Artificial Intelligence and Machine Learning

Applications

Lecture Outline

- Linear Regression Tutorial & Playground

- Image Compression

- Logistic Regression Interactive Demo

- Neural Network Regression Tutorial & Playground

- Auto-Encoders

Linear Regression Tutorial

https://mlu-explain.github.io/linear-regression/

Linear Regression Playground

Image Compression with Linear Regression

- An image can be transformed into the frequency domain and represented as a combination of some basic components.

- Cosine Basis Functions and Discrete Cosine Transforms (DCT) can enable this.

- The human eye is most sensitive to low frequencies. Therefore, most of the high frequencies can be ignored.

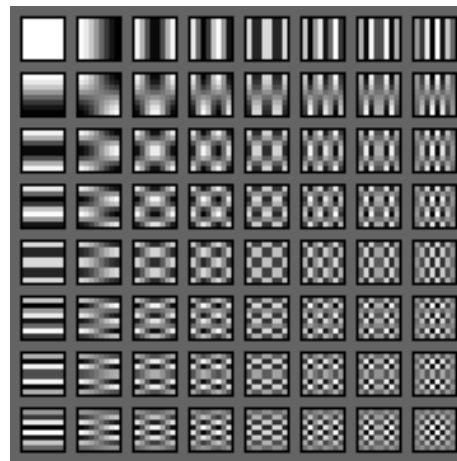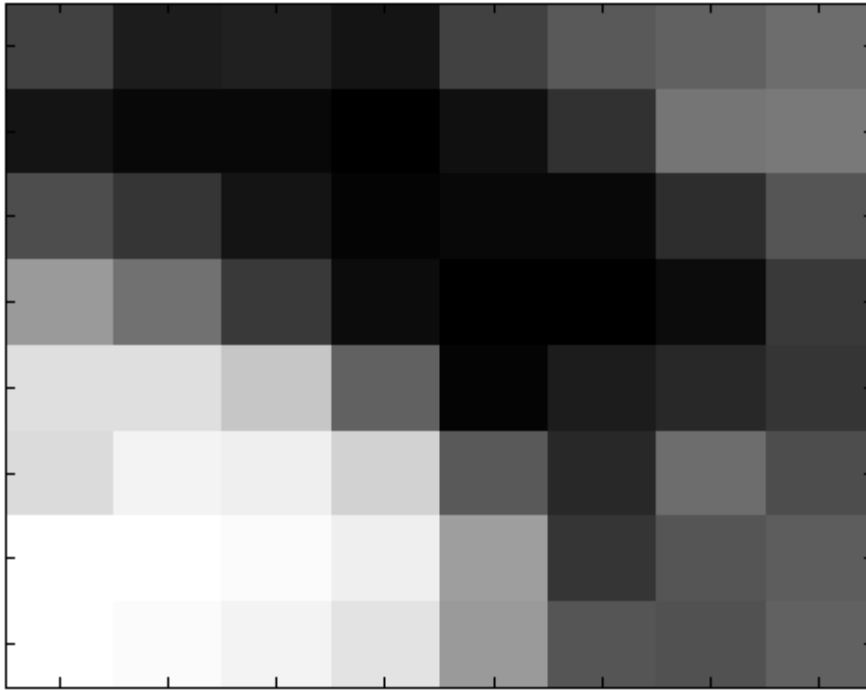- Principal behind JPEG Image Compression.

Image Compression with Linear Regression

- Using linear regression, we can learn the weight of each of these cosine basis.

- We only need to store the weights of the basis frequencies.

- The image is reconstructed using these weights.

