# RF FINGERPRINT IDENTIFICATION USING MACHINE LEARNING


Nazlı Hilal ERTEK – 21528076

Onur Cem HAN - 21528186

**Supervisor**

Prof. Dr. Emre AKTAŞ

Electrical and Electronics Engineering, Hacettepe University


## Introduction

Radio frequency fingerprint is a process that identifies the device or signal from which a radio transmission originates, based on the characteristics of its transmission. The RF fingerprint technology used in the identification of wireless devices is playing an important role in the security industry today. In order to identify mobile phones in our project, we made a high accuracy rate identification by recording the specific features of the LTE signal in the transient response and creating a machine learning model.

## Specifications and Design Requirements

In our project, we used the USRP B210 Software Defined Radio device produced by Ettus Research as a signal receiver. There are many programs that can be used as an interface for the communication of this device with the computer. It is necessary to choose one of these programs and learn how to establish this connection.

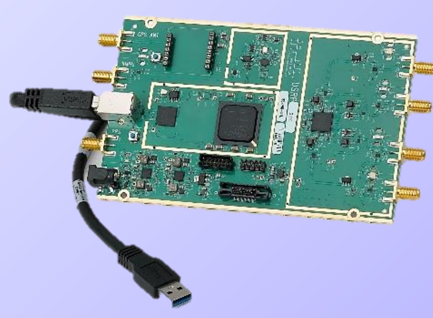

***Figure 1:*** *USRP B210 SDR*

There are also multiple signals emitted by wireless devices that can be used for RF fingerprint processing. The signal to be used for this process should be determined and information about its frequency band and width should be obtained.


***Figure 2:*** *Some Useful Cell Phone Signals*

Determining the machine learning model to be used after the signal is obtained is an important step of the project. Extensive research should be conducted on these models and a high accuracy model should be created.

## Solution Methodology

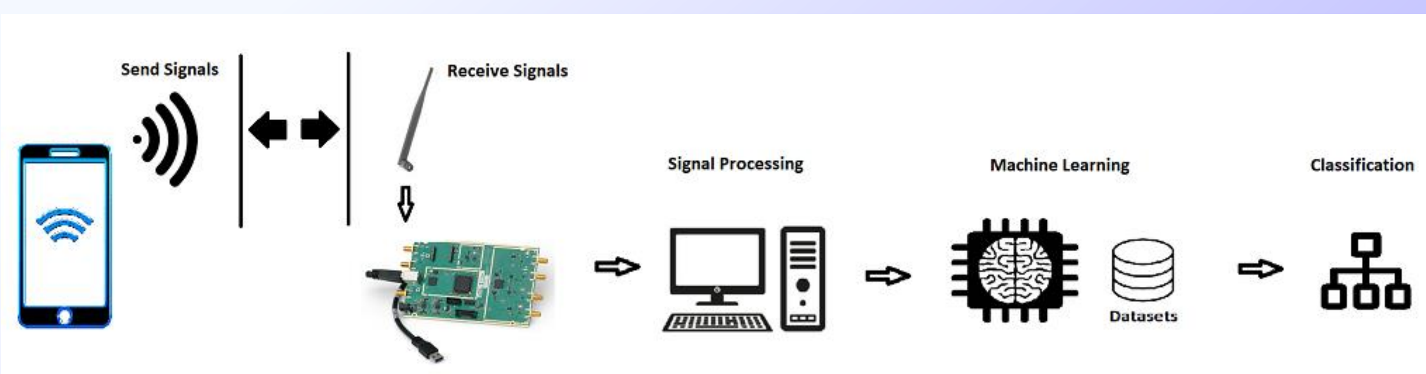


***Figure 3:*** *Cell Phone Identification Concept*

We have established a connection between our computer and the USRP device by using the tool created by the MATLAB program for USRP. We designed an algorithm that captures LTE signals using MATLAB Simulink.

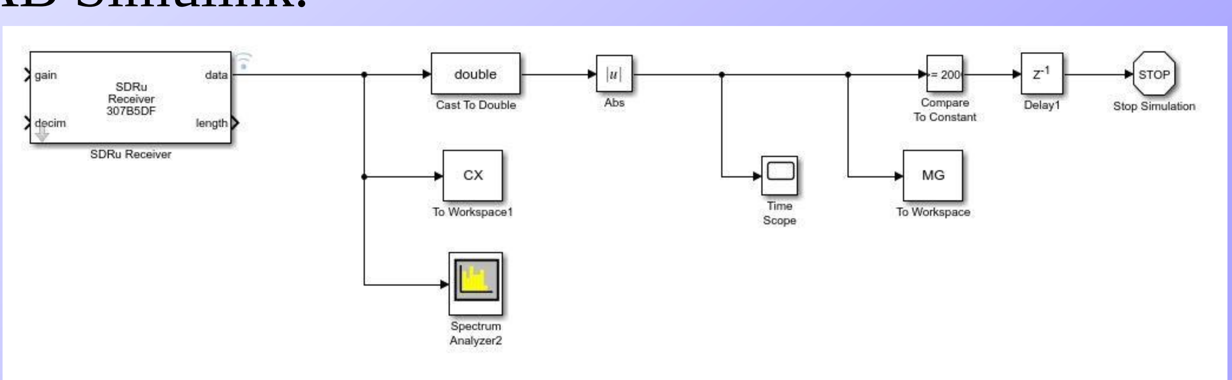


***Figure 4:*** *Signal Capture Algorithm via MATLAB Simulink*

We pre-processed the signal we obtained for RF fingerprint identification. We then divided this signal into sub-sections to create a feature table and recorded the skewness, kurtosis, mean, and variance values of the instantaneous phase, frequency, and amplitude values.

