Finding MIMO

Weekly Meeting: Week 6

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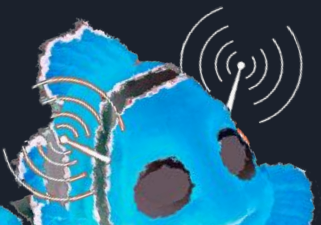
Project Goals

- Model receiver-side CEs to determine the best way to decode received signals
  - Choose equalization algorithm and parameters
  - Choose channel estimation technique
- Optimize parameters for the best Bit Error Rate (BER), Power Gain, or throughput



Progress and challenges

- SNR/Sampling Rate play a big role in BER
  - Need a good assumption.
- Matlab equalizers not compatible with OFDM
- Working Q-Learning Algorithm
  - Training one parameter at a time.
    - Local optimum only.
    - Inadequate for equalizer param-sets

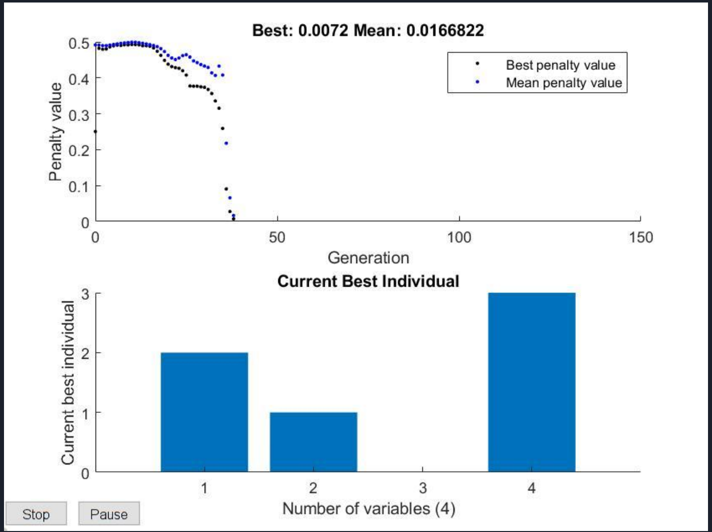
Progress and challenges Contd.

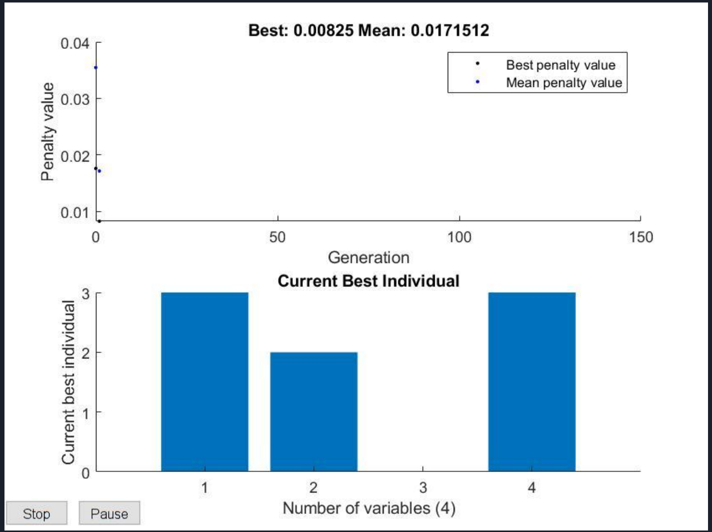
- Working Genetic Algorithm
    - Often stuck in local optimum
        - Need to play with rate of mutation, stall generation, number of population, or generations to avoid it.
        - Focus on faster convergence.
        - Only utilizing one variable at this time.
- Big searching space and complexity still causes troubles for both cognitive algorithms.
- Broken computer

