A MACHINE LEARNING APPROACH FOR THE CLASSIFICATION OF INDOOR ENVIRONMENTS USING RF SIGNATURES

Mohamed I. AlHajri[1,3] Nazar T. Ali[2] Raed M. Shubair[3]

[1]Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, USA

[2]Department of Electrical and Computer Engineering, Khalifa University, UAE

[3]Research Laboratory of Electronics, Massachusetts Institute of Technology, USA

malhajri@mit.edu

System Model

RF Signature (CTF, FCF) → Classifier (SVM, RF, k-NN, DNN) → Indoor Environment (Corridor, Lobby, Open space)

Accuracy : 99.3%

Computational Time : <10μs

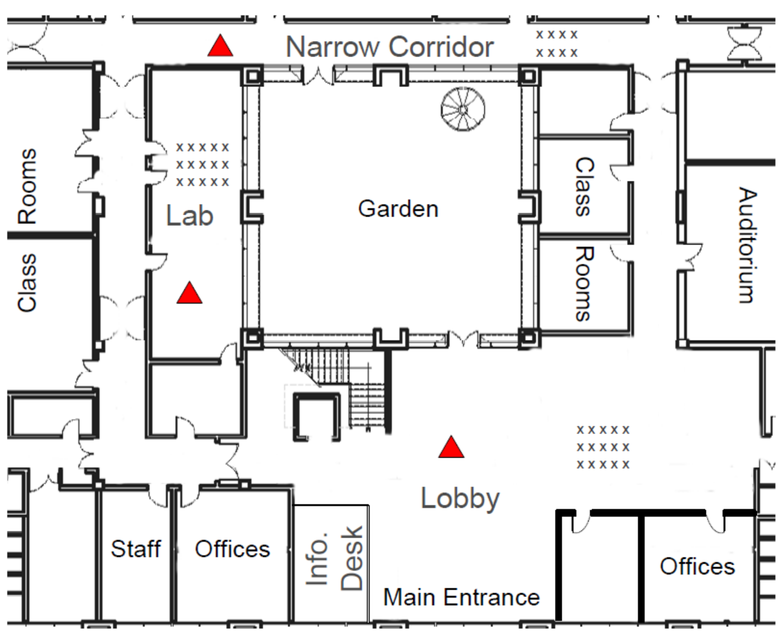
RF Signature

RF Signatures

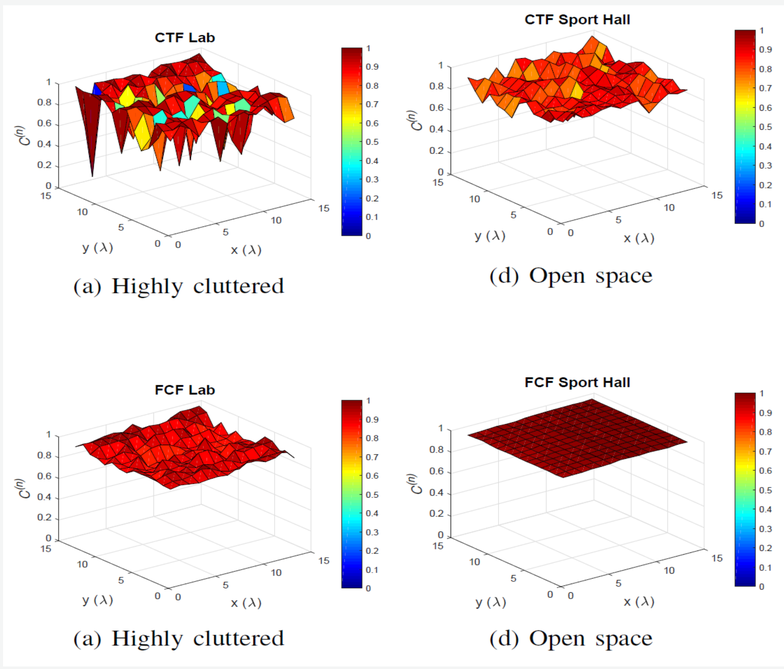
- **Channel Transfer Function**
  - $H(f) = \sum_{l=1}^{L} a_l \exp[-(2\pi f \tau_l - \theta_l)]$
  - CTF is distinctively unique for every position
  - Under frequency selective fading, CTF becomes more sensitive to channel variations
- **Frequency Coherence Function**
  - $R(f) = \int_{-\infty}^{\infty} H(\hat{f}) H^*(\hat{f} + f) d\hat{f}$
  - FCF has a slow changing nature in the spatial domain

