NAME: JUBESH JOSEPH

DATE: 16.07.2024

PROBLEM STATEMENT:

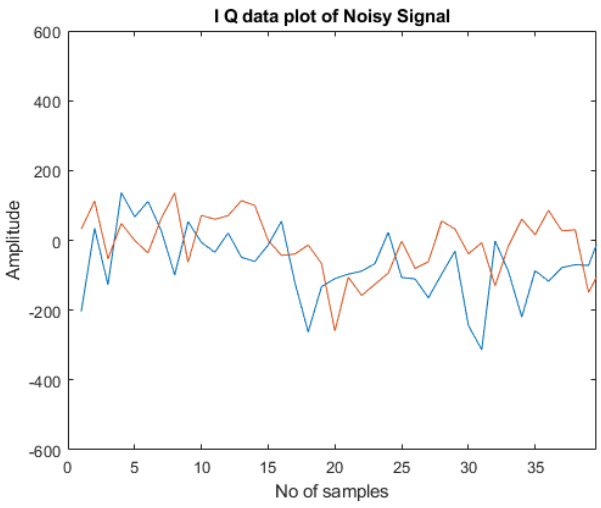
TO CLASSIFY DIFFERENT DRONE SIGNALS IN CASE OF NOISY SIGNAL CAPTURED FROM THE DRONE.

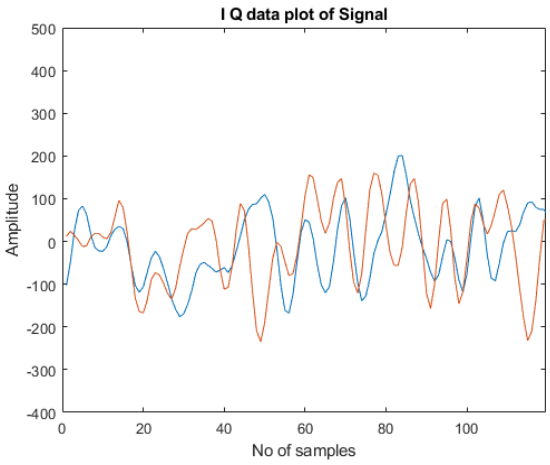
DRONE SIGNALS USED:

1. Elsec
2. Mavic Classic
3. Mavic Pro
4. Phantom Pro

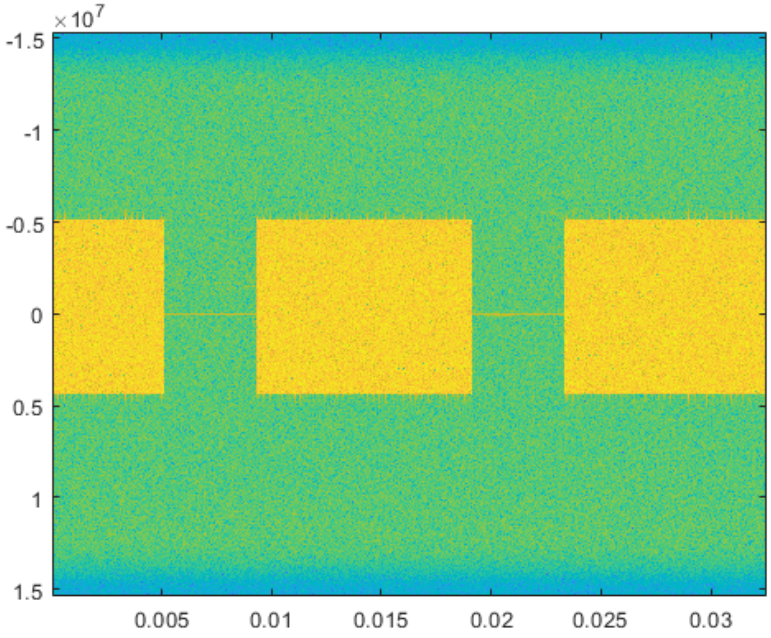
SNR Value used while classifying: 15dB

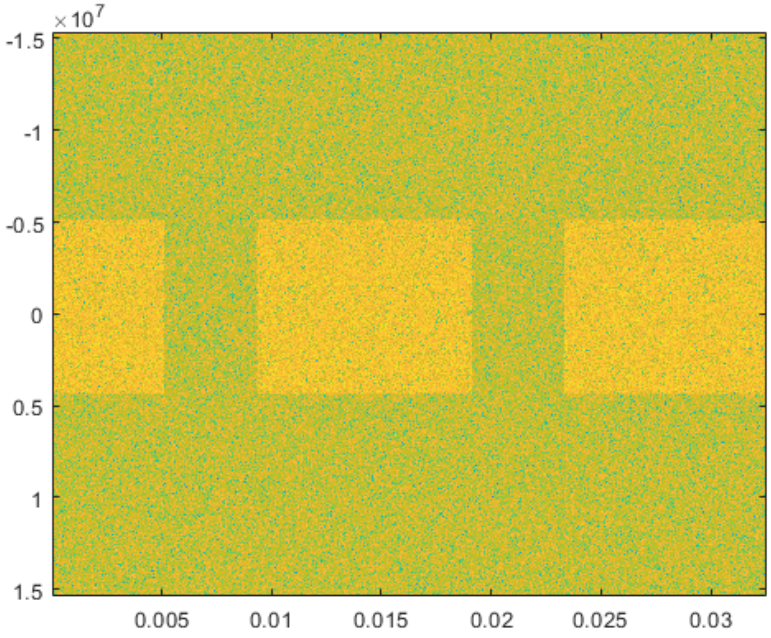
Signal Vs Noisy Signal: (At 0dB)





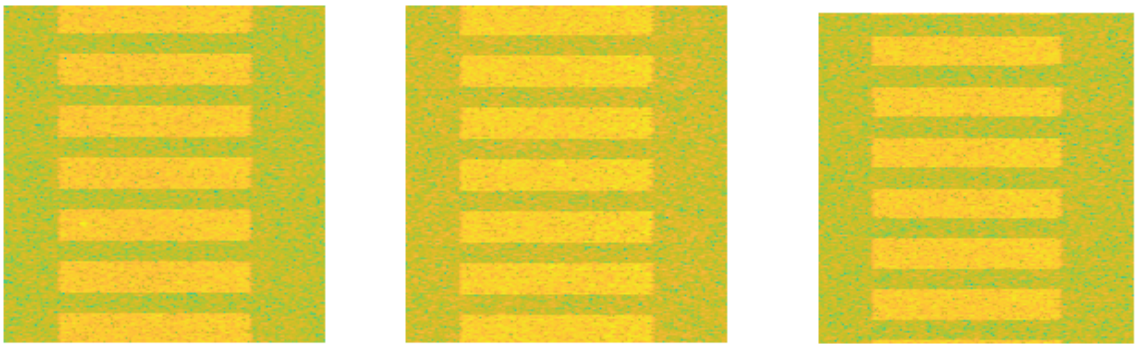
Spectrograms of Signal Vs Noisy Signal:



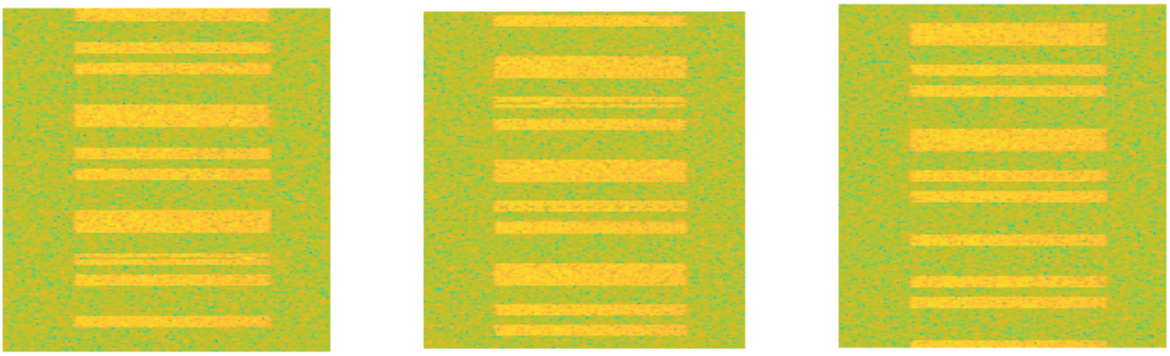


So basically here we used the spectrograms of a signal as a feature to classify between different Signals of Drones.