Genetic Algorithm for MIMO

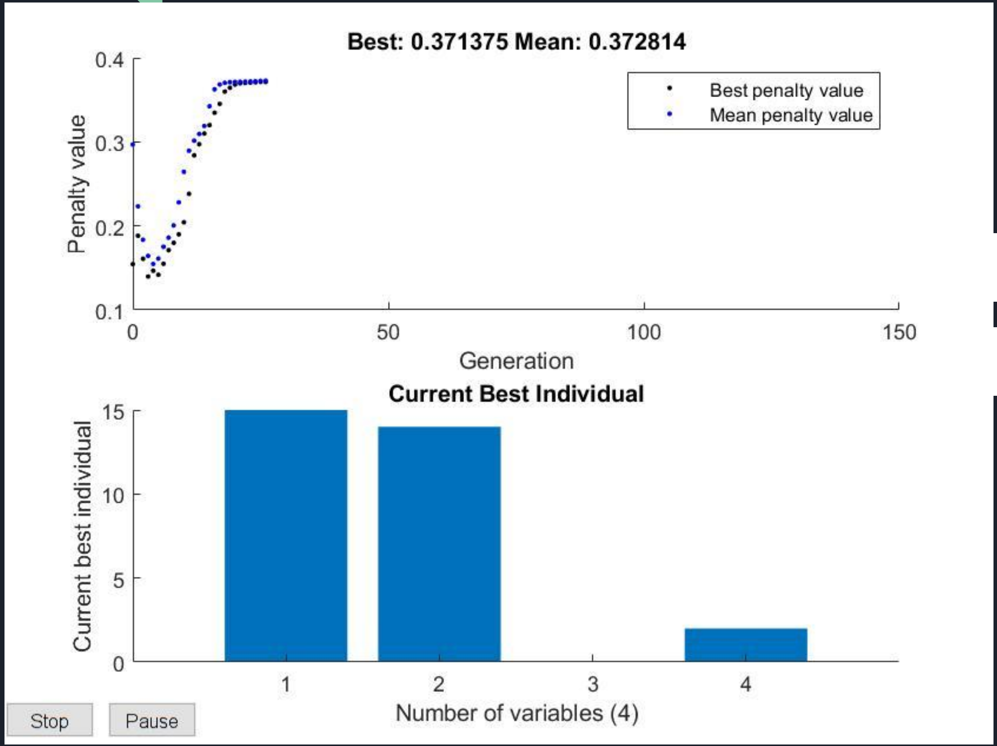
- Graphs acquired under the same conditions. (SNR 15/ SR 20e6)

```
opts = optimoptions(...
    @ga,...
    'PopInitRange',[lb;ub],'Generations',150,'StallGenLimit',20,...
    'PopulationSize',300, 'FitnessLimit',0.01,...
    'Display', 'iter', 'PlotFcn', plots);
```





Genetic Algorithm for MIMO



Often stuck in a local optimum, and fails to yield global optimum.Higher the population size, lower chance of stuck in a local optimum.

38	11700	0.0072	0.01668	0
1	600	0.00825	0.01715	0

Convergence time not guaranteed even with the same configuration due to the nature of epsilon greedy.

CurrSNR	BestErr	BestrefTap	BestnFwdT...	BestnFdbk...	Beststepsz	Bestforgfec	Bestalg
Number	Number	Number	Number	Number	Number	Number	Number
CurrSNR	BestErr	BestrefTap	BestnFwdTa...	BestnFdbkT...	Beststepsz	Bestforgfec	Bestalg
1	0.5040	3	5	9	3.8083e-04	0.3486	1
2	0.5145	3	10	5	4.2466e-04	0.5167	1
3	0.5025	1	9	15	1.8374e-04	0.4742	1
4	0.5045	3	13	11	6.5090e-04	0.1870	1
5	0.3999	4	4	5	1.8267e-04	0.9884	2
6	0.3885	4	4	4	2.5004e-04	0.9886	2
7	0.3281	2	4	4	6.2917e-04	0.9861	2
8	0.3216	4	5	4	6.3129e-04	0.9896	2
9	0.2858	3	7	5	6.8571e-04	0.9898	2
10	0.2845	4	6	5	5.2671e-04	0.9897	2
11	0.2480	1	6	4	6.5377e-04	0.9897	2
12	0.2277	2	4	7	6.7757e-04	0.9882	2
13	0.2054	3	9	8	3.8304e-04	0.9897	2
14	0.1798	3	6	5	2.2029e-04	0.9898	2
15	0.1667	1	4	4	8.0408e-04	0.9876	2
16	0.1527	2	4	6	5.7538e-04	0.9889	2
17	0.1320	1	4	4	6.6420e-04	0.9888	2
18	0.1227	1	4	5	9.1625e-04	0.9892	2
19	0.1067	2	5	4	7.8707e-04	0.9881	2
20	0.0953	1	4	4	2.1829e-04	0.9887	2

