Biogeography-Based Optimization of Neuro-Fuzzy System Parameters for Diagnosis of Cardiac Disease

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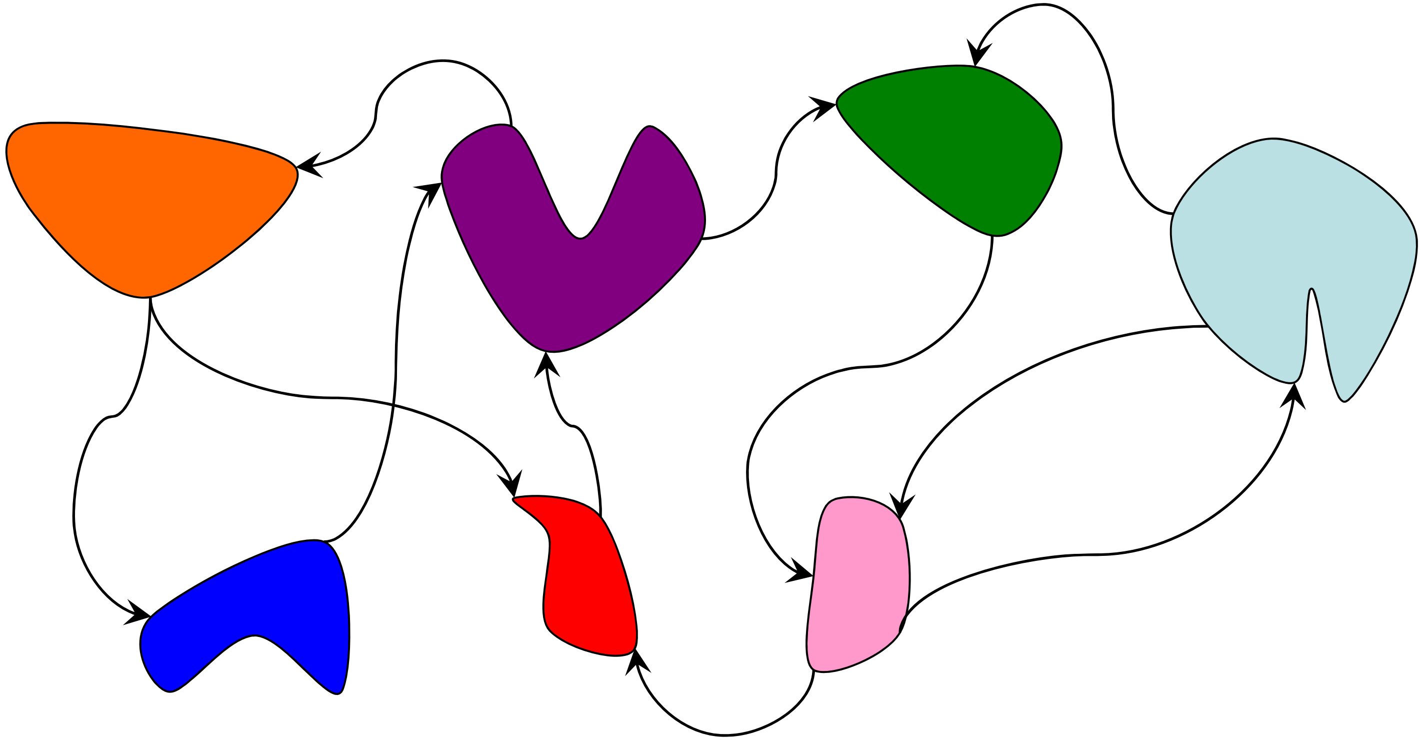
Outline

