14 August 2025

Benchmark dataset test: RML2018.01A

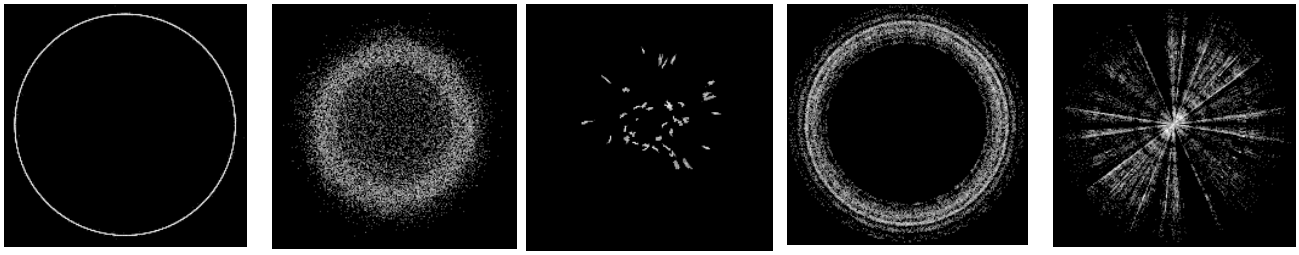
SNR: +00db (this is an extreme challenge as SNR +00 = 50% signal and 50% noise).

Training times: Backpropagation (BP) models approximately 24 hours each. IGL models: 20-30 minutes each. IGL training and inference time reduction is >98%.

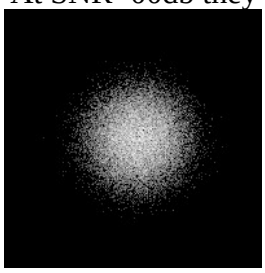
BP networks with less than 5MB parameter size failed to learn or converge. The BP network tested in this study required frequent manual restarts (>3 times for each attempt) in order to get network to train and converge. IGL networks trained and converged 100% of the time.

Architectures: BP uses 4 hidden layers with 1,440,504 parameters (4-byte floats) = 5.762MB parameter size. IGL uses 120,825 1-byte parameters for 121kb parameter size.

Input data: IQ histogram constellation diagrams. At SNR+30db they look like this (very little noise). Each diagram image represents a specific RF modulation type out of 24 total included in the dataset:



At SNR+00db they all look like this (because of the noise added):



Final test data consists of 2,000 images that must be classified by the network. The 2,000 images contain an assortment of all 24 RF modulation types. Final test accuracy percent reflects correct prediction of all 2,000 images.

Final Test Accuracies

Index	RF Modulation	Parameter Memory Size: 1x IGL 121kb	48x Back Propagation 5,762kb
1	OOK	99.85	97.80
2	4ASK	99.50	99.90
3	8ASK	99.00	98.55
4	BPSK	98.65	98.15
5	QPSK	99.15	98.75
6	8PSK	98.75	98.85
7	16PSK	99.60	97.90
8	32PSK	99.10	98.55
9	16APSK	99.15	97.70

10	32APSK	99.55	99.10
11	64APSK	99.15	98.05
12	128APSK	100.00	99.95
13	16QAM	99.50	97.85
14	32QAM	99.80	99.05
15	64QAM	99.70	98.40
16	128QAM	100.00	99.90
17	256QAM	99.75	98.45
18	AM-SSB-WC	99.15	98.25
19	AM-SSB-SC	99.05	98.90
20	AM-DSB-WC	98.75	97.95
21	AM-DSB-SC	99.35	98.90
22	FM	99.95	99.80
23	GMSK	99.90	98.25
24	OQPSK	99.90	98.95
	Average	99.43%	98.66%

Classification accuracy reflects correct prediction percent based on the RF modulation type the network is trained to look for. For example, if the 2,000 images in the final test set contain 80 images of the target modulation, the classification accuracy is the percentage of these 80 correctly predicted. Also included in the percentage are negatives not incorrectly predicted as targets.

Classification Accuracies

Index	Parameter Memory Size: RF Modulation	1x IGL 121kb	48x Back Propagation 5,762kb
1	OOK	95.95%	40.54%
2	4ASK	86.67%	97.33%
3	8ASK	74.36%	62.82%
4	BPSK	67.86%	55.95%
5	QPSK	77.33%	66.67%
6	8PSK	71.26%	73.56%
7	16PSK	90.80%	51.72%
8	32PSK	76.32%	61.84%
9	16APSK	77.92%	40.26%
10	32APSK	89.41%	78.82%
11	64APSK	83.33%	61.76%
12	128APSK	100.00%	98.75%
13	16QAM	89.69%	55.67%
14	32QAM	95.00%	76.25%
15	64QAM	92.41%	59.49%
16	128QAM	100.00%	97.96%
17	256QAM	93.98%	62.65%
18	AM-SSB-WC	80.68%	60.23%
19	AM-SSB-SC	77.38%	73.81%
20	AM-DSB-WC	64.79%	42.25%
21	AM-DSB-SC	83.75%	72.50%
22	FM	98.72%	94.87%
23	GMSK	97.92%	63.54%
24	OQPSK	97.67%	75.58%
	Average	85.97%	67.90%