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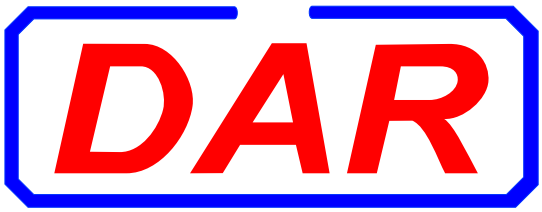
Content



7^{th} International Workshop on
Data - Algorithms - Decision Making

Session 1.

Knowledge Processing

November 27, 2011, Afternoon

Chairman: Radim Jiroušek

Dreaming About Universal Nonmanipulative Fair Democracy

[1]Vlach Milan

The paper deals with recently proposed frameworks for analyzing functions which map n-tuples of linear orders on a fixed set A to a set of binary relations on A. This framework makes it possible to show that the classical impossibility results of Arrow [1, 2] on *social welfare functions* and that of Gibbard [3] and Satterthwaite [4] on *social choice functions* are special cases of a general impossibility theorem on so called *social aggregators* [5].

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Conditionals in Uncertain Reasoning

[1]Kleiter Gernot D.

The talk consists of

1. a short overview of the LogICCC programme of the European Science Foundation and
2. a report of our psychological work on uncertain reasoning within this programme.

Our group investigated (i) how people interpret conditional if-then sentences and (ii) the implications of this interpretation for probabilistic reasoning. In a series of experiments involving more than 350 participants we found that most people interpret a conditional if-then sentence as a conditional event and not as a material implication. Correlations with the performance in Wason's four-cards task, with the performance in a working memory task, and with the performance in a probabilistic modus ponens task will be reported.

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Rank of Tensors of l-out-of-k Functions: an Application in Probabilistic Inference

[1]Vomlel Jiří

Bayesian networks are a popular model for reasoning under uncertainty. We study the problem of efficient probabilistic inference with these models when some of the conditional probability tables represent deterministic or noisy ℓ-out-of-k functions. These tables appear naturally in real-world applications when we observe a state of a variable that depends on its parents via an addition or noisy addition relation. We provide a lower bound of the rank and an upper bound for the symmetric border rank of tensors representing ℓ-out-of-k functions. We propose an approximation of tensors representing noisy ℓ-out-of-k functions by a sum of r tensors of rank one, where r is an upper bound of the symmetric border rank of the approximated tensor.

We applied the suggested approximation to probabilistic inference in probabilistic graphical models. We performed experiments with the game of Minesweeper, see Figure 1.

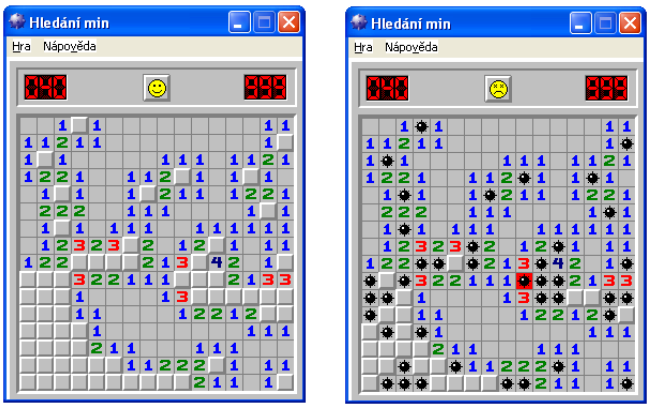

Figure 1: Two screenshots from the game of Minesweeper. The screenshot on the right hand side is taken after the player stepped on a mine. It shows the actual position of mines.

Numerical experiments reveal that we can get a gain in the order of two magnitudes but at the expense of a certain loss of precision. See Figure 2.

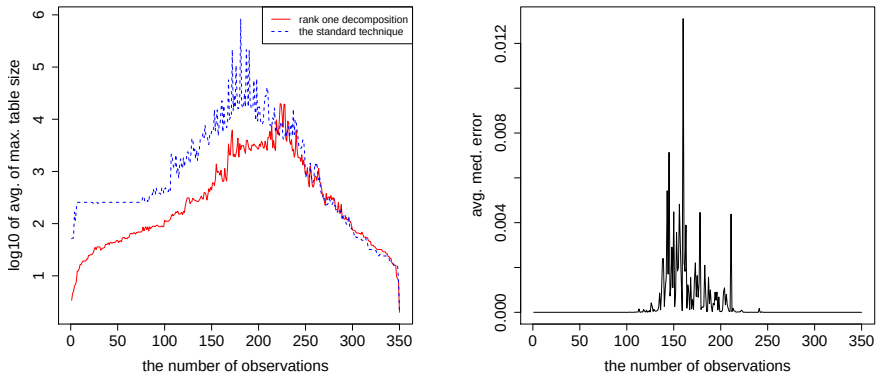

Figure 2: Results of the experiments for the game of Minesweeper on the 20×20 grid.

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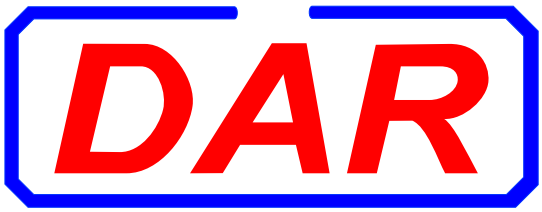

7^{th} International Workshop on
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Session 2.

Soft Computing and Fuzzy Modelling

November 27, 2011, Afternoon

Chairman: Vilém Novák

A Comparison of FT-smoothing Filter and Nadaraya-Watson Estimator

[1]Holčapek Michal , [2]Tichý Tomáš

Data smoothing is an important step within a data processing allowing one to stress the most important patterns. In literature we can find many different smoothing techniques and filter types. Recently, Holčapek and Tichý in [1, 2] suggested smoothing filters based on fuzzy transform approach introduced by Perfilieva in [5]. For this purpose, a generalization of the concept of fuzzy partition was proposed and the smoothing filter was defined as a combination of the direct discrete fuzzy transform and a slightly modified inverse continuous fuzzy transform. In this presentation we compare the proposed FT-smoothing filter (FT) with the Nadaraya-Watson estimator (NW) (see [3, 6, 4]). We clarify the following approximative relation of both filters by an optimal parameter selection

$$h^{\mathrm{FT}}_{\mathrm{AMSE}} \approx 0.76 h^{\mathrm{NW}}_{\mathrm{AMSE}}. \tag{1}$$

This approximative relation enables us to correct the parameters to obtain a similar smoothing function for FT-smoothing filter and Nadaraya-Watson estimator as it is demonstrated in Figure 3.

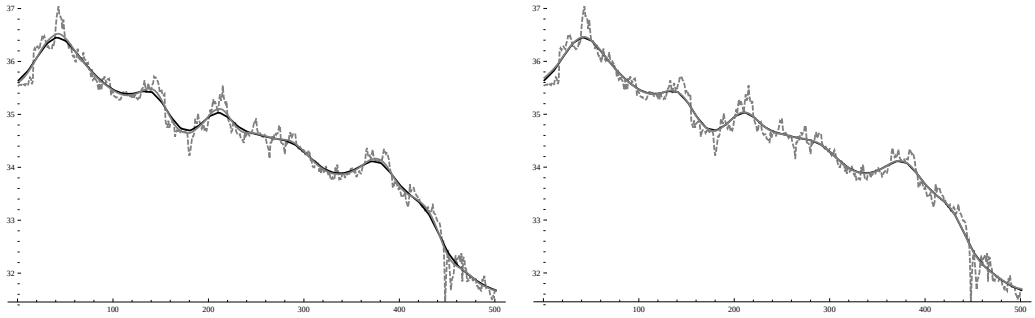

Figure 3: Comparison of $h^{\mathrm{NW}} = h^{\mathrm{FT}}$ (left) and $h^{\mathrm{NW}} = 1/0.76 h^{\mathrm{FT}}$ (right)

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From Time Series Analysis to Redundancies in Linguistic Descriptions

[1]Dvořák Antonín , [2]Štěpnička Martin , [3]Vavříčková Lenka

In this contribution we briefly review the main directions of the research on time series analysis provided by the Institute for Research and Application of Fuzzy Modeling in the last two years and recall main achieved results.

We will show that this application-oriented research led us also to interesting theoretical problems. Particularly, we investigate which fuzzy/linguistic rules are redundant in systems of such rules called linguistic descriptions. This problem mostly occurs in the case when a linguistic description is automatically generated from data and the data contains redundancies. Obviously, existence of such redundant fuzzy rules is not desirable and such rules should be detected and removed [1].

We present a formal definition of redundancy and show that rules which are seemingly redundant can be in fact indispensable. This formal understanding of redundancy, which stresses the fact that original and new linguistic descriptions are equivalent from the point of view of their behavior, is significantly different in comparison with other approaches aiming mainly at a simplification of linguistic descriptions [5, 6] that use various techniques, e.g. rules merging.