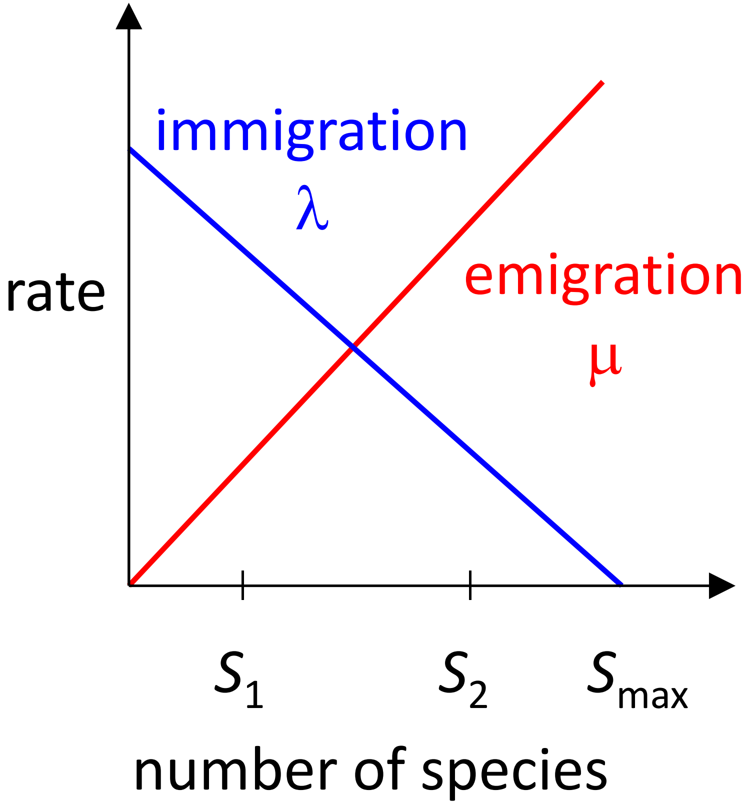
1. Biogeography-Based Optimization (BBO)
2. Opposition Based Learning (OBL)
3. Neuro-Fuzzy Networks
4. Cardiomyopathy
5. Experimental Results
6. Conclusions

Biogeography-Based Optimization



Species migrate between islands via flotsam, wind, flying, swimming, …

Biogeography-Based Optimization



As habitatability improves:

1. Number of species increases
2. Emigration increases: more species leave the island
3. Immigration decreases: fewer species enter the island

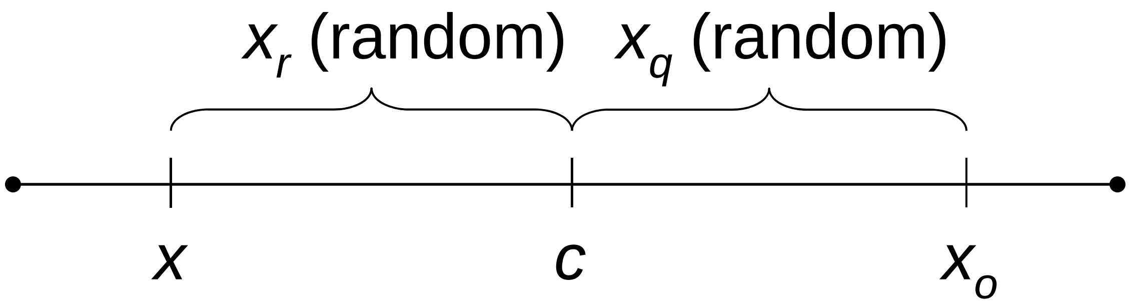
Migration rates vary with the number of species on an island

Biogeography-Based Optimization

For each solution H_i
  For each solution feature s
    Select solution H_i with probability λ_i
    If solution H_i is selected then
      Select H_k with probability μ_k
      If H_k is selected then
        $H_i(s) \leftarrow H_k(s)$
      end
    end
  next solution feature
next solution

