Welcome to the

Special Semester on

New Trends in Calculus of Variations

Linz, October 13 – December 12, 2014

http://www.ricam.oeaw.ac.at/specsem/specsem2014

Organizer

Maïtine Bergounioux, Universite d'Orleans, France

Local Organizer

Karl Kunisch, University of Graz & RICAM, Austria
Otmar Scherzer, University of Vienna & RICAM, Austria

Workshops

Workshop 1: Shape and topological optimization
October 13-17, 2014

Workshop 2: Variational methods in imaging
October 27-31, 2014

Workshop 3: Geometric control and related fields
November 17-21, 2014

Workshop 4: Optimal Transport in the Applied Sciences
December 08-12, 2014

Schools

School 1: Imaging
October 22-24, 2014

School 2: Optimal Transport in the Applied Sciences
December 02-05, 2014

Workshop 2: Variational methods in imaging
October 27-31, 2014

Main topics

The workshop “Variational methods in imaging” is composed of invited lectures given by experts in the field of imaging sciences. It aims at presenting an interplay between research in applied mathematics (PDE’s, optimization, inverse problems, optimal transport, shape spaces) and applications in imaging (image processing, computer vision, computer graphics, computational anatomy).

Organizers

Christoph Schnörr (Heidelberg)
Gabriel Peyré (Paris-Dauphine)

Scientific comitee :

Alain Trouvé (ENS de Cachan)
Antonin Chambolle (Ecole Polytechnique)
Mila Nikolova (ENS de Cachan)
Mario Figueiredo (Lisboa)
Gabriele Steidl (Kaiserslautern)
Michael Hintermüller (Berlin)

List of speakers

Martin Bauer (Wien)
Kristian Bredies (Graz)
Martin Burger (Münster)
Antonin Chambolle (Ecole Polytechnique)
Emilie Chouzenoux (Paris-Est)
Daniel Cremers (Munich)
Jalal Fadili (Caen)
Massimo Fornasier (RICAM)
Guy Gilboa (Technion)
Michael Hintermüller (Berlin)
Sarang Joshi (Utah)
Ron Kimmel (Technion)
Peter Michor (Wien)
Mila Nikolova (ENS de Cachan)
Thomas Pock (Graz)
Martin Rumpf (Bonn)
Carola Schoenlieb (Cambridge)
Anuj Srivastava (Florida State University)
Gabriele Steidl (Kaiserslautern)
Alain Trouvé (ENS de Cachan)
Joachim Weickert (Saarland)

Abstracts

Plenary speakers

Jean-François Aujol (Bordeaux)
Title: Examplar based image colorization with a non convex model
Abstract: In this talk, we present an examplar based method to colorize a gray-scale image. We introduce a non convex functional whose minimizer is the colorized image we want to recover. We propose a primal-dual algorithm, and we prove the convergence to some stationary point. We illustrate the method with numerous examples. We also introduce an extension of the method to improve the examplar-based colorization with the addition of some scribbles by the user. This is joint work with Fabien Pierre, Aurélie Bugeau, Vinh Ta, and Nicolas Papadakis.

Martin Bauer (Wien)
Title: Infinite dimensional Riemannian Geometry with applications to Shape analysis
Abstract: I will provide an overview of various notions of shape spaces, including the space of parametrized and unparametrized surfaces. I will discuss the Riemannian metrics that can be defined thereon, and what is known about the properties of these metrics. I will put particular emphasis on the induced geodesic distance, the geodesic equation and its well-posedness, geodesic and metric completeness and properties of the curvature. In addition I will present selected numerical examples illustrating the behavior of these metrics.

Kristian Bredies (Graz)
Title: Preconditioned Douglas-Rachford algorithms for the solution of variational imaging problems
Abstract: We present a preconditioned version of the Douglas-Rachford (DR) splitting method for the solution of convex-concave saddle-point problems which often arise in variational imaging. This iteration is shown to converge in Hilbert space under minimal assumptions on the preconditioner and for any step-size. In particular, the method enables to replace the solution of a linear system in each iteration step in the corresponding DR iteration by approximate solvers without the need to control the error.
The methods are applied to non-smooth and convex variational imaging problems. We discuss denoising and deconvolution with L^2 and L^1 discrepancy and total variation (TV) as well as total generalized (TGV) penalty. Preconditioners which are specific to these problems are presented, the results of numerical experiments are shown and the benefits of the respective preconditioned iterations is discussed. Joint work with Hongpeng Sun.

Martin Burger (Münster)
Title: Variational Methods for 4D Motion Sequences
Abstract: This talk will discuss several approaches to the reconstruction of image sequences including fluid or solid body motion as appearing in various applications. We discuss different modelling approaches in which the image sequence as well as the deformation or velocity are used as variables. Those offer enormous potential for improved reconstruction, in particular in for low data quality, but on the other hand lead to enormous challenges with respect to its mathematical analysis and numerical solution. We discuss these aspects in certain cases and present results in biomedical imaging applications.

Antonin Chambolle (Ecole Polytechnique)
Title: Convergence rates for primal-dual algorithms
Abstract: We review primal-dual methods for solving convex problems and give new and more precise proofs of convergence than was previously known. This is a joint work with T. Pock.

Emilie Chouzenoux (Paris-Est)
Title: A stochastic 3MG algorithm with application to 2D estimation problems
Abstract: In the context of optimization of a differentiable objective function being the sum of a data fidelity term and a penalization (e.g. a sparsity promoting function), Majorize-Minimize (MM) subspace methods have recently attracted much interest. These approaches proceed by building at each iteration a simple majorant (e.g. a quadratic majorant) of the cost-function, which is minimized within a subspace of low dimension. When the subspace is restricted to the gradient computed at the current iterate and to a memory part, one obtains the MM Memory Gradient (3MG) algorithm which presents the advantage of being fast, highly flexible and effective in ensuring convergence, even in the nonconvex case. The goal of this paper is to show how 3MG algorithm can be successfully extended to a stochastic framework. Simulation results illustrate the good practical performance of the proposed approach when applied to 2D estimation problems.

Daniel Cremers (Munich)
Title: Convex Relaxation Techniques for Functions with Values in a Riemannian Manifold
Abstract: Since their introduction in 2008, functional lifting and convex relaxation techniques have become a popular framework to solve a large variety of orginally non-convex variational problems. The key idea is to add an additional dimension representing the space of feasible values (functional lifting) and to subsequently perform a convex relaxation. While this leads to optimal or near-optimal solutions for many non-convex problems, it comes at the sacrifice that solutions take on values which tend to lie on the finite set chosen to discretize the space of feasible values. In my talk, I will present a more general convex relaxation technique which improves over previous approaches in several ways: Firstly, it allows to treat functions which take values in an arbitrary Riemannian manifold. Secondly, the primal-dual formulation exploits the local structure of the Riemannian manifold in a way that gives rise to solutions which show less directional bias and less grid bias (sub-label precision). Numerous experiments on problems with convex and non-convex data and regularity terms (denoising, inpainting, optical flow) show that the computed solutions take on values which do not exhibit any preference for the grid points selected to discretize the underlying manifold. This is joint work with Jan Lellmann (Cambridge) and Evgeny Strekalovskiy (TUM).

