ANNs
Algorithms
Experiments
Conclusions & Future Work

Training Neural Networks with GA Hybrid Algorithms

Lenguajes y Ciencias de la Computación

Enrique Alba and J. Francisco Chicano

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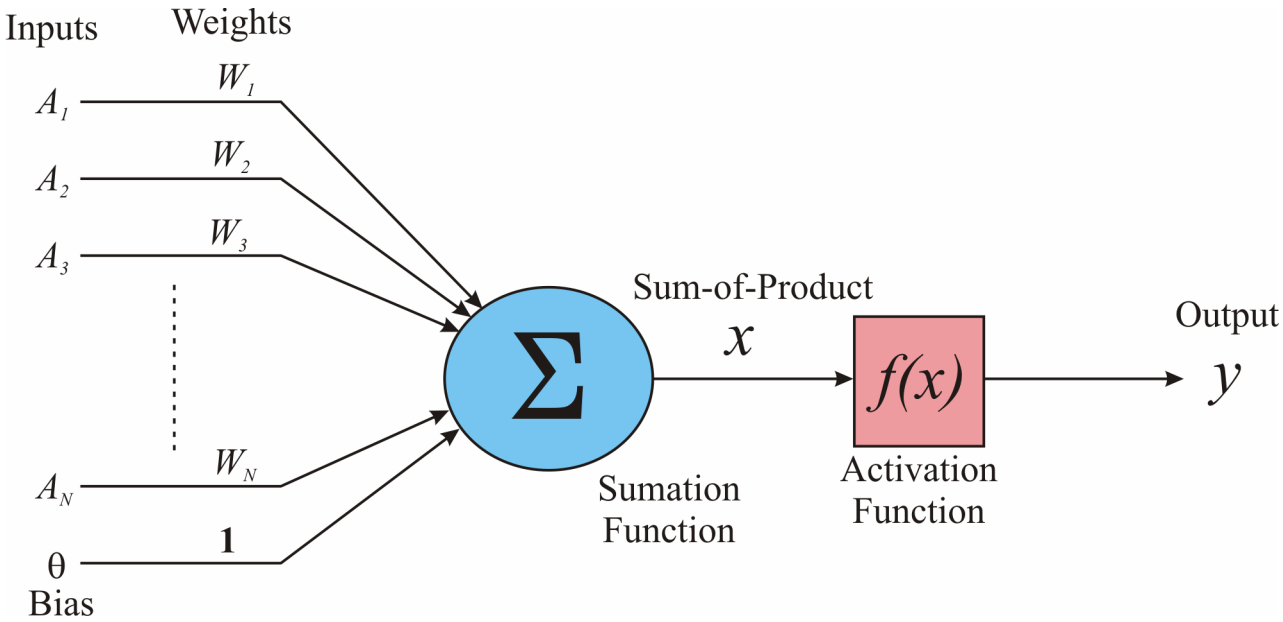
Artificial Neural Networks

- An ANN is a structured pool of Artificial Neurons:



- The architecture determines how the neurons are connected:
  - Feedforward networks (used here)
  - Recurrent networks

