

mnist__noise-current

October 6, 2020

```
[19]: '''  
      VARIABLE: METHOD OF DR  
  
      CONSTANT: N_EPOCHS, N_COMPONENTS, NOISE TYPE AND MAGNITUDE  
  
      '''
```

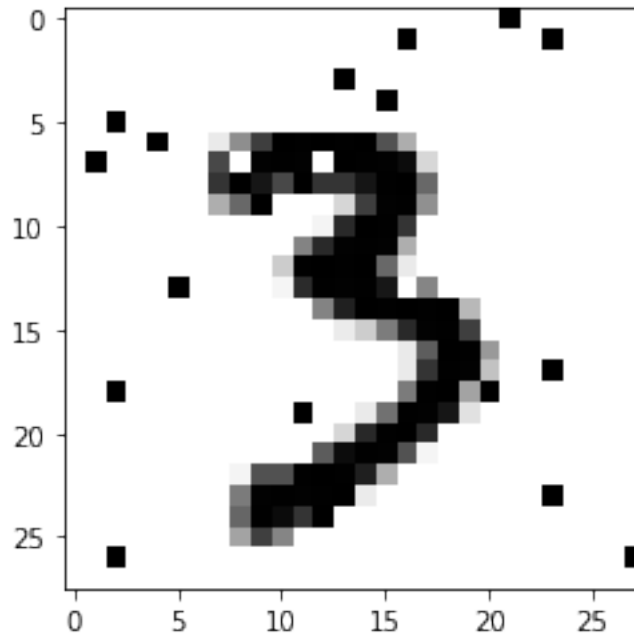
```
[19]: '\nVARIABLE: METHOD OF DR\n\nCONSTANT: N_EPOCHS, N_COMPONENTS, NOISE TYPE AND  
MAGNITUDE\n\n'
```

```
[20]: # -- IMPORTS -- #  
import math  
import scipy  
import numpy as np  
from skimage import util  
import matplotlib.pyplot as plt  
from keras.datasets import mnist  
from keras.utils import to_categorical
```

```
[21]: # -- TRAIN AND TEST DATA PREPARATION -- #  
(x_train, y_train), (x_test, y_test) = mnist.load_data()  
x_test_noisy = np.empty((len(x_test),28,28),dtype="float64")  
  
std = 0.1  
for i in range(len(x_test)):  
    x_test_noisy[i] = util.random_noise(x_test[i],mode="s&p")
```

```
[22]: # -- OUTPUT SNR AND SAMPLE NOISY IMAGE -- #  
p_signal = np.mean(x_test[30])  
p_noise = std  
snr = 10 * math.log(p_signal/p_noise,10)  
print(snr)  
  
plt.imshow(x_test_noisy[30],cmap=plt.cm.binary)  
plt.show()
```

25.023887949131005



```
[23]: # -- CONVERTING DATA FOR INPUT INTO NEURAL NETWORK -- #
```

```
x_train = x_train.reshape((60000,28*28))
x_train = x_train.astype("float32") / 255

x_test = x_test.reshape((10000,28*28))
x_test_noisy = x_test_noisy.reshape((10000,28*28))

y_train = to_categorical(y_train)
y_test = to_categorical(y_test)
```

```
[24]: # -- DIMENSIONALITY REDUCTION -- #
```

```
import dim_reduction
x_train0, x_test_noisy0 = x_train.copy(), x_test_noisy.copy()
x_train1, x_test_noisy1 = dim_reduction.apply(30, x_train, x_test_noisy, "PCA")
x_train2, x_test_noisy2 = dim_reduction.apply(30, x_train, x_test_noisy, "FA")
x_train3, x_test_noisy3 = dim_reduction.apply(700, x_train, x_test_noisy, "ICA")
```

```
[25]: # -- NEURAL NETWORK -- #
```

```
import neural_network
history0 = neural_network.fit(784, 30, x_train0, y_train, x_test_noisy0, y_test)
history1 = neural_network.fit(30, 30, x_train1, y_train, x_test_noisy1, y_test)
history2 = neural_network.fit(30, 30, x_train2, y_train, x_test_noisy2, y_test)
history3 = neural_network.fit(700, 50, x_train3, y_train, x_test_noisy3, y_test)
```