Image Compression

8 x 8 Pixels

Image

Image Compression

- Gray-Scale Example:

- Value Range 0 (black) --- 255 (white)

63 33 36 28 63 81 86 98

27 18 17 11 22 48 104 108

72 52 28 15 17 16 47 77

132 100 56 19 10 9   21 55

187 186 166 88 13 34 43 51

184 203 199 177 82 44 97 73

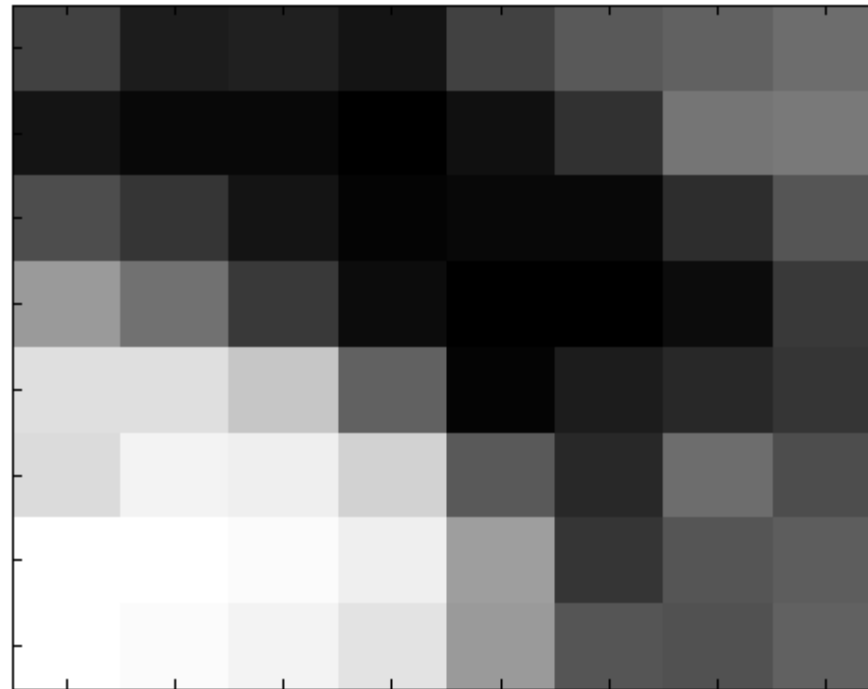211 214 208 198 134 52 78 83

211 210 203 191 133 79 74 86