The presented results apply for IF-THEN rules which use evaluative linguistic expressions (e.g., *small*, *very big*, etc.) [3] and inference method called *perception-based logical deduction* (PbLD) [4]. However, they are also valid for inference systems which use compatible design choices with PbLD.

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Linguistic Associations and Dependencies among Them

[1]Tomanová Iva , [2]Kupka Jiří

Our work contributes to theoretical background of association analysis. Its task is to extract previously unknown interesting dependencies among attributes. Especially in this work, we were focused on fuzzy association analysis. Advantage of this kind of association analysis is that mined associations can be represented in natural language (e.g., see [1], [2]).

We work with confirmation measures (i.e., support and confidence measures) that determine specific relationships among associations. Good understanding of such relationships is very important - for instance, subsequent work with found associations, creating more efficient algorithms as well as cooperation with the consumer of the data mining process.

For each pair of considered fuzzy confirmation measures we study eight properties. Six of them are motivated by so-called Armstrong axioms that, among other things, can be used for database design (see e.g. [3]) and are also valid in fuzzy attribute logic developed e.g. in [4]. This logic can be applied to data sets similar to ours and, under some additional assumptions, establishes a complete and sound system of associations.

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Using Fuzzy Reasoning to Improve Engineering Processes

[1]Procházka Jaroslav , [2]Klimeš Cyril

This presentation summarizes our work, elaborates and practically evaluates results. Our work was focused on design and implementation of generic decision making tool applicable in different business domains under uncertainty. We have chosen Information System support and maintenance as well as Information Systems security to verify defined model supporting decision making under uncertainty. Mentioned problem domains were chosen based on the fact that vagueness is natural input for those rather engineering formal approaches. In different words, we try to formally describe vague linguistic inputs.

To solve outlined problem, we defined four step model supporting this reasoning. Fuzzy logic is used as a mean of expression of vague terms. The model itself comprises of four following steps:

- Selection of relevant data,
- Application of defined rules,
- The mapping for modeling the effects of admissible solutions,
- The mapping for acceptance of the solution itself.

Thanks to the fact, that the described domain areas are pretty complex in term of input variables, we use hierarchical model to process more input variables. As a tool support we have chosen LFLC 2000 and Fpn2lfln developed in IRAFM (Institute for Research and Applications of Fuzzy Modeling) Ostrava.

This presentation will summarize the sequence model, selected approach, results and applications as well as next steps.

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7^{th} International Workshop on
Data - Algorithms - Decision Making

Session 3.

Image Fusion

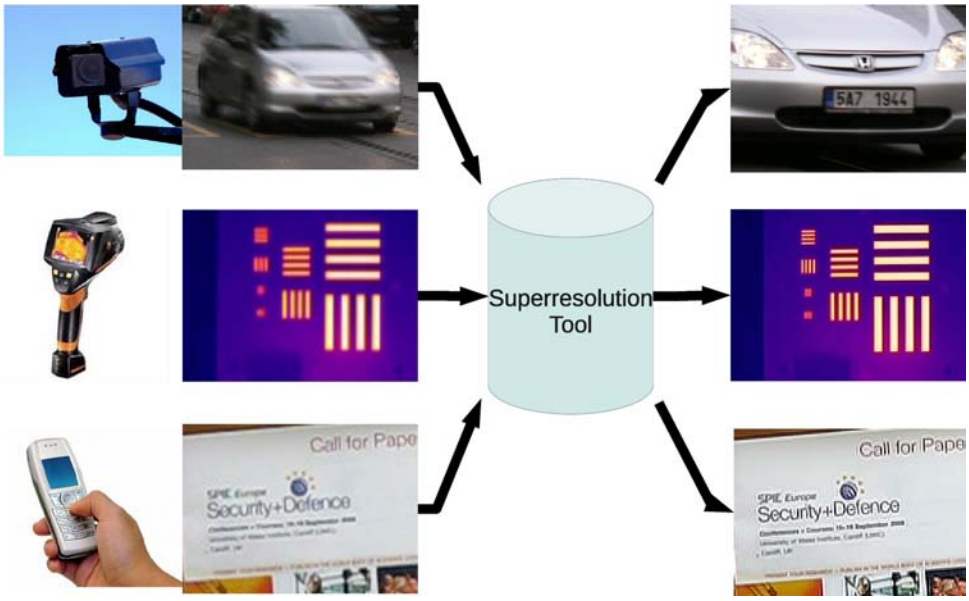
November 28, 2011, Morning

Chairman: Jan Flusser

Superresolution Imaging - from Equations to Mobile Applications

[1]Šroubek Filip , [2]Šorel Michal , [3]Kamenický Jan , [4]Flusser Jan

In the last five years a remarkable improvement has been achieved in methods that perform image restoration, such as, denoising, deconvolution and superresolution. We will provide an brief mathematical background to the problem of superresolution and summarize our contribution [1, 2, 3]. Three different superresolution applications, which were realized in the frame of the DAR project, will be discussed in more detail. First we mention the superresolution and blind deconvolution tool actively used by the Institute of Criminalistics, Prague, which aids criminologists in their video analysis tasks. Then we continue with a short overview of our commercial project for fast superresolution, which is suitable for implementation inside infrared cameras. Finally, we discuss our blind deconvolution implementation for portable devices, such as mobile phones, which can either run as a remote task on a server or can be implemented inside smartphones equipped with an appropriate hardware.



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Ophthalmological Image Processing and Analysis in DAR - a Survey

[1]Jan Jiří , [2]Kolář Radim , [3]Kubečka Libor , [4]Odstrčilík Jan , [5]Gazárek Jiří

The overview lecture will provide a brief overview of activities of the Brno UT DAR group in medical image analysis, and namely in the application area of ophthalmologic (retinal) image data analysis, during the period of the DAR project.

In order to emphasise the methodological aspects, the individual methods and results are ordered according to consequential phases of processing of the data rather then divided according to individual medical aspects.

The methodologies that will be consecutively mentioned are:

- advanced information based illumination correction in retinal fundus – camera images and
- signal-to-noise enhancement by flexibly registered averaging, as pre-processing steps are briefly described;
- mono- and multimodal registration methods developed for specific types of ophthalmological images,
- methods for segmentation of the terminal of the optical nerve bundle, so called optical disc and of retinal vessel tree,
- segmentation and evaluation of autofluorescence areas.
- the designed methods for neural fibre layer detection and evaluation in retinal images, utilising different combined texture analysis approaches and several types of classifiers, are shown as the most important results in this area.

Besides briefly formulating the methods, the results concerning real retinal data in all the areas are shown on figures and shortly commented on at the respective sections.

As the most novel result, a comparison of the neural layer detection of texture analysis in retinal fundus-camera images with the quantitative data on the neural layer thickness, obtained by the modern (though demanding) method of optical coherence tomography, is presented.

The lecture is based primarily on the overview paper [1] and papers referenced there. The newest results are matter of the paper [2].

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fMRI Image Data Analysis in DAR - a Survey

[1]Havlíček Martin , [2]Lamoš Martin , [3]Jan Jiří

Functional magnetic resonance imaging (fMRI) utilising the blood-oxygen-level- dependent (BOLD) effect as an indicator of local activity is a very useful technique to identify brain regions that are active during perception, cognition, action, and also during rest. Currently, there is a growing interest to study connectivity between different brain regions [2], particularly in the resting-state.

This contribution summarizes a new original approach to problem of indirect relationship between observed hemodynamic response and its cause - the neuronal signal, as this indirect relationship complicates the estimation of effective connectivity (causal influence) between different brain regions from fMRI data [1]. The novelty of this approach is in (generalised nonlinear) blind-deconvolution technique that allows estimation of the endogenous neuronal signals (system inputs) from measured hemodynamic responses (system outputs). Thus, it enables a fully data-driven evaluation of effective connectivity on neuronal level, even though only fMRI hemodynamic responses are observed. The solution to this difficult inverse problem based on the Friston's model of BOLD signal generation from neural signals is obtained through a nonlinear recursive Bayesian estimation framework for joint estimation of hidden model states and parameters [3].

The method for solving the inversion problem uses a square-root form of a nonlinear cubature Kalman filtering and cubature Rauch-Tung-Striebel smoothing extended to a joint estimation problem defined as a simultaneous estimation of states and parameters in a sequential manner. The method is designed particularly for continuous-discrete systems and obtains an accurate and stable solution to model discretisation by combining nonlinear (cubature) filtering with local linearization. Moreover, the inversion method is equipped with the adaptive estimation of measurement, state, and parameter noise statistics.

The whole process is divided into three consecutive steps:

- Single time-course model inversion; i.e. estimation of the neuronal signal from a single run of the measured fMRI signal.
- Generalisation of the proposed approach and its application to multiple fMRI time-courses measured at different brain locations in order to enable the estimation of coupling parameters of a neuronal interaction model; i.e. estimation of effective connectivity in the brain.
- Validation of the proposed approach by using both simulated and empirical fMRI data.

