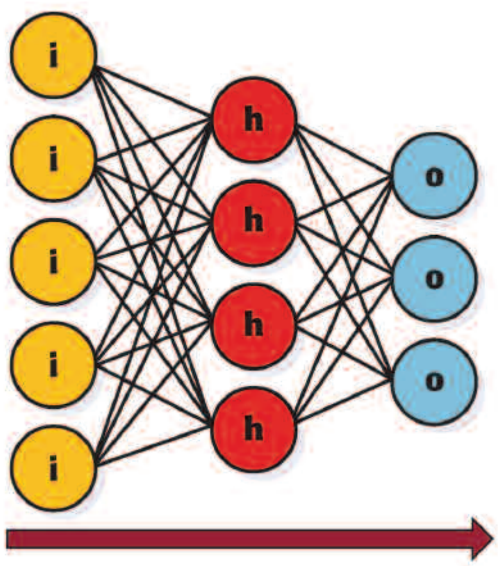
INDUSTRIAL VISION SYSTEMS LTD

CASE STUDY

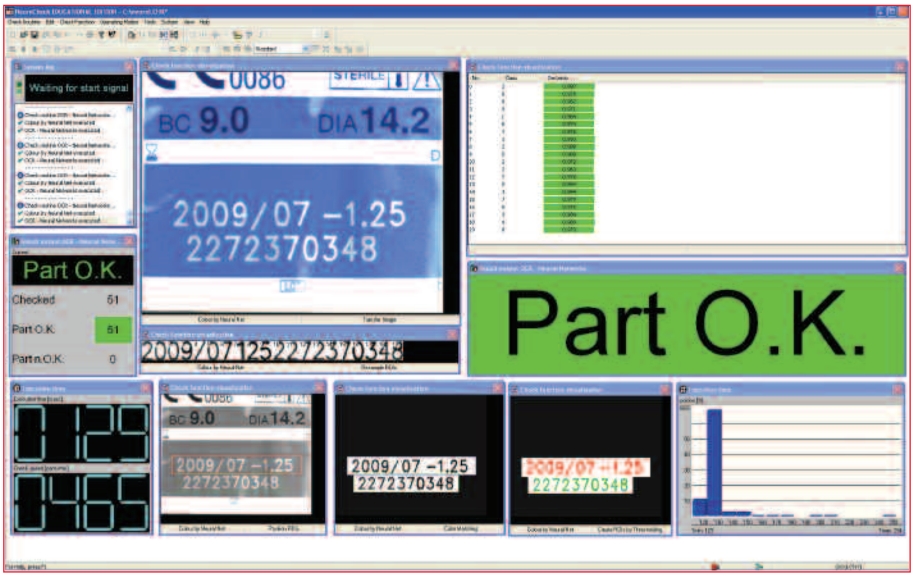
Utilising Neural Networks for Machine Vision in Printing & Packaging

The latest generation of machine vision solutions are utilizing neural network classification to provide more robust and repeatable Optical Character Recognition (OCR) and product identification in printing and packaging applications. Neural networks try to exploit some of the principles of information processing in the brain and are thus highly adaptable for machine vision processes. The information processing power of the brain stems from the large number of neurons and the even larger number of interconnections between these basically rather simple processors. In analogy to this, an artificial neural network is constructed from a large number of simple units connected by many weighted links. This architecture allows the realization of practically arbitrary transfer functions, i.e. relationships between input signals and output signals. The transfer function actually created depends on the weights of the internal connections. One of the main advantages of neural networks is that it is not necessary to construct this function explicitly.