Image Compression

- ## 2D-DCT of matrix

Numbers are coefficients
of polynomial

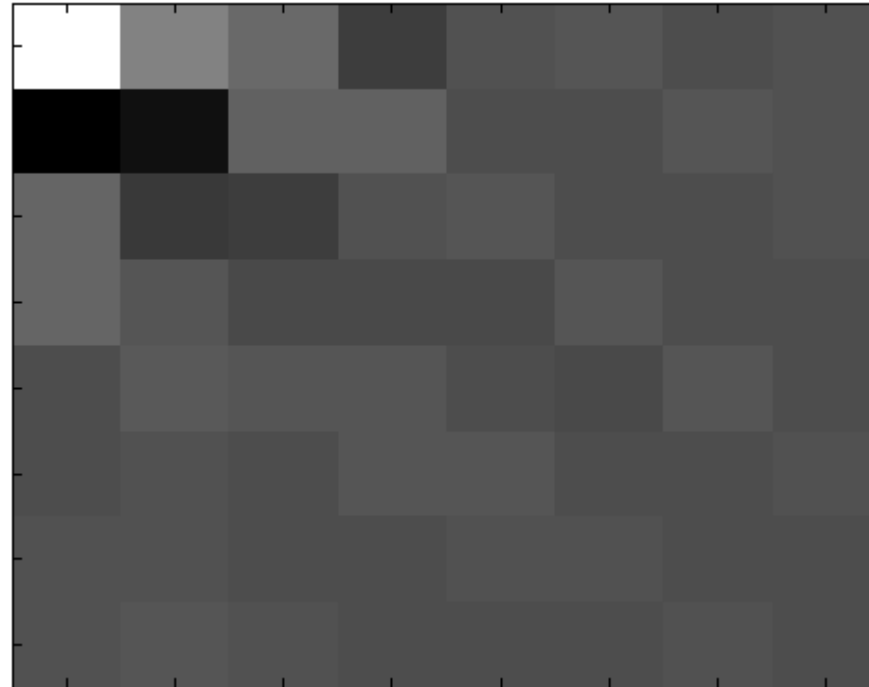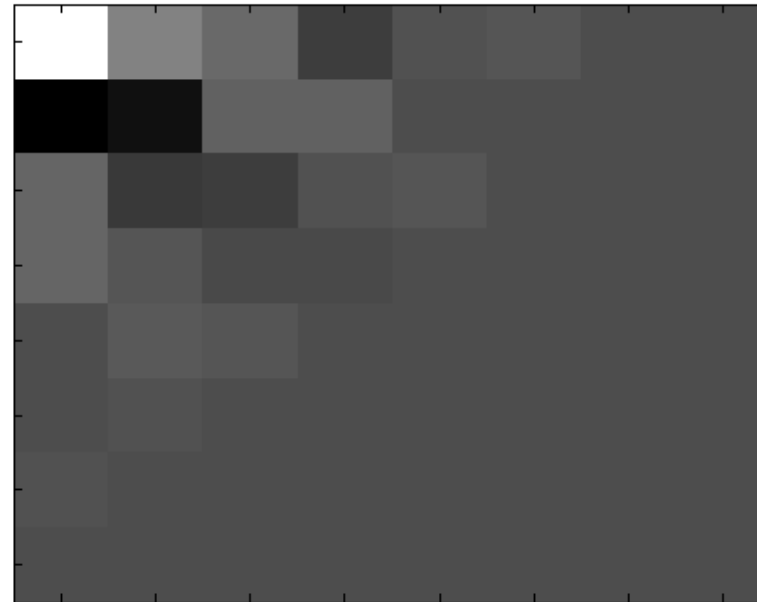|							
-304	210	104	-69	10	20	-12	7
-327	-260	67	70	-10	-15	21	8
93	-84	-66	16	24	-2	-5	9
89	33	-19	-20	-26	21	-3	0
-9	42	18	27	-7	-17	29	-7
-5	15	-10	17	32	-15	-4	7
10	3	-12	-1	2	3	-2	-3
12	30	0	-3	-3	-6	12	-1

