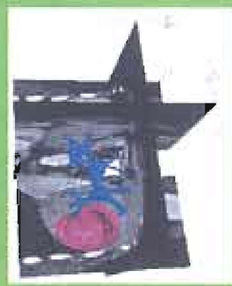
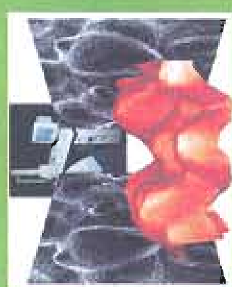
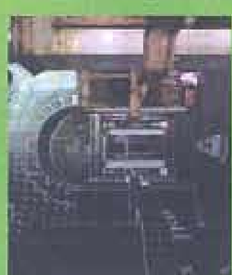
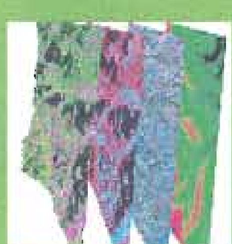
computer graphics & vision

www.icg.tu-graz.ac.at









1992 - 2002

Ten Year Anniversary

Institute for Computer Graphics & Vision

Table of Contents

Institute's Highlights

The Institute was started in October 1992 to cover Computer Graphics and Computer Vision in education and research at Graz University of Technology, an area that was new to the university at the time. Focal points are 3D-object reconstruction, 3D medical image analysis, robotic and industrial vision, augmented reality, 3D visualization and 3D objects on the Internet. Applications range from the Virtual Habitat with buildings and urban ensembles via manufacturing and medicine to environmental remote sensing with satellites and airborne sensors. A civil service staff of five scientific and two support positions forms the hard core, augmented by a considerable but variable number of additional staff supported by "soft money" through contracts with industry, administrative bodies and research grants.

Franz Leberl is Head of Institute since 1992. He is author of more than 200 publications, has won best paper and other awards from IEEE and the American Society for Photogrammetry and Remote Sensing, and is a Fellow of the IEEE. Franz Leberl is president of the Commission III (Theory and Algorithms) of the ISPRS, the International Society for Pattern Recognition and Remote Sensing.

For the period of 2000 – 2002, Franz Leberl is Chairman of the Studienkommission Telematik, which recently has adapted a new curriculum with Bachelor/Master-degrees. Since 2002, Prof. Leberl is also Chairman of the Studienkommission Software Development and Knowledge Management and was a main driver to create this new degree program.

What is „Computer Vision and Computer Graphics"?

Digital Processing of Visual Information
A Presentation of Sub-Themes and Fields

The following is an attempt at explaining the many sub fields and communities dealing with the computer processing of visual information. These sub fields often are separate specialties as documented by their own textbooks, scientific or engineering journals and international conference series.

Many of these fields or sub fields are brand new. This is not surprising, given the advent of a global software industry and the growing abilities of computers which have made it possible to deal with images and spatial objects in computers in a manner which only recently was entirely impossible.

A. PROCESSING OF VISUAL SENSOR DATA (VISION)

A.1 Applications- and Sensor-Neutral Areas

1. Image Processing
Digital manipulation of an image to aid feature visibility, to make measurements or alter image contents. From raw sensor signals to refined image data.
Most relevant conferences: ICIP International Conference on Image Processing

2. Image Understanding
Find semantic interpretations of images and visual scenes. Methods from Artificial Intelligence (AI) get applied to visual source data. Related concept: Cognitive Vision Systems.
Most relevant conferences: ACIVS Adv. Concepts for Intelligent Vision Systems
DARPA Image Understanding WS

3. Image Analysis

Evaluation of an image based on its features, and used for decision making. Focussing on iconic image representations and segmentations.

Most relevant conferences: CAIP (Computer Analysis of Images and Patterns)


4. Image Pattern Recognition

A process which identifies an object based on analysis of its features. Classification of image features created by Image Analysis methods

Most relevant conferences: ICPR (Int. Conf. On Pattern Recognition), CVPR (Computer Vision and Pattern Recognition)

5. Computer Vision

From signals to symbols using knowledge, often concerning 3-dimensional data and/or objects.

Most relevant conference series: ICCV (Int. Conf. on Computer Vision), ECCV (European Conference o Computer Vision)

6. Machine Vision
The use of devices for optical non-contact sensing to automatically receive and interpret an image of a real scene, in order to obtain information and/or control machines or processes.
Most relevant conferences: MVA (Machine Vision and Applications)

7. Robot Vision
Autonomous navigation of robots. Self-localization and mapping of a robot's environment. Manipulation of objects using visual data and a robot's manipulator. Action-perception cycle, visual servoing, telepresence
Most relevant conferences: RobVis, ICRA (Int. Conference on Robotics and Automation)

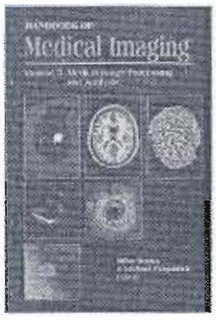
A.2 Applications- and Sensor-Inspired Areas

8. Industrial Vision
Quality control and measurements using machine vision methods.
Most relevant conferences: MVA (Machine Vision and Applications)

9. Medical Computer Vision

Addressing the analysis and interpretation of medical image data. A wide and growing range of sensor modalities (X-ray, nuclear, sound, tomography...). Processing of 3-dimensional voxels.

Most relevant conferences: SPIE Symposium on Medical Imaging



10. Photogrammetric Computer Vision

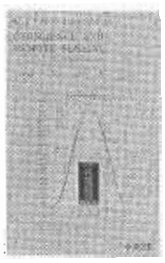
3D reconstruction from images of terrain surfaces and objects on the terrain, as well as of industrial and other objects, with an emphasis on high geometric accuracy. Very large images, airborne and space borne platforms carrying the sensors.

Most important conferences: International Congress for Photogrammetry and Remote Sensing; ISPRS-Symposia of its Commission III (e.g. PCV Photogrammetric Computer Vision).

11. Remote Sensing

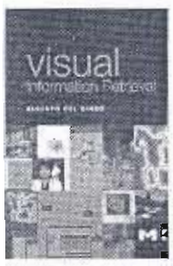
Image analysis and interpretation of remotely sensed images. Processing of multi-image sources, hyper-spectral sensor data, images of topographic surfaces, very large images, airborne and space borne sensors

Most important conferences: IEEEE Geoscience and Remote Sensing Symposium, SPIE Earth Observation Symposium, International Conference on Remote Sensing (ERIM Conference series).



12. Video Processing

Focussing on the processing and interpretation of streams of video data. Digital television, rapid image sequences at a small format, surveillance, image based retrieval.
Most important conferences: EC-VIP, EUROSIP (Conference on Video Image Processing and Conference on Multimedia Processing).



B. PROCESSING OF COMPUTER GENERATED VISUAL INFORMATION (GRAPHICS)

B.1 Applications Neutral Areas

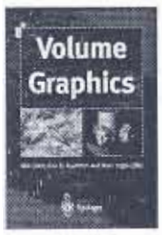
1. Computer Graphics

Computer-generated imagery, modeling pipelines, rendering, illumination, motion...
Most important conferences: ACM-SIGGRAPH, Eurographics

2. Animation

Motion of objects and viewers
Most relevant conferences: Computer Animation, Symposium on Computer Animation

3. Visualization
Visualizing data
Most relevant conferences: IEEE Visualization 2002, Symposium on Volume Visualization and Graphics



4. Virtual Reality
Computer-based sensory stimulation and interaction, tele presence, tele collaboration
Most important conferences: ACM Collaborative Virtual Environments, ACM Symposium on Virtual Reality Software and Technology

5. Augmented and Mixed Reality
Real and computer-generated worlds interact.
Most relevant conferences: IEEE and ACM International Symposium on Augmented Reality (ISAR).

6. Human-Computer Interaction
Immersive and non-traditional man-machine interaction, face and gesture tracking
Most relevant conferences: Int. Conference on Human Computer Interaction

7. Image-Based Modeling and Rendering
3D object models from visual sensor sources.
Most relevant conferences: EGRW – Europgraphics Rendering Workshop

8. Web-Based Graphics
Geometric and visual data over the Internet
Most relevant conferences: Web 3D Symposion

9. Spatial Information Systems
Geometric data bases associated with 2 or more dimensions
Most relevant conferences: Web Information Systems Engineering

B.2 Applications-Inspired Areas

1. Geographic Information Systems
Topographic and urban spaces, Dimensions: 2d (traditional), 2.5d (one z-value for each x,y-location), 3d, 4d (including time...)
Most relevant conferences: IEEE Colloquium on Latest Developments in GIS, IEEE International Conference on Data Mining ICDM

2. Picture Archiving and Communications Systems (PACS)
Medical application connecting patients with their visual data and medical analyses
Most relevant conferences: Medical Imaging and Augmented Reality, 3-D Imaging Techniques for Medicine

3. Multi-Media Systems
Increasingly visual systems of storing, editing, retrieveing and presenting spatial and spatial information
Most relevant conferences: ACM Multimedia, International Conference on Web Delivering of Music

4. Entertainment Graphics & Entertainment Technology
Advertisement, Computer Art
Most relevant conferences: GDC – Game Developers Conference

5. Simulation
Geometric and texture data, displays, immersion, ...
Most relevant conferences: Behavioral Modeling and Simulation, BMAS 2001, 2002.

6. Computer-Aided Design (CAD)
Mechanical, architectural, civil engineering drawing and design
Most relevant conferences: CADSM 2001. The Experience of Designing and Application of CAD Systems in Microelectronics.

7. Computer-Integrated Manufacturing (CIM)
Integration of graphics and vision systems on the factory floor
Most relevant conferences: IEEE Colloquium on Human Factor in CIM; HCI: Issues for the Factory

Awards and Distinctions at ICG

Franz Leberl:

- NASA Achievement Award for Magellan Science (1992)
- Fellow of the IEEE (1996)
- Presidential Citation by the American Society for Photogrammetry and Remote Sensing (ASPRS) (2000)

Joachim Bauer:

- ÖAGM Best Paper Award 2001, for paper "A two stage approach to Contour Matching"

Regine Bolter:

- ÖAGM Best Presentation Award 2000, for presentation "Shape-from-Shadow Building Reconstruction from Multiple View SAR Images"

Hermann Borotschnig:

- Best demonstration award at the British Machine Vision Conference in 1998, for paper "Apearance-based Active Object Recognition"

Andrej Ferko:

- ITTT 2001 conference Best Presentation Award for paper, "Information technology power aspects"
- Union of Slovak Mathematicians & Physicists Diploma for Longstanding Valuable Organizing of Scientific Life, 2002

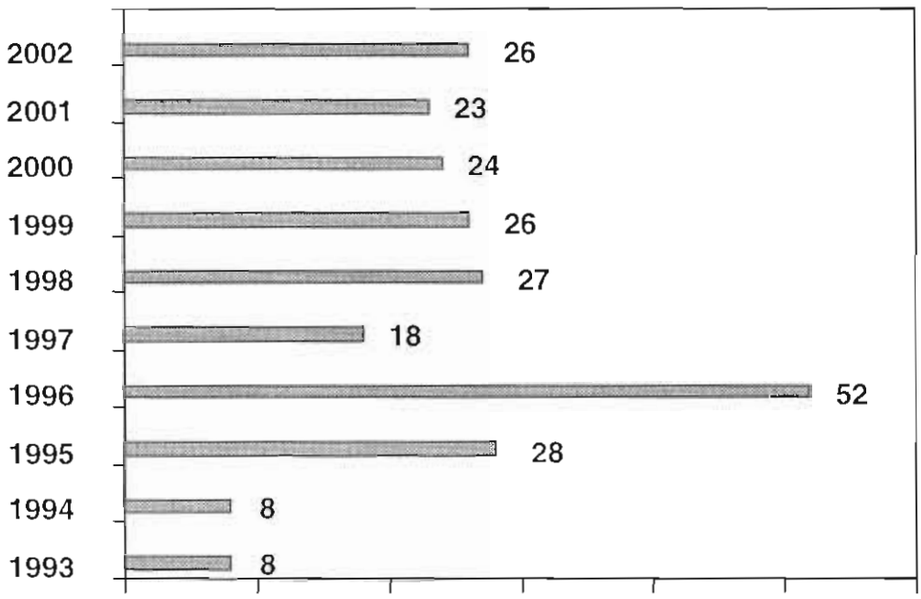
Markus Grabner:

- The Springer Best SCCG 2000 presentation award for paper "Consistency of the VDPM Framework"
- SCCG 2001 Conference Springer best papers award for paper "Smooth High-quality Interactive Visualization"
- OCG Förderpreis 2001 for diploma-thesis "Multiresolution based on View-dependent Progressive Meshes"

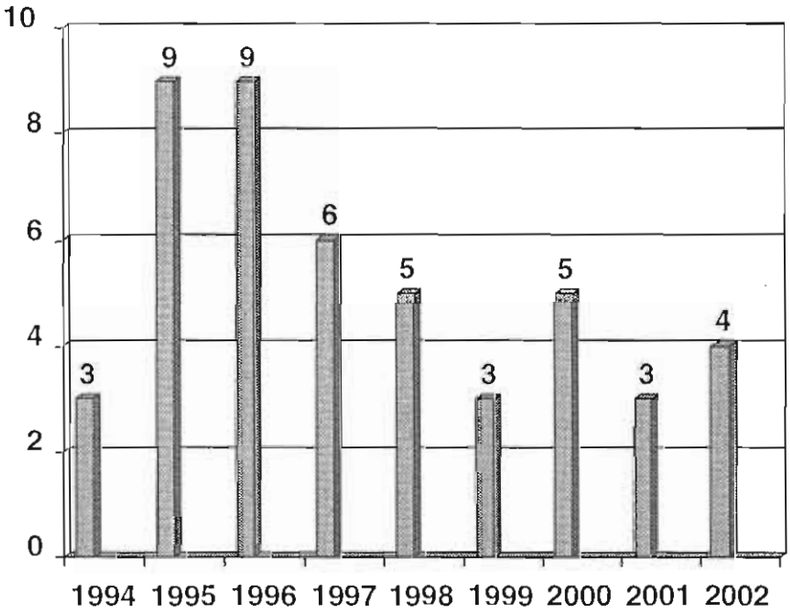
Stefan Scherer:

- ÖAGM Best Paper Award 1999, for paper ""Surface Reconstruction using Photometric Ratios of Backscatter Electron Images"

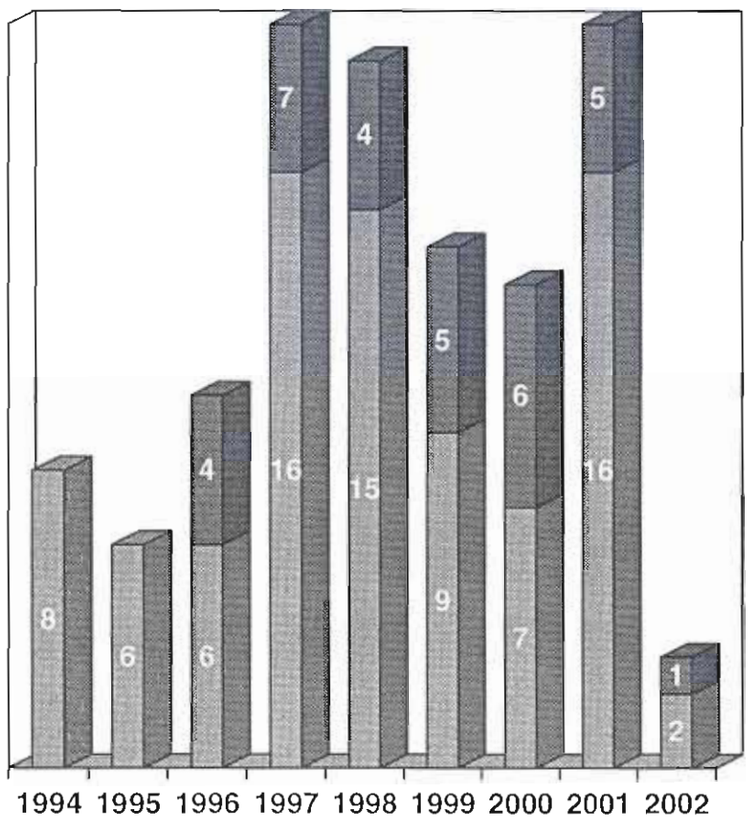
Publications



Guest Scientists



Finished Diploma and Doctoral Theses



Diploma theses 1992 - 2002: 85
Doctoral theses 1992 - 2002: 32

Actual Members of Staff

Professors & Guest Professors
Leberl Franz
Bischof Horst
Ferko Andrej

Lecturers and Associates with Habilitation
Pinz Axel

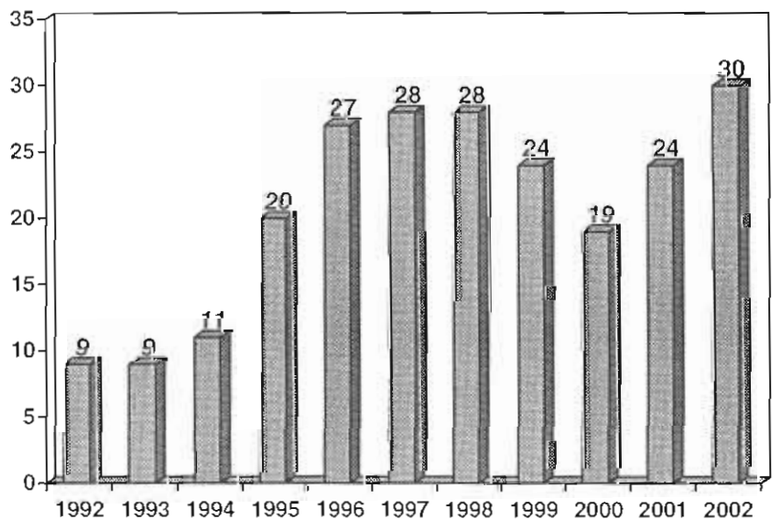
Assistant Professors & Scientific Assistants
Beichel Reinhard
Grabner Markus
Bornik Alexander
Fraundorfer Friedrich

Administrative & Technical Staff
Hönel Renate
Zunegg Andrea
Meszaric Silke
Wurm Andreas

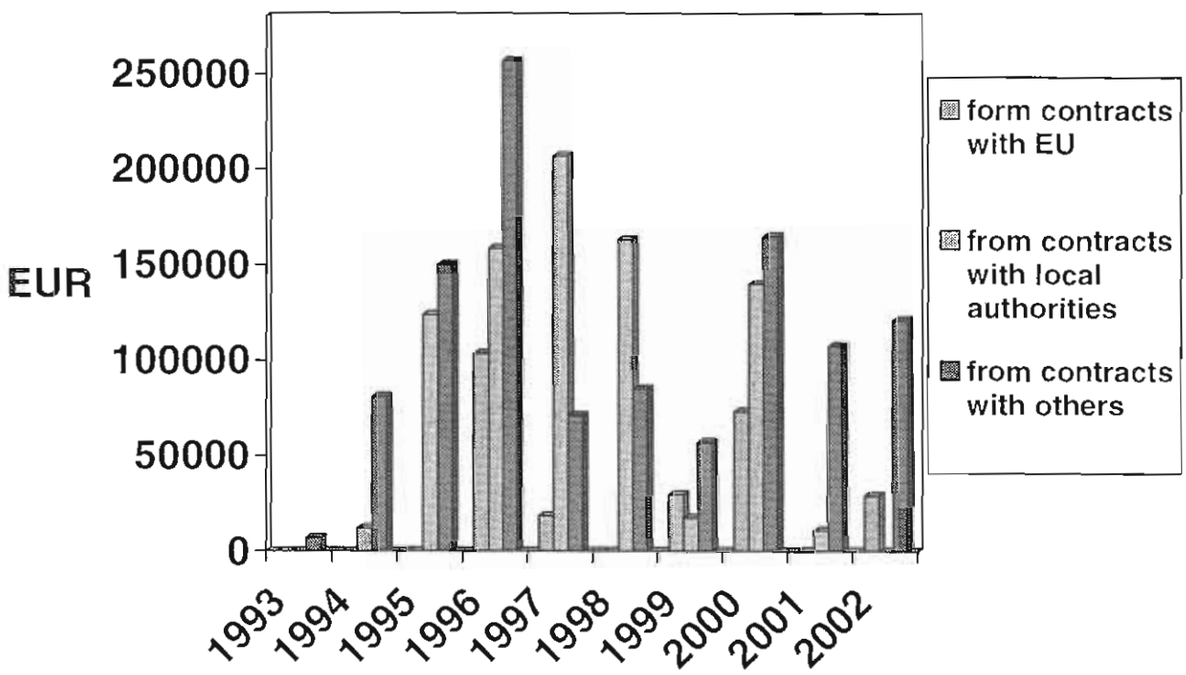
Project Staff (Full Time)
Bauer Joachim
Danzl Reinhard
Elbischger Pierre
Fernandez Gustavo
Kalliany Rainer
Karner Konrad
Klaus Andreas
Perko Roland
Reitinger Bernhard
Schindler Konrad
Sengel Martin
Urschler Martin
Zach Christopher

Project Staff (Part Time)
Gruber Barbara
Rüther Matthias
Schwann Günther
Sormann Mario
Zotter Benjamin

Overview Staff 1992 – 2002



Project money from different sources



Partners, Cooperations and Customers

National

- ABIS-Softwareentwicklung GmbH., Graz
- Amt der Steiermärkischen Landesregierung
- Akademie der Wissenschaften, Weltraumforschung, Vienna
- Alicona Imaging GmbH
- Arge Digitplan, Graz
- AutomationX GmbH, Grambach
- AVL List, Graz
- Austrian Research Center Seibersdorf
- Böhler-Uddeholm, Kapfenberg
- Bundesamt für Eich- und Vermessungswesen, Vienna
- Bundesministerium für Bildung, Wissenschaft und Kultur
- Bundesministerium für Verkehr, Innovation und Technologie
- BT-Anlagenbau GmbH u. CoKG, Gleisdorf
- Cure Center for Usability Research Engineering, Wien
- Erich-Schmidt-Institut, Montanuniversität Leoben
- European Center for Parallel Computing (VCPC), Vienna
- Funder, St. Veit/Glan
- Hisoft Automatisierungs- und Informationstechnik GmbH
- Geodata Ziviltechniker GmbH, Leoben
- GHS Global Home System Telekommunikation AG, Wien
- Graz Institut für Baustatik, TU Graz
- Grips Electronic GmbH., Graz
- Imagination Services GmbH, Wien
- Institut für Felsmechanik und Tunnelbau, TU Graz
- Institut für Elektrische Messtechnik und Messsignalverarbeitung, TU Graz
- Joanneum Research, Institut für Digitale Bildverarbeitung, Graz
- Joanneum Research, Institut für Informationsverarbeitung, Graz
- Johannes Kepler Universität Linz, Institut für Systemwissenschaften
- K. Fink GmbH, Leibnitz
- Landeskrankenhaus Graz, Abt. für Allgemeine Radiologie und klinische Diagnostik
- Magistrat Graz, Stadtvermessungsamt
- Magistrat Graz, Umweltamt
- Magistrat Wien, Abteilung ADV
- Mischek Ziviltechniker GmbH, Wien
- M&R Automatisierung von Industrievorlagen, Graz
- No Limits GmbH, Graz
- Österreichische Nationalbank, Vienna
- ÖFAI, Austrian Research Institute for Artificial Intelligence, Wien
- Projektgruppe „Fernerkundung" BM:BWK with 50 partners
- Projekt MISSION with 16 Teams
- Schuster, St. Radegund
- Sattler, Thondort
- Silicon Graphics Computer GmbH, Wien
- Skidata, St.-Leonhard
- Steyr-Daimler-Puch Fahrzeugtechnik, Graz
- Technische Universität Wien, Institut für Computergraphik
- Technische Universität Wien, Institut für Automation
- Tiani Medgraph AG, Brunn am Gebirge
- Universität Innsbruck, Institut für Meteorologie und Geophysik
- Universität Wien, Augenklinik
- Universität Wien, Dermatologie
- Universität Wien, Institut für Softwaretechnologie und Parallele Systeme
- Universitätsklinik für Radiologie, Abt. für Digitale Information und Bildverarbeitung
- Wall, Graz
- Velox Bau Systeme, Maria Rojach
- Vexcel Imaging GmbH, Graz
- Zumtobel Licht AG, Dornbirn

Partners, Cooperations and Customers

International

- Aalborg University, Aalborg (DK)
- DLR - Deutsche Forschungsanstalt für Luft- und Raumfahrt, Oberpfaffenhofen (D)
- Carnegie Mellon University (USA)
- Comenius University, Bratislava (SK)
- Czech Technical University, Prag (CZ)
- Daimler Chrysler Aerospace, Friedrichshafen (D)
- Eidgenössische Technische Hochschule (ETH), Zürich, (CH)
- EU-Project ICIM with Partners in Bulgaria, Slovakia, Germany
- EU-Project ORFEAS with 5 European Teams
- EU-Project VIRGO with 10 European Teams
- EU-Project MURALE with 4 European Teams
- Forschungszentrum Informationstechnik GmbH, St. Augustin (D)
- Infobyte, s.r.l., Rome (I)
- INRIA, Sophia-Antipolis (F)
- Institut Cartographic de Catalunya, Barcelona (E)
- International Institute for Aerospace Surveys and Earth Sciences, Enschede (NL)
- Joint Research Center (JRC), Ispra (I)
- NASA-Headquarters, Planetary Data System (USA)
- NASA, Jet Propulsion Laboratory (USA)
- Politecnico di Milano (I)
- Rheinische Friedrich-Wilhelms-Universität, Bonn (D)
- Royal Institute of Technology, CVAP Lab (S)
- Syseca S.A. Thompson-CSF, Paris (F)
- The Aristotle University of Thessaloniki (GR)
- Technische University Munich, Photogrammetry (D)
- Telecom Paris, Image Department (F)
- University College London, Dept. of Photogrammetry (UK)
- Universita degli Studi di Napoli Federico II, Neapel (I)
- University College Berkley (USA)
- University of Coloroado, Boulder (USA)
- University of Copenhagen (DK)
- University of Genova (I)
- University of Iowa, Iowa City (USA)
- University of Padua (I)
- University of Ljubljana (SI)
- University of Maribor (SI)
- Technische Universität München (D)
- Universität Hannover (D)
- Universität Zürich (CH)
- Vexcel Corporation Boulder (USA)
- Vexcel Imaging Corporation, Boulder (USA)

3D MURALE: Three-dimensional measurement and virtual reconstruction of ancient lost worlds in Europe

An international team of multimedia content creators is developing and using 3D Multimedia tools to measure, reconstruct and visualize archaeological ruins in virtual reality using as a test case the ancient city of Sagalassos in Turkey.

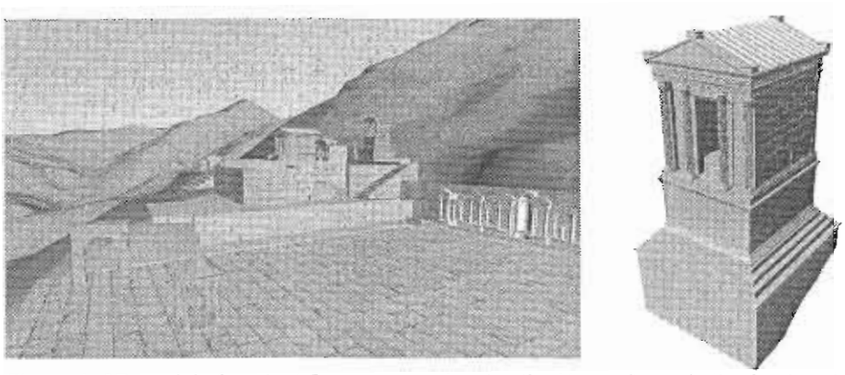


Figure 1: 3D model of ancient Sagalossos, showing the Upper Agora in the front and the Augustan northwest Heroon in the back (left image), detail view of Heroon (right image)

The new multimedia technologies will produce rich new ways of recording, cataloguing, conserving, restoring and presenting archaeological artefacts, monuments and sites. These technologies are used to model the Sagalassos site and show how they can be used for preserving and presenting the cultural heritage of Europe in two important ways: Firstly, by putting such new technologies in the hands of the archaeologists themselves rather than creating multimedia content after the excavations. As an important consequence, a more complete record of the finds can be created and presented to the public.
Secondly, by presenting the site not as a static entity from a long-gone past, but as a vibrant place that underwent a lot of changes throughout its existence. This includes the visualization of the situation in different eras or phases and of the excavation as they proceeded through different time layers. Both these aspects of the project will help to produce records and visualizations that are more complete and scientifically precise.

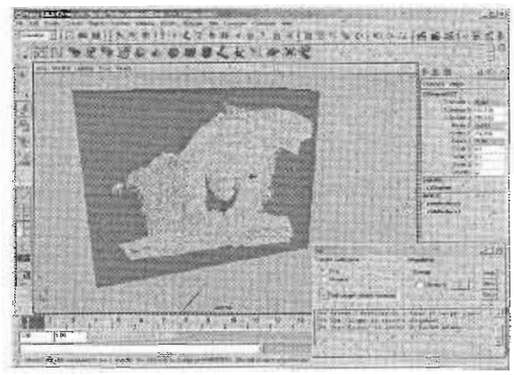


Figure 2: Screenshot of the "MMI"-interface for MAYA, showing the combination of a user-generated piece with a Medusa head from the Antonine Nympaeum.

The Institute for Computer Graphics and Vision is responsible for two tasks within this EU-funded project:

1. Automatic generation of 3D models of archaeological building blocks and artefacts from images taken with a digital consumer camera. Automation of the photogrammetric modeling process allows fast and detailed documentation of the archaeological finds, while still providing correct models with quantitatively estimated uncertainties for measurement purposes. Interfaces for interactive 3D building and scene reconstruction and storage of the reconstructions in the 3D MURALE database support the task of virtual reconstruction and provide input for the visualization systems.
2. The 3D-models created by the recording and reconstruction tools should not only be available to experts on site, but also to their colleagues all over the world as well as to interested people with little or no archaeological knowledge. The visualization system is designed to work even with low-bandwidth internet connections and on machines without powerful graphics hardware. This involves techniques such as geometry compression, progressive transmission, and multiresolution visualization.

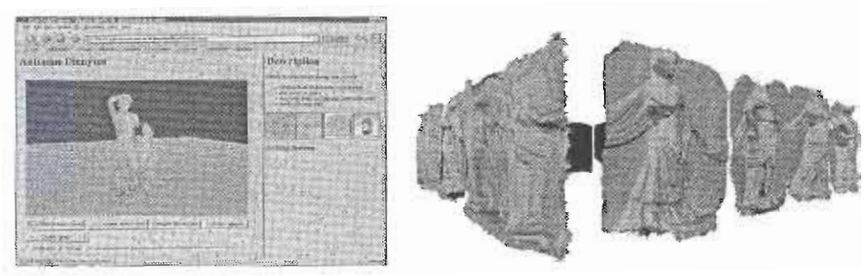


Figure 3: Screenshot of the "WebCAME"-plugin, showing a Dionysos and satyr marble statue from the Antonine Nymphaeum of the Upper Agora at Sagalassos (left image), reconstruction of the frieze of dancing girls originally belonging to the upper part of the socle of the Augustan northwest Heroon of Sagalassos (right image)

Publications:

1. Joachim Bauer, Konrad Schindler, and Konrad Karner. Plane parameter estimation by edge set matching. In *Proceedings Annual Conference of the Austrian Association for Pattern Recognition (AAPR)*, pages 29-36, Graz, Austria, September 2002.
2. John Cosmas, Take Itegaki, Damian Green, Edward Grabczewski, Fred Weimer, Luc Van Gool, Alexy Zalesny, Desi Vanrintel, Franz Leberl, Markus Grabner, Konrad Schindler, Konrad Karner, Michael Gervautz, Stefan Hynst, Marc Waelkens, Marc Pollefeys, Roland DeGeest, Robert Sablatnig, and Martin Kampel. 3D MURALE: A multimedia system for archaeology. In *Proceedings ACM Virtual Reality, Archaeology and Cultural Heritage (VAST 2001)*, November 2001.
3. John Cosmas, Take Itegaki, Damian Green, Edward Grabczewski, Fred Weimer, Luc Van Gool, Alexy Zalesny, Desi Vanrintel, Franz Leberl, Markus Grabner, Konrad Schindler, Konrad Karner, Michael Gervautz, Stefan Hynst, Marc Waelkens, Marc Pollefeys, Roland DeGeest, Robert Sablatnig, and Martin Kampel. A novel multimedia system for archaeology. In *Forum International des Musees*, 2002.
4. Markus Grabner. Advanced techniques for interactive visualization of multi-resolution meshes. *The Journal of Visualization and Computer Animation*, 12(5):241-252, 2001.
5. Markus Grabner. Smooth high-quality interactive visualization. In Tosiyasu L. Kunii, editor, *Proceedings of SCCG 2001*, pages 139-148. Comenius University, Bratislava, April 2001. ISBN 80-223-1606-7.

6.Markus Grabner. Compressed adaptive multiresolution encoding. *Journal of WSCG*, 10(1):195-202, February 2002. ISSN 1213-6972.
7.Markus Grabner. Feature preservation in view-dependent multiresolution meshes. In Alan Chalmers, editor, *Proceedings of SCCG 2002*, pages 153-162. Comenius University, Bratislava, April 2002. ISBN 80-223-1730-6.
8.Markus Grabner. Tree balancing for mesh simplification. In Isabel Navazo and Philipp Slusallek, editors, *Eurographics 2002 Short Presentations*, pages 61-69, September 2002.
9.Markus Grabner, Günter Schwann, Mario Sormann, Konrad Schindler, and Stefan Hynst. Navigation in virtual reality cultural heritage sites. In *First international workshop on 3D cultural heritage*, October 2002.
10.Konrad Schindler, Joachim Bauer, and Horst Bischof. MDL selection for piecewise planar reconstruction. In *Proceedings Annual Conference of the Austrian Association for Pattern Recognition (AAPR)*, pages 13-20, Graz, Austria, September 2002.
11.Konrad Schindler and Markus Grabner. From mental model to virtual monument. In *Proceedings CIPA Symposium*, September 2001.
12.Konrad Schindler. Spatial subdivision for piecewise planar object reconstruction. In *Proceedings SPIE Electronic Imaging 2003 – Videometrics VIII*, Sta. Clara, CA, to appear.

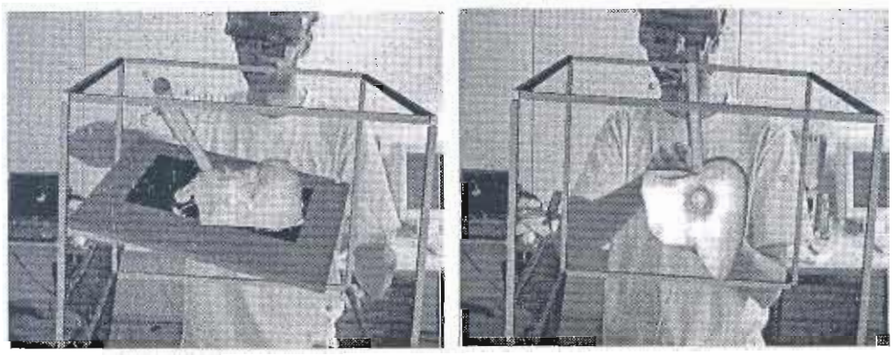
Medical Image Analysis and Augmented Reality

Modern medical imaging modalities like X-ray computed tomography (CT) or magnetic resonance imaging (MRI) allow to image inner organs of the human body in 3D. CT and MRI data are used by physicians for various kinds of diagnostic tasks as well as for planning of surgical interventions. To do so, preparation of the 3D data sets is needed. Considering the large amount of data, this step can be quite challenging and very time consuming, if done manually. Our research in this area focuses on the development of algorithms that are capable of segmenting organs or structures of interest in an highly automated fashion. We also utilize our expertise in computer graphics, especially in the field of Augmented Reality (AR), for building user interfaces that can be used in an easy and intuitive way, thus quickly providing physicians with the information they need. Beside the advantages that Augmented Reality has to offer for collaborative user interaction with virtual 3D objects, it's also well suited for Telemedicine applications, allowing experts to join physicians at remote locations for complicated diagnosis and surgical planning tasks.

Selected Projects:

- **Virtual Liver Surgery Planning**

Resection is the treatment of choice for patients suffering from liver tumors. In order to ensure sufficient liver functionality following surgery and to enhance detailed surgery planning it is necessary to identify the involved liver segments, the tumor's size, and the topographic relationship between tumor and blood vessels. The main source of information are cross sectional imaging modalities such as X-ray computed tomography (CT). The radiologist must combine the information of the cross sectional images to provide the surgeons with information about the 3D topology of the liver. This process is difficult, tedious, and time consuming. A combination of medical computer vision and computer graphics allows for the development of a liver surgery planning system that provides a better visualization and helps to unleash the full potential of surgical methods.

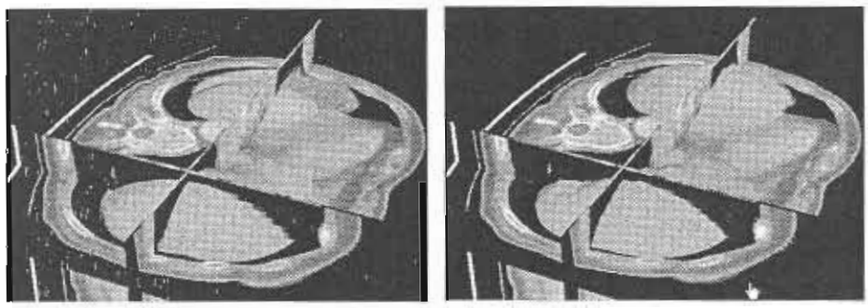


(a) (b)

Augmented Reality based user-interaction with a segmented liver CT data set.
(a) 3D Visualization of complex anatomical structures inside the liver.
(b) Simulation of a surgical intervention.

- **Diaphragm Dome Surface Segmentation in CT Data Sets**
  (A 3D Active Appearance Model Approach) [1, 2]

Knowledge about the location of the diaphragm dome surface, which separates the lungs and the heart from the abdominal cavity is of vital importance for applications like automated segmentation of adjacent organs (e.g. liver) or functional analysis of the respiratory cycle. A new 3D Active Appearance Model (AAM) based approach to segmentation of the top layer of the diaphragm dome is being developed. The 3D AAM consists of three parts: a 2D closed curve (reference curve), an elevation image and texture layers. The first two parts combined represent 3D shape information and the third part image intensity of the diaphragm dome and the surrounding layers. Differences in height between dome voxels and a reference plane are stored in the elevation image. The reference curve is generated by a parallel projection of the diaphragm dome outline in the axial direction. Landmark point placement is only done on the (2D) reference curve, which can be seen as the bounding curve of the elevation image. Matching is based on a gradient-descent optimization process and uses image intensity appearance around the actual dome shape. Results achieved in 60 computer generated phantom data sets show a high degree of accuracy (positioning error -0.07+/-1.29 mm). Validation using real CT data sets yielded a positioning error of -0.16+/-2.95 mm. Additional training and testing on in-vivo CT image data is ongoing.

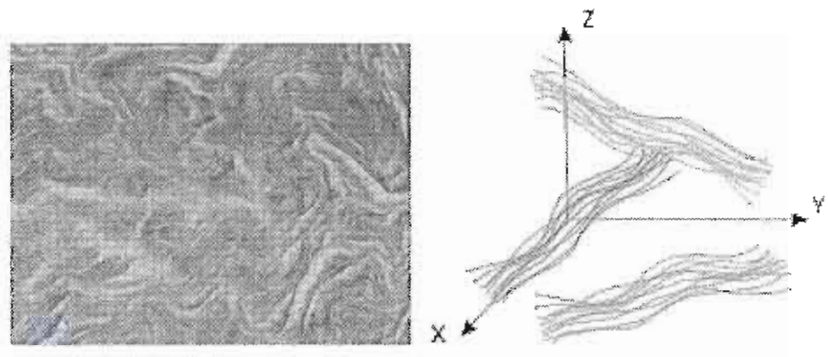


(a) (b)

AAM based diaphragm dome segmentation. (a) Start position of the Model. (b) Matched model.

- **Computer Vision Based Analysis of Collagen Fibers in the Outer Layer of Blood Vessels**

Soft tissue like tendons, arteries, veins or skins are important biological materials. A greater understanding of the foundations and interactions of structure and function of soft tissue, and, in particular, the associated mechanobiology is of great interest in the field. A thorough understanding of the complex interrelations between mechanical factors and the associated biological responses may help to improve diagnostics which allow disease and injury to be treated earlier. One critical component is to describe the concentration and structural arrangements of collagen fibers in biological soft tissue. We are developing a fully automatic system for analyzing macroscopic structures obtained from histological images by means of modern computer vision techniques. The main task of this research is the development of novel segmentation techniques for robustly segmenting individual fibril bundles and estimating their parameters, like location and shape, fibril density, mean fibril orientation, wriggling of fibrils etc. Another major challenge of this research is to extend the structural analysis from two dimensional images to the three dimensional domain using slices of tissues.

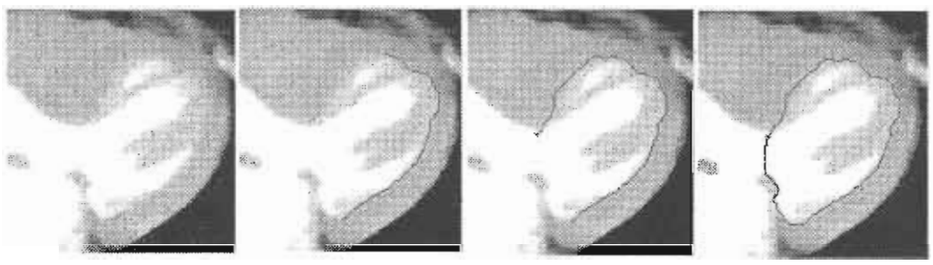


(a) (b)

(a) A microscopic image of a soft tissue that shows partial fibrous bundles. A set of such images is used to represent one tissue slice and a set of slices provides the 3D structural information. (b) Bundles in 3D.

- **Semiautomatic Segmentation of the Left Ventricle in Electron-Beam CT Images [3]**

Measuring the volume of heart ventricles is an important issue in heart disease diagnosis. Therefore many radiologists investigate computer tomographic images, searching for representative projections of the left ventricle. They use parametric models by measuring ellipse parameters in certain images under the assumption that the left ventricle has an ellipsoid shape. This work is based on a LiveWire approach, an interactive segmentation technique, which can be used as an alternative volume estimation method. The implementation of LiveWire approach and volume estimation was applied on 31 data sets showing the left ventricle in long-axis configuration from EBCT movie-mode images. We found an excellent correlation of 97% between volumes from an expert's manually drawn ventricle contours and the contours produced with the LiveWire tool. The comparison of the LiveWire volumes with the parametric model shows a correlation of 84% lying in the same range as the manually drawn contours vs. the parametric model (86%). We conclude that LiveWire is an excellent tool for left ventricle segmentation in the hands of a radiologist.



(a) (b) (c) (d)

Example for drawing a LiveWire contour. (a) Start point. (b) and (c) Drawing of some intermediate points. (d) Resulting segmentation.

Selected References:

[1] R. Beichel, S. Mitchell, E. Sorantin, F. Leberl, A. Goshtasby, and M. Sonka. Shape- and Appearance-Based Segmentation of Volumetric Medical Images. In Proceedings of the International Conference for Image Processing (ICIP), pages 589-592, 2001.

[2] R. Beichel, G. Gotschuli, E. Sorantin, F. Leberl, and Sonka M. Diaphragm dome surface segmentation in CT data sets: A 3D active appearance model approach. In Milan Sonka and J. Michael Fitzpatrick, editors, Proceedings of SPIE: Medical Imaging: Image Processing, volume 4684, pages 475-484, 2002.

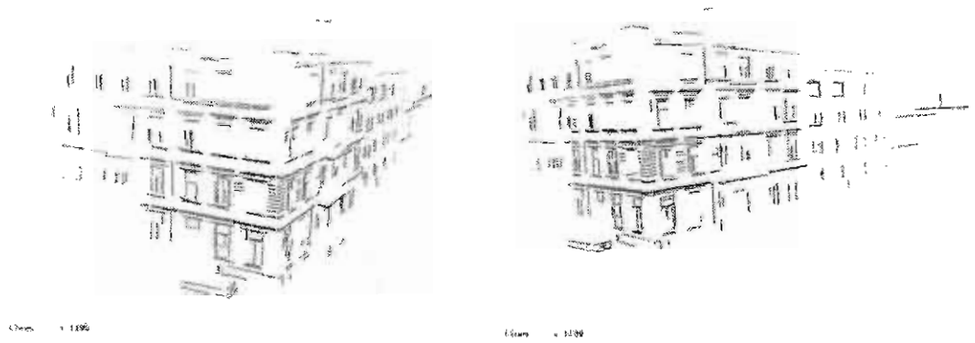
[3] M. Urschler, H. Mayer, R. Bolter, and F. Leberl. The LiveWire Approach for the Segmentation of Left Ventricle Electron-Beam CT Images. In Friedrich Fraundorfer and Franz Leberl, editor, 26th Workshop of the Austrian Association for Pattern Recognition: Vision with Non-Traditional Sensors, volume 160, pages 319-326. Oesterreichische Computer Gesellschaft, 2002.

- Application Research Area 2

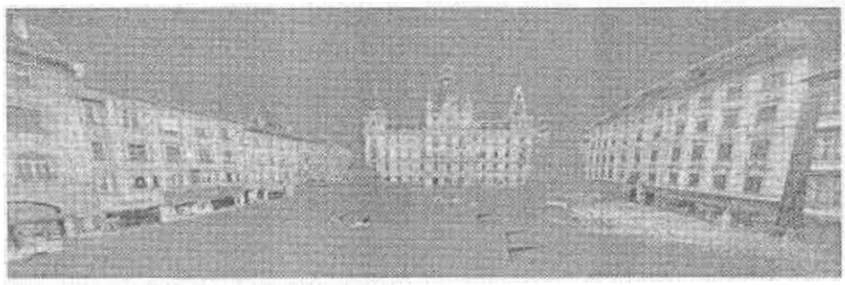
The application research area 2 (AR2) is part of the VRVis Research Center and is embedded at the Institute for Computer Graphics and Vision at the Technical University of Graz. The VRVis Research Center (http://www.vrvis.at) is a joint venture in Research & Development for virtual reality and visualisation. VRVis is a part of the K plus program and has been initiated by the federal ministry of education, science and culture to improve cooperation between science and industry in Austria.

The AR2 focuses on the modeling of real cities, the 3D data management and visualization of obtained virtual habitats, and simulation of environmental flows like flooding, avalanches and wind within the virtual world. A new project designing a digital microscope for the 3D reconstruction of probes was started in January 2002. AR2 is carrying out three application research projects for five company partners in the Kplus program as well as three projects with a total of about 80000 Euro in the nonKplus domain. The two projects focusing on 3D modeling from image information are:

MetropoGIS: In this project a novel city modeling system is designed and implemented. The key features of this system are: automatic feature extraction and image orientation, semiautomatic geo-referencing of image sequences, dense point and line matching, and the estimation of plane hypothesis [Karner2002]. Facade image data are captured with an off-the-shelf digital camera or a mobile acquisition platform. In the following processing steps the images are resampled to compensate for potential lens distortion. Line segments which are the most prominent features in architectural objects are extracted with sub-pixel accuracy. Subsequently vanishing points and line intersections are computed. These high level features are then used to perform the image orientation. For the oriented image sequences a transform into a geo-referenced coordinate system can easily be performed using some 3D control points.
In the modeling process dense 3D point clouds as well as 3D line sets are extracted from the oriented image sequences.



Two views of the extracted 3D line segments

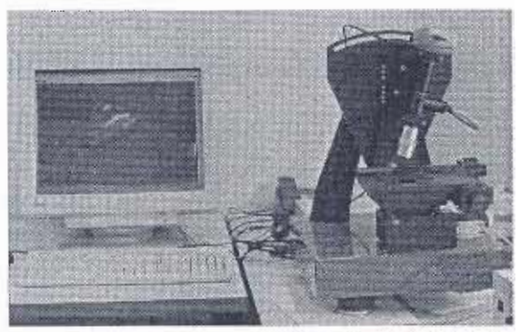


Geo-referenced model of the Grazer Hauptplatz composed of 2.8 millions points

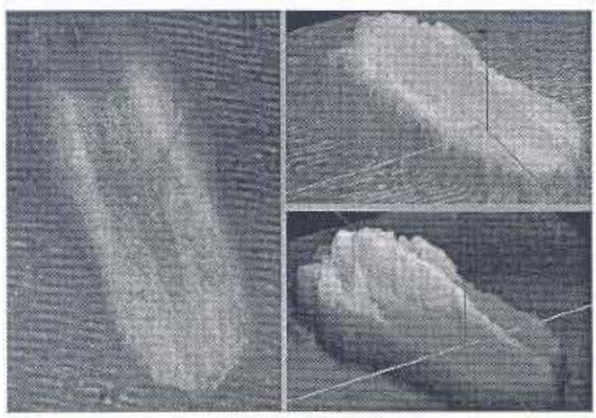
From these simple 3D primitives, planar faces are derived with a set of grouping algorithms. Once the 3D geometry of the captured object is known, high quality texture information, making use of all input images, is generated. In this process most of the disturbing artefacts in the individual images, such as vegetation or vehicles, can be eliminated. This final set of textures represents the so called 'true orthophotos' of the object.

- **Advanced Digital Microscopy**

The goal of this project is the development of a digital microscopy system to reconstruct the 3D surface of different specimen. Due to the small depth of field of microscopes a small area of the specimen can be seen in focus only. With the use of a rotatable imaging tube, a motorized xyz-stage, and different light sources image stacks can be obtained that allow to reconstruct a 3D model of the specimen with a combination of different 'Shape from X ' techniques. In this case X stands for Stereo, Focus and Shading. Once a 3D model is obtained the system can be used to reconstruct an image of the specimen that is all over sharp. The main questions treated are the setup design, setup calibration, image acquisition, reconstruction and visualization.



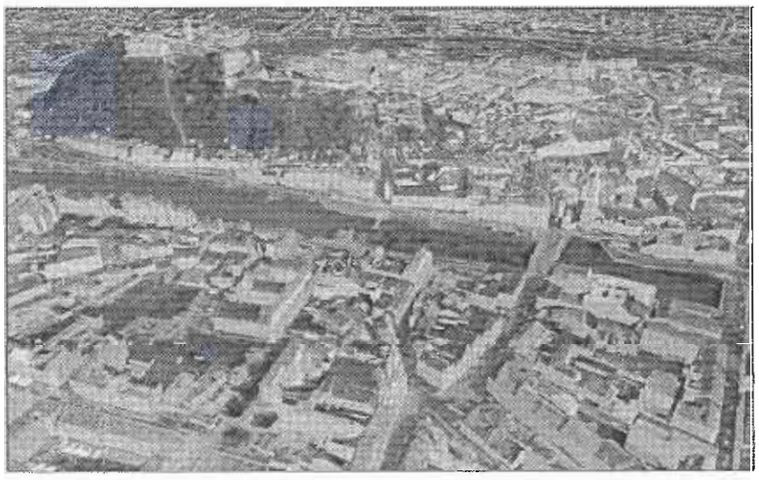
Setup of the digital stereo microscope system including a motorized xyz-stage and an imaging tube that can be rotated.



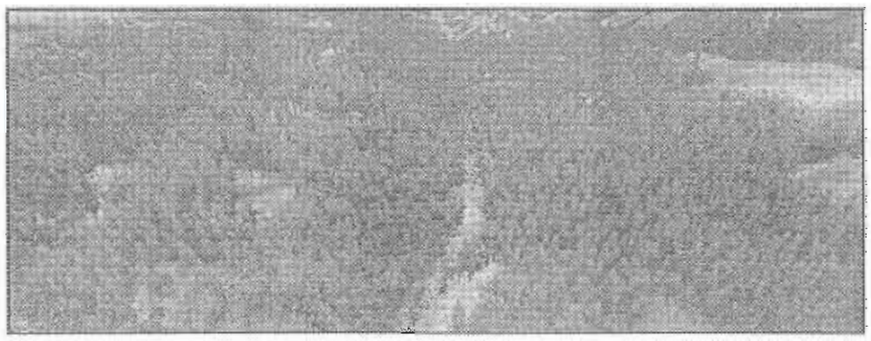
A sharp image and two 3D models of a specimen reconstructed with the digital microscope.

Another project within the VRVis-AR2 focuses on:

3D Data Management and Visualization: The AR2 designed and implemented two visualization prototypes for virtual habitats. The first one is web standard compliant (VRML and Java) and uses an encryption mechanism to ensure the security of the transmitted data. The second one is a stand alone application incorporating rendering techniques not available in current standards for web based graphics. Specific methods to display architectural models, huge terrain heightfields and realistic vegetation in realtime are combined within one rendering framework [Zach 2002]. Additionally a stand alone application allows fine grained control over acceleration techniques based on the hardware capabilities of the client computer.



A view on the virtual model of Graz



A terrain flyover application showing vegetation with advanced rendering methods

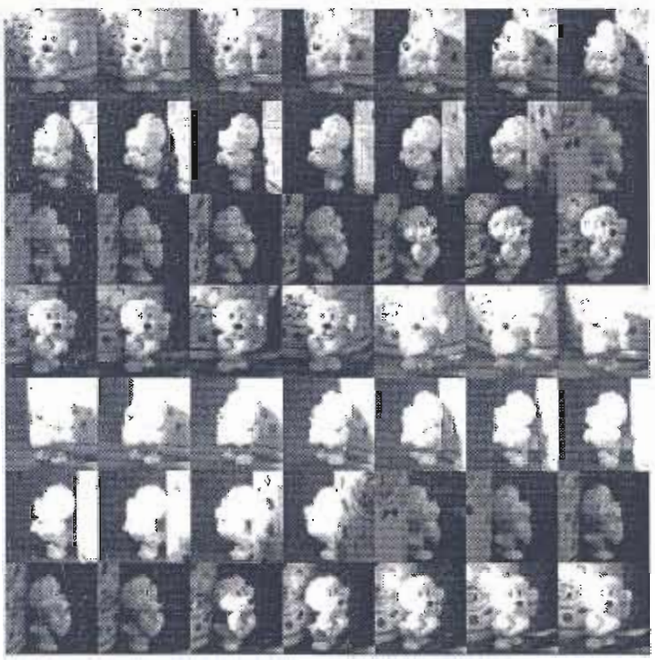
[Zach2002] Ch. Zach, S. Mantler and K. Karner. *Time-critical Rendering of Discrete and Continuous Levels of Detail.* Accepted for the ACM Symposium on Virtual Reality Software and Technology, Hongkong, 2002.
[Karner2002] K. Karner, J. Bauer, A. Klaus, K. Schindler. *MetropoGIS: A City Information System.* IEEE 2002 International Conference on Image Processing. Sep 22-25, 2002. Rochester, New York, USA.

Object Recognition and Robotics

One central problem in computer vision is to recognize known objects reliably, independent of variations in position, orientation, and size, even when those objects are partially occluded. A solution to this problem would have a variety of applications ranging from industrial manufacturing to autonomous robotics. Our research at ICG in this area concentrates on two major aspects of this problem. On the one hand we are interested in building robust view based object recognition systems which are insensitive to occlusions, background clutter, and illumination variations. The methods developed are used in an industrial setting for robust bin-picking tasks in robotics. On the other hand we are using "recognition inspired" methods for localization of robots in the so-called SLAM (Simultaneous-localization and mapping) paradigm.

Robust Recognition and Learning

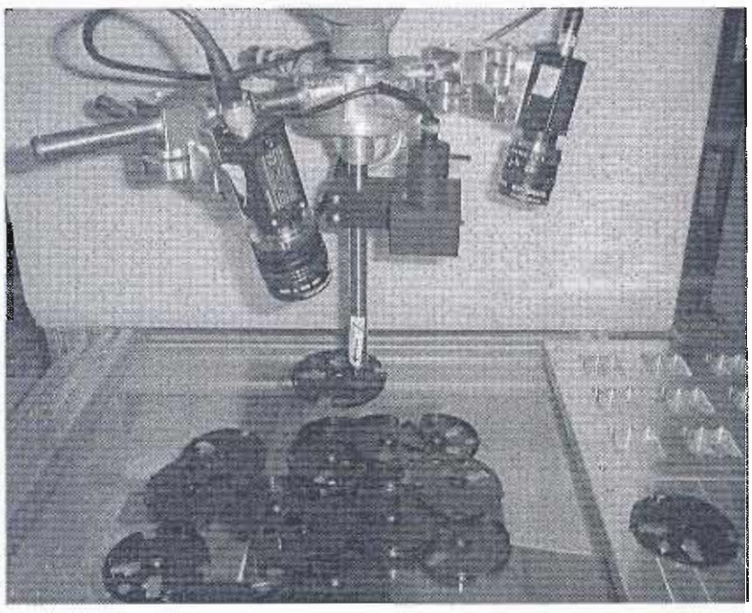
We have developed robust approaches to recognition and learning using global view-based (appearance based) representations based on subspace methods like Principal Component Analysis. The methods developed can handle significant clutter in the background, occlusions and severe illumination variations. These methods have also been successfully used for mobile robot navigation using panoramic cameras. Recently we have extended the methods to allow also for robust learning in the presence of noise.



Examples of objects correctly recognized under difficult conditions (illumination, occlusion, background clutter).

Robotic system for 6DoF pose determination

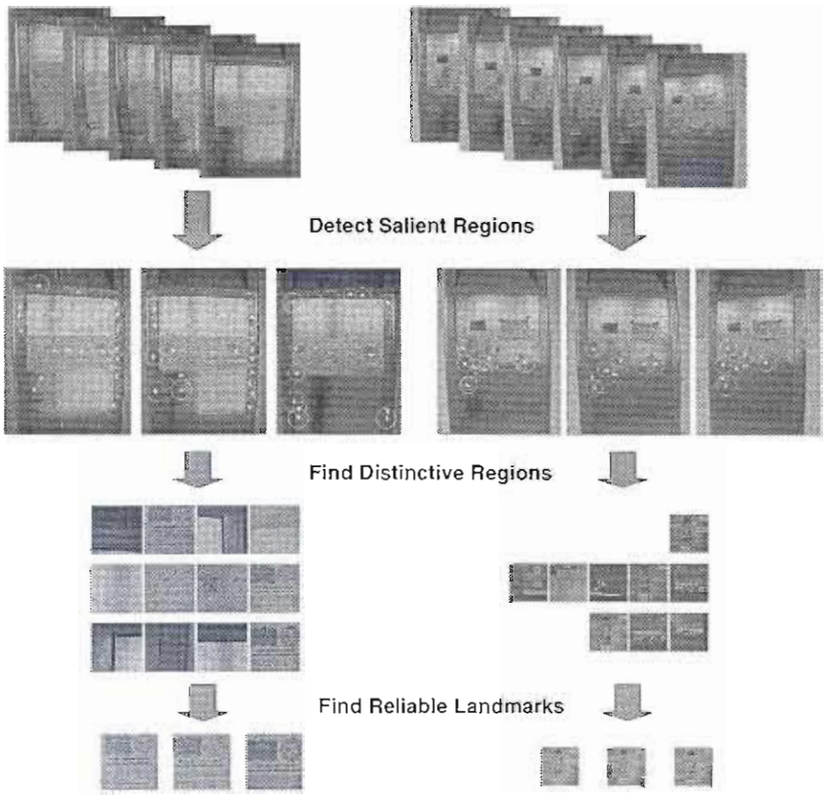
We are developing a robotic system for the exact pose estimation of rigid objects in six degrees of freedom (DoF). The term "pose" describes the 3-dimensional position and the 3D orientation of the object. Our approach is based on the following scenario: Given be a set of unordered objects in arbitrary position which come from a small variety (<10) of different types as may happen on a conveyor belt during an assembly process. We assume the objects to be mostly un-occluded and their CAD-model given. Our goal is to pick with a robot a specific object in such a way that it has a defined position. The robot is equipped with multiple black and white cameras (e.g., 2-3). In order to achieve maximum generality we do not intend to use range information nor calculate a 3D-representation from stereo images.



Robot equipped with a stereo camera grasps object from a heap.

Simultaneous-localization and mapping (SLAM)

The goal of SLAM is to simultaneously do self-localization and map building with a minimal amount of pre-knowledge about the environment. This concept is a key feature for future mobile robots but might also be used for augmented/virtual reality applications. We are exploring the SLAM paradigm based on visual sensors for indoor scenarios. We have proposed a world representation using a 3D model combined with appearance based features. This representation combines the advantages of a 3D model, like the possibility for path planning with the advantages of appearance-based methods, like discriminative features for matching and localization.



Extraction of reliabfe landmarks from a sequence of images.

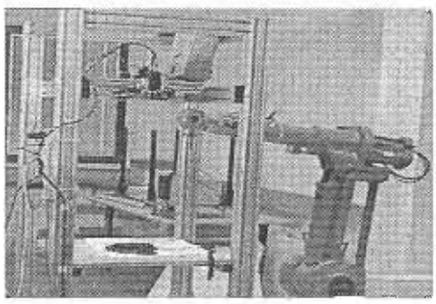
Publications

1. A. Leonardis, H. Bischof, and J. Maver. Multiple eigenspaces. Pattern Recognition, 35(11):2613-2627, 2002.
2. D. Skocaj, H. Bischof, and A. Leonardis. A robust pca algorithm for building representations from panoramic images. In A. Heyden, G. Sparr, M. Nielsen, and P. Johansen, editors, Proc. ECCV02, volume IV, pages 761-775. Springer, 2002.
3. M. Sengel and H. Bischof. Efficient representation of in-plane rotation within a PCA framework. In F. Leberl and F. Fraundorfer, editors, Vision with non-traditional sensors, Proc. of 26th Workshop of the Austrian Association for Pattern Recognition, volume 160, pages 63-70. Austrian Computer Society, 2002.
4. F. Fraundorfer. A map for mobile robots consisting of a 3D model with augmented salient image features. 26th Workshop of the Austrian Association for Pattern Recognition (ÖAGM/AAPR) 2002, pages 249-256, 2002
5. Berger M., T.Auer, G. Bachler, S. Scherer, A. Pinz. 3D Model Based Pose Determination in Real-Time: Strategies, Convergence, Accuracy. Proc. International Conference on Pattern Recognition (ICPR), volume 4, pages 567-570, 2000.

Industrial Machine Vision

In industrial machine vision we utilize our expertise in computer vision to solve problems in industrial applications for our partners. The applications range from quality control to factory automation. A variety of projects is currently in progress and we look back at a considerable string of successes. For example we have supported the production of micro-electronic devices or high quality steels which require the assessment of the microscopic surface topology. The common inspection device for this purpose, the scanning electron microscope does not provide three dimensional information. Starting from a feasibility study, we developed a high quality surface reconstruction and analysis tool for scanning electron microscope images. In the area of factory automation we have developed an automatic, vision driven assembly unit in order to meet the needs for flexible automation in production lines. Below some examples of current or recently finished projects are shown.

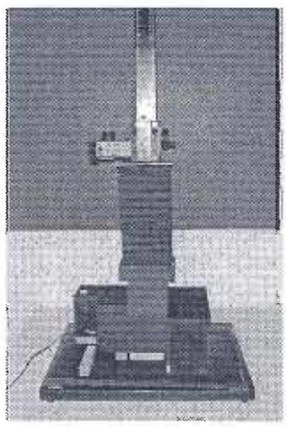
A Vision Driven Automatic Assembly Unit

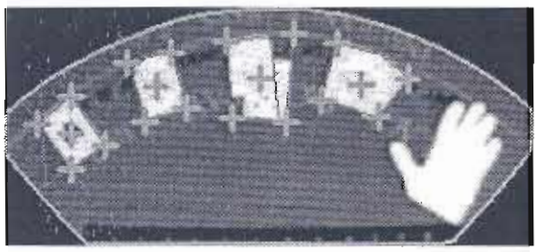


The project was part of a larger effort to build a vision driven robot cell, the so-called "Assembly Cell", to pick and mount unorganized objects out of a bin. The picking of an object from a bin of unorganized parts is followed by an exact pose measurement in three degrees of freedom on a known flat surface which enables the robot to grasp and mount objects precisely.

Surface Error Detection & Sorting of Melamine Faced Chipboards

The goal of the project was the development of a prototype system for the detection of faint flaws on melamine faced chipboards in real time. The flaws to be detected range from small scale, dark dots to medium scale inclusions and bumps, up to linear dark and bright scratches and faults. Some bumps and scratches are even invisible expect when viewed from distinct, shallow directions. The surfaces under inspection are bright but slightly textured with an irregular pattern. The system should be able to process 1000 pieces per hour which results in a processing time of 3,6 seconds per piece.

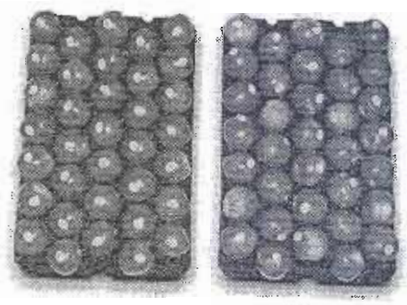




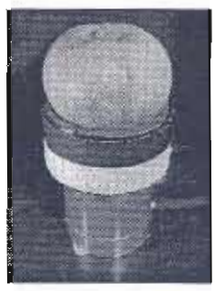
Golden Eye: Real Time Black Jack Analysis

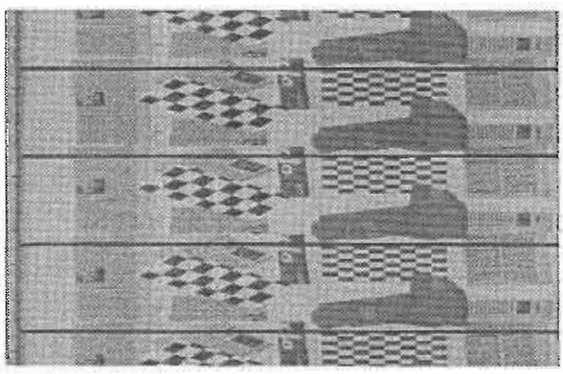
The aim was the development of a computer aided system, which is capable to analyze the card game Blackjack and provides various output information for statistical purposes. The developed system is able to detect the table states (Idle, Game, Payment), game information like the amount of games and participating players are counted and player events like Bust and Blackjack are detected.

Sorting and packaging of apples by means of digital image processing



Apples that are offered for sale are usually packaged in trays. For top quality apples it is profitable to manually sort them such that they all have the same orientation on the trays and their most appealing sides face towards the customer. The first step of the packaging process rotates the apple so that its symmetry axis is vertical with either stalk or bloom facing upwards. The next step determines the position of the most appealing side of the apple (i.e. the horizontal angle) and decides whether stalk or bloom is facing upwards (the vertical angle). A digital camera captures a sequence of images at different orientations and the image processing software measures fruit quality and vertical orientation in real-time. In the last step, a robot brings the apple to its ideal position and puts it into the tray.



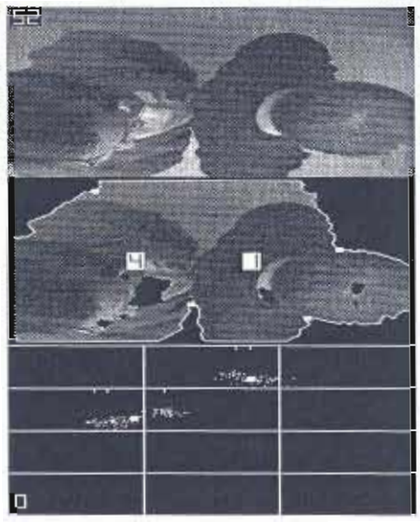


Optical Waste Paper Sorting

The task is to sort waste paper fed onto a conveyor belt. Color and texture information is used to recognize the different kinds of waste paper. The detected different kinds of paper will then be separated automatically. The recognition step makes use of color classification and texture analysis based on Fast Fourier Transform.

Entrance Surveillance

The task is to survey entrances using video images and register the people passing the entrance. The system has to operate under outdoor conditions (sun light, fog, etc.). The system works by detecting moving objects in the video stream and tracking it until the object leaves the surveillance area. One of the most challenging tasks is to separate people if the entry area is crowded. The system makes use of multiple hypotheses implementing the Condensation algorithm.



Publications

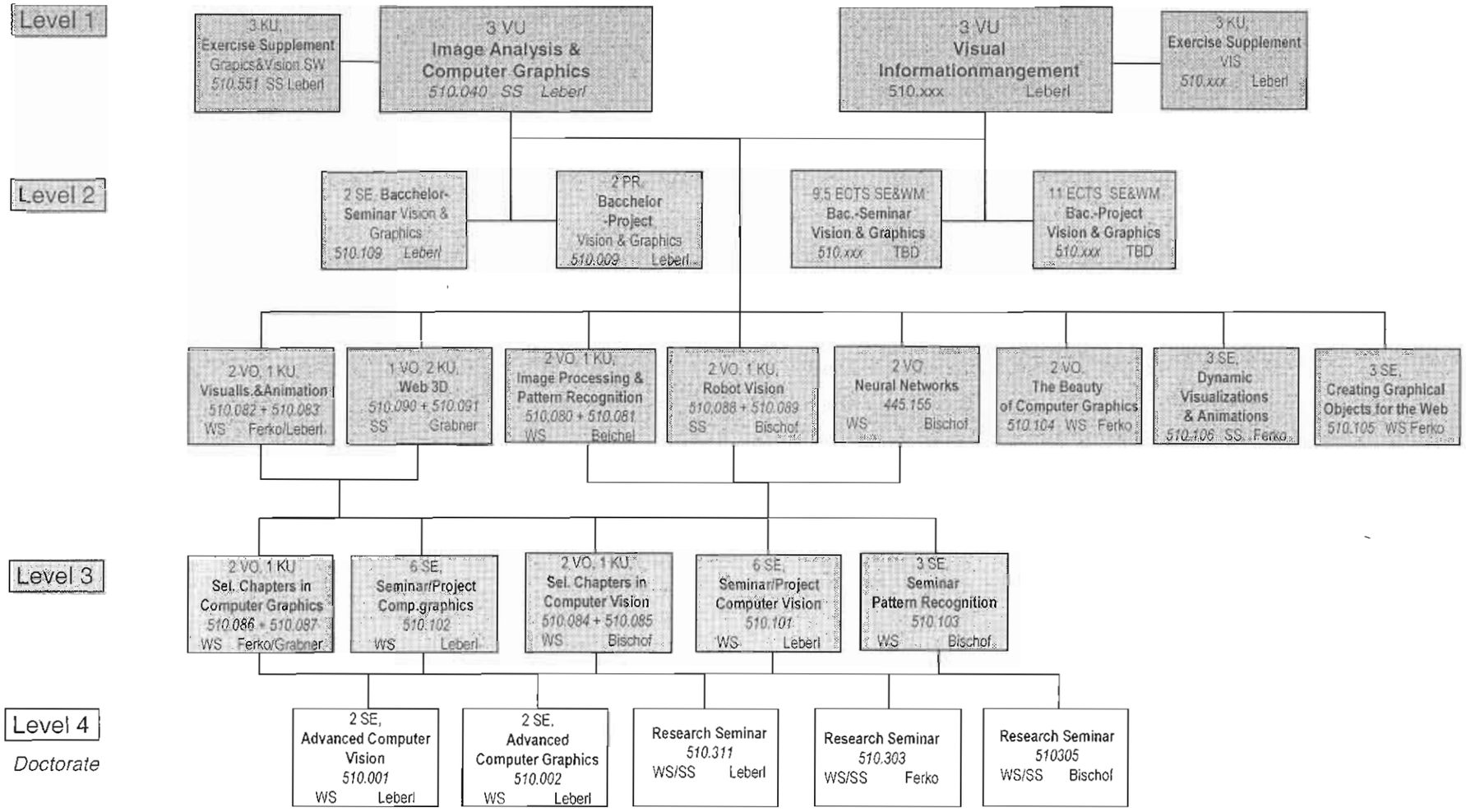
1. Rüther M., Grabner M.
   Determining Color Distribution and Orientation of Apples for Automatic Packaging 26th Workshop of the Austrian Association for Pattern Recognition (ÖAGM/AAPR) 2002, pages 225-232, 2002
2. Bolter R., Fernandez G., Lenz G., Leberl F.
   Detection of Flaws on Melamine Faced Chipboards using Wavelet based Texture Analysis Computer Vision, Computer Graphics and Photogrammetry - a Common Viewpoint, 25th Workshop of the Austrian Association for Pattern Recognition (ÖAGM/AAPR) Berchtesgaden, June 7-8, 2001. Österreichische Computer Gesellschaft, Band 147, pp. 159-165, 2001
3. Berger M., Bachler G., Scherer S.
   Vision Guided Bin Picking and Mounting in a Flexible Assembly Cell Proceedings of the 13th International Conference on Industrial & Engineering Applications of Artificial Intelligence & Expert Systems IEA/AIE2000, pp. 109-118, New Orleans, Louisiana, USA, June 2000.
4. Wiltschi K., Pinz A., Lindeberg T.
   An automatic assessment scheme for steel quality inspection Machine Vision and Applications (2000) 12:113-128, 2000
5. Scherer S., Werth P.
   Automatic local deformation measurements by means of a digital image analysis System Advances in Mechanical Behaviour, Plasticity and Analysis, EUROMAT - Volume 4, pp. 151-156, Weimheim, Germany 2000

Project Title	Source
• 34p24 Robust and Adaptive Computer Vision and Pattern Recognition Methods	Aktion Österreich - Tschechien
• 3D Heart Modeling	Technische Universität Graz und LKH Graz
• 3D Objects over the Internet	ICG
• 3-Dimensional Measurement and Virtual Reconstruction of Ancient Lost Worlds of Europe (MURALE)	EU
• Applied Biocatalysis	K-plus
• Augmented Reality Infrastructure	Technische Universität Graz
• Feasibility Study "Form aus Schärfenvariation"	Alicona Imaging GmbH
• Feasibility Study FREEMOTION	SkiData
• Large Format-Digital Camera	Vexel Imaging GmbH
• Liver Surgery Planning System	FWF
• Physical Modeling and Computer Simulation of Balloon Angioplasty	FWF
• Research Centre(Kplus) for Virtual Reality and Visualistion	K-plus
• Robotic Pose Positioning with 6 DoF	M&R
• Robust Approaches to Recognition Problems in Computer Vision	Aktion Österreich – Slowenien
• Robust Approaches to Recognition Problems in Computer Vision	Technische Universität Graz
• Softwarebildverarbeitung zur Papiersortierung	BT-Anlagenbau Binder
• The Virtual Vehicle	K-plus
• Theory and Algorithms for Photogrammetrie and Remote Sensing	BMBWK/Land Steiermark
• Verbesserung der geotechnischen Aufnahme- und Auswertetechniken und der numerischen Simulation vor Ort	FWF
• Vermessung von Glasscheiben vor der Härtung	HiSoft

Project Title	Research Area
• 3D Object Scanner	Object Reconstruction
• A Concept for Realistic Image Synthesis	Computer Graphics
• A Flexible Assembling Unit for Industrial Applications	Machine Vision
• A Scanner Evaluation System	Computer Vision
• Active Fusion Using Bayesian Networks	Computer Vision
• Active Fusion with Evidence Theory	Computer Vision
• Active Fuzzy Fusion	Computer Vision
• Active Inspection System for Steel Quality Control	Industrial Machine Vision
• Active Interpretation of Occlusion	Computer Vision
• Analysis of Combustion Processes in Engines	Industrial Machine Vision
• Application of Image Processing in Materials Science	Machine Vision
• Automated 3D Reconstruction of Buildings from Aerial Images Using GIS Data	Object Reconstruction
• Automated Geocoding of Satellite Radar Images	Remote Sensing
• Automated Melanoma Recognition	Medical Imaging
• CARO - CEO (Center for Earth Observation) Austrian Relay Office	Remote Sensing
• Blob Detection on Textile Surfaces	Machine Vision
• Buildings from Radar	Remote Sensing
• CCD Camera System for Facade Recording	Object Reconstruction
• Comparing Computer Generated Images	Computer Graphics
• Design of a Hypermedia Data and a Method Data Base	Remote Sensing
• Detection of Flaws on Melamin Surfaces	Object Recognition
• European Magellan Data Node	Remote Sensing
• EXPO 2000	Computer Graphics
• Golden Eye: Real Time Black Jack Analysis	Machine Vision
• High Performance Data Networking	Remote Sensing
• Hyperspectral Parallel Classification	Machine Vision
• Improvement of Acquisition Methods for Geotechnical Gata and on site Application of Numerical Simulation Methods	Machine Vision
• Indoor Room Imaging	Object Reconstruction

Project Title	Research Area
• Information Fusion in Image Understanding	Machine Vision
• Integrated Image Analysis System for the Early Recognition of Malignant Melanoma	Machine Vision
• Integrating Shape from Stereo and Physics Based Vision for Uncalibrated Surface Reconstruction	Machine Vision
• Interactive Operation Planning at the Face Skull Model	Computer Graphics
• Mapping the Human Retina	Medical Imaging
• Micro Image Understanding Environment MyUE	Computer Vision
• MISSION-DatenPool	Remote Sensing
• Modelling of a Room	Computer Graphics
• Morphos Development of a measuring system for verifying existing models from combustion engine industry	Object Reconstruction
• Multimedia-Methods for Application of Multisensor Remote Sensing Data for Environmental Tasks	Remote Sensing
• National Library	Object Reconstruction
• Numerical Simulation in Tunnelling	Machine Vision
• Optical-Radar sensor Fusion for Environmental Applications – ORFEAS	Remote Sensing
• Parallel and Distributed Processing Strategies for Large Image Data Sets	Remote Sensing,
• Pose-positioning of Apples	Computer Graphics
• Radar Interferometry	Computer Graphics
• Radargrammetry	Remote Sensing
• Route Tracer	Computer Graphics
• Stereoscopic 3-D Surface Reconstruction Using Scanning Electron Microscope Images	Object Reconstruction
• Studierstube	Computer Graphics
• The Cybercity Project	Object Reconstruction
• The Remote Sensing Information System DIVA	Remote Sensing
• Tools for Exploitation of Radar Image Geometry	Remote Sensing
• Theory and Applications of Digital Image Processing and Pattern Recognition	Machine Vision
• Vision Based Robot Navigation Research Network	Machine Vision
• Visualization Methods for Volumetric Medical Datasets	Medical Imaging

Structure of ICG-Lectures, 2002/2003



Academic Teaching

510.001 **Advanced Computer Vision**	Oral presentation and written exposure about a technical scientific subject taken from the literature in computer vision or computer graphics, taken from planning thesis and dissertations, participating in talking by visiting professors
510.002 **Advanced Computer Graphics**	Research seminar with presentation of theses proposals and diploma results, with guest scientists.
510.009 **Bacchelor Project – Vision and Graphics**	Initial project work Written technical report
510.080 **Image Processing & Pattern Recognition**	State of the art image processing and pattern recognition. Techniques are treated in detailed manner. Practical course with MatLab exercises.
510.082 **Visualization, Rendering & Animation**	Introduction to basic visualization and animation techniques like parametric curves and surface representations, light-material interactions, visualization software, volume rendering.
510.084 **Selected Chapters in Computer Vision**	A current research topic in computer vision is presented in detail. In the exercises practical hands-on experience is teached.
510.086 **Selected Chapters in Computer Graphic**	The current research top quality papers are presented and discussed. In the exercises practical problems are solved. Written and oral presentation
510.094 **Image Understanding**	High-level computer vision methods with emphasis on symbolic representations and information fusion.
510.101 **Seminar/Project Image Analysis**	Introduction into scientific work with a practical implementation of a small research project.
510.103 **Seminar Pattern Recognition**	Current pattern recognition techniques are studied by the student and presented in an oral presentation and written exposure.
510.104 **The Beauty of Computer Graphics**	Computer Graphics before Computers and Today, Special Modeling of Natural Phenomena, the Beauty of Fractals, Motion Capture and Facial Expressions, Visually Critiquing the Webpages, Computer Graphics for Visual Arts, Iterated Functional Systems and Fractal Compression, Chaos Game and Stochastic Fractals, L-systems, Sound Spaces Construction, Functional Analysis View, the Disadvantages of Fourier Analysis and Wavelets, Wavelets Applications, Image Data Compression and HCI, the Future of You and the Future of Computer Graphics

510.105 **Creating Graphical Objects for the Web**	Different methods for creating graphical objects for the Web are discussed and applied.
510.110 **Introduction to Software Development & Knowledge Management**	Introduction of the subject. Demarcation against similar studies like computer science, telematics, technical mathematics, economical informatics, information technology. Introduction in selected literature. The national and international infrastructure of the studies.
510.301/510.303/510.305 **Image Analysis – Tutorials for postgraduate students**	Contents of the scientific doctoral project of participating students
510.109 **Bacchelor Seminar – Vision and Graphics**	Initial project work Written technical report
510.040 **Image Analysis & Computer Graphics**	Introduction to the basic terms and techniques in image processing and computer graphics with special emphasis on common topics.
510.088 **Robot Vision**	3-D computer vision methods such as stereo, structured light, shape-from-x are presented in detail.
510.090 **Web 3D**	Fundamentals on CAD, applications, and related techniques, Object description, Data exchange, OpenGL, Scenegraph APIs and file formats, Introduction to Microstation and survey on other software, Guest lectures from different faculties of TU Graz
510.102 **Seminar/Project Image Graphics**	Topics in computer graphics (and image analysis), Independent task definition, Literature review, Analysis, Conclusions, Written technical report, Oral presentation
510.106 **Creating Dynamic Visualizations and Animation**	Various methods and authoring tools for creating dynamic visualizations and animations are discussed and applied.
510.101/510.103/510.105 **Image Analysis/Tutorials for postgraduate students**	Contents of the scientific doctoral project
510.551 **Tutorial in Image Analysis & Computer Graphics**	Introduction to various software packages for computer vision and computer graphics.

Name	Topic	Start	Supervisor
Berger Robert	• Lernen von Personenbewegungen	24.06.2002	Bischof
Dechant Martin	• Software zur Erkennung und Zählung von Partikeln in digitalisierten Bildern	01.02.1993	Leopold
Grohmann Peter	• 3D-Objektkonstruktion nach dem Lichtschnittverfahren	01.10.1995	Leberl
Hauser Roland	• Texturbasiertes Matching	01.10.1998	Pinz
Kammerhofer Martin	• Evaluier. von objektorientierten Datenbanken zur Visualisierung großer Datenmengen	01.07.1995	Gruber/ Leberl
Kellinger Peter	• Interaktive Operationsplanung am Gesichtsschädelmodell	01.12.1996	Leberl
Lee Felix	• Personendetektion aus einer Videosequenz	01.05.2002	Bischof
Maierhofer Alois	• Entwurf und Implementierung eines Programms zur globalen Beleuchtungsberechnung nach dem Radiosity-Verfahren	01.12.1993	Karner/ Leberl
Panzer Jürgen	• Unternehmensweite Visualisierung von Produktdaten	22.01.2002	Leberl
Reisenhofer Erich	• Wide baseline matching	04.12.2001	Leberl
Ruhaltinger Norbert	• Erzeugung von Oberflächen aus unregelmäßigen Stützstellen unter Verwendung von "3-D-Alpha-Shapes"	01.11.1994	Gruber
Rüther Matthias	• Metric 3D Reconstruction using the Trifocal Tensor	23.08.2001	Leberl
Schwann Günter	• Semi Automatic Object matching in an augmented Reality System	06.12.2001	Leberl
Sormann Mario	• View dependent Texture simplification	07.08.2002	Leberl
Steiner Helmut	• Ein 3D graphischer Editor für parametr. Objektmodelle	01.07.1997	Pinz/ Gruber
Traussnig Helfried	• Processing of 3D point clouds	01.02.2002	Leberl
Weinbergmeier Friedrich	• Layoverauswertung in Magellan Bilddaten	01.01.1996	Gelautz/ Leberl
Weiss Josef	• Semantische Interpretation von Videosequenzen	13.02.2002	Bischof
Wilawitzer Harald	• Objektrekonstruktion mit strukturiertem Licht	01.07.1997	Leberl

Name	Topic	Period	Supervisor
1994			
Deutschl Edwin	• Vergleich verschiedener Reflexionsmodelle	1993-94	Karner
Lukmann Walter	• Methoden zur Korrelationsberechnung in der digitalen Signalverarbeitung	1993-94	Leberl/ Pfurtscheller
Prantl Manfred	• Stereokorrelation	1993-94	Gruber
Schenk Andreas	• Verbesserung des Photorealismus beim Radiosity Verfahren	1993-94	Karner
Walcher Wolfgang	• Untersuchung von Datenstrukturen und Algorithmen zur Manipulation großer Bilddatenmengen	1993-94	Gruber
Ganster Harald	• Computerunterstützte Bildverarbeitung zur Auflichtmikroskopie pigmentierter Hautläsionen	1993-94	Gelautz
Kastner Markus	• Bildtransformation in XLTT	1993-94	Gruber
Salhofer Peter	• Herstellung eines Interfaces für CAD-Programm und Beleuchtungsprogramm	1993-94	Karner
1995			
Kellerer-Pirklbauer Walter	• Entwurf und Programmierung eines Verfahrens zur Bewertung von Präzisionsabtastgeräten	1994-95	Seywald
Nischelwitzer Alexander	• Maschinelle Sichtprüfung zur industriellen Qualitätssicherung CERES	1994-95	Gruber/ Pinz
Schabernack Harald	• Berufsmöglichk. für Hochschulabsolventen aus Informationstechnik in Österreich	1994-95	Leberl
Wiltschi Klaus	• Automatische Auswertung der Karbidverteilung v.Werkzeugstählen durch Bildverarb.	1994-95	Pinz/ Gelautz
Zweimüller Karl	• Klassifizierung von Stahlschliffen: Karbidverteilung in Werkzeugstählen	1995	Pinz/ Wiltschi
Frick Helmut	• Bildverarbeitung in der Fernerkundung	1995	Gelautz
1996			
Goller Alois	• Parallelisierung von Bildverarbeitungs-Algorithmen	1993-96	Gelautz
Hahn Eberhard	• Farbmetrik für das Druckereigewerbe	1993-96	Karner
Mayer Heinz	• Berechnung der Reflexionseigenschaften aus Bildern	1995-96	Karner
Böhm Rainer	• Erstellung eines dreidimensionalen Stadtmodells	1994-96	Gruber
Knapp Karl	• Ein elektro-optischer Versuchsaufbau zur visuellen Inspektion eines automatischen Produktionsprozesses .von Alugußteilen	1994-96	Gruber
Mitteregger Erwin	• Automatische Passpunktsuche in SAR-Bildern gebirgigen Geländes unter Verwendung von simulierten Layover- und Schattenmasken	1996	Gelautz

Name	Topic	Period	Supervisor
1997			
Bernögger Stefan	• Kartierung der Menschlichen Retina	1996-97	Pinz
Haage Ulrich	• Objektorientierte Datenbank- und Benutzeroberflächengestaltung eines Programmes zur Visualisierung von Geometrieabweichungen an CNC-Maschinen	1995-97	Karner
Lindbichler Wolfgang	• Interactive Venus Map Browser	1994-97	Leberl/ Pinz
Schallauer Peter	• Digital Image Sequence Restoration	1995-97	Seywald
Sommer Peter	• Maschinelles Sichtprüfsystem zur Vermessung von Rohrlängen	1996-97	Seywald
Trenkwalder Kurt	• Gabor Filter für Multiscale Textur-Analyse	1996-97	Pinz
Bolter Regine	• Simulationsgestützte Auswertung von SAR-Bildern unter besonderer Berücksichtigung von Layover	1996-97	Gelautz
Nussbauer Thomas	• Semiautomatic Generation of Flythrough Sequences	1994-97	Karner
Braun Bettina	• CAD-Datenaustausch über das neutrale Schnittstellenformat IGES	1995-97	Karner
Röhrer Reinhard	• Die Qualität bildanalytischer Merkmale zur Melanomerkennung	1996-97	Pinz
Bachler Gernot	• Effiziente Merkmalserzeugung und Okklusionsbestimmung in Bildsequenzen	1996-97	Pinz/ Sidla
Herzog Reinhard	• Visualisierung und Animation von BEM-Simulationen	1996-97	Karner
Lenz Gunther	• Automatisches Zählen von Span- und Faserplatten	1995-97	Pinz
Potzmann Stefan	• Studies about Digital Film Restoration Systems	1995-97	Seywald
Werth Peter	• Kalibrierung eines 3D Objektscanners mit Elektro-optischem Aufnahmesystem	1995-97	Pinz/ Gruber
Andexer Wilfried	• Entwicklung eines adaptiven Merkmalsvektor-Matchers zur Rekonstruktion von Bruchoberflächen	1996-97	Pinz/ Scherer
1998			
Bachmann Dieter	• A distributed Image Processing Back-end	1997-98	Pinz
Meissl Stephan	• Visualisierung von dreidimensionalen Daten einer Stadt	1994-98	Karner
Berger Martin	• Oberflächenrückührung aus Bilddaten	1997-98	Pinz/ Gruber
Fabschitz Andreas	• Bildgestützte Objektrekonstruktion mit parametrisierten Modellen	1997-98	Pinz/ Gruber
Holzer Johannes	• Rekonstruktion und Visualisierung von Altstadtensembles - digital,dreidimensional,fotorealistisch	1995-98	Gruber

Name	Topic	Period	Supervisor
Oberhuber Martin	• Distributed High-Performance Image Processing on the Internet	1995-98	Kalliany
Peitler Werner	• Entwurf und Bau eines zeilen-basierten Stereomeßsystems	1997-98	Pinz/ Gruber
Glatz Klaus	• Entfernung von Untertiteln aus Kinofilmen	1997-98	Pinz
Lampert Roman	• Implementierung eines Radarbild-Matchingalgorithmus	1997-98	Pinz/ Gelautz
Wildling Ernst	• Automatische Segmentierung von Pigmentläsionen sowie Low-level Routinen zur Merkmalsextraktion	1996-98	Pinz
Augsten Nikolaus	• Robuste Schätzung der Fundamental Matrix	1997-98	Pinz
Brantner Stefan	• A vision-based Tracking Technique for Augmented Reality	1997-98	Pinz
Koholka Roland	• Korrektur von Objektbewegungen in dynamischen MR-Untersuchungen	1998	Stollberger/ Pinz
Schinnerl Dietmar	• Interaktive modellbasierte Gebäuderekonstruktion aus digitalem Bildmaterial	1997-98	Pinz
Beichel Reinhard	• Klassifikation von Fernerkundungsdaten	1995-98	Pinz
1999			
Birchbauer Josef	• Entzerrung und Verschmelzung von Fingerabdruck-Bildern	1998-99	Pinz
Heinrich Markus	• Aufbereitung medizinischer Volumsdaten	1998-99	Pinz
Kemmer Thomas	• Design and Implementation of a distributed Information System for Remote Sensing Image Data	1997-99	Pinz
Prenner Richard	• Analyse und Synthese von Texturen	1996-99	Pinz/ Karner
Schupfer Stephan	• GeoEdit: Ein graphischer Editor zur bildunterstützten Auswertung geologischer Daten	1997-99	Gruber/ Mayer
Windhaber Dieter	• Clusteranalyse: Beschreibung und Anwendung clusteranalytischer Methoden auf Daten der Ganganalyse	1998-99	Pinz
Grabner Markus	• Multiresolution based on View-Dependent Progressive Meshes	1999	Pinz
Harrer Norbert	• Implementation of a Distributed Graphics Laboratory in Java	1997-99	Pinz
Hofer Gerald	• 3D-Editor mit 3D-Eingabegerät	1994-99	Leberl
2000			
Bauer Joachim	• Konturzordnung für die Stereorekonstruktion	1998-2000	Pinz/ Leberl
Siegl Hannes	• Quantification of Posterior Capsule Opacification after cataract Surgery	1998-2000	Pinz
Angermayer Lukas	• Intelligente Datenschnittstellen in der Computergraphik	1998-2000	Pinz/ Leberl

Name	Topic	Start	Supervisor
Martin Jochen	• Selection of Natural Landmarks for Vision based Tracking in Augmented Reality	1998-2000	Pinz
Lutzmayr Dieter	• Verteiltes Rechnen im Internet	1997-2000	Pinz
Konrad Harald	• Segementierung von Einezlbaumkronen aus hochauflösenden Laserscannerdaten	1999-2000	Pinz
Reif Christoph	• Darstellung von gasförmigen Körpern zur Visualisierung atmosphärischer Effekte	1999-2000	Leberl
2001			
Pachernegg Rene	• Automatische Klassifikation von Zellen in zytologischen Ausstrichen	1999-2001	Leberl
Klaus Andreas	• Oberflächenrekonstruktion mittels photometrischen Verhältnissen von Backscatter-Elektronen-Bildern	1998-2001	Pinz
Danzl Reinhard	• Integration von "Shape from Shading" und "Shape from Stereo" unter Verwendung variabler Reflexionsfunktionen für Rasterelektronenmikroskop-Bildern	2000-2001	Leberl/ Scherer
Kandlbauer Johann	• Ein Client/Server Modell für 3D-GIS Internetanwendungen	1999-2001	Leberl
Perko Roland	• Korrelationsmethoden für multitemporale Satellietenbilddaten	2000-2001	Scherer
Steinke Hannes	• Relative Orientierung	1999-2001	Scherer/ Leberl
Della Schiava Markus	• Evaluierung von Algorithmen zur Blobdetektion	2000-2001	Leberl
Hochegger Norbert	• Automatische Generierung von Gahnstreckenmodellen aus GIS-Daten	2000-2001	Leberl
Helmli Franz	• Ein adaptives System für Form aus Schärfenvariation mit einer Fehlerabschätzung in der Lichtmikroskopie	2000-2001	Leberl
Doberer Josef	• Automatische Void-Erkennung bei direkt gebondeten Wafern	1999-2001	Leberl
Dragoti Adnand	• Automatische Zuordnung von Eckpunkten in Stereobildpaaren	1997-2001	Scherer
Zaworka Arno	• Machine Vision Driven Real-time Black Jack Analysis	2000-2001	Leberl
Urschler Martin	• Image-based Verification of Parametric Models in Heart-Ventricle Volumetry	2000-2001	Leberl
Fraundorfer Friedrich	• Robust Estimation of the Trifocal Tensor	1999-2001	Leberl
Moltner Dietmar	• Estimation of the Fundamental Matrix - Evaluation and Comparision of State-of-the-Art-Algorithmus	2000-2001	Leberl
Boor Thomas	• Design and Implementation of a Prototype for www-based Geocoding of Satellite Image Data	1998-2001	Mayer
2002			
Schröcker Gerald	• Visibility Culling for Game Applications	2000-2002	Leberl
Hladik Michael	• Tools for Multimedial Presentation of Institutional Data	1999-2002	Leberl

Name	Topic	Start	Supervisor
Anda Bernd	• Mapping of Ocean Floor Topography using Surface Radar Images	01.01.2001	Leberl
Bauer Joachim	• Feature Based Modeling	01.05.2000	Leberl
Beichel Reinhard	• Automated Liver Segmentation in Spiral CT-Scans	20.04.2000	Leberl
Bornik Alexander	• Virtual Liver Surgery Planning using Augmented Reality Techniques	06.02.2002	Leberl
Danzl Reinhard	• Bildverarbeitung in der Mikroskopie	01.04.2002	Bischof
Elbischger Pierre	• Analyse von kolagenen Fasern mit Hilfe von Methoden der Computer Vision	01.12.2001	Bischof
Fernandez Gustavo	• Medical Image Processing Automatic Liver Segmentation	01.10.2001	Leberl
Grabner Markus	• Shape complexity: Problems, Solutions and Applications	01.01.2002	Leberl
Klaus Andreas	• Object Reconstruction from Image Sequences	01.05.2001	Leberl
Krivec Vuk	• Face Recognition (Gesichtserkennung)	13.10.2000	Leberl
Parziale Giuseppe	• Fingerprint Images Enhancement through Multiresolution Analysis	01.03.2002	Bischof
Perko Roland	• Large Format Digital Camera	15.09.2001	Leberl
Reitinger Bernhard	• Volume Visualization and Measurements by means of Liver Data Sets	01.08.2002	Leberl
Scheiblhofer Dietmar	• Minimalsystem zur Fingerabdruckserkennung	06.11.2001	Bischof
Schindler Konrad	• Piecewise Planar Object Reconstruction from Images	01.06.2001	Leberl
Sengel Martin	• Robotic Vision	01.10.2000	Leberl
Urschler Martin	• Modellierung und Visualisierung der Herz- und Lungenfunktion unter Berücksichtigung der Lungenventilation und der Herz-Lungen Durchblutung	01.01.2002	Leberl
Zach Christopher	• Echtzeitvisualisierung von virtuellen Städten	01.06.2001	Leberl

Name	Topic	Period	Supervisor
1996			
Karner Konrad	• Photorealistische Visualisierung	1992-96	Leberl
Madritsch Franz	• Immersive User Interface	1993-96	Leberl
Salcher Ewald	• Automatische Generierung einer grafischen Benutzerschnittstelle	1993-96	Leberl
Uray Peter	• Rekonstruktion realer Objekte unter Einbeziehung von Geometrie und Bildinformationen	1994-96	Pinz
1997			
Gelautz Margrit	• Radar Image Processing of Layover Regions	1993-97	Leberl
Gruber Michael	• Ein System zur umfassenden Erstellung und Nutzung dreidimensionaler Stadtmodelle	1993-97	Leberl
Maresch Markus	• Linear CCD array Based Recording of Buildings for Digital Models	1994-97	Leberl
Rehatschek Herwig	• Entwurf eines verteilten Bild-Archivs mit ATM Netzwerk Backbone am Beispiel von Planetendaten	1995-97	Leberl
Schäffler Jodok	• Kalibrierung einer linearen CCD-Kamera	1994-97	Leberl
Seywald Raimund	• Automated and Interactive Procedures for Efficient and Objective Evaluation of Filmscanners	1994-97	Leberl/ Pinz
Walcher Wolfgang	• Hypermedialer Zugang zu großen, räumlich zusammenhängenden Bilddatenmengen	1994-97	Leberl
1998			
Kellerer-Pirklbauer Walter	• Matching Dissimilar Opposite-Side Images of Spaceborne Radar Imaging Systems for Planetary Surface Reconstruction	1995-98	Leberl/ Pinz
Kofler Michael	• Datenstrukturen für digitale Stadtmodelle	1995-98	Leberl
Neuschmied Helmut	• Analyse endoskopisch erfasster Verbrennungsvorgänge in Motoren	1995-98	Pinz
Wiltschi Klaus	• An Active Inspection System for the Asessment of Steel Quality	1995-98	Pinz
1999			
Borotschnig Hermann	• Uncertain Information Fusion in active Object Recognition	1995-99	Pinz
Ganster Harald	• An Image Analysis System for Automated Melanoma Recognition	1994-99	Pinz
Goller Alois	• Parallel and distributed Processing of Large Data Sets	1996-99	Leberl
Niederl Franz	• Interaktive www-basierte Werkzeuge zur Remote Prozessierung von Fernerkundungsdaten	1996-99	Leberl
Prantl Manfred	• Active Object Recognition	1994-99	Pinz

Name	Topic	Period	Supervisor
2000			
Bachler Gernot	• Flexible, fast and robust Pin Picking in an Industrial Assembly Unit	1998-2000	Leberl/Pinz
Gaich Andreas	• Panoramic Vision for Geotechnical Analyses in Tunnelling	1997-2000	Leberl
Paletta Lucas	• Geometric Requirements for Active Fusion	1996-2000	Pinz
Scherer Stefan	• Stereoscopic and Photometric Surface Reconstruction in Scanning Electron Microscopy	1996-2000	Pinz
Zlatanova Siyka	• 3D GIS For Urban Development	2000	Leberl
Ribo Miguel	• Sensor Fusion-Based Map Building for Mobile Robot Exploration	2000	Pinz
2001			
Berger Martin	• Integrating Appearance Based and Model based Pose Determination	1998-2001	Leberl/Pinz
Bolter Regine	• Buildings from SAR: Detection and Reconstruction of Buildings from Multiple View High Resolution Interferometric SAR Data	1997-2001	Leberl
Mayer Heinz	• Capturing and Representing Real World Surface Properties for digital Image Synthesis	1998-2001	Leberl
Sehovic Amer	• Application of Imaging CCD-linear Sensor for 3D Object Reconstruction	1996-2001	Leberl
Werth Peter	• Refinement of Area-Based Correlation Techniques for Scanning Electron Microscope Images	1998-2001	Leberl
2002			
Nischelwitzer Alexander	• Fernerkundung und Multimedia im e-Tourismus	1995-2001	Leberl