Neural Networks image recognition - ConvNet

1. Add random noise (see below on `size parameter` on `np.random.normal` (https://numpy.org/doc/stable/reference/random/generated/numpy.random.normal.html)) to the images in training and testing. **Make sure each image gets a different noise feature added to it. Inspect by printing out several images. Note - the `size` parameter should match the data. **
2. Compare the `accuracy` of train and val after N epochs for MLNN with and without noise.
3. Vary the amount of noise by changing the `scale` parameter in `np.random.normal` by a factor. Use `.1, .5, 1.0, 2.0, 4.0` for the `scale` and keep track of the `accuracy` for training and validation and plot these results.
4. Compare these results with the previous week where we used a MultiLayer Perceptron (this week we use a ConvNet).

Neural Networks - Image Recognition

In [1]:
```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.optimizers import RMSprop
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D
from keras import backend


import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
```

```
WARNING:tensorflow:From C:WUsersWkcosmWanaconda3WLibWsite-packagesWkerasWsrcWlosses.py:2976: The name tf.los
ses.sparse_softmax_cross_entropy is deprecated. Please use tf.compat.v1.losses.sparse_softmax_cross_entropy
instead.
```

Conv Net

Trains a simple convnet on the MNIST dataset. Gets to 99.25% test accuracy after 12 epochs (there is still a lot of margin for parameter tuning).

In [2]:
```
# input image dimensions
img_rows, img_cols = 28, 28

# the data, shuffled and split between train and test sets
(x_train, y_train), (x_test, y_test) = mnist.load_data()

if backend.image_data_format() == 'channels_first':
    x_train = x_train.reshape(x_train.shape[0], 1, img_rows, img_cols)
    x_test = x_test.reshape(x_test.shape[0], 1, img_rows, img_cols)
    input_shape = (1, img_rows, img_cols)
else:
    x_train = x_train.reshape(x_train.shape[0], img_rows, img_cols, 1)
    x_test = x_test.reshape(x_test.shape[0], img_rows, img_cols, 1)
    input_shape = (img_rows, img_cols, 1)

x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255
x_test /= 255
print('x_train shape:', x_train.shape)
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')
```

```
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
```

1. Add noise

In [3]:
```
# Noise is added here
# The max value of the noise should not grossly surpass 1.0
noise_train = np.random.normal(0.5, 0.05, (60000, 28, 28, 1))
noise_test = np.random.normal(0.5, 0.05, (10000, 28, 28, 1))
x_train2 = x_train + noise_train
x_test2 = x_test + noise_test
```

In [4]:
```
#check the minimun and maximum value of the noise

print(np.max(noise_train))
print(np.min(noise_train))
print(np.max(noise_test))
print(np.min(noise_test))
```

```
0.7937039777445263
0.22592893773982398
0.790001239714075
0.23102239788898254
```

2. Compare Accuracy

2-A. Accuracy without noise = 83.89%

In [5]:
```
batch_size = 128
num_classes = 10
epochs = 12

# convert class vectors to binary class matrices
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3),
                 activation='relu',
                 input_shape=input_shape))
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss=keras.losses.categorical_crossentropy,
              optimizer=keras.optimizers.Adadelta(),
              metrics=['accuracy'])

model.fit(x_train, y_train,
          batch_size=batch_size,
          epochs=epochs,
          verbose=1,
          validation_data=(x_test, y_test))
score = model.evaluate(x_test, y_test, verbose=0)

print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
WARNING:tensorflow:From C:\Users\kcosm\anaconda3\Lib\site-packages\keras\src\backend.py:873: The name tf.get
_default_graph is deprecated. Please use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From C:\Users\kcosm\anaconda3\Lib\site-packages\keras\src\layers\pooling\max_pooling2d.p
y:161: The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d instead.

Epoch 1/12
WARNING:tensorflow:From C:\Users\kcosm\anaconda3\Lib\site-packages\keras\src\utils\tf_utils.py:492: The name
tf.ragged.RaggedTensorValue is deprecated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

WARNING:tensorflow:From C:\Users\kcosm\anaconda3\Lib\site-packages\keras\src\engine\base_layer_utils.py:384:
The name tf.executing_eagerly_outside_functions is deprecated. Please use tf.compat.v1.executing_eagerly_out
side_functions instead.

469/469 [==============================] - 67s 137ms/step - loss: 2.2815 - accuracy: 0.1424 - val_loss: 2.25
40 - val_accuracy: 0.2601
Epoch 2/12
469/469 [==============================] - 71s 150ms/step - loss: 2.2349 - accuracy: 0.2375 - val_loss: 2.19
69 - val_accuracy: 0.4094
Epoch 3/12
469/469 [==============================] - 64s 136ms/step - loss: 2.1766 - accuracy: 0.3216 - val_loss: 2.12
15 - val_accuracy: 0.5204
Epoch 4/12
469/469 [==============================] - 63s 134ms/step - loss: 2.0958 - accuracy: 0.4020 - val_loss: 2.01
88 - val_accuracy: 0.6073
Epoch 5/12
469/469 [==============================] - 68s 144ms/step - loss: 1.9894 - accuracy: 0.4690 - val_loss: 1.88
16 - val_accuracy: 0.6847
Epoch 6/12
469/469 [==============================] - 65s 139ms/step - loss: 1.8534 - accuracy: 0.5320 - val_loss: 1.70
92 - val_accuracy: 0.7397
Epoch 7/12
469/469 [==============================] - 58s 123ms/step - loss: 1.6922 - accuracy: 0.5810 - val_loss: 1.51
23 - val_accuracy: 0.7718
Epoch 8/12
469/469 [==============================] - 59s 127ms/step - loss: 1.5241 - accuracy: 0.6144 - val_loss: 1.31
16 - val_accuracy: 0.7962
Epoch 9/12
469/469 [==============================] - 68s 145ms/step - loss: 1.3667 - accuracy: 0.6445 - val_loss: 1.12
93 - val_accuracy: 0.8099
Epoch 10/12
469/469 [==============================] - 60s 127ms/step - loss: 1.2290 - accuracy: 0.6694 - val_loss: 0.97
80 - val_accuracy: 0.8234
Epoch 11/12
469/469 [==============================] - 63s 135ms/step - loss: 1.1168 - accuracy: 0.6922 - val_loss: 0.86
07 - val_accuracy: 0.8319
Epoch 12/12
469/469 [==============================] - 58s 124ms/step - loss: 1.0278 - accuracy: 0.7056 - val_loss: 0.77
08 - val_accuracy: 0.8389
Test loss: 0.7707778215408325
Test accuracy: 0.8389000296592712
```

