4 Neural Networks Architectures

Contents

Abstract

There exist many types of architectures used in neural networks; that is the ways in which the neurons are connected. Here we describe a few of the more popular architectures.

4.1 Feed-forward neural networks

These are the commonest type of neural network in practical applications.

- They compute a series of transformations that change the similarities between cases.
- Each unit in one layer is connected to *every* unit on the next layer.
- Each layer get a new representation of the input - in order to achieve this, the activities of the neurons in each layer are a *non-linear* function of the activities in the layer below.

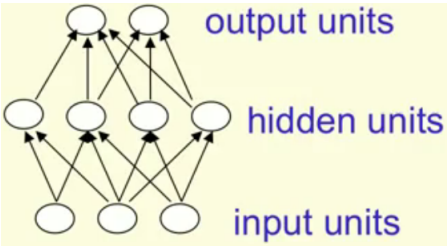

Figure 4.1: A feed-forward network with one hidden layer. The first layer is the input, and the last layer is the output.

Remark. If there is more than one hidden layer, we call them "*deep*" neural networks.

Remark. Examples include:

- convolutional neural networks (typically used in image classification).

4.2 Recurrent neural networks (RNNs)

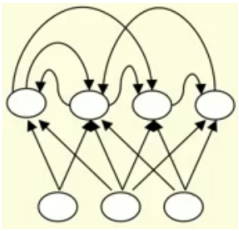

Figure 4.2: **RNNs**: They have directed cycles in their connection graph (i.e. you can sometimes get back to where you started by following the arrows).

Remark. RNNs with multiple hidden layers are just a special case that has some of the hidden-to-hidden connections missing.

Remark. These are much *more powerful* and *more biologically realistic*; indeed, there is a lot of interest at present in finding efficient ways of training recurrent nets as they can have complicated dynamics that makes them very difficult to train.

4.2.1 RNNs for modelling sequences

- RNNs are a very natural way to model sequential data (e.g. good for time series).
- RNNs are equivalent to very deep nets with one hidden layer per time slice (except they use the same weights at every time slice, and they get input at every time slice).

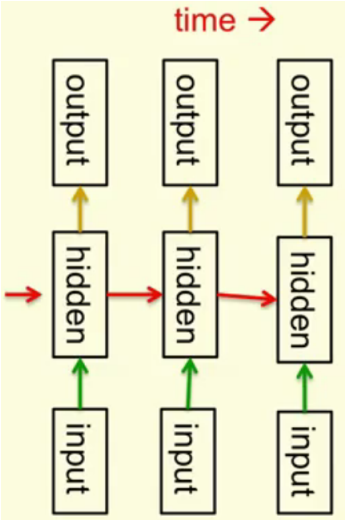

Figure 4.3: They have the ability to remember information in their hidden state for a long time (but its very hard to train them to use this potential).

4.3 Symmetrically connected neural networks

These are similar to RNNs, except the connections between units (or neurons) are symmetrical - that is they have the same weight in both directions.

- John Hopfield (and others) realised that symmetric networks are much easier to analyse than recurrent networks.
- They are also more restricted in what they can do, because they obey an *energy function* (for example, they cannot model cycles).

Definition 4.1. Symmetrically connected nets *without* hidden units are called **Hopfield nets**.

Definition 4.2. Symmetrically connected networks *with* hidden units asre called **Boltzmann machines**

Remark. Boltzmann machines are much more powerful models than Hopfield nets, but are less powerful than RNNs, and have a beautifully simple learning algorithm (these will be study later in the course).