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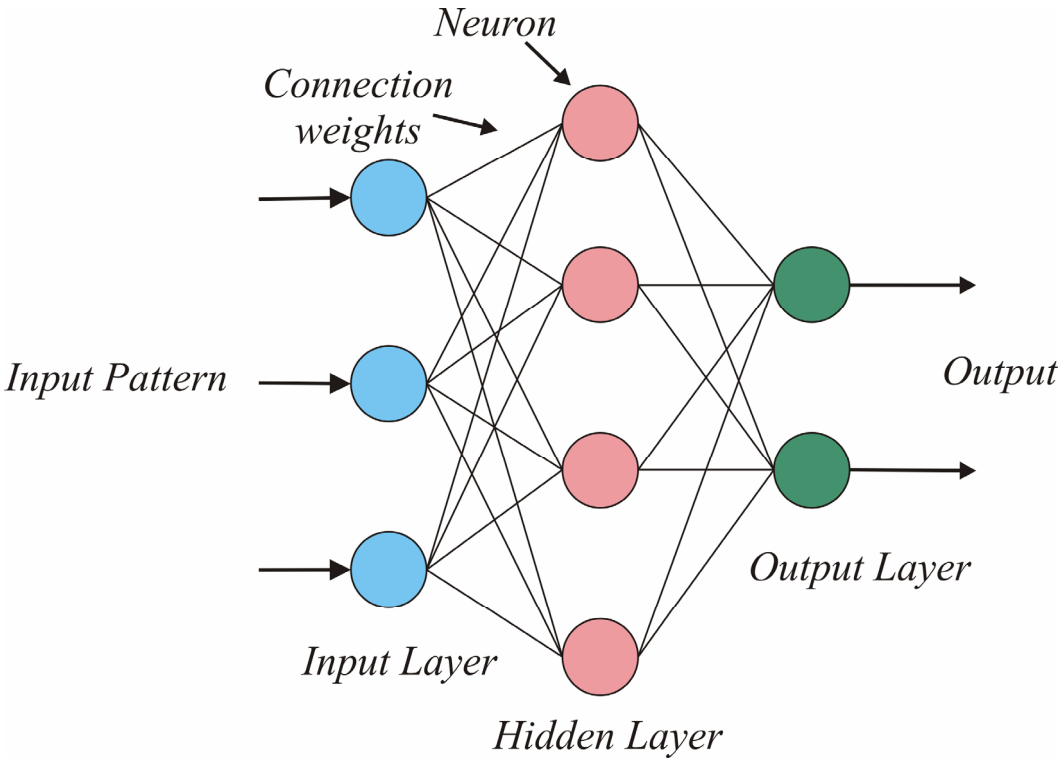
Multilayer Perceptron

- We use Multilayer Perceptrons



- Parameters: number of layers, neurons per layer, activating functions

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Training

- The training process consists in adjusting the network weights:
  - Supervised learning
  - Non-supervised learning

- Supervised training process consists in adjusting the weights to get the desired output for the present input patterns

- To measure de quality of the network several options exist:
  - SEP

$$SEP = 100 \cdot \frac{o_{max} - o_{min}}{P \cdot S} \sum_{p=1}^{P} \sum_{i=1}^{S} (t_i^p - o_i^p)^2$$

  - CEP: percentage of incorrectly classified patterns

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Backpropagation

- BP is a gradient-based method

$$E = \sum_{p=1}^{P} \sum_{i=1}^{S} (t_i^p - o_i^p)^2$$

learning rate

$$\Delta \mathbf{w} = -\eta \nabla E$$

```
InitializeWeights;
while not StopCriterion do
    for all i,j do
        w_ij := w_ij - η ∂E/∂w_ij ;
    endfor;
endwhile;
```

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Levenberg-Marquardt

- LM is a "quasi" second order method

variable parameter Jacobian

$$\Delta \mathbf{w} = -\left[\mu I + \sum_{p=1}^{P} J^p(\mathbf{w})^T J^p(\mathbf{w})\right]^{-1} \nabla E(\mathbf{w})$$

```
InitializeWeights;
while not StopCriterion do
    Calculates e^p(w) for each pattern;
    e1 := sum_{p=1}^{P} e^p(w)^T e^p(w);
    Calculates J^p(w) for each pattern;
    repeat
        Calculates Δw;
        e2 := sum_{p=1}^{P} e^p(w + Δw)^T e^p(w + Δw);
        if (e1 <= e2) then
            μ := μ * β;
        endif;
    until (e2 < e1);
    μ := μ/β;
    w := w + Δw;
endwhile;
```

