NavIC Multipath Classification Using Deep Learning

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Introduction

- NavIC (Navigation with Indian Constellation) is a constellation of GEO and GSO satellites which may experience different kind of multipath due to their orbits.
- NavIC receivers measure pseudo-ranges, carrier-ranges and Doppler observables.
- Pseudo-range measurements are absolute in nature, robust and therefore more widely used for the positioning purposes.
- However, pseudo-range measurements are more prone to multipath which is usually in meters.
- On the other hand, carrier-range measurements are very precise and experience very less multipath which is usually in mm level.

A Deep Learning Approach

- Accuracy and robust position information from GNSS receivers is one of the challenges in multipath affected scenarios
- Although, if receiver has the knowledge of Line of Sight (LOS), Multipath and Non Line of Sight (NLOS) signals, degradation in position accuracy due to the multipath affected signals can be addressed

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- Previously, the study conducted used unsupervised machine learning algorithms to classify signals as LOS, multipath and NLOS based on NavIC data collected at Dehradun, India.
- Present study uses Deep Learning model for classification of NavIC multipath.

Code Minus Carrier Observable for Multipath

Equations for Code ($\boldsymbol{\rho}$)and Carrier Phase ($\emptyset$) observables are as follows:

$$\boldsymbol{\rho} = [\boldsymbol{r} + \boldsymbol{I} + \boldsymbol{T}] + \boldsymbol{c}(\boldsymbol{\delta t_u} - \boldsymbol{\delta t^s}) + \boldsymbol{MP} + \boldsymbol{\varepsilon_\rho}$$

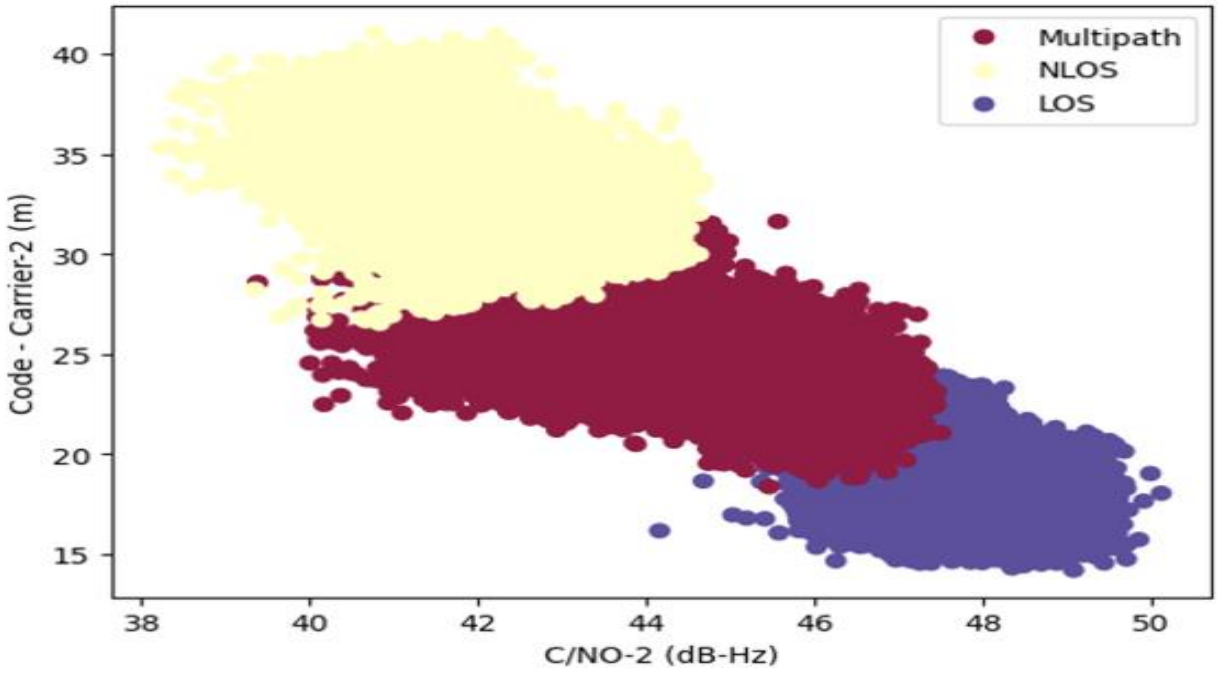
$$\emptyset = \boldsymbol{\lambda^{-1}}[\boldsymbol{r} - \boldsymbol{I} + \boldsymbol{T}] + \boldsymbol{f}(\boldsymbol{\delta t_u} - \boldsymbol{\delta t^s}) + \boldsymbol{N} + \boldsymbol{MP} + \boldsymbol{\varepsilon_\emptyset}$$

$$\boldsymbol{\rho} - \emptyset = \boldsymbol{CMC} = \boldsymbol{\rho}\text{-}\emptyset = 2\mathrm{I} + \mathrm{N} + \mathrm{MP} + (\boldsymbol{\varepsilon_\rho} - \boldsymbol{\varepsilon_\emptyset})$$

Code Minus Carrier (CMC) after subtracting 2 times ionosphere delay is obtained as follows assuming N will remain constant throughout:

$$\boldsymbol{\rho} - \emptyset = \boldsymbol{CMC} = \boldsymbol{\rho}\text{-}\emptyset = \mathrm{MP} + (\boldsymbol{\varepsilon_\rho} - \boldsymbol{\varepsilon_\emptyset})$$

Multipath Classification using Unsupervised Learning



Clustering using Mini Batch K-means was done to generate multipath labels

Classification Accuracy using ANN

NavIC PRN 2

CLASSIFIER	TESTING ACCURACY
KNN	68.47%
SVM	85.74%
RF	67.82%
NB	84.41%
LR	82.68%
ANN	95.09%

NavIC PRN 4

CLASSIFIER	TESTING ACCURACY
KNN	68.47%
SVM	85.73%
RF	68.43%
NB	83.23%
LR	81.22%
ANN	94.37%

PRN-2 & 4 Accuracy with 5-Fold Cross-Validation

Generated labels were used for training of ML and DL Models

Conclusion

- Multipath labels were generated using Unsupervised Machine Learning.
- Deep learning model is implemented for NavIC multipath classification using the generated labels.
- After comparison with other models it is found that ANN performs better for NavIC multipath classification.


Thank You