One generation of the BBO algorithm

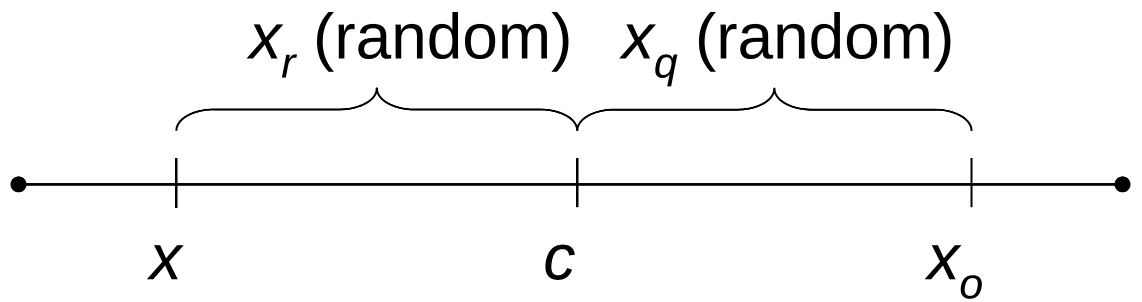
Opposition Based Learning



"*Social revolutions* are, compared to progress rate of natural systems, extremely fast changes in human society." Hamid R. Tizhoosh, 2005

- x = individual in optimization algorithm
- x_o = opposite individual
- x_q = quasi-opposite
- x_r = quasi-reflected opposite

