

diffusion

```
from fastai.basics import *
from fastai.vision.models.unet import *
from fastai.vision.all import *
from fastai.torch_basics import *
from denoising_diffusion_pytorch import Unet

import wandb
wandb.init(reinit=True)
from fastai.callback.wandb import *
```

Failed to detect the name of this notebook, you can set it manually with the WANDB_NOTEBOOK_ wandb: Currently logged in as: marii. Use `wandb login --relogin` to force relogin

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```
def gather(consts: torch.Tensor, t: torch.Tensor):
    """Gather consts for $t$ and reshape to feature map shape"""
    c = consts.gather(-1, t)
    return c.reshape(-1, 1, 1, 1)

class DenoiseDiffusion:
    """
    ## Denoise Diffusion
    """

    def __init__(self, eps_model: nn.Module, n_steps: int, device: torch.device):
        """
        * `eps_model` is $\textcolor{lightgreen}{\epsilon_\theta}(x_t, t)$ model
        * `n_steps` is $t$
        * `device` is the device to place constants on
        """
```

```

super().__init__()
self.eps_model = eps_model

# Create  $\beta_1, \dots, \beta_T$  linearly increasing variance schedule
self.beta = torch.linspace(0.0001, 0.02, n_steps).to(device)

#  $\alpha_t = 1 - \beta_t$ 
self.alpha = 1. - self.beta
#  $\bar{\alpha}_t = \prod_{s=1}^t \alpha_s$ 
self.alpha_bar = torch.cumprod(self.alpha, dim=0)
#  $T$ 
self.n_steps = n_steps
#  $\sigma^2 = \beta$ 
self.sigma2 = self.beta

def q_xt_x0(self, x0: torch.Tensor, t: torch.Tensor) -> Tuple[torch.Tensor, torch.Tensor]
    """
    ##### Get  $q(x_t|x_0)$  distribution
    \begin{align}
    q(x_t|x_0) &= \mathcal{N}(\mathbf{x}_t; \sqrt{\bar{\alpha}_t} \mathbf{x}_0, (1-\bar{\alpha}_t) \Sigma)
    \end{align}
    """

    # [gather](utils.html)  $\alpha_t$  and compute  $\sqrt{\bar{\alpha}_t} \mathbf{x}_0$ 
    mean = gather(self.alpha_bar, t) ** 0.5 * tensor(x0)
    #  $(1-\bar{\alpha}_t) \Sigma$ 
    var = 1 - gather(self.alpha_bar, t)
    #
    return mean, var

def q_sample(self, x0: torch.Tensor, t: torch.Tensor, eps: Optional[torch.Tensor] = None)
    """
    ##### Sample from  $q(x_t|x_0)$ 
    \begin{align}
    q(x_t|x_0) &= \mathcal{N}(\mathbf{x}_t; \sqrt{\bar{\alpha}_t} \mathbf{x}_0, (1-\bar{\alpha}_t) \Sigma)
    \end{align}
    """

    #  $\epsilon \sim \mathcal{N}(\mathbf{0}, \Sigma)$ 
    if eps is None:
        eps = torch.randn_like(x0)

```

```

# get  $q(x_t|x_0)$ 
mean, var = self.q_xt_x0(x0, t)
# Sample from  $q(x_t|x_0)$ 
return mean + (var ** 0.5) * eps

def p_sample(self, xt: torch.Tensor, t: torch.Tensor):
    """
    ##### Sample from  $p_{\theta}(x_{t-1}|x_t)$ 
    \begin{align}
    p_{\theta}(x_{t-1} | x_t) &= \mathcal{N}(x_{t-1}; \\
    \mu_{\theta}(x_t, t), \sigma_t^2 \mathbf{I}) \\
    &= \frac{1}{\sqrt{\alpha_t}} \text{Big}(x_t - \\
    &\quad \frac{\beta_t}{\sqrt{1-\bar{\alpha}_t}} \epsilon_{\theta}(x_t, t)) \\
    \end{align}
    """