So we got 192 features for a phone. In this way, we created a training set for our machine learning model that includes 200 samples using 2 different phones. Using the training set, we created a machine learning model using the matrix again. While creating this model, we used the SVM (Support Vector Machine) model. In this way, our project was able to identify two phones in real-time.

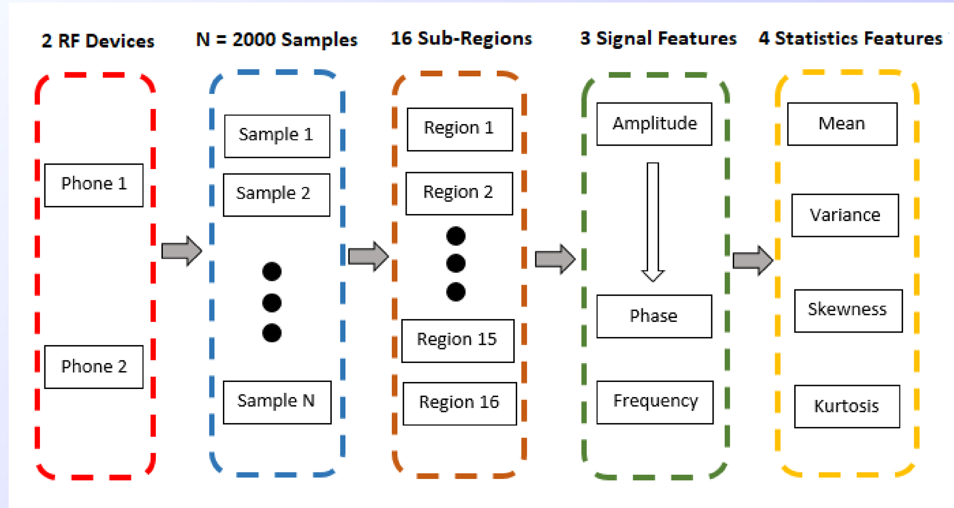


***Figure 5:*** *Feature Extraction*

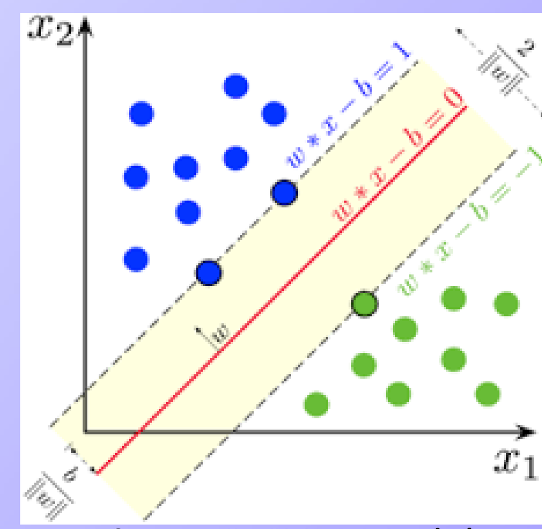

***Figure 6:*** *SVM Model*

$$H(\alpha(n)) = s_I(n) + s_Q(n)$$

$$\varphi(n) = \tan^{-1}\left(\frac{s_Q(n)}{s_I(n)}\right)$$

$$f(n) = \frac{1}{2\pi}\left(\frac{d\varphi(n)}{dt}\right)$$

($L$: the number of sampling points.)