Real-Time Measurement Campaign

Type of Environment & (Example):	▪ Open Space (Sports Hall) ▪ Low Cluttered (Lobby) ▪ Medium Cluttered (Narrow Corridor) ▪ Highly Cluttered (Lab)
Frequency:	2.4 GHz
Bandwidth:	100 MHz
Sweeps:	10
Frequency points:	601 points (0.167 MHz spacing)



Spatial Correlation Coefficient



(a) Highly cluttered (d) Open space

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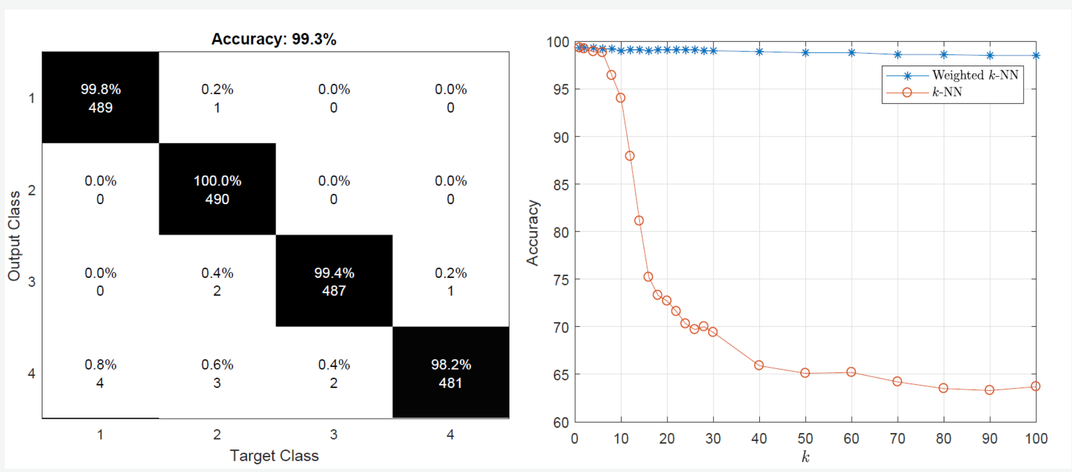
Classification Algorithms

- Decision Tree (DT)
- Support Vector Machine (SVM)
- k-Nearest Neighbor (k-NN)

Features	DT	Gaussian SVM	k-NN ($k = 1$)	k-NN ($k = 10$)	Wk-NN ($k = 1$)	Wk-NN ($k = 10$)
RSS	42.5%	42.7%	32.6%	40.1%	32.6%	33.5%
CTF	57.1%	60.7%	78%	77.2%	78.0%	79.9%
FCF	62.2%	50.9%	83.4%	76.6%	83.4%	83.1%
RSS + CTF	57.4%	62.7%	78.2%	76.1%	78.2%	80.0%
RSS + FCF	69.1%	72.0%	93.4%	84.8%	93.4%	92.8%
CTF + FCF	73.7%	90.3%	**99.3%**	94.0%	**99.3%**	99.0%
RSS + CTF + FCF	72.5%	91.7%	**99.3%**	93.7%	**99.3%**	98.8%



Extension of Current Results

- Complex Environments:
  - Partial Line-of-Sight (LOS) & Non-Line-of-Sight (NLOS)
- Deep Learning for new complex environments.