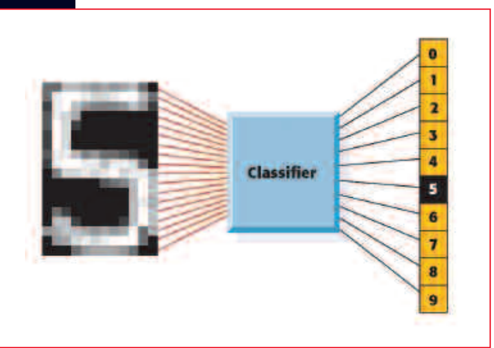


A three layer perceptron

Training algorithms enable neural networks to derive the weights needed to create the desired relationship between input and output from a set of training patterns. Machine vision software applications such as NeuroCheck, supplied by Industrial Vision Systems Ltd and sister company NeuroCheck GmbH, use networks of the multilayer perceptron type, a very widely and successfully applied type of network. They consist of three layers of processing units. The sole function of the first layer is to receive the input signals and transfer them to the second layer. The second layer is also called 'hidden layer', because it is not directly visible to the user. It does the actual processing of the signals. The internal representation of the pattern created by this processing is translated by the final layer into an output signal, directly encoding the class membership of the input pattern. Neural networks of this type can realise arbitrarily complex relationships between feature values and class designations. The relationship actually incorporated in the network depends on the weights of the connections between the layers and can be derived by special training algorithms from a set of training patterns. Figure 1 shows a simple network with five inputs, four hidden units and three outputs. Typical networks for digit classification have between 100 and 300 inputs, 10 to 50 hidden units and 10 output units (one for each digit).



An Optical Character Recognition (OCR) system running in the pharmaceutical industry utilising the powerful neural networks classifier in NeuroCheck



The digit 5, defined by a 256 byte image, is reduced to two bytes by the classifier

Neutal Network Training

A training pattern consists of an input signal, i.e. a collection of feature values or templates for character recognition, and the correct class information for the object described by the feature values. The training patterns are repeatedly processed by the network. In case of an error, i.e. a deviation between the actual network output and the correct class information, the internal weights of the network are changed in such a way that the deviation is reduced, until after a number of passes through the training set all training patterns are recognised correctly.

Constructing a Neural Network Application

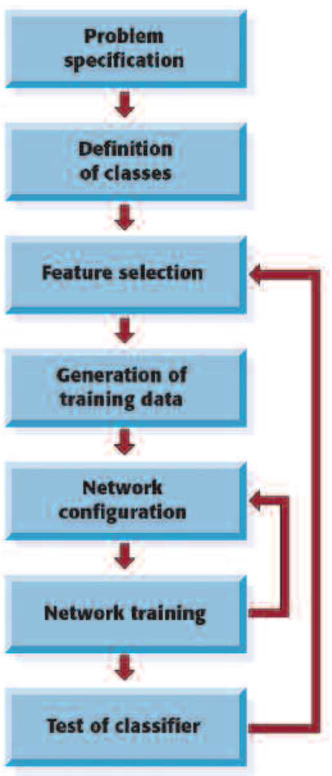
The first step is a precise specification of the classification task, usually defining the required classes, such as 10 classes for digit recognition, 26 for a complete alphabet, good-bad for a basic quality assessment. The next step is to choose the features describing the objects. The features have to represent properties of the objects essential for distinguishing the classes. Apart from this requirement the feature selection largely

depends on the specific problem and may have to be revised, if it turns out that the objects cannot be recognised reliably using the selected features. In the next step training data have to be generated, i.e. a collection of objects described by the selected feature

values has to be stored. These objects then have to be assigned to the correct classes by hand.

In the NeuroCheck software, network configuration restricts itself to setting the number of hidden units, because input and output configuration are already given by the problem specification. Afterwards the network can be trained. If a network of the defined size proves unable to learn the classification task, the network size may have to be changed.

Finally the classifier has to be tested, preferably with a set of pattern data not used for training. A possible reason for an unsatisfactory recognition rate in the test is an inappropriate selection of features, which should be revised in such a case.



Building neural nets: The steps required for training the neural network within NeuroCheck

Using Classifiers

Classification tries to model aspects of human reasoning, therefore it is a complex subject. NeuroCheck makes applying a classifier to a problem as easy as possible, performing many of the tasks necessary for creating and using classifiers automatically, but nevertheless a specific procedure has to be observed and some thought has to be invested in how to make the best use of this technology.