Train on 60000 samples, validate on 10000 samples
Epoch 1/30

60000/60000 [=====] - 1s 15us/step - loss: 1.5661 - accuracy: 0.6150 - val_loss: 1.0724 - val_accuracy: 0.7804
Epoch 2/30
60000/60000 [=====] - 1s 13us/step - loss: 0.7584 - accuracy: 0.8361 - val_loss: 0.6214 - val_accuracy: 0.8564
Epoch 3/30
60000/60000 [=====] - 1s 13us/step - loss: 0.4985 - accuracy: 0.8770 - val_loss: 0.4770 - val_accuracy: 0.8781
Epoch 4/30
60000/60000 [=====] - 1s 15us/step - loss: 0.3999 - accuracy: 0.8958 - val_loss: 0.4096 - val_accuracy: 0.8920
Epoch 5/30
60000/60000 [=====] - 1s 14us/step - loss: 0.3505 - accuracy: 0.9064 - val_loss: 0.3704 - val_accuracy: 0.8994
Epoch 6/30
60000/60000 [=====] - 1s 15us/step - loss: 0.3203 - accuracy: 0.9132 - val_loss: 0.3475 - val_accuracy: 0.9052
Epoch 7/30
60000/60000 [=====] - 1s 14us/step - loss: 0.2988 - accuracy: 0.9190 - val_loss: 0.3319 - val_accuracy: 0.9086
Epoch 8/30
60000/60000 [=====] - 1s 13us/step - loss: 0.2822 - accuracy: 0.9231 - val_loss: 0.3225 - val_accuracy: 0.9104
Epoch 9/30
60000/60000 [=====] - 1s 13us/step - loss: 0.2684 - accuracy: 0.9264 - val_loss: 0.3115 - val_accuracy: 0.9123
Epoch 10/30
60000/60000 [=====] - 1s 12us/step - loss: 0.2568 - accuracy: 0.9296 - val_loss: 0.2997 - val_accuracy: 0.9158
Epoch 11/30
60000/60000 [=====] - 1s 12us/step - loss: 0.2464 - accuracy: 0.9323 - val_loss: 0.2917 - val_accuracy: 0.9184
Epoch 12/30
60000/60000 [=====] - 1s 14us/step - loss: 0.2371 - accuracy: 0.9350 - val_loss: 0.2879 - val_accuracy: 0.9186
Epoch 13/30
60000/60000 [=====] - 1s 13us/step - loss: 0.2286 - accuracy: 0.9373 - val_loss: 0.2820 - val_accuracy: 0.9198
Epoch 14/30
60000/60000 [=====] - ETA: 0s - loss: 0.2221 - accuracy: 0.93 - 1s 13us/step - loss: 0.2209 - accuracy: 0.9394 - val_loss: 0.2770 - val_accuracy: 0.9205
Epoch 15/30
60000/60000 [=====] - 1s 13us/step - loss: 0.2138 - accuracy: 0.9412 - val_loss: 0.2715 - val_accuracy: 0.9217
Epoch 16/30
60000/60000 [=====] - 1s 14us/step - loss: 0.2071 - accuracy: 0.9431 - val_loss: 0.2707 - val_accuracy: 0.9227

Epoch 17/30
60000/60000 [=====] - 1s 13us/step - loss: 0.2007 -
accuracy: 0.9445 - val_loss: 0.2636 - val_accuracy: 0.9243

Epoch 18/30
60000/60000 [=====] - 1s 13us/step - loss: 0.1949 -
accuracy: 0.9462 - val_loss: 0.2678 - val_accuracy: 0.9223

Epoch 19/30
60000/60000 [=====] - 1s 14us/step - loss: 0.1892 -
accuracy: 0.9477 - val_loss: 0.2632 - val_accuracy: 0.9241

Epoch 20/30
60000/60000 [=====] - 1s 13us/step - loss: 0.1839 -
accuracy: 0.9498 - val_loss: 0.2533 - val_accuracy: 0.9261

Epoch 21/30
60000/60000 [=====] - 1s 14us/step - loss: 0.1788 -
accuracy: 0.9510 - val_loss: 0.2551 - val_accuracy: 0.9253

Epoch 22/30
60000/60000 [=====] - 1s 15us/step - loss: 0.1740 -
accuracy: 0.9523 - val_loss: 0.2473 - val_accuracy: 0.9279

Epoch 23/30
60000/60000 [=====] - 1s 15us/step - loss: 0.1696 -
accuracy: 0.9536 - val_loss: 0.2450 - val_accuracy: 0.9281

