

# Schriftliche Prüfung aus Grundlagen der Digitalen Bildverarbeitung WS 2004

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Bitte tragen Sie Ihre Matrikelnummer und Ihren Namen in die dafür vorgesehenen Kästchen ein:

Prüfung aus <b>Grundlagen der Digitalen Bildverarbeitung</b> LV 183.126		
Mat.Nr.	Name	Datum: 30.1.2004

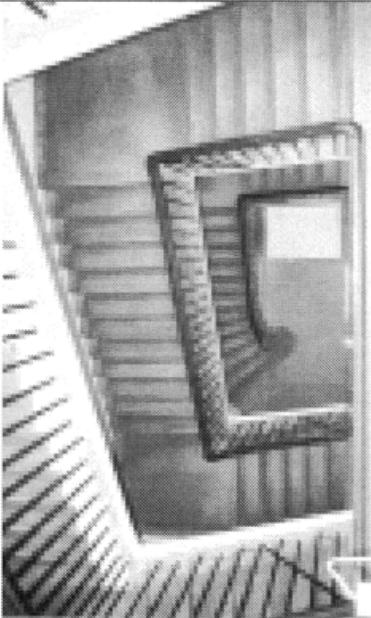
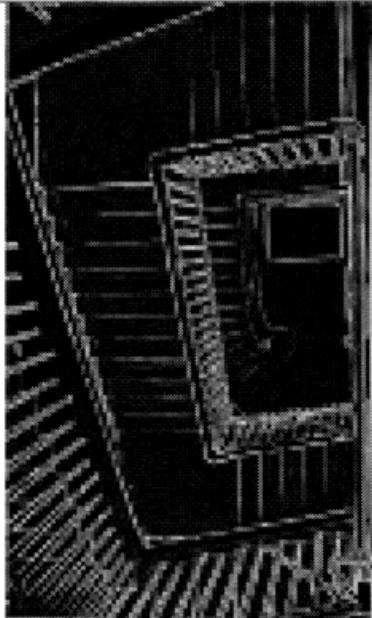
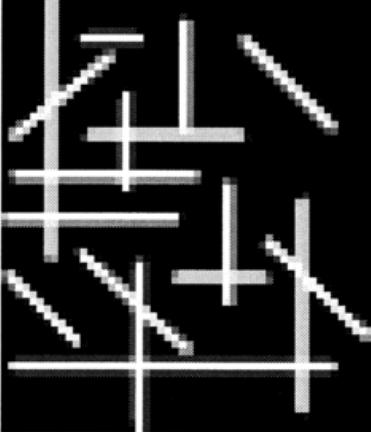
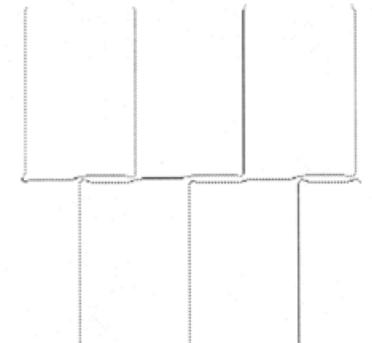
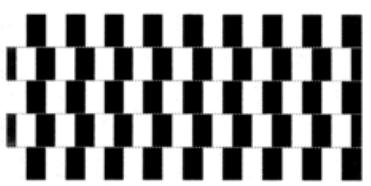
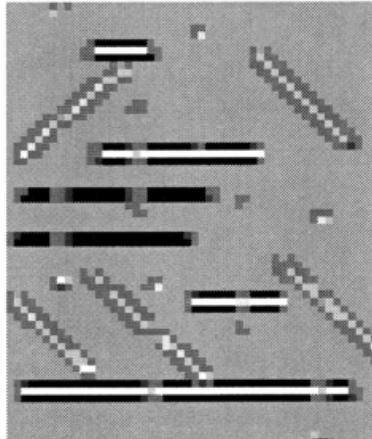
Diese Prüfung besteht aus drei Teilen auf die Sie insgesamt 50 Punkte erreichen können. Für besonders gute Begründungen können Zusatzpunkte erreicht werden. Die Dauer der Prüfung beträgt 90 Minuten. Es gilt der folgende Notenschlüssel:

Note:	1	2	3	4	5
Punkte:	> 42	37:42	31:36	25:30	0:24

## Teil I: Interpretation von Bildoperationen (20)

In den drei Abschnitten des ersten Teiles sollen Sie Ergebnisbilder über vorgegebene Operationen mit den gegebenen Eingabebildern in Beziehung setzen. Dabei können im Teil 1 mehrere Operationen am Zustandekommen des Resultats beteiligt sein, in den anderen beiden Abschnitten jeweils nur eine Operation. Beachten Sie, dass nicht immer ALLE Bilder und ALLE Operationen verwendet werden, es kann also auch Eingabebilder geben, die nicht als Ergebnis aufscheinen. Tragen Sie bitte rechts neben das Ergebnisbild die Nummer des Eingabebildes und den/die Buchstaben der Operationen in der entsprechenden Reihenfolge ein. Z.B. wenn das Ergebnis durch schrittweise Anwendung der Operationen D, A und C auf Bild 2 entstand, so tragen Sie **2 D A C** ein. Für entsprechend gute und korrekte Begründungen kann es Zusatzpunkte geben, die Verluste in anderen Abschnitten ausgleichen können!

# 1 Filter (4)

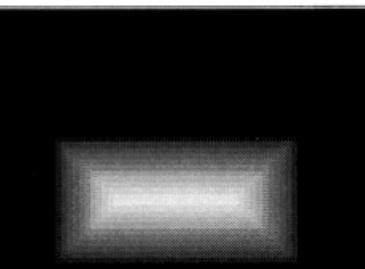
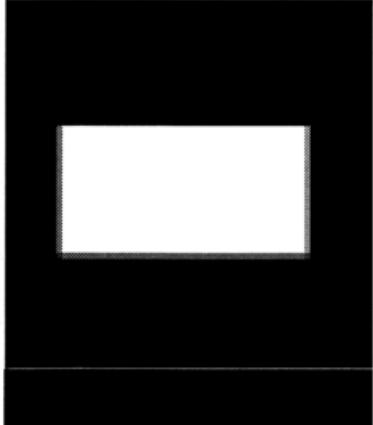
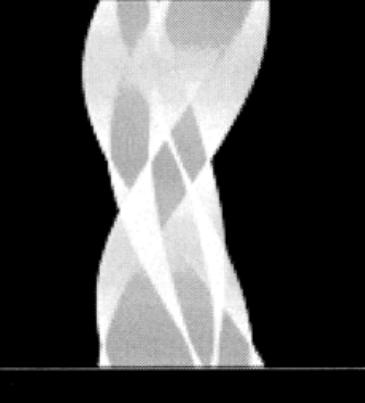
x	Eingabebild	O	Operation	Ergebnis =	$ x, O_1, O_2, \dots $
1			A Laplacian-of-Gaussian $* \begin{pmatrix} -1 & +2 & -1 \\ +2 & -4 & +2 \\ -1 & +2 & -1 \end{pmatrix}$		<input type="text"/>
2		D	$* \frac{1}{16} \begin{pmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{pmatrix}$		<input type="text"/>
3		E	$* \frac{1}{12} \begin{pmatrix} -1 & -1 & -1 \\ +2 & +2 & +2 \\ -1 & -1 & -1 \end{pmatrix}$		<input type="text"/>

Begründung 1: .....

Begründung 2: .....

Begründung 3: .....

## 2 Transformationen (8)

x	Eingabebild	O Transformation	Ergebnis =	$  \underline{x}   \underline{O}  $
1		A Medialachsen-		$  \underline{\quad}   \underline{\quad}  $
2		B Hough-		$  \underline{\quad}   \underline{\quad}  $
3		C Distanz-		$  \underline{\quad}   \underline{\quad}  $
4		D Fourier-		$  \underline{\quad}   \underline{\quad}  $

Begründung 1: .....

Begründung 2: .....

Begründung 3: .....

Begründung 4: .....

### 3 Binärbildverarbeitung (8)

x	Eingabebild	O	Operation	Ergebnis =	$  \underline{x}   \underline{O}  $
1		A	Dilate		$  \underline{\quad}   \underline{\quad}  $
2		B	Erode		$  \underline{\quad}   \underline{\quad}  $
3		C	Open (•)		$  \underline{\quad}   \underline{\quad}  $
4		D	Open (I)		$  \underline{\quad}   \underline{\quad}  $

Begründung 1: .....

Begründung 2: .....

Begründung 3: .....

Begründung 4: .....

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## Teil II: Numerisches Nachvollziehen (12)

In diesem Abschnitt sollen Sie einfache Bildverarbeitungsoperationen numerisch nachvollziehen.

## 4 Distanztransformation (8)

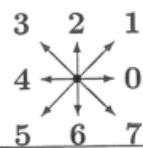
1. Tragen Sie bitte in die folgende  $8 \times 10$  Matrix  $d_{23}$  in Zeile 0, Spalte M (M ist die letzte Ziffer Ihrer Matrikelnummer)  $d_{23}(0, M) = 0$  ein.
  2. Füllen Sie diese Matrix mit den Distanzwerten der 2/3-Metrik  $d_{23}$  vollständig auf.

$d_{23}$	diskrete 2/3 Distanzen									
7										
6										
5										
4										
3										
2										
1										
Start → 0										
	0	1	2	3	4	5	6	7	8	9

3. Bestimmen Sie dann das **Histogramm** ( $d_{23}$ ) dieser Matrix:

4. Daraus läßt sich der Median bestimmen:

5. Zuletzt bestimme den Freeman chain code des diskreten Kreises mit Radius = Median. Um Löcher zu schliessen, werden auch um 1 größere Distanzwerte verwendet:



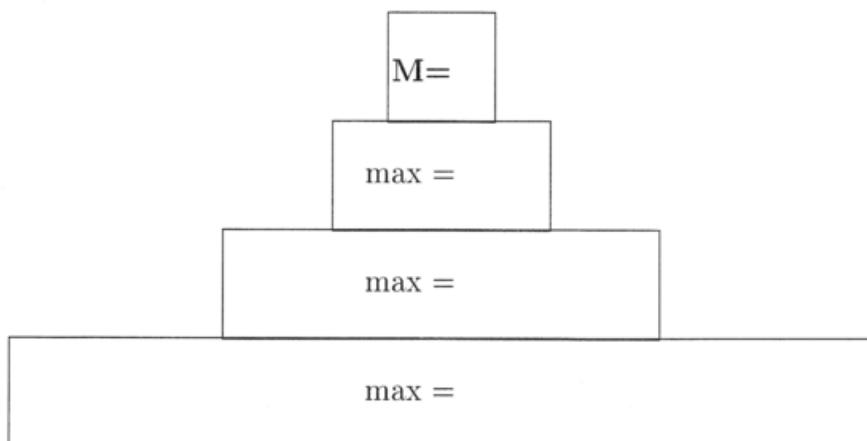
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## 5 $2 \times 2/4$ Mittelwertpyramide (4)

In Ebene 4 der  $2 \times 2/4$  Mittelwertpyramide (mit ganzzahliger Rundung) tritt der Wert M (= letzte Ziffer Ihrer Matrikelnummer) auf.

Ganzzahlige Rundung: z.B.  $[2.5] = 2$ ,  $[6.4] = 6$ ,  $[7.6] = 8$ .

Bestimme die grössten Grauwerte, die in den drei Ebenen darunter auftreten können:



Begründung: .....

.....

.....

.....

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### Teil III: Selektion von Literatur (18)

In der Beilage finden Sie drei Listen mit je 10 numerierten Titel, Abstracts und Keywords aus Artikeln einiger neuer Zeitschriften. Leider ist die Reihenfolge und die Zuordnungen der entsprechenden Beiträge verloren gegangen. Bitte stellen Sie in der folgenden Tabelle die inhaltlichen Zuordnungen wieder her und tragen pro Zeile jene drei Ziffern ein, die den Titel, das Abstract und die Keywords eines Artikels bezeichnen. Die Wahl ist in den ersten drei Zeilen dadurch eingeschränkt, daß der Titel, das Abstract bzw. die Keywords durch die letzten Ziffer Ihrer Matrikelnummer (M) festgelegt ist, die weiteren Entsprechungen können frei unter den restlichen Artikeln geählt werden. Die ersten 6 Korrespondenzen bestimmen die Punktzahl dieser Aufgabe (18), zwei weitere Korrespondenzen sind optional und können zusätzliche 6 Punkte bringen.

**Entsprechungen**

Titelnummer [0..9]	Abstract-Nr. [0..9]	Keywords-Nr. [0..9]
$M =$		
	$M =$	
		$M =$

## 6 Titel

0. Face detection and tracking in a video by propagating detection probabilities
1. A similarity metric for edge images
2. Moment computation for objects with spline curve boundary
3. Face recognition based on fitting a 3D morphable model
4. Comparison and combination of ear and face images in appearance-based biometrics
5. Rectilinearity measurements for polygons
6. Automatic facial expression analysis: a survey
7. A new method for representing and matching shapes of natural objects
8. Robust edge detection
9. Iris detection using intensity and edge information

## 7 Keywords

0. Shape representation; Shape matching; Object recognition; Object classification; Polar transformation; Contour extraction.
1. biometrics (access control); computer vision; face recognition; image recognition; performance evaluation; appearance-based biometrics; ear image comparison; experiments; face image comparison; face recognition; image recognition; multimodal recognition; principal component analysis; recognition performance.
2. Facial expression recognition; Facial expression interpretation; Emotion recognition; Affect recognition; FACS.
3. Edge detection; Robust statistics; Experimental design; Contrast test.
4. computational geometry; image processing; image reconstruction; closed polygon; computer vision; image processing; image reconstruction; perceptual grouping; photogrammetry; rectilinearity; shape measure; stereo reconstruction.
5. image recognition; interpolation; object recognition; splines (mathematics); complexity; explicit formulae; geometric moments; parametric curve; plane object; spline; spline curve boundary.
6. Face recognition; Iris detection; Facial features; Template matching; Hough transform.
7. edge detection; image matching; assignment problem; edge detection; edge images; image similarity; optimal matching; performance evaluation; pixel correspondence metric; weighted matching in bipartite graphs.
8. face recognition; image morphing; image representation; image texture; lighting; solid modelling; visual databases; 3D morphable model fitting; 3D shape; 3D space; CMU-PIE database; FERET database; computer graphics; face identification; face recognition; frontal views; illuminations; image database; image formation; image texture; pose variations; profile view; shadows; specular reflections; statistical morphable model.
9. face recognition; image sequences; condensation filter; face detection; face probabilities; face tracking; video sequence; zero order model.

## 8 Abstracts

0. The paper introduces a shape measure intended to describe the extent to which a closed polygon is rectilinear. Other than somewhat obvious measures of rectilinearity (e.g., the sum of the differences of each corner's angle from multiples of 90/spl deg/), there has been little work in deriving a measure that is straightforward to compute, is invariant under scale, rotation, and translation, and corresponds with the intuitive notion of rectilinear shapes. There are applications in a number of different areas of computer vision and photogrammetry. Rectilinear structures often correspond to human-made objects and are therefore justified as attentional cues for further processing. For instance, in aerial image processing and reconstruction, where building footprints are often rectilinear on the local ground plane, building structures, once recognized as rectilinear, can be matched to corresponding shapes in other views for stereo reconstruction. Perceptual grouping algorithms may seek to complete shapes based on the assumption that the object in question is rectilinear. Using the proposed measure, such systems can verify this assumption.
1. Edge detection is an important issue in computer vision and image understanding systems. Most conventional techniques have assumed Gaussian noise, and their performance could decrease with the departure of noise distribution from normality. In this paper, we present an edge detection approach using robust statistics. The edge structure is first detected by a robust one-way design model, and then localized by a robust contrast test. Finally, hysteresis thresholding is applied to yield the output edge map. To evaluate its performance, experiments were carried out on synthetic and real images corrupted with both Gaussian noise and a mixture of Gaussian and impulsive noise. The results show that the performance of the proposed edge detector is stable and reliable under severe impulsive noise conditions.
2. The performance of several discrepancy measures for the comparison of edge images is analyzed and a novel similarity metric aimed at overcoming their problems is proposed. The algorithm finds an optimal matching of the pixels between the images and estimates the error produced by this matching. The resulting Pixel Correspondence Metric (PCM) can take into account edge strength as well as the displacement of edge pixel positions in the estimation of similarity. A series of experimental tests shows the new metric to be a robust and effective tool in the comparison of edge images when a small localization error of the detected edges is allowed.
3. Researchers have suggested that the ear may have advantages over the face for biometric recognition. Our previous experiments with ear and face recognition, using the standard principal component analysis approach, showed lower recognition performance using ear images. We report results of similar experiments on larger data sets that are more rigorously controlled for relative quality of face and ear images. We find that recognition performance is not significantly different between the face and the ear, for example, 70.5 percent versus 71.6 percent, respectively, in one experiment. We also find that multimodal recognition using both the ear and face results in statistically significant improvement over either individual biometric, for example, 90.9 percent in the analogous experiment.

4. A new method for the representation and comparison of irregular two-dimensional shapes is presented. This method uses a polar transformation of the contour points about the geometric centre of the object. The distinctive vertices of the shape are extracted and used as comparative parameters to minimize the difference of contour distance from the centre. Experiments are performed, more than 39 000 comparisons of database shapes, provided by Sebastian et al. (ICCV (2001) 755), are made and the results are compared to those obtained therein. In addition, 450 comparisons of leaf shape are made and leaves of very similar shape are accurately distinguished. The method is shown to be invariant to translation, rotation and scaling and highly accurate in shape distinction. The method shows more tolerance to scale variation than that of Sebastian et al. (ICCV (2001) 755) and is less computationally intense.
5. This paper presents a new probabilistic method for detecting and tracking multiple faces in a video sequence. The proposed method integrates the information of face probabilities provided by the detector and the temporal information provided by the tracker to produce a method superior to the available detection and tracking methods. The three novel contributions of the paper are: 1) Accumulation of probabilities of detection over a sequence. This leads to coherent detection over time and, thus, improves detection results. 2) Prediction of the detection parameters which are position, scale, and pose. This guarantees the accuracy of accumulation as well as a continuous detection. 3) The representation of pose is based on the combination of two detectors, one for frontal views and one for profiles. Face detection is fully automatic and is based on the method developed by Schneiderman and Kanade (2000). It uses local histograms of wavelet coefficients represented with respect to a coordinate frame fixed to the object. A probability of detection is obtained for each image position and at several scales and poses. The probabilities of detection are propagated over time using a Condensation filter and factored sampling. Prediction is based on a zero order model for position, scale, and pose; update uses the probability maps produced by the detection routine. The proposed method can handle multiple faces, appearing/disappearing faces as well as changing scale and pose. Experiments carried out on a large number of sequences taken from commercial movies and the Web show a clear improvement over the results of frame-based detection (in which the detector is applied to each frame of the video sequence).
6. This paper presents a method for face recognition across variations in pose, ranging from frontal to profile views, and across a wide range of illuminations, including cast shadows and specular reflections. To account for these variations, the algorithm simulates the process of image formation in 3D space, using computer graphics, and it estimates 3D shape and texture of faces from single images. The estimate is achieved by fitting a statistical, morphable model of 3D faces to images. The model is learned from a set of textured 3D scans of heads. We describe the construction of the morphable model, an algorithm to fit the model to images, and a framework for face identification. In this framework, faces are represented by model parameters for 3D shape and texture. We present results obtained with 4,488 images from the publicly available CMU-PIE database and 1,940 images from the FERET database.

7. Over the last decade, automatic facial expression analysis has become an active research area that finds potential applications in areas such as more engaging human computer interfaces, talking heads, image retrieval and human emotion analysis. Facial expressions reflect not only emotions, but other mental activities, social interaction and physiological signals. In this survey, we introduce the most prominent automatic facial expression analysis methods and systems presented in the literature. Facial motion and deformation extraction approaches as well as classification methods are discussed with respect to issues such as face normalization, facial expression dynamics and facial expression intensity, but also with regard to their robustness towards environmental changes.
8. In this paper we propose a new algorithm to detect the irises of both eyes from a face image. The algorithm first detects the face region in the image and then extracts intensity valleys from the face region. Next, the algorithm extracts iris candidates from the valleys using the feature template of Lin and Wu (IEEE Trans. Image Process. 8 (6) (1999) 834) and the separability filter of Fukui and Yamaguchi (Trans. IEICE Japan J80-D-II (8) (1997) 2170). Finally, using the costs for pairs of iris candidates proposed in this paper, the algorithm selects a pair of iris candidates corresponding to the irises. The costs are computed by using Hough transform, separability filter and template matching. As the results of the experiments, the iris detection rate of the proposed algorithm was 95.3% for 150 face images of 15 persons without spectacles in the database of University of Bern and 96.8% for 63 images of 21 persons without spectacles in the AR database.
9. A new approach is proposed for computation of area and geometric moments for a plane object with a spline curve boundary. The explicit formulae are obtained for area and low order moment calculation. The complexity of calculation depends on the moment order, spline degree, and the number of control points used in spline representation. The formulae proposed use the advantage that the sequence of spline control points is cyclic. It allowed us to reduce substantially the number of summands in them. The formulae might be useful in different applications where it is necessary to perform measurements for shapes with a smooth boundary.