Some theoretical work gives guidance as to which kinds of pooling one should use in various situations (Boureau *et al.*, 2010). It is also possible to dynamically pool features together, for example, by running a clustering algorithm on the locations of interesting features (Boureau *et al.*, 2011). This approach yields a different set of pooling regions for each image. Another approach is to *learn* a single pooling structure that is then applied to all images (Jia *et al.*, 2012).

Pooling can complicate some kinds of neural network architectures that use top-down information, such as Boltzmann machines and autoencoders. These issues will be discussed further when we present these types of networks in part III. Pooling in convolutional Boltzmann machines is presented in section 20.6. The inverse-like operations on pooling units needed in some differentiable networks will be covered in section 20.10.6.

Some examples of complete convolutional network architectures for classification using convolution and pooling are shown in figure 9.11.

9.4 Convolution and Pooling as an Infinitely Strong Prior

Recall the concept of a **prior probability distribution** from section 5.2. This is a probability distribution over the parameters of a model that encodes our beliefs about what models are reasonable, before we have seen any data.

Priors can be considered weak or strong depending on how concentrated the probability density in the prior is. A weak prior is a prior distribution with high entropy, such as a Gaussian distribution with high variance. Such a prior allows the data to move the parameters more or less freely. A strong prior has very low entropy, such as a Gaussian distribution with low variance. Such a prior plays a more active role in determining where the parameters end up.

An infinitely strong prior places zero probability on some parameters and says that these parameter values are completely forbidden, regardless of how much support the data gives to those values.

We can imagine a convolutional net as being similar to a fully connected net, but with an infinitely strong prior over its weights. This infinitely strong prior says that the weights for one hidden unit must be identical to the weights of its neighbor, but shifted in space. The prior also says that the weights must be zero, except for in the small, spatially contiguous receptive field assigned to that hidden unit. Overall, we can think of the use of convolution as introducing an infinitely strong prior probability distribution over the parameters of a layer. This prior