# A System for Diagnosis Support of Patients with Facialis Paresis

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**Abstract**

In this contribution we present a system for diagnosis support of patients with single–sided facial paresis. This kind of paresis produces clearly visible asymmetries inside the patient's face. The system bases on the analysis of these asymmetries. There are two areas of application for the system: On the one hand it provides an objective judgement of a paresis in the clinic, and on the other hand it can be used for the patient's rehabilitation process as a "home trainer".

## 1 Introduction

In this article, we consider the problem of diagnosis support of patients with single–sided facial paresis. Approximately 350 patients per year are registered in the Department of Oto–Rhino–Larygology of the University of Erlangen with new occurrences of this type of paresis (cf. [6] as an overview). The current way to diagnose the paresis is a subjective judgement of the functionality of the face muscles by a physician. The patient performs mimic exercises such as closing the eyes or showing the teeth, while he is observed by the physician. The subjective observations of the physician are then graded by facial nerve grading systems[2, 5].

The applications of our system are on the one hand diagnosis support in the clinic. We want to improve the subjective judgments of a physician by objective measurements and numerical features from the face. On the other hand the supervision of the rehabilitation process of the patient will be enhanced by placing the system to the patient's home. One part of the rehabilitation program is to perform certain mimic exercises. The patient can use the system as a home trainer and does not have to travel to the clinic.

In section Sect. 2 we show examples of the appearance of facial paresis. Three major modules of the system are the localization of faces and facial features in portrait images (Sect. 3.1), the evaluation of facial asymmetries (Sect. 3.2), and the classification of a face whether it contains facial paresis (Sect. 3.3). In Sect. 4 results are presented. and we summarize in Sect. 5.

## 2 Appearance of Single–Sided Facialis Paresis

The appearance of single–sided facial paresis differs in a broad range. It dependends on the grade of the paresis and of the current state of the mimic musculature. In many cases, almost no signs of the paresis can be observed in a relaxed face. The appearance can be emphasized in a canonical way by performing specific mimic exercises. In Fig. 1a) and Fig. 1b) the patient tries to close his eyes while in Fig. 1c) and Fig. 1d) he tries to show his teeth or point his mouth. The missing control of some facial muscles produces clearly visible asymmetries inside a patient's face.

## 3 System

The presented system is adapted for patients with single–sided facial paresis i.e.,approximately 99% of all patients with facial nerve paresis. The presence of a paresis is determined by the evaluation of facial asymmetries during the performance of mimic exercises. Five color portraits ${}_i\boldsymbol{f}, i = 1, ..., 5$ of the patient are captured where the patient keeps his face relaxed (1), lifts his eyebrows (2), closes his eyes (3), shows his teeth (4), and points his mouth (5). Additionally, a background color image $\boldsymbol{b}$ without the patient is generated prior to the exercises.

The diagnosis supporting system can be subdivided into several modules. The major modules presented in the following are the localization of faces and facial features in portrait images, the evaluation of the asymmetries inside the face, and a classification module of the paresis. The system is embedded in a knowledge–based environment as shown in [4], which is still work in process.

### 3.1 Localization

The system bases on the local image analysis in the neighborhood of the eye and the mouth corners. Therefore the goal of the localization module is to localize those corners. We proceed in a coarse–to–fine strategy.

The first step is to detect and localize the patients head inside the portrait images ${}_i\boldsymbol{f}$. The proceeding is shown in Fig. 2. In Fig. 2a) we see the image $\boldsymbol{b}$ of the heterogenous, static background. Fig. 2b) shows image ${}_1\boldsymbol{f}$: the user in the foreground with a relaxed face. The binary difference image ${}_1d$ of ${}_1\boldsymbol{f}$ and $\boldsymbol{b}$ shown in Fig. 2c) contains the segmented patient. A row–wise, top–to–bottom search delivers the top of the head $\boldsymbol{H}$ (Fig. 2d). The intersection points of the shoulders and the image border $\boldsymbol{S}_1$ and $\boldsymbol{S}_2$ are found by tracking the margins of ${}_1d$. To get the neck points $\boldsymbol{N}_1$ and $\boldsymbol{N}_2$ we use the connection lines $l_1$ of $\boldsymbol{H}$ and $\boldsymbol{S}_1$ and $l_2$ of $\boldsymbol{H}$ and $\boldsymbol{S}_2$. The biggest difference of the $x$–coordinates of $l_1$ and the left contour of the patient is assumed to be neck point $\boldsymbol{N}_1$. $\boldsymbol{N}_2$ is determined similarily with $l_2$ and the right side of the contour. The

