**Data Processing:**

The MNIST Database contains 70000 digitized handwritten numerals distributed in ten different classes. The whole dataset is divided into 60000 images for training purposes, and the remaining 10000 are reserved for the test set. The graylevel values of each pixel are coded in this work in the [0,1] interval, using a 0 value for white pixels and 1 for black ones. An important point for managing a high performance in the learning process is the construction of a useful training set. The 60000 different patterns contained in the MNIST database can be seen as a rather generous set, but evidence shows that the usual learning algorithms run into serious trouble for about one hundred or more of the test set samples [10]. Therefore, some strategy is needed in order to increase the training set cardinality and variability. Usual actions comprise geometric transformations such as displacements, rotation, scaling and other distortions. Here a specific set of transformations is combined with an image size reduction and an additive input noise schedule. In this work displacements and rotations are combined with an alternative deformation procedure that yields rather good results. A problem with which the Back Propagation algorithm tackles is the relative high input dimensionality for the original 28x28 sized digits. Using downsized images helps to reduce the error rate in a small amount. Therefore, a second version of both the training and test sets are generated where each pattern is downsized through interpolation to 20x20 pixels. Each digit is randomly shifted zero, one or two pixels both in the horizontal and in the vertical axis. The final performance is rather sensible to the probability distribution of the different displacements. Finding an optimal probability distribution is a cumbersome task. An interesting possibility is to design different displacement schemas in order to reduce the error correlation of the trained networks, which in turn can induce an improvement with the ensemble averaging procedure. This is shown further on in the Experimental Results Section. The most important transformation relies on the so called deformation, which involves pulling or pushing each of the four image corner pixels in a random amount along the vertical and horizontal axis. The rest of the pixels are proportionally displaced simulating an elastic behavior. This leads to a combination of partial stretching and/or compression of the image. Fig. 1 illustrates this process. For the full sized images the displacement interval of the corner pixels is [-5, +5] (distance measured as pixels). For the 20x20 sized images, the best results are achieved with displacements in the order of [-4, +4] pixels. In parallel with the deformation, a rotation is applied around the image center selecting a random angle between -0.15 and +0.15 radians. For technical reasons, the deformation and the rotation need to be computed in an inverse way.

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