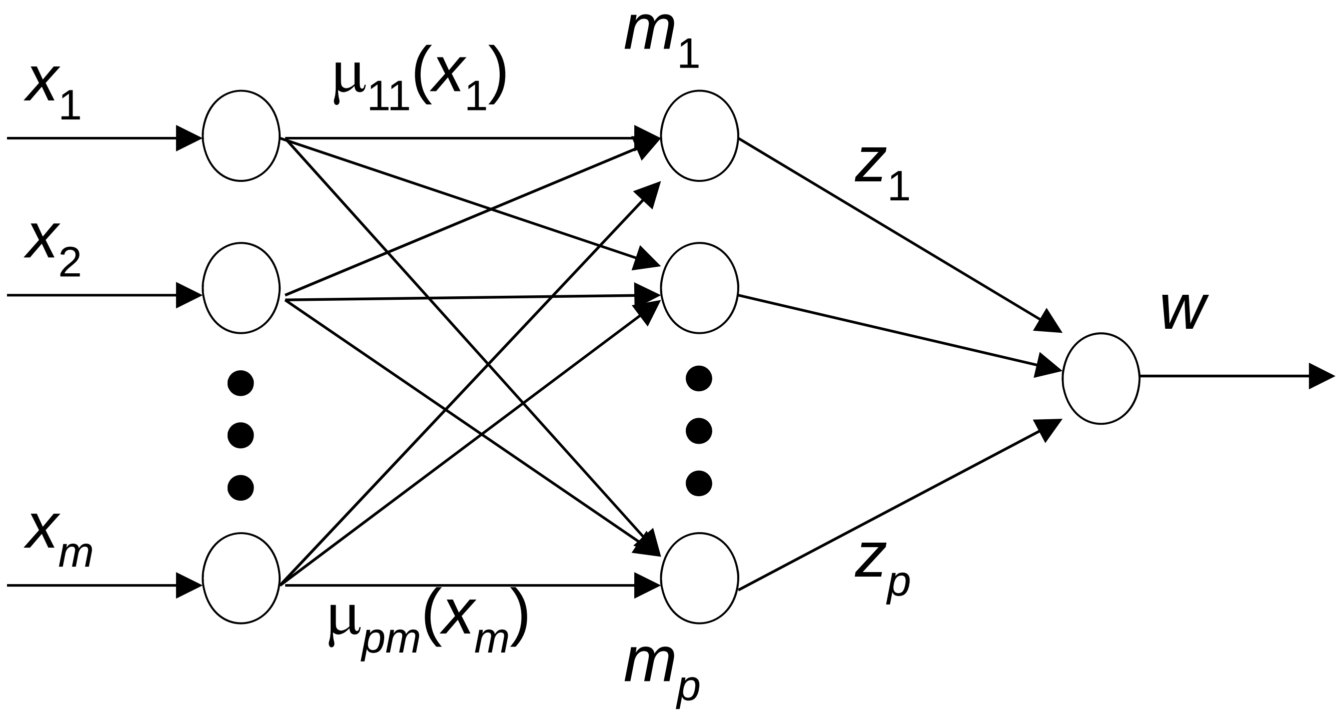
Opposition Based Learning



Prob(x_o better than x)	1/2
Prob(x_q better than x)	9/16
Prob(x_r better than x)	11/16
Prob(x_q better than x_o)	11/16
Prob(x_r better than x_o)	9/16

Source: Mehmet Ergezer, CSU doctoral student

Neuro-Fuzzy Networks



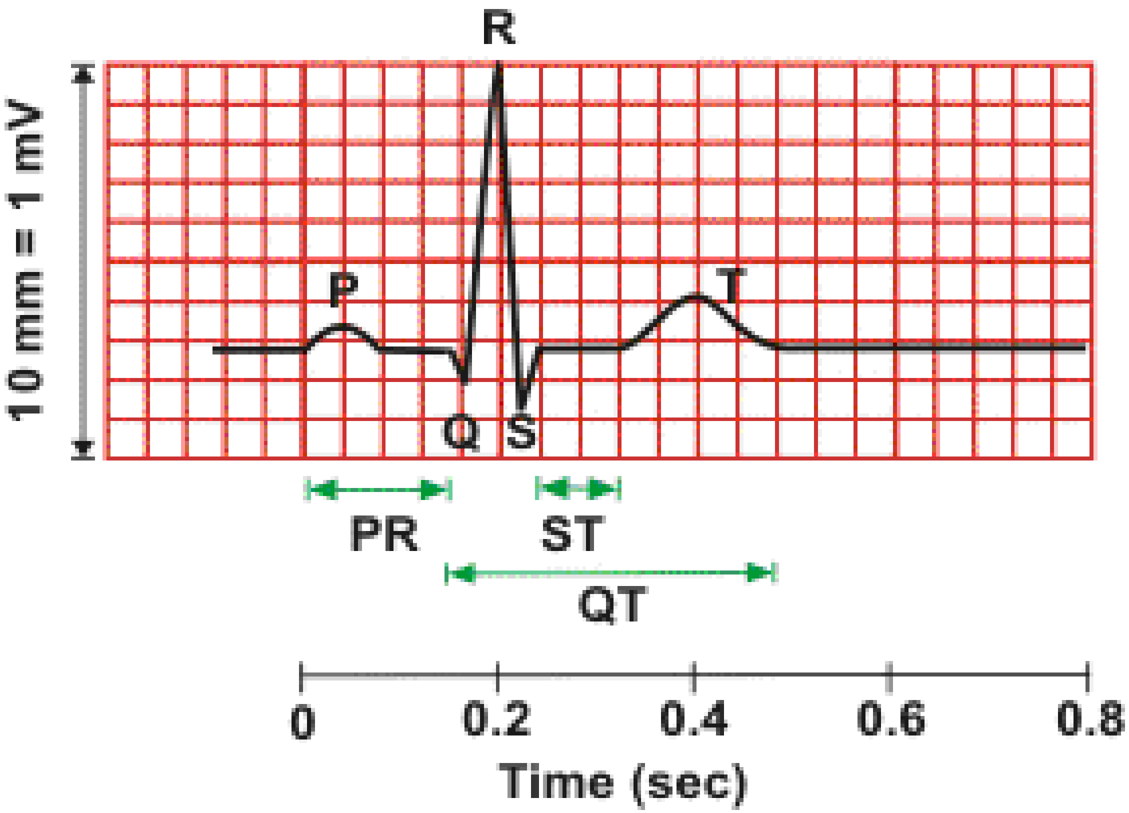
Universal approximation properties

$pm+pm+p = p(2m+1)$ adjustable parameteres

Cardiomyopathy

- Cardiovascular diseasei s the leading cause of death in the western world
  - Over 800,000 deaths per year in the United States
  - One in five Americans has cardiovascular disease
- Cardiomyopathy: weakening of the heart muscle
- Could be inherited or acquired (unknown cause)
- Biochemical considerations show that cardiomyopathy will affect the P wave of an ECG

Cardiomyopathy



The P wave is at the sub-mV scale.

