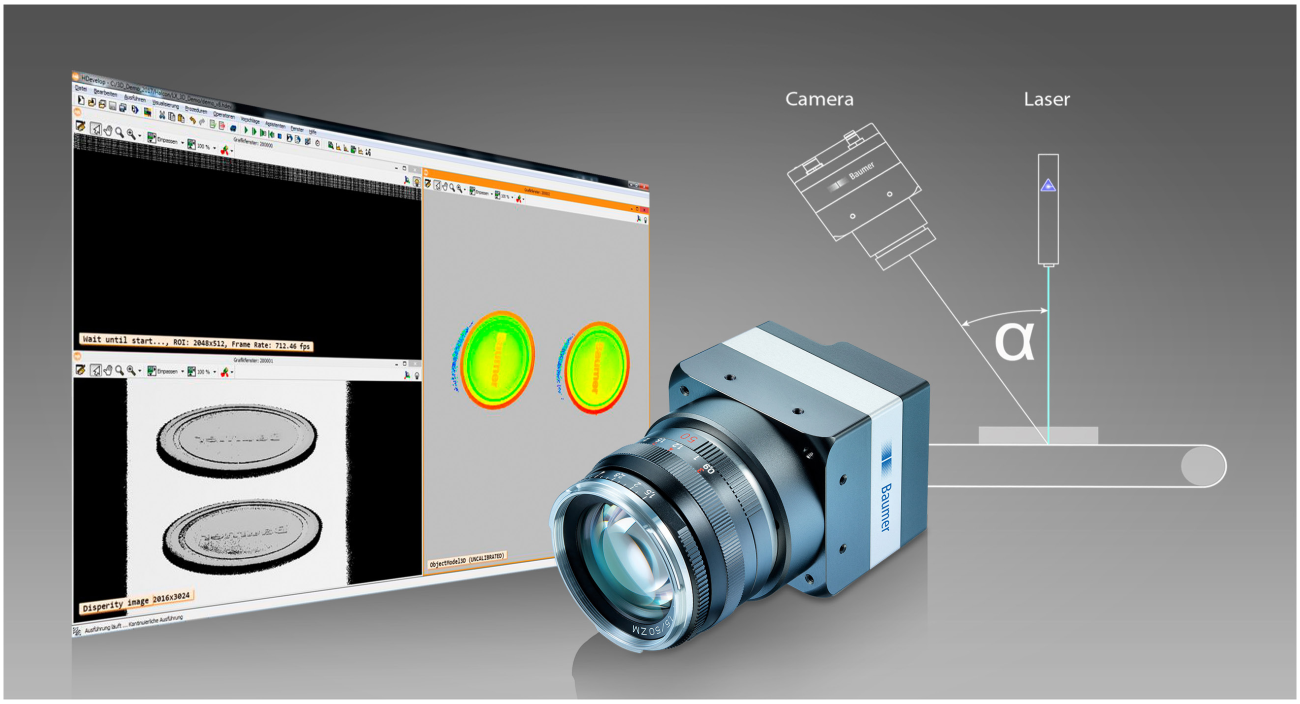
Baumer



User´s Guide

Laser Triangulation with LXG VisualApplets Cameras

Document Version: 1.2
Release: 22.07.2020
Document Number: 11184850

Table of Contents

1. General Information

Thanks for purchasing a LXG *VisualApplets* camera of the Baumer family. This User´s Guide describes how to set up and use the camera with the applet for 3D laser triangulation.

Read this manual carefully and observe the notes and safety instructions!

Notice

This User's Guide is specifically for using LXG *VisualApplets* cameras with 3D laser triangulation applet. Also observe the user's guide of the camera.

Support

If you have any problems with the camera, then feel free to contact our support.

Worlwide:

Baumer Optronic GmbH
Badstrasse 30
DE-01454 Radeberg, Germany

Tel: +49 (0)3528 4386 845

Website: www.baumer.com

E-mail: support.cameras@baumer.com

Target group for this User´s Guide

This User's Guide is aimed at experienced users, which want to integrate a LXG *VisualApplets* camera for 3D Laser Triangulation into a vision system.

Intended Use

LXG *VisualApplets* cameras for 3D Laser Triangulation measure distances based on the laser triangulation principle.

Notice

Use the camera only for its intended purpose!

For any use that is not described in the technical documentation poses dangers and will void the warranty. The risk has to be borne solely by the unit´s owner.

Classification of the safety instructions

In the User´s Guide, the safety instructions are classified as follows:

Notice
Gives helpful notes on operation or other general recommendations.

	Caution
Pictogram	Indicates a possibly dangerous situation. If the situation is not avoided, slight or minor injury could result or the device may be damaged.

	Danger!
Pictogram	Indicates an immediate imminent danger. If the danger is not avoided, the consequences are death or very serious injury.

1.1 Camera Models

On LXG-20M.3D / LXG-120M.3D cameras the applet for 3D Laser Triangulation is pre-installed. For the LXG-20M.PS / LXG-120M.PS cameras it is possible to configure and install the applet for 3D Laser Triangulation manually.

The following camera models support the 3D laser triangulation applet:

LXG-20M.PS (11174305), CMV2000, mono (can be modified by customer)
LXG-20M.3D (11174306), CMV2000, mono (pre-installed, not user programmable)
LXG-120M.PS (11174307), CMV2000, mono (can be modified by customer)
LXG-120M.3D (11174308), CMV2000, mono (pre-installed, not user programmable)

Common features:

- Single GigE
- PoE and AUX
- IO connector 1: 1 In / 3 Out (24 V)
- IO connector 2: 2 In / 1 Out (TTL, for encoder)
- Camera has a new test image to emulate a laser line which are useful for automated tests (Category Image Format Control / Test Pattern Generator Selector: Sensor Processor / Test Pattern: Diagonal Laser Line

2. General safety Instructions

Caution

Observe precautions for handling electrostatic sensitive devices!

Danger!

Danger of injury from laser radiation. Looking into the laser beam can lead to eye injuries.

Do not look directly into the laser beam! Observe the general laser safety regulations (see information on Laser documentation)!

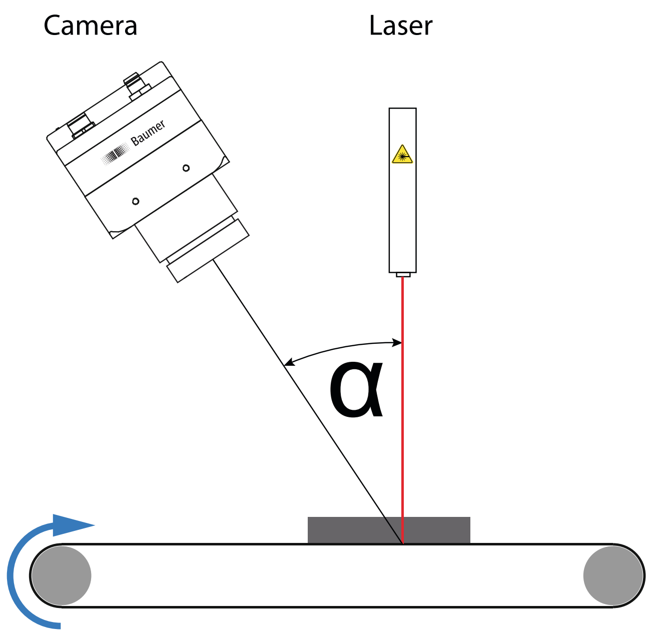
3. Introduction

LXG *VisualApplets* cameras for 3D Laser Triangulation measure distances based on the laser triangulation principle.

The laser projects a laser line onto the object which is reflected back onto the sensor in the camera. Due to the triangulation angle between the laser line, object and the camera, the reflected laser line appears at different positions on the sensor depending on different distances to the measured object.

Triangulation Setup

In this setup the camera looks with the viewing angle on the laser line projected from the top. A larger angle leads to a higher resolution. With larger angles the range of height is reduced. Small angles have the benefit of little occlusions. Other setups possible.



3.1 Development Environment

The following development environment is necessary for customizing the 3D laser triangulation applet:

- Camera: LXG-20M.PS / LXG-120M.PS
- Baumer GAPI SDK (11117626_SW_Baumer_GAPI_SDK_Win_v2.6.12714)
- Baumer *VisualApplets* SDK (11166632_SW_Baumer_VisualApplets_SDK_Win_v2)
- Silicon Software *VisualApplets* v3.0.4
- MVTec HALCON® v13 (optional)

4. Applet Description

LaserTriangulation_LXG-20M.PS_R1.va / LaserTriangulation_LXG-120M_R1.va

- Applet for Center of Gravity (CoG) algorithm for laser triangulation implemented
- High resolution (2k or 4k)
- Fast processing (e.g. 2048 × 128 @ 2691 fps, 4096 × 128 @ 1326 fps)
- Applet for LXG-20M.PS / LXG-120M.PS can be modified by customer, still a lot of FPGA resources available for user customization
- Applet is pre-installed for LXG-20M.3D / LXG-120M.3D (not user programmable)
- Post processing examples with MVTec HALCON® for demonstration purposes

Scope

- CoG Processing according to Silicon Software SDK example
- Insertion of status information
- Aggregation of images for transmission to reduce frame rate and CPU load
- Generation of meta data for the Interface eVA/Camera to signal images have been aggregated
- Evaluation of encoder, attached via second IO connector (TTL level)

4.1 Applet Parameters

The applet has the following parameters.

TOP Level

Input	
StartFIFO	buffers data, must not overflow (e.g. Fill Level = 100 %)

Processing.COG_Processing	
Binarization.Threshold	Dynamic, default is 30 pixels below this will not be considered for CoG.
RemoveallButLastLine.LastLineNumber	Dynamic, default is 1087, needs to be adjusted to ROI height -1.
ROI_Offset.Value	Enables to add a fixed offset to the CoG result. This is useful when using an ROI to obtain the real sensor row within the transferred profile data.
FrameCombine	Dynamic, default is 8, how many incoming images should be combined.

MetaData	
HeighWidht.Height	Dynamic, default is 32, needs to be adjusted if FrameCombine is changed.
HeighWidht.Width	Dynamic, default is 2048, needs to be adjusted if ROI_X is changed.
ImageSquenceFlags	First frame of sequence is valid, frames 2 ... 8 are marked as discarded.

4.2 Image Data Format

Output of CoG algorithm is intermediate image with 32 bit per column (2048/4096 values)

- 24 bits for row, 8 bit subpixel row information
- to get the real row divide value by 256 (2^8)

First pixels of peak data are overwritten with status information

- can be enabled/disabled
- DWORD 0: frame counter
- DWORD 1: time stamp
- DWORD 2: encoder counter forward
- DWORD 3: encoder counter all

8 intermediate images are combined

- purpose is to reduce frame rate, make transmission more robust and save CPU cycles
- output 2048 or 4096 × 32 @ 8 bit
- to get the original 32 bit data the contents has to be type casted
  to 2048 or 4096 × 8 @ 32 bit

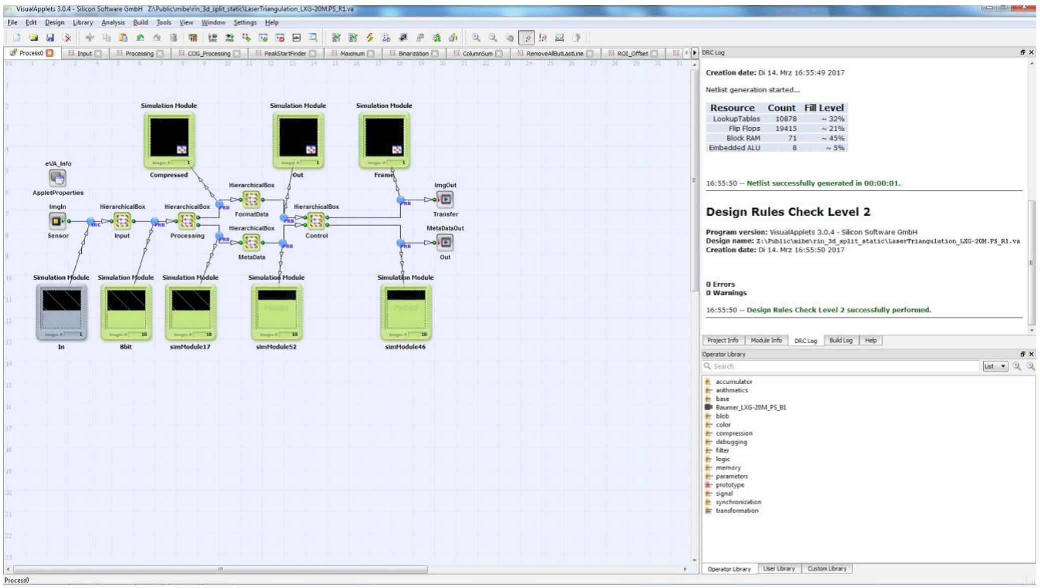
5. Applet Simulation

1. Install VAsetup3.0.4.

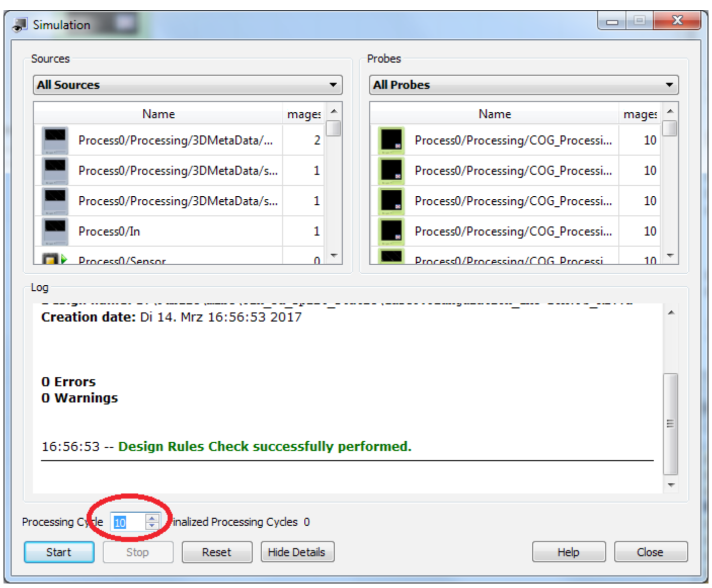
2. Install platform for LXG-20M.PS camera:install_eVA_Platform_Baumer_LXG-20M.PS (or 120).

3. Open applet: LaserTriangulation_SIM_LXG-20M.PS_R1.va (or 120).

4. Load Laser Pattern test image to Simulation Sources (top level and Processing.3DMetaData).

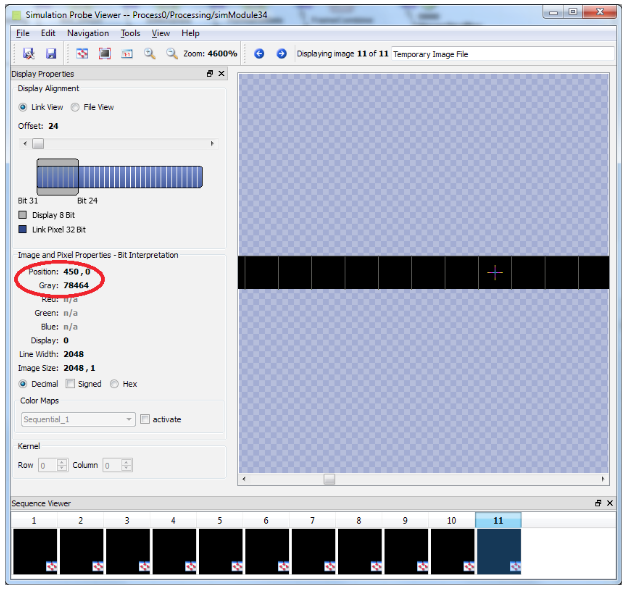


5. Start simulation with 10 iterations.



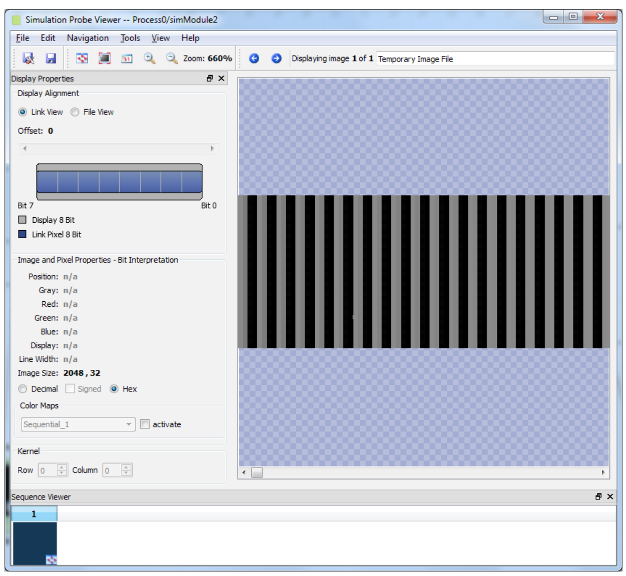
6. Validate CoG processing.

- Open Processing Box, simulation probe after ROI_Offset
- Enlarge image at column 450 (example)
- CoG value is 784464
- Divide by 256 (8 subpixel bits) to get the row: 306.5



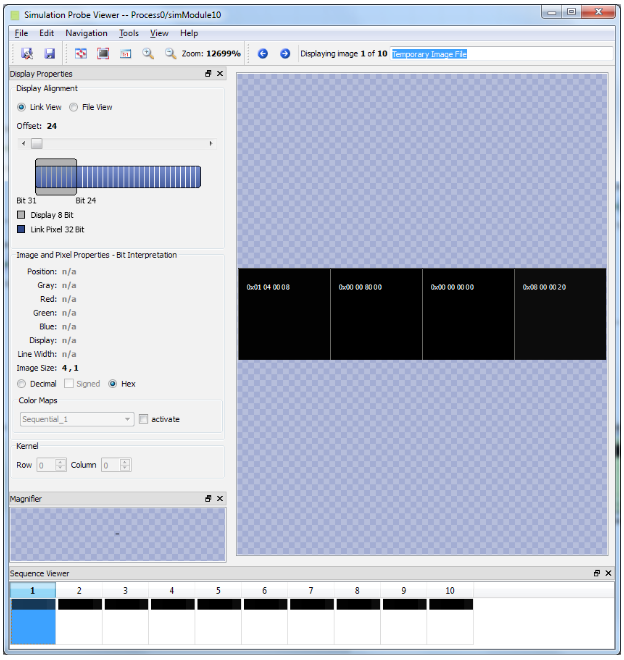
7. Check result image before ImgOut operator.

- There should be one image (after 8 images have been processed).



8. Check result image before MetaDataOut operator.

- There should be 10 images (1 for each incoming image).
- MetaDataOut images 1, 9, 17… signal a new image.
- MetaDataOut image 2-8, 10-16… signal incoming frame was aggregated, no image at ImgOut.



6. Camera Firmware Build

The following table shows the resource consumption of the 3D laser triangulation applet:

Firmware Update File:	LaserTriangulation_LXG-20M_R1_001.zip	LaserTriangulation_LXG-120M.PS_R1_001.zip
FPGA resource usage (mapper summary)		
Number of Slice Registers	24 %	25 %
Number of Slice LUT´s	36 %	38 %
Number of RAMB16BWERs	44 %	42 %
Number of RAMB8BWERs	7 %	7 %

7. Firmware Installation to new Camera

Follow the steps below to install the firmware on a camera.

1. Install Baumer Update Tool from Baumer *VisualApplets* SDK.

2. Switch to C:\Baumer Update Tool\data\

3. Follow the instructions below your camera.

LXG-20M.PS

- Rename directory 11174305 to 11174305_org (if exists).
- Extract LaserTriangulation_LXG-20M_R1_001.zip to C:\Baumer Update Tool\data\
- There should be a new directory 11174305 which includes the LaserTriangulation firmware.

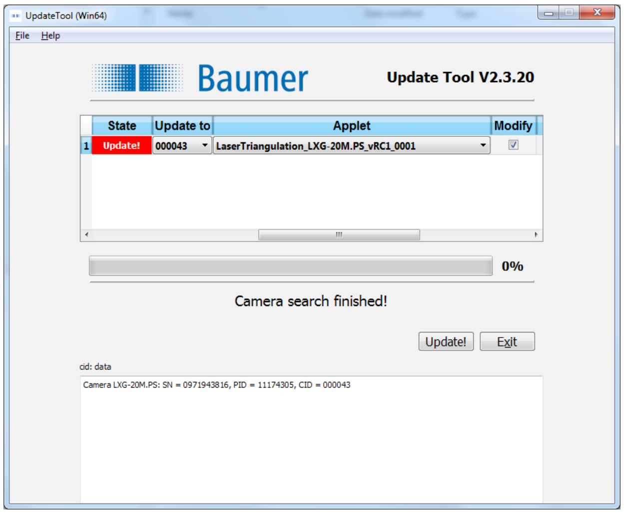
LXG-120M.PS

- Rename directory 11174307 to 11174307_org (if exists).
- Extract LaserTriangulation_LXG-120M_R1_001.zip to C:\Baumer Update Tool\data\
- There should be a new directory 11174307 which includes the LaserTriangulation firmware.

4. Connect camera to PC.

5. Start Baumer Update Tool.

6. Select new applet and start "Update".



8. Validate Camera Operation with Baumer Camera Explorer (Baumer GAPI SDK)

1. Connect camera with installed applet to PC.

2. Start Camera Explorer.

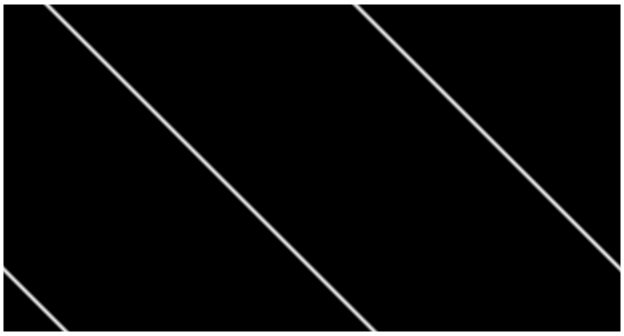
3. Stop image acquisition [F11].

4. Set Profile to “GenICam Guru” (located top right).

5. Enable internal test pattern (optional).

- Open category “Image Format Control”.
- Set “Test Pattern Generator Selector” to “Sensor Processor”.
- Start image acquisition [F12].

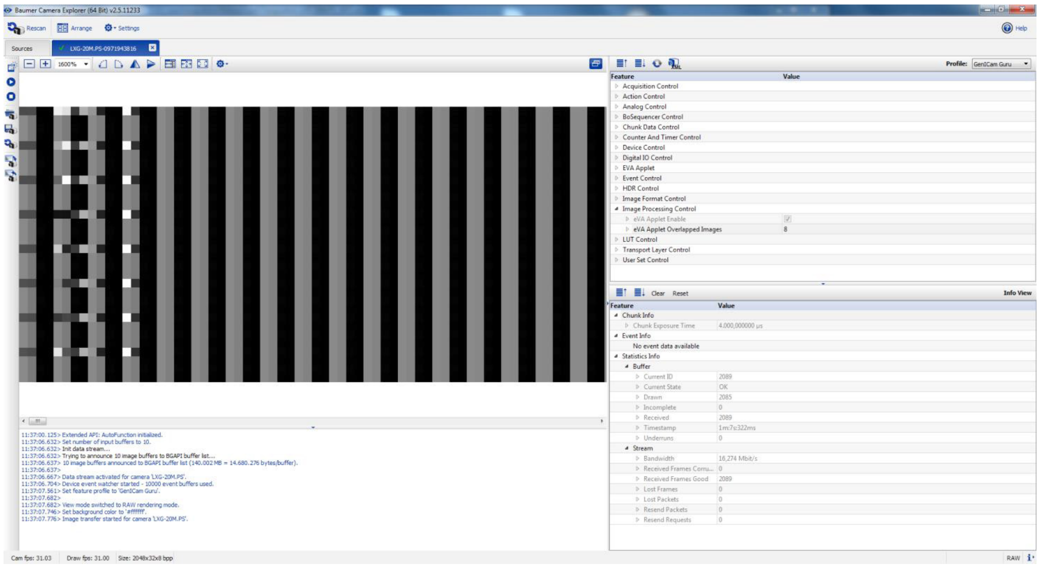
Live image should look like this (~53 fps):



6. Stop image acquisition [F11].

7. Enable Applet.

- Open category “Image Processing Control”.
- Check “eVA Applet Enable”.
- Set “eVA Applet Overlapped Images” to 10 (this is required to process multiple images at once within eVA).
- Start image acquisition [F12].
- Zoom in on the left part of the image.



Camera Explorer frame rate should be: 31 fps

- Default exposure time: 4ms
- Sensor frame rate is 31 * 8 = 248 fps (=maximum with default exposure time)

8. Set exposure time to minimum: 30 us.

- Camera Explorer Frame rate is: 42.29 fps
- Sensor frame rate is 42.29 * 8 = 338 fps (=sensor maximum at full frame)

The first 2 DWORDs should change:

- DWORD 0: frame counter
- DWORD 1: time stamp

The next 2 DWORDs should change if an encoder is attached and is moving:

- DWORD 2: encoder counter forward
- DWORD 3: encoder counter all

8.1 Test maximum frame rate

Follow the instructions to determine the maximum framerate.

1. Perform device reset (see Known Issues), camera should reboot, wait until it is ready in Camera Explorer (live image with factory defaults).

2. Enable internal test pattern (category Image Format Control).

3. Set exposure time to minimum: 30 us.

4. Check “eVA Applet Enable” (category “Image Processing Control”).

5. Set “eVA Applet Overlapped Images” to 10 (this is required to process multiple images at once within eVA).

6. Set ROI to 2048 × 128.

- Open category “Image Format Control”.
- Set “Height” to 128.
- Set “Offset Y” 500 (or wherever the laser line is located, optional).

7. Configure applet for new ROI.

- Open “EVA Applet \ Process0 \ Processing \ COG_Processing \ RemoveAllButLast-Line”.
- Set “LastLineNumber” to 127 (default 1087).

Camera Explorer frame rate should be: 336.46 fps

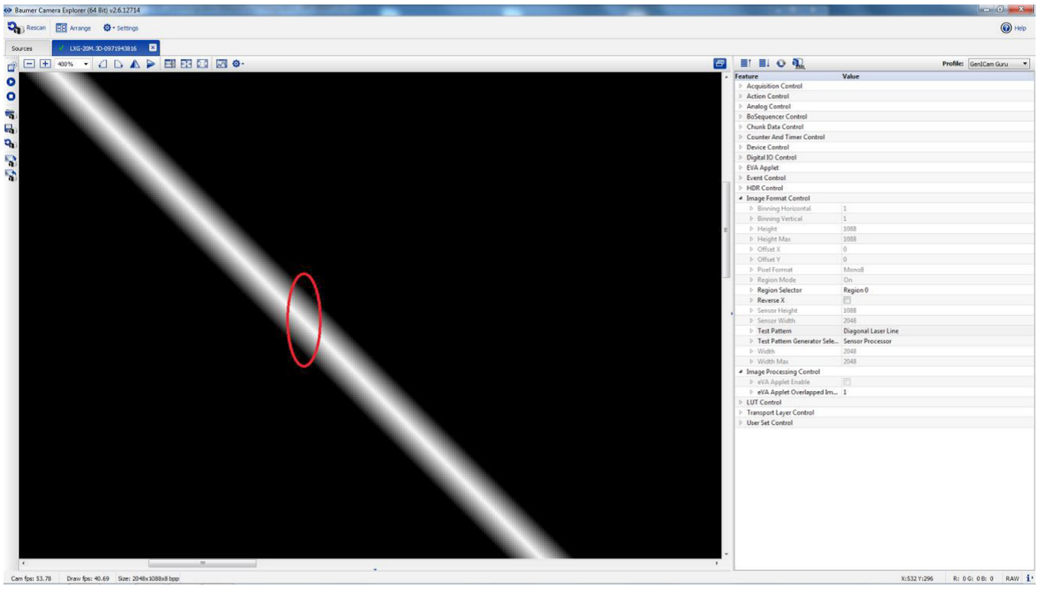
- Sensor frame rate is 336.46 * 8 = 2691 fps (=sensor maximum at full frame)

8.2 Validate Center of Gravity (CoG) Processing

Follow the instructions to validate the center of gravity (CoG).

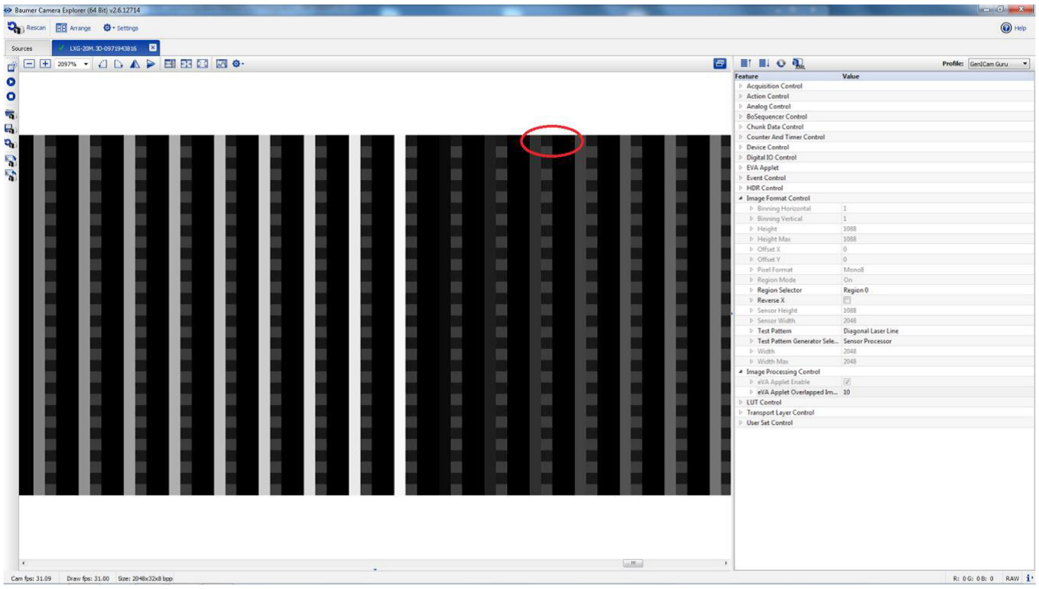
1. Start Camera Explorer with laser line test image (Diagonal Laser Line), Applet is disabled.

2. Enlarge image and determine laser maximum: e.g. column 450, laser peak row: ~307.



3. Enable applet with default ROI (category “Image Processing Control”).

4. Enlarge image at column 450 * 4 = 1800 (8 bit transferred but data is 32 bit)



GrayValue[1800.0] = 128

GrayValue[1801.0] = 50

GrayValue[1802.0] = 1

GrayValue[180.0] = 0

Sub Pixel Row = (128 + 50 * 2^8 + 3 * (2^16) + 0 * (2^24)) / 256

= (128 + 12800 + 65536) / 256

= 306.5

9. Processing Performance

The following table shows the frame rate depending on the set Offset Y. The processing performance depends only on Offset Y not Offset X.

The minimum exposure time was set and the ROI was set in the camera and not within the applet.

Notice

A smaller Offset Y than 32 lines are not tested / supported.

Sensor Offset Y	LXG-20M.3D LXG-20M.PS [fps]	LXG-120M.3D LXG-120M.PS [fps]
3072	-	60
1024	359	179
512	477	354
256	1396	692
128	2691	1326
64	5019	2441
32	8844	4215

10. HALCON® Examples

10.1 Performance Test

Follow the instructions to test the performance of the example (Script: LX_3D_Performance_v1.hdev).

1. Configure LXG-20M.PS (120, 3D) camera for laser triangulation.

2. Capture and display images as fast as possible with different ROIs.

3. Log status information and achieved frame rate.

A log file is generated in the directory of the Halcon script. This is how the log file should look like:

*** LX 3D Performance Test ***

DeviceModelName:	LXG-20M.PS
AppletProjectName:	LaserTriangulation_LXG-20M.PS_R1
Start:	20170314_140715
ExposureTime:	30 us
FrameCombineValue:	8
TestPattern:	1

NumProfiles;TotalTime [s];TotalLostFrames;ROI_OffsetX;ROI_OffsetY;ROI_Width;ROI_Height;FrameRate;SensorFiFoOverflow;AppletFIFO [%];Temperature [°C]

3672;10.9;0;0;0;2048;1088;338.3;0;0;39

3784;10.9;0;0;0;2048;1056;348.4;0;0;39

…

125000;14.1;0;0;0;2048;32;8844.1;0;0;39

Stop: 20170314_143430

TotalTime: 1634.6 s

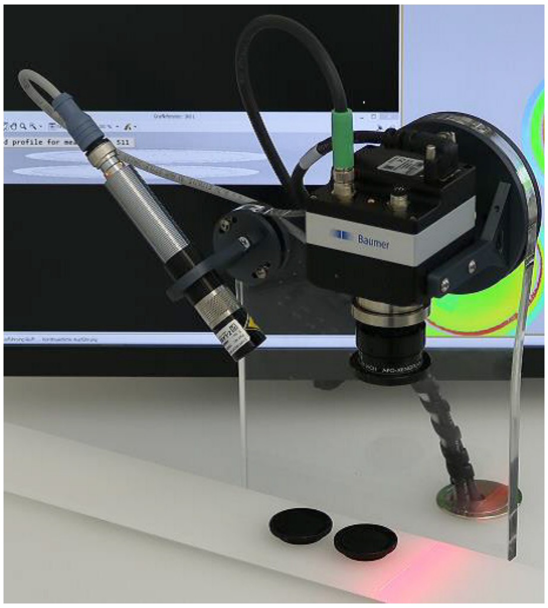
Make sure that you see no lost frames in the log file column. In the directory results are examples of the expected output for both cameras.

10.2 3D Demo

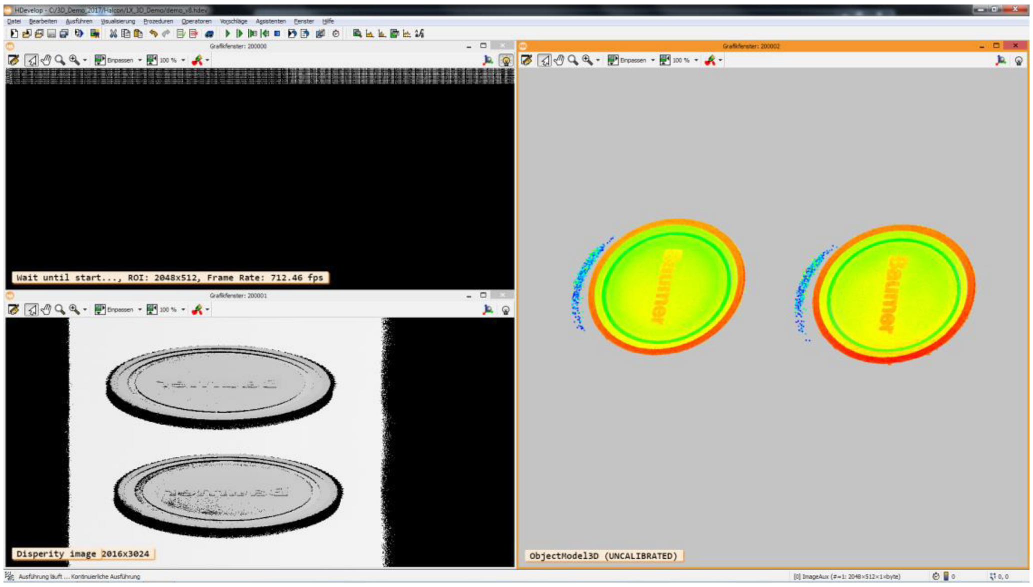
Script: LX_3D_Demo_v1.hdev

This is the demo for the LXG-20M.PS camera for laser triangulation. The intention is to capture and display images as fast as possible (default: 2048 x 512 @ ~700 fps). The software display derived disparity image and 3D visualization.

Test Setup



Screenshot of Application



10.2.1 Pogram Structure

The program sequence of the 3D demos is shown below.

Open windows

  WindowHandleLiveImage → for display of 3D data transmitted by camera

  WindowHandleDisparity → for resulting disparity image

  WindowHandle3D → for 3D visualisation

Camera init (open_framegrabber, set camera parameters…)

while(true)

{

Wait until linear unit is stopped

  Capture images until EncoderForward does not change any more

Wait until linear unit is moving fast fardword

  Capture images until EncoderForward changes faster than a threshold

Do measurement until linear unit is stopped

  Capture images until EncoderForward does not change any more

  Profiles are concatenated in an array of images → Image

Create Disparity image

  Tile concatenated Image to a single CamProfileImage

  Change to 32 bit per pixel (cameras transfers 8 bit data, 3D info is 32 bit)

  Display Disparity Image

Reduce disparity image domain

  Allows to extract areas like background

3D visualization

  create_sheet_of_light_model, apply_sheet_of_light_calibration with disparity image, …

  Display 3D model

}

10.2.2 What can be changed

ExposureTime	should be adjusted if different object material is used, frame rate may change
ROI (e.g.OffsetX, OffsetY, Width, Height)	should be adjusted if field of view is different, frame rate may change
Threshold (DisparityImageReal…)	change if object or background does not fit in 3D visualisation
VisPose1/2	change if a different view is needed, uncomment Instructions.. visualize_object_model_3d, set breakpoint → afterwards copy VisPose to VisPose1/2

11. Know Issues an Limitations

11.1 Reducing the camera ROI in X direction

Tests were performed with full width (2048 or 4096) only. This needs testing.

11.2 Aggregation of more than 8 pictures

Camera supports up to 64 images than can be aggregated. This needs testing.

11.3 Camera Stop handling

The camera needs to process multiples of 8 pictures (equal to FrameCombine parameter). If the user stops the camera before a number of images that can be divided by 8 have been processed the applet will wait for further images and delay camera stop. Then the camera has to be powered off before using it again.

Work arounds:

1. Switch the camera from free run to trigger mode. Read how many images were processed by the applet. Perform software triggers until a multiple of 8 frames is reached.

2. Use device reset command. The camera will reboot, user can set new param eters and start the applet again.

3. Use sequencer or hardware trigger to generate a multiple of 8 images before performing camera stop.

Example: use sequencer with predefined number of pictures (e.g. 800). This can be achieved like this:

1. Connect camera with installed applet to PC

2. Open Camera Explorer

3. Stop image acquisition [F11].

4. Set Profile to “GenICam Guru” (located top right, this is the default)

5. To validate the number of acquired images:
- Open category “Chunk Data Control”
- Set “Chunk Selector” to “Frame ID”
- Check “Chunk Enable”

6. Open category “Acquisition Control”.
- Set “Trigger Mode” to “On”
- Set “Trigger Source” to “Software”

7. Open “BoSequencerControl”
- Set “BoSequencerEnable” to “On”
- Set “BoSequencerMode” to “Free Running Init Trigger”
- Set “BoSequencerEnable Frames Per Trigger” to 800 (example, needs to be divisible by 8)
- Set “BoSequencer Set Repeats” to 800 (must be the same as above)
- Set “BoSequencerStart” to “On”

8. Start image acquisition (F12)

9. Open category “Acquisition Control”

- Execute “Trigger Software”

→ The camera should take 800 images.

Notice
Note the “Chunk Frame ID” in “Chunk Info” and repeat the software trigger command. Difference should be exactly 800.

11.4 Using the 5 VDC power of the 2nd connector

For internal tests an encoder was successfully directly powered by the camera. The camera was powered via PoE. Depending on the camera power (AUX or PoE) and the used current the voltage may be between 4.6 V and 5.6 V. This could be not compatible with external devices having smaller voltage tolerances.

12. Spectral Filter

The laser spectral range is very narrow: e.g. 640 nm +/- 5 nm compared with the camera sensor. Narrow band pass filters can be used to block background illumination. This will make the measurement more robust.

13. Compatibility

This section shows devices that were successfully tested with the LX 3D camera for laser triangulation.

13.1 Laser

13.1.1 Z-Laser

Model: Z10M18S3-F-640-LP20

13.2 Encoder

13.2.1 Baumer

Model: ITD 01 B14 500 T NI KR1 S 4, SAP 11077587

13.2.2 Nanotec

Model: NOE2-05-B10

Baumer Optronic GmbH
Badstrasse 30
DE-01454 Radeberg, Germany
Phone +49 (0)3528 4386 0 · Fax +49 (0)3528 4386 86
sales@baumeroptronic.com · www.baumer.com