LSD Analyzer
Software documentation

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Evropský sociální fond
Praha & EU: Investujeme do vaší budoucnosti
(1) Red monochromatic laser (He Ne, 633 nm, 5 mW)
(2) CMOS high speed camera, with maximal framerate 10 kiloframes per second
(3) The camera is connected to notebook Dell Latitude E6510 with 1 Gb/s Ethernet card.
Camera technical specification

- **Interface:** Gigabit Ethernet
- **Greyscale resolution:** 12 bit / 10 bit / 8 bit
- **Technology:** CMOS active pixel (APS)
- **Scanning system:** progressive scan
- **Resolution:** 1312 x 1082 pixels
- **Pixel size:** 8 μm x 8 μm
- **Exposure time:** 10 μs … 1.67 s
- **Exposure time increment:** 100 ns
- **Pixel clock frequency:** 40 MHz
- **Pixel clock cycle:** 25 ns
- **Operating temperature:** 0°C – 50°C
- **Power supply:** +12 V DC … +24 V DC
- **Dimension:** 60 x 60 x 51 mm^3
Laser and laptop technical specification

Laser Linos

- Wavelength: 632.8 nm
- Output power: 5 mW
- **Working gasses**: He Ne
- Beam diameter: 0.49 mm
- Divergence: 1.7 mrad
- Polarization: N/A

Laptop Dell Latitude E6510

- 1 Gb/s Ethernet card
- Processor: i5
- RAM: 4 GB
- **SSD disk transfer rate**: 135 MB/s
Two modes of measurement were discussed:

1D mode
- Used image size: 544 x 1 px
- **Maximal possible frame rate:** 10 000 fps
- Data loss: minimal, usually no.
- Disadvantage: x-axis movement detection only

2D mode
- Image size: 544 x 200 px
- **Maximal possible frame rate:** 800 fps
- **Data loss:** up to 1%
- X and y axis movement detection

Both modes are implemented in the LSD Analyzer.
The 1D mode is recommended for normal measurement. The 2D mode should be modified to decrease data loss.
Software usage

• To run the program use one of these:
  – LSDAnalyzer.exe
  – Run LSDAnalyzer.sln with the MS Visual C++ Express
    • Use this to modify or debug program

• Enter the experiment name to the windows console dialog
  – Use “cal” instead the name to start the autocalibration
  – Autocalibration function calculates the camera gain value and x, y offsets of the image.
  – It is necessary to calibrate camera each time it is powered on.
  – Use autocalibration with laser and plasma on

• Choose the camera in the camera connection dialog after the experiment typing

• Once you autocalibrate the camera, start the program again and measure data.
Configuration parameters

There are **three groups of parameters**, that can be stored to the camera

- **Calibration files** (Implemented in LSD Analyzer)
  - These parameters are stored to the camera memory by LSD Analyzer each time measurement is started.
  - Can be changed in the configuration file

- **Autocalibration** (implemented in LSD Analyzer)
  - Autocalibration set gain, x and y offset
  - These parameters are stored to the camera memory after the camera calibration is finished

- **PF Gev software** (supplied by the camera manufacturer)
Configuration file

The file is located in the same directory as LSD Analyzer software and is named settings.ini

Parameters:

**OutputDataPath** – the path and the name of the file, where the read data will be saved. The experiment name set by the user, will be used as a prefix. (Default value is: E:\Lab\%s_DATA.txt)

**ErrorPath** - destination of the error output file. Data loss and brightness under threshold errors are written into the log file. (Default value is: E:\Lab\%s_ERR.txt)

**ExperimentDuration** – set the experiment duration in seconds. It is limited by the file size. 10 min experiment produces 687 MB of data. (Default value is: 10 s)

**CameraFramerate** – set the camera framerate. Maximal recommended value for 1D image is 10 000 fps (Default value is: 10 000 fps)

**BrightnessThresholdValue** – set the threshold to calculate x and y laser spot center. (Default value is: 180)

**CameraExposureTime** – set the time of camera exposure in microseconds. Max 1.67 s. (Default value is: 10 μs)

**CameraBlacklevel** – set the camera black level. Optimal value is 100. (Default value is: 100)

**OptimumMaxBrightness** – the parameter for gain penalty function used in the autocalibration. (Default value is: 230)

**UdpBridgeEnabled** – the parameter to enable the UDP bridge to send read data to future GUI. (Default value is: 0 – not enabled).
Autocalibrated parameters

- The procedure set gain, x and y offsets. It tries a range of values for each parameter to find an optimum value (minimum of penalty function).
- Gain penalty function is defined as absolute value of the difference between maximal brightness of the image and optimal gain parameter (OptimumMaxBrightness), that is defined in the configuration file.
- Offset X penalty function is defined as distance of computed laser beam spot center from the half value of image width.
- Offset Y penalty function is defined as negative count of pixels which brightness is above BrightnessThresholdValue, that can be set in the configuration file.

(!) These parameters should be recalibrated after the camera is touched somehow or laser intensity changes for any reason.

(!) Autocalibration should be done EACH time the camera is powered on.
Parameters via PF Gev software

- All parameters can be set or checked by the PF Gev software.
- Keep in mind, that LSD Analyzer software will reset parameters that are written in configuration file.
- Autocalibration will reset gain, x and y offset.
- PF Gev software is recommended to use to check parameters or camera function itself.
You can check the result of autocalibration

- If autocalibration is OK, the laser spot would be in the middle of the row image
- In case the spot is not in the middle, try to move the camera. Check the image during moving.
Beam position calculation was implemented by Zd. Navratil and is used in the last version of LSD Analyzer.

- **Algorithm:**
  - Calculate the position of pixels which brightness is over threshold.
  - X and Y axis value is the mean of all position of chosen pixels.

- Calculated values are written into the output CSV file.
Software output CSV columns

- **Frame number** - Index of captured image
- **Block ID** - Index of block. Value is taken from camera
- **Framerate** - Actual framerate
- **Time stamp** - The image time stamp (actual time, when it was captured)
- **X** - Calculated x value of center of the image.
- **Sx** - Standard deviation for x-axis
- **Y** - Calculated y value of center of the image
- **Sy** - Standard deviation for y-axis
- **Count** - The number of pixels which brightness is higher then BrightnessThresholdValue parameter
- **Max** - The maximum brightness value in the image
Implementation details

- No mutex or semaphore is used
- Processing thread is faster than Capture thread
UDP communication

- If Udp Communication is enabled in settings (UdpBridgeEnabled = 1), data about each processed frame are sent via UDP datagram.
- Destination of UDP Datagram is set by two parameters in the configuration file:
  - DestinationIpAddress
  - DestinationUdpPort
- Each datagram contains information about one captured frame.
- Transferred data are in binary format.
- C language structure matching sent data is in DataResult.h.
Data loss

• Data loss occurs rarely. It happens before the capturer thread can handle losses.

• Possible reasons:
  – Resource intensive (probably interrupt request intensive) tasks running in parallel on background

• Possible solution:
  – Limit any performance stress on laptop (do not touch mouse or keyboard, if it is not really necessary)
  – Turn the antivirus and all other programs off
  – The LSD Analyzer is running with realtime priority (is set automatically)
Waiting to be implemented or modified

• Modify the 2D mode to prevent data loss
  – Possible solution: disable the antivirus and OS background services

• Implement data processing
  – Moving average filter
  – FFT processing and frequency detection
  – Temperature calculation with histogram information

• Implement the graphical user interface
  – Connection with GUI could be by the UDP, implemented in the actual software version
Signal measured with LSD Analyzer

- 2 seconds of the signal and its spectrum
- Plasma parameters:
  total Power = 80 W
  total Flow = 2.02
  10 jets
- Measurement duration: 10 min
- Frame rate: 10 000 fps
- Data loss: no
- Jet measured: 9.
Filament rotation frequency is depended on supply power

Measurement duration: 1 min each
Frame rate: 10 000 fps
Data loss: no
# Jet measured: 9.
Locked mode set for jets: 8., 9., 10.

Miniaturized non-thermal atmospheric pressure plasma jet—characterization of self-organized regimes
J Schäfer, R Foest, A Ohl and K-D Weltmann
Temperature dependency

- Plasma parameters:
  total Flow = 2.02
  10 jets

- Measurement duration: 10 min
- Frame rate: 10 000 fps
- Data loss: no
- Jet measured: 9.
Thank you for your attention