Changes due to cardiomyopathy:

- Shape
- Amplitude

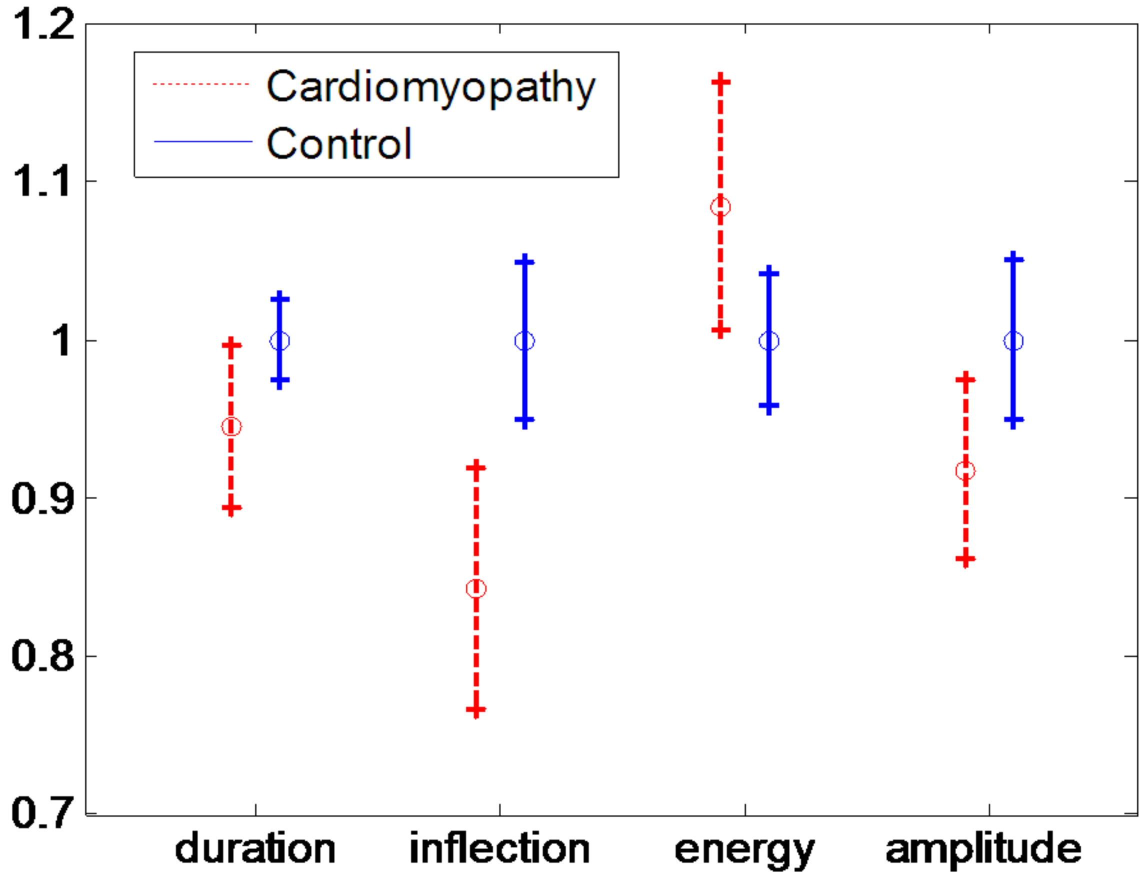
Cardiomyopathy

- ECG data collection
  - Data collected for 24 hours
  - Average P wave data calculated each minute
    - Duration
    - Inflection
    - Energy
    - Amplitude
  - 37 cardiomyopathy patients, 18 control patients