2-PSK-Bests | 2-PSK-Scores | 4-PSK-Bests | 4-PSK-Scores | 8-PSK-Bests | 8-PSK-Scores | 16-PSK-Bests | 16-PSK-Scores | 32-PSK-Bests | 32-PSK-Scores | 64-PSK-Bests | 64-PSK-Scores

Data acquisition

Accumulating lookup database of trained params in the hope of reducing the searching space and avoid stucking in local optimum.

HF MIMO Baseline Model

- Found published data using various techniques
  - Convolutional Coding
  - Standard with QPSK
- Implemented modular code for easy testing
  - Need to integrate simple equalizers

Vasily Yu. Doroshenko, Inna O. Dvorakova, Alexander A. Malyutin, and Yuri B. Nechaev "Experimental Study of Cooperative MIMO at HF Band," in Proc. 36th International Conf. on Telecommunications and Signal Processing (TSP), Rome, Italy, 2013, pp 160-165.

R. C. Daniels and S. W. Peters, "A New MIMO HF Data Link: Designing for High Data Rates and Backwards Compatibility," MILCOM 2013 - 2013 IEEE Military Communications Conference, San Diego, CA, 2013, pp. 1256-1261.

O. C. Oghre and S. Salous, "BER performance evaluation of HF MIMO spatial multiplexing systems," 2014 XXXIth URSI General Assembly and Scientific Symposium (URSI GASS), Beijing, 2014, pp. 1-2.