2-B. Accuracy with noise = 87.22%

In [6]:
```
model.fit(x_train2, y_train,
          batch_size=batch_size,
          epochs=epochs,
          verbose=1,
          validation_data=(x_test2, y_test))
score = model.evaluate(x_test2, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Epoch 1/12
469/469 [==============================] - 62s 131ms/step - loss: 1.2414 - accuracy: 0.5860 - val_loss: 0.74
09 - val_accuracy: 0.8406
Epoch 2/12
469/469 [==============================] - 58s 125ms/step - loss: 1.0687 - accuracy: 0.6628 - val_loss: 0.71
81 - val_accuracy: 0.8469
Epoch 3/12
469/469 [==============================] - 58s 125ms/step - loss: 1.0200 - accuracy: 0.6833 - val_loss: 0.68
73 - val_accuracy: 0.8491
Epoch 4/12
469/469 [==============================] - 57s 121ms/step - loss: 0.9890 - accuracy: 0.6926 - val_loss: 0.65
76 - val_accuracy: 0.8518
Epoch 5/12
469/469 [==============================] - 58s 125ms/step - loss: 0.9613 - accuracy: 0.7024 - val_loss: 0.63
08 - val_accuracy: 0.8561
Epoch 6/12
469/469 [==============================] - 56s 119ms/step - loss: 0.9321 - accuracy: 0.7112 - val_loss: 0.60
63 - val_accuracy: 0.8580
Epoch 7/12
469/469 [==============================] - 58s 123ms/step - loss: 0.9051 - accuracy: 0.7191 - val_loss: 0.58
50 - val_accuracy: 0.8608
Epoch 8/12
469/469 [==============================] - 58s 124ms/step - loss: 0.8856 - accuracy: 0.7260 - val_loss: 0.56
58 - val_accuracy: 0.8641
Epoch 9/12
469/469 [==============================] - 59s 125ms/step - loss: 0.8629 - accuracy: 0.7293 - val_loss: 0.54
88 - val_accuracy: 0.8674
Epoch 10/12
469/469 [==============================] - 57s 122ms/step - loss: 0.8396 - accuracy: 0.7377 - val_loss: 0.53
30 - val_accuracy: 0.8686
Epoch 11/12
469/469 [==============================] - 64s 137ms/step - loss: 0.8250 - accuracy: 0.7397 - val_loss: 0.51
89 - val_accuracy: 0.8709
Epoch 12/12
469/469 [==============================] - 73s 155ms/step - loss: 0.8081 - accuracy: 0.7473 - val_loss: 0.50
58 - val_accuracy: 0.8722
Test loss: 0.50580894947052
Test accuracy: 0.8722000122070312
```

Result: Accuracy increased by 3.33%p due to the noise (Why??)

