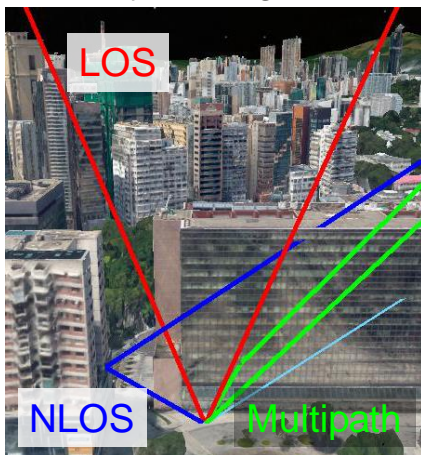


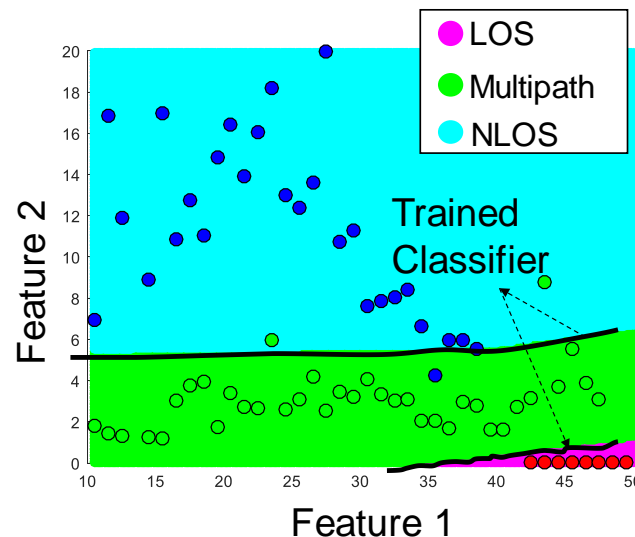
LOS/NLOS/Multipath Classifications using Machine Learning Approaches

- Can we obtain the same signal visibility prediction without 3D city model and accurate prior information?
- Train a **classifier** by supervised machine learning to separate the type of GNSS pseudorange measurement into three categories, **clean**, **multipath** and **NLOS**.

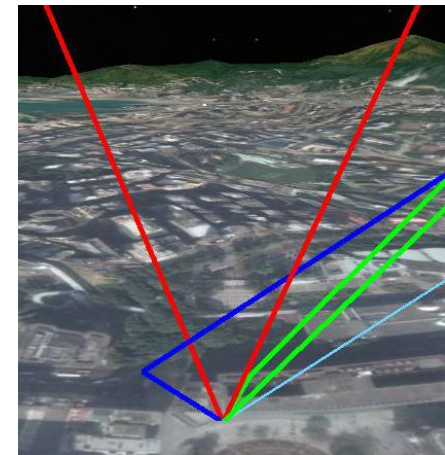
1. LOS/Multipath/NLOS Classification with 3D Maps and Ray-tracing



