portfolio_8

March 31, 2023

1 The Auto Encoder

I then trained the autoencoder on the dataset CIFAR10 for varying values of the number of latent dimensions on BluePebble. Let's now investigate our resulting models. First for an autoencoder with 512 latent dimensions. Let's first explore what the dataset looks like, we will now run some code chunks which will print out a grid of 4 of the images in CIFAR10 along with their labels:

[ ]:
```
# Do some imports from libraries and custom python scripts
import data
import matplotlib.pyplot as plt
import torch.cuda as cuda
import numpy as np
import torch
import torchvision

# We check the device
device = "cuda" if cuda.is_available() else "cpu"
print("Using device: ", device)

# Create the training and testing dataloaders and extract some images and their␣
 ↪labels from the training set and test set
training_loader, test_loader = data.get_data_loader("CIFAR10", 64, device)
train_images, train_targets = next(iter(training_loader))
test_images, test_targets = next(iter(test_loader))
```

```
Using device:  cuda
Files already downloaded and verified
Files already downloaded and verified
```

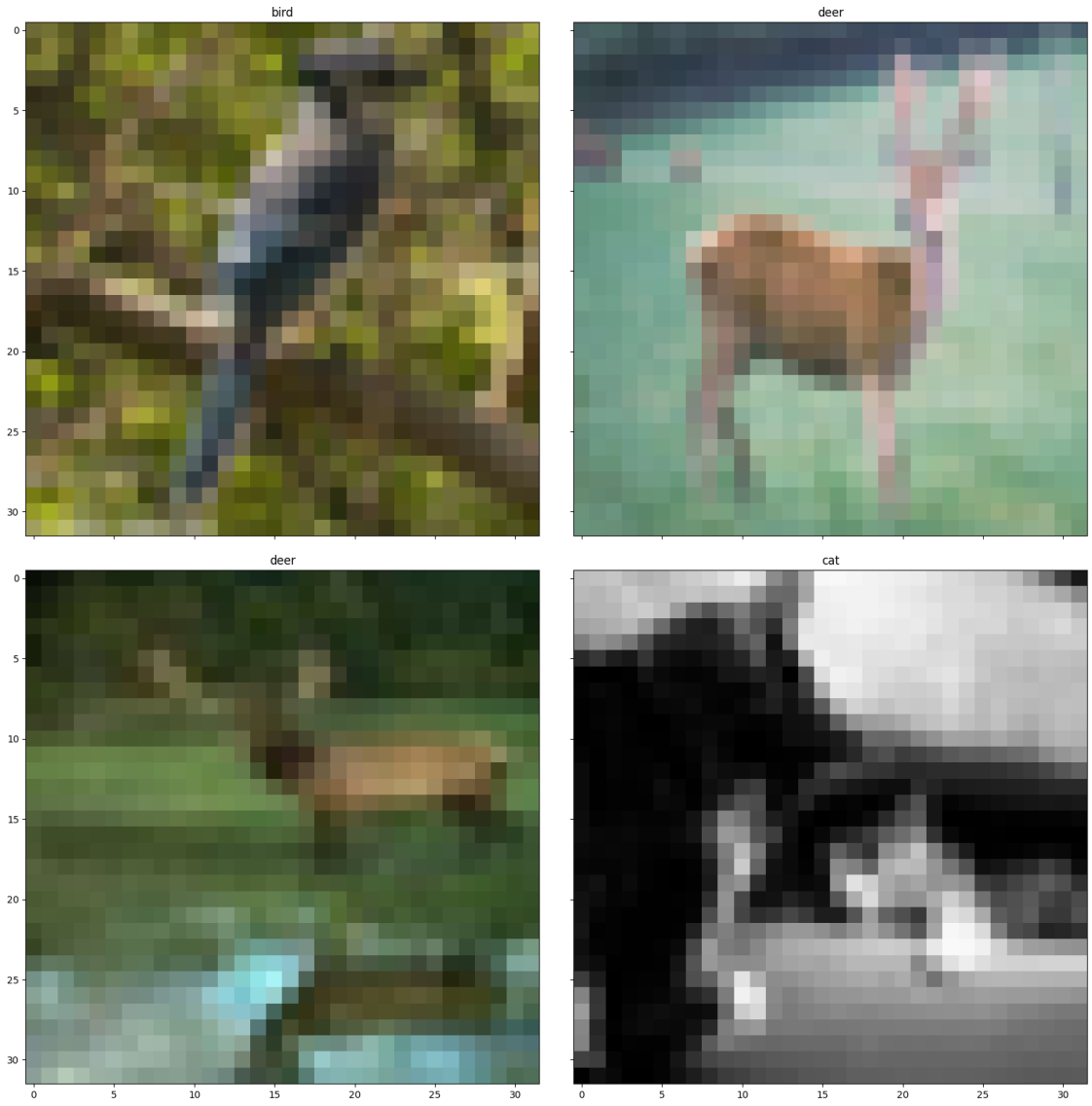
[ ]:
```
# We will now create a function which given the targets will return the␣
 ↪corresponding labels
def cifar10_label(target):
    """
    Returns the label for a given target value in the CIFAR10 dataset.
    """
    cifar10_labels = [
        'airplane', 'automobile', 'bird', 'cat', 'deer',
        'dog', 'frog', 'horse', 'ship', 'truck'
```

```
    ]
    return [cifar10_labels[t] for t in target]
```