Image Compression

- Cut the least significant components

```
-304  210  104  -69  10   20  -12  0
-327 -260   67   70 -10  -15    0  0
  93  -84  -66   16  24    0    0  0
  89   33  -19  -20   0    0    0  0
  -9   42   18    0   0    0    0  0
  -5   15    0    0   0    0    0  0
  10    0    0    0   0    0    0  0
   0    0    0    0   0    0    0  0
```
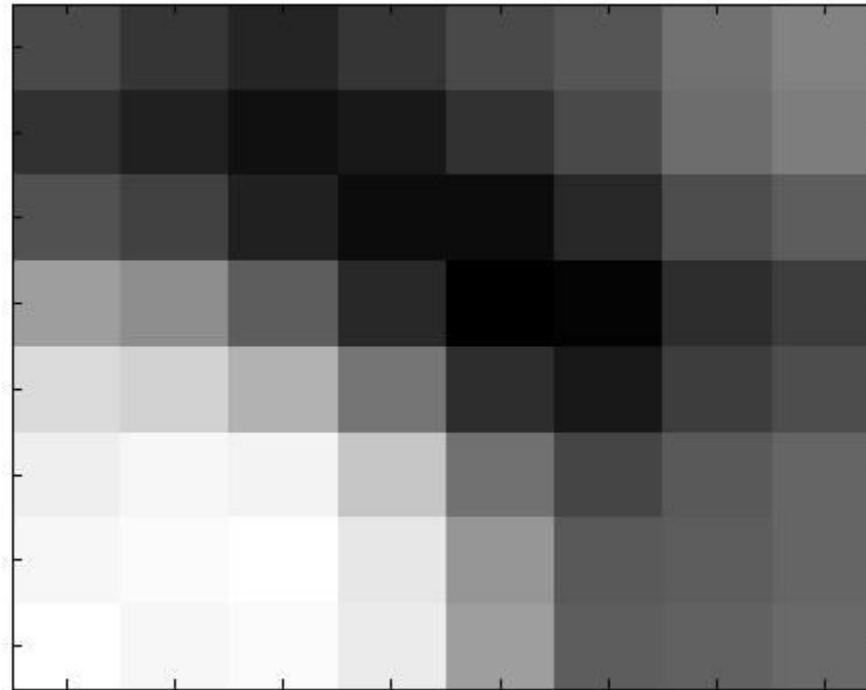
As you can see, we save a little over half the original memory.
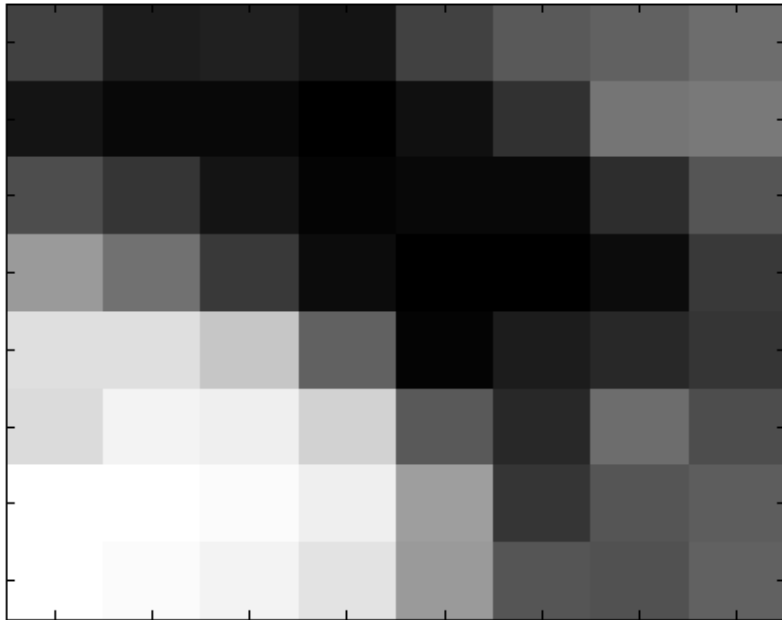
Reconstructing the Image

- New Matrix and Compressed Image

55	41	27	39	56	69	92	106
35	22	7	16	35	59	88	101
65	49	21	5	6	28	62	73
130	114	75	28	-7	-1	33	46
180	175	148	95	33	16	45	59
200	206	203	165	92	55	71	82
205	207	214	193	121	70	75	83
214	205	209	196	129	75	78	85

Can You Tell the Difference?

