim q(z|x)$.

Note: This class is a special case of the *CrossEntropy* class. You can get the same result with *CrossEntropy*.

loss_text

estimate ($x=\{\}$)

2.3 Negative log-likelihood

2.3.1 NLL

class pixyz.losses.**NLL** (p , $input_var=None$)

Bases: [pixyz.losses.losses.Loss](#)

Negative log-likelihood.

$$-\log p(x)$$

loss_text

estimate ($x=\{\}$)

2.4 Lower bound

2.4.1 ELBO

class pixyz.losses.**ELBO** (*p*, *approximate_dist*, *input_var=None*)

Bases: `pixyz.losses.losses.Loss`

The evidence lower bound (Monte Carlo approximation).

$$\mathbb{E}_{q(z|x)}[\log \frac{p(x, z)}{q(z|x)}] \approx \frac{1}{L} \sum_{l=1}^L \log p(x, z_l),$$

where $z_l \sim q(z|x)$.

loss_text

estimate (*x*={}, *batch_size=None*)

2.5 Divergence

2.5.1 KullbackLeibler

class pixyz.losses.**KullbackLeibler** (*p1*, *p2*, *input_var=None*)

Bases: `pixyz.losses.losses.Loss`

Kullback-Leibler divergence (analytical).

$$D_{KL}[p||q] = \mathbb{E}_{p(x)}[\log \frac{p(x)}{q(x)}]$$

loss_text

estimate (*x*, ***kwargs*)

2.6 Similarity

2.6.1 SimilarityLoss

class pixyz.losses.**SimilarityLoss** (*p1*, *p2*, *input_var=None*, *var=['z']*, *margin=0*)

Bases: `pixyz.losses.losses.Loss`

Learning Modality-Invariant Representations for Speech and Images (Leidai et. al.)

estimate (*x*)

2.6.2 MultiModalContrastivenessLoss

class pixyz.losses.**MultiModalContrastivenessLoss** (*p1*, *p2*, *input_var=None*, *margin=0.5*)

Bases: `pixyz.losses.losses.Loss`

Disentangling by Partitioning: A Representation Learning Framework for Multimodal Sensory Data

estimate (*x*)

2.7 Adversarial loss (GAN loss)

2.7.1 AdversarialJensenShannon

```
class pixyz.losses.AdversarialJensenShannon (p, q, discriminator, input_var=None, opti-
                                             mizer=<class 'torch.optim.adam.Adam'>,
                                             optimizer_params={},
                                             inverse_g_loss=True)
```

Bases: `pixyz.losses.adversarial_loss.AdversarialLoss`

Jensen-Shannon divergence (adversarial training).

$$D_{JS}[p(x)||q(x)] \leq 2 \cdot D_{JS}[p(x)||q(x)] + 2 \log 2 = \mathbb{E}_{p(x)}[\log d^*(x)] + \mathbb{E}_{q(x)}[\log(1 - d^*(x))],$$

where $d^*(x) = \arg \max_d \mathbb{E}_{p(x)}[\log d(x)] + \mathbb{E}_{q(x)}[\log(1 - d(x))]$.

loss_text

estimate (x={}, discriminator=False)

d_loss (y1, y2, batch_size)

g_loss (y1, y2, batch_size)

2.7.2 AdversarialKullbackLeibler

```
class pixyz.losses.AdversarialKullbackLeibler (q, p, discriminator, **kwargs)
```

Bases: `pixyz.losses.adversarial_loss.AdversarialLoss`

Kullback-Leibler divergence (adversarial training).

$$D_{KL}[q(x)||p(x)] = \mathbb{E}_{q(x)}[\log \frac{q(x)}{p(x)}] = \mathbb{E}_{q(x)}[\log \frac{d^*(x)}{1 - d^*(x)}],$$

where $d^*(x) = \arg \max_d \mathbb{E}_{p(x)}[\log d(x)] + \mathbb{E}_{q(x)}[\log(1 - d(x))]$.

Note that this divergence is minimized to close q to p.

loss_text

estimate (x={}, discriminator=False)

g_loss (y1, batch_size)

d_loss (y1, y2, batch_size)

2.7.3 AdversarialWassersteinDistance

```
class pixyz.losses.AdversarialWassersteinDistance (p, q, discriminator,
                                                    clip_value=0.01, **kwargs)
```

Bases: `pixyz.losses.adversarial_loss.AdversarialJensenShannon`

Wasserstein distance (adversarial training).

$$W(p, q) = \sup_{||d||_L \leq 1} \mathbb{E}_{p(x)}[d(x)] - \mathbb{E}_{q(x)}[d(x)]$$

loss_text

```

d_loss (y1, y2, *args, **kwargs)
g_loss (y1, y2, *args, **kwargs)
train (train_x, **kwargs)
    Train the implicit (adversarial) loss function.

```

2.8 Auto-regressive loss

2.8.1 ARLoss

```

class pixyz.losses.ARLoss (step_loss, last_loss=None, step_fn=<function ARLoss.<lambda>>,
                           max_iter=1, return_params=False, input_var=None, series_var=None,
                           update_value=None)
    Bases: pixyz.losses.losses.Loss

```

Auto-regressive loss.

This loss performs “scan”-like operation. You can implement arbitrary auto-regressive models with this class.

$$\mathcal{L} = \mathcal{L}_{last}(x_1, h_T) + \sum_{t=1}^T \mathcal{L}_{step}(x_t, h_t),$$

where $h_t = f_{step}(x_{t-1}, h_{t-1})$.

```

loss_text
slice_step_from_inputs (t, x)
estimate (x={})

```

2.9 Loss for special purpose

2.9.1 Parameter

```

class pixyz.losses.losses.Parameter (input_var)
    Bases: pixyz.losses.losses.Loss
    estimate (x={}, **kwargs)
    loss_text

```

2.10 Operators

2.10.1 LossOperator

```

class pixyz.losses.losses.LossOperator (loss1, loss2)
    Bases: pixyz.losses.losses.Loss
    loss_text
    estimate (x={}, **kwargs)

```

```
train (x, **kwargs)  
    TODO: Fix  
test (x, **kwargs)  
    TODO: Fix
```

2.10.2 LossSelfOperator

```
class pixyz.losses.losses.LossSelfOperator (loss1)  
    Bases: pixyz.losses.losses.Loss  
  
    train (x={}, **kwargs)  
        Train the implicit (adversarial) loss function.  
  
    test (x={}, **kwargs)  
        Test the implicit (adversarial) loss function.
```

2.10.3 AddLoss

```
class pixyz.losses.losses.AddLoss (loss1, loss2)  
    Bases: pixyz.losses.losses.LossOperator  
  
    loss_text  
  
    estimate (x={}, **kwargs)
```

2.10.4 SubLoss

```
class pixyz.losses.losses.SubLoss (loss1, loss2)  
    Bases: pixyz.losses.losses.LossOperator  
  
    loss_text  
  
    estimate (x={}, **kwargs)
```

2.10.5 MulLoss

```
class pixyz.losses.losses.MulLoss (loss1, loss2)  
    Bases: pixyz.losses.losses.LossOperator  
  
    loss_text  
  
    estimate (x={}, **kwargs)
```

2.10.6 DivLoss

```
class pixyz.losses.losses.DivLoss (loss1, loss2)  
    Bases: pixyz.losses.losses.LossOperator  
  
    loss_text  
  
    estimate (x={}, **kwargs)
```

2.10.7 NegLoss

```
class pixyz.losses.losses.NegLoss (lossl)
    Bases: pixyz.losses.losses.LossSelfOperator

    loss_text

    estimate (x={}, **kwargs)
```

2.10.8 AbsLoss

```
class pixyz.losses.losses.AbsLoss (lossl)
    Bases: pixyz.losses.losses.LossSelfOperator

    loss_text

    estimate (x={}, **kwargs)
```

2.10.9 BatchMean

```
class pixyz.losses.losses.BatchMean (lossl)
    Bases: pixyz.losses.losses.LossSelfOperator

    Loss averaged over batch data.
```

$$\mathbb{E}_{p_{data}(x)}[\mathcal{L}(x)] \approx \frac{1}{N} \sum_{i=1}^N \mathcal{L}(x_i),$$

where $x_i \sim p_{data}(x)$ and $\mathcal{L}$ is a loss function.

```
loss_text

estimate (x={}, **kwargs)
```

2.10.10 BatchSum

```
class pixyz.losses.losses.BatchSum (lossl)
    Bases: pixyz.losses.losses.LossSelfOperator

    Loss summed over batch data.
```

$$\sum_{i=1}^N \mathcal{L}(x_i),$$

where $x_i \sim p_{data}(x)$ and $\mathcal{L}$ is a loss function.

```
loss_text

estimate (x={}, **kwargs)
```


3.1 Model

```
class pixyz.models.Model (loss, test_loss=None, distributions=[], optimizer=<class
                        'torch.optim.adam.Adam'>, optimizer_params={})
    Bases: object
    set_loss (loss, test_loss=None)
    train (train_x={}, **kwargs)
    test (test_x={}, **kwargs)
```

3.2 Pre-implementation models

3.2.1 ML

```
class pixyz.models.ML (p, other_distributions=[], optimizer=<class 'torch.optim.adam.Adam'>, optimizer_params={})
    Bases: pixyz.models.model.Model
    Maximum Likelihood (log-likelihood)
    train (train_x={}, **kwargs)
    test (test_x={}, **kwargs)
```

3.2.2 VAE

```
class pixyz.models.VAE (encoder, decoder, other_distributions=[], regularizer=[], optimizer=<class
                        'torch.optim.adam.Adam'>, optimizer_params={})
    Bases: pixyz.models.model.Model
    Variational Autoencoder
```

[Kingma+ 2013] Auto-Encoding Variational Bayes

```
train (train_x={}, **kwargs)
test (test_x={}, **kwargs)
```

3.2.3 VI

```
class pixyz.models.VI(p, approximate_dist, other_distributions=[], optimizer=<class
    'torch.optim.adam.Adam'>, optimizer_params={})
    Bases: pixyz.models.model.Model
    Variational Inference (Amortized inference)
    train (train_x={}, **kwargs)
    test (test_x={}, **kwargs)
```

3.2.4 GAN

```
class pixyz.models.GAN(p_data, p, discriminator, optimizer=<class 'torch.optim.adam.Adam'>,
    optimizer_params={}, d_optimizer=<class 'torch.optim.adam.Adam'>,
    d_optimizer_params={})
    Bases: pixyz.models.model.Model
    Generative Adversarial Network
    train (train_x={}, adversarial_loss=True, **kwargs)
    test (test_x={}, adversarial_loss=True, **kwargs)
```

CHAPTER 4

pixyz.utils

```
pixyz.utils.set_epsilon(eps)
pixyz.utils.epsilon()
pixyz.utils.get_dict_values(dicts, keys, return_dict=False)
pixyz.utils.delete_dict_values(dicts, keys)
pixyz.utils.detach_dict(dicts)
pixyz.utils.replace_dict_keys(dicts, replace_list_dict)
pixyz.utils.tolist(a)
```


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