    #  $\epsilon_{\theta}(x_t, t)$ 

    # NOTEDDDD REMOVED t

    eps_theta = self.eps_model(xt, t)
    # [gather](utils.html)  $\bar{\alpha}_t$ 
    alpha_bar = gather(self.alpha_bar, t)
    #  $\alpha_t$ 
    alpha = gather(self.alpha, t)
    #  $\frac{\beta_t}{\sqrt{1-\bar{\alpha}_t}}$ 
    eps_coef = (1 - alpha) / (1 - alpha_bar) ** .5
    #  $\frac{1}{\sqrt{\alpha_t}} \text{Big}(x_t -$ 
    #  $\frac{\beta_t}{\sqrt{1-\bar{\alpha}_t}} \epsilon_{\theta}(x_t, t))$ 
    mean = 1 / (alpha ** 0.5) * (xt - eps_coef * eps_theta)
    #  $\sigma_t^2$ 
    var = gather(self.sigma2, t)

    #  $\epsilon \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$ 
    eps = torch.randn(xt.shape, device=xt.device)
    # Sample
    return mean + (var ** .5) * eps

```

```

class Q_sample(ItemTransform):
    order=101
    def __init__(self,diffusion):
        self.diffusion=diffusion
    def encodes(self,xy):
        x=xy[0]
        y=xy[-1]
        ts = xy[2][:,0]#torch.randint(0, self.diffusion.n_steps, (x.shape[0],), device=x.device)
        x_type=type(x)
        x=self.diffusion.q_sample(x, x_type(ts), eps=y)
        return (x,*xy[1:-1],y)

```

```

class LabelToNoise(ItemTransform):
    order=100
    def encodes(self,xy):
        y=xy[-1]
        return (*xy[:-1],retain_type(torch.randn(y.shape,device=y.device),old=y))

```

```

def sample():
    """
    ### Sample images
    """
    with torch.no_grad():
        #  $x_T \sim p(x_T) = \mathcal{N}(x_T; \mathbf{0}, \mathbf{I})$ 
        x = torch.randn([n_samples, image_channels, 32, 32],
                        device=device)

        # Remove noise for  $T$  steps
        for t_ in range(n_steps):
            #  $t$ 
            t = n_steps - t_ - 1
            # Sample from  $p_{\theta}(x_{t-1}|x_t)$ 
            x = diffusion.p_sample(x, x.new_full((n_samples,), t, dtype=torch.long))
        return x

```

```

n_steps=1000

```

```

path = untar_data(URLs.MNIST)
path = untar_data(URLs.CIFAR)

```

```
m=Unet(dim=32,channels=3)#UnetTime(img_channels=1,dims=[32, 64, 128, 256, 256],ks=3,stem_s
```

```
@typedispatch
```

```
def show_batch(x:tuple, y:TensorImage, samples, ctxs=None, max_n=10, nrows=None, ncols=None):
    if ctxs is None: ctxs = get_grid(3*min(len(samples), max_n), nrows=nrows, ncols=3, fig
    ctxs[0::3] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(0),ctxs[0::3],r
    ctxs[0::3] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(2),ctxs[0::3],r
    ctxs[1::3] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(1),ctxs[1::3],r
    ctxs[2::3] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(3),ctxs[2::3],r
    return ctxs
```

```
diffusion = DenoiseDiffusion(m,n_steps,torch.device(0))
dls=DataBlock((ImageBlock(cls=PILImageBW),
                ImageBlock(cls=PILImageBW),
                TransformBlock(type_tfms=[DisplayedTransform(enc=lambda o: TensorCategory(o
                ImageBlock(cls=PILImageBW))),
                n_inp=3,
                item_tfms=[Resize(32)],
                batch_tfms=(Normalize.from_stats(0.5,1.),LabelToNoise,Q_sample(diffusion)),
                get_items=get_image_files,
                get_x=[lambda x:x,lambda x:x,
                        lambda x: torch.randint(0, n_steps, (1,), dtype=torch.long)],
                splitter=GrandparentSplitter(train_name='training', valid_name='testing'),
                ).dataloaders(path,bs=128,val_bs=2*128)
dls.show_batch()
```

IndexError: list index out of range