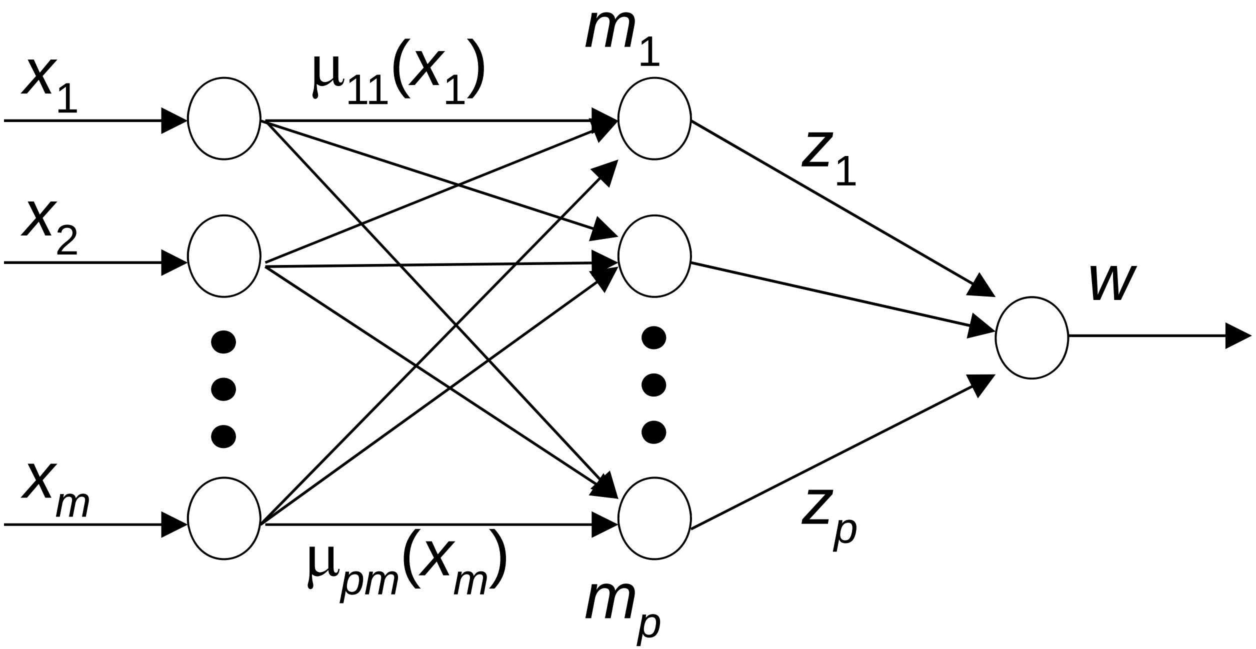
Cardiomyopathy

Normalized P wave features with 1-σ bars.

Data is complex due to its time-varying nature.



Experimental Results



4 inputs: $m = 4$

p chosen as a tradeoff (training vs. testing)

output = +1 for cardiomyopathy and –1 for control

Experimental Results

p	Training Error		Training CCR		Testing CCR	
	Best	Mean	Best	Mean	Best	Mean
2	0.85	0.88	76	72	66	58
3	**0.77**	**0.84**	**82**	**77**	**75**	**62**
4	0.78	0.83	84	77	65	55
5	0.78	0.83	82	76	63	58

Training error and correct classification rate (CCR) as a function of the number of middle layer neurons *p*.

