Learning-based Blockage Prediction for Robust Links in Dynamic Millimeter Wave Networks

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Introduction

Millimeter Wave (mmW) spectrum is a promising frequency band to accommodate the increased traffic.

- Path loss due to atmospheric absorption
  - Beamforming is used to concentrate the signal power in a specific direction
- Important to have the beams of both transmitter (Tx) and receiver (Rx) aligned
- mmW signal cannot go around objects or penetrate them

Two main challenges:

- Beam miss-alignment can happen easily
  - When at least one of them is moving
- The objects (specially water) can block the signal fatally
  - Human body is capable of blocking mmW link

Problem Statement

- Important to know the reason for link quality drop
  - Link blockage or beam miss-alignment
- Traditional method for detecting blockage or beam miss-alignment [1]
  - Uses windowed RSSI recording
  - Takes up to 30 ms
  - Link is in halt state, can degrade QoE
  - Equivalent of losing 210Mb with IEEE 802.11ad rates

Proposed Solution

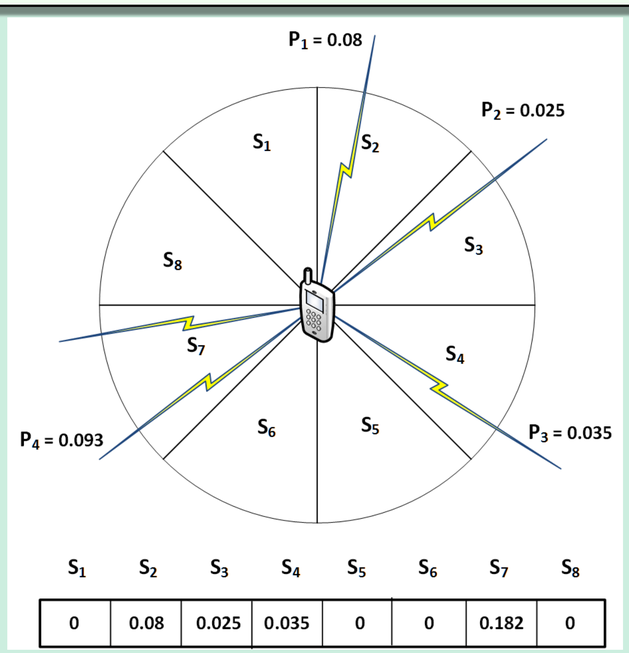
- A learning based prediction framework to predict blockage and discriminate between blockage and beam miss-alignment
  - Requires less time than the traditional method [1]
  - High prediction accuracy can be achieved
  - Has the overhead of learning at first
    - Simulation show limited training dataset can achieve high precision
  - Overhead of prediction is very low

Learning Phases

- The training phase
  - Get the diffraction values due to presence of obstacles near mmW paths
  - Compute the feature vector
  - Detect the label (blockage or miss-alignment)
  - Feed the feature vector to a classifier
- Prediction phase
  - Get the diffraction values due to presence of obstacles near mmW paths
  - Predict the label of the feature vector by using the classifier

Feature Vector

- The space around the receiver divided into sectors
- The mmW paths in each are measured for diffraction values due to presence of obstacles
- Diffraction values are added when there are more than one paths in one sector
- Each sector is one feature
- Burst feature measures the burstiness of blockage incidents
  - Measures the burstiness by computing Exponential Moving Average (EMA)



S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
0	0.08	0.025	0.035	0	0	0.182	0

Fig. 1: Sectors around Rx and feature vector

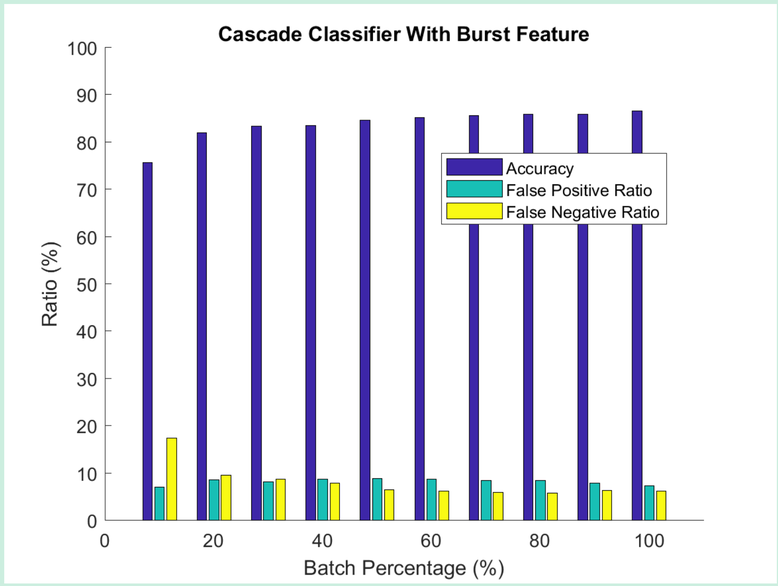


Fig. 2: Accuracy of classifier with online boosting and burst feature

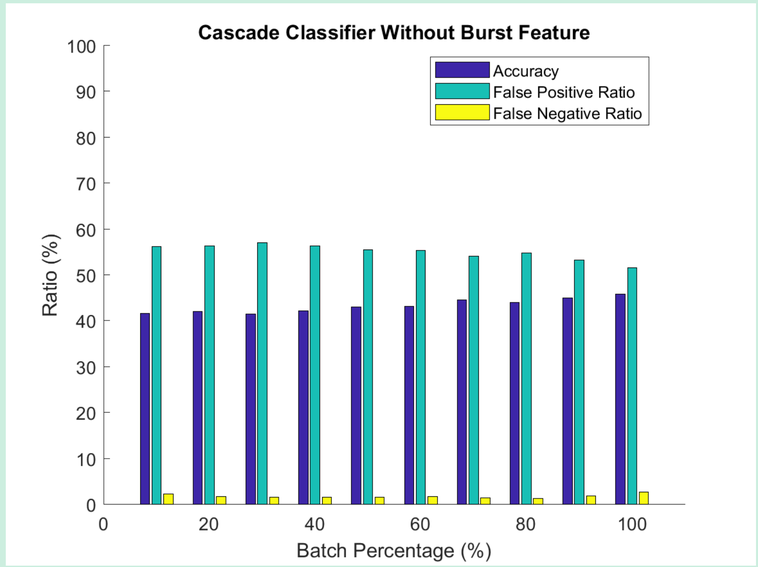


Fig. 3: Accuracy of classifier with online boosting and without burst feature

Conclusion

- Proposed a prediction framework for blockage
- Classifier with online boosting has the best result
- Adding burst feature increases accuracy

References

[1] S. Sur, V. Venkateswaran, X. Zhang, and P. Ramanathan, “60 ghz indoor networking through flexible beams: A link-level profiling,” in Proceedings of the 2015 ACM SIGMETRICS International Conference on Measurement and Modeling of Computer Systems, ser. SIGMETRICS ’15. New York, NY, USA: ACM, 2015, pp. 71–84. [Online]. Available: http://doi.acm.org/10.1145/2745844.2745858