Original   Compressed
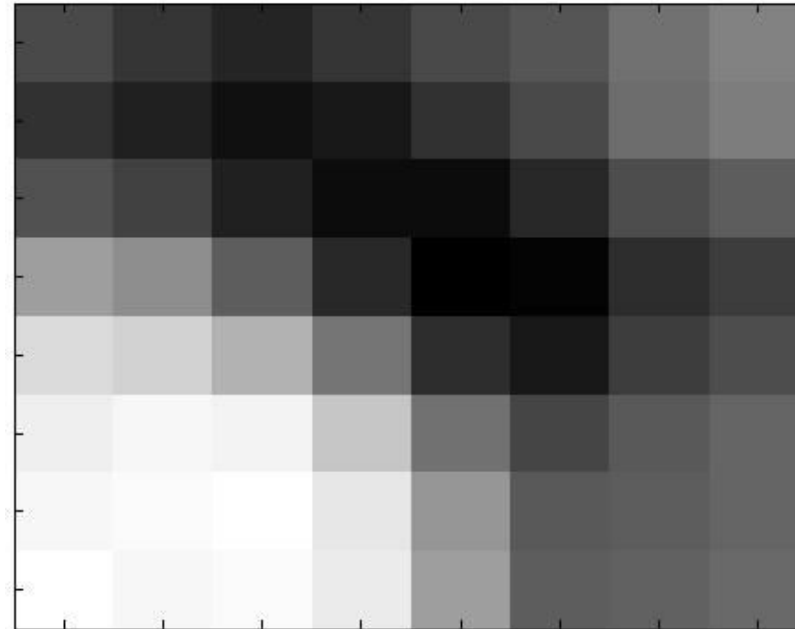
Image Compression

Original

Compressed

Logistic Regression Interactive Tutorial

https://mlu-explain.github.io/logistic-regression/

Neural Networks Tutorial

https://mlu-explain.github.io/neural-networks/

Neural Networks Playground

https://playground.tensorflow.org/

Try it Yourself – Digit Classification

https://trekhleb.dev/machine-learning-experiments/#/experiments/DigitsRecognitionMLP

Try it Yourself – Sketch Recognition

https://trekhleb.dev/machine-learning-experiments/#/experiments/SketchRecognitionMLP

Applications – AutoEncoders

- Autoencoders are a type of neural networks where the input is also the output.

- They come under unsupervised learning and there are no labels involved.

- An autoencoder consists of two parts: encoder and decoder.

- The idea here is that you take a higher dimensional input, project it into a lower dimensional space and then project it back into the input space.

Applications – AutoEncoders
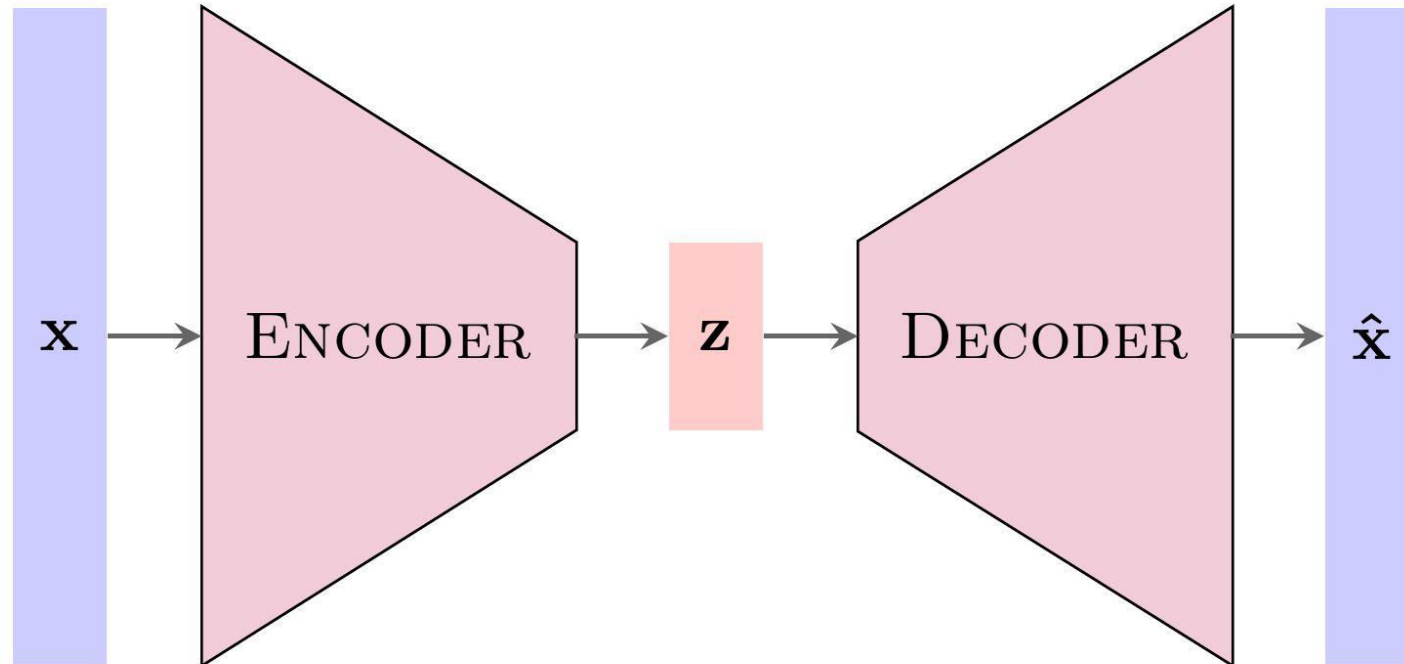
Applications – AutoEncoders