Experimental Results

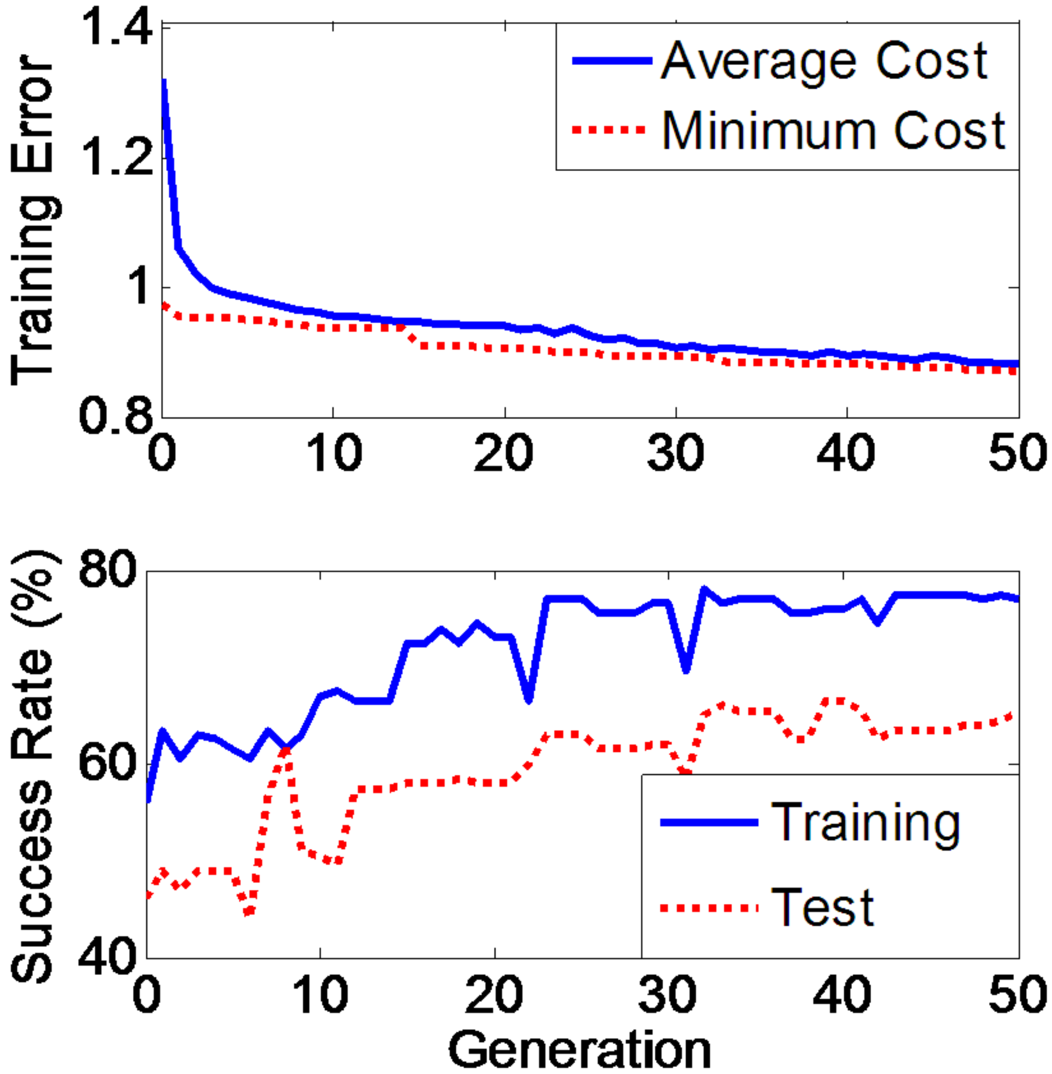
	Training Error		Training CCR		Testing CCR	
	Best	Mean	Best	Mean	Best	Mean
BBO	0.77	0.86	84	76	66	58
Q-BBO	**0.83**	**0.86**	**79**	**74**	**69**	**62**
R-BBO	0.80	0.85	81	75	65	60

Training error and correct classification rate (CCR) for BBO and oppositional BBO (p = 3).