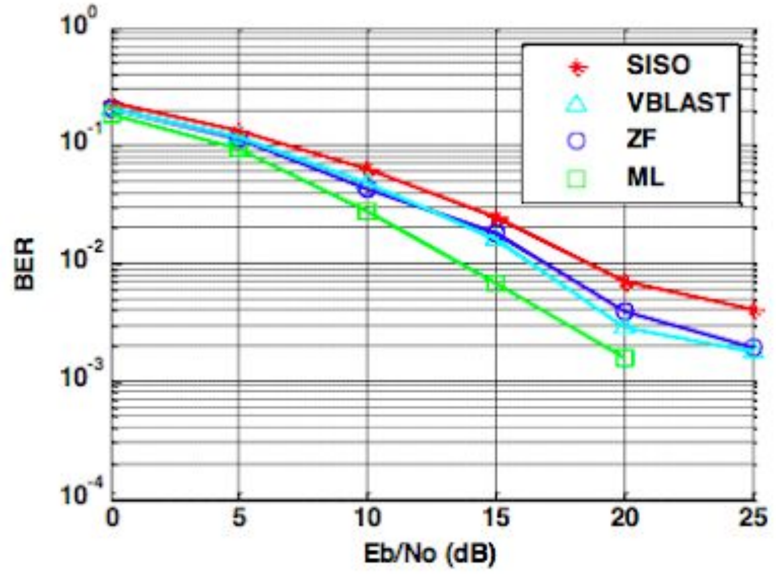
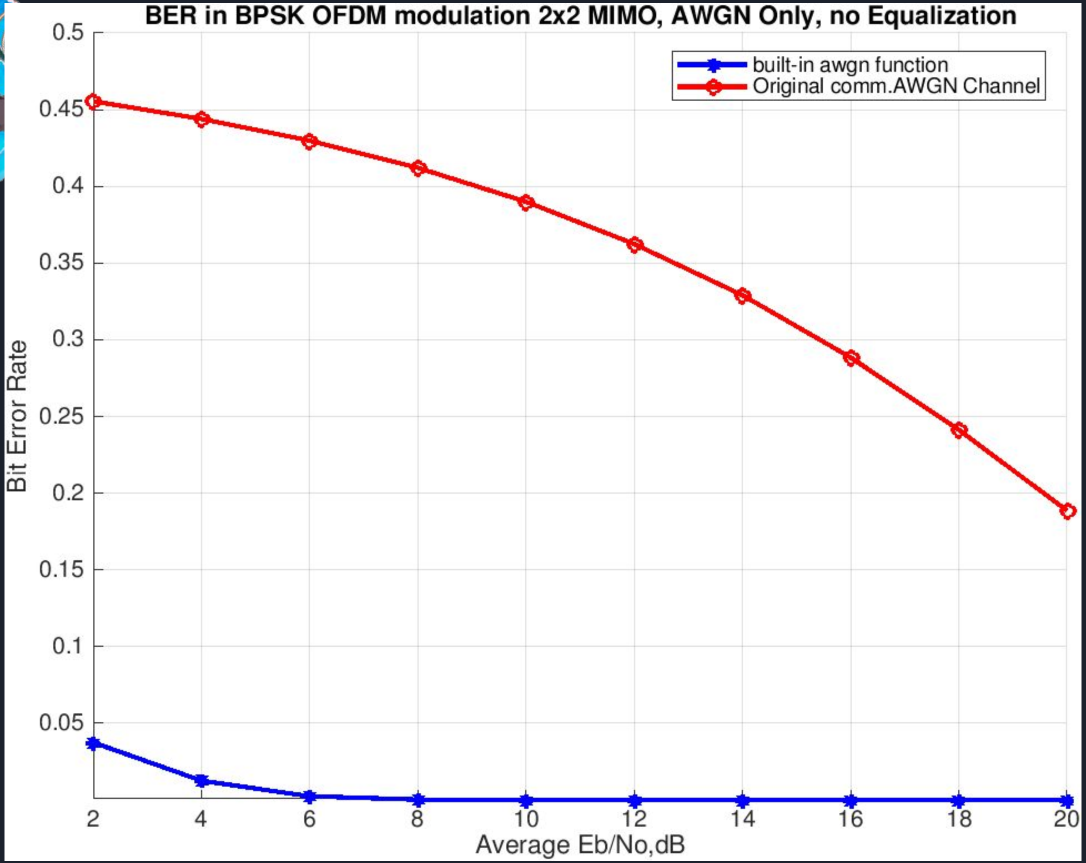


Figure 2 BER Performance for a 2x2 MIMO System

From Oghre and Salous.

What Was Wrong?

- Last week, we were told that our BER was concerningly high
- Appears to be a difference in MATLAB implementations of AWGN
  - Built-in AWGN
  - Communications Toolbox AWGN object



Conclusion: use the built-in function

Q-Learning

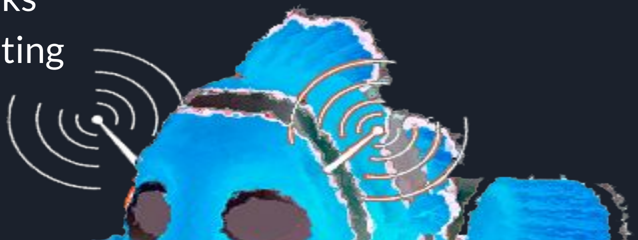
- Q-Learning function is working for variables independent of one another and finds local optimums of each variable.

- Currently adapting function to work with with multiple variables in conjunction with one another to find plural optimum.

- Programming a new methodology to handle multiple variable without using a n-dimensional Q-Table using an n-ordered counting system and a hash table to calculate rewards to achieve n^2 space requirements in n lookup-time.

Roadmap

- Week 6
  - Invent modification of Q-Learning Algorithm for multiple variables in conjunction.
  - Determine parameters for CEs, determine testing conditions
  - Finish integrating equalizers with baseline model
- Weeks 7
  - Work on producing data and derive novel and meaningful conclusion
  - Optimization
- Week 8-10
  - Other tasks
  - paper writing



Questions?