TINE/ACOP state-of-the-art video controls at Petra III

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Data Acquisition and Transport

- Image grabber server in C++, pre-processing (compression)
- TINE transport protocol
  - High-Resolution images, user configurable up to 2 megapixels, with IMAGE data type
  - allows network optimizations: multicasting, unicast UDP and TCP
  - easily up to 10 frames per seconds

Image Visualization Component

- Java based client solution
  - Platform independence strong requirement
  - Takes care of video analysis, processing and display
- AcopVideo component, part of Acop family of Java widgets
  - Displays TINE video channel and still images (TINE format or loaded as JPEG or PNG files)
  - Image visualization and enhancements
    - different color modes for luminosity data
    - histogram equalization
    - aspect ratio changes and zooming
    - additional display of meta information

Image Processing and Analysis

- Done by analysis module on client side within AcopVideo component or within central image analysis server.
- Strong constrain to be done fast, within image stream frame rate.
- Statistical analysis:
  - Simple statistical algorithm for approximation with elliptical shape, produces: mean value and standard deviation of the beam profile, rotational parameter of the beam ellipse. And in addition:
    - Side profile data
    - Analysis of two 1-dimensional side-view projection of beam.
  - AcopVideo visualize (approximated ellipse, crosshair marker) these parameters together with the live image, side projections are plotted at the bottom and side of the image.
- Improvements of statistical analysis
  - Region of Interest (ROI) - cuts off irrelevant or noisy surrounding area, improves analysis speed.
  - Threshold value, pixels below are discarded - eliminates low amplitude noise in background (gray background)
    - Value specified by the user or calculated for each frame, user specifies a region where mean pixel value is calculated.
  - Background image subtraction.
    - Eliminates irregular static background artifacts.
  - User can choose pre-stored image from the file system or grab a live image from the TINE channel
  - Smoothing algorithm
    - For extremely noisy images.
    - For each pixel the new value is calculated as the average value of a few points around it.
- Best Fit Analysis
  - Statistical methods does not tell when result is bad or inaccurate.
  - Least square curve fitting algorithm on beam image horizontal and vertical side projections fixes this.
    - Gauss function with linear background: \[ y = A e^{-\frac{k}{x}} + k, \] \( A, \tau, \sigma, k, n \) are the fitted parameters.
  - Levenberg-Marquardt algorithm used to find numerical solution.
  - Starting value is seeded by results for statistical analysis, subsequent seeds are previous frame results.
  - More reliable results than statistical analysis. When combined with the background image and threshold calculation, the algorithm produces very stable and accurate results.
  - Algorithm is processing power demanding: up to 2 frames per second can be processed, intermediate frames are dropped.