Epoch 24/30
60000/60000 [=====] - 1s 15us/step - loss: 0.1653 -
accuracy: 0.9545 - val_loss: 0.2382 - val_accuracy: 0.9302

Epoch 25/30
60000/60000 [=====] - 1s 14us/step - loss: 0.1611 -
accuracy: 0.9556 - val_loss: 0.2381 - val_accuracy: 0.9309

Epoch 26/30
60000/60000 [=====] - 1s 14us/step - loss: 0.1573 -
accuracy: 0.9565 - val_loss: 0.2394 - val_accuracy: 0.9292

Epoch 27/30
60000/60000 [=====] - 1s 16us/step - loss: 0.1535 -
accuracy: 0.9578 - val_loss: 0.2384 - val_accuracy: 0.9294

Epoch 28/30
60000/60000 [=====] - 1s 16us/step - loss: 0.1499 -
accuracy: 0.9582 - val_loss: 0.2293 - val_accuracy: 0.9320

Epoch 29/30
60000/60000 [=====] - 1s 14us/step - loss: 0.1466 -
accuracy: 0.9594 - val_loss: 0.2353 - val_accuracy: 0.9297

Epoch 30/30
60000/60000 [=====] - 1s 15us/step - loss: 0.1433 -
accuracy: 0.9602 - val_loss: 0.2293 - val_accuracy: 0.9306

Train on 60000 samples, validate on 10000 samples

Epoch 1/30
60000/60000 [=====] - 0s 5us/step - loss: 2.6097 -
accuracy: 0.1999 - val_loss: 4.6323 - val_accuracy: 0.2151

Epoch 2/30
60000/60000 [=====] - 0s 4us/step - loss: 1.4699 -

accuracy: 0.5324 - val_loss: 3.9180 - val_accuracy: 0.3275
 Epoch 3/30
 60000/60000 [=====] - 0s 5us/step - loss: 0.8814 -
 accuracy: 0.7461 - val_loss: 3.7010 - val_accuracy: 0.3994
 Epoch 4/30
 60000/60000 [=====] - 0s 5us/step - loss: 0.6115 -
 accuracy: 0.8272 - val_loss: 3.7212 - val_accuracy: 0.4403
 Epoch 5/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.4835 -
 accuracy: 0.8623 - val_loss: 3.8292 - val_accuracy: 0.4665
 Epoch 6/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.4139 -
 accuracy: 0.8798 - val_loss: 3.9922 - val_accuracy: 0.4772
 Epoch 7/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.3712 -
 accuracy: 0.8910 - val_loss: 4.1558 - val_accuracy: 0.4826
 Epoch 8/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.3417 -
 accuracy: 0.8994 - val_loss: 4.3548 - val_accuracy: 0.4842
 Epoch 9/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.3197 -
 accuracy: 0.9051 - val_loss: 4.5542 - val_accuracy: 0.4812
 Epoch 10/30
 60000/60000 [=====] - 0s 5us/step - loss: 0.3025 -
 accuracy: 0.9097 - val_loss: 4.7095 - val_accuracy: 0.4820
 Epoch 11/30
 60000/60000 [=====] - 0s 5us/step - loss: 0.2885 -
 accuracy: 0.9137 - val_loss: 4.8460 - val_accuracy: 0.4812
 Epoch 12/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.2766 -
 accuracy: 0.9171 - val_loss: 4.9822 - val_accuracy: 0.4809
 Epoch 13/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.2663 -
 accuracy: 0.9197 - val_loss: 5.1169 - val_accuracy: 0.4804
 Epoch 14/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.2572 -
 accuracy: 0.9225 - val_loss: 5.2428 - val_accuracy: 0.4800
 Epoch 15/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.2491 -
 accuracy: 0.9248 - val_loss: 5.3318 - val_accuracy: 0.4811
 Epoch 16/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.2418 -
 accuracy: 0.9269 - val_loss: 5.4446 - val_accuracy: 0.4790
 Epoch 17/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.2351 -
 accuracy: 0.9293 - val_loss: 5.5175 - val_accuracy: 0.4786
 Epoch 18/30
 60000/60000 [=====] - 0s 4us/step - loss: 0.2290 -

