

Teledyne DALSA • 880 Rue McCaffrey • St-Laurent, Québec, H4T 2C7 • Canada <u>http://www.teledynedalsa.com/Genie-Nano</u>

G3-AN0005-Laser Line Profiler Application Note

Genie Nano: Laser Line Profiler Firmware

For Nano models with P/N: G3-GM10-M0640/M0800/M1280/M1930/M2590

Overview

Genie Nano custom firmware that supports line profile data output is available for camera models equipped with monochrome On-Semi Python P1 sensors (0.3M to 5M).

Line profiles are calculated from 2D images and results are output as a single line buffer with each profile point represented by a 64-bit value.

The following table lists the required Genie Nano firmware and software to support line profile output.

Genie Nano Firmware Design	Software SDK
Custom Design with Laser Profiler	Sapera LT 8.32 or higher

Sapera LT SDK (full version), the image acquisition and control SDK for Teledyne DALSA cameras is available for download from the Teledyne DALSA website:

http://teledynedalsa.com/imaging/support/downloads/sdks/

If the required version is not available, contact your Teledyne DALSA representative.

Sapera LT includes the CamExpert application, which provides a graphical user interface to access camera features for configuration and setup.

The Custom Design with Laser Profiler firmware is also available for download from the Teledyne DALSA ftp site:

<u>ftp://ftp.dalsa.com/Private/p_ProductSupport/Genie/Genie Nano_Firmware/GenieNan</u> <u>o_On-Semi_Python-0.3_to_5M_Laser_Profiler_Firmware.zip</u>

Camera Setup and Calibration

The Custom Design with Laser Profiler firmware can be loaded to the camera using the File Access Control features. CamExpert provides a dialog interface to perform the firmware update; select the required firmware file and click **Upload (to Camera)**.

File Access Control		\times		
Select the type of	file to upload or download from the device.			
File Type Availa	able	1		
Туре:	Device Firmware			
File selector:	Firmware			
Description: Upload new firmware to the camera which will execute on the next camera reboot cycle. Select the DeviceReset feature after the upload completes.				
Note: Depending on the file size and communication speed, the transfer could take many minutes, but must not be aborted.				
File path:				
E:\GENIE NANC	LINE PROFILER\Genie_Nano_OnSem			
Upload (to Camera) Download (from Camera) Delete				
	Close			

When the file upload is completed, a prompt appears to reset the camera.

File Upload Completed	\times
The file upload completed successfully. You need to reset the device for changes to take effect. Press YES to reset now or NO to reset later.	
<u>Yes</u> <u>N</u> o	

When the custom firmware is loaded, the *DeviceManufacturerInfo* feature (in the Camera Information category) reads "Custom Design with Laser Profiler".

Parameters - Visibility: Beginner X				
Category		Parameter	Value	
Camera Information		Manufacturer Name	Teledyne DALSA	
Sensor Control		Family Name	Genie	
1/0 Controls		Model Name	Nano-M640	
		Device Version	1.06 Beta	
Advanced Processing		Manufacturer Part	G3-GM10-M0640AA	
Image Format Controls	C	Manufacturer Info	Custom Design with Laser Profiler	
Acquisition and Transfer Contr		Firmware Version	5CA18.0003	

The *DeviceScanType* feature (available in the Sensor Control or Image Format Controls category) determines whether the camera outputs 2D 8-bit monochrome images (*Areascan* mode) or 64-bit 1D line profile data (*Linescan3D* mode).

To display the camera sensor output as a 2D 8-bit monochrome image for camera setup and calibration (exposure, frame rate, and so forth), set the *DeviceScanType* feature to *Areascan* mode.

Parameters - Visibility: Guru				×
Category		Parameter	Value	
Camera Information	^	Device Scan Type	Areascan	•
Sensor Control	-	Sensor Color Type	Areascan	
1/0 Controls	1	Input Pixel Size	Linescan3D	
I/O CONTROLS		6 N.C.W.	4000	

The *Areascan* mode also allows an ROI to be set for image capture using the *OffsetX*, *OffsetY*, *Height* and *Width* features. The image height for the ROI to capture profiles is limited between 16 and 512 rows, in increments of 1. The *Width* feature is limited by the maximum supported by the sensor, and can be set to smaller values in supported increments, depending on the camera model.

Profile Data Output

To output profile data, set the *DeviceScanType* feature to *Linescan3D*. Each profile point is formatted as a 64-bit value that contains the following information:

- **Antiscatter**: Maximum intensity of the peak (8-bit integer). The maximum intensity does not include any threshold subtraction.
- Scatter: Number of pixels composing the peak (8-bit integer).

Peak Position Calculation:

- Weighted Column Sum: Sum of weighted pixel values (Y position * pixel value) composing the peak. Limited by max search radius, threshold and image border (32-bit integer).
- **Pixel Sum:** Sum of pixel values composing the peak. Limited by max search radius, threshold and image border (16-bit integer).

The calculation of the peak position is performed on the host PC using the following calculation:

Peak Position = Weighted Column Sum ÷ Pixel Sum

The 64-bit value for each profile point is ordered as follows:

N e	1SB 53	64-bit Value per Profile Point			
	Pixel Sum [63-48]	Weighted Column Sum [47-16]	Scatter [15-8]	Antiscatter [7-0]	

The 64-bit value for each profile position in X is determined by analyzing the pixels in the corresponding Y column.



For columns where the max value is lower or equal to the minimum programmable intensity threshold, the 64-bit value for the Antiscatter, Scatter, Weighted Column Sum and Pixel Sum is 0. That is, if the 64-bit value is 0, no peak is detected at that profile position.



To ensure compatibility with third-party software that do not support 64-bit profile output, the Pixel Format feature may be set to *Monochrome 8-bit* (Mono8) in Linescan3D mode. In this setting, each profile point value consists of a combination of 8 x 8-bit values. The Width feature will indicate 8 times the sensor width.

Profile Peak Detection

The profile peak detection features are available in the LaserLineProfiler sub-category of the Advanced Processing category.

Parameters - Visibility: Beginner		×
Category	Parameter	Value
Camera Information	Maximum Search Radius	20
Sensor Control	Intensity Threshold	128
1/O Controls	Substract Threshold	False
Advanced Processing		Show More >>
LaserLineProfiler		

The maxSearchRadius feature sets the maximum number of pixels on each side of the peak to consider when calculating the peak position. The maximum search radius value is limited to the smallest value of either 127 or (Height -1) / 2. The search radius can be limited by the image border, depending on the peak position.

The *intensityThreshold* feature determines the minimum pixel intensity that can be considered as a valid peak. To calculate the peak position, the first pixel <u>below</u> the threshold on each side of the peak and within the max search radius is used.

The *subtractThreshold* feature, when enabled, subtracts the *intensityThreshold* value from the pixel (negative values are replaced with 0) before calculating the pixel sum and weighted column sum.

The following figure shows an example column (Y-axis) of intensity values for a single X position.



With a threshold intensity of 128, the pixels composing the peak (scatter) range from
Y = 6 to 20 (assuming a sufficient max search radius). The peak position calculation
using the weighted column sum and pixel sum is:

Y position	Value	Weighted Value
6	100	6 x 100 = 600
7	130	7 x 130 = 910
8	128	8 x 128 = 1024
9	180	9 x 180 = 1620
10	200	10 x 200 = 2000
11	240	11 x 240 = 2640
12	250	12 x 250 = 3000
13	250	13 x 250 = 3250
14	208	14 x 208 = 2912
15	195	15 x 195 = 2925
16	177	16 x 177 = 2832
17	128	17 x 128 = 2176
18	145	18 x 145 = 2610
19	128	19 x 128 = 2432
20	95	20 x 95 = 1900
	Pixel Sum = 2554	Weighted Column Sum = 32 831
	Peak Position: 32 831 /	2554 = 12.855

If *subtractThreshold* is enabled, the corresponding example values, with intensityThreshold = 128, are:

Y position	Value	Weighted Value			
6	100 - 128 = 0	$6 \times 0 = 0$			
7	130 – 128 = 2	7 x 2 = 14			
8	128 – 128 = 0	$8 \times 0 = 0$			
9	180 - 128 = 52	9 x 52 = 468			
10	200 - 128 = 72	10 x 72 = 720			
11	240 - 128 = 112	11 x 112 = 1232			
12	250 - 128 = 122	12 x 122 = 1464			
13	250 - 128 = 122	13 x 122 = 1586			
14	208 - 128 = 80	14 x 80 = 1120			
15	195 – 128 = 67	15 x 67 = 1005			
16	177 – 128 = 49	16 x 49 = 784			
17	128 - 128 = 0	$17 \times 0 = 0$			
18	145 – 128 = 17	18 x 17 = 306			
19	128 – 128 = 0	$19 \times 0 = 0$			
20	95 - 128 = 0	20 x 0 = 0			
	Pixel Sum = 695	Weighted Column Sum = 8699			
	Peak Position : 8699 / 695 = 12.517				

Peak Position and Height Value Considerations

When the *DeviceScanType* = *Linescan3d* mode, the peak position calculation (*peak position* = *weighted column sum / pixel sum*) has a range that corresponds to the image height in 2D.

For example, with an image height of 512, a valid *peak position* can range from 1-511 (the value 0 represents a profile position where no peak was detected), where 1 always represents the highest point in the field of view and the lowest point corresponds to the image height -1 (in this case, 511).



Using Triggers to Acquire Line Profiles

Trigger related features are grouped in the I/O Controls category. The *TriggerSelector* feature determines the type of trigger (*FrameStart*, *FrameBurstStart* or *AcquisitionStart*).

Parameters - Visibility: Beginner			×
Category	Parameter	Value	
Camera Information	Trigger Selector	Single Frame Trigger(Start)	-
Sensor Control	Trigger Mode	Single Frame Trigger(Start)	
L/O Controls	Trigger Frames C	MultiFrame Trigger(Start)	
1/0 Controis	Software Trigger	Press	

To use an acquisition trigger the *TriggerMode* feature must be enabled.

Parameters - Visibility: Beginner				x
		Parameter	Value	^
Camera Information		Trigger Selector	MultiFrame Trigger(Start)	
Sensor Control		Trigger Mode	On 🔻	
1/O Controls		Trigger Frames Count	Off	
1/0 Controis		Software Trigger	On	

When using a MultiFrame Tirgger (*FrameBurstStart*), the *triggerFrameCount* sets how many line profiles are aquired with each trigger.

Parameters - Visibility: Beginner				×
Category		Parameter	Value	
Camera Information		Trigger Selector	MultiFrame Trigger(Start)	
Sensor Control		Trigger Mode	On	
I/O Controls	-(Trigger Frames Count	200	
		Software Tripper	Press	

The *ExposureTime* and *exposureDelay* features (available in the Sensor category) control the acquisition frame rate when acquiring multiple frames with a trigger. The delay is introduced before the exposure is started.

Parameters - Visibility: Beginner X			
	Parameter	Value	
Camera Information	Sensor Color Type	Monochrome Sensor	
Sensor Control	Acquisition Frame Rate (in	Not Enabled	
I/O Controls	Exposure Mode	Timed	
	Exposure Alignment	Synchronous	
Advanced Processing	Exposure Delay (in us)	50.0	
Image Format Controls	Exposure Time (in us)	1000	
Acquisition and Transfer Contr	Actual Exposure Time (in us)	1000.0	
Action Control	Sensor Shutter Mode	Global	
Event Control	Gain Selector	Sensor Analog	
GigE Vision Transport Layer	Gain	1.0	
File Access Control	Black Level Selector	Analog	
	Black Level (in DN)	1.0	
GigE Vision Host Controls		Show More >>	

The maximum frame rate is calculated using the following equation (refer to Genie Nano user manual for more information):

$$Maximum \ Frame \ Rate = \frac{1}{exposureDelay + Exposure \ Time + Sensor \ Readout \ Time}$$

Adjusting the *exposureDelay* time allows you to slow the frame rate in multi-frame trigger mode.

3D Image Reconstruction

Profile image acquisition can be free-running or controlled using a hardware trigger (for example, a shaft encoder). When acquiring in *Linescan3D* mode, the profile output does not provide any specific information to group profiles into a 3D image. The expected spacing between triggers can be used for 3D image construction, along with the acquisition timestamp.



Genie Line Profile Output Demo

The Genie Line Profile Output Demo application demonstrates the line profile output capabilities using a live acquisition and includes source code.

The demo is available for download at from the Teledyne DALSA ftp site: <u>ftp://ftp.dalsa.com/Private/p_ProductSupport/Genie/Demo/LaserLineProfilerDemo.zip</u>

When the application is launched, the Acquisition Configuration dialog appears to select the required camera (a configuration file is optional and not required).

Acquisition Server: Nano-M640_2	Acquisition Device:	OK Cancel
Configuration File		
Please select a CCF fil	e	Browse
File Description		
File Name:	N/A	
Company Name:	N/A	
Model Name:	N/A	
Camera Name:	N/A	
Vic Name:	N/A	
Server Name:	N/A	
	If no Configuration file exists for your board/camera	

When the application is launched, the Acquisition Configuration dialog allows selection of the required camera (a configuration file is optional and not required).

The Profiling Features section allows selection of the scan type using the Calibration (area scan output) or Line Scan 3D (profile output) radio buttons.

🕋 Sapera Gig	gE-Vision Camera Demo Pixel data not a	vailable	
	General Options	Generic Features	
	View	Acquisition Frame Rate 599.88	
	Save Image To File		
	Acquisition		A
	Snap		
	Grab		
	Freeze		
	Profiling Features		
	Calibration		
	Image Height 256		
	Image Offset X 0		
	Image Offset Y 256		~
	C Line Scan 3D	4	•

In both modes, the mouse position in the image display area updates the pixel position and Z value in the status bar at the top of the application.

```
The Sapera GigE-Vision Camera Demo Position x:403 y:004 Value 0xce
```

For display purposes, to maintain the same orientation in 2D or 3D output when the laser is at the bottom of the image, the demo uses the following equation to calculate the peak position, such that higher values in peak positions represent greater object height (0 represents a blind spot where no peak position can be measured).





Calibration Image Output

The demo Calibration mode raw image output (*DeviceScanType* feature = *Areascan*) is used to validate the hardware setup, such as adjusting the lens (for example focus, aperture), camera gain and exposure, as well as the image height and vertical offset. The image format is monochrome 8-bit.

For example, the following object (a small decorative pin) generates the line profile shown as part of the scan.



Line Scan 3D Mode

In Line Scan 3D mode, the acquisition is performed as a snap of a number of profiles; this allows the image peak position data to be extracted and displayed as a 16-bit monochrome image (peak positions used as pixel values for display can be greater than 8-bits, depending on the 2D image height). Each profile is single line in X; each successive profile is added to the image as a new row in Y (use the *Number of Profile* field to set the how many profiles to grab with each acquisition snap).

* Sapera GigE-Vision Camera Demo Pixel data n	ot available	
General Options	Generic Features	
Buffer	Exposure Time (us) 850 Apply	
View	Acquisition Frame Rate 900.09	
Save Image To File	Frame count = 500 Profile snap count = 62	
Acquisition		
Snap		
Grab		
Freeze		
Profiling Features		
C Calibration		
Image Height 128		
Image OffsetX 0		
Image Offset Y 384		
 Line Scan 3D 		
Substract Threshold		
MaxSearchRadius 10		
IntensityThreshold 50		
Number of Profile 500	4	*

Features such as the *maxSearchRadius, intensityThreshold*, and *subractThreshold* can be set. The Frame count and Profile snap count are also displayed.

The General Options section provides access to buffer and view properties, as well as the option to save images to file.

	View X
	Scaling
	Width 656 <u>*</u> pixels 100 <u>*</u> %
	Height 30 🔹 lines 100 🔹 %
Buffer X	✓ Lock aspect ratio Fit to Window No scaling
Count and Size	Range
Count : 20	
Width: 656	
Height: 500	Range: specifies how many of the most significant bits are not to be viewed.
- Format	View Format
	_
Pixel Depth (significant bits) : 8	View Format: specifies what to display for multi-format buffers (like RGB-IR 8-bit)
	OK Cancel

In the View dialog, the Range setting specifies how many of the most significant bits are display (for example, when displaying line profile output as a 16 bit image).