A Neural Network Identifies Faces with Morphological Syndromes

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Abstract

The diagnosis of craniofacial dysmorphic signs has a high medical importance. Physicians specialized on human genetics need to get quick reliable information about dysmorphic syndromes characterized by facial abnormalities to give a prognosis about the risk of incidence for following children. In numerous cases of dysmorphic syndromes no chromosomal aberration can be found. Therefore the dysmorphic diagnosis is based on an extensive phenotyp analysis of craniofacial signs. In this study we investigate an artificial neural network approach to identify face images with morphological abnormalities. Different full-connected multi-layer perceptrons (MLP) are trained only with a small set of observations using back-propagation as learning algorithm. The gray level images are sampled, preprocessed and scaled to a size of 55 x 72 pixel. The best results are achieved with a network architecture of 4 hidden and 2 output units. The individual classification error of each investigated network architecture is calculated by the leaving-one-out method. The average classification error was 5 %, the best percentage of correct identifications of one network architecture reached 100 %. The presented results show that classifications generated by aritificial neural networks based on small sets of training examples are able to support a dysmorphic diagnosis.

1. Introduction

The human ability to recognize, identify or distinguish faces is very remarkable. This skill is quite robust and very accurate, despite several visual changes due to viewing conditions, facial expressions, aging and so on. As a consequence the visual processing of human faces has fascinated philosophers and scientists for centuries.

The recognition of minor facial abnormalities are important to identify dysmorphic syndromes [1]. Most dysmorphic signs are affecting the face but, by definition, do not lead to functional disturbances. A syndrome is a grouping of two or more signs into a characteristic constellation that allows a medical prediction of a disorder [2]. These constellations are occasionally very complex, so that no accurate or reliable definition can be found to charaterize the underlying syndrome.

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The study reported here shows an approach identifying gray level face images of children with dysmorphic signs by training an artificial neural network. Full connected multi-layer perceptrons (MLP) are known to perform well complex recognition tasks, like sex-recognition in faces by assumption of a sufficient amount of training examples [3]. The aim of this research was to find appropriate network architectures performing this identification task by a small set of training examples.

2. Methods

The presented approach works on frontal viewed face images of young children. The small database consists of 10 dysmorphic and 21 non dysmorphic, 512 x 512 high resolution, gray level images. All the face images have to be scanned and preprocessed before using as input for the networks.

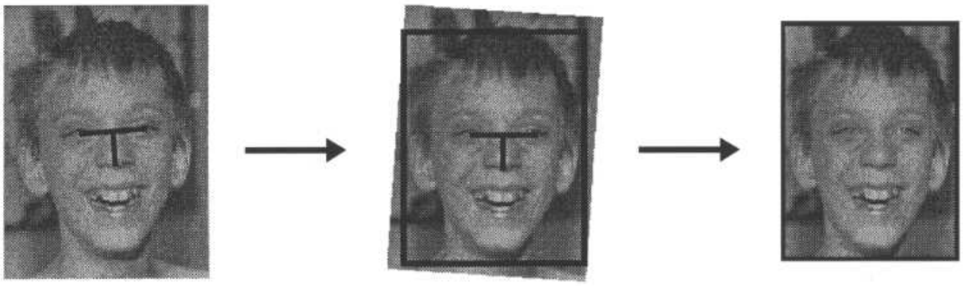

Figure 1: Preprocessing of the face images. After locating the eyes the images were rotated, scaled and cropped.

The preprocessing and the modelling of the network architectures are based on investigations of B. A. Golomb et al., who identify the sex from human faces [3]. After locating the eyes, the 8-bit digitized images are rotated to align the line joining the eyes (Figure 1).