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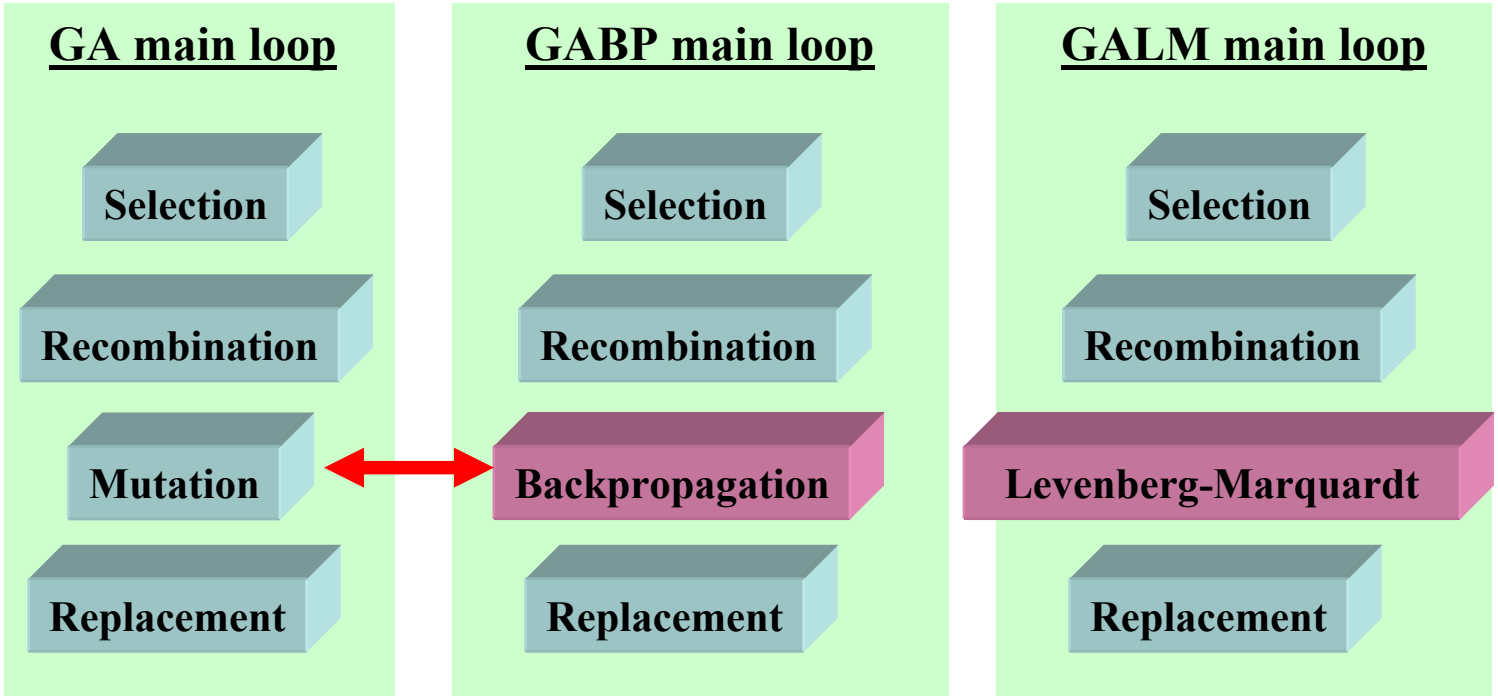
Hybrid Algorithms

- Hybridization: Inclusion of problem knowledge into the algorithm
- Two possible classes of hybrid algorithms:
  - Strong: Specific representation and operators
  - Weak: Combination of several algorithms (cooperation)



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Experiments

- Three classification problems from PROBEN1 benchmark

	Inputs	Outputs	Patterns
Cancer	9	2	699
Diabetes	8	2	768
Heart	35	2	920

- Multilayer perceptrons with one output neuron per class
- Six neurons in the hidden layer
- Sigmoid activating function
- In GA and hybrids, fitness = the inverse of SEP
- Pattern sets: Training (75%) and Test (25%)