When to use a Classifier

Not every problem needs a classifier. If the distinction between objects of different classes can be made by simply comparing some measurements to certain thresholds, a screening process will be sufficient as it is realised by function Screen ROIs (region of interest). As soon as there are more complex, possibly non-linear relationships between measurements, one might think of using a classifier. The same holds, when not only simple features, but the overall appearance of the object has to be taken into consideration as is the case in character recognition.

Other ways of generating class information

Standalone classifiers (neural networks in NeuroCheck) are not the only way to generate class information. For example, after an object has been found using template matching NeuroCheck has the information about which template was most similar to the object and thus is able to attach a class to the object, namely the class of the template. The correlation algorithm used by template matching is by nature a linear classifier and therefore it is not as powerful and robust as a neural network.

Types of Classifiers

The task of a classifier in image processing is to assign an object described by a large set of feature values to one of comparatively few possible classes. Figure 2 shows the assignment of a digit to an image consisting of 216 pixels. The object description comprises 216 bytes (using one byte per pixel, as is typical for a standard grey level image). The object can belong to one of 10 possible classes. Two bytes are sufficient for this information.

Threshold Classifiers

There are very simple classification problems, which can be solved by checking whether all feature values lie within certain prescribed ranges. An example would be the inspection of the homogeneity of a dark surface. Possible criteria for this application are the maximum size of bright objects, the maximum overall brightness of the surface or a maximum standard deviation of the brightness values, in conjunction with a maximum average brightness. Another such example would be the dimensional accuracy of a geometrically complex object. This type of application can be solved in NeuroCheck using functions like Screen ROIs (for simple geometrical and brightness measurements computed by function Measure ROIs) and Check allowances (for complex geometrical measurements computed by the functions Gauge ROIs and Derive measures) The weakness of such simple thresholding methods is that they are unable to consider complex relationships between the different feature values.

A feature analysis application screening products based on the neural network classifier result.

Distance Classifiers

Distance classifiers store a set of typical patterns, so called prototypes, for each class. For every object to be classified, they compute the distance of the object to each of the prototypes, usually as the sum of the squared deviations of all feature values. Classifiers of this kind are very easy to construct and can be augmented by additional prototypes at any time, but for difficult classification problems they need a large number of prototypes, requiring a lot of memory and computing time

Example Applications

Neural network classification in the context of machine vision can be used in a diverse range of applications. Just a few of the varied applications provided by Industrial Vision Systems Ltd which are currently utilizing the technology include high reliability Optical Character Recognition (OCR) in pharmaceutical applications, automatic flatpack furniture inspection and pharmaceutical inspection criteria on miniature needle tip sub assemblies

Neural network classification offers a more robust and repeatable vision solution compared to some of the more traditional methods of industrial image processing, and with the continued deployment of these solutions in mass applications they continue to be the preferred choice for many manufacturers when specifying machine vision solutions.

www.industrialvision.co.uk

IVS (UK and Ireland)

Kingston Business Park • Kingston Bagpuize
Oxfordshire • OX13 5FE • UK
Tel :: +44 (0) 1865 823322
Fax :: +44 (0) 1865 823393
E-mail :: sales@industrialvision.co.uk

NeuroCheck GmbH (Germany)

For Germany Engineering Centre:
Tel :: +49 (0) 71 468956-0

For Germany Software Design & Training Centre:
Tel :: +49 (0) 711 229646-30

Worldwide Distributors:

Austria +49 7146 89 56 0
Ireland +44 1865 823322
Malaysia +65 6272 2766
Spain +34 91 692 21 17
France +33 4 50392466
Israel +972 9 76767654
Portugal +34 91 692 21 17
Thailand +65 6272 2766
Indonesia +65 6272 2766
Italy +39 0444 96 21 28
Singapore +65 6272 2766
USA +1 630 932 9380