- The autoencoder model tries to minimize the reconstruction error (RE).
- Typically, mean squared is used as the loss function for autoencoders.
- The objective is to minimize the following:

$$L(x, \hat{x}) = \frac{1}{N} \sum_{i=1}^{N} ||x_i - \hat{x}_i||^2$$
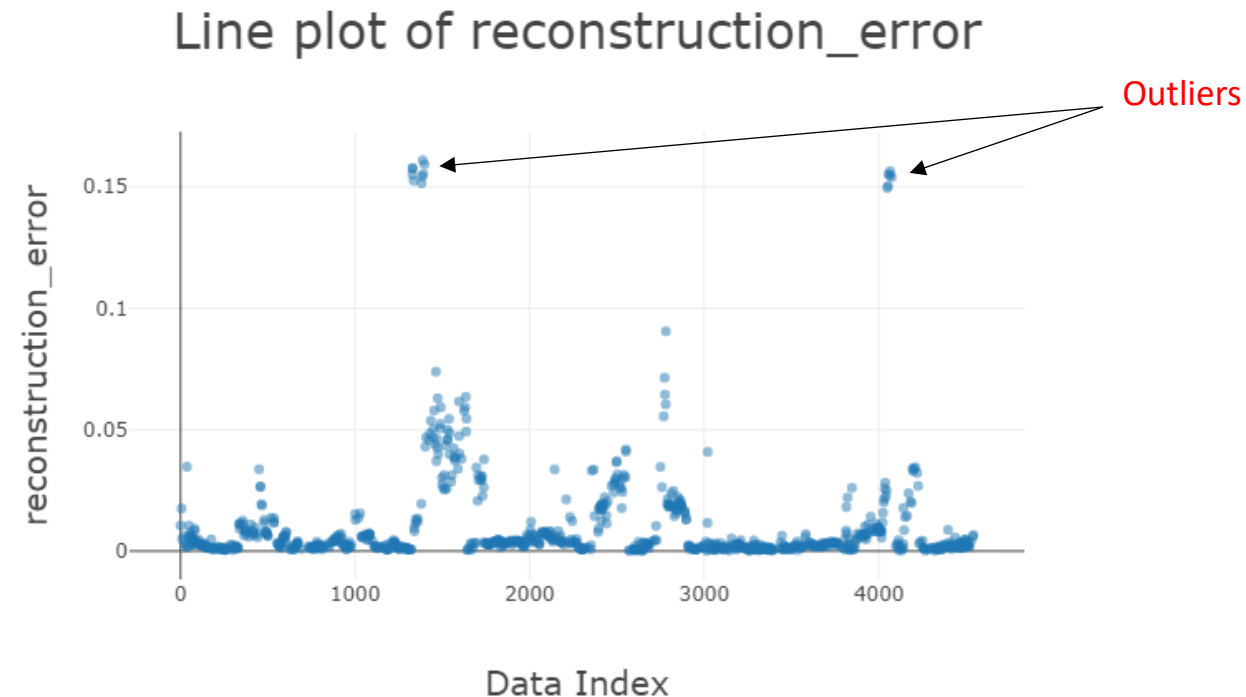
AutoEncoders for Dimensionality Reduction