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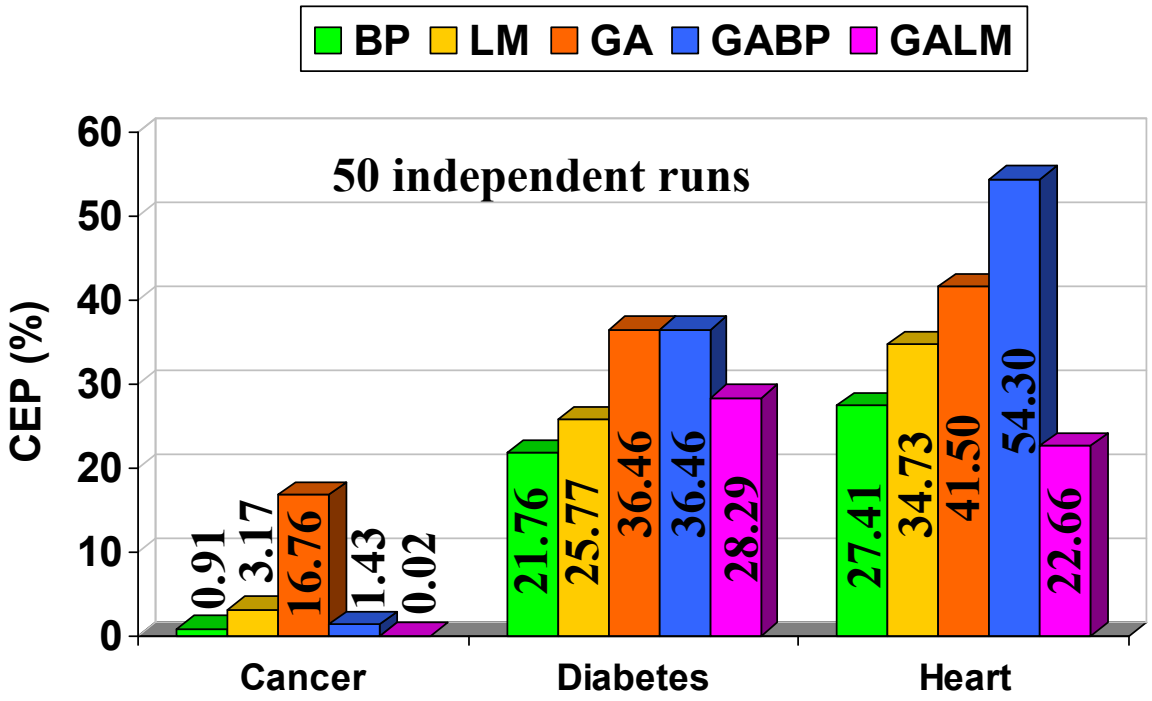
Results

- GA gets higher CEP than BP and LM (expected result)
- BP more accurate than LM
- GALM more accurate than GABP



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Results

- GA gets ~~higher CEP than~~ BP and LM (expected result)
- BP more accurate than LM
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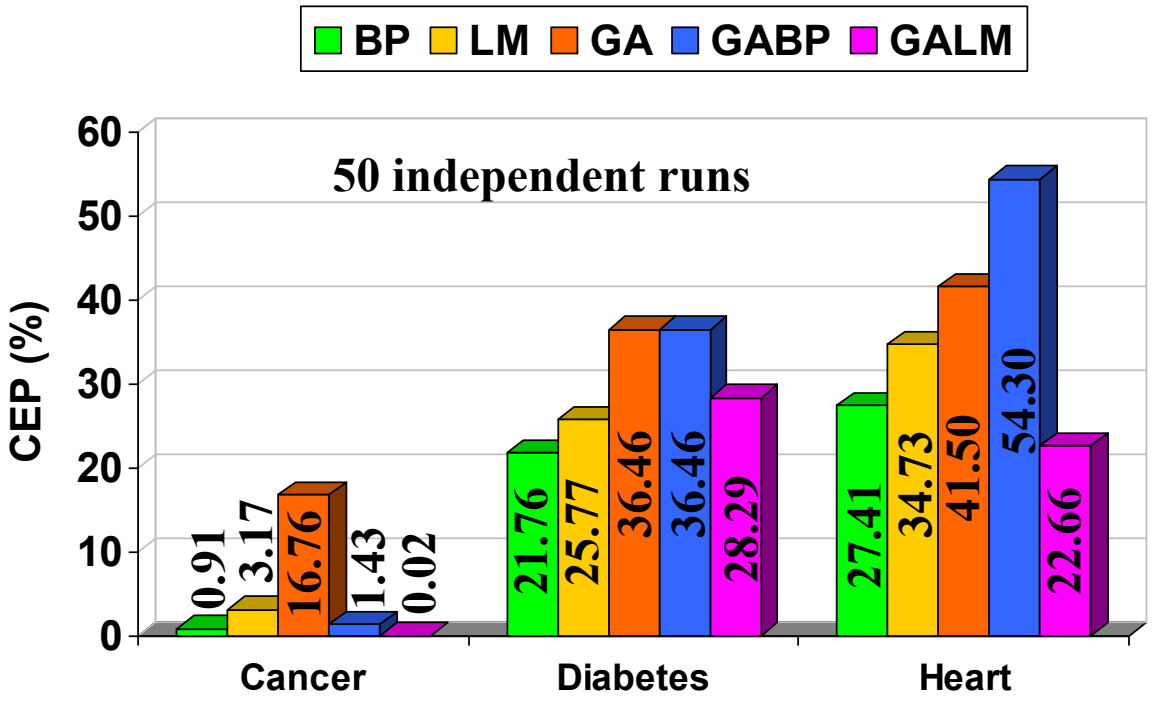
unexpected behavior!