$$Mean = \mu = \frac{1}{L}\sum_{n=1}^{L}\alpha(n)$$

$$Variance = \sigma^2 = \frac{1}{L}\sum_{n=1}^{L}(\alpha(n)-\mu)^2$$

$$Skewness = \gamma = \frac{1}{L\sigma^3}\sum_{n=1}^{L}(\alpha(n)-\mu)^3$$

$$Kurtosis = \kappa = \frac{1}{L\sigma^4}\sum_{n=1}^{L}(\alpha(n)-\mu)^4$$

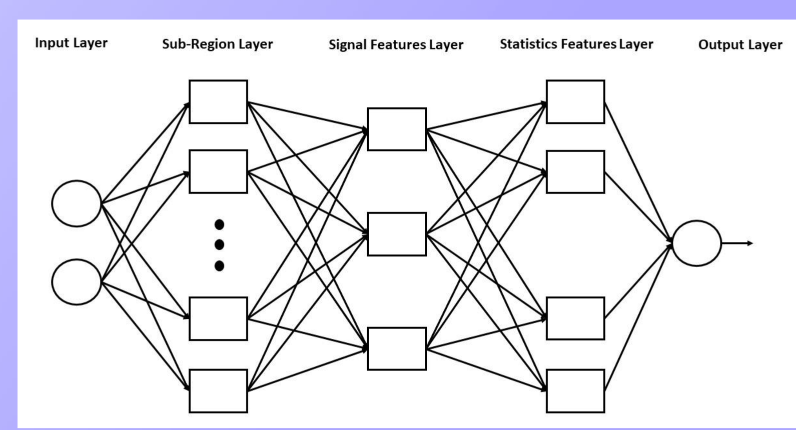


***Figure 7:*** *Neural Network Structure For SVM Based Machine Learning*

## Conclusion

We made real-time trials to test our project. Then we created a test set of 100 samples using two different phones to get accuracy. As a result of this test, we drew a confusion matrix.

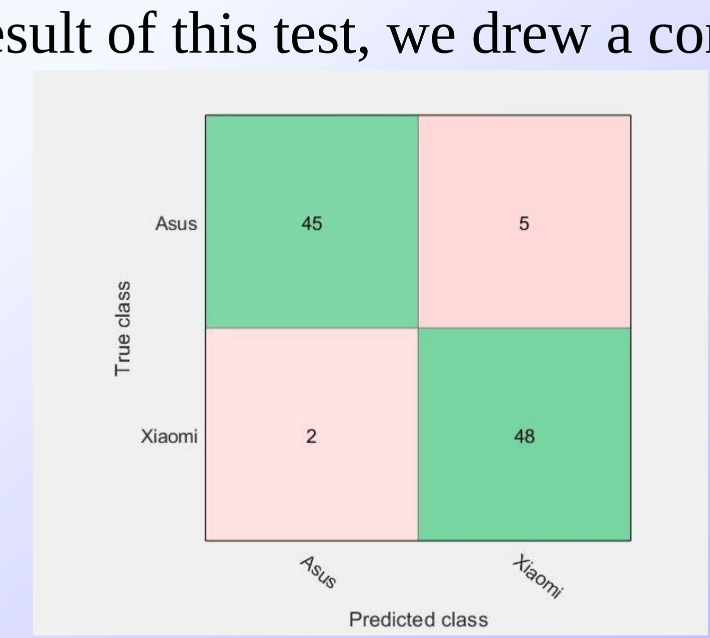


***Figure 8:*** *Confusion Matrix*

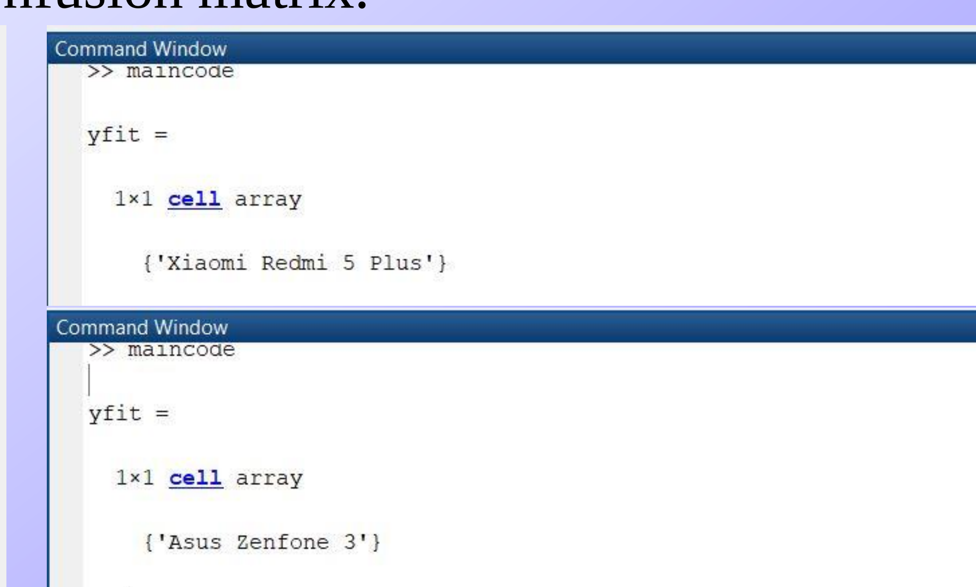


***Figure 9:*** *Outputs of Machine Learning Model*

As seen in the figure, the accuracy value we obtained is 93%. By looking at this result, we achieved high accuracy for identifying two phones in real-time.

The number of phones introduced to the model can be increased in future studies related to this project. In addition, different signal types can be used. A wider environment can be controlled by increasing the range of the antenna used.

## Acknowledgements


This project was completed within the context of ELE401-402 Graduation Project courses in Hacettepe University, Faculty of Engineering, Department of Electrical and Electronics Engineering.