

Unet

```
from fastai.basics import *
from fastai.vision.models.unet import *
from fastai.torch_basics import *
```

```
class SequentialExDict(nn.Sequential):
    "Like `nn.Sequential`, but has a dictionary passed along with x."
    def __init__(self, *layers, dict_names=['seq_dict']):
        super().__init__(*layers)
        self.dict_names=dict_names
    def forward(self, x,**kwargs):
        dicts = getattr(x,*self.dict_names,default=kwargs)
        for module in self:
            for k,v in zip(self.dict_names,dicts): setattr(x,k,v)
            x = module(x)
        for k,v in zip(self.dict_names,dicts): setattr(x,k,v)
        return x
```

```
class TimeEmbedding(nn.Module):
    """
    ### Embeddings for $t$
    """

    def __init__(self, n_channels: int):
        """
        * `n_channels` is the number of dimensions in the embedding
        """
        super().__init__()
        self.n_channels = n_channels
        # First linear layer
        self.layers = nn.Sequential(
            nn.Linear(self.n_channels // 4, self.n_channels),
            nn.ReLU(True),
            nn.Linear(self.n_channels, self.n_channels)
        )

    def forward(self, x):
        # Create sinusoidal position embeddings
        # [same as those from the transformer](../transformers/positional_encoding.html)
        #
```

```

# \begin{align}
# PE^{\{(1)\}}_{t,i} &= \sin\Bigg(\frac{t}{10000^{\{\frac{i}{d-1}\}}}\Bigg) \backslash
# PE^{\{(2)\}}_{t,i} &= \cos\Bigg(\frac{t}{10000^{\{\frac{i}{d-1}\}}}\Bigg)
# \end{align}
#
# where $d$ is `half_dim`
t=torch.tensor(x.seq_dict['t']) if isinstance(x.seq_dict['t'],int) else x.seq_dict['t']
t=t.view(t.shape[0])
half_dim = self.n_channels // 8
emb = math.log(10_000) / (half_dim - 1)
emb = torch.exp(torch.arange(half_dim, device=t.device) * -emb)
emb = t[:, None] * emb[None, :]
emb = torch.cat((emb.sin(), emb.cos()), dim=1)

# Transform with the MLP
emb = self.layers(emb)
x.seq_dict['time']=emb
return x

```

```

class OnKey(nn.Module):
    def __init__(self,k_in,module,k_out=None):
        super().__init__()
        if(k_out is None): k_out=k_in+'_out'
        self.k_in=k_in
        self.k_out=k_out
        self.f=module
    def forward(self, x):
        x.seq_dict[self.k_out]=self.f(x.seq_dict[self.k_in])
        return x

```

```

class Stack(nn.Module):
    def __init__(self,key,f=lambda x:x):
        super().__init__()
        self.key,self.f=key,f
    def forward(self,x):
        if(self.key not in x.seq_dict): x.seq_dict[self.key]=[]
        x.seq_dict[self.key]+=[self.f(x)]
        return x

```

```

class Pop(nn.Module):
    def __init__(self, key, f, clear=True, **kwargs):
        super().__init__()
        self.key, self.clear, self.f, self.kwargs = key, clear, f, kwargs
    def forward(self, x):
        o = x.seq_dict[self.key]
        if (is_listy(o)):
            o = x.seq_dict[self.key].pop(-1) if (self.clear) else o[-1]
        elif (self.clear): x.seq_dict[self.key] = None
        return self.f(x, o, **self.kwargs)

def merge(x, o, dense=False): return torch.cat((x, o), dim=1) if (dense) else x + o.view(o.shape + (1,))

class UnetTime(nn.Module):
    "A little Unet with time embeddings"
    def __init__(self, dims=[96, 192, 384, 768, 768], img_channels=3, ks=7, stem_stride=4, t_channels=1):
        super().__init__()
        i_d = 0
        h = dims[i_d]
        self.time_emb = TimeEmbedding(t_channels)
        # Not putting in for loop for ease of understanding arch
        self.down = SequentialExDict(
            nn.Conv2d(img_channels, h, ks, 1, ks//2),
            Stack('u'),
            Stack('s', lambda x: x.shape[-2:]),
            self.down_sample(h, (h:=dims[(i_d:=i_d+1)]), 2, stem_stride, 1),
            nn.GroupNorm(1, h),
            Stack('u'),
            Stack('s', lambda x: x.shape[-2:]),
            self.basic_block(h, t_channels, ks=ks),
            self.down_sample(h, (h:=dims[(i_d:=i_d+1)]), 2, 2, 1),
            Stack('u'),
            Stack('s', lambda x: x.shape[-2:]),
            self.basic_block(h, t_channels, ks=ks),
            self.down_sample(h, (h:=dims[(i_d:=i_d+1)]), 2, 2, 1),
            Stack('u'),
            Stack('s', lambda x: x.shape[-2:]),
            self.basic_block(h, t_channels, ks=ks),
            self.down_sample(h, (h:=dims[(i_d:=i_d+1)]), 2, 2, 1),
            Stack('u'),
        )

```

```

    )
    self.middle=SequentialExDict(
        self.basic_block(h,t_channels)
    )
    self.up=SequentialExDict(
        Pop('u',merge,dense=True),
        self.up_sample(h*2,(h:=dims[(i_d:=i_d-1)]),4,1,1),
        self.basic_block(h,t_channels),
        Pop('u',merge,dense=True),
        self.up_sample(h*2,(h:=dims[(i_d:=i_d-1)]),4,1,1),
        self.basic_block(h,t_channels),
        Pop('u',merge,dense=True),
        self.up_sample(h*2,(h:=dims[(i_d:=i_d-1)]),4,1,1),
        self.basic_block(h,t_channels),
        Pop('u',merge,dense=True),
        self.up_sample(h*2,(h:=dims[(i_d:=i_d-1)]),4,1,1),
        self.basic_block(h,t_channels),
        Pop('u',merge,dense=True),
        self.down_sample(h*2,img_channels,5,1,2,bias=True),
        self.basic_block(img_channels,t_channels,bias=True),
    )
    self.layers=SequentialExDict(
        self.time_emb,
        self.down,
        self.middle,
        self.up
    )
    @delegates(nn.Conv2d.__init__)
    def up_sample(self,in_channels,out_channels,kernel_size,stride,padding,**kwargs):
        return SequentialExDict(
            Pop('s',lambda x,o:F.interpolate(x, size=[oi+1 for oi in o], mode='bilinear'))
            self.down_sample(in_channels,out_channels,kernel_size,stride,padding,**kwargs)
        )
    @delegates(nn.Conv2d.__init__)
    def down_sample(self,in_channels,out_channels,kernel_size,stride,padding,**kwargs):
        return SequentialExDict(
            nn.GroupNorm(1,in_channels),
            nn.Conv2d(in_channels,out_channels,kernel_size,stride,padding,**kwargs),
        )
    def basic_block(self,channels,time_channels,expansion=4,ks=7,stride=1,pad=None,bias=False):
        if pad is None: pad=ks//2

```

```

return SequentialExDict(
    Stack('r'),
    nn.Conv2d(channels,channels,ks,padding=pad,bias=bias,stride=stride),
    nn.GroupNorm(1,channels),
    nn.Conv2d(channels,channels*expansion,1,bias=bias),
    OnKey('time',nn.Linear(time_channels,channels*expansion)),
    Pop('time_out',merge),
    nn.GELU(),
    nn.Conv2d(channels*expansion,channels,1,bias=bias),
    Pop('r',merge),
)
def forward(self,x,x_o,t):
    return self.layers(x,t=t)

```

hello