The method in the second step represents a novel stochastic treatment of the dynamic causal modelling, which makes it distinct from any previously introduced approach. This part also deals with methods for Bayesian model selection and proposes a technique for detection of irrelevant connectivity parameters to achieve improved performance of the parameter estimation.

Results which are obtained by the above mentioned approach demonstrate robust and very good performance.

Based on this method of modelling we are starting to deal with the topical problem of data fusion from electroencephalography and from functional magnetic resonance imaging.

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7^{th} International Workshop on
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Session 4.

Multiple-Participant Decision-Making

November 28, 2011, Morning

Chairman: Miroslav Šimandl

Can We Learn What We Prefer?

[1]Kárný Miroslav , [2]Guy Tatiana V.

Decision making (DM) of multiple interacting participants under uncertainty can be viewed as a collection of selfish interacting participants. An applicable theory should support both elicitation of their individual knowledge, preferences and information offered by neighbours into a quantitative description needed for a design of an optimal DM strategy. The support of preference elicitation is the least developed one. The talk focuses on this problem and assumes that the supported participant: i) uses so-called fully probabilistic design [2], which expresses preferences via an ideal distribution of closed-loop behaviour; ii) provides a full ordering of respective scalar preference-determining attributes; iii) has a probabilistic model of the environment it interacts with; iv) has a probabilistic description of closed decision loop describing either its personal past or a closed-loop behaviour of a group, which the participant is willing to mimic.

Under these conditions, it is possible to automatically construct the needed ideal distribution using so-called optimistic ideal distribution and by employing axiomatically justified minimum cross-entropy principle [6]. The needed models (of the environment and of the past closed-loop behaviour) can be gradually improved using both the standard Bayesian learning [1] and the merging with models offered by neighbours [3, 4]. Consequently, the ideal distribution can be learnt from data while taking into account preferences of neighbours.

Any standard Bayesian decision making, determined by the environment model and utility, can be arbitrarily well approximated by the fully probabilistic design [3]. Thus, the methodology (developed for the fully probabilistic design) to a significant extent solves the problem unsolved within the standard set up. Among others, it provides both the justified functional form of the utility and its parameters.

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Acknowledgement

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Decentralized Distributed Bayesian Estimation

[1]Dedecius Kamil , [2]Sečkárová Vladimíra

The increasing spatial complexity of modern adaptive wireless and sensor networks and the diversity of its elements call for reliable estimation of several variables of interest. In most regular cases it can be naturally assumed that each participating element carries (to some degree) valid information about these variables and that they could potentially benefit from cooperation and information sharing. We will refer to this *modus operandi* as the distributed estimation [1].

The problem has attained certain attention during past few decades, resulting in several methods, e.g. [2, 3, 4, 5, 6]. The popular and widely used centralized distributed estimation, in which the network nodes communicate their measurements with a single specialized point suffers from high communication overheads and represents a potentially dangerous concept with a single point of failure needing special treatment [5]. The presented distributed estimation method is its decentralized counterpart. Its philosophy is motivated by saving as much resources (time, energy, communication resources...) as possible without significantly decreasing the estimation quality.

The basic setting of the decentralized estimation method put the following limitation on the internodal communication: it divides the network into smaller overlapping units (called closed neighbourhoods, Fig. 4) consisting of a node and its adjacent neighbours. This node is allowed to exchange data (measurements, regressors...) only within its closed neighbourhood. The Bayesian formulation of the problem and

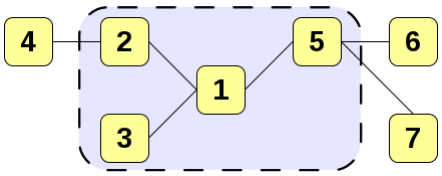

Figure 4: Example of a closed neighbourhood of node 1.

its solution abstracts from any particular model case. This leads to a very scalable and universal method, applicable to a wide class of different models. A particularly interesting case – the Gaussian regressive model – is derived as an example. It coincides with the diffusion recursive least-squares algorithm [5], which proves the method feasibility.

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Probability Density Fusion in Particle Filtering Framework

[1]Ajgl Jiří , [2]Šimandl Miroslav

The classic state estimation uses measured data to estimate the state of a dynamic stochastic system. The multisensor formulation [2] of the problem introduces a new dimension to explore. Supposing the individual sensors or groups of sensors are equipped with their own estimator, various local estimates conditioned by the corresponding local data are produced. Combining the local estimates in a fusing estimator in order to obtain a global estimate is the task of the information fusion.

The centralised estimate is such estimate that is equal to the estimate obtained by exploiting the sensor data directly at the fusing estimator. Typically, it is impossible to obtain the centralised estimate based on the local estimates. Local knowledge of the problem, measurement noise dependence across sensors or multiple use of an estimate due to the multipath information propagation are the main reasons for that. A conservative fusion [4] combines the local estimates in the way the information corresponding to the state is not overestimated. The solution for Gaussian densities is known [5], [8] and it is given by the weighted geometric mean of the local Gaussian densities.

Particle filtering [3], [6] is a popular technique that is based on Monte Carlo simulation. Its main advantage is that it can cope with general probability densities. Therefore, there arises a question how to implement the fusion of the local densities that are provided by the local particle filters. A conversion of the density representation is proposed in [7]. The previous work [1] of the authors deals with the fusion without the need to leave the particle framework. However, there are several weak spots that have to be treated carefully.

This contribution focuses on the probability density fusion in the particle filtering framework. The different samples corresponding to different local densities form the problem essence. The individual steps of the solution and possible modifications of them are discussed. New perspective is offered and the directions of the further research are outlined.

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7^{th} International Workshop on
Data - Algorithms - Decision Making

Session 5.

Control under Uncertainty

November 28, 2011, Afternoon

Chairman: Miroslav Kárný

Algorithms for Estimation of Vehicle Trajectory during GPS Signal Outages Based on Inertial Sensor Data

[1]Machan Jaroslav , [2]Herda Zdeněk , [3]Pavelková Lenka

The Institute of Information Theory and Automation works with Škoda Auto, a.s. on the joint project under the DAR centre. The main aim of this project is to refine the information about the moving vehicle position obtained from global positioning system (GPS). In the case of signal outage, GPS does not work properly. During this outage, the vehicle position is estimated.

The estimation is based on the principle of the inertial navigation (INS), i.e., the following kinematic relationships are utilized

$$s = \int v(t)\mathrm{d}t; \quad v = \int a(t)\mathrm{d}t; \quad \varphi = \int \omega(t)\mathrm{d}t$$

where t means time, s is travelled distance, v is velocity, a is acceleration, φ is azimuth and ω is angular velocity.

Data required for the estimation are obtained from the following sources: (i) controller-area network (CAN) that provides a data from the vehicle sensors; (ii) external device that provides an acceleration and an angular velocity in the three axes from MEMS sensors; (iii) GPS navigation. All above mentioned devices are tightly connected with the vehicle. Therefore, the INS is called a strap down one.

Using INS data, the position is computed by integration and related computation error continuously grows. It means that the input data have to be very precise. Therefore, the big part of the project deals with processing of measured data and with choice of the most suitable ones from the position estimation point of view.

The vehicle position is estimated using a stochastic state-space model with uniformly distributed noise. The Bayesian approach is applied to obtain position estimates.

The mentioned model utilizes vehicle velocity and azimuth as inputs. The input data are preprocessed by separate pre-processing program. The way of data preprocessing depends on the current driving mode of the vehicle. In the presentation, resulting courses of the used input data are discussed together with estimated vehicle position.

To obtain required data, many rides both on the testing polygon and on the real road were realized. Data from the testing polygon contain no outages. Therefore, simulated outages are used in experiments. On the other side, the real road data were intentionally measured in the area where the GPS signal outage occurs. So, the position estimation could be verified under real condition.

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Recent Advances of Sigma Point Methods in Nonlinear Filtering

[1]Straka Ondřej

The presentation deals with state estimation of nonlinear stochastic systems, which plays an indispensable role in fields such as tracking, navigation, signal processing and decision making.

The aim of state estimation is to find an estimate of state, which is not completely measurable, using a set of measured data. Although a complete description of the state estimate is given by the probability density function of the state, which can be computed by the Bayesian recursive relations,, in many cases the objective of the estimation is only a point estimate of the state. The point estimate is usually obtained by minimizing the mean squared error criterion, which leads to the conditional mean of the state conditioned by the measurements.

Unfortunately, the mean is available in closed form for a few special cases only, such as the linear systems with Gaussian noises. For this case, the solution is provided in the seminal paper of Kalman [1]. If the system is nonlinear, an approximate solution such as the extended Kalman filter (EKF) [2] is usually used.

In the last decade, a new approach to state estimation has appeared. Instead of linearizing the nonlinear functions by the Taylor series used in the EKF, this new approach utilizes stochastic linearization. The stochastic linearization approximates a random variable by a set of deterministically chosen points, called sigma point, and uses them to obtain first and second moments of a nonlinear transformation of the random variable. The method is called sigma-point method and is utilized withing the sigma point filters such as the unscented Kalman filter [3, 4], cubature Kalman filter or Gauss-Hermite quadrature filter.

