Visual analysis of dynamic processes

Report of Contributions

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Contribution ID: **2** Type: **not specified**

Contributed talk 1

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Contribution ID: **10** Type: **not specified**

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Contributed talk

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Welcome

Monday 9 January 2017 13:00 (20 minutes)

Presenter: Dr KAESTNER, Anders (Paul Scherrer Institut, NIAG)

Contribution ID: **14** Type: **not specified**

Tomviz, ParaView, and VTK: Open, Scalable Visualization and Data Analysis for Tomographic Data

Monday 9 January 2017 14:20 (1 hour)

Materials tomography involves a number of steps to go from projection images taken on the instrument to an aligned, reconstructed 3D volume. The Tomviz project builds upon a number of open source frameworks to deliver a powerful desktop application for research, leveraging the Python environment along with a number of scientific Python modules to deliver a comprehensive solution for materials tomography at nanoscale to atomic resolution. The development of the application will be discussed, along with the Python-based data processing pipeline, and the XML format used to enable complex, reproducible data processing, segmentation, and visualization pipelines. The application is based on Qt, VTK, ParaView, and ITK with a bundled Python distribution making use of NumPy, SciPy, and Python wrapped ITK/ParaView to offer a powerful visualization and data analysis application.

In addition new challenges are emerging as supercomputer architectures become more diverse, and complex. The addition of GPGPU, many-core CPUs, burst buffers and in-situ analysis/visualization lead to the increased need for closer integration of the data analysis and visualization pipeline with simulation codes. Computational power is outstripping I/O bandwidth as we move towards exascale computing, and the importance of in situ processing coupled with strategies for performing processing in burst buffers is more pronounced.

Summary

At Kitware we are working on a number of highly scalable, open source HPC solutions for data analysis and visualization. Well known projects such as ParaView and Catalyst offer solutions for post-processing, and in situ visualization. VTK-m offers a platform where scientists can develop a computational kernel once, and the framework will deploy this as a TBB, OpenMP or CUDA kernel. Tomviz offers an intuitive open source application to create a compelling tomography application aimed at experimentalists. As we move forward it is critical that simulation developers and experimentalists engage with visualization and data analysis teams as they develop codes for next generation architectures in order to fully reap the rewards of these systems, by more deeply engaging as data formats, movement, and reconstruction algorithms are designed, developed and deployed.

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Presenter: Dr HANWELL, Marcus (Kitware)

Contribution ID: **15** Type: **not specified**

Visualization and analysis of multidimensional data using morphological techniques

Monday 9 January 2017 13:20 (1 hour)

This talk centers around the analysis and visualization of multidimensional scalar and tensor data within the framework of mathematical morphology. Initiated in the 1960s, mathematical morphology was developed to describe image operators for enhancement, segmentation, and extraction of shape information from digital images. In contrast to traditional linear image processing, the morphological image operators focus on the geometrical content of images and are nonlinear.

In this talk we first discuss morphological pyramids for multiresolution visualization of volume data. Then we describe recent work on morphological filters for multidimensional tensor-valued data. From the theoretical point of view, an important aspect in the design of morphological operators is their invariance under translation, rotation or scale changes, or, more generally, under an arbitrary group of transformations. A recent approach to group invariance (and particularly rotation invariance) for tensor fields is presented, based on the concept of frames.

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Presenter: Prof. ROERDINK, Jos (University of Groningen)

Track Classification: Lectures

Contribution ID: **16** Type: **not specified**

Putting the human back in the loop - vis for dynamic 4D tomography

Wednesday 11 January 2017 10:20 (20 minutes)

Dynamic experiments require careful planning and visualisation is key for the next generation of 4D control for dynamic objects.

Experience of integrating HPC/ visualisation and feedback of the human in the facility data capture is being built at SCD/STFC; UK.

Summary

As part of the Visualisation Group, within the Technology Division of SCD, we have been founded to support and maintain visualisation software and skills for large projects and user communities across STFC and the national facilities. This includes working with the Diamond Light Source and ISIS facilities in the UK making the data through visualisation them human understandable. This has included on related projects; for the TSB Space Application Catapult and European Space Agency (ESA) producing bespoke solutions for their data analytical and command and control needs; for ISIS and DLS data creating remote and distance data gathering and visualisation work-flows to control the computational processes; and providing specialist local high-end equipment within the centres that are near to the main data capture locations.

Managed and setup high-end visualisation centres within STFC, with the key objective to consider the human-in-the-loop as an integral part to pre- mid- and post-data visualisation needs from the major facilities. This it is believed is a key component to increasing the efficiency of the major STFC facilities allowing researchers' work-plans to be controlled, changed and even stopped on the fly.

We have an emphasis to work in harmony with collaborators across the STFC mission and are building up for the needs of a dynamical experimental visualisation service.

This presentation considers how specialist remote GPU enabled workstations can assist in the data capture process, and followed by providing specialist reconstruction software and quantification utilities to gain understanding from data sets specifically tomographic ones.

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Session Classification: Contributed talks Wednesday I

Track Classification: Lectures

Contribution ID: **17** Type: **not specified**

Advanced visualization of neutron scattering data

The combination of large multi detector neutron instruments that measure large areas of reciprocal space and collecting neutron scattering data in event mode provides facility users with new opportunities to investigate the structure and dynamics of materials

Collecting data in event mode allows the user to probe S(q,w) with a continually varying control parameter such as sample temperature, pressure or applied field. It is increasingly common to generate large event mode data sets that form a data volume of the scattering function with the control parameter.

In this talk the use of parview to visualize data volumes from neutron scattering experiments will be discussed with respect to:

1. Packaging paraview in a user application.
2. Data formats to maximise performance.
3. User interface considerations for non expert users.
4. Generating toolkits for domain specific applications in direct geometry spectroscopy

Author: Dr TAYLOR, jonathan (ess)

Presenter: Dr TAYLOR, jonathan (ess)

Track Classification: Lectures

Contribution ID: **18** Type: **not specified**

WAVE: A 3D Online Previewing Framework for Big Data Archives

Wednesday 11 January 2017 10:40 (20 minutes)

With data sets growing beyond petabytes or even terabytes in scientific experiments, there is a trend of keeping data at facilities and providing remote cloud-based services for analysis. However, accessing these data sets remotely is cumbersome due to additional network latency and incomplete metadata description. To ease the data set browsing on remote data archives, our WAVE framework applies an intelligent cache management to provide scientists with a visual feedback on the large data set interactively. We present methods to reduce the large data set size while preserving the visual quality. Our framework supports volume rendering and surface rendering for data inspection and analysis. Furthermore, we enable zoom-on-demand approach, where a selected volumetric region is reloaded with higher details. Finally, we evaluated the WAVE framework using a data set from the entomology science domain.

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Presenter: TAN JEROME, Nicholas (Karlsruhe Institute of Technology)

Session Classification: Contributed talks Wednesday I

Track Classification: Lectures

Contribution ID: **19** Type: **not specified**

Visual Analysis of Damage Mechanisms in Glass Fiber Reinforced Polymers

Tuesday 10 January 2017 14:40 (20 minutes)

Interrupted in situ tensile tests are used in industry to study the evolution and accumulation of damages under load in glass fiber reinforced polymers (GFRPs).
During these tests, a test specimen is scanned multiple times using a computed tomography (CT) device under increasing load.
The obtained series of CT scans is analyzed by material engineers regarding defects to draw conclusions about the material.
In particular, material engineers are interested in visualization of individual defects, visualization of series of CT scans, and visualization of quantitative information of defects.
To address these requirements, we have extended and improved a tool, which material engineers are currently using to perform analysis of such tests.
We have extended the Defect Viewer tool to render defects in 3D.
We have implemented a juxtaposition visualization to track changes between steps in a series of CT scans.
Finally, we have implemented a heapmap visualization to calculate and render quantitative information of defects in 2D.

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Presenter: Mr AMIRKHANOV, Alexander (University of Applied Sciences Upper Austria, Wels Campus)

Session Classification: Contributed talks Tuesday II

Track Classification: Lectures

Contribution ID: **20** Type: **not specified**

Visualization techniques for the analysis of ensemble variability

Tuesday 10 January 2017 10:30 (1 hour)

In many scientific fields, the recognition that predictability is limited has led to a paradigm shift in how predictions of dynamic processes are created. Instead of making a single deterministic computation of the future field state, ensembles of many numerical simulations are computed—based on a set of possible initial states and random variations to account for model uncertainty—and predictions take the form of probabilities of occurrence of specific features derived. In meteorology, ensemble forecasting is used to estimate the uncertainty inherent in the prediction of weather events, by providing a representative sample of the possible states of the atmosphere that could evolve out of perturbed initial conditions and different models.
In my talk I will address ensemble visualization techniques, which aim at analysing the variability of an ensemble, so that from the rate of divergence of the individual ensemble members the uncertainty of a single weather forecast can be estimated stochastically. I will shed light on ensemble visualization techniques for specific features in scalar- and vector-valued ensembles, such as iso-contours and particle trajectories, and I will hint on some basic problems we encountered when dealing with ensemble data, such as curve and shape comparison, visual abstractions for ensembles, as well as the visual representation of probabilities.

Author: Prof. WESTERMANN, Rüdiger (Technical University Munich)

Presenter: Prof. WESTERMANN, Rüdiger (Technical University Munich)

Track Classification: Lectures

Contribution ID: **21** Type: **not specified**

Tensor Visualization

Wednesday 11 January 2017 09:00 (1 hour)

Tensor-field visualization has got special attention of the visualization community in the last decades. An important force on this development is the advance of diffusion weighted magnetic resonance imaging (DW-MRI) acquisition. This MRI modality allows the acquisition of water diffusion information in living tissue. This information measured at the macro level (mm) allows the unprecedented in-vivo visualization of fibrous structures (e.g., white matter fiber bundles) at the microscopic level. The diffusion information can be represented by a second-order positive definite tensor, but also by higher-order descriptors that provide more insight in the complexity of the fibrous structure. In this talk, I will present an overview of the different visualization techniques that have been developed for tensor field visualization focusing on the medical domain, and touch upon uses in material sciences. I will also describe my view on the current main challenges on tensor-field visualization.

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Presenter: Dr VILANOVA, Anna (TUDelft)

Track Classification: Lectures

Contribution ID: **22** Type: **not specified**

Interactive Visual Analysis in the Material and Computational Sciences

Tuesday 10 January 2017 09:00 (1 hour)

Visualization and visual computing use computer-supported, interactive, visual representations of (abstract) data to amplify cognition. In recent years data complexity concerning volume, veracity, velocity, and variety has increased considerably. This is due to new data sources as well as the availability of uncertainty, error and tolerance information. Instead of individual objects entire sets, collections, and ensembles are visually investigated. There is a need for visual analyses, comparative visualization, quantitative visualizations, and scalable visualizations. The simultaneous exploration and visualization of spatial and abstract information is an important case in point. Several examples from the material and computational sciences will be discussed in detail. Given the amplified data variability, interactive visual data analyses are likely to gain in importance in the future. Research challenges and directions are sketched at the end of the talk.

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Presenter: Prof. GROELLER, Eduard (TU Wien)

Track Classification: Lectures

Contribution ID: **23** Type: **not specified**

RB-SIRT: capturing the dynamics of polyurethane foam under compression

Monday 9 January 2017 16:00 (20 minutes)

A conventional 4D computed tomography (CT) acquisition consists of several CT (sub) scans that are acquired sequentially. Conventionally, each sub scan is independently reconstructed. A straight forward method to improve the temporal resolution and reduce deformation artefacts the acquisition time of each sub scan can be shortened. However, this strategy results in low signal to noise ratio reconstructions and/or in under sampling artefacts. The proposed Registration Based SIRT algorithm allows lowering the acquisition time of the sub scans without compromising the reconstruction quality. This is achieved by introducing a motion model into the reconstruction process, which allows including projections of other time points into the reconstruction process without causing deformation artefacts. The method was validated on a 4DCT dataset of polyurethane foam under compression.

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Presenter: Mr VAN NIEUWENHOVE, Vincent (University of Antwerp)

Session Classification: Contributed talks Monday

Track Classification: Lectures

Contribution ID: **24** Type: **not specified**

Neutron imaging –an ideal tool for the observation of processes involving low density elements

Tuesday 10 January 2017 11:50 (20 minutes)

Many dynamic processes have active components consisting of mainly low density elements like hydrogen or lithium. Neutron imaging has the characteristic feature that the modality is very sensitive to in particular these elements. This is used to observe processes in applications like porous media research (soil hydrology, geology, and civil engineering), foams (food and polymers) and electrochemistry (batteries and fuel cells). The neutron flux is the main limiting factor for the speed of the observed processes. Different acquisition strategies are successfully used depending on the process speed. The strategies ranges from steady state observations, golden ratio, and on-the-fly. Each method with increasing acquisition rate and decreasing signal to noise ratio. Speeding up the acquisition rate often also mean reducing the number of projections. This has led to the development of reconstruction techniques that successfully utilize the time structure in the data for the regularization to improve image quality. The next step is the analysis and quantification of the time series of CT data. The nature of the experiments varies therefore different analysis strategies have to be developed.

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Session Classification: Contributed talks Tuesday I

Track Classification: Lectures

Contribution ID: **25** Type: **not specified**

Iterative reconstruction and three-phase segmentation of low-contrast undersampled time-lapse X-ray synchrotron data

Monday 9 January 2017 15:40 (20 minutes)

Technological advances in tomographic acquisition speeds allow multiple 3D data to be acquired in a short period of time, meaning that the structural changes of an object can be interpreted as a function of time. Dynamic experiments are crucial since they can shed a light on structural changes under realistic conditions. The critical limitation of dynamic imaging is a number of projections required per scan. While reducing the angular density of projections increases scans frequency (with less incorporated motion per time-frame), reconstruction from undersampled data poses major difficulties related to mathematical ill-posedness of inversion. Iterative image reconstruction (IIR) methods are much better adapted to deal with ill-posed inversion from undersampled measurements than direct methods as they use error-correcting refinements in iterations and allow the use of a priori information.
In order to demonstrate the possibilities of IIR for time-lapse data we will show a challenging case of reconstructing undersampled low-contrast dynamic data of ice-cream. The temperature of a sample changes during the experiment which leads to various structural deformations and interesting physical phenomena to occur. Although IIR reconstruction significantly improves contrast and SNR of images, segmentation of three-phase material (air, ice-crystals, ice-matrix) remains a challenge. We will present a novel post-processing approach to tackle the problem of varying intensities within one-phase region which impedes successful segmentation.

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Presenter: Dr KAZANTSEV, Daniil (The University of Manchester)

Session Classification: Contributed talks Monday

Track Classification: Lectures

Contribution ID: **26** Type: **not specified**

Multi-Dimensional Data Challenges in Neutron Imaging

Tuesday 10 January 2017 11:30 (20 minutes)

4D imaging data might first be understood as time resolved 3D tomographic imaging data. However, this is not necessarily the most representative case in particular in neutron imaging. While neutron imaging despite low available phase space densities in neutron beams and the corresponding relatively long exposure times, does not only allow for kinetic studies in some limited cases even with 3D spatial resolution, it often produces different multi-dimensional data sets not even limited to 4D. These can only in some cases be reduced straightforwardly especially in terms of dimensions for simplified visualization and analyses. The challenges of and current solutions for multidimensional neutron imaging data and their diversity in state-of-the-art neutron imaging as well as related to recent developments but apart from the conventional case of kinetic tomography studies shall be illustrated and discussed along some specific examples conveying:
(i) phase transitions in SOFC anodes under operation conditions: a time-of-flight (ToF) imaging study of reduction/oxidation kinetics in a moving sample with 2D spatial resolution
(ii) time and wavelength resolved modulated beam imaging e.g. of the setting process of dental cements
(iii) 3D neutron grain mapping and indexing –ToF tomography with multidimensional results
(iv) polarized neutron studies: from depolarization imaging to polarimetric ToF imaging and vector field reconstructions
(v) 4D through bi-modal imaging by combining x-ray and neutron tomographic data
(vi) micro-second time resolution in neutron imaging combining ToF and process kinetics resolution on the same time scale –the doubled time dimension in 2D imaging

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Presenter: Prof. STROBL, Markus (ESS-ERIC)

Session Classification: Contributed talks Tuesday I

Track Classification: Lectures

Contribution ID: **27** Type: **not specified**

Quantitative analysis of 3D lung image data at the micrometer scale

Tuesday 10 January 2017 14:20 (20 minutes)

With the advent of highly brilliant third-generation synchrotron X-ray sources in vivo imaging of biological samples has recently reached micrometer spatial and sub-second temporal resolutions. Analyzing high-resolution 3D biological structures such as lung tissue, however, still poses a great challenge due to its complexity and hierarchical branching scheme. In this work we demonstrate the application of quantitative tools for morphological and topological analyses applied to high-resolution murine 3D lung image data, inflated at different pressure levels under immediate post mortem conditions. We show how the tools might be used for a detailed description of lung inflation patterns, providing deeper insight into lungs physiology and opening a whole new range of applications. In particular, we observe first indications for heterogeneous intra-lobar and inter-lobar distension patterns and find no evidence for cyclic opening and closing of alveolar structures.

Summary

Here, I will present a full route to quantitative analysis of high-resolution 3D lung image data, starting from the image acquisition scheme for intact animals, how it particularly affects the segmentation and by making the link to quantitative 3D characterization of lung tissue. We employ local structural thickness analyses for assessing volumetric changes at various structural scales. For the topological analysis of the air-to-tissue surface in the lung, we apply the theory from differential geometry to calculate localized surface curvatures. We show for the first time the results of thickness map and curvature analyses performed on dose-efficient fast tomographic images of intact lungs.

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Presenter: LOVRIC, Goran (Paul Scherrer Institut)

Session Classification: Contributed talks Tuesday II

Track Classification: Lectures

Contribution ID: **28** Type: **not specified**

Towards the reconstruction of the mouse brain vascular networks with high- resolution synchrotron radiation X-ray tomographic microscopy

Tuesday 10 January 2017 14:00 (20 minutes)

The formation and progression of several vascular diseases in the brain is accompanied by changes in the vessel micro-structure and morphology. A clear visualisation and an in-depth knowledge of the vascular system is essential for better understanding the pathophysiological mechanisms of neurovascular disorders. Micro-Optical Sectioning Tomography has shown potentials in imaging the vessel network of an entire mouse brain with a voxel resolution of 0.35×0.4×2.0 µm3 [1]. However, available imaging tools are unsuited for non-destructive cerebral mapping of the three-dimensional vascular microstructures. To overcome these difficulties, the brain vasculature architecture is currently documented at 16 ⊠m resolution in micro-Computed Tomography (CT) [2] and about 5.9 ⊠m pixel size with synchrotron-radiation based micro-CT [3]. Within the context of the Human Brain Project (HBP), we aim at using synchrotron radiation X-ray tomographic microscopy at the Swiss Light Source of the Paul Scherrer Institute (Switzerland) as a key technology for reconstructing, in a non-descructive way, the entire vascular system of the mouse brain at 1 µm resolution. During the experimental work, PCO.Edge camera with high efficiency (QE>70%) coupled with 10× objective and filtered white-beam radiation are used to further decrease exposure times. This configuration yields a pixel size of 0.65 ⊠m and an effective resolution of about one micron. Filtered white-beam refers to the polychromatic configuration of the beamline where 95% of the total beam power is filtered out of the beam incident on the sample. The bandwidth of the X-ray beam is narrowed down around a mean energy of 25–30 keV. The exposure time in such conditions is set to 30 ms. The sample is prepared by intravascular filling with consecutive embedding of the tissue, adopting a protocol suggested by [1]. Local CTs are performed for a total of 792 scans in 30 hours scanning time to cover the whole brain volume. In total, 7 TB of datasets are acquired and need to be processed. To address this challenge, we extend the method in order to work on several scans by enabling the use of many machines in parallel, thus allowing the stitching and analysis of such large datasets. At this point, these pioneering efforts are pointing towards new horizons in the investigation of large biological samples with 3D high spatial resolution.

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Session Classification: Contributed talks Tuesday II

Track Classification: Lectures

Contribution ID: **29** Type: **not specified**

Visualisation of mobile magnetic domain walls with neutron grating interferometry

Tuesday 10 January 2017 12:10 (20 minutes)

The visualisation of dynamic processes with neutron grating interferometry (nGI) has not yet been studied to an extend where application could be useful. This is mostly due to the typically long exposure time of nGI experiments that are in the range of 20 minutes to several hours per dataset. We present an experimental, as well as data analysis, procedure that allows us to image repetitive processes using nGI while still being able to tune neutron statistics to an appropriate level by adjusting exposure time.
Neutron grating interferometry is a neutron imaging technique that builds on the wave nature of the neutron by introducing three gratings into the beam that either absorb parts of the beam or introduce well defined phase shifts. As a consequence of these gratings interference patterns are generated. Changes in the shape of the interference pattern can be analysed with regard to attenuation (TI), phase shift (DPCI) and small angle scattering (DFI) within the sample.
In order to retrieve TI, DPCI and DFI the interference pattern is scanned using a phase stepping approach with an analyser grating. The more phase steps are recorded the better the quality of the images. Each phase step is an image itself with the typical rule of more exposure time, better statistics. The type of data acquisition makes nGI a rather slow technique that is not typically suited for the investigation of dynamic processes. However, advanced detector technology in combination with appropriate hardware triggering makes it possible to investigate repetitive processes using nGI.
The investigation of magnetic domains in electrical sheets has been an important subject in which neutron grating interferometry contributed to the development in recent years [1,2]. These studies investigate the magnetic domains walls as static and drew conclusions from the extrapolated behaviour that the static data suggested about the mobile nature of the domains. In our work, we present the next experimental step in the analysis of mobile magnetic domains by presenting a setup in combination with appropriate data analysis to visualise the movement of the domain walls directly up to 50 Hz.

[1] Betz, B., et al. "Frequency-Induced Bulk Magnetic Domain-Wall Freezing Visualized by Neutron Dark-Field Imaging." Physical Review Applied 6.2 (2016): 024024.

[2] Rauscher, P., et al. "The influence of laser scribing on magnetic domain formation in grain oriented electrical steel visualized by directional neutron dark-field imaging." Scientific Reports 6 (2016): 38307.

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Presenter: HARTI, Ralph Patrick

Session Classification: Contributed talks Tuesday I

Track Classification: Lectures

Contribution ID: **30** Type: **not specified**

Streaming reconstruction for time evolving tomography experiments

Tuesday 10 January 2017 15:00 (20 minutes)

In tomography, a series of 2D projections are acquired as a 3D object is rotated about one or more axes, after which a 3D reconstruction of the object is obtained. Implicit in the approach is the idea that the only differences between the projections are the known rotational angles, with no additional motions or distortions of the object. This condition is easy to meet in traditional forms of tomography at millimeter length scales when using precision rotation stages and low-dose imaging systems; however, it is not easy to meet at the sub-100 nanometer length scale of synchrotron or electron tomography, where one uses high-resolution microscopes to obtain 2D projections revealing nanoscale features. At these fine length scales, imperfections in rotary stage motion become more noticeable, and high-dose radiation exposure could induce changes in sample. In this talk, I will compare conventional tomography algorithms and lay stress on the limitations of these algorithms for reconstructing slowly-changing samples. I will then present how streaming algorithms based on iterative refinement can alleviate these issues in practice, and allow us to visualize motion in experiments.

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Presenter: Dr GURSOY, Doga (Argonne National Laboratory)

Session Classification: Contributed talks Tuesday II

Track Classification: Lectures

Contribution ID: **31** Type: **not specified**

Region of view tomography

Monday 9 January 2017 16:20 (20 minutes)

Today, most imaging software pipelines distinguish between (at least) the steps of (1) data acquisition, (2) volumetric reconstruction and (3) visualization and analysis. Those parts are usually treated as separate "modules" with only marginal interaction, e.g., through calibration parameters. In particular, reconstruction is almost always performed on a whole volume, and the reconstructed 3D image is often visualized by 2D slicing or a 3D rendering technique.

We propose a new paradigm where visualization and reconstruction are integrated in the sense that the reconstruction is focused on the region of view (ROV), i.e. the region at which a user is currently looking by means of a visualization tool. For non-iterative methods this means that points outside the ROV can be ignored altogether since the algorithms work point-per-point. In iterative schemes, the "outside" part can be represented with a very coarse discretization, thereby strongly lowering the required computational cost.

The talk introduces the concepts and shows some early results.

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Presenter: Dr KOHR, Holger (CWI, Amsterdam)

Session Classification: Contributed talks Monday

Track Classification: Lectures