Experimental Results

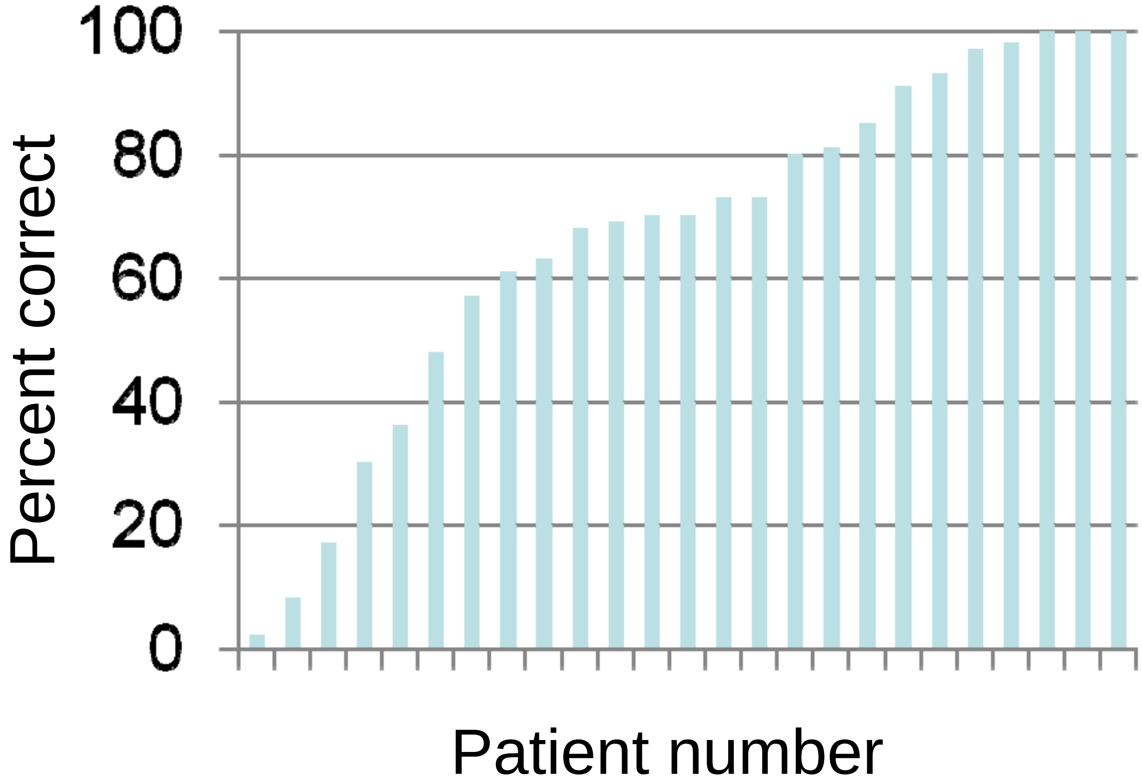
Mutation rate (%)	Training Error		Training CCR		Testing CCR	
	Best	Mean	Best	Mean	Best	Mean
0.1	**0.79**	**0.85**	**81**	**76**	**71**	**61**
0.2	**0.82**	**0.86**	**80**	**75**	**72**	**59**
0.5	**0.77**	**0.85**	**82**	**76**	**69**	**62**
1.0	0.80	0.85	80	74	67	57
2.0	0.83	0.86	79	74	69	62
5.0	0.82	0.87	81	74	68	58
10.0	0.80	0.87	78	73	65	59

Training error and correct classification rate (CCR) for different mutation rates using Q-BBO (*p* = 3).



Typical
Q-OBBO training
and test results

Experimental Results



Success varies from one patient to the next. Demographic information needs to be included in the classifier.

Conclusions

- Successful feasibility study
  - BBO for neuro-fuzzy training
  - Cardiomyopathy classification
- Future work
  - Time varying classification (majority rules)
  - Inclusion of demographics
  - Combination with gradient-based training
  - Product development