The goal of the presentation is to introduce recent advances of the method. First, the placement of the sigma points will be analyzed with a special focus on accuracy of the approximation. To increase the accuracy, an adaptation technique will be proposed to adjust placement of the points [5]. Second, the disadvantage of the deterministic placement of the points will be analyzed and a randomized version of the technique will be introduced to eliminate the disadvantage [6]. Both techniques, when used within the sigma point filters, lead to higher quality of the state estimate.

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Summary of Probabilistic Models with Uniformly Distributed Uncertainty

[1]Pavelková Lenka

Recursive estimation is an important part of the adaptive decision making tasks such as prediction and adaptive control. Adaptivity is based on the on-line learning of the underlying local model.

The system is often modelled by black-box, locally valid models. Autoregressive model with exogenous inputs (ARX) is an important representative of this model class. Uncertainty of the model is expressed by the noise that is white, zero mean and has time-invariant variance. Mostly, the noise is assumed to be normal. It induces least squares as the adequate estimation procedure. Light tails of the normal distribution imply that its unbounded support can often be accepted as a reasonable approximation of reality, which is mostly bounded.

To get more precise model, unobservable quantities (states) are to be considered. The system is then described by the state space model and the subtask of the state filtering arises. Considering normal noises in the model, Kalman filtering is the first-option method for its addressing.

In some case, however, the assumption of the noise normality is unrealistic or do not fit subsequent processing, for instance, robust control design. Then, techniques similar to those dealing with unknown-but-bounded equation errors are used. They often intentionally give up stochastic interpretation of the innovations and develop and analyze various algorithms of a min-max type. The resulting algorithms are definitely useful. But the related decision-making tasks are unnecessarily difficult because of the missing statistical tools. Thus, it makes sense to address the discussed estimation and filtering within the "classical" probabilistic setting.

The presentation summarizes results of the research of both ARX and state space models under the assumption that noises are bounded but stays within the standard, here Bayesian, estimation setup by assuming their uniform distribution. The proposed uniform models are compared with their normal counterparts.

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7^{th} International Workshop on
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Session 6.

Decision-Making and Classification

November 28, 2011, Afternoon

Chairman: Martin Janžura

Robustness of Spacing-Based Power Divergence Statistics

[1]Boček Pavel

The robustness of spacing-based power divergence statistics, based on the asymptotic results introduced in [1, 2], are studied. The generated data, with normal distribution and contamination from 5 to 40 percent, are used for the computation of the statistics for selected representative orders of $\alpha > -1/2$. Rejection of hypothesis $H0$ was used as criterion for robustness. New version of program package PODISTAT [3] was developed for the computation of the simulation study.

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Divergence-Based Tests of Homogeneity for Spatial Data

[1]Hobza Tomáš , [2]Morales Domingo , [3]Pardo Leandro

The problem of testing homogeneity in contingency tables when the data are spatially correlated is considered. We derive statistics defined as divergences between unrestricted and restricted estimated joint cell probabilities and we show that they are asymptotically distributed as linear combinations of chi-square random variables under the null hypothesis of homogeneity. Monte Carlo simulation experiments are carried out to investigate the behavior of the new divergence test statistics and to make comparisons with the statistics that do not take into account the spatial correlation. We show that some of the introduced divergence test statistics have a significantly better behavior than the classical chi-square one for the problem under consideration when we compare them on the basis of the simulated sizes and powers.

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A Survey of Matrix and Tensor Decomposition Methods

[1]Tichavský Petr

Tensor decompositions and factorizations provide natural representations for multidimensional data by capturing multi-linear and multi-aspect structures in a much lower dimensions. Nowadays, tensor have been becoming increasingly important in applications across diverse disciplines, especially signal processing, data mining, feature extraction, classification and multi-way clustering.

In this talk, we present a survey of existing tensor decomposition models and methods which include the parallel factor (canonical decomposition) and Tucker decomposition of tensors, nonnegative matrix/tensor factorizations, convolutive matrix/tensor factorizations, and Kronecker matrix/tensor factorizations. Examples of utilization of these factorizations in image and music analysis will be provided.

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7^{th} International Workshop on
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Session 7.

Multidimensional Signal Processing and Pattern Recognition

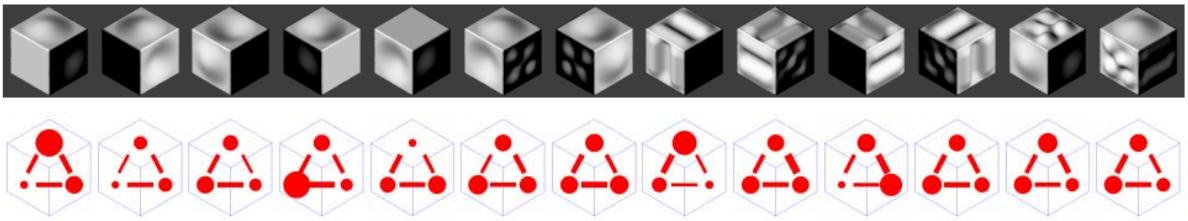
November 29, 2011, Morning

Chairman: Michal Haindl

Analysis of Human Gaze Interactions with Texture and Shape

[1]Filip Jiří , [2]Vácha Pavel , [3]Haindl Michal

Understanding of human perception of textured materials is one of the most difficult tasks of computer vision. In this paper we designed a strictly controlled psychophysical experiment with stimuli featuring different combinations of shape, illumination directions and surface texture. Appearance of five tested materials was represented by measured view and illumination dependent Bidirectional Texture Functions. Twelve subjects participated in visual search task - to find which of four identical three dimensional objects had its texture modified. We investigated the effect of shape, texture and illumination direction on subjects attention. We are not looking at low level salience, as the task is to make a high level quality judgment. Our results revealed several interesting aspects of human perception of different textured materials and, surface shapes.



Geometry significantly influences human gaze attention to texture. Intra-cube (second row) saccades (gaze shifts) and fixations for all tested cube poses (first row). Thickness of red lines (inter-face saccades) and dots (intra-face fixations) represent a number of saccades/fixations.

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[3]ÚTIA AV ČR, Pattern Recognition Department, *haindl@utia.cz*

Dynamic Texture Segmentation

[1]Mikeš Stanislav , [2]Haindl Michal

An unsupervised multi-spectral dynamic textures segmenter with unknown number of classes is presented. Multi-spectral textured frames from segmented video mosaics are locally represented by illumination invariants derived from four directional causal multispectral Markovian models recursively evaluated for each pixel. The single frame segmentation part of the algorithm is based on the underlying Gaussian mixture model and starts with a segmentation estimate from the previous video frame which is subsequently adaptively modified. The performance of the presented method is extensively tested on the Prague segmentation benchmark using the commonest segmentation criteria.

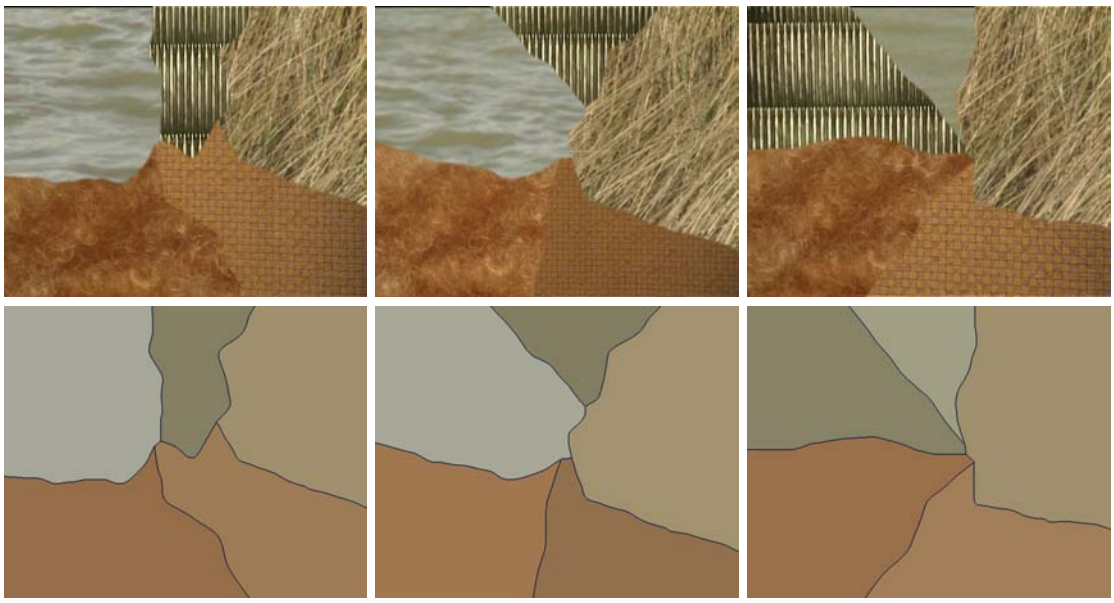

Figure 5: Selected dynamic mosaic frames (0, 125, 249) and their corresponding ground truth.