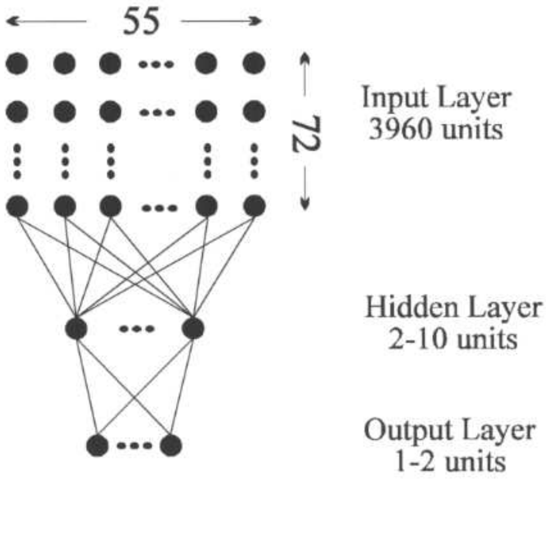

Figure 2: Design of used network architectures

We use a gaussian convolution kernel to reduce the image size and the resulting parts are cropped and scaled to a size of 55 x 72 pixel. Thus, the input is limited to 3960 units and the natural proportion of the human head is taken into account. Furthermore, all the images are adjusted to the same average brightness. We use various network configurations to train and classify different image sets. The number of units in the hidden layer is varied from 2 to 10 units. The amount of hidden units serves the network to generalize, while the number of output units is responsible for the classification result. One output unit coded "1" for dysmorphic, "0" for non-dysmorphic and two output units coded "0; 1" and "1; 0" for the different classification results are alternatively used (Figure 2).

For the realization of this study we choose the Stuttgart Neural Network Simulator [4] because of the fast computation and batch programming properties. The different networks are trained with 7 to 30 preprocessed face images of the database using standard backpropagation as learning algorithm [5] with a sigmoid activation function and a learning rate of 0.2 or 0.3. The learning process is supervised and determined after right identification of all trained samples. We use the leaving-one-out method [6] for training and testing all examined networks because of the small number of the considered images (Figure 3).

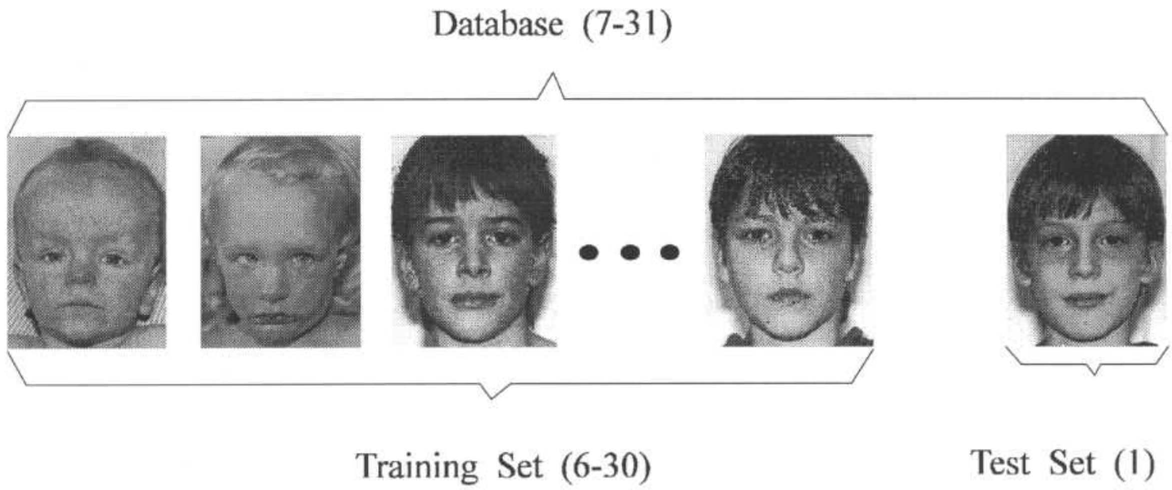

Figure 3: Leaving-one-out method for training and testing the different network configurations

Only one unknown test image of each sampling set is used for testing the network. The test image is changed until each image of the sampling set was used. The network is trained respectively with the remaining ones. Thus, we train repeatedly one network configuration with different training sets of one sampling set. The average classification error of each configurated network architecture is calculated by the amount of misclassifications of all considered examinations.

3. Results

The small sampling set of available observations effects a reduced ability of generalization of each examined network architecture. The average classification error calculated by counting the misclassifications of 8 samples per network configuration reaches about 25 %. Using all available face images (30 training + 1 testing sample respectively) and classifying dysmorphic and non-dysmorphic faces the percentage of misclassification decreases down to 5 %. In our best considered investigation the percentage of correct identifications reaches 100 % configurating the network with 4 or 6 hidden and 2 output units (Figure 4).

