

Bjarne Kjær Ersbøll  
Kim Steenstrup Pedersen (Eds.)

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# Image Analysis

15th Scandinavian Conference, SCIA 2007  
Aalborg, Denmark, June 2007  
Proceedings

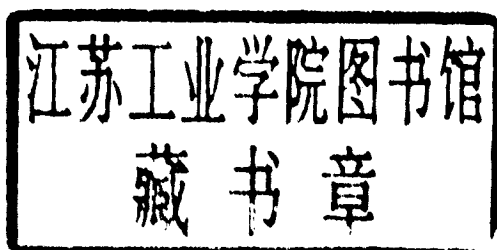
SCIA2007



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Aalborg, Denmark, June 10-14, 2007  
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# Preface

The present volume contains the proceedings of the Scandinavian Conference on Image Analysis, SCIA 2007, held at Hotel Hvide Hus, Aalborg, Denmark, June 10–14, 2007.

Initiated in 1979 by Torleiv Orhaug in Sweden, SCIA 2007 represented the 15th in the biennial series of conferences. It is arranged in turn by the Scandinavian countries of Sweden, Finland, Denmark, and Norway, making it a regional conference. However, judging by the nationalities of contributing authors and participants, it is also an international conference.

Worldwide, there is no lack of conferences on image analysis. Indeed, hardly a day passes without an announcement of yet another conference. Therefore the pattern recognition societies of the Scandinavian countries take particular pride in being able to continue the SCIA tradition. SCIA has indeed matured over the many years it has been in existence, but in our opinion SCIA has maintained flexibility and has been able to adopt and incorporate necessary changes and adjustments over that time span. An important key to the success of SCIA is the constant and continuing high quality of the scientific content. Furthermore, the relaxed and friendly atmosphere of the conference itself is well known within the community. The objective to keep in mind must be to continue along those lines.

The number of submissions for this year's event was an impressive 228. Of these, 99 can be found in the present proceedings, leading to an acceptance rate of 43%. In order to optimize the outcome for the participants, the conference was organized as a single track event. Thirty-three papers were presented in the oral sessions and 66 were presented in the poster sessions. Each paper was reviewed by at least two peers. Acceptance was based solely on these reviews. The papers can roughly be grouped into the following topics: computer vision; 2D and 3D reconstruction; classification and segmentation; medical and biological applications; appearance and shape modeling; face detection, tracking and recognition; motion analysis; feature extraction and object recognition. Two tutorials preceded the conference.

A conference is the result of careful planning and lots of work from numerous volunteers. It is important that we acknowledge these important contributions. We thank the invited speakers for enlightening us in their areas of research and the contributing scientists for their presentations. Furthermore, we thank the reviewers for the pleasant interaction during the review process and for the excellent work in helping to maintain the high quality of SCIA.

It is our sincere hope that the participants had an enjoyable and fruitful experience, both scientifically and socially, in Aalborg.

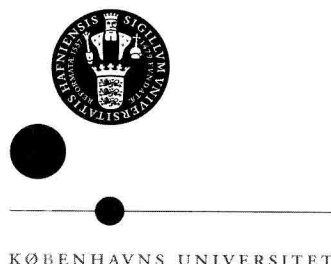
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SCIA 2007 was organized jointly by Aalborg University, the Technical University of Denmark (DTU), the Department of Computer Science at University of Copenhagen, and the IT University of Copenhagen.



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# Table of Contents

## Appearance and Shape Modeling

Accurate Interpolation in Appearance-Based Pose Estimation . . . . .	1
<i>Erik Jonsson and Michael Felsberg</i>	
Automatic Segmentation of Overlapping Fish Using Shape Priors . . . . .	11
<i>Sigmund Clausen, Katharina Greiner, Odd Andersen, Knut-Andreas Lie, Helene Schulerud, and Tom Kavli</i>	
Automatic Feature Point Correspondences and Shape Analysis with Missing Data and Outliers Using MDL . . . . .	21
<i>Kalle Åström, Johan Karlsson, Olof Enquist, Anders Ericsson, and Fredrik Kahl</i>	
Variational Segmentation of Image Sequences Using Deformable Shape Priors . . . . .	31
<i>Ketut Fundana, Niels Chr. Overgaard, and Anders Heyden</i>	

## Face Detection, Tracking and Recognition

Real-Time Face Detection Using Illumination Invariant Features . . . . .	41
<i>Klaus Kollreider, Hartwig Fronthaler, and Josef Bigun</i>	
Face Detection Using Multiple Cues . . . . .	51
<i>Thomas B. Moeshund, Jess S. Petersen, and Lasse D. Skalski</i>	
Individual Discriminative Face Recognition Models Based on Subsets of Features . . . . .	61
<i>Line H. Clemmensen, David D. Gomez, and Bjarne K. Ersbøll</i>	
Occluded Facial Expression Tracking . . . . .	72
<i>Hugo Mercier, Julien Peyras, and Patrice Dalle</i>	

## Medical and Biological Applications

Model Based Cardiac Motion Tracking Using Velocity Encoded Magnetic Resonance Imaging . . . . .	82
<i>Erik Bergvall, Erik Hedström, Håkan Arheden, and Gunnar Sparr</i>	
Fractal Analysis of Mammograms . . . . .	92
<i>Fredrik Georgsson, Stefan Jansson, and Christina Olsén</i>	
Reconstructing Teeth with Bite Information . . . . .	102
<i>Katrine Hommelhoff Jensen and Jon Sparring</i>	

Sparse Statistical Deformation Model for the Analysis of Craniofacial Malformations in the Crouzon Mouse ..... 112  
*Hildur Ólafsdóttir, Michael Sass Hansen, Karl Sjöstrand, Tron A. Darvann, Nuno V. Hermann, Estanislao Oubel, Bjarne K. Ersbøll, Rasmus Larsen, Alejandro F. Frangi, Per Larsen, Chad A. Perlyn, Gillian M. Morriss-Kay, and Sven Kreiborg*

**Computer Vision**

Monocular Point Based Pose Estimation of Artificial Markers by Using Evolutionary Computing ..... 122  
*Teuvo Heimonen and Janne Heikkilä*

Camera-to-Camera Mapping for Hybrid Pan-Tilt-Zoom Sensors Calibration ..... 132  
*Julie Badri, Christophe Tilmant, Jean-Marc Lavest, Quonc-Cong Pham, and Patrick Sayd*

Recursive Structure and Motion Estimation Based on Hybrid Matching Constraints ..... 142  
*Anders Heyden, Fredrik Nyberg, and Ola Dahl*

Efficient Symmetry Detection Using Local Affine Frames ..... 152  
*Hugo Cornelius, Michal Perd'och, Jiří Matas, and Gareth Loy*

**2D and 3D Reconstruction**

Triangulation of Points, Lines and Conics ..... 162  
*Klas Josephson and Fredrik Kahl*

Robust Variational Reconstruction from Multiple Views ..... 173  
*Natalia Slesareva, Thomas Bühler, Kai Uwe Hagenburg, Joachim Weickert, Andrés Bruhn, Zachí Karni, and Hans-Peter Seidel*

A Robust Approach for 3D Cars Reconstruction ..... 183  
*Adrien Auclair, Laurent Cohen, and Nicole Vincent*

Novel Stereoscopic View Generation by Image-Based Rendering Coordinated with Depth Information ..... 193  
*Maiya Hori, Masayuki Kanbara, and Naokazu Yokoya*

**Motion Analysis**

Using Hidden Markov Models for Recognizing Action Primitives in Complex Actions ..... 203  
*Volker Krüger and Daniel Grest*

Variational Segmentation Using Dynamical Models for Rigid Motion ...	213
<i>Jan Erik Solem and Anders Heyden</i>	

Context-Free Detection of Events .....	223
<i>Benedikt Kaiser and Gunther Heidemann</i>	

Supporting Structure from Motion with a 3D-Range-Camera .....	233
<i>Birger Streckel, Bogumil Bartczak, Reinhard Koch, and Andreas Kolb</i>	

## Feature Extraction and Object Recognition

Object Recognition Using Frequency Domain Blur Invariant Features ...	243
<i>Ville Ojansivu and Janne Heikkilä</i>	

Regularized Neighborhood Component Analysis .....	253
<i>Zhirong Yang and Jorma Laaksonen</i>	

Finding the Minimum-Cost Path Without Cutting Corners .....	263
<i>R. Joop van Heekeren, Frank G.A. Faas, and Lucas J. van Vliet</i>	

Object Class Detection Using Local Image Features and Point Pattern Matching Constellation Search .....	273
<i>Alexander Drobchenko, Jarmo Ilonen, Joni-Kristian Kamarainen, Albert Sadovnikov, Heikki Kälviäinen, and Miroslav Hamouz</i>	

## Classification and Segmentation

Image Segmentation with Context .....	283
<i>Anders P. Eriksson, Carl Olsson, and Fredrik Kahl</i>	

Improving Hyperspectral Classifiers: The Difference Between Reducing Data Dimensionality and Reducing Classifier Parameter Complexity ...	293
<i>Asbjørn Berge and Anne Schistad Solberg</i>	

A Hierarchical Texture Model for Unsupervised Segmentation of Remotely Sensed Images .....	303
<i>Giuseppe Scarpa, Michal Haindl, and Josiane Zerubia</i>	

A Framework for Multiclass Reject in ECOC Classification Systems ...	313
<i>Claudio Marrocco, Paolo Simeone, and Francesco Tortorella</i>	

Scale-Space Texture Classification Using Combined Classifiers .....	324
<i>Mehrdad J. Gangeh, Bart M. ter Haar Romeny, and C. Eswaran</i>	

## Poster Session 1

Multiresolution Approach in Computing NTF .....	334
<i>Arto Kaarna, Alexey Andriyashin, Shigeki Nakauchi, and Jussi Parkkinen</i>	

Generation and Empirical Investigation of *h<sub>v</sub>*-Convex Discrete Sets . . . . . 344  
*Péter Balázs*

The Statistical Properties of Local Log-Contrast in Natural Images . . . . . 354  
*Jussi T. Lindgren, Jarmo Hurri, and Aapo Hyvärinen*

A Novel Parameter Decomposition Approach for Recovering Poses of  
Distal Locking Holes from Single Calibrated Fluoroscopic Image . . . . . 364  
*Guoyan Zheng and Xuan Zhang*

Covariance Estimation for SAD Block Matching . . . . . 374  
*Johan Skoglund and Michael Felsberg*

Infrared-Visual Image Registration Based on Corners and Hausdorff  
Distance . . . . . 383  
*Tomislav Hrkać, Zoran Kalafatić, and Josip Krapac*

Watertight Multi-view Reconstruction Based on Volumetric  
Graph-Cuts . . . . . 393  
*Mario Sormann, Christopher Zach, Joachim Bauer,  
Konrad Karner, and Horst Bishof*

Grain Size Measurement of Crystalline Products Using Maximum  
Difference Method . . . . . 403  
*Leena Lepistö, Iivari Kunttu, Matti Lähdeniemi, Tero Tähti, and  
Juha Nurmi*

Robust Boundary Delineation Using Random-Phase-Shift Active  
Contours . . . . . 411  
*Astrit Rexhepi and Farzin Mokhtarian*

Accurate Spatial Neighborhood Relationships for Arbitrarily-Shaped  
Objects Using Hamilton-Jacobi GVD . . . . . 421  
*Sumit K. Nath, Kannappan Palaniappan, and Filiz Bunyak*

FyFont: Find-your-Font in Large Font Databases . . . . . 432  
*Martin Solli and Reiner Lenz*

Efficiently Capturing Object Contours for Non-Photorealistic  
Rendering . . . . . 442  
*Jiyoung Park and Juneho Yi*

Weighted Distances Based on Neighbourhood Sequences in  
Non-standard Three-Dimensional Grids . . . . . 452  
*Robin Strand*

Unsupervised Perceptual Segmentation of Natural Color Images Using  
Fuzzy-Based Hierarchical Algorithm . . . . . 462  
*Junji Maeda, Akimitsu Kawano, Sato Saga, and Yukinori Suzuki*

Line-Stepping for Shell Meshes .....	472
<i>Kenny Erleben and Jon Sporring</i>	
Nonlinear Functionals in the Construction of Multiscale Affine Invariants .....	482
<i>Esa Rahtu, Mikko Salo, and Janne Heikkilä</i>	
A New Fuzzy Impulse Noise Detection Method for Colour Images .....	492
<i>Samuel Morillas, Stefan Schulte, Etienne E. Kerre, and Guillermo Peris-Fajarnés</i>	
On Reasoning over Tracking Events .....	502
<i>Daniel Rowe, Jordi González, Ivan Huerta, and Juan J. Villanueva</i>	
FPGA Implementation of $k$ NN Classifier Based on Wavelet Transform and Partial Distance Search .....	512
<i>Yao-Jung Yeh, Hui-Ya Li, Wen-Jyi Hwang, and Chiung-Yao Fang</i>	
Affine Illumination Compensation for Multispectral Images .....	522
<i>Pedro Latorre Carmona, Reiner Lenz, Filiberto Pla, and Jose M. Sotoca</i>	
GPU-Based Edge-Directed Image Interpolation .....	532
<i>Martin Kraus, Mike Eissele, and Magnus Strengert</i>	
Graph-Based Range Image Registration Combining Geometric and Photometric Features .....	542
<i>Ikuko Shimizu, Akihiro Sugimoto, and Radim Šára</i>	
Automatic Identification and Validation of Tie Points on Hyperspectral Satellite Images from CHRIS/PROBA .....	553
<i>André R.S. Marçal</i>	
Boneless Pose Editing and Animation .....	562
<i>J. Andreas Bærentzen, Kristian Evers Hansen, and Kenny Erleben</i>	
Text Driven Face-Video Synthesis Using GMM and Spatial Correlation .....	572
<i>Dereje Teferi, Maycel I. Faraj, and Josef Bigun</i>	
Accurate 3D Left-Right Brain Hemisphere Segmentation in MR Images Based on Shape Bottlenecks and Partial Volume Estimation .....	581
<i>Lu Zhao, Jussi Tohka, and Ulla Ruotsalainen</i>	
Image Inpainting by Cooling and Heating .....	591
<i>David Gustavsson, Kim S. Pedersen, and Mads Nielsen</i>	
Evaluating a General Class of Filters for Image Denoising .....	601
<i>Luis Pizarro, Stephan Didas, Frank Bauer, and Joachim Weickert</i>	

Efficient Feature Extraction for Fast Segmentation of MR Brain Images .....	611
<i>László Szilágyi, Sándor M. Szilágyi, and Zoltán Benyó</i>	
Automated Mottling Assessment of Colored Printed Areas .....	621
<i>Albert Sadovnikov, Lasse Lensu, and Heikki Kälviäinen</i>	
Image Based Measurements of Single Cell mtDNA Mutation Load .....	631
<i>Amin Allalou, Frans M. van de Rijke, Roos Jahangir Tafrechi, Anton K. Raap, and Carolina Wählby</i>	
A PCA-Based Technique to Detect Moving Objects .....	641
<i>Nicolas Verbeke and Nicole Vincent</i>	
Page Frame Detection for Marginal Noise Removal from Scanned Documents .....	651
<i>Faisal Shafait, Joost van Beusekom, Daniel Keysers, and Thomas M. Breuel</i>	
<b>Poster Session 2</b>	
Representing Pairs of Orientations in the Plane .....	661
<i>Magnus Herberthson, Anders Brun, and Hans Knutsson</i>	
Improved Chamfer Matching Using Interpolated Chamfer Distance and Subpixel Search .....	671
<i>Tai-Hoon Cho</i>	
Automatic Segmentation of Fibroglandular Tissue .....	679
<i>Christina Olsén and Aamir Mukhdoomi</i>	
Temporal Bayesian Networks for Scenario Recognition .....	689
<i>Ahmed Ziani and Cina Motamed</i>	
Comparison of Combining Methods of Correlation Kernels in kPCA and kCCA for Texture Classification with Kansei Information .....	699
<i>Yo Horikawa and Yujiro Ohnishi</i>	
A Visual System for Hand Gesture Recognition in Human-Computer Interaction .....	709
<i>Matti-Antero Okkonen, Vili Kellokumpu, Matti Pietikäinen, and Janne Heikkilä</i>	
Single View Motion Tracking by Depth and Silhouette Information .....	719
<i>Daniel Grest, Volker Krüger, and Reinhard Koch</i>	
Face Recognition with Irregular Region Spin Images .....	730
<i>Yang Li, William A.P. Smith, and Edwin R. Hancock</i>	

Performance Evaluation of Adaptive Residual Interpolation, a Tool for Inter-layer Prediction in H.264/AVC Scalable Video Coding .....	740
<i>Koen De Wolf, Davy De Schrijver, Jan De Cock, Wesley De Neve, and Rik Van de Walle</i>	
3D Deformable Registration for Monitoring Radiotherapy Treatment in Prostate Cancer .....	750
<i>Borja Rodríguez-Vila, Johanna Pettersson, Magnus Borga, Feliciano García-Vicente, Enrique J. Gómez, and Hans Knutsson</i>	
Reconstruction of 3D Curves for Quality Control .....	760
<i>Hanna Martinsson, Francois Gaspard, Adrien Bartoli, and Jean-Marc Lavest</i>	
Video Segmentation and Shot Boundary Detection Using Self-Organizing Maps .....	770
<i>Hannes Muurinen and Jorma Laaksonen</i>	
Surface-to-Surface Registration Using Level Sets .....	780
<i>Mads Fogtmann Hansen, Søren Erbou, Martin Vester-Christensen, Rasmus Larsen, Bjarne Ersbøll, and Lars Bager Christensen</i>	
Multiple Object Tracking Via Multi-layer Multi-modal Framework .....	789
<i>Hang-Bong Kang and Kihong Chun</i>	
Colorimetric and Multispectral Image Acquisition Using Model-Based and Empirical Device Characterization .....	798
<i>Daniel Nyström</i>	
Robust Pseudo-hierarchical Support Vector Clustering .....	808
<i>Michael Sass Hansen, Karl Sjöstrand, Hildur Ólafsdóttir, Henrik B.W. Larsson, Mikkel B. Stegmann, and Rasmus Larsen</i>	
Using Importance Sampling for Bayesian Feature Space Filtering .....	818
<i>Anders Brun, Björn Svensson, Carl-Fredrik Westin, Magnus Herberthson, Andreas Wrangsjö, and Hans Knutsson</i>	
Robust Moving Region Boundary Extraction Using Second Order Statistics .....	828
<i>Astrit Rexhepi and Farzin Mokhtarian</i>	
A Linear Mapping for Stereo Triangulation .....	838
<i>Klas Nordberg</i>	
Double Adaptive Filtering of Gaussian Noise Degraded Images .....	848
<i>Tuan D. Pham</i>	
Automatic Extraction and Classification of Vegetation Areas from High Resolution Images in Urban Areas .....	858
<i>Corina Iovan, Didier Boldo, Matthieu Cord, and Mats Erikson</i>	

An Intelligent Image Retrieval System Based on the Synergy of Color and Artificial Ant Colonies . . . . .	868
<i>Konstantinos Konstantinidis, Georgios Ch. Sirakoulis, and Ioannis Andreadis</i>	
Filtering Video Volumes Using the Graphics Hardware . . . . .	878
<i>Andreas Langs and Matthias Biedermann</i>	
Performance Comparison of Techniques for Approximating Image-Based Lighting by Directional Light Sources . . . . .	888
<i>Claus B. Madsen and Rune E. Laursen</i>	
A Statistical Model of Head Asymmetry in Infants with Deformational Plagiocephaly . . . . .	898
<i>Stéphanie Lanche, Tron A. Darvann, Hildur Ólafsdóttir, Nuno V. Hermann, Andrea E. Van Pelt, Daniel Govier, Marissa J. Tenenbaum, Sybill Naidoo, Per Larsen, Sven Kreiborg, Rasmus Larsen, and Alex A. Kane</i>	
Real-Time Visual Recognition of Objects and Scenes Using P-Channel Matching . . . . .	908
<i>Michael Felsberg and Johan Hedborg</i>	
Graph Cut Based Segmentation of Soft Shadows for Seamless Removal and Augmentation . . . . .	918
<i>Michael Nielsen and Claus B. Madsen</i>	
Shadow Resistant Direct Image Registration . . . . .	928
<i>Daniel Pizarro and Adrien Bartoli</i>	
Classification of Biological Objects Using Active Appearance Modelling and Color Cooccurrence Matrices . . . . .	938
<i>Anders Bjorholm Dahl, Henrik Aanæs, Rasmus Larsen, and Bjarne K. Ersbøll</i>	
Estimation of Non-Cartesian Local Structure Tensor Fields . . . . .	948
<i>Björn Svensson, Anders Brun, Mats Andersson, and Hans Knutsson</i>	
Similar Pattern Discrimination by Filter Mask Learning with Probabilistic Descent . . . . .	958
<i>Yoshiaki Kurosawa</i>	
Robust Pose Estimation Using the SwissRanger SR-3000 Camera . . . . .	968
<i>Þigurjón Árni Guðmundsson, Rasmus Larsen, and Bjarne K. Ersbøll</i>	
Pseudo-real Image Sequence Generator for Optical Flow Computations . . . . .	976
<i>Vladimír Ulman and Jan Hubeník</i>	
<b>Author Index . . . . .</b>	<b>987</b>

# Accurate Interpolation in Appearance-Based Pose Estimation

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**Abstract.** One problem in appearance-based pose estimation is the need for many training examples, i.e. images of the object in a large number of known poses. Some invariance can be obtained by considering translations, rotations and scale changes in the image plane, but the remaining degrees of freedom are often handled simply by sampling the pose space densely enough. This work presents a method for accurate interpolation between training views using local linear models. As a view representation local soft orientation histograms are used. The derivative of this representation with respect to the image plane transformations is computed, and a Gauss-Newton optimization is used to optimize all pose parameters simultaneously, resulting in an accurate estimate.

## 1 Introduction

Object recognition and pose estimation can be done in several ways. In the bag-of-features approach, local coordinate frames are constructed around points of interest [5], [9], and features from each local frame vote for a certain object and pose hypothesis. In the model-based approach [2], [11], a geometrical model is fitted to the observed image. This approach is often very accurate, but requires a good initial guess and a manually constructed 3D model. Global appearance-based methods extract features from the appearance of the entire object and match these to training views in memory. Ever since [10], [7], the most common approach seems to be using PCA.

In this paper, we use an appearance-based method using full object views, but avoid PCA due to the global nature of this representation. The main goal is to maximize the accuracy of the pose estimate by interpolating between a limited number of training views. The interpolation method is based on representing the views with *channel-coded orientation* [3], [4], and optimizing all pose parameters (including position, rotation and scale in the image plane) simultaneously using a Gauss-Newton method. The method requires an initial guess, which in a real system could be obtained using your favorite fast but inaccurate bag-of-features approach.

---

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The motivation for using full object views is two-fold. The first reason is that once we have formed an initial object hypothesis, it makes sense to use as much image information as possible in order to get an accurate estimate. The second reason is that using full views, we can focus on the interpolation and view representation, and ignore other aspects like how to choose interest points and construct local frames in a bag-of-features approach. This makes it easier to compare different view representations. Similar interpolation techniques as proposed here should however be possible to integrate also in a bag-of-features framework.

In contrast to model-based methods, our approach requires no knowledge of 3D geometry in the system, and is in no way specific to 3D pose estimation. The training set could consist of any parameterized image set, e.g. a robotic arm in different configurations etc.

## 2 Algorithm

### 2.1 Pose Estimation

The appearance of an object is determined by the object state  $\mathbf{p} = [\theta, \phi, s, \alpha, x, y]$ . The parameters  $s, \alpha, x, y$  represent the scale, rotation and position of the object in the image plane and will be referred to as the *image parameters*  $\mathbf{p}_{\text{img}}$ . The two auxiliary angles  $\theta$  and  $\phi$  cover all pose variations not explained by rotation in the image plane and will be referred to as the *pose angles*  $\mathbf{p}_{\text{pose}}$ .

During training, we learn the appearance of the object given  $(\theta, \phi)$  using canonical image parameters. The result of the learning can be seen as a function  $\mathbf{f}$  that maps the pose angles to a predicted feature vector:

$$\hat{\mathbf{c}} = \mathbf{f}(\theta, \phi) . \quad (1)$$

During operation of the system, we maintain a current hypothesis of the object state, and cut out an image patch around the current  $(x, y)$  with rotation  $\alpha$  and size  $s$ . This can be formalized by a function

$$\mathbf{c} = \mathbf{g}(s, \alpha, x, y) \quad (2)$$

producing an observed feature vector from the image given certain image parameters. The pose estimation problem is now to find an object state  $\mathbf{p}_*$  which minimizes the difference between the observed and predicted feature vectors:

$$\mathbf{p}_* = \arg \min_{\mathbf{p}} \|\mathbf{r}(\mathbf{p})\|^2 \quad (3)$$

where

$$\mathbf{r}(\mathbf{p}) = \mathbf{f}(\theta, \phi) - \mathbf{g}(s, \alpha, x, y) . \quad (4)$$

This can be solved using your favorite optimization method. We use a Gauss-Newton method, with a simple backtracking line search [8]. The update step direction  $\mathbf{s}$  is given by

$$\mathbf{J}\mathbf{s} = -\mathbf{r} , \quad (5)$$