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BTF Rendering in Blender

[1]Hatka Martin , [2]Haindl Michal

Bidirectional texture function (BTF) is 7D function of planar coordinates, spectral coordinate, and viewing and illumination angles, respectively. BTF is the recent most advanced representation of visual properties of surface materials. Unlike smooth textures, it specifies their altering appearance due to varying illumination and viewing conditions. This BTF visual appearance dependency on viewing and illumination conditions significantly complicates not only its acquisition, representation, and modeling but also makes its rendering noticeably more demanding. BTF textures are acquired by costly measurements of real materials and their subsequent nontrivial processing. While several techniques for measurement or processing of BTF textures have been described already, there is no environment allowing to support BTF texture rendering. This contribution describes novel Blender texture plugin for the purpose of BTF texture mapping and rendering. The plugin benefits from our previously developed BTF Roller texture enlargement method which is integral part of its implementation. The presented plugin allows to create realistic computer animations with additional BTF textures of any required size mapped onto an object surfaces while the other functionality of Blender retains.

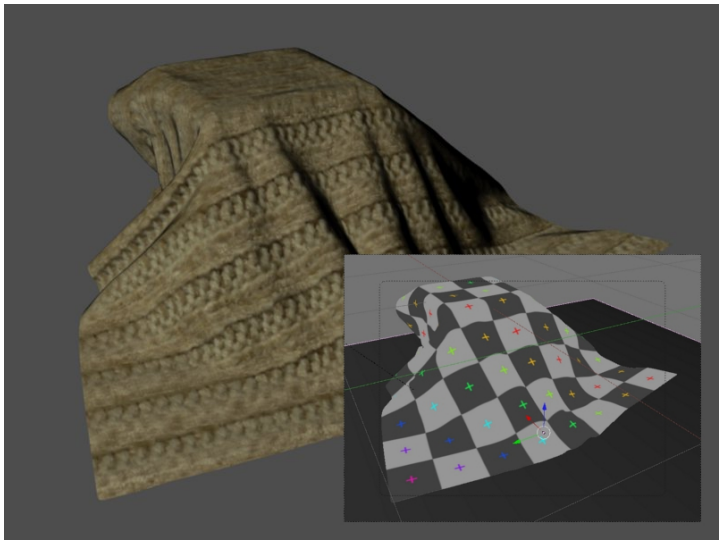

Figure 6: Drapery 3D model created and textured using UV-mapping in Blender can be easily coated with BTF texture thanks to our BTF texture plugin.

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Bidirectional Texture Function Simultaneous Autoregressive Model

[1]Havlíček Michal , [2]Haindl Michal

The Bidirectional Texture Function (BTF) is the recent most advanced representation of visual properties of surface materials. It specifies their altering appearance due to varying illumination and viewing conditions. Corresponding huge BTF measurements require a mathematical representation allowing simultaneously extremal compression as well as high visual fidelity. We present a novel Markovian BTF model based on a set of underlying simultaneous autoregressive models (SAR). This complex but efficient BTF-SAR model combines several multispectral band limited spatial factors and range map sub-models to produce the required BTF texture space. The BTF-SAR model enables very high BTF space compression ratio, texture enlargement, and reconstruction of missing unmeasured parts of the BTF space.

Figure 7: A modelled wood texture mapped to the conch model.

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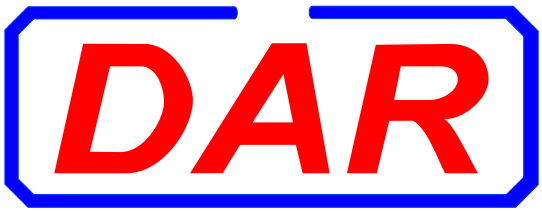

7^{th} International Workshop on
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Poster Session

November 28, 2011

Chairman: Jan Flusser

Potts Model-Based Texture Synthesis

[1]Remeš Václav , [2]Haindl Michal

Textures with several irregular components often occur in natural visual scenes. Some of these textures can be successfully represented by the Potts Markov random field model (PMRF) which is a multiclass generalization of the binary Ising MRF model. The PMRF model can be used not only to directly synthesize and enlarge a target texture without visible regularities and seams (Fig.15) but also as a building block for more complex compound MRF models [2]. This contribution presents a modification of the efficient Swendsen-Wang Markov chain Monte Carlo method [1]. The modified Swendsen-Wang sampler guarantees that the synthetic Potts MRF realizations have similar clusters size and similar cluster area ratios with the original target texture. The method works best on natural textures such as lichen covering stones, different flowers on a meadow, rust on a metallic plate, etc.

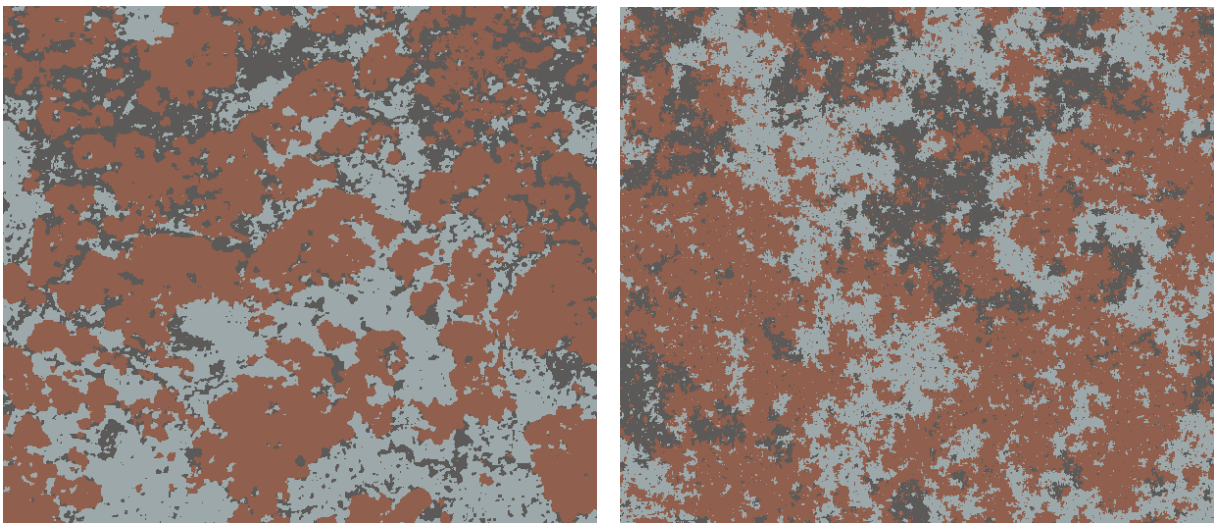

Figure 8: The lichen natural texture (left) and its synthesis.

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Texture Recognition using Robust Markovian Features

[1]Vácha Pavel , [2]Haindl Michal

We provide a thorough experimental evaluation of several state-of-the-art textural features on four representative and extensive image databases. Each of the experimental textural databases: ALOT, Bonn BTF, UEA Uncalibrated, and KTH-TIPS2 aims at specific part of real-world conditions that are encountered in acquisition of surface materials appearance, subsequently, represented as multispectral textures. More specifically, the textural features are evaluated in recognition under the following variations of acquisition conditions: illumination spectrum, illumination direction, viewpoint declination, and acquisition device. Example images, which demonstrate such a variation of material appearance, are displayed in Fig. 9.

The extensive experimental evaluation proves the outstanding reliable and robust performance of efficient Markovian textural features [1, 2], which were analytically derived from a wide-sense Markov random field causal model. These features systematically outperform leading alternatives as Gabor, Opponent Gabor, LBP, and LBP-HF textural features. Moreover, they even allow successful recognition of arbitrary illuminated samples using a single training image per material. Our features are successfully applied also for the recent most advanced textural representation in the form of 7-dimensional Bidirectional Texture Function (BTF).

The performance of Markovian textural features can be explored in interactive demonstrations, which are available online at `http://cbir.utia.cas.cz/`.

Figure 9: Example images from the ALOT dataset, each column shows images of the same material captured under different illumination spectrum, illumination direction, and viewpoint declination, respectively.

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Iris Recognition

[1]Krupička Mikuláš , [2]Haindl Michal

Iris is a structure in eye, which is considered to be one of the most trustworthy sources for human identification. As an internal organ it is well protected against damage and simultaneously it is visible from outside. The iris texture was also proved to be very stable during human aging process. Biometric systems based on iris recognition are already being used for passport-free border-crossings or as national ID system [2]. However currently used systems require wilful cooperation from identified person and carefully controlled environment. Iris recognition is a complex task, which consists of several main processing steps - mainly iris localization, iris features extraction, and classification. Each of these steps has obviously a decisive impact on the quality of final result. While iris localization have been widely researched already, the other two remaining problems have not been satisfactorily solved yet. The presented method benefits from using novel multispectral MRF based representation and outperforms alternative approaches on standard benchmarking data [1].

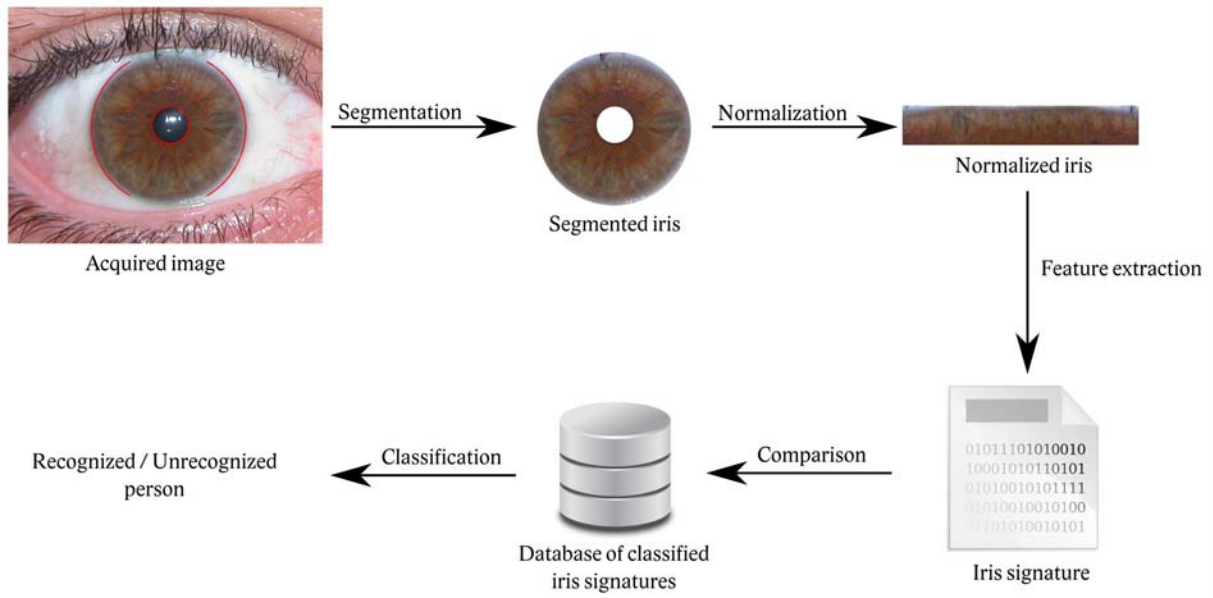

Figure 10: The iris recognition processing pipeline.

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Dynamic Texture Modelling

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A simple and fast approach for synthesizing dynamic textures that realistically matches given colour texture appearance and the optic flow is presented. The method generalizes the previous work [1, 2] which works well for static textures to the dynamic textures domain. The method is based on overlapping tiling and subsequent minimum boundary cut. An optimal toroidal dynamic texture patch is created in each spatial and dynamic dimension, where it is derived from the optical flow of the modelled texture. The toroidal patch is created in the analytical step which is separated from the synthesis part. The method is extremely fast (both in the spatial as well as in the time dimension), works well for many types of natural dynamic textures, and it is very easy to implement.

Figure 11: Horizontally enlarged natural dynamic texture from the DynTex database [3].

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Progress in Supra-Bayesian Merging of Information

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Everyday life in the world of statistics consists of computing various characteristics based on observations. In fact, computation is a merging process. That is why the merging of information given by different decision makers has become a popular topic in recent years and many procedures were developed towards it. Still, there are several issues which can not be overcome. The main and the most discussed problem is the incompleteness of given information. There are attempts trying to solve this problem by developing different methods, based on, e.g. reduction of the combination space by representing the notion of source redundancy or source complementarity [1] or Bayesian networks and factor graphs [2]. Altogether, they often lack one thing – they are usable only if the information is of unified form, e.g. data. But the expectation on a common form of provided data can be too restrictive demand on the sources.

The answer to issues mentioned above brings a Supra-Bayesian [3] merger: where the task of merging of the given pieces of information is expressed as a task of constructing a posterior probability mass function (pmf) or probability density function (pdf) for a fictitious decision maker. It consists of three main steps: transformation of given information into unified form, filling the places where the information is missing and finally merging of transformed and completed information.

In this paper we will focus on the discrete case - the built merger will be a posterior pmf. This may lead to an invalid conclusion, that given data should have a form of pmf. Such a restriction can easily be overcome, since there exist many tools for transforming the forms of input data considered in this paper, namely (conditional) expected values and realizations of random vectors, into pmfs. In the case when (conditional) pmfs of a random vector are given, no transformation step is needed. Once we have treated the incompatibility of the raw information pieces, we face the problem of incompleteness - missing information. This will be solved by inserting the appropriate versions of a not–yet–constructed merger into the places where the information is missing. Now that the information has unified form and is complete, the previously mentioned Supra-Bayesian approach can easily be applied.

The final merger is then the result of the Bayesian methodology, where the Kerridge inaccuracy [4] is used as a loss function and the constrained maximum entropy principle [5] is used to determine its exact form. In this paper we give just a short version of the procedure leading to this merger, the extended version can be found in [6]. It is complemented by an important check of the solution's logical consistency: the final merger reduces to the standard Bayesian learning when the processed data meets standard conditions leading to it.

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Decentralization of Fully Probabilistic Control Design using Variational Bayes Approximation

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We are concerned with design of decentralization control strategy for stochastic systems with global performance measure. Such a strategy is required e.g. for creation of a distributed control systems for traffic light signalization [1]. The technique of Fully Probabilistic Control Design (FPD) [2, 3] is capable of solving the task for centralized control strategy via Kullback-Leibler divergence (KLD) minimization. In this contribution, we propose a way for decentralization of FPD using the Variational Bayes (VB) approximation. This approximation is a well known technique of Bayesian estimation [4, 5] and it is based on approximation of the true posterior density by a product of conditionally independent densities, VB-marginals. The fundamental principle is again minimization of the KLD between a product of conditionally independent densities and the true posterior. Typically, the solution is found in the form of a set of implicit equations. Solution of the set can be found by an iterative algorithm in which evaluation of shaping parameters of each VB-marginal requires evaluation of moments from the remaining densities.

We design imperfect decision makers for control of the distributed system by imposing a conditional independence restriction on the control strategy. The resulting optimum is found to be equivalent to application of the VB approximation on the result of the FPD. The resulting strategy is thus computed iteratively. Each decision-maker computes its own strategy using moments from its neighbors that are obtained by means of communication. The original algorithm operates on the decision horizon that is common to all decision makers. At each time step of the horizon, the decision makers iterate the resulting strategy using VB approximation. When a consensus is reached they proceed backwards as is typical for FPD. The communication load under this scheme is however rather high. Therefore, we propose to use an alternative way of solution of the implied set of implicit equations. Specifically, the decision makers design their own strategy for the whole decision horizon with respect to moments obtained from the other decision makers. The VB iterations are run on moments of the joint densities on the whole horizon.

We apply this methodology to distributed control of a linear Gaussian system with two inputs and three outputs with quadratic loss function. Each input is controlled by one decision maker. We study convergence of the terminal loss of the decentralized algorithms to the terminal loss obtained by the centralized FPD solution. The first algorithm is found to be faster in convergence, however, the number of sent messages is much higher then that of the second algorithm.

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James-Stein Estimator: Aspects and Comparison

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The first moment of a random variable called mean value is one of the most important statistics. Calculation of this value is a very important task appearing in state estimation, signal processing and control of stochastic systems[1]. Here, the stress will be laid on estimating the mean of a normally distributed random variable and admissibility of the estimators of the mean.

The estimator is inadmissible if there is another estimator with less or equal expected mean squared error from true value of the estimated parameter with strict inequality holding for some parameter. The estimator is admissible if it is not inadmissible[2].

The mean is the best estimate of a random variable with respect to minimizing mean squared error. But in many cases the mean is unknown, and the problem of finding the unknown mean arises. Sample mean is the best linear unbiased estimate of the unknown mean in terms of the minimum squared error[3,4]. The question is whether this estimator stays admissible without the requirement of unbiasedness and linearity of the estimator.

Stein[5] was able to prove that for dimension of the unknown mean greater than 2, the sample mean is not the admissible estimator. After that he, with his college James, invented a new estimator of the mean, called the James-Stein estimator[6]. It is a better estimator of the mean than the sample mean with respect to the mean squared error, which, however, is biased.

In this poster the James-Stein estimator and some of its variants will be introduced. The comparison of the James-Stein estimator with the sample mean will be made using several experiments. Further, inadmissibility of the sample mean will be shown. Also the derivation of the James-Stein estimator will be outlined.

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Superfast Superresolution

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We propose a fast algorithm for solving the inverse problem of resolution enhancement (superresolution). Robustness is achieved by a non-linear regularizer and an iterative method based on variable splitting is used to obtain an equivalent linear formulation. Special attention is paid to fast implementation using the Fourier transform. An additive and multiplicative half-quadratic linearization scheme are compared and we show that the additive form [2] is superior as all operations can be implemented in the frequency domain using the FFT. In particular, we show that a degradation operator (downsampling) can be implemented in the frequency domain [1] and that all computations can be performed very efficiently without losing robustness. To our knowledge, this is the first attempt towards a very fast SR algorithm, which retains favorable edge-preserving properties of non-linear regularizers.

	400×300	800×600	1600×1200
Multiplicative form	4.1s	11.1s	43.0s
Additive form	0.5s	1.6s	6.0s

Table 1: Average speed of one iteration for different image sizes with superresolution factor of 2. The additive form with the proposed implementation is by far superior to the multiplicative form in terms of time complexity.

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Removing the Artifacts from Artwork Cross-Section Images

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We present a recent achievement in the image data preprocessing in the Nephele system for art conservation [1]. In order to improve the quality of the data segmentation (dividing the image into meaningful segments) we have to deal with often low quality input images due to the data acquisition process and the sample preparation, respectively. We propose a method for automatic removal of the artifacts from artwork cross-section images of samples, acquired during the painting material research before actual conservation is performed.

The input image data acquired during the material research - microscopic images of minute surface samples - are often damaged due to grinding of the polyester resin in which the samples are embedded. The grinding forms noisy artifacts in the background. The images are acquired in several modalities. Stratigraphy (learning about painting layers) is usually studied in visible spectrum (VIS) and ultraviolet spectrum (UV) images, where the UV analysis makes use of the luminescence. The images from electron microscope (SEM) further extend the data set.

The proposed method exploits the properties of common Fourier transform [2]. The artifacts are omnipresent and in form of parallel lines. Therefore a considerable amplitude response can be observed in the amplitude spectrum of the transform. The response is automatically found and masked. After applying inverse Fourier transform the artifacts are completely or at least significantly diminished (see figure 12).

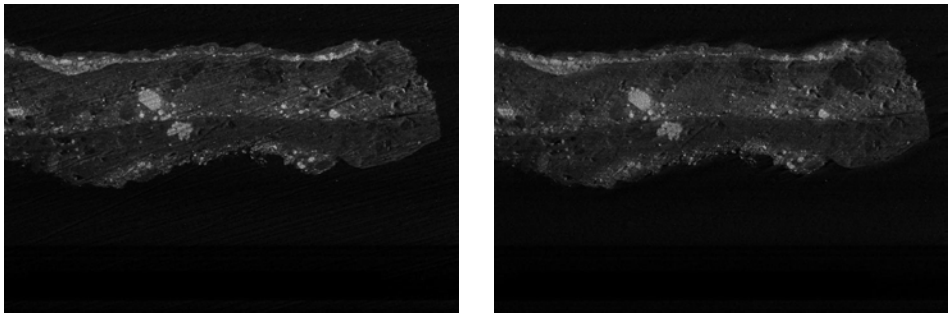

Figure 12: The SEM images before (left) and after (right) the enhancement

The algorithm was tested on all three modalities coming from ALMA image data set (ALMA - Academic Laboratory of Materials Research of Paintings). Generally its performance was quite satisfactory, but the results in case of UV images were poor.

Also a different area of cultural heritage can exploit the performance of the proposed method, processing of infrared (IR) images of old paintings. The IR light enables to see hidden underdrawing, which capture the painter's original intentions. Unfortunately, IR backlighting captures also the canvas structure and its inhomogeneity. The algorithm helps to remove them and simplifies further analysis.

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Detection of Elliptical Particles in Atomic Force Microscopy Images

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We introduce an effective method for detection and measurement of elliptical particles in atomic force microscopy (AFM) images. AFM imaging [1] is utilized in physics for scanning surfaces: the value of each pixel reflects the height of the surface at corresponding coordinates. Each sample analyzed in our project consisted of approximately elliptical, similarly sized particles. Particles in such a sample can be characterized by the average length and width of a statistically significant number of particles. The proposed method is based on segmentation of salient particles and approximation of their shapes by ellipses (see Fig. 15); the length and width of each particle are estimated by the major and minor axes, respectively. The method is robust to noise distortions typical of AFM images. Its performance was tested on AFM images of phenylpyridyldiketopyrrolopyrrole (PPDP) [2]. Results indicated that values measured manually by an expert can be computed fast by the automatic method instead. A detailed description of the proposed method is given in [3].

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

Figure 13: (a) An AFM image of a PPDP sample. (b) The surface of the AFM image after blurring (detail). (c) Approximation of the surface of salient particles by ellipsoids (detail). (d) Approximation of the shape of salient particles by ellipses.

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EEG/fMRI Analysis Enhancement using EEG Data Processing

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Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) are two most common techniques used in neuroscience research [1]. Currently , there is a growing interest to analyse simultaneous measured data from both modalities. The main motivation is to achieve the best time (by EEG) and spatial (by fMRI) resolution for the analysed data. This paper describes how EEG data processing may enhance analysis of EEG/fMRI.

All of the fMRI/EEG data was collected during the experiment which was focused on attention monitoring (oddball with distractor paradigm). The paradigm is based on very short stimulating impulses represented by pictures of symbols on the display. A patient has to press the button in case of symbol X is shown (Target) and does nothing in case of symbol O (Frequent) or any other symbol (Distractor). Targets and Distractors are uncommon on the contrary to Frequent events. The fMRI data was acquired on 1.5 T MR scanner with following set-up: Gradient Echo sequence, axial orientation, TE = 40 ms, TR = 3 s, 64×64×17 voxels. The 32-electrode EEG was measured simultaneously with fMRI compatible equipment and preprocessed with BrainVision and SPM8 software.

EEG preprocessing in BrainVision software contains suppression of gradient (caused by MR scanner) and pulse (caused by heart) artefacts. Thereafter the data is converted to SPM format file and processed in SPM8 software. Electrocardiogram channel is removed at first than data is downsampled to 200 Hz and filtered with bandpass filter 0.5-30 Hz. When data is epoched and averaged baseline is also corrected. First step of the preprocessing fMRI data is realignment when scans are realigned by rotation and translation. After that the fMRI dataset is coregistered to reference anatomical image. Spatial normalisation to MNI space is useful for potential group analysis. The last step is smoothing which normalises the distribution of the dataset.

Source EEG signal from the region of interest (ROI) is obtained by 3D source reconstruction which is divided into four consecutive steps. Source space modelling creates head meshes describing the boundaries of different head compartments based on the Montreal Neurological Institute (MNI) template. EEG electrode positions is transformed to match the template head. Thereafter EEG data is coregistered into the structural MRI space. Next step is forward computation which refers to computing for each of the dipoles on the cortical mesh the effect it would have on the sensors. We use EEG Boundary Element Method (BEM) model that is included in SPM8. Finally, the inverse reconstruction problem is solved by Multiple Sparse Priors (MSP) algorithm to get signal from ROI.

The source EEG signal is adjusted into the model signal for fMRI statistical analysis [2]. It includes resampling to the required length and convolution with the hemodynamic response function. Currently, we can perform fMRI analysis using general linear model (GLM) [1]. The calculation is based on the linear regression analysis which assumes that the blood oxygenation level dependent signal is a linear summation of the constant element, multiple of model functions and a vector of residues. Model signals (regressors) in typical fMRI analysis are comprised of information about motion artifacts and stimulation function (if design of the experiment includes stimulation). We extend number of model signals in the GLM by adding the adjusted source EEG signal from ROI as the one of regressors. It allows us to be more specific about spatial localisation in the brain (considering ROI) with proper contrast vector selection.

We demonstrate the technique for enhancing the analysis of the EEG/fMRI by implementation of EEG data processing into the fMRI statistical analysis based on GLM.

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Retinal Image Processing and Possibilities of Automated Diagnosis

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The nowadays advanced fundus cameras can acquire images with high signal to noise ratio, high resolution and large field of view without need of pupil dilatation. Therefore, this imaging technique is ideal for screening application for many retinal diseases. This contribution summarizes the methods, which are used for automatic processing and analysis of retinal images. Here is an example of the most occurring retinal diseases and their specific expression on retina, which can be diagnosed by fundus camera:

- glaucoma (nerve fiber losses, 'geometry' of optic disc);
- diabetic retinopathy (microaneurysm, exudates);
- (age related) macular degeneration (specific spots and pigmentation in macula region);
- ischemic optic neuropathy (low contrast optic disc);
- choroidal neovascularization (changes around optic disc, new blood-vessels);
- Best disease ('orange spots' in macula region);

The suggested automatic processing pipeline then must include several image processing methods and approaches from pattern recognition:

- correction of non-uniform illumination [1];
- image contrast equalization and enhancement [1];
- segmentation of:
  - optic disc [4];
  - macula;
  - blood vessels [2];
  - pathologies (hard/soft exudates, microaneurysm, hemorrhages, retinal nerve fibers losses etc.);
- extraction of diagnostic parameters, e.g. feature extraction;
- decision making;
- visualization;

In a case of temporal fundus image series (long-term or short term) the registration has to be applied to follow up the retinal changes during disease progression or treatment [3].