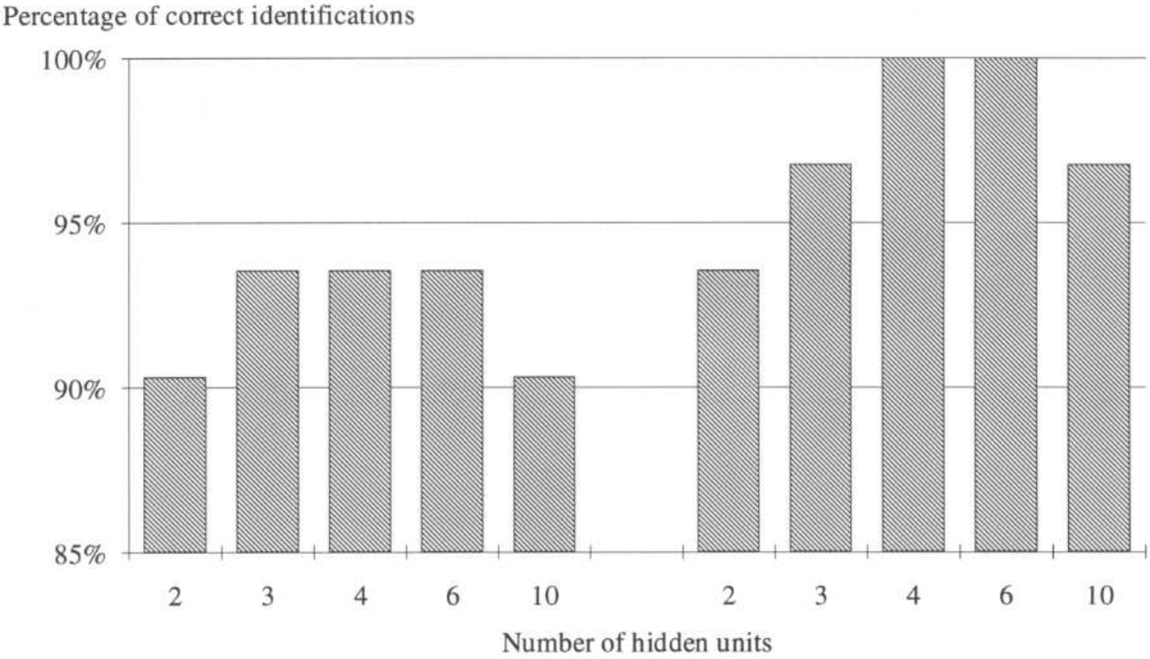

Figure 4: Diagram of the percentage of correct identifications to the number of used hidden units of two different network architectures.The first group is configurated with one output unit, the second with two output units.

The increasing of the amount of hidden units doesn't enhance the classification result but reduces the generalization properties of the network. In comparison to a network configuration with two output units the classification error improves for a network configurations with only one output unit, because the discrimination properties of the output layer cannot be trained so exactly. With these conditions of available observations an identification of different subsamples of dysmorphic face images wasn't possible.

4. Discussion

We have shown that the complex visual pattern recognition task of identifying face images with dysmorphic signs can be adequately performed by artificial neural networks without a large number of training examples. The evaluation of the neural network classifier by estimation of the average classification error using the leaving-one-out method offers robust performance and allows to transfer the results to similar problems. Dependent on the amount of training examples an optimal network architecture can be found so that the percentage of correct identifications reaches 100 %. By using only few hidden units the network has good generalization qualities.

However, the features being responsible for the classification cannot be reconstructed without paying attention to the underlying dysmorphic signs. It is intended to examine the face images on local facial features of morphological abnormalities. The local charateristic dysmorphic signs will be detected automatically by an attentional mechanism [7] and processed by specialized algorithms [8]. The extracted local features might build an understandable and reasonable basis for a sophisticated image processing system.

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References

[1] S. Stengel-Rutkowski, P. Schimanek and A. Wernheimer, *Anthropometric definition of dysmorphic facial signs,* Hum. Genet. 67, pp. 272-295 (1984)

[2] P. R. Dyken and M. D. Miller, *Facial features of neurologic syndromes,* St. Louis, Missouri, C. V. Mosby Company (1980)

[3] B. A. Golomb, D. T. Lawrence and T. J. Sejnowski, *Sexnet: A neural network identifies sex from human faces,* R. P. Lippmann (eds.) Advances in Neural Information Processing Systems 3, pp. 572-577 (1990)

[4] A. Zell et al., *SNNS Stuttgart Neural Network Simulator Vers. 3.0,* Report No. 3/93, Institut für parallele und verteilte Hochleistungssysteme, Stuttgart (1993)

[5] D. E. Rumelhart and J.L. McClelland, Parallel Distributed Processing, volume 1, MIT Press (1986)

[6] G. Deichsel and H. J. Trampisch, *Biometrie, Clusteranalyse und Diskriminanzanalyse,* Gustav Fischer Verlag (1985)

[7] R. Herpers, H. Kattner and G. Sommer, *GAZE: An attentional mechanism for the extraction of prominent facial features,* In this proceedings (1993)

[8] M. Michaelis and G. Sommer, *Characterization of key-points in images,* accepted by Int. Symp. on Subst. Ident. Techn. ´93, Innsbruck (1993)