[ ]:
```
# Let's now print the image grid
from mpl_toolkits.axes_grid1 import ImageGrid

fig = plt.figure(figsize=(20., 20.))
grid = ImageGrid(fig, 111,
                 nrows_ncols=(2, 2),  # creates 2x2 grid of axes
                 axes_pad=0.5,  # pad between axes
                 )
labels = cifar10_label(train_targets[:4])
for i, (ax, im) in enumerate(zip(grid, train_images[:4])):
    ax.imshow(np.transpose(im.numpy(), (1, 2, 0)))
    ax.set_title('{0}'.format(labels[i]))

plt.show()
```



Above we can see some of the images from CIFAR10 with their class label written above. Let's now run some images through the encoder part of the autoencoder and then through the decoder and plot our results:

[ ]:
```
!pip install pytorch-lightning
!pip install FastAPI
```

```
Requirement already satisfied: pytorch-lightning in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (2.0.1)
Requirement already satisfied: fsspec[http]>2021.06.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (2023.3.0)
Requirement already satisfied: packaging>=17.1 in
```

```
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (23.0)
Requirement already satisfied: torch>=1.11.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (2.0.0)
Requirement already satisfied: numpy>=1.17.2 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (1.24.2)
Requirement already satisfied: typing-extensions>=4.0.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (4.5.0)
Requirement already satisfied: torchmetrics>=0.7.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (0.11.4)
Requirement already satisfied: PyYAML>=5.4 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (6.0)
Requirement already satisfied: tqdm>=4.57.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (4.65.0)
Requirement already satisfied: lightning-utilities>=0.7.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from pytorch-
lightning) (0.8.0)
Requirement already satisfied: aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
fsspec[http]>2021.06.0->pytorch-lightning) (3.8.4)
Requirement already satisfied: requests; extra == "http" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
fsspec[http]>2021.06.0->pytorch-lightning) (2.28.2)
Requirement already satisfied: sympy in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (1.11.1)
Requirement already satisfied: nvidia-cuda-runtime-cu11==11.7.99;
platform_system == "Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (11.7.99)
Requirement already satisfied: networkx in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (3.0)
Requirement already satisfied: nvidia-cublas-cu11==11.10.3.66; platform_system
== "Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (11.10.3.66)
Requirement already satisfied: nvidia-nvtx-cu11==11.7.91; platform_system ==
"Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (11.7.91)
Requirement already satisfied: nvidia-cusolver-cu11==11.4.0.1; platform_system
```

```
== "Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (11.4.0.1)
Requirement already satisfied: nvidia-cudnn-cu11==8.5.0.96; platform_system ==
"Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (8.5.0.96)
Requirement already satisfied: nvidia-cusparse-cu11==11.7.4.91; platform_system
== "Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (11.7.4.91)
Requirement already satisfied: nvidia-cuda-nvrtc-cu11==11.7.99; platform_system
== "Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (11.7.99)
Requirement already satisfied: nvidia-cuda-cupti-cu11==11.7.101; platform_system
== "Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (11.7.101)
Requirement already satisfied: nvidia-nccl-cu11==2.14.3; platform_system ==
"Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (2.14.3)
Requirement already satisfied: jinja2 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (3.1.2)
Requirement already satisfied: nvidia-curand-cu11==10.2.10.91; platform_system
== "Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (10.2.10.91)
Requirement already satisfied: nvidia-cufft-cu11==10.9.0.58; platform_system ==
"Linux" and platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (10.9.0.58)
Requirement already satisfied: triton==2.0.0; platform_system == "Linux" and
platform_machine == "x86_64" in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (2.0.0)
Requirement already satisfied: filelock in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
torch>=1.11.0->pytorch-lightning) (3.10.0)