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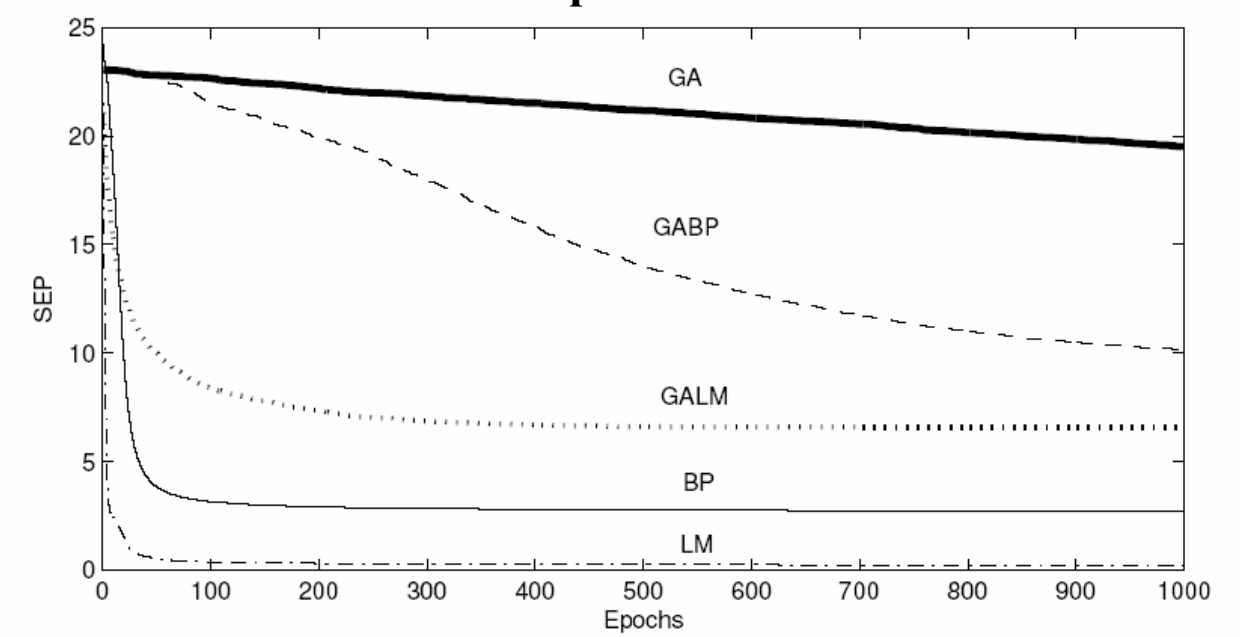
Results

- LM is the fastest algorithm in minimizing the SEP
- GA evolution is accelerated with the inclusion of BP and LM
- BP and LM over-train the ANN to the used pattern set

50 independent runs



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Conclusions

- BP and LM outperform GA
- Hybrid algorithms outperform pure ones
- GALM hybrid found the best CEP (known to our knowledge) for Cancer (0.02%) and Heart (22.66%)

Future Work

- Study other algorithms for these problems (ES, ESBP, ESLM)
- Solve additional instances (Gene, Soybean, Thyroid, …)

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THE END

Thanks for your attention !!!