3. Vary noises

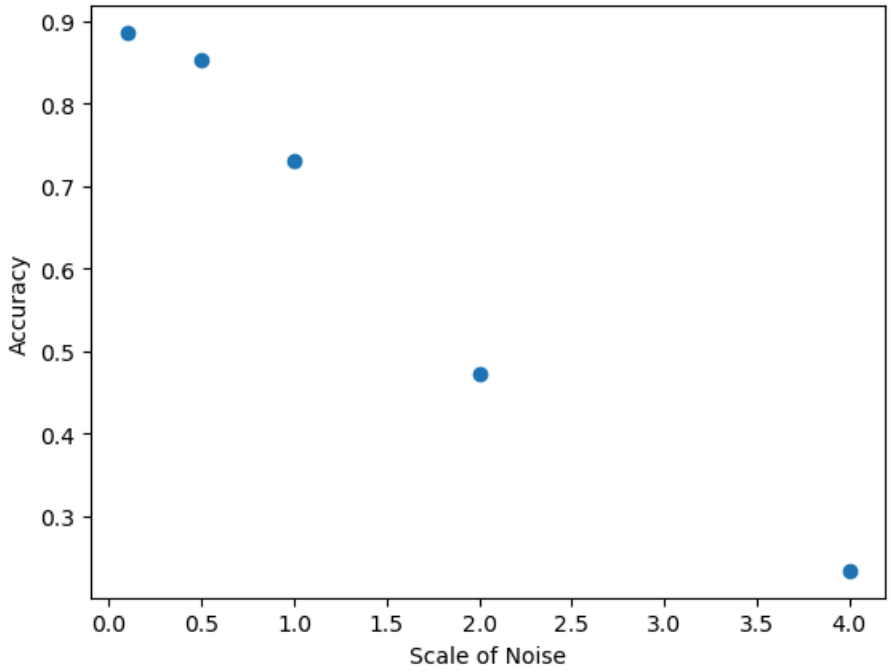
In [7]:
```
accuracy_score = []
noise_scale = [.1, .5, 1.0, 2.0, 4.0]

#set for loop to see scores for each scale of noise
for scale in noise_scale:

    noise_train = np.random.normal(0.5, scale, (60000, 28, 28, 1))
    noise_test = np.random.normal(0.5, scale, (10000, 28, 28, 1))
    x_train3 = x_train + noise_train
    x_test3 = x_test + noise_test

    history3 = model.fit(x_train3, y_train,
                    batch_size=batch_size,
                    epochs=epochs,
                    verbose=1,
                    validation_data=(x_test3, y_test))

    score3 = model.evaluate(x_test3, y_test, verbose=0)
    accuracy = score3[1]
    accuracy_score.append(accuracy)
```

```
0.8462 - val_accuracy: 0.7295
Epoch 11/12
469/469 [==============================] - 77s 164ms/step - loss: 1.1225 - accuracy: 0.6255 - val_loss:
0.8444 - val_accuracy: 0.7299
Epoch 12/12
469/469 [==============================] - 73s 155ms/step - loss: 1.1165 - accuracy: 0.6286 - val_loss:
0.8411 - val_accuracy: 0.7312
Epoch 1/12
469/469 [==============================] - 75s 148ms/step - loss: 1.8616 - accuracy: 0.3892 - val_loss:
1.5972 - val_accuracy: 0.4643
Epoch 2/12
469/469 [==============================] - 73s 156ms/step - loss: 1.7951 - accuracy: 0.3807 - val_loss:
1.6242 - val_accuracy: 0.4608
Epoch 3/12
469/469 [==============================] - 68s 144ms/step - loss: 1.7910 - accuracy: 0.3816 - val_loss:
1.6225 - val_accuracy: 0.4639
Epoch 4/12
469/469 [==============================] - 70s 149ms/step - loss: 1.7834 - accuracy: 0.3857 - val_loss:
1.6175 - val_accuracy: 0.4648
```

In [8]:
```
print(accuracy_score)
```

```
[0.8865000009536743, 0.8525999784469604, 0.7311999797821045, 0.4729999899864197, 0.2337000072002411]
```

In [9]:
```
plt.scatter(noise_scale, accuracy_score)
plt.xlabel('Scale of Noise')
plt.ylabel('Accuracy')
plt.show()
```



Result: The accuracy significantly dropped as scale of noise increased

4. Compare noises with the result of the previous week

Scale of Noise : 0.1 0.5 1.0 2.0 4.0

- Accuracy Score Using Multilayer: [0.9778000116348267, 0.9319999814033508, 0.7793999910354614, 0.44780001044273376, 0.22589999437332153]
- Accuracy Score Using ConvNet: [0.8865000009536743, 0.8525999784469604, 0.7311999797821045, 0.4729999899864197, 0.2337000072002411]

Result: In lower noises(scale =< 1.0), the accuracy scores of Multilayer were higher; in high noises(scale >= 2.0), the accuracy scores of ConvNet were higher.