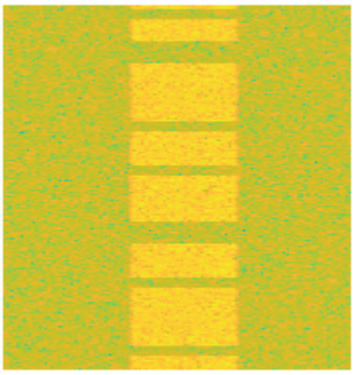
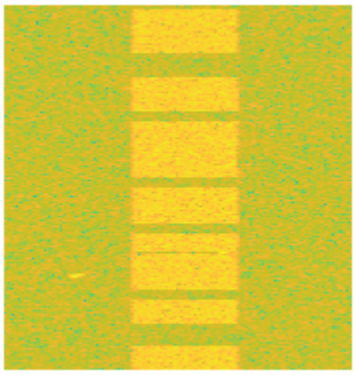
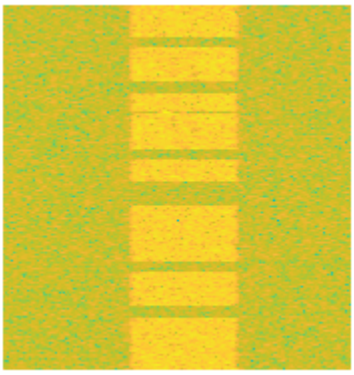
1. **Elsec**



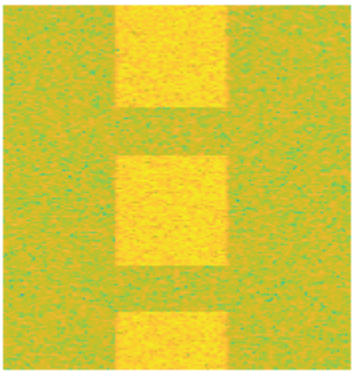
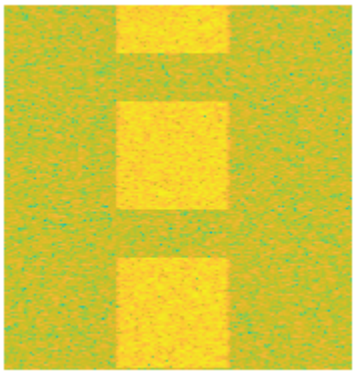
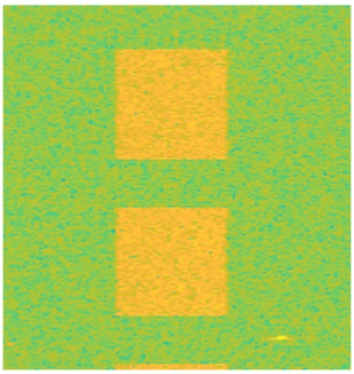
2. **Mavic Classic**