2. Classifier Trained by Machine Learning Approach

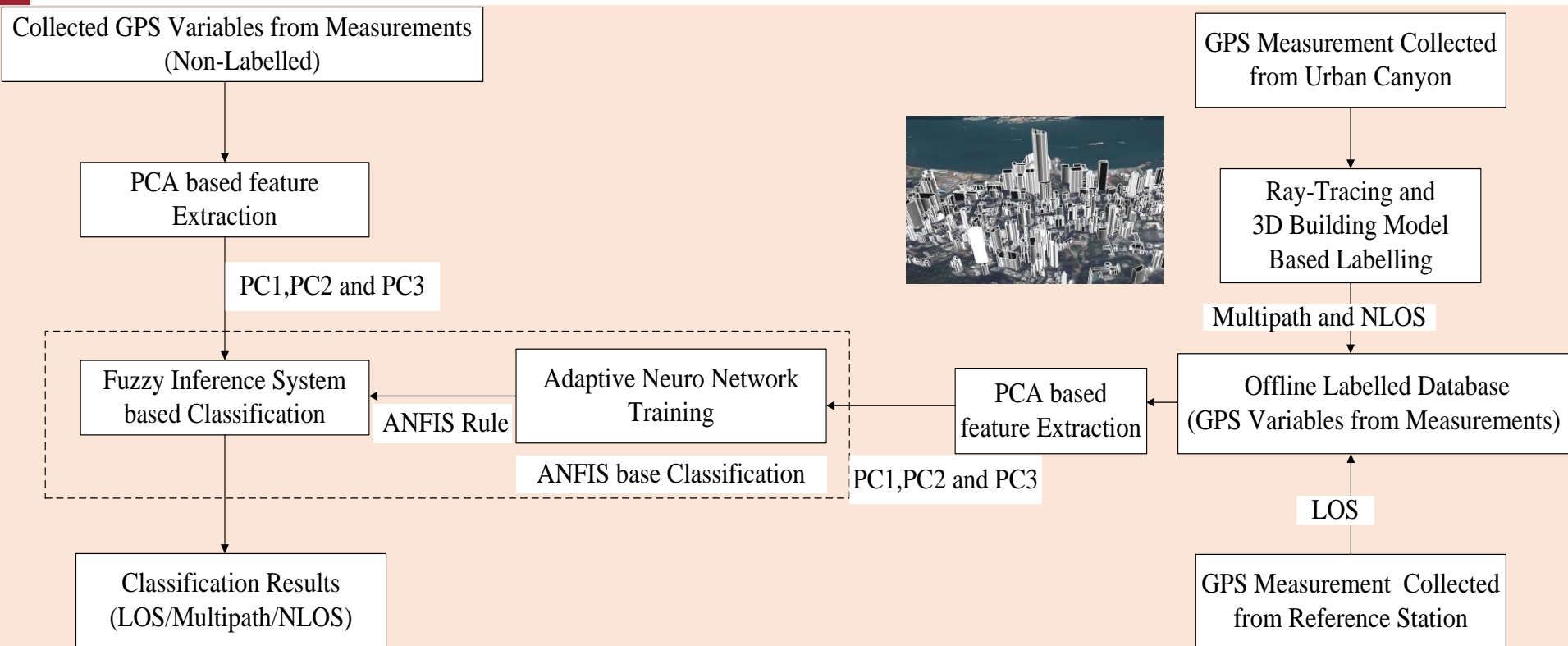


3. NLOS and Multipath Detection using the Trained Classifier



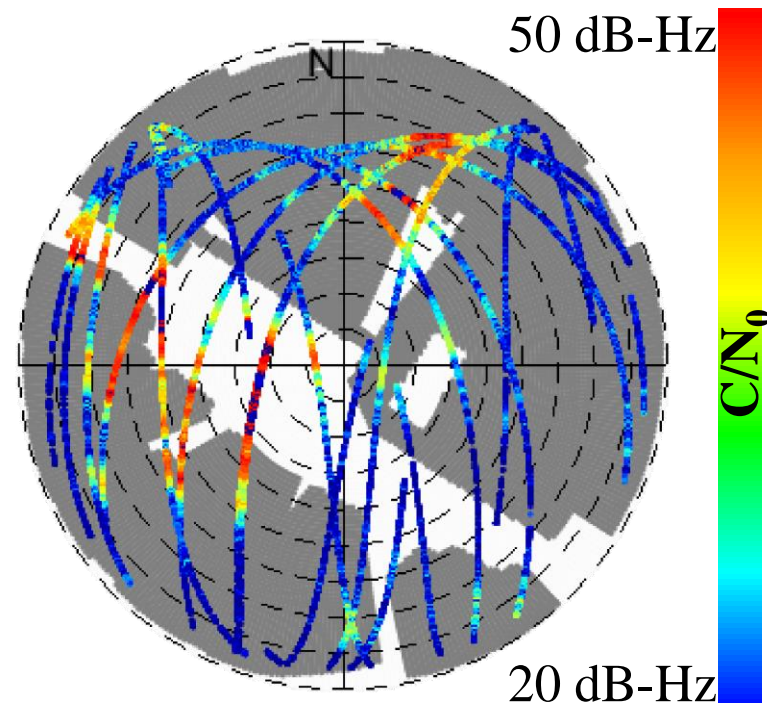
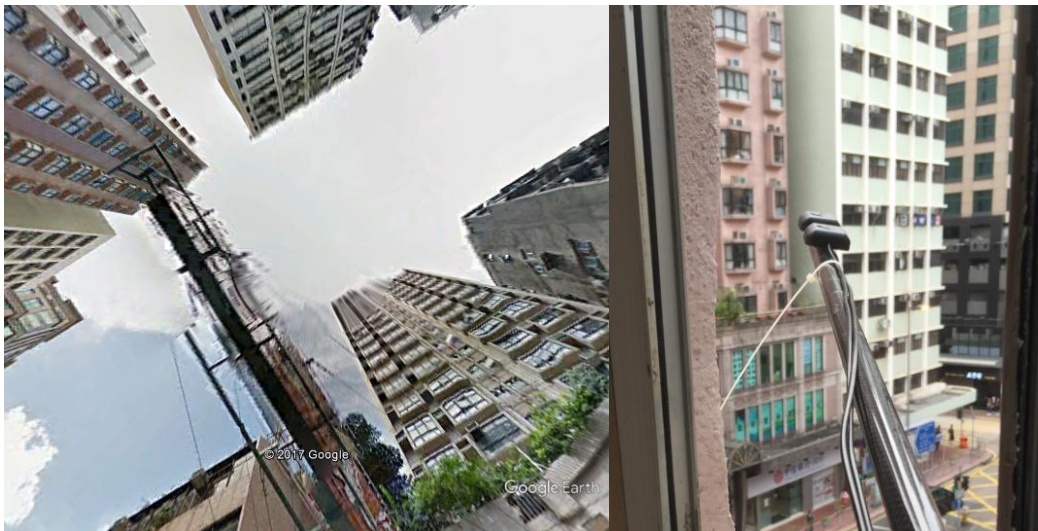
Flowchart of the proposed algorithm

- Train the ANFIS model offline
- Use the ANFIS model to classify LOS/Multipath/NLOS online



Data Collection (Multipath and NLOS)

- Multipath and NLOS collected at super urban canyon (assuming no real *clean* LOS signal can be received)
- Commercial level GNSS receiver and patch antenna
- Stationary Collecting 24 hours





Current result (New ANFIS classifier)

- Based on collaborations with Dr. Rui Sun and Prof. Washington Ochieng

General C/No		ANFIS			Decision Tree		
		-1	0	1	-1	0	1
Label	-1	3211	2789	0	5581	419	0
Result	0	2195	2275	1530	4518	1279	203
	1	0	528	5472	96	151	5753
Accuracy		60.9%			70.1%		
Accuracy for each class	-1	51.5%	37.9%	91.2%	-1	93.0%	21.3%
	0				0	21.3%	95.9%
	1				1		

Multi-feature based classification		Proposed ANFIS			Decision Tree		
		-1	0	1	-1	0	1
Label	-1	4914	1086	0	5423	577	0
Result	0	582	5376	42	3326	2674	0
	1	0	0	6000	0	0	6000
Accuracy		90.5%			78.3%		
Accuracy for each class	-1	81.9%	89.6%	100%	-1	90.4%	44.5%
	0				0	44.5%	100%
	1				1		

Sun, R., Hsu, L.T.*, Xue, D., Zhang, G., Washington, Y.O., (2019) [GPS Signal Reception Classification Using Adaptive Neuro-Fuzzy Inference System](#), Journal of Navigation, 72(3): 685-701.