Jalal Fadili (Caen)
Title: Stable Recovery with Partly Smooth functions.
Abstract: In this work, we investigate regularization properties of linear inverse problems with a prior promoting some notion of low-complexity. This is achieved through a class of convex regularizers coined partly smooth functions. Locally, these functions behave smoothly along a manifold and sharply normal to it. As such, they force the solutions of the so regularized problem to live on a low-dimensional (model) manifold which is stable under small perturbations of the regularizer.
In the first part of this talk, we show that a sharp criterion implies the stability of the model manifold to small noise perturbations of the observation when the regularization parameter is tuned proportionally to the noise level. This unifies and generalizes most of previous work in the field, and encompasses as special cases those of sparsity, group sparsity, total variation and low-rank regularizations.
In the second part of the talk, we turn to the forward-backward (FB) splitting algorithm to solve the structured variational problem, and show that under the same conditions as those of exact manifold recovery, the FB algorithm identifies the model manifold after a finite number of iterations, and then enters a local linear convergence regime that we characterize precisely.
This is a joint work with Gabriel Peyré, Samuel Vaiter and Jingwei Liang.

Massimo Fornasier (RICAM)
Title: Rotation Invariance in Exemplar-based Image Inpainting
Abstract: Due to their good performance on textured images, exemplar-based methods for image recovery have been subject of research in recent years. In this talk, the variational framework of exemplar-based inpainting is enriched by rotation invariance as an additional degree of freedom, including an extension of the analysis to the rotation invariant setting, which is developed in detail. For an efficient rotation invariant comparison of image patches we present methods based on discrete Circular Harmonics expansions, in particular, we also elaborate a method for gradient-based comparisons thanks to their property of being eigenfunctions of the Laplacian. These comparison methods allow for an implementation of a fast alternating optimization scheme of exemplar-based inpainting functionals. The patch non-local means algorithm and its performance in the recovery of image structures and textures are described in detail and we demonstrate by numerical examples the improvement in recovering smooth edges, which is due to the additional rotation invariance.

Guy Gilboa (Technion)
Title: A spectral variational approach for image analysis
Abstract: Linear eigenfunction decomposition is a very powerful technique used broadly in the signal and image processing community. In this talk an alternative variational processing methodology is introduced which is based on nonlinear eigenfunction analysis, referred to as a spectral approach. Some motivation will be given and analogues to Fourier filtering methods and linear eigenfunction decomposition will be drawn. A spectral total-variation framework will be presented. The more general case of one-homogeneous functionals will be discussed as well. Applications for image representation, decomposition and texture analysis will illustrate possible benefits of this framework.

Michael Hintermüller (Berlin)
Title: A bilevel optimization based parameter choice rule in total variation based image restoration.
Abstract: A new bilevel approach to total variation based image restoration is presented. While the lower level problem is the classical ROF-model, the upper level objective represents a local variance based functional, which allows to automatically adjust a locally varying regularization parameter in the ROF-model. Analytical as well as numerical results are presented.

Sarang Joshi (Utah)
Title: "Analyzing the Changing Anatomy."
Abstract: In this talk I will present computational and analytical tools we have been developing at University of Utah for the analysis of anatomical image ensembles that are designed to capture changes in anatomy. The fundamental analytical framework we have been using is that of regression analysis where the dependent variable is the anatomical configuration while the independent variable is application domain specific. I will exemplify the application of this general methodology to various medical imaging applications ranging from the analysis of Internal Organ Motion as imaged in 4D respiratory correlated CT imaging spanning few minutes to that of the study changes in brain anatomy associated with normal aging and neurodegenerative diseases such as Alzheimer's spanning decades.

Ron Kimmel (Technion)
Title: The geometric structure of shapes and images
Abstract: I will explore the power of the Laplace Beltrami Operator (LBO) in processing and analyzing visual and geometric information. The spectrum provided by the decomposition of the LBO at one end, and the heat operator at the other end provide us with natural tools for dealing with images and shapes. Denoising, segmenting, filtering, exaggerating are just few of the problems for which the LBO provides a solution.

Peter Michor (Wien)
Title: Overview on Convenient Calculus and Differential Geometry in Infinite dimensions, with Applications to Diffeomorphism Groups and Shape Spaces
Abstract: Parts of the following will be covered.
1. A short introduction to convenient calculus in infinite dimensions which is mainly adapted to the the infinitely differentiable (smooth) case.
2. Manifolds of mappings (with compact source) and diffeomorphism groups as convenient manifolds. Spaces of planes curves will be treated with special emphasis.
3. A diagram of actions of diffeomorphism groups.
4. Riemannian geometries of spaces of immersions, diffeomorphism groups, and shape spaces, their geodesic equations with well posedness results and vanishing geodesic distance.
5. Riemannian geometries on spaces of Riemannian metrics and pulling them back to diffeomorphism groups.
6. Robust Infinite Dimensional Riemannian manifolds, and Riemannian homogeneous spaces of diffeomorphism groups. We will discuss geodesic equations of many different metrics on these spaces and make contact to many well known equations (Camassa-Holm, KdV, Hunter-Saxton, Euler for ideal fluids), if time permits.

Mila Nikolova (ENS de Cachan)
Title: Relationship between the optimal solutions of least squares regularized with l_0-norm and constrained by k-sparsity
Abstract: Given an MxN real-valued matrix A with M<N and a data-vector d, consider that d must be expressed as a linear combination of a small number of basis vectors taken from A. Two popular options to find the sought-after sparse solution are (R_b) to minimize the least-squares *regularized* with the counting function $|.|_0$ (called usually the l_0-norm) via a trade-off parameter b>0, and (C_k) to solve the least-squares *constrained* by k-sparsity, i.e. $|.|_0 \leq k$. This work provides an exhaustive description of the relationship between the optimal solution sets of these two nonconvex (combinatorial) optimization problems. A general quasi-equivalence between these problems holds in the following sense: there is a set of integers $\{k_n\} \subseteq \{0,...,M\}$ and a strictly decreasing sequence $\{b_{k\_n}\}$ so that for any $b \in \{b_{k\_n}, b_{k\_\{n-1\}}\}$ problem (R_b) and problem (C_{k_n}) share exactly the same set of optimal solutions. For $b=b_{k\_n}$, the optimal solution set of (R_b) contains the optimal solutions of (C_{k_n}) and (C_{k_{n+1}}), and possibly the optimal sets of some (C_m) where $k_n<m<k_{n+1}$. All these integers and parameters are clearly identified. The case when the set of integers is $\{k_n\}=\{0,..., M\}$ is considered as well. Small-size exact numerical tests give a flavour of the meaning of the obtained theoretical results.

Thomas Pock (Graz)
Title: An Inertial Forward-Backward Algorithm for Solving Monotone Inclusions
Abstract: We propose a new inertial forward backward splitting algorithm to minimize the sum of two monotone operators, with one of the two operators being co-coercive. We prove convergence of the algorithm in a Hilbert space setting and show that several recently proposed first-order methods can be obtained as special cases of the general algorithm. Numerical results show that the proposed algorithm converges faster than existing methods, while keeping the computational cost of each iteration basically unchanged.
Joint work with Dirk Lorenz, TU Braunschweig

Martin Rumpf (Bonn)
Title: Institute for Numerical Simulation, University of Bonn
Abstract: In this talk the space of images is considered as a Riemannian manifold using the metamorphosis and the optimal transportation approach. For a pair of given input images geodesic paths in the space of images are defined as minimizers of a resulting path energy. To this end, the underlying Riemannian metric measures the rate of viscous dissipation, the transport cost or a combination of both. Furthermore, the model is capable to deal with strongly varying image contrast and explicitly allows for sources and sinks in the transport equations which are incorporated in the metric related to the metamorphosis approach by Trouvé and Younes. A robust and effective variational time discretization of geodesics paths is proposed. This requires to minimize a discrete path energy consisting of a sum of consecutive image matching functionals over a set of image intensity maps and pairwise matching deformations.
For the metamorphosis model the existence of discrete geodesic paths and Gamma-convergence of the underlying discrete path energy to the continuous path energy will be proved. A spatial discretization via finite elements combined with an alternating descent scheme in the set of image intensity maps and the set of matching deformations is presented to approximate discrete geodesic paths numerically. Computational results underline the efficiency of the proposed approach and demonstrate important qualitative properties.