3. **Mavic pro**

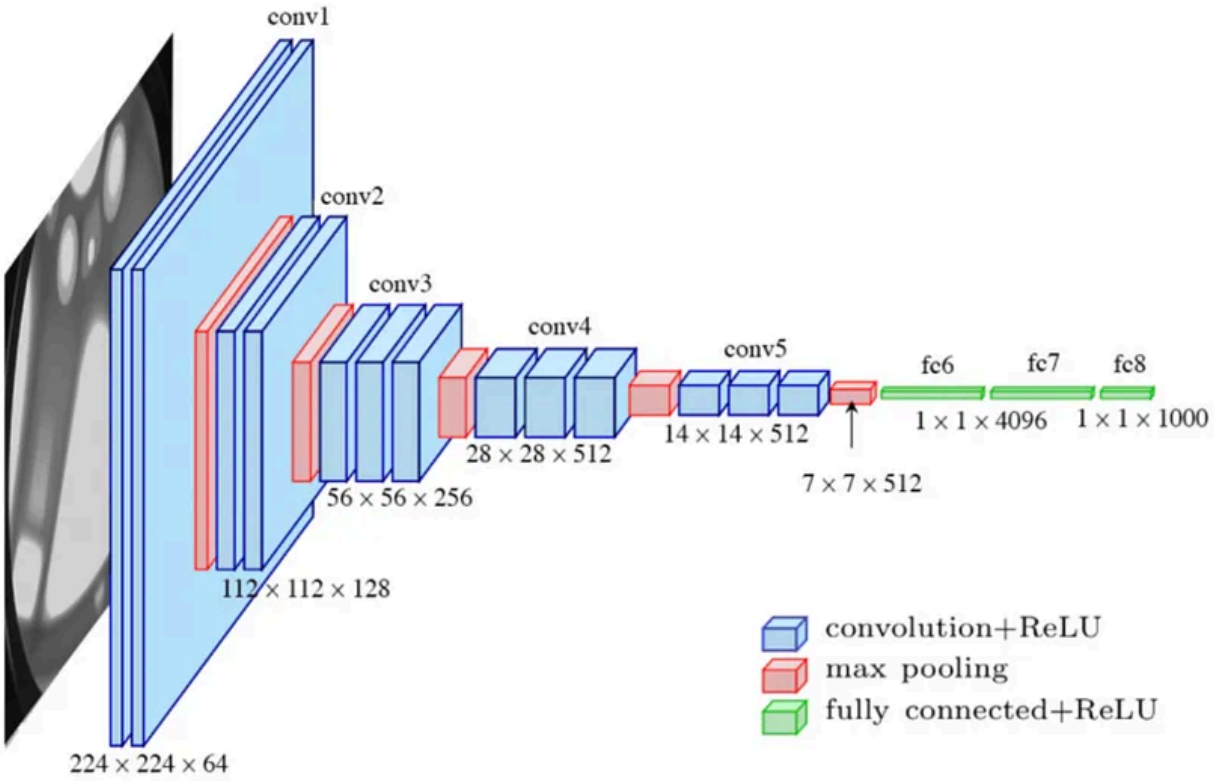




4. Phantom pro

Mode Used:

We used the VGG16 model for the classification of the drone signals with Noise of 15dB.



VGG16 is composed of 13 convolutional layers, 5 max-pooling layers, and 3 fully connected layers. Therefore, the number of layers having tunable parameters is 16 (13 convolutional layers and 3 fully connected layers).

Outcomes:

Training Accuracy: 88.13 %

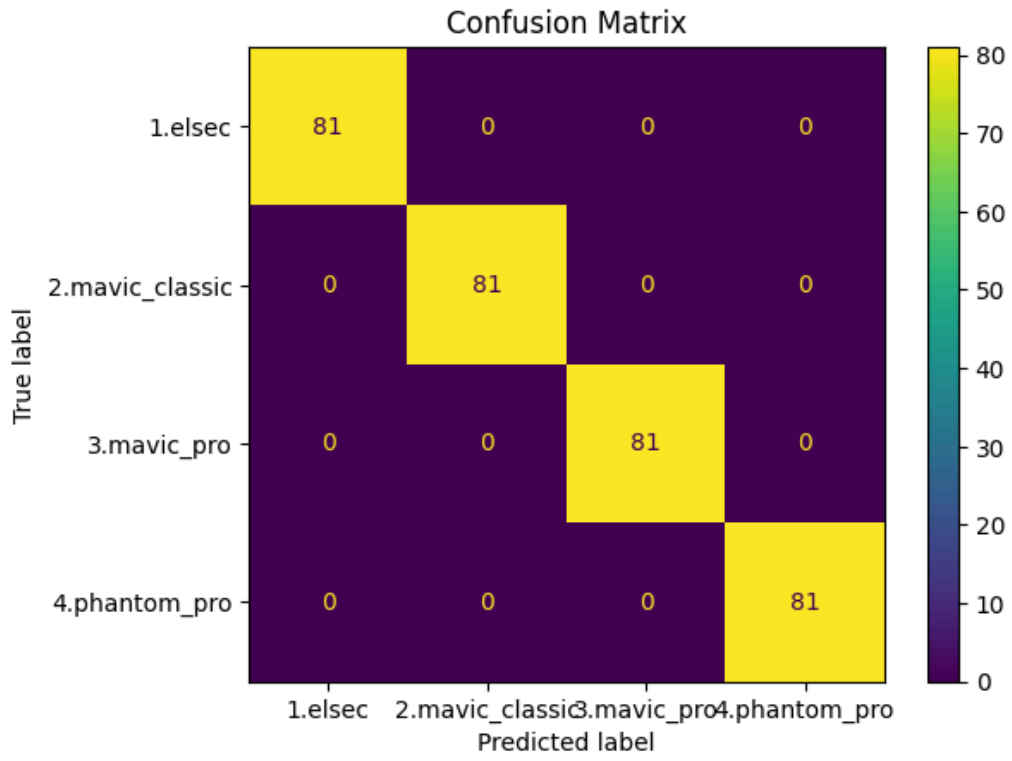
Validation Accuracy: 100 %

```
Epoch 1/25
280/280 [==============================] - 25s 67ms/step - loss: 0.4227 - accuracy: 0.8902 - val_loss: 0.0195 - val_accuracy: 1.0000
Epoch 2/25
280/280 [==============================] - 18s 63ms/step - loss: 0.0249 - accuracy: 0.9969 - val_loss: 0.0020 - val_accuracy: 1.0000
Epoch 3/25
280/280 [==============================] - 18s 65ms/step - loss: 0.0092 - accuracy: 0.9991 - val_loss: 5.5647e-04 - val_accuracy: 1.0000
Epoch 4/25
280/280 [==============================] - 18s 64ms/step - loss: 0.0039 - accuracy: 1.0000 - val_loss: 2.5117e-04 - val_accuracy: 1.0000
Epoch 5/25
280/280 [==============================] - 20s 70ms/step - loss: 0.0865 - accuracy: 0.9710 - val_loss: 0.0158 - val_accuracy: 1.0000
Epoch 6/25
280/280 [==============================] - 18s 65ms/step - loss: 0.0888 - accuracy: 0.9679 - val_loss: 0.0157 - val_accuracy: 1.0000
Epoch 7/25
280/280 [==============================] - 18s 64ms/step - loss: 0.0949 - accuracy: 0.9594 - val_loss: 0.0015 - val_accuracy: 1.0000
Epoch 8/25
280/280 [==============================] - 18s 64ms/step - loss: 0.1026 - accuracy: 0.9536 - val_loss: 0.0037 - val_accuracy: 1.0000
Epoch 9/25
280/280 [==============================] - 19s 69ms/step - loss: 0.0970 - accuracy: 0.9554 - val_loss: 0.0031 - val_accuracy: 1.0000
Epoch 10/25
280/280 [==============================] - 18s 65ms/step - loss: 0.1264 - accuracy: 0.9451 - val_loss: 0.0034 - val_accuracy: 1.0000
Epoch 11/25
280/280 [==============================] - 18s 64ms/step - loss: 0.1358 - accuracy: 0.9420 - val_loss: 3.9487e-04 - val_accuracy: 1.0000
Epoch 12/25
280/280 [==============================] - 18s 65ms/step - loss: 0.1951 - accuracy: 0.9125 - val_loss: 1.3197e-04 - val_accuracy: 1.0000
Epoch 13/25
280/280 [==============================] - 18s 65ms/step - loss: 0.1805 - accuracy: 0.9165 - val_loss: 6.4996e-05 - val_accuracy: 1.0000
Epoch 14/25
280/280 [==============================] - 19s 69ms/step - loss: 0.1666 - accuracy: 0.9272 - val_loss: 1.1483e-04 - val_accuracy: 1.0000
Epoch 15/25
280/280 [==============================] - 18s 64ms/step - loss: 0.1570 - accuracy: 0.9362 - val_loss: 9.3456e-05 - val_accuracy: 1.0000
Epoch 16/25
280/280 [==============================] - 18s 64ms/step - loss: 0.1721 - accuracy: 0.9263 - val_loss: 8.7913e-06 - val_accuracy: 1.0000
Epoch 17/25
280/280 [==============================] - 18s 64ms/step - loss: 0.2142 - accuracy: 0.8978 - val_loss: 3.8048e-04 - val_accuracy: 1.0000
Epoch 18/25
280/280 [==============================] - 18s 64ms/step - loss: 0.2307 - accuracy: 0.8929 - val_loss: 3.9013e-04 - val_accuracy: 1.0000
Epoch 19/25
280/280 [==============================] - 18s 64ms/step - loss: 0.2131 - accuracy: 0.9080 - val_loss: 1.4904e-04 - val_accuracy: 1.0000
Epoch 20/25
280/280 [==============================] - 18s 65ms/step - loss: 0.2051 - accuracy: 0.9098 - val_loss: 5.9767e-05 - val_accuracy: 1.0000
Epoch 21/25
280/280 [==============================] - 18s 65ms/step - loss: 0.2580 - accuracy: 0.8786 - val_loss: 0.0067 - val_accuracy: 1.0000
Epoch 22/25
280/280 [==============================] - 18s 64ms/step - loss: 0.2553 - accuracy: 0.8844 - val_loss: 2.7182e-04 - val_accuracy: 1.0000
Epoch 23/25
280/280 [==============================] - 18s 64ms/step - loss: 0.2838 - accuracy: 0.8893 - val_loss: 0.0056 - val_accuracy: 1.0000
Epoch 24/25
280/280 [==============================] - 18s 64ms/step - loss: 0.3309 - accuracy: 0.8723 - val_loss: 0.0345 - val_accuracy: 1.0000
Epoch 25/25
280/280 [==============================] - 18s 63ms/step - loss: 0.2983 - accuracy: 0.8813 - val_loss: 0.0269 - val_accuracy: 1.0000
```

Testing Accuracy: 100%

```
81/81 [==============================] - 4s 27ms/step - loss: 0.0281 - accuracy: 1.0000
test loss:  0.028078844770789146
test accuracy:  100.0
```

Confusion Matrix:



Precision Score of the Model:

```
from sklearn.metrics import precision_score,recall_score

precision = precision_score(y_true, y_pred, average='weighted')
recall = recall_score(y_true, y_pred, average='weighted')

print(f'Precision: {precision:.2f}')
print(f'Recall: {recall:.2f}')
```

```
Precision: 1.00
Recall: 1.00
```