```
path.ls()
```

```
(#3) [Path('/home/molly/data/cifar10/labels.txt'),Path('/home/molly/data/cifar10/test'),Path
```

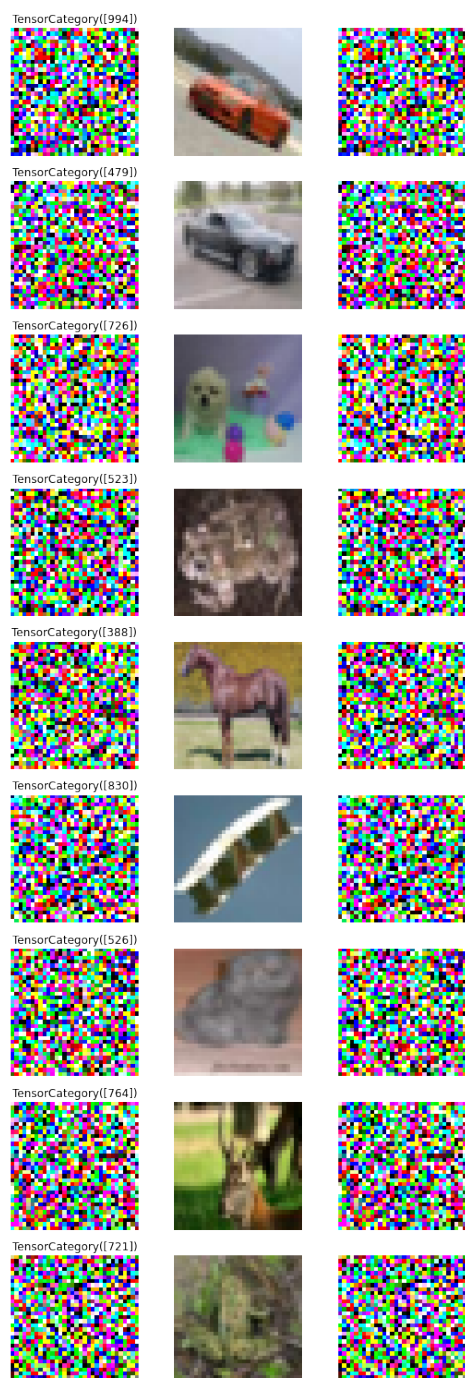
```
bs=128
diffusion = DenoiseDiffusion(m,n_steps,torch.device(0))
dls=DataBlock((ImageBlock(),
                ImageBlock(),
                TransformBlock(type_tfms=[DisplayedTransform(enc=lambda o: TensorCategory(o
                ImageBlock()),
```

```

n_inp=3,
item_tfms=[Resize(32)],
batch_tfms=(Normalize.from_stats(0.5,1.),LabelToNoise,Q_sample(diffusion)),
get_items=get_image_files,
get_x=[lambda x:x,lambda x:x,
        lambda x: torch.randint(0, n_steps, (1,), dtype=torch.long)],
splitter=IndexSplitter(range(bs)),
).dataloaders(path,bs=bs,val_bs=2*bs)
dls.show_batch()

```

Input/Original/Target



```

class FlattenCallback(Callback):
    def before_batch(self):
        self.learn.xb=(self.xb[0],self.xb[-1].view(self.xb[-1].shape[::2]),)

learn = Learner(dls,m,MSELossFlat(),opt_func=Lamb,cbs=[FlattenCallback,WandbCallback(log_p

inp=m.layers0:0 inp.seq_dict['t']=torch.tensor([5]).cuda() m.layers1:4.shape

learn.fit_flat_cos(6,lr=1e-4,wd=0.)

```

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epoch	train_loss	valid_loss	time
0	0.699252	0.648226	01:58
1	0.375051	0.354264	01:54
2	0.185453	0.168021	01:52
3	0.102715	0.080112	01:53
4	0.064207	0.043586	01:56
5	0.055305	0.053669	01:52

WandbCallback was not able to get prediction samples -> Match length mismatch

```

@typedispatch
def show_results(x:tuple, y:TensorImage, samples, outs, ctxs=None, max_n=10, figsize=None,
    if ctxs is None: ctxs = get_grid(6*min(len(samples), max_n), ncols=6, figsize=figsize,
    ctxs[0::6] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(0),ctxs[0::6],r
    ctxs[1::6] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(1),ctxs[1::6],r
    ctxs[0::6] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(2),ctxs[0::6],r
    ctxs[2::6] = [(b-o).show(ctx=c, **kwargs) for b,o,c,_ in zip(samples.itemgot(0),outs.i
    ctxs[3::6] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(samples.itemgot(3),ctxs[3::6],r
    ctxs[4::6] = [b.show(ctx=c, **kwargs) for b,c,_ in zip(outs.itemgot(0),ctxs[4::6],rang
    ctxs[5::6] = [(b-targ).show(ctx=c, **kwargs) for b,targ,c,_ in zip(outs.itemgot(0),sam
    return ctxs