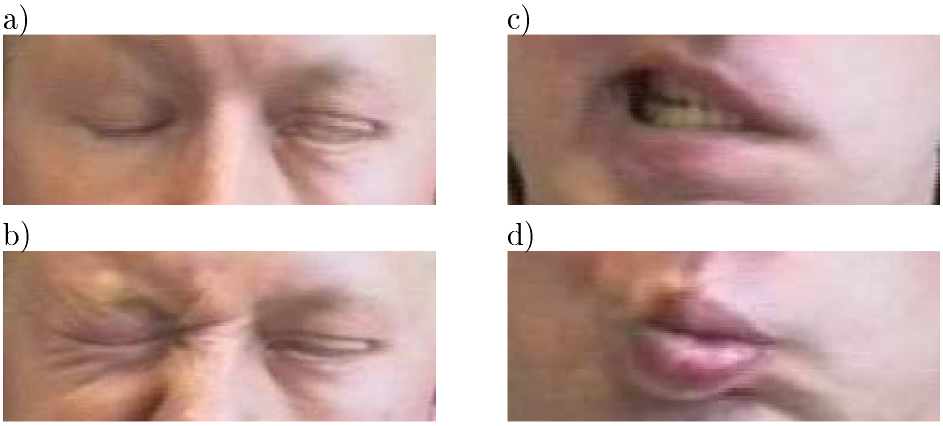

Fig. 1: Appearance of facialis paresis

face center $\boldsymbol{F}_M$ is calculated from $\boldsymbol{H}$, $\boldsymbol{N}_1$, and $\boldsymbol{N}_2$: ${}_x\boldsymbol{F}_M = \frac{{}_x\boldsymbol{H}+{}_x\boldsymbol{N}_1+{}_x\boldsymbol{N}_2}{3}$, and ${}_y\boldsymbol{F}_M = \frac{2{}_y\boldsymbol{H}+{}_y\boldsymbol{N}_1+{}_y\boldsymbol{N}_2}{4}$.

Starting from $\boldsymbol{F}_M$ five rays search the upper head silhouette in W(est), NW, N, NE and E direction. Every last point inside the foreground part (${}_id = 1$) is assumed to be a sampling point of the head outline. That gives the upper points $\boldsymbol{F}_1$ to $\boldsymbol{F}_5$ of the head silhouette. $\boldsymbol{F}_2$ to $\boldsymbol{F}_4$ are mirrored on the connection line of $\boldsymbol{F}_1$ and $\boldsymbol{F}_5$. The resulting points are $\boldsymbol{F}_8$, $\boldsymbol{F}_7$, and $\boldsymbol{F}_6$, which are estimates of the lower points of the head contour.

The next step is to localize the eyes' and the mouth's region inside the faces. We proceed as shown in Fig. 3. Fig. 3a) shows the edge strength representation of a human face. The eyes, nose and mouth appear lighter as they contain a higher amount of vertical gradient. With the optimization of the model parameters shown in Fig. 3b) the localization of the feature regions is performed. The goal of the optimization is to determine the model parameters in a way that the ratio of the edge energy inside the feature regions to the area of the regions is as large as possible. The optimization is performed in a sequential way. The eyes are found in the middle of the face and beneath the the eyes the nose/mouth region is found. For the optimization a simplex method with an adaptive random search initialization [1] is used. A localization result is given in Fig. 3c).

The last step is to localize the corners of the eyes and the mouth. We observe that those corners produce dark areas in the image compared with their surrounding. We use a search method to localize the corners of facial features: Starting at the outer columns of the determined feature regions we calculate the column's average gray value and compare it with the minimal gray value of the column. If the ratio of both values is lower than a given threshold, we assume that the position of the minimal gray value is the position of the angle of the facial feature.

### 3.2 Evaluation of Facial Asymmetries

In our system facial asymmetries are analyzed with averaging Gaussian masks [3, 7], a special kind of a steerable filter. The localized eye and mouth corners (Sect. 3.1) are used as keypoints of the Gaussian masks shown in Fig. 4. Fig. 4a) shows a averaging Gaussian mask. The extracted signatures $S_l^e, S_r^e, S_l^m$, and $S_r^m$ at the keypoints contain local orientation information of the surrounding of the eye and mouth corners (e.g. the opening angles of the mouth and the eyes). The orientation information is used to evaluate the asymmetries of the two halves of the face. Features for the asymmetry are the correlations of the left and right signatures extracted at the eyes' and mouth's angles. These features extracted from the correlation of the signatures will be used to classify the facial paresis.

### 3.3 Classification of Facial Paresis

Facial paresis is determined by the evaluation of the facial asymmetries. We assume that the asymmetries which can be observed in the case of the image ${}_1\boldsymbol{f}$ (patient with relaxed face) depend on illumination or anatomic facts which are not related to the paresis and therefore have to be ignored. This is done by normalizing the features extracted from the images ${}_2\boldsymbol{f}$ to ${}_5\boldsymbol{f}$ by those extracted from ${}_1\boldsymbol{f}$ (cf. Sect. 3.2). The normalization is done by calculating the ratios of the signature correlations. We get four ratios for the eye and the mouth region. If one of the ratios of the eye region is above a threshold, we assume facial paresis in the eye region. We proceed analogically for the mouth region.

## 4 Results

We tested our system with 19 persons (10 with paresis in the eye region, 12 with paresis in the mouth region). The problem was to decide whether the user has paresis in the eyes' and/or mouth's region or not. First experiments showed promising results.

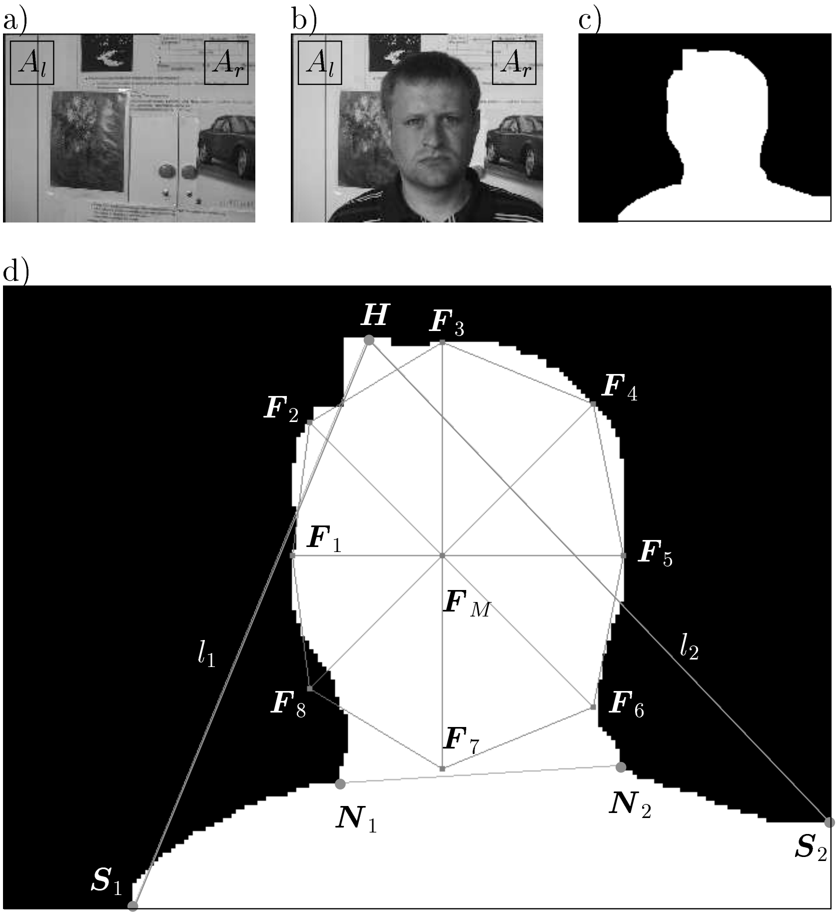


Fig. 2: Segmentation of the patient and localization of the face region.

7 of the 10 eyes and 10 of the 12 mouthes with paresis were recognized correctly. Also 8 of the 9 eyes and all 7 mouthes without paresis were recognized correctly.

## 5 Summary

We presented a system for diagnosis support of patients with single–sided facial paresis. Portrait images of a patient performing certain mimic exercises were analyzed with averaging Gaussian masks. The local structural information was used to evaluate the facial asymmetries inside the patient's face. The asymmetries where normed to avoid asymmetries as result from the illumination. If a feature representing the normed asymmetry exceeds a threshold the facial region is assumed to contain facial paresis.

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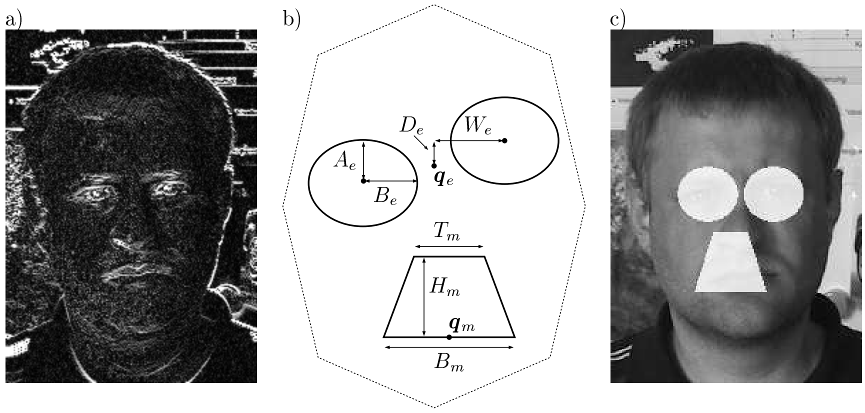


Fig. 3: Localization of facial features. a) Vertical edge strength representation of a face image. b) Parametric model for facial features. c) Localization results.

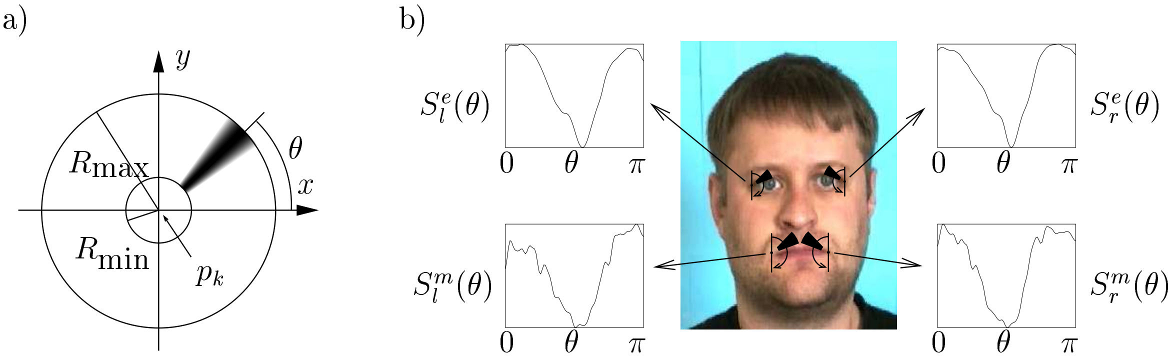


Fig. 4: Averaging Gaussian masks applied to a face.

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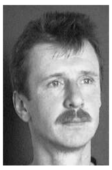

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