Artificial Neural Networks (ANNs) Training

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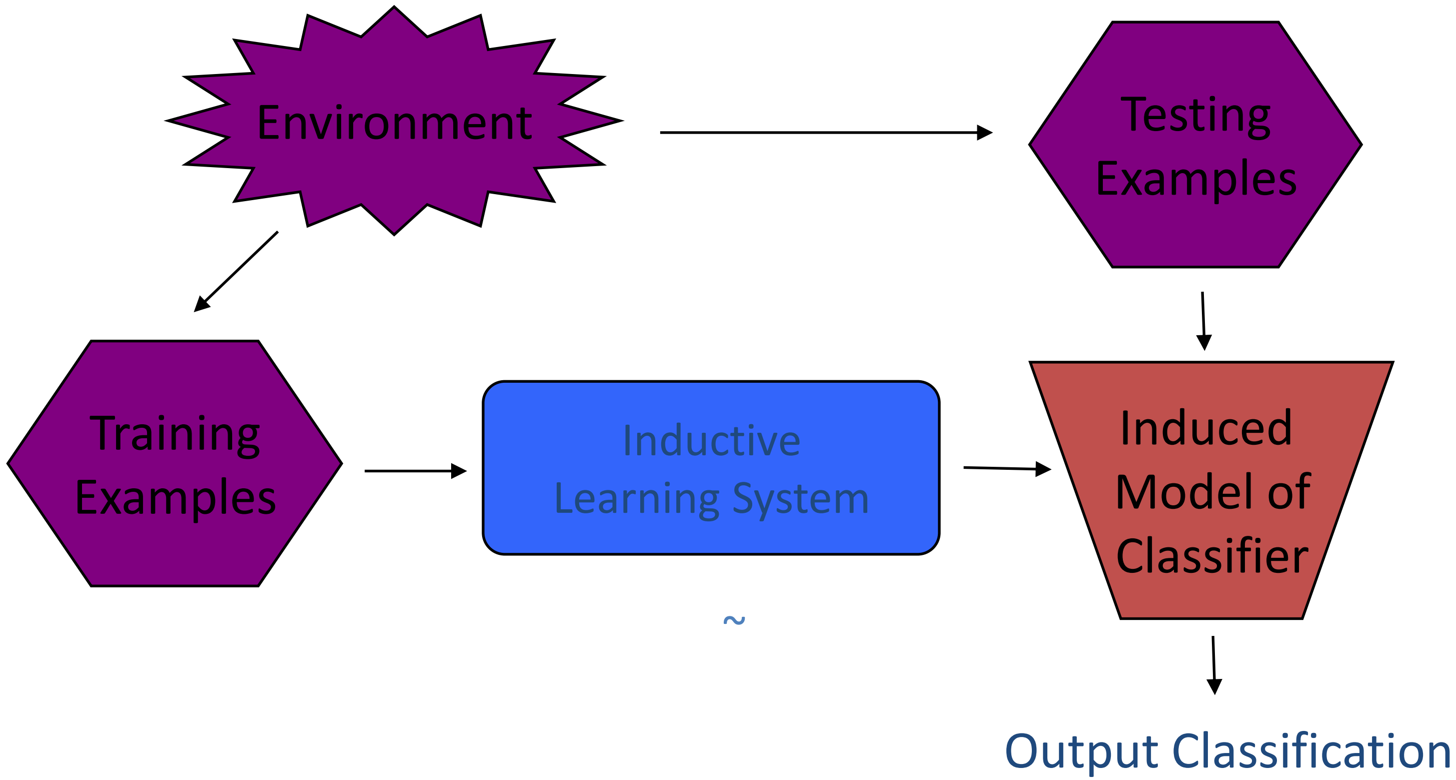
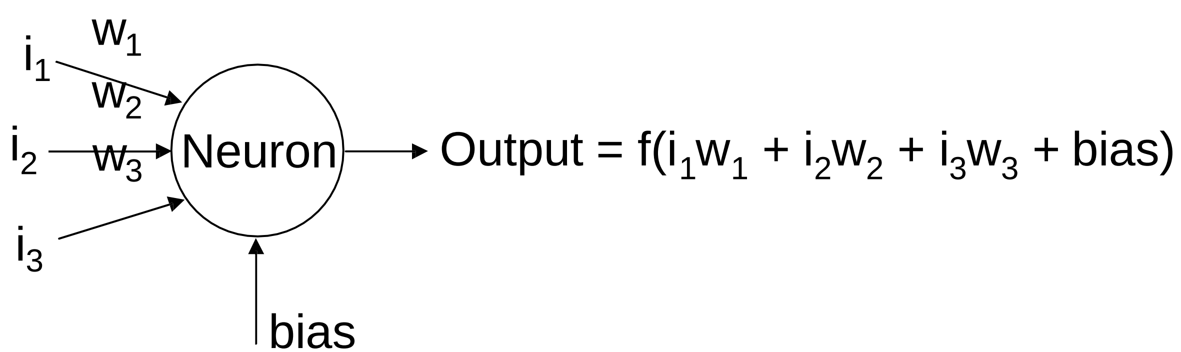
Classification Systems and Inductive Learning

Basic Framework for Inductive Learning



Node biases

- A node’s output is a weighted function of its inputs
- What is a bias?
- **Bias** allows you to shift the activation function by adding a constant (i.e. the given **bias**) to the input
  - output = sum (weights * inputs) + bias
- **Bias** in **Neural Networks** has the same role of a constant in a linear function
  - y =mx + c
- How can we learn the bias value?
  - treat them like just another weight
  - Just add one more input unit to the network topology



Network training

- Two main types of training
  - Supervised Training
    - Supplies the neural network with inputs and the desired outputs
    - Response of the network to the inputs is measured
      - The weights are modified to reduce the difference between the actual and desired outputs
  - Unsupervised Training
    - Only supplies inputs
    - The neural network adjusts its own weights so that similar inputs cause similar outputs
      - The network identifies the patterns and differences in the inputs without any external assistance

Epoch

- One iteration through the process of providing the network with an input and updating the network's weights
- Many epochs are required to train the neural network

Learning rate

- The learning rate is important
  - Range 0.01 - 0.99

  - Too small
    - Convergence extremely slow

  - Too large
    - Converges to a local minimum

Hidden Layers and Neurons

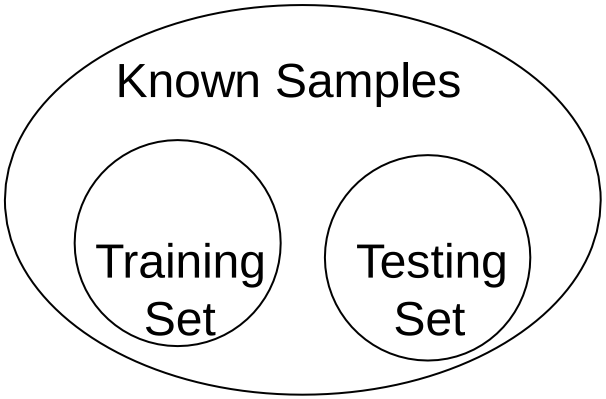
- For most problems, one layer is sufficient
- Two layers are required when the function is discontinuous
- The number of neurons is very important:
  - Too few
    - Underfit the data – NN can't learn the details
  - Too many
    - Overfit the data – NN learns the insignificant details (poor generalization)
  - Start small and increase the number until satisfactory results are obtained

Verification

- Provides an unbiased test of the quality of the network
- Common error is to test the neural network using the same samples that were used to train the neural network
  - The network was optimized on these samples, and will obviously perform well on them
  - Doesn't give any indication as to how well the network will be able to classify inputs that weren't in the training set

Training / Testing set

- The set of all known samples is broken into two independent sets:
  - Training set
    - A group of samples used to train the neural network
  - Testing set
    - A group of samples used to test the performance of the neural network
    - Used to estimate the error rate

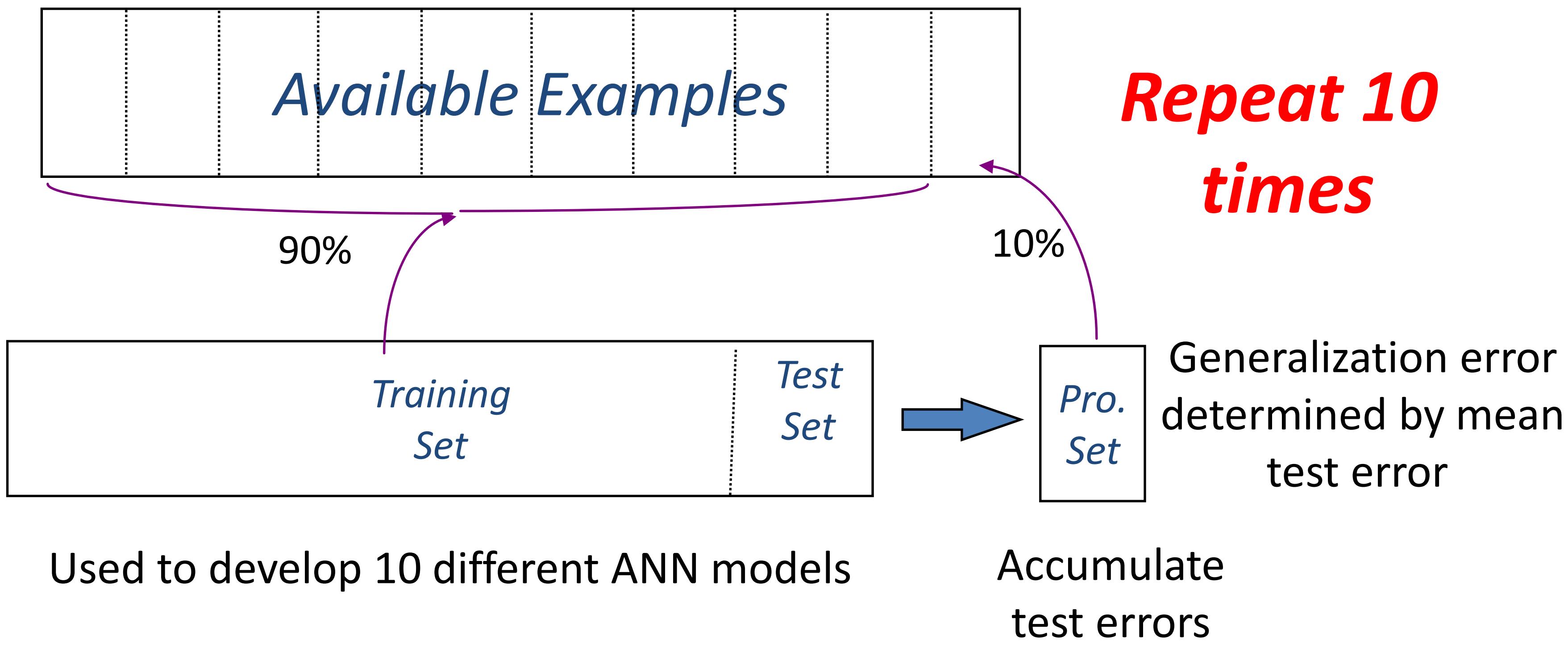


Training Set

- Good training set can avoid Overfitting
- What is the good training set?
  - Samples must represent the general population
  - Samples must contain members of each class
  - Samples in each class must contain a wide range of variations or noise effect
- The size of the training set is related to the number of hidden neurons
  - Eg. 10 inputs, 5 hidden neurons, 2 outputs:
  - 11(5) + 6(2) = 67 weights (variables)
  - If only 10 training samples are used to determine these weights, the network will end up being overfit
    - Any solution found will be specific to the 10 training samples
    - Having 10 equations, 67 unknowns, you can come up with a specific solution, but you can't find the general solution with the given information

Cross-validation

When the amount of available data is small ...



Data Preparation

- The quality of results relates directly to quality of the data
- Eliminate or estimate missing values
- Remove outliers (obvious exceptions)
- Reduce attribute dimensionality
  - remove redundant and/or correlating attributes
  - combine attributes (sum, multiply, difference)
- **Normalization**: De-correlate example attributes via normalization of values:
  - Euclidean: *n = x/sqrt(sum of all x^2)*
  - Percentage: *n = x/(sum of all x)*
  - Variance based: *n = (x - (mean of all x))/variance*

Weights initialization

- Random initial values +/- some range
- Smaller weight values for nodes with many incoming connections
- Rule of thumb: initial weight range should be approximately

$$\pm \frac{1}{\# weights}$$

coming into a node

- Genetic Algorithm

Training FFNN using Back propagation

1. Randomly initialize weights.
2. Apply feed forward pass with one input record.
3. Calculate the total error on output layer.
   – If total error <= accepted value then *stop*
   – Else *continue*
4. Apply backward pass.
5. Update weights.
6. Go to step 2.

➢ When all records of training are attempted, then one epoch is done.

➢ Usually thousands of epochs are executed to get the final weights for a trained network