learn.show_results()

```

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Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers)

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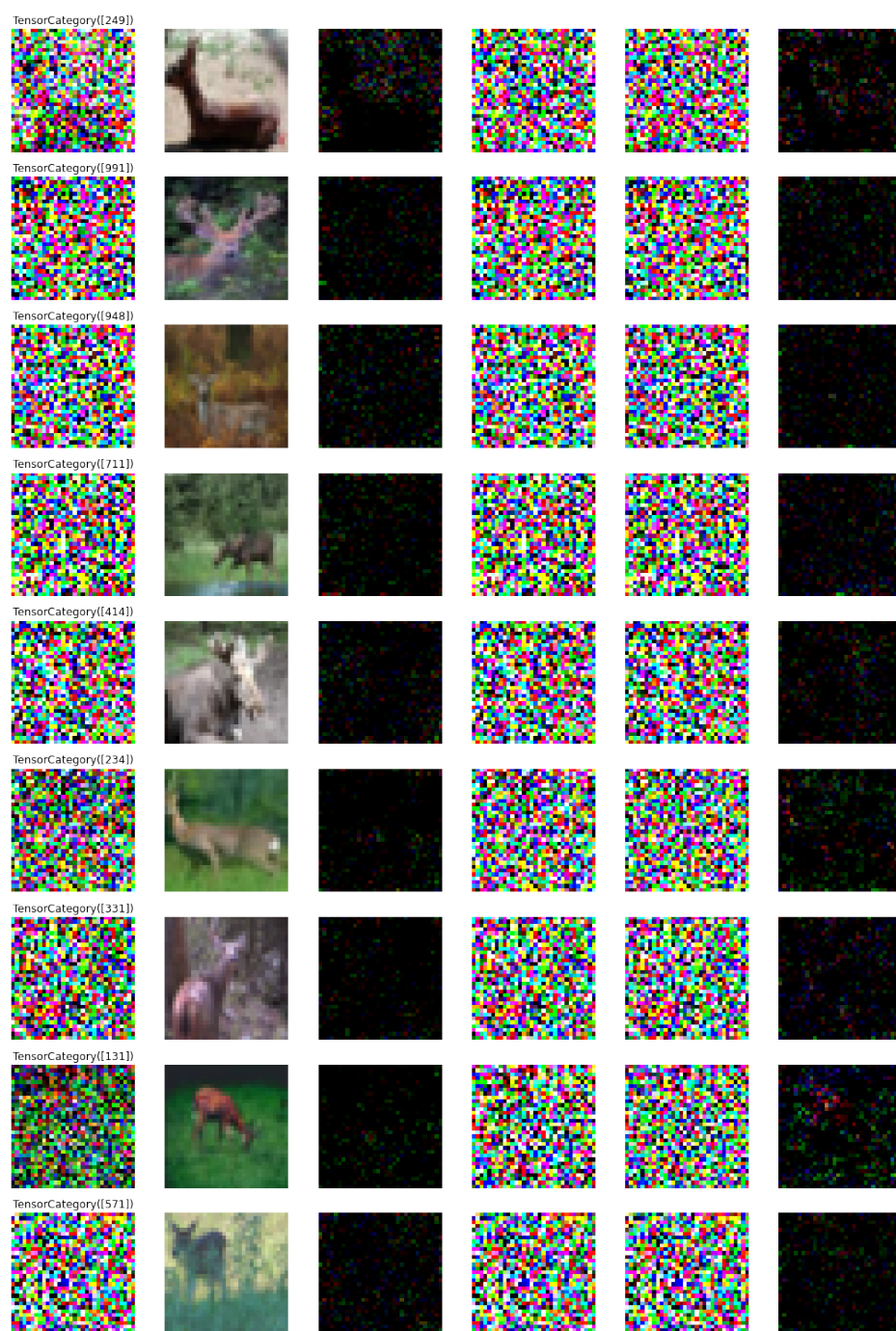
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers)

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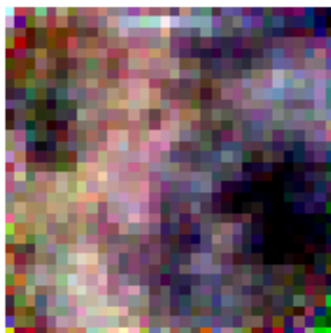
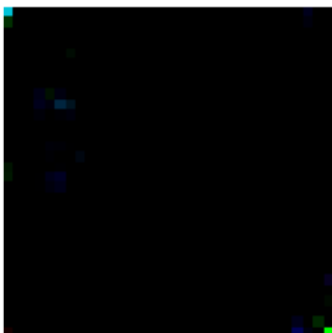
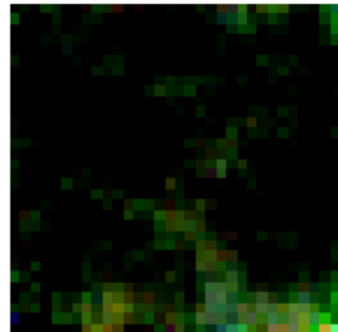
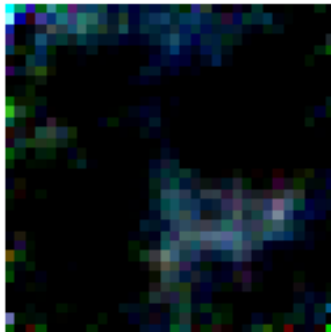
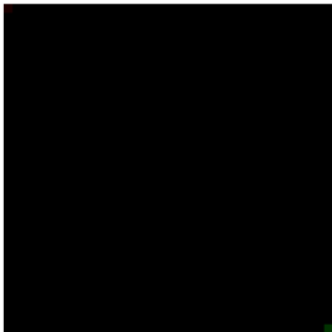
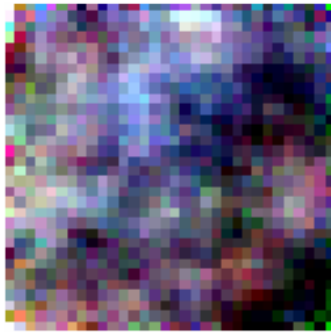
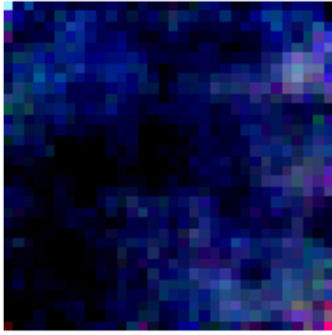
Input/Original/DenoisedImage/Target/Prediction/Diff