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accuracy: 0.9313 - val_loss: 5.5773 - val_accuracy: 0.4788
Epoch 19/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2234 -
accuracy: 0.9324 - val_loss: 5.6751 - val_accuracy: 0.4764
Epoch 20/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2182 -
accuracy: 0.9344 - val_loss: 5.7574 - val_accuracy: 0.4748
Epoch 21/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2133 -
accuracy: 0.9357 - val_loss: 5.8129 - val_accuracy: 0.4743
Epoch 22/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2087 -
accuracy: 0.9370 - val_loss: 5.8761 - val_accuracy: 0.4727
Epoch 23/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2045 -
accuracy: 0.9383 - val_loss: 5.8867 - val_accuracy: 0.4734
Epoch 24/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2004 -
accuracy: 0.9393 - val_loss: 5.9312 - val_accuracy: 0.4717
Epoch 25/30
60000/60000 [=====] - 0s 4us/step - loss: 0.1967 -
accuracy: 0.9405 - val_loss: 5.9706 - val_accuracy: 0.4725
Epoch 26/30
60000/60000 [=====] - 0s 4us/step - loss: 0.1930 -
accuracy: 0.9419 - val_loss: 6.0106 - val_accuracy: 0.4718
Epoch 27/30
60000/60000 [=====] - 0s 4us/step - loss: 0.1896 -
accuracy: 0.9428 - val_loss: 6.0536 - val_accuracy: 0.4715
Epoch 28/30
60000/60000 [=====] - 0s 4us/step - loss: 0.1864 -
accuracy: 0.9441 - val_loss: 6.0587 - val_accuracy: 0.4719
Epoch 29/30
60000/60000 [=====] - 0s 4us/step - loss: 0.1832 -
accuracy: 0.9450 - val_loss: 6.0853 - val_accuracy: 0.4721
Epoch 30/30
60000/60000 [=====] - 0s 4us/step - loss: 0.1803 -
accuracy: 0.9456 - val_loss: 6.1160 - val_accuracy: 0.4717
Train on 60000 samples, validate on 10000 samples
Epoch 1/30
60000/60000 [=====] - 0s 6us/step - loss: 2.2332 -
accuracy: 0.2216 - val_loss: 2.1151 - val_accuracy: 0.2700
Epoch 2/30
60000/60000 [=====] - 0s 4us/step - loss: 1.8769 -
accuracy: 0.4886 - val_loss: 1.8044 - val_accuracy: 0.4966
Epoch 3/30
60000/60000 [=====] - 0s 5us/step - loss: 1.5658 -
accuracy: 0.6859 - val_loss: 1.5416 - val_accuracy: 0.6391
Epoch 4/30

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60000/60000 [=====] - 0s 5us/step - loss: 1.2956 -
accuracy: 0.7750 - val_loss: 1.3221 - val_accuracy: 0.7061
Epoch 5/30
60000/60000 [=====] - 0s 6us/step - loss: 1.0690 -
accuracy: 0.8167 - val_loss: 1.1441 - val_accuracy: 0.7449
Epoch 6/30
60000/60000 [=====] - 0s 6us/step - loss: 0.8851 -
accuracy: 0.8404 - val_loss: 1.0041 - val_accuracy: 0.7686
Epoch 7/30
60000/60000 [=====] - 0s 5us/step - loss: 0.7410 -
accuracy: 0.8559 - val_loss: 0.8979 - val_accuracy: 0.7802
Epoch 8/30
60000/60000 [=====] - 0s 6us/step - loss: 0.6308 -
accuracy: 0.8676 - val_loss: 0.8188 - val_accuracy: 0.7921
Epoch 9/30
60000/60000 [=====] - 0s 6us/step - loss: 0.5480 -
accuracy: 0.8768 - val_loss: 0.7618 - val_accuracy: 0.7995
Epoch 10/30
60000/60000 [=====] - 0s 5us/step - loss: 0.4859 -
accuracy: 0.8844 - val_loss: 0.7199 - val_accuracy: 0.8045
Epoch 11/30
60000/60000 [=====] - 0s 7us/step - loss: 0.4393 -
accuracy: 0.8903 - val_loss: 0.6909 - val_accuracy: 0.8085
Epoch 12/30
60000/60000 [=====] - 0s 6us/step - loss: 0.4037 -
accuracy: 0.8966 - val_loss: 0.6704 - val_accuracy: 0.8124
Epoch 13/30
60000/60000 [=====] - 0s 5us/step - loss: 0.3762 -
accuracy: 0.9006 - val_loss: 0.6566 - val_accuracy: 0.8167
Epoch 14/30
60000/60000 [=====] - 0s 5us/step - loss: 0.3543 -
accuracy: 0.9035 - val_loss: 0.6451 - val_accuracy: 0.8198
Epoch 15/30
60000/60000 [=====] - 0s 5us/step - loss: 0.3366 -
accuracy: 0.9074 - val_loss: 0.6360 - val_accuracy: 0.8215
Epoch 16/30
60000/60000 [=====] - 0s 4us/step - loss: 0.3218 -
accuracy: 0.9099 - val_loss: 0.6307 - val_accuracy: 0.8239
Epoch 17/30
60000/60000 [=====] - 0s 4us/step - loss: 0.3094 -
accuracy: 0.9129 - val_loss: 0.6253 - val_accuracy: 0.8251
Epoch 18/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2987 -
accuracy: 0.9153 - val_loss: 0.6215 - val_accuracy: 0.8268
Epoch 19/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2892 -
accuracy: 0.9174 - val_loss: 0.6200 - val_accuracy: 0.8287
Epoch 20/30