Requirement already satisfied: yarl<2.0,>=1.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http"->fsspec[http]>2021.06.0->pytorch-
lightning) (1.8.2)
Requirement already satisfied: async-timeout<5.0,>=4.0.0a3 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http"->fsspec[http]>2021.06.0->pytorch-
```

```
lightning) (4.0.2)
Requirement already satisfied: attrs>=17.3.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http"->fsspec[http]>2021.06.0->pytorch-
lightning) (22.2.0)
Requirement already satisfied: aiosignal>=1.1.2 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http"->fsspec[http]>2021.06.0->pytorch-
lightning) (1.3.1)
Requirement already satisfied: frozenlist>=1.1.1 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http"->fsspec[http]>2021.06.0->pytorch-
lightning) (1.3.3)
Requirement already satisfied: multidict<7.0,>=4.5 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http"->fsspec[http]>2021.06.0->pytorch-
lightning) (6.0.4)
Requirement already satisfied: charset-normalizer<4.0,>=2.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
aiohttp!=4.0.0a0,!=4.0.0a1; extra == "http"->fsspec[http]>2021.06.0->pytorch-
lightning) (3.1.0)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from requests;
extra == "http"->fsspec[http]>2021.06.0->pytorch-lightning) (1.26.15)
Requirement already satisfied: idna<4,>=2.5 in /usr/lib/python3/dist-packages
(from requests; extra == "http"->fsspec[http]>2021.06.0->pytorch-lightning)
(2.8)
Requirement already satisfied: certifi>=2017.4.17 in /usr/lib/python3/dist-
packages (from requests; extra == "http"->fsspec[http]>2021.06.0->pytorch-
lightning) (2019.11.28)
Requirement already satisfied: mpmath>=0.19 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
sympy->torch>=1.11.0->pytorch-lightning) (1.3.0)
Requirement already satisfied: wheel in /usr/lib/python3/dist-packages (from
nvidia-cuda-runtime-cu11==11.7.99; platform_system == "Linux" and
platform_machine == "x86_64"->torch>=1.11.0->pytorch-lightning) (0.34.2)
Requirement already satisfied: setuptools in /usr/lib/python3/dist-packages
(from nvidia-cuda-runtime-cu11==11.7.99; platform_system == "Linux" and
platform_machine == "x86_64"->torch>=1.11.0->pytorch-lightning) (45.2.0)
Requirement already satisfied: MarkupSafe>=2.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
jinja2->torch>=1.11.0->pytorch-lightning) (2.1.2)
Requirement already satisfied: cmake in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
triton==2.0.0; platform_system == "Linux" and platform_machine ==
"x86_64"->torch>=1.11.0->pytorch-lightning) (3.26.0)
Requirement already satisfied: lit in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
```

```
triton==2.0.0; platform_system == "Linux" and platform_machine ==
"x86_64"->torch>=1.11.0->pytorch-lightning) (15.0.7)
Requirement already satisfied: FastAPI in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (0.88.0)
Requirement already satisfied:
pydantic!=1.7,!=1.7.1,!=1.7.2,!=1.7.3,!=1.8,!=1.8.1,<2.0.0,>=1.6.2 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from FastAPI)
(1.10.7)
Requirement already satisfied: starlette==0.22.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from FastAPI)
(0.22.0)
Requirement already satisfied: typing-extensions>=4.2.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
pydantic!=1.7,!=1.7.1,!=1.7.2,!=1.7.3,!=1.8,!=1.8.1,<2.0.0,>=1.6.2->FastAPI)
(4.5.0)
Requirement already satisfied: anyio<5,>=3.4.0 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
starlette==0.22.0->FastAPI) (3.6.2)
Requirement already satisfied: sniffio>=1.1 in
/home/jd1830@bristol.ac.uk/.local/lib/python3.8/site-packages (from
anyio<5,>=3.4.0->starlette==0.22.0->FastAPI) (1.3.0)
Requirement already satisfied: idna>=2.8 in /usr/lib/python3/dist-packages (from
anyio<5,>=3.4.0->starlette==0.22.0->FastAPI) (2.8)
```

[ ]:
```
import VAE
# Load in our model that we trained on BluePebble
model = VAE.AutoEncoder.load_from_checkpoint("saved_models/autoencoder_512.
  ↪ckpt")

# disable randomness, dropout, etc...
model.eval()

# Let's encode two of the images
encoded_images = model.encoder(train_images[:2])

# Let's now decode two of the images
decoded_images = model.decoder(encoded_images)
```

```
Lightning automatically upgraded your loaded checkpoint from v1.9.4 to v2.0.1.
To apply the upgrade to your files permanently, run `python -m
lightning.pytorch.utilities.upgrade_checkpoint --file
saved_models/autoencoder_512.ckpt`
```