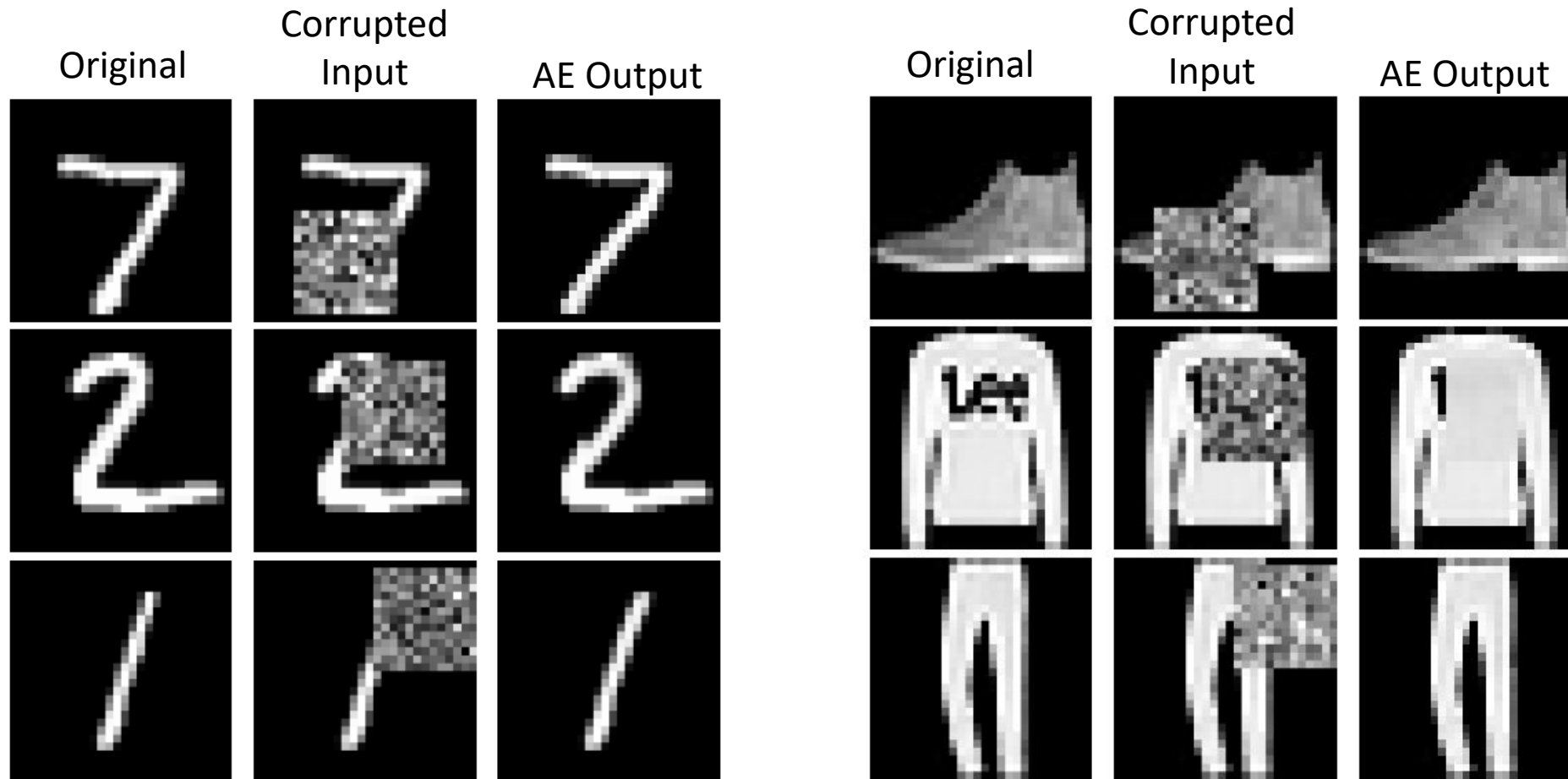- The encoder output can be used for dimensionality reduction
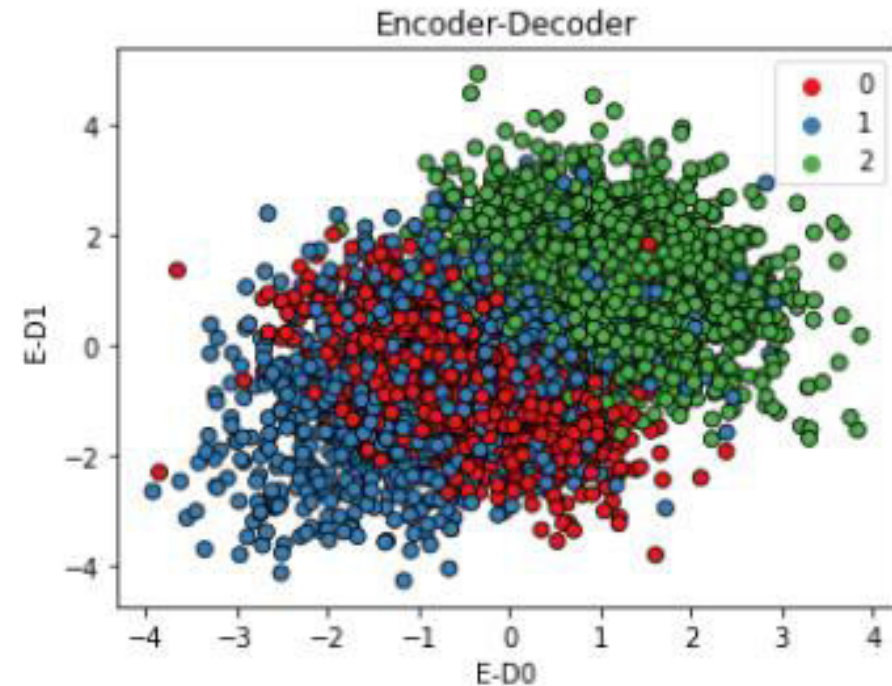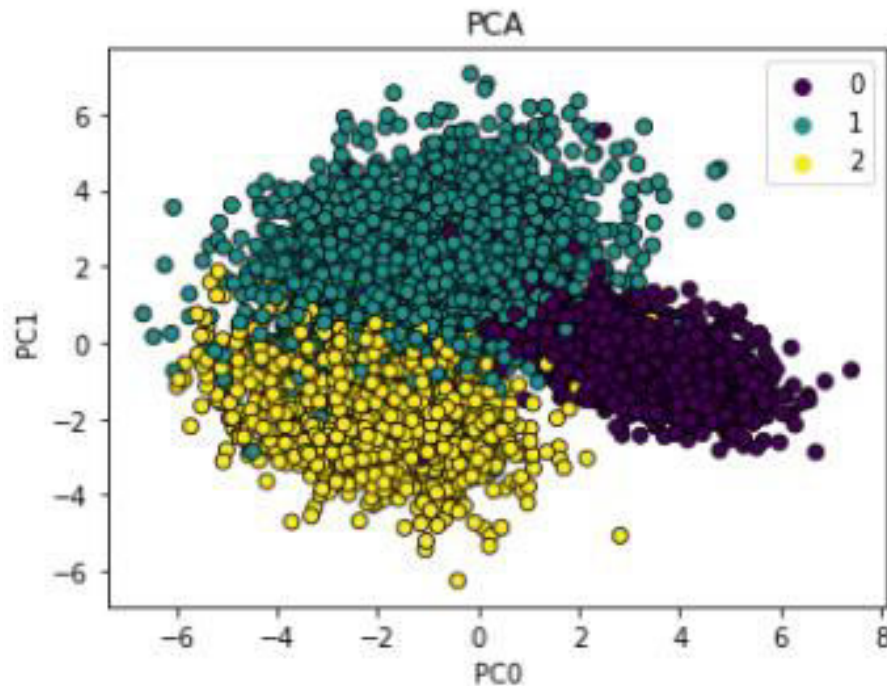
AutoEncoders for Outlier Detection

- The reconstruction error can be used to detect outliers. Out of distribution samples will have high Reconstruction error.

Line plot of reconstruction_error

AutoEncoders for Image Completion

Smieja et. al. Can auto-encoders help with filling missing data?

Summary