The combined model will be explored on the range from merely optimal transport to strongly dissipative dynamics. In the non-viscous case with source term existence of geodesic paths in the space of measures can be established. Finally, the model is generalized to define discrete weighted barycentres with applications to textures and objects.
This is joint work with Benjamin Berkels, Alexander Effland, Jan Maas, and Carola Schönlieb.

Carola Schoenlieb (Cambridge)
Title: Optimising the optimisers - what is the right image and data model?
Abstract: When assigned with the task of reconstructing an image from given data the first challenge one faces is the derivation of a truthful image and data model. Such a model can be determined by the a-priori knowledge about the image, the data and their relation to each other. The source of this knowledge is either our understanding of the type of images we want to reconstruct and of the physics behind the acquisition of the data or we can thrive to learn parametric models from the data itself. The common question arises: how can we optimise our model choice?
Starting from the first modelling strategy this talk will lead us from the total variation as the most successful image regularisation model today to non-smooth second- and third-order regularisers, with data models for Gaussian and Poisson distributed data as well as impulse noise. Applications for image denoising, inpainting and surface reconstruction are given. After a critical discussion of these different image and data models we will turn towards the second modelling strategy and propose to combine it with the first one using a bilevel optimisation method. In particular, we will consider optimal parameter derivation for total variation denoising with multiple noise distributions and optimising total generalised variation regularisation for its application in photography.

Anuj Srivastava (Florida State University)
Title: Metric-Based Registration and Analysis of Objects (Curves, Surfaces, and Images)
Abstract: The problem of statistical analysis and modeling of objects using image data is encountered in many applications. While past works in shape analysis mostly relied on discrete, landmark-based representations of objects, the recent trend has been to study parametrized objects -- curves and surfaces. The key novelty here is the one performs registration of objects, i.e. optimal matching of points across objects, while comparing their shapes. This framework, termed elastic shape analysis, is enabled by: (1) a proper choice of metric that satisfies certain isometry properties, and (2) a square-root based transform that maps this elastic metric into the common Euclidean metric. This framework has been developed for shape analysis of curves in Euclidean spaces and surfaces, and has been demonstrated in many applications with real data. This success has motivated renewed interest in registration problems in signal and image analysis, where current methods have certain important shortcomings including the lack of "inverse consistency" -- the registration of A to B is not consistent with the registration of B to A. I will describe the use of shape-type metrics that can not only help register images, with lot more desired properties than the current methods, but also be used for further statistical analyses such as PCA or regression modeling. The biggest advantage comes from the fact that registration and comparisons of images are all performed in a unified way, under the same metric. I will demonstrated these ideas using examples of functional data analysis (biosignals, mass-spectrometry, etc) and image analysis (MRI slices, handwritten characters, etc).

Gabriele Steidl (Kaiserslautern)
Title: Second Order Differences of Cyclic Data and Applications in Variational Denoising
Abstract: In many image and signal processing applications, as interferometric synthetic aperture radar (SAR), electroencephalogram (EEG) data analysis or color image restoration in HSV or LCh spaces the data has its range on the one-dimensional sphere S1. Although the minimization of total variation (TV) regularized functionals is among the most popular methods for edge-preserving image restoration such methods were only very recently applied to cyclic structures. However, as for Euclidean data, TV regularized variational methods suffer from the so called staircasing effect. This effect can be avoided by involving higher order derivatives into the functional. This is the first paper which uses higher order differences of cyclic data in regularization terms of energy functionals for image restoration. We introduce absolute higher order differences for S1-valued data in a sound way which is independent of the chosen representation system on the circle. Our absolute cyclic first order difference is just the geodesic distance between points. Similar to the geodesic distances the absolute cyclic second order differences have only values in [0,pi]. We update the cyclic variational TV approach by our new cyclic second order differences. To minimize the corresponding functional we apply a cyclic proximal point method which was recently successfully proposed for Hadamard manifolds. Choosing appropriate cycles this algorithm can be implemented in an efficient way. The main steps require the evaluation of proximal mappings of our cyclic differences for which we provide analytical expressions. Under certain conditions we prove the convergence of our algorithm. Various numerical examples with artificial as well as real-world data demonstrate the advantageous performance of our algorithm. Joint work with R. Bergmann, F. Laus (Univ. Kaiserslautern), A. Weinmann (Helmholtz Center Muench).

Alain Trouvé (ENS de Cachan)
Title: A Shape Space Point of View on Functional Shapes
Abstract: Functional shapes, or fshapes, can be mainly described as signal functions supported on varying geometrical supports. Analysing variability of fshapes' ensembles require the modelling and quantification of joint variations in geometry and signal, which have been treated separately in previous approaches. Instead, in the talk, building on the ideas of shape spaces for purely geometrical objects, we will propose the extended concept of fshape bundles and discuss the use of Riemannian metrics for fshape metamorphoses to model geometrico-functional transformations within these bundles. Joint work with Benjamin Charlier and Nicolas Charon.

Joachim Weickert (Saarland)
Title: A Theory for Space-Discrete and Fully Discrete Diffusion that Permits Negative Diffusivities
Abstract: Forward-and-backward (FAB) diffusion has been proposed by Gilboa et al. (2002) as a method for sharpening blurry images. It combines forward diffusion with a positive diffusivity and backward diffusion where negative diffusivities are used. It can be seen as the gradient descent of an energy functional that is nonconvex and may even be decreasing for large arguments. The well-posedness properties of continous FAB diffusion are unknown, and it has been observed that standard discretisations can violate a maximum-minimum principle and lead to instabilities. We show that with a suitable nonstandard space discretisation which

pays specific attention to image extrema, the dynamical system for two-dimensional FAB diffusion becomes a well-posed process. It satisfies a maximum-minimum principle, possesses a Lyapunov function, and converges to a flat steady state. Moreover, we extend our results to the fully discrete 2-D case with an explicit time discretisation. For this scheme we derive a stability bound, supplement it with dynamic time step size adaptation, and demonstrate its performance with several examples. Joint work with Martin Welk (UMIT, Hall) and Guy Gilboa (Technion).

Posters

Aouatif Amine (Ibn Tofail University, Morocco)
Title: Hypovigilance Analysis using Iris and Mouth Detections to Extract Driver's Micro Sleep Periods
Abstract: Driver hypovigilance, often caused by fatigue and/or drowsiness, receives increasing attention in the last years, especially after it became evident that hypovigilance is a one of the major factor causing traffic accidents.
The increasing number of traffic accidents due to a diminished drivers vigilance level resulting from sleep deprivation has become a serious problem for society. Statistics show that about 20% of all accidents are due to hypovigilante drivers. In fact, the hypovigilance reduces driver's capacity to react, judge and analyze information and it is often caused by fatigue and/or drowsiness. However, drowsiness and fatigue are different. Drowsiness refers to the inability to stay awake while fatigue refers to a cumulative process producing difficulty to pay attention. Therefore, it is very important to monitor driver's vigilance level and issue an alarm when he is not paying enough attention to the road. Several visual behaviors can be used to characterize hypovigilante driver.
The eye state is often assumed to give a good indication of drowsiness level characterized by microsleep which is short period (2-6 s) during which driver rapidly closes the eyes and sleep. Drivers eye detection methods based on computer vision use camera to obtain facial information, extract the eye, and decide their openness degree. Many researchers use Percent of Eyelid Closure (PERCLOS) as a drowsiness indicator. Others researchers use the presence of iris to predict if the eye is open. To extract nformation about driver fatigue level, some authors consider that a high yawning frequency is a strong fatigue indicator. Existing works use generally one criterion to determine driver's vigilance level. In this work, we propose a system that uses two criteria. The first criterion detects drowsiness by extracting microsleeps using the presence of the iris. The second one detects fatigue using yawning deduced from large mouth opening. In this work, the proposed scheme begins by a face detection using local Successive Mean Quantization Transform (SMQT) features and split up Sparse Network of Winnows (SNoW) classifier. After performing face detection, the novel approach for eye/mouth detection, based on Circular Hough Transform (CHT), is applied on eyes and mouth extracted regions. Our proposed methods works in real-time and yield a high detection rates whether for drowsiness or fatigue detections.

Mohamed Badr Benboubker (ENSA Tetouan, Morocco)
Title: Renormalized solutions for a class of nonlinear parabolic equations without sign condition involving nonstandard growth
Abstract: An existence result of a renormalized solution for a class of doubly nonlinear parabolic equations with variable exponents is established. The main contribution of our work is to prove the existence of a renormalized solution without the sign condition and the coercivity condition on the nonlinearity H. The second term f belongs to $L^1(Q)$ and $b(u_0) \in L^1(\Omega)$.

Jean-Luc Bouchot (RWTH Aachen)
Title: Registration, structural similarities, and monotonicity
Abstract: Image and signal registration is an important part in many processes such as image fusion, information retrieval, and data analysis in a general sense. While most of the research is carried out on keypoint detection and matching little effort has been put towards structural similarities between signals and images. These ideas are motivated by applications involving a high stochasticity of the data or when the keypoints are not necessarily reproducible. In such cases it it interesting to look at other approaches that rely more on the inherent structural aspects of the data.
We present here some results towards structural similarity based image and signal processing. It is shown that structure-based signal comparisons offer the possibility to generate (dis-)similarity measures that are monotonic with respect to translation patterns and hence well suited for local optimization methods. We introduce in particular such distances: the discrepancy norm, and the scaled-distance transform.

Eva-Maria Brinkmann (WWU Münster, Germany)
Title: Color Bregman TV
Abstract: We present a novel approach to restore noisy color and multichannel images using variational methods with total variation regularization. In contrast to known total variation-based image processing methods for multichannel images we do not couple the intensities of different color channels, but instead we assume that the channels share a common edge set and therefore we couple subgradients. Using Bregman distances we thereby introduce a new regularization technique which iteratively leads to a solution with a reasonably small total variation in each channel on condition of a resemblance of the edge sets of the different image channels. This idea can be realized via a novel Bregman iteration, which is analyzed and implemented efficiently.
Computational results for denoising synthetic as well as real color images demonstrating the potential improvements are presented.

Luca Calatroni (Cambridge, UK)
Title: Designing a reliable TV-denoising method by means of bilevel optimization
Abstract: We consider a nonlinear PDE-constrained optimization approach to learn the optimal weights for a total variation image denoising model that features different noise distributions possibly present in the data. A training set of images is considered for a robust estimation, overcoming the computational costs by means of dynamic sampling schemes. The distribution of the noise is a-priori unknown, so we also describe how to enforce sparsity in the vector of weights for a blind selection of the correct model.

This is joint work with J. C. De Los Reyes (ModeMat, Quito, Ecuador) and C.-B. Schoenlieb (DAMTP, University of Cambridge, UK).

Quentin Denoyelle (Univ. Paris-Dauphine, France)
Title: Asymptotic of Sparse Recovery for Positive Measures
Abstract: This poster studies sparse spikes deconvolution over the space of Radon measures when the input measure is a finite sum of positive Dirac masses using the BLASSO convex program. The BLASSO corresponds to the minimization problem over the space of measures of the sum of the L2 recovery error and a regularization term which is the total variation of measures, i.e. the extension of the l1 norm to measures. We study the recovery properties of the support and the amplitudes of the initial measure in the presence of noise when the minimum separation of the input measure (the minimum distance between two spikes) tends to zero. This is a joint work with V. Duval and G. Peyré.

Azzouz Dermoune (Univ. Lille 1, France)
Title: Scaling of Gibbs measures around LASSO
Abstract: The aim of this poster is to show two scaling of Gibbs measures around LASSO. Using these scaling and Metropolis-Hastings algorithm, we show how to estimate LASSO. We also compare numerically our method with FISTA algorithm.

Marion Foare (LAMA, Université de Savoie)
Title: The anisotropic Mumford-Shah functional
Abstract: In this work, we propose to reconstruct a grayscale image using an anisotropic variant of the Mumford-Shah model, in order to have a better approximation of corners. We use the Ambrosio-Tortorelli approximation in the anisotropic version given by Focardi to obtain a smooth reconstruction and the set of discontinuities of the original image. We try two different anisotropies(an L1 norm and a structure tensor extracted from the image) and we implement numerically using standard and discrete calculus methods.

Lena Frerking (WWU Münster, Germany)
Title: TGV-based flow estimation for 4D cell transmigration
Abstract: Our aim is to track migrating leukocytes. Recent results have shown the advantages of the nonlinear and higher order terms of TGV-regularizers especially in static models for denoising and reconstruction. We present TGV-based models for flow estimation with the goal to get an exact recovery of simple flows, as well as its implication on realistic tracking situations. To distinguish and quantify different pathways of transmigrating leukocytes, we use large scale 4D fluorescence live microscopy data in vivo.

Joana Grah (WWU Münster, Germany)
Title: Methods for automatic mitosis detection and tracking in phase contrast images
Abstract: Nowadays, research in the biomedical sciences including mitotic index analysis of cancer cells strongly depends on evaluation and processing of digital microscopy images. We present a framework for automatic detection of mitotic cells based upon the Circular Hough transform as well as two new variational cell tracking methods specifically adjusted for phase contrast microscopy image sequences.

Barbara Gris (CMLA, ENS Cachan, France)
Title: A modular multi-scale model in the LDDMM framework
Abstract: We develop a multi-scale modular model in the framework of LDDMM : at each time the allowed vector field is a sum of local modules acting at a particular scale. These modules do not share localisation or momenta (both are optimised), which allow qualitative interpretation of the deformation at each scale.

Guozhi Dong (Universität Wien)
Title: Scale and edge detection with topological derivatives
Abstract: The purpose of this work is detecting scales of discontinuities of the image. A recently developed topological derivative(TD) way for minimizing the Mumford-Shah(MS) functional is employed. For the scale selection we use a squared norm of the gradient at edge points. During the iteration progress, the square norm, as a function varied with iteration numbers, provides information about different scales of the discontinuity sets. For realistic image data, the graph of the norm function is regularized by using TV minimization to provide stable separation.

Martin Holler (University of Graz)
Title: Infimal-Convolution of Total-Generalized-Variation-Type Functionals as Regularization for Video Reconstruction
Abstract: Regularization is key issue in variational image processing. Functionals that both provide a realistic data model and are computationally tractable allow a high quality reconstruction even from severely degraded data. While, in the still image context, extensive research on such functionals has led to image priors satisfying these demands to a large extend, research on regularization for image sequences is not that evolved yet. But in particular image sequences typically have a high redundancy along the temporal dimension and are thus amenable to regularization. We propose the infimal convolution of total generalized variation type functionals (ICTGV) as regularization in this context. Assuming that an image sequence is represented by a function u defined on the three dimensional space-time domain, a simple form of the proposed regularization term can be given formally as

$$\mathrm{ICTGV}(u) = \min_v \| |\nabla (u-v)|_{\beta_1} \|_{\mathcal{M}} + \| |\nabla v|_{\beta_2} \|_{\mathcal{M}}.$$

Here, \nabla$ denotes the spatio-temporal derivative and $|\cdot |_{\beta_ 1}, |\cdot |_{\beta_ 2}$ denote two norms on $\mathbb{R} ^3$ that apply a different weighting of the temporal derivative. Thus, evaluation of ICTGV performs an additive decomposition of the image sequence by suitably combining spatial and temporal regularity requirements. The introduction of the functional will be motivated by the problem of reconstructing compressed video data. After providing a rigorous definition and basic properties, we also consider its application for the reconstruction of dynamic MRI data. We present results from the ISMRM (International Society for Magnetic Resonance in Medicine) challenge on accelerating cardiac dynamic imaging, where the second place could be achieved.
This is joint work with Karl Kunisch.

José A. Iglesias (Universität Wien)
Title: A shell model for level set matching
Abstract: A level set formulation for the matching of embedded surfaces, inspired on hyperelastic variational models, is proposed. Exploiting the information available in the surface matching scenario, we obtain a functional involving only first-order derivatives for which existence of minimizers can be proved through the direct method, while still reflecting resistance to compression and bending. For its numerical solution, we propose a discretization through conforming multilinear finite elements on adaptive octree grids, and a coarse-to-fine multilevel minimization using Sobolev metrics. This approach allows for high-resolution computations.

Irene Kaltenmark (CMLA, ENS Cachan)
Title: A Growth Model in Computational Anatomy based on Diffeomorphic Matching
Abstract: We present an extension of the LDDMM method to address the problem of non diffeomorphic structural variations in longitudinal scenarios during a growth or degenerative process. We keep the geometric central concept of a group of deformations acting on a shape space. However, the shapes will be encoded by a new enriched mathematical object allowing an intrinsic evolution dissociated from external deformations. We focus on the specific case of the growth of animal horns.

Michael Moeller (Technische Universität München)
Title: Mixed Matrix Norm Total Variation Regularization
Abstract: We propose to use mixed matrix norms as a framework to extend the total variation (TV) regularization to vector valued images. The gradient of a multichannel image is considered to be a three dimensional matrix/tensor with dimensions corresponding to the pixels, the derivatives in x- and y-direction, and the channels of the image. Applying different ℓ^p and Schatten-p norms along the different dimensions of this matrix yields several known as well as new extensions of the TV to multichannel images. We study the properties of the resulting regularizers with a particular focus on the differences arising from different ways of coupling the color channels.

Mirko Myllykoski (University of Jyväskylä, Finland)
Title: A New Augmented Lagrangian Approach For L¹-Mean Curvature Image Denoising
Abstract: This poster presents an augmented Lagrangian based image denoising method which uses the L¹-norm of the mean curvature of the graph of the image as a regularizer. The application of a particular alternating direction method of multipliers (ADMM) leads to the sequential iterative solution of four sub-problems. The approach considered here differs from existing augmented Lagrangian approaches for the solution of the same problem as it contains three Lagrange multipliers ‘only’. In addition, the associated augmentation terms are quadratic. The poster presents the results of numerical experiments demonstrating the functionality of the method. A related manuscript has been submitted to SIAM Journal on Imaging Sciences.

Giacomo Nardi (Univ. Orléans, France)
Title: Geodesics on Shape Spaces with Bounded Variation and Sobolev Metrics
Abstract: This poster studies the space of BV2 planar curves endowed with the BV2 Finsler metric over its tangent space of displacement vector fields. Such a space is of interest for applications in image processing and computer vision because it enables piecewise regular curves that undergo piecewise regular deformations, such as articulations. The main contribution of this paper is the proof of the existence of a shortest path between any two BV2 curves for this Finsler metric. This is a joint work with F.X. Vialard and G. Peyré

Kostas Papafitsoros (University of Cambridge)
Title: Higher order non-local regularisation
Abstract: we introduce a higher order non-local model for image restoration. As numerical examples indicate, our model competes with the current state of the art higher order method, Total Generalised Variation (TGV). We also provide a detailed analysis for some specific cases that leads to novel derivative-free characterisations of higher order Sobolev and BV spaces.

Evangelos Papoutsellis (University of Cambridge)
Title: Total Variation Regularisation in Sinogram space for PET reconstruction.
Abstract: This poster presents a novel technique for image reconstruction in positron emission tomography, based on total variation regularisation on both the image space and the projection space. The additional regularising penalty on the sinogram provides a better reconstruction on data with thin structures and creates a more realistic smoothing along the boundaries, eliminating the unpleasant staircasing effect. We also discuss the well-posedness of the problem and its numerical solution using the split Bregman algorithm. Finally, we present some results from our numerical experiments to PET phantoms demonstrating the advantage of this approach.

Bernhard Schmitzer (Université Paris-Dauphine)
Title: Isometry Invariant Shape Priors for Variational Image Segmentation
Abstract: Prior knowledge about the shape of objects constitutes an important cue for image segmentation. Constructing shape prior functionals entails a delicate trade-off between descriptive power and computational feasibility. Simple approaches are often unsatisfying in properly describing the set of allowed shapes, while sophisticated techniques usually yield highly non-convex functionals that are difficult to optimize globally.
We present functionals for object segmentation through simultaneous matching with a shape template. By using optimal transport it is possible to combine contour based shape models with the framework of convex variational image segmentation. A particular focus is put on achieving isometry invariance and on overcoming the initialization problem from which typical contour based models use to suffer.

Samuel Vaiter (CMAP, Ecole Polytechnique, France)
Title: Low Complexity Regularizations for Inverse Problems
Abstract: This poster is concerned with recovery guarantees and sensitivity analysis of variational regularization for noisy linear inverse problems. This is cast as a convex optimization problem by combining a data fidelity and a regularizing functional promoting solutions conforming to some notion of low complexity related to their non-smoothness points. Our

approach, based on partial smoothness, handles a variety of regularizers including analysis/structured sparsity, antisparsity and low-rank structure. We first give an analysis of the noise robustness guarantees, both in terms of the distance of the recovered solutions to the original object, as well as the stability of the promoted model space. We then turn to sensivity analysis of these optimization problems to observation perturbations. With random observations, we build unbiased estimator of the risk which provides a parameter selection scheme.

David Vicente (Université d'Orléans, France)
Title: Anisotropic Functional for detection of tubes and its approximation with Gamma-convergence
Abstract: This poster is a contribution to the problem of detection of thin structures, namely *tubes*, in a 2D or 3D image. We introduce a *bimodal* model for the case where the histogram of the image has two main modes. This model involves an energy functional depending on a function and a riemannian metric. One of the term of this energy is the anisotropic perimeter associated to the dual metric. We perform an approximation of this functional and prove it Γ-converges to the original one. Numericals results are presented.

Vincent Duval (INRIA, France)
Title: Discrete and continuous approaches for sparse spikes deconvolution
Abstract: The problem of sparse spikes deconvolution consists in recovering a sum of Dirac masses from their convolution with the impulse response of a low-pass filter in the presence of noise. In many classical approaches such as the Lasso or the Basis Pursuit, one defines a grid and solves a finite dimensional variational problem. On the contrary, several authors have recently proposed to remove the grid and to solve the analogue of l1 minimization in the continuous domain.
In this poster, I will compare those « discrete » and « continuous » approaches.

Cong Shi (Universität Wien)
Title: Some results on the PAT operator in attenuated wave equations
Abstract: Photoacoustic Tomography (PAT) is a hybrid medical imaging method, which works by measuring the pressure wave induced by an EM pulse. The mathematical problem is to recover the thermal expansion rates from the detection of the ultrasound wave. Because of its high contrast between healthy and cancerous cells and harmless to the body, so now this method becomes popular.
In this poster, I will present our research results about the PAI operator. The first part shows the mathematical problem in PAT, then give some known models and our general model, then give some basic assumptions. In the second part it is our first result, the ill-posedness analysis, we show that under some assumptions, the decay rates of the general operator is exponential. In the third part, it is our second result, causality analysis of this general model, we give a necessary and sufficient condition for causality of our general model obeying attenuation.

List of Participants

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Welcome to the

Special Semester on

New Trends in Calculus of Variations

Linz, October 13 – December 12, 2014

http://www.ricam.oeaw.ac.at/specsem/specsem2014

General Information

General Information

Some useful pieces of information.
Please READ CAREFULLY.
Thank you!

ACCOMMODATION

for our invited speakers and for those who receive financial support we have booked rooms at:

University Guesthouse: "Hotel Sommerhaus"
Address: Julius-Raab-Straße 10, 4040 Linz
http://www.sommerhaus-hotel.at/en/
Check-in desk: open from 0-24 h; English speaking

Breakfast included, Shower/toilet in every room, 10 minutes walk to university, indoor swimming pool, internet connection in every room, fitness room, music room...

If support on accommodation has been agreed upon by the organizers, accommodation will directly be paid by RICAM (those with double rooms shared with a non participating person, will be asked to pay for the difference themselves when they move out).

For the regular participants: please take care for your own bookings. You can find recommendations of Hotels on our website!

REIMBURSEMENT

to all who have been granted support:
Keep ALL the ORIGINAL RECEIPTS (boarding passes, passenger receipts, train tickets, taxi receipts, tram/bus tickets ... **everything**) otherwise we will NOT be able to transfer money to your accounts!!!
There is NO CASH involved in the reimbursements.
In Linz you will receive a form where you can write down all your expanses and hand it in.

YOU CAN REACH RICAM VIA

Linz Airport to university and hotel:
Shuttle bus (see link below) to main train station and then take tram
http://www.flughafen-linz.at/www/cm/en/passengers/approach/bus.html
or taxi (approx. 40 Euro).

Linz main train station ("Linz Hauptbahnhof", Hauptbhf.) to university and hotel:
Purchase with cash **a MIDI** (1 hour, € 2) **or MAXI** (24 hours, € 4) **ticket** from a ticket machine or from a tobacco store ("Trafik"). Take tram 1 or 2 (stops directly at the underground of the train station) into the direction of "JKU Universität" and get off at the stop **"JKU Universität"** (last stop).

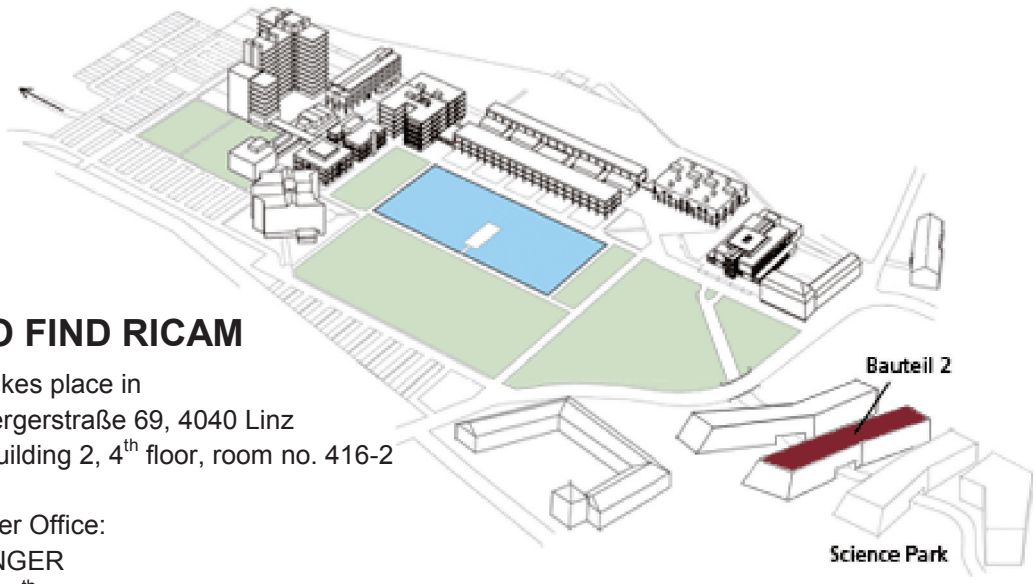
Vienna Airport ("Schwechat") to Vienna train station ("Wien-Westbahnhof"):
There is a shuttle bus every 30 minutes directly to the Viennese train station.
Time table Bus: http://www.viennaairport.com/jart/prj3/va/uploads/data-uploads/Passagier/Parken/VIE_Postbus_1187_de_en.pdf
If you take the Train, use "Schnellbahn - S7" in direction "Wien Floridsdorf" via "Wien Mitte - Landstraße" (U3, Underground) to "Wien-Westbahnhof"
Time table Train: http://www.viennaairport.com/en/passengers/arrival__parking/s-bahn__suburban_railway or check http://www.oebb.at/en

Vienna Central Station (Westbahnhof) - Train from Vienna to Linz:
https://westbahn.at (cheaper tickets!)
www.oebb.at/en

PUBLIC TRANSPORT MAP „LINZ LINIEN“

https://www.linzag.at

UNIVERSITY CAMPUS



WHERE TO FIND RICAM

the workshop takes place in
RICAM, Altenbergerstraße 69, 4040 Linz
Science Park Building 2, 4th floor, room no. 416-2

Special Semester Office:
Verena GRAFINGER
Science Park 2, 4th floor, room no. 456
fax machine, copy machine, office supplies ...

Open: Monday: 8:00 – 14:30
Wednesday: 9:00 – 14:30
Tuesday, Thursday, Friday: 9:00 – 12:00

WORKSHOP SCHEDULE

Registration starts Monday 8:00, Science Park2, 4th floor
We will be there to help if questions arise and to hand out your personal folders and name badges.

Opening: Monday, 13:30 in seminar room 416-2

Let us most politely ask you to try to be on time for the opening.

COFFEE BREAKS & EVENING SNACKS

Coffee breaks - as mentioned on the workshop timetable - take place in room no. 416-1 (small seminar room, next to the big one).
In the evenings there is the possibility to have access to this seminar room to come together.
Small snacks and drinks are available.

CAR PARKING

is possible directly at the Science Park Parking Deck for € 2/ hour or free in the streets around, however there is usually not much space.

INTERNET

w-Lan connection possible all over the campus and in all RICAM offices
w-Lan-name: ricam
Password: agodaricamo

COMPUTER ROOM / PRINTER

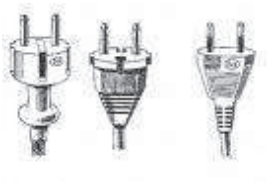
If needed, go to room no. 413.
Username and password are on the screen. The printer is installed.

TECHNICAL SUPPORT

If you need any help concerning w-lan, laptops, printers etc. please contact:
Florian TISCHLER or Wolfgang FORSTHUBER
Room no. 458

PLUGS IN AUSTRIA

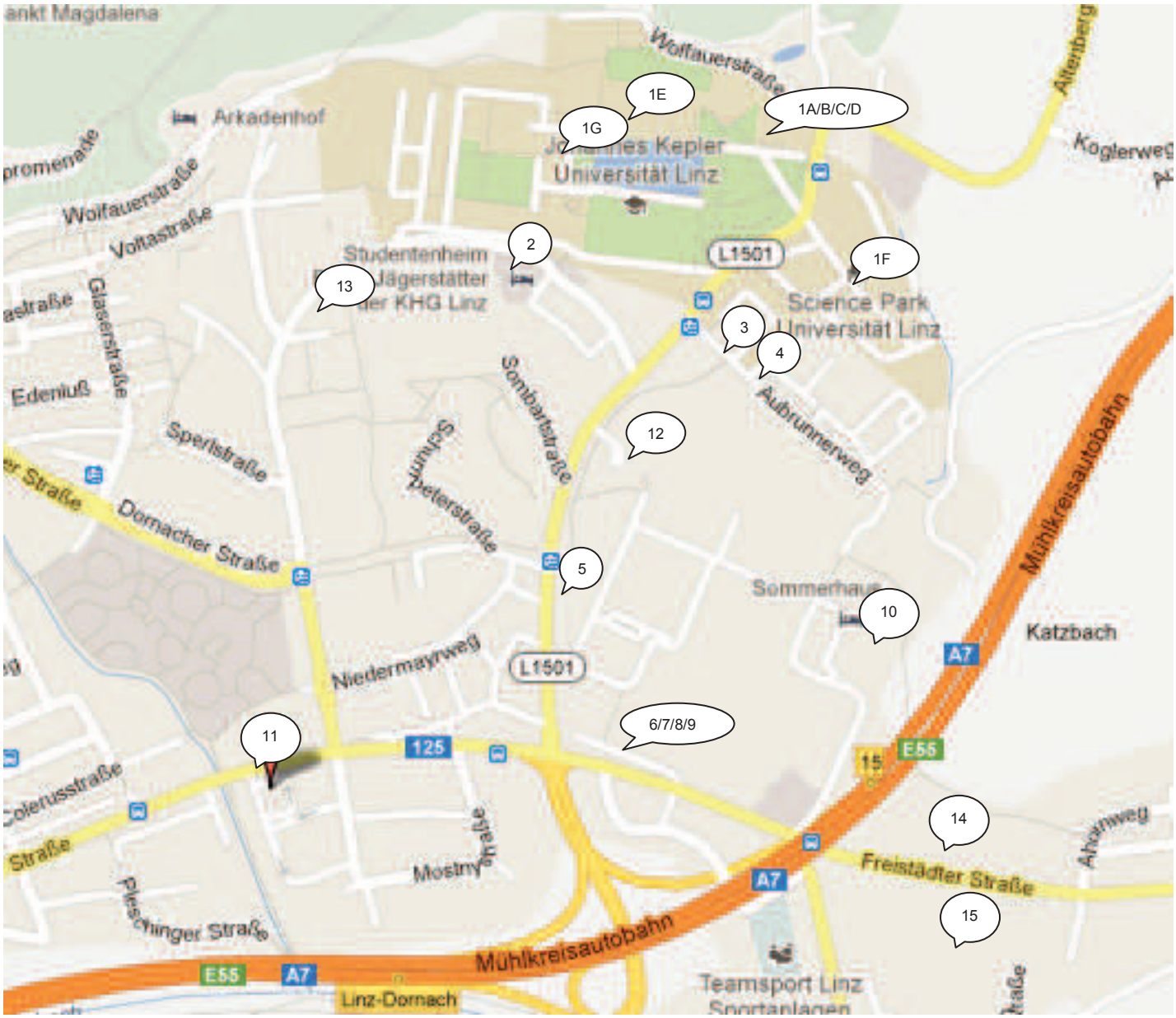
please, see photo



RESTAURANTS & FOOD

1	At University campus *Check your dish:* http://www.jku.at/content/e213/e175/e6780	**A) Mensa**	Mo-Fri	11:15 – 13:30
		B) Choice (in Mensa)	Mo-Thu Fri	10:30 – 14:30 10:30 – 13:30
		C) Kepler's Restaurant	Mo-Thu Fri	11:30 – 14:00 11:30 – 13:30
		D) Café (in Mensa)	Mo-Thu Fr	08:00 – 14:30 08:00 – 13:30
		E) Ch@t (Cafe Keplergebäude)	Mon-Thu Fri	08:00 – 19:00 08:00 – 14:00
		F) Science Cafe (Science Park3)	Mon-Thu Fri	08:00 – 16:00 08:00 – 14:00
		G) Cafe SASSI (Bankengebäude)	Mon-Fri Sa	08:00 – 20:00 09:00 – 14:00
2	KHG Mensa	Mengerstraße 23 Tel: 0732 244011	Mon-Fri 11:00 - 13:00	
3	„Bella Casa“ - Pizzeria	Aubrunnerweg 1a Tel: 0732 245646	Open daily 11:00-15:00 and 17:00 - 24:00	
4	„Jadegarten“ – Chinese Restaurant	Aubrunnerweg 11 Tel: 0732 750160	Open daily 11:00 – 23:00	
5	Burgers	Altenbergerstraße 6-8 Tel: 050 66 66 66	Mo-Thu 10:30 – 22:00 Fri-Sat 10:30 – 23:00 Sun 10:30 – 22:00	
6	Pizza Mann	Freistädter Straße 313 Tel: 05 10 10 10 www.pizzamann.at	Open daily 11:00 – 03:00 (Online order)	
7	Subway	Freistädter Straße 313 Tel.: 05 995 9910 http://linz.suborder.at	Open daily 08:30 – 24:00 (Online order)	
8	Burger Checker	Freistädter Straße 313 Tel.: 0660 1101 200	Mon – Sun 11:00 – 14:00 and 17:00 – 20:30	
9	„Goldener Hof” – Chinese Restaurant	Freistädter Straße 315 Tel: 0732 24 40 42	Open daily 11:30 – 14:30 and 17:30 – 23:00	
10	„RaabMensa.Lounge.Restaurant. Bar” – Hotel Sommerhaus	Julius Raab-Straße 10 Tel: 0732 24570	Lounge, Bar: Mon – Thu 06:30 – 23:30 Fri 06:30 – 14:00 Sat – Sun 06:30 – 11:00 Hot food daily: 11:30 – 14:30 17:00 – 21:30	
11	Mc Donalds & Mc Cafe	Freistädter Straße 298	Mon – Thur 07:00 – 01:00 Fri – Sat 07:00 – 02:00 Sun 07:00 – 01:00	
12	Supermarket „Winkler Markt“	Altenbergerstraße 40 **Sunday closed!**	Mon – Thur 07:30 – 18:30 Fri 07:30 – 19:00 Sat 07:30 – 17:00	
13	Supermarket “Penny”	Johann-Wilhelm-Klein-Strasse 58 **Sunday closed!**	Mon – Fri 7:30 – 19:00 Sat 7:30 – 18:00	

14	Supermarket „Hofer“	Freistädter Straße 401 **Sunday closed!**	Mon-Fri Sat	08:00 – 20:00 08:00 – 18:00
15	Supermarket „Billa“	Freistädter Straße 400 **Sunday closed!**	Mon-Fri Sat	07:40 – 20:00 07:40 – 18:00



PHYSICIANS, HOSPITALS AND PHARMACIES

The following physicians have offices in the area of Hotel Sommerhaus and the university:

Dr. Winfried Mraczansky Altenbergerstraße 43 4040 Linz Phone +43 (0) 732 245655	Dr. Kurt Kellermair Freistädter Straße 41 4040 Linz Phone +43 (0) 732 730595	Dr. Gottfried Maria Jetschgo Pulvermühlstraße 23 4040 Linz Phone +43 (0) 732 254121
Mon 8–11:30 and 16–17:30 Tue 8–11:30, Thu 8–11:30 Wed 8–11:30 and 16–17:30 Fri 8–11	Mon 8–12 and 17–19 Tue 9–12, Wed 8–11 Thu 8–11 and 16–19 Fri 8–11	Mon 8–12 Tue-Fri 8–11 Tue 16-18 Thu 16-18

Should you need medication the doctor will give you a prescription which you can take to any pharmacy to pick up the medicine. Usually, you will have to pay for a small part of the medication yourself. Pharmacies are also the only places which sell over-the-counter drugs like pain relievers etc. The **pharmacy** nearest to the campus is located **in the Winkler-Markt building (nr.12)**. After hours, a sign in any pharmacy's window will always tell you the nearest pharmacy on duty. The general hospital in Linz is Allgemeines Krankenhaus (AKH Linz), Krankenhausstraße 9. It provides an emergency room. In addition, Linz has a number of specialized hospitals, some of which also have emergency rooms. In case of a medical emergency, call 144.

EMERGENCIES

In case of emergencies, here are a few useful phone numbers to remember:

Fire Department **122**
Police **133**
Medical Emergencies **144**
Emergency calls at the University campus **8144** (for urgent cases), otherwise **9100**
Europe-wide general emergency call **112**
Car Breakdown **120** or **123**
Mountain Rescue **140**
Information about physicians on duty after hours **141**
Intoxication hotline **01/4064343**

Note that the europe-wide general emergency number **112** can be called in particular from any cell phone even without a valid subscription or prepaid SIM card inserted.

VACCINATION

NO vaccinations necessary!

WEATHER FORECAST FOR AUSTRIA

http://www.wetter.at/wetter/oesterreich/oberoesterreich/linz

We wish you all a very pleasant time in Linz!

Social Event: VoestAlpine Stahlwelt
Wednesday, October 29

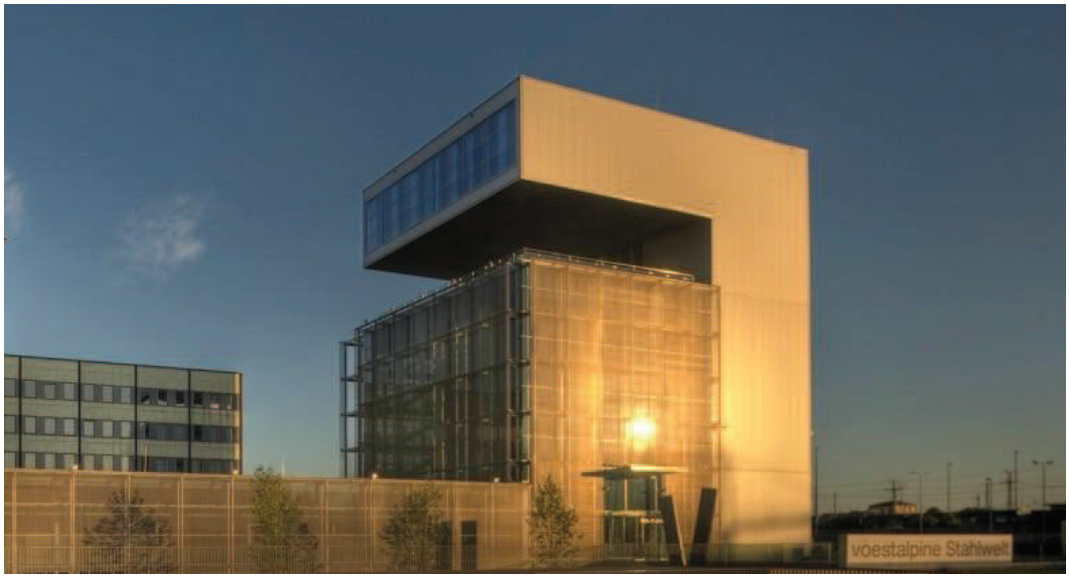
Meeting Point: 14:25
We will **meet at 14:25** at the parking area in front of the SCIENCE PARK and travel together by BUS to the Industrial Area of Linz.

Start of the Guided Tour: 15:30
Duration of the Tour: about 70 minutes
Language: English
Back at Science Park: approx. 17:30

If you don´t want to participate, please let the secretary (Verena Grafinger) know as soon as possible.
Thank you ☺!

What will you experience?
http://www.voestalpine.com/stahlwelt/en

"Come and be amazed.
Discover steel. How it is made and processed. And the many places it is used.
Take a behind-the-scenes peek at technologies on the cutting edge in the world of steel.
"Get a grasp" on steel in the truest sense of the word;
get to know the voestalpine Group and hear success stories both large and small from the experts at voestalpine."



Workshop Timetable

Workshop 2: Variational methods in imaging

October 27-31, 2014

	Monday Oct 27	Tuesday Oct 28	Wednesday Oct 29	Thursday Oct 30	Friday Oct 31
09:00 - 09:45	09:00 - 12:00 REGISTRATION	Peter Michor (Wien)	Alain Trouvé (ENS de Cachan)	Michael Hintermüller (Berlin)	Thomas Pock (Graz)
9:45 - 10:30		Sarang Joshi (Utah)	Martin Rumpf (Bonn)	Kristian Bredies (Graz)	Gabriele Steidl (Kaiserslautern)
10:30 - 11:15		***Coffee Break***	***Coffee Break***	***Coffee Break***	***Coffee Break***
11:15 - 12:00		Jalal Fadili (Caen)	Anuj Srivastava (Florida State University)	Daniel Cremers (Munich)	Joachim Weickert (Saarland)
12:00 - 14:00	***Lunch Break*** 13:30 - 14:00 Opening	***Lunch Break***	***Photo then Lunch Break***	***Lunch Break***	12:00 Closing
14:00 - 14:45	Guy Gilboa (Technion)	Emilie Chouzenoux (Paris-Est)		Ron Kimmel (Technion)	
14:45 - 15:30	Massimo Fornasier (RICAM)	Martin Burger (Münster)	**Start to Excursion: 14:25 "VOEST Alpine - Steel world" (15:30 Tour start)**	Martin Bauer (Wien)	
15:30 – 16:15	***Coffee Break***	***Coffee Break***		***Coffee Break***	
16:15 - 17:00	Jean-Francois Aujol (Bordeaux)	Antonin Chambolle (Ecole Polytechnique)		Carola Schoenlieb (Cambridge)	
17:00 - 19:00	***Poster Session 1 and Welcome Reception***	17:00 - 17:45 Mila Nikolova (ENS de Cachan)		***Poster Session 2***	
19:00				***Conference Dinner at Mensa (JKU)***	