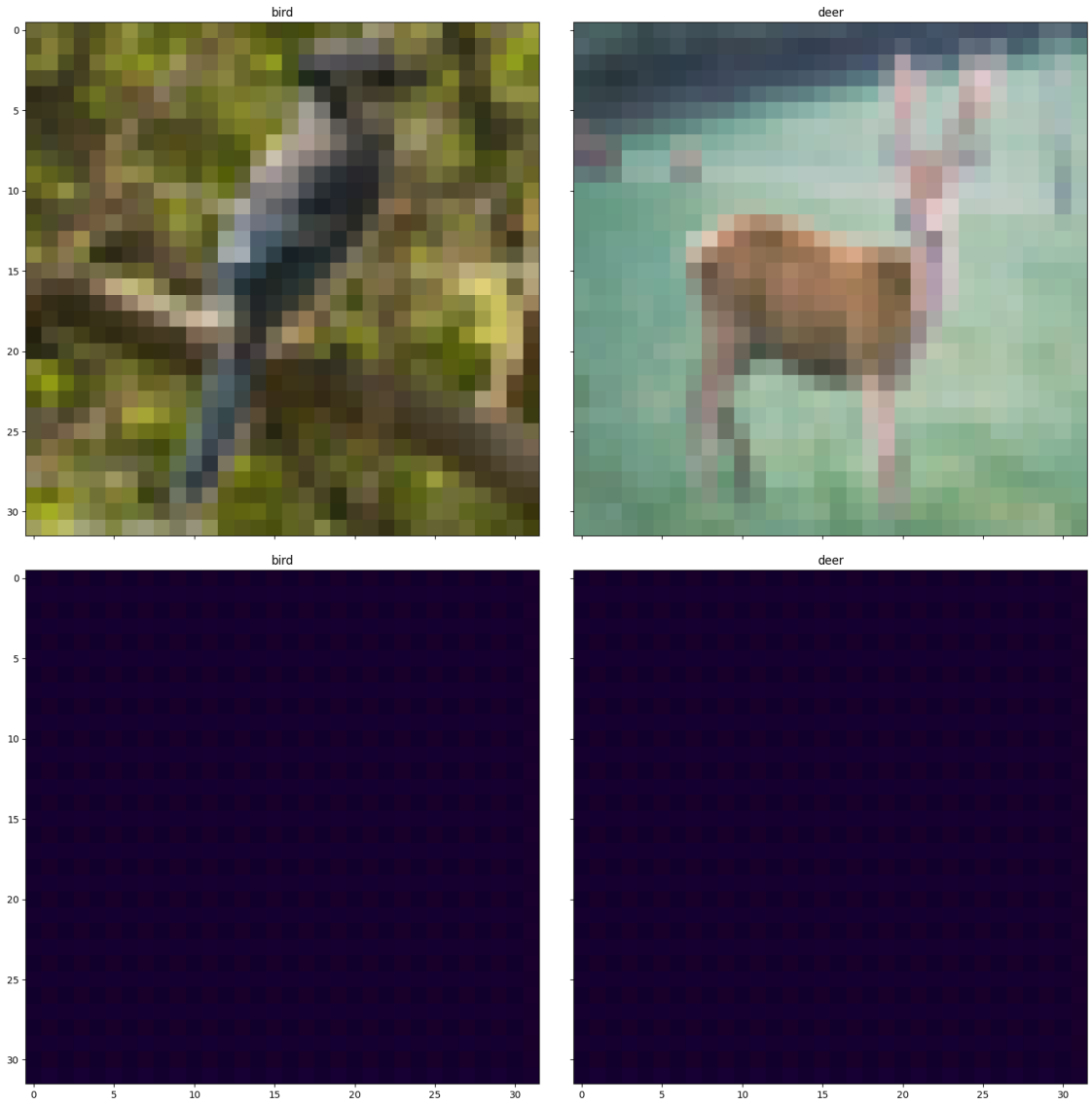
We've now encoded and decoded two of our images, let's plot our decoded images from the autoencoder against the original images:

[ ]:
```
fig = plt.figure(figsize=(20., 20.))
grid = ImageGrid(fig, 111,
```

```
                nrows_ncols=(2, 2),  # creates 2x2 grid of axes
                axes_pad=0.5,  # pad between axes
                )
labels = cifar10_label(train_targets[:2])
for i, ax in enumerate(grid):
    if i==0 or i==1 :
        ax.imshow(np.transpose(train_images[i].numpy(), (1, 2, 0)))
        ax.set_title('{0}'.format(labels[i]))
    if i==2 or i==3:
        ax.imshow(np.transpose(decoded_images[i-2].detach().numpy(), (1, 2, 0)))
        ax.set_title('{0}'.format(labels[i-2]))

plt.show()
```

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



Let's now do the same but for models trained with differing sizes of latent dimensions:

[ ]:
```
# TODO: Load in all the models you want to compare
# TODO: Add code here from lightning tutorial to create plot
```

Now we have examined what our decoded images look like in comparison to our original images, let's examine the encoding of the images. First let's examine what the latent space of our images looks like when we are using very small latent dimensions: