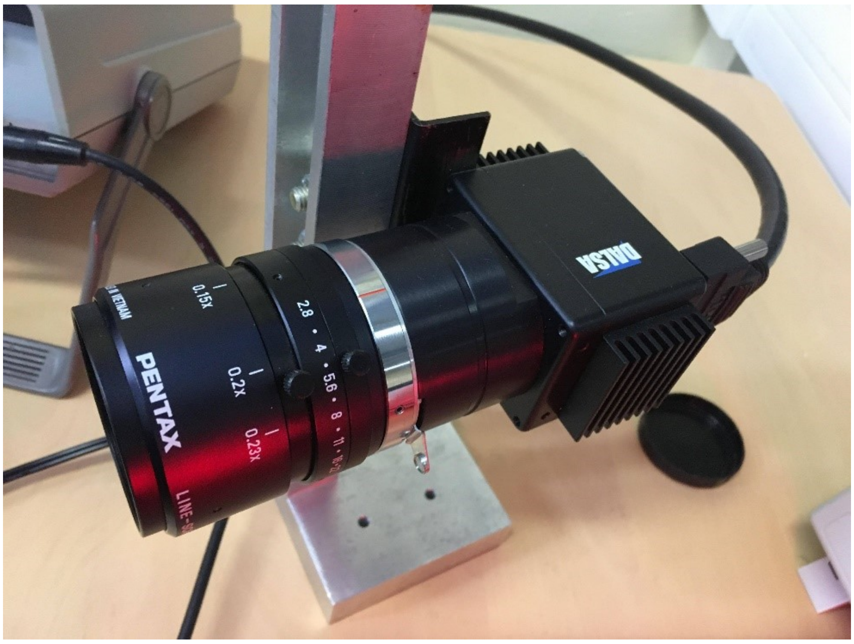
Sensors And Digitization

Lab 5 - Moving Objects Imaging



Submitted by **Meldrick REIMMER, Danie SONIZARA, Awuraa Amma Okyere-BOATENG**

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Chapter 1

Introduction

1.1 Background of Study

In our course module sensors and digitization, one of the laboratory tutorials was on Moving Object Imaging. We are to study am imaging solution to analyze moving objects and understand specific features of the systems. Our moving object will be captured by a line scan camera made by Dalsa and also use external signal in triggering the camera to get images. Linear cameras by design can describe multiple perspectives and orthographic camera functions.

Line scan cameras require a moving subject in order to obtain an image. Synchronization of the movement between the object and camera is required to ensure a constant aspect ratio. Line scan imaging will require synchronization between the moving object and the camera. Synchronization is often achieved with the use of an encoder.

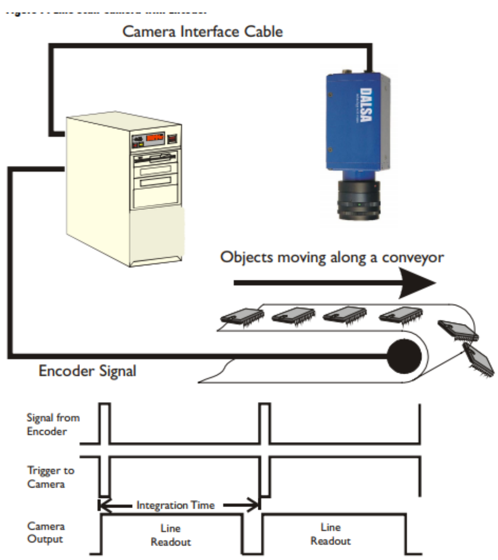

Figure 1.1: Line Scan Camera withe encoder

This is a similar application of the line scan camera in which we will be using in this laboratory course. For our laboratory team to understand the line scan camera applications, we have investigated via the Internet, lecture notes from the course module and report the findings in this lab review, along with sources. The investigations have allowed for the interpretation of discoveries and benefits of line scan cameras and camera triggering by external signal, in reference to high resolution imaging, efficient scanning applications, and the ability to image large objects.

1.2 Objectives

The goal of this practical work is to discover analytical imaging and measurement techniques through hands on practical work.

In this practical work, observations are made of a linear camera. The camera images a ?moving parts? mechanism. The part of the mechanism to be imaged is an object attached to a rotation device.
For us to accomplish these tasks we underwent the necessary procedures advised by our supervisor to enable to us get our goals :

1. Reading thoroughly our lecture notes and also the brochure of the camera and the frame grabber.
2. Begin the set up by plugging in the moving parts motor, switching on the back-light, the signal generator and also the oscilloscope.
3. Run the 'CamExpert' software, which is the camera interfacing tool for the frame grabber.
4. Select the right configuration file for the camera to be used.
5. Adjust camera settings to obtain and satisfactory image.
6. Study camera features
7. Study camera applications
8. Perform camera triggering by external signal

Chapter 2

Hardware And Software Specifications

2.1 Hardware Specifications

We will be using the following hardware components for the laboratory practicals :

1. PC Component
2. Frame Grabber : DALSA XCELERA-CL LX1
3. Digital Camera : DALSA S2-1X-02K40
4. 50mm Lens : PENTAX YF5028A-02
5. Video Cables
6. 12V Power Supply
7. Moving Industrial Parts
8. Signal Generator: Gwinstek (GFG-8015G)
9. Oscilloscope : Tektronix (TDS-2002C)

2.1.1 PC Component

A basic windows operating systems which has the CamExpert software installed on it.

Figure 2.1: PC Component

2.1.2 Frame Grabber : DALSA XCELERA-CL LX1

[1]The X64 Xcelera -CL LX1 Base is a cost effective frame grabber based on the PCI Express x1 interface. Fully compliant with Camera Link (V. 1.20) specifications, the Xcelera-CL LX1 supports single Base cameras and can acquire images from a wide variety of multi-tap area and line scan, color and monochrome cameras.
The Xcelera-CL LX1 Base is built within DALSA?s Trigger-to-Image Reliability technology framework and

combines acquisition and external control signals on a single PCIe slot. Trigger-to-Image Reliability leverages DALSA?s hardware and software innovations to control, monitor and correct the image acquisition process from the time that an external trigger event occurs to the moment the data is sent to the host, providing traceability when errors do occur and permitting recovery from those errors.

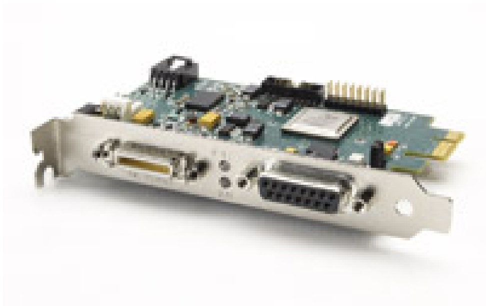

Figure 2.2: Frame Grabber(DALSA XCELERA-CL LX1)

Key Features :

- Image acquisition from Camera Link Base camera
- Supports Camera Link operations up to 85MHz
- Supports 32/64-bit Windows platforms
- Quarter-length PCI Express x1 Board
- Power Over Camera Link (PoCL) Compliant
- Offers external acquisition control signals on single PCIe x1 slot
- ROHS compliant
- DALSA Platform Development Advantage ? Free Run-time Licensing

Specifications :

- Board : Camera Link Specifications Rev 1.20 compliant
- Acquisition : Supports one Base Camera Link area and line scan camera
- Resolution : Horizontal Size (min/max): 8 byte/256K bytes Vertical Size (min/max): 1 line/infinite lines for line- scan cameras
- Pixel Format and Tap configurations : Supports Camera Link tap configurations for 8, 10, or 12-bit mono and RGB cameras:
- Dimensions : 3.0' (7.5cm) Length X 4.20' (10.7 cm) Height
- Power Output : Power-on-reset fused +12V output @ 1.5A +5V DC output at 1.5A
- Markings : FCC Class B - Approved, ROHS - Compliant

2.1.3 Digital Camera : DALSA S2-1X-02K40

The Spyder2 is a small, fast, and cost effective camera boasting a full feature set and a Camera Link interface. The Spyder2 surpasses its predecessor in responsivity and programmability, requires less lighting, and offers precise control over key performance variables such as gain and offset. The Spyder2 does not require a new optics design because pixel size and fill factor remain unchanged from the original Spyder. [2]

Figure 2.3: Digital Camera : DALSA S2-1X-02K40

Key Features :

- Compact design for easy mounting and minimized optical path
- Single power supply (12-15 V)
- Easy, standard lensing options (C-mount, F-mount)
- 40 MHz single output for ease of interface
- Correlated double sampling (CDS) for low noise
- Over 40% more sensitive than original Spyder to reduce lighting requirements
- 8 or 10 bit digital output (user selectable)
- Test pattern and diagnostics for cable/system troubleshooting

Specifications :

- Resolution : 512 / 1024 / 2048
- Data Rate : 40MHz
- Max. Line/Frame Rate : 65 / 35 / 18 kHz
- Pixel Size : 14 ?m
- Data Format : 8, 10 bit
- Output Base: Camera Link
- Dynamic Range : 54 dB
- Size : 50 mm x 85 mm x 53.7 mm
- Mass : <450 g
- Operating Temp : 10 °C to 50 °C
- Power Supply: 12 V to 15 V
- Power Dissipation : <5 W
- Regulatory Compliance : CE
- Control MDR26 : Camera Link
- Power : Hirose HR10 6 pin

2.1.4 50mm Lens : PENTAX YF5028A-02

This is a line scan lens, which is normally used in inspection of steel, pulp, fiber/textile, film and other flat materials.

Features :

- Ultra-High Resolution. High Contrast
- Suitable for sensors up to 45mm
- Abundant Light Distribution
- Minimal distortion
- Available in F-mount and PENTAX K mounts
- Lockable focus & iris rings

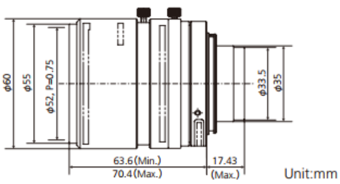

Figure 2.4: Dimensions for PENTAX YF5028A-02

Figure 2.5: PENTAX YF5028A-02

Specifications :

- Format Size : 45mm Image Circle
- Focal Length : 50.0mm
- Max. Aperture Ratio: 12.8
- Working Distance 361 : 242mm
- Back Focal Length 30.43: 34.54mm
- Filter size : 52 P=0.75mm

- Dimensions : 60×63.6*mm*

2.1.5 Video Cables

We will connect the video cable to the frame grabber from the camera which will enable us to see what the camera sees and help in achieving our goal.

Figure 2.6: Video Cable

2.1.6 12V Power Supply

This was powering the industrial moving parts and had a also control its speed.

Figure 2.7: 12V Power Supply

2.1.7 Industrial Moving Parts

A motor connected with gears and a chain, mounted on a stable frame, operating a track that circulates a label that is periodically illuminated by a panel of red LED back-lighting

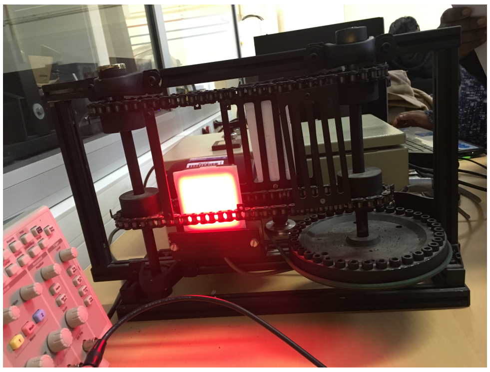

Figure 2.8: Industrial Moving Parts

2.1.8 Signal Generator : Gwinstek (GFG-8015G)

The GFG-8015G Function Generator delivers the most economic solution available for signal generating demand within a 2MHz frequency range. GFG-8015G offers extra value with TTL output, and a 1000:1 Tuning Range. Offering standard functions, such as Variable DC Offset Control, Output Overload Protection, and VCF input, the GFG-8015G is the most affordable choice for production line testing and educational use at the most competitive price.

Features :

- Frequency Range : 0.2Hz 2MHz
- Waveform : Sine, Triangle, Square, TTL Pulse
- Variable DC Offset Control
- Output Overload Protection
- VCF Input Function
- 1000 : 1 Tuning Range

Specifications :

- Waveforms : SINE, TRIANGLE, RAMP, SQUARE, and TTL pulse output
- Amplitude : >20Vp-p (open circuit)
- POWER SOURCE : AC100V/120V/220V/230V 10%, 50/60Hz
- DIMENSIONS & WEIGHT : 230(W) x 95(H) x 280(D)mm Approx. 2.0 kg

Figure 2.9: Gwinstek (GFG-8015G)

2.1.9 Oscilloscope : Tektronix (TDS-2002C)

The TDS2002C Digital Storage Oscilloscope Series provides you with affordable performance in a compact design. Packed with standard features - including USB connectivity, 16 automated measurements, limit testing, data logging, and context-sensitive help - the TDS2002C Series oscilloscopes help you get more done in less time.

Features

- 16 automated measurements and FFT analysis for simplified waveform analysis
- Built-in waveform limit testing
- Automated, extended data logging feature

- Autoset and signal auto-ranging
- Built-in context-sensitive help
- Probe check wizard
- 11-language user interface
- 144 mm (5.7 inch) active TFT color display
- Small footprint and lightweight - only 124 mm (4.9 inches) deep and 2 kg (4.4 lb)
- USB 2.0 host port on the front panel for quick and easy data storage
- Includes Tektronix OpenChoice Software for connecting to your oscilloscopes

Specