Neural Network Ensembles

4/12/17
Neural Network Bagging

Train on resample #1

Train on resample #2

Train on resample #3

What’s the problem here?

• Deep networks are slow to train.
• Networks may be correlated.
Neural Network Boosting

- Network architectures are often chosen carefully.
- Boosting expects weak learners; that’s the opposite of a deep net.
Neural Network AdaBoost

Recall the key idea of AdaBoost:
• Give more weight to training examples previous classifiers got wrong.

How can we give a particular example greater weight in neural network training?

Present the example more often.
• Instead of looping through all training examples in random order, choose each example randomly, with probability proportional to weight.
• Nodes have a dropout probability \( p \).
• Each time a training example is presented nodes are randomly selected to drop out.
• Dropped nodes have activation = 0.
Training with Dropout

Backpropagation update:

$w_{ij} += \alpha \delta_j a_i$

$\delta_h = a_h(1 - a_h) \sum_o w_{ho}\delta_o$

If $a_i = 0$, then $w_{ij}$ is not updated.

- Therefore weights coming out of dropped nodes don’t get changed.

Similarly, $a_i = 0$ means that $\delta_i = 0$

- Therefore weights coming into dropped nodes don’t get changed.
- And errors don’t propagate through dropped nodes.
Prediction with Dropout

For prediction, none of the nodes get dropped.

Problem: during training, there were fewer nodes contributing to the weighted sum of inputs.

How can we compensate for this?

• Include dropout probability in the weighted sum.

\[ \sum_i w_{ij} a_i \rightarrow \sum_i p_i w_{ij} a_i \]
How does a dropout network resemble an ensemble learning algorithm?

• It’s like we’re training $2^n$ different networks.
  • Each node can be present or absent: $2^n$ combinations.
  • Training them all on the same data set, so there is a slight resemblance to boosting.

What happens if input nodes get dropped?

• This modifies the data set that some of the networks get trained on.
  • This has a slight resemblance to bagging.