```
n_samples=12
image_channels=3
diffusion = DenoiseDiffusion(m,n_steps,torch.device(0))
device=torch.device(0)
xs = sample()

show_images((logit((xs.repeat(1,3,1,1)-xs.repeat(1,3,1,1).mean())/xs.repeat(1,3,1,1).std()))

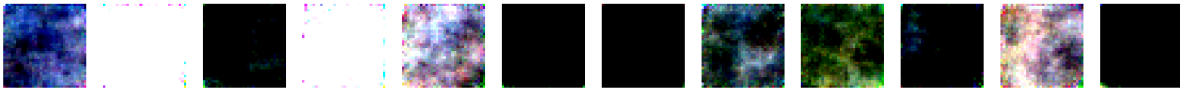
show_images((logit((xs-xs.mean())/xs.std()).sigmoid()),nrows=4)
```



```
xs.min()
```

```
show_images(xs)
```

Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 1/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 2/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 3/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 4/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 5/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 6/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 7/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 8/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 9/10
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers): 10/10



```
with learn.removed_cbs(WandbCallback):  
    show_images(dls.one_batch()[0][:4])
```

```
learn.show_results??
```

```
dls.show_batch(show=False)[2]
```

```
@typedispatch
```

```
def wandb_process(x:tuple, y, samples, outs, preds):  
    "Process `sample` and `out` depending on the type of `x/y`"  
    res_input, res_pred, res_label = [],[],[]  
    for s,o in zip(samples, outs):  
        img = s[0].permute(1,2,0)  
        res_input.append(wandb.Image(img, caption='Input_data'))  
        for t, capt, res in ((o[0], "Prediction", res_pred), (s[1], "Ground_Truth", res_label)):  
            fig, ax = _make_plt(img)  
            # Superimpose label or prediction to input image  
            ax = img.show(ctx=ax)
```

```

        ax = t.show(ctx=ax)
        res.append(wandb.Image(fig, caption=capt))
        plt.close(fig)
    return {"Inputs":res_input, "Predictions":res_pred, "Ground_Truth":res_label}

learn.show_results()

%debug

::: {.cell 0='h' 1='i' 2='d' 3='e'}

from nbdev import nbdev_export
nbdev_export()

:::

```