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60000/60000 [=====] - 0s 4us/step - loss: 0.2809 -
accuracy: 0.9195 - val_loss: 0.6151 - val_accuracy: 0.8309
Epoch 21/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2734 -
accuracy: 0.9213 - val_loss: 0.6150 - val_accuracy: 0.8317
Epoch 22/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2665 -
accuracy: 0.9228 - val_loss: 0.6133 - val_accuracy: 0.8330
Epoch 23/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2603 -
accuracy: 0.9242 - val_loss: 0.6110 - val_accuracy: 0.8341
Epoch 24/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2545 -
accuracy: 0.9257 - val_loss: 0.6087 - val_accuracy: 0.8352
Epoch 25/30
60000/60000 [=====] - 0s 5us/step - loss: 0.2491 -
accuracy: 0.9272 - val_loss: 0.6071 - val_accuracy: 0.8368
Epoch 26/30
60000/60000 [=====] - 0s 5us/step - loss: 0.2440 -
accuracy: 0.9287 - val_loss: 0.6059 - val_accuracy: 0.8379
Epoch 27/30
60000/60000 [=====] - 0s 5us/step - loss: 0.2393 -
accuracy: 0.9298 - val_loss: 0.6041 - val_accuracy: 0.8386
Epoch 28/30
60000/60000 [=====] - 0s 5us/step - loss: 0.2347 -
accuracy: 0.9310 - val_loss: 0.6022 - val_accuracy: 0.8407
Epoch 29/30
60000/60000 [=====] - 0s 5us/step - loss: 0.2305 -
accuracy: 0.9321 - val_loss: 0.6022 - val_accuracy: 0.8409
Epoch 30/30
60000/60000 [=====] - 0s 4us/step - loss: 0.2264 -
accuracy: 0.9332 - val_loss: 0.6023 - val_accuracy: 0.8420
Train on 60000 samples, validate on 10000 samples
Epoch 1/50
60000/60000 [=====] - 2s 27us/step - loss: 2.3001 -
accuracy: 0.1255 - val_loss: 2.3669 - val_accuracy: 0.1037
Epoch 2/50
60000/60000 [=====] - 2s 26us/step - loss: 2.2947 -
accuracy: 0.1157 - val_loss: 2.3692 - val_accuracy: 0.1097
Epoch 3/50
60000/60000 [=====] - 2s 28us/step - loss: 2.2887 -
accuracy: 0.1173 - val_loss: 2.3742 - val_accuracy: 0.1193
Epoch 4/50
60000/60000 [=====] - 2s 25us/step - loss: 2.2819 -
accuracy: 0.1209 - val_loss: 2.3809 - val_accuracy: 0.1243
Epoch 5/50
60000/60000 [=====] - 2s 25us/step - loss: 2.2743 -
accuracy: 0.1349 - val_loss: 2.3873 - val_accuracy: 0.1295

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Epoch 6/50
60000/60000 [=====] - 2s 25us/step - loss: 2.2659 - accuracy: 0.1554 - val_loss: 2.3954 - val_accuracy: 0.1352

Epoch 7/50
60000/60000 [=====] - 2s 25us/step - loss: 2.2568 - accuracy: 0.1881 - val_loss: 2.4058 - val_accuracy: 0.1419

Epoch 8/50
60000/60000 [=====] - 2s 25us/step - loss: 2.2467 - accuracy: 0.2470 - val_loss: 2.4165 - val_accuracy: 0.1483

Epoch 9/50
60000/60000 [=====] - ETA: 0s - loss: 2.2358 - accuracy: 0.31 - 2s 25us/step - loss: 2.2358 - accuracy: 0.3108 - val_loss: 2.4284 - val_accuracy: 0.1549

Epoch 10/50
60000/60000 [=====] - 2s 26us/step - loss: 2.2240 - accuracy: 0.3658 - val_loss: 2.4437 - val_accuracy: 0.1597

Epoch 11/50
60000/60000 [=====] - 2s 26us/step - loss: 2.2113 - accuracy: 0.4465 - val_loss: 2.4574 - val_accuracy: 0.1644

Epoch 12/50
60000/60000 [=====] - 2s 26us/step - loss: 2.1977 - accuracy: 0.5197 - val_loss: 2.4731 - val_accuracy: 0.1701

Epoch 13/50
60000/60000 [=====] - 2s 25us/step - loss: 2.1831 - accuracy: 0.5756 - val_loss: 2.4898 - val_accuracy: 0.1745

Epoch 14/50
60000/60000 [=====] - 2s 26us/step - loss: 2.1677 - accuracy: 0.6236 - val_loss: 2.5104 - val_accuracy: 0.1790

Epoch 15/50
60000/60000 [=====] - 2s 25us/step - loss: 2.1513 - accuracy: 0.6453 - val_loss: 2.5316 - val_accuracy: 0.1827

Epoch 16/50
60000/60000 [=====] - 2s 25us/step - loss: 2.1341 - accuracy: 0.6794 - val_loss: 2.5559 - val_accuracy: 0.1867

Epoch 17/50
60000/60000 [=====] - 2s 25us/step - loss: 2.1160 - accuracy: 0.7171 - val_loss: 2.5805 - val_accuracy: 0.1906

Epoch 18/50
60000/60000 [=====] - 1s 24us/step - loss: 2.0970 - accuracy: 0.7356 - val_loss: 2.6091 - val_accuracy: 0.1947

Epoch 19/50
60000/60000 [=====] - 1s 24us/step - loss: 2.0772 - accuracy: 0.7483 - val_loss: 2.6383 - val_accuracy: 0.1969

Epoch 20/50
60000/60000 [=====] - 1s 25us/step - loss: 2.0565 - accuracy: 0.7546 - val_loss: 2.6640 - val_accuracy: 0.1998

Epoch 21/50
60000/60000 [=====] - 1s 24us/step - loss: 2.0349 -

accuracy: 0.7720 - val_loss: 2.6962 - val_accuracy: 0.2020
 Epoch 22/50
 60000/60000 [=====] - 1s 23us/step - loss: 2.0127 -
 accuracy: 0.7773 - val_loss: 2.7312 - val_accuracy: 0.2047
 Epoch 23/50
 60000/60000 [=====] - 1s 24us/step - loss: 1.9895 -
 accuracy: 0.7855 - val_loss: 2.7726 - val_accuracy: 0.2091
 Epoch 24/50
 60000/60000 [=====] - 1s 23us/step - loss: 1.9656 -
 accuracy: 0.7964 - val_loss: 2.8131 - val_accuracy: 0.2099
 Epoch 25/50
 60000/60000 [=====] - 1s 23us/step - loss: 1.9410 -
 accuracy: 0.7988 - val_loss: 2.8525 - val_accuracy: 0.2121
 Epoch 26/50
 60000/60000 [=====] - 1s 24us/step - loss: 1.9158 -
 accuracy: 0.8044 - val_loss: 2.8981 - val_accuracy: 0.2138
 Epoch 27/50
 60000/60000 [=====] - 1s 24us/step - loss: 1.8899 -
 accuracy: 0.8106 - val_loss: 2.9473 - val_accuracy: 0.2160
 Epoch 28/50
 60000/60000 [=====] - 1s 24us/step - loss: 1.8633 -
 accuracy: 0.8136 - val_loss: 3.0014 - val_accuracy: 0.2199
 Epoch 29/50
 60000/60000 [=====] - 1s 25us/step - loss: 1.8361 -
 accuracy: 0.8181 - val_loss: 3.0548 - val_accuracy: 0.2219
 Epoch 30/50
 60000/60000 [=====] - 2s 27us/step - loss: 1.8083 -
 accuracy: 0.8214 - val_loss: 3.1120 - val_accuracy: 0.2258
 Epoch 31/50
 60000/60000 [=====] - 2s 27us/step - loss: 1.7799 -
 accuracy: 0.8226 - val_loss: 3.1726 - val_accuracy: 0.2270
 Epoch 32/50
 60000/60000 [=====] - 1s 25us/step - loss: 1.7512 -
 accuracy: 0.8258 - val_loss: 3.2325 - val_accuracy: 0.2269
 Epoch 33/50
 60000/60000 [=====] - 1s 25us/step - loss: 1.7221 -
 accuracy: 0.8279 - val_loss: 3.2955 - val_accuracy: 0.2288
 Epoch 34/50
 60000/60000 [=====] - 1s 24us/step - loss: 1.6925 -
 accuracy: 0.8323 - val_loss: 3.3649 - val_accuracy: 0.2298
 Epoch 35/50
 60000/60000 [=====] - 1s 24us/step - loss: 1.6626 -
 accuracy: 0.8317 - val_loss: 3.4319 - val_accuracy: 0.2306
 Epoch 36/50
 60000/60000 [=====] - 1s 25us/step - loss: 1.6323 -
 accuracy: 0.8360 - val_loss: 3.5016 - val_accuracy: 0.2316
 Epoch 37/50
 60000/60000 [=====] - 1s 25us/step - loss: 1.6019 -

```

accuracy: 0.8379 - val_loss: 3.5768 - val_accuracy: 0.2335
Epoch 38/50
60000/60000 [=====] - 1s 24us/step - loss: 1.5713 -
accuracy: 0.8387 - val_loss: 3.6451 - val_accuracy: 0.2342
Epoch 39/50
60000/60000 [=====] - 1s 25us/step - loss: 1.5404 -
accuracy: 0.8403 - val_loss: 3.7233 - val_accuracy: 0.2344
Epoch 40/50
60000/60000 [=====] - 1s 24us/step - loss: 1.5095 -
accuracy: 0.8415 - val_loss: 3.8028 - val_accuracy: 0.2357
Epoch 41/50
60000/60000 [=====] - 1s 24us/step - loss: 1.4785 -
accuracy: 0.8431 - val_loss: 3.8834 - val_accuracy: 0.2350
Epoch 42/50
60000/60000 [=====] - 1s 24us/step - loss: 1.4475 -
accuracy: 0.8440 - val_loss: 3.9758 - val_accuracy: 0.2353
Epoch 43/50
60000/60000 [=====] - 1s 24us/step - loss: 1.4167 -
accuracy: 0.8459 - val_loss: 4.0585 - val_accuracy: 0.2354
Epoch 44/50
60000/60000 [=====] - 1s 25us/step - loss: 1.3859 -
accuracy: 0.8473 - val_loss: 4.1395 - val_accuracy: 0.2351
Epoch 45/50
60000/60000 [=====] - 2s 26us/step - loss: 1.3554 -
accuracy: 0.8482 - val_loss: 4.2250 - val_accuracy: 0.2357
Epoch 46/50
60000/60000 [=====] - 2s 25us/step - loss: 1.3250 -
accuracy: 0.8493 - val_loss: 4.3179 - val_accuracy: 0.2363
Epoch 47/50
60000/60000 [=====] - 2s 26us/step - loss: 1.2949 -
accuracy: 0.8502 - val_loss: 4.4132 - val_accuracy: 0.2378
Epoch 48/50
60000/60000 [=====] - 1s 25us/step - loss: 1.2651 -
accuracy: 0.8516 - val_loss: 4.5081 - val_accuracy: 0.2382
Epoch 49/50
60000/60000 [=====] - 1s 25us/step - loss: 1.2356 -
accuracy: 0.8526 - val_loss: 4.6056 - val_accuracy: 0.2392
Epoch 50/50
60000/60000 [=====] - 1s 25us/step - loss: 1.2067 -
accuracy: 0.8537 - val_loss: 4.7042 - val_accuracy: 0.2401

```

```

[26]: # -- OUTPUT PLOTS -- #
plt.plot(history0.history["val_accuracy"])
plt.plot(history1.history["val_accuracy"])
plt.plot(history2.history["val_accuracy"])
plt.plot(history3.history["val_accuracy"])
plt.title("Model Accuracy (Salt and Pepper)")

```

```
plt.ylabel("Accuracy")
plt.xlabel("Epoch")
plt.legend(["None", "PCA", "FactorAnalysis", "FastICA"],loc="lower right")
plt.show()
```