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Fast 3D Simulation for Ultrasound Transmission Tomography

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The ultrasound transmission tomography is a promising alternative to X-Ray imaging modality in medical diagnostic systems, however the reconstruction algorithms are still subject of research. During the development of these algorithms it is crucial to have access to testing data and it is not always possible or desired to obtain data from real system.

The simulations of the ultrasound propagation employing the Finite Element Method, or Finite Differences Method to solve the Helmholtz equation turned out to be computationally very demanding even for a fraction of the USTC system and infeasible for the whole system. Therefore we have developed a simulation tool based on following approximations:

- **Discretization of the simulated volume** – the volume describing the shape and material properties of the depicted phantom is discretized into regular voxels (cubes) representing areas with homogeneous material properties.
- **Straight propagation** – the ultrasonic pulses are modeled along straight line between sending and receiving transducer assuming a spherical wave.
- **Point transducers** – the shape and size of the transducers is neglected in the simulation, however the effects the heterogeneous radiation characteristic of the transducers can be defined by the user as a function of angle-dependent frequency response.
- **Scattering effects** – to simulate the reflection/scattering effects the volume is filled with large number of scattering points and the propagation of the ultrasonic pulse is computed for the first-order scattering paths (sender-scatterer-receiver).

We have decoupled the computations of the direct paths and the scatterer paths to enable better distribution of workload and to improve the data locality. The simulation is embarrassingly parallel with respect to the particular rays. The resulting application is written in Matlab and publicly available [5]. The computations were performed on the machines of Czech national grid MetaCentrum using PBS to describe and schedule the parallel jobs. As a result we were able to perform simulation of the full USCT system [1] with 3.5 millions of sender-receiver combinations, 10000 scatterers and cube voxels of size approximately 3 mm.

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Evaluation of Ultrasound-Speed Transmission Tomography

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Ultrasound computer tomography (USCT) is an imaging modality developed for breast cancer diagnosis. Due to the complexity of the ultrasound-field interaction with the imaged object, this modality is still in the reasearch phase. The imaged object is imersed in a water tank and surrounded by ultrasound transducers, which emit and receive ultrasound wave. The tissue parameters that can be reconstructed from the measured radiofrequency signals are reflectivity, sound speed and attenuation. This contribution is focused on sound-speed imaging. The known sound-speed reconstruction techniques in USCT are inherently 2D because they are used for 2D image reconstruction from data acquired using a ring of transducers (2D USCT setup). Here, a fully 3D method is presented and evaluated. It is intended for a 3D USCT system [1], where the transducers are distributed on a 3D surface. Such a setup brings several challenges: 1. the transducer distribution is sparse due to technical limitation s of the number of transducers, 2. small SNR, due to small transducer size, 3. high computational and memory demands [2].

These challenges are approached using total-variation algebraic reconstruction, synthetic aperture focusing and parallel implementation. The limits of this imaging scheme is tested on real and mostly simulated data. The tests illustrate the achievable contrast for different lesion types.

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Gold Standard Database to Support Evaluation of Fundus Image Segmentation Methods

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Digital imaging using fundus camera is widely considered as an integral part of medical examination in ophthalmology. Common fundus images contain various regions (objects) of interest which can be useful for diagnosis [1]. One of these objects is the blood vessel tree. Thus, segmentation of retinal vessels is in focus of many international researchers, since accurate and precise extraction of blood vessels is even a pretty challenging image processing task. However, all recent authors evaluates performance of vessel segmentation methods using famous, but now quite old database DRIVE [2], containing only low-resolution (565 x 584 pixels) images. Thus, quantitative evaluation of the methods is so far limited.

Hence, we created a new publicly available high-resolution fundus image database of healthy and pathological retinas. This database resulted from a long-term cooperation between Department of Biomedical Engineering at Brno University of Technology, Czech Republic, and Pattern Recognition Lab at the University of Erlangen- Nuremberg, Germany. We want to support comparative studies on automatic segmentation algorithms on retinal images and provide a novel opportunity to researchers working in the field of retinal image processing to evaluate their vessel segmentation methods. The database is available online at the website: "http:// www5.informatik.uni-erlangen.de/research/data/fundus-images".

The database contains currently three sets of fundus images of healthy (H), glaucomatous (G) and diabetic retinopathy (DR) retinas. The H set contains 15 images of healthy patients without any retinal pathology. The DR set consists of 15 images with pathological changes, such as neovascular nets, hemorrhages, bright lesions, spots after laser treatment, etc. The G group includes 15 images of patients with glaucoma in advanced stage appearing with focal and also diffuse nerve fiber layer loss. All fundus images were acquired by the mydriatic fundus camera CANON CF-60 UVi equipped with EOS-20D digital camera with the 60 degrees field of view (FOV). The pixel resolution of each image is 3504 x 2336 pixels. The images were taken at the collaborative Tomas Kubena's Ophthalmology Clinic, Zlin, Czech Republic. The vascular tree for each image was manually segmented as a ground truth by three experts working in the field of retinal image processing (Fig. 1).

Figure 14: Image *"14_g.jpg"* from the group of glaucomatous retinas with corresponding hand-labeled gold standard

In the future, we intend to add further gold standard data to help the evaluation of segmentation algorithms aimed to differentiate between arteries and veins and measuring blood vessel diameters. Furthermore, we plan to expand the database to support evaluation of methods focused on other tasks in the area of retinal image processing, e.g. glaucoma diagnosis, segmentation of optic disc, fovea and detection of vessel bifurcations and crossings).

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Blind Deconvolution and Superresolution for Mobile Phones

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Current mobile devices are usually equipped with low-budget cameras with low quality optics and sensors. Therefore, digital images acquired by these cameras are generally deteriorated by noise and blur and may have effective resolution lower than the number of pixels. The task of image restoration is the recovery of a noise-free and sharp image with possibly higher spatial resolution from one or several such input images. For achieving all these tasks together, an image restoration framework performing registration, denoising, deblurring and possibly resolution enhancement (in case of pictures with sufficient quality) is used [1, 2]. The main contribution of this work is the effective and fast implementation of these algorithms in the form of a real working application running either remotely on a dedicated server or (in special cases) directly on the mobile phone (for an example, see Fig. 15).

Hardware demands of the computational process are still very high. Therefore the acquired images are automatically transferred to a remote server where the computation is performed, which is significantly faster. In the case of a smart-phone with build-in gyroscopes, the convolution kernels can be estimated directly from the measured motion during acquisition. The deconvolution can be then computed much faster even directly on the smart-phone.

Figure 15: Multichannel blind deconvolution example: (top) input images, (bottom) deconvolution result

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Numerical Analysis of the Rebellious Voter Model

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The rebellious voter model, introduced by Sturm and Swart (2008), is a variation of the standard, one-dimensional voter model, in which types that are locally in the minority have an advantage. It is related, both through duality and through the evolution of its interfaces, to a system of branching annihilating random walks that is believed to belong to the "parity-conservation" universality class. We present an analysis of numerical data for the rebellious voter model and for a closely related one-sided version of the model. Both models appear to exhibit a phase transition between noncoexistence and coexistence as the advantage for minority types is increased. For the one-sided model (but not for the original, two-sided rebellious voter model), it appears that the critical point is exactly a half and two important functions of the process are given by simple, explicit formulas, a fact for which we have no explanation.

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Forward Simulation of Ultrasonic Fields: A Summary

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The contribution summarizes techniques, applied for direct forward simulation of ultrasonic (US) fields in ultrasonic computed tomography (USCT) during the Data-Algorithms-Decision making (DAR) project, 2006-2011. Under the image processing section of the project, the simulations were pursued in connection with development of the image reconstruction techniques for the generation I experimental USCT setup, as built in Karlsruhe Institute for Technology, Germany [1]. The main simulation techniques discussed were:

- direct 4D harmonic synthesis of pulsed signals from steady state components for generalised wave equation [2]-[6]
- analytic propagation of US rays within FEM [7]
- wave envelope technique simulation of simple US sources field
- US analogue of Zoeppritz coefficients for pressure field amplitude and intensity propagation [8]

The specific properties, advantages and drawbacks of the individual techniques are pointed out.

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Výzkumné centrum Data – Algoritmy – Rozhodování

Výzkumné centrum Data – Algoritmy – Rozhodování (DAR) bylo založeno v roce 2005 v rámci programu MŠMT Výzkumná centra PP2 – DP01 (č. p. 1M6798555601; CEP 1M0572). Je tvořeno těmito subjekty:

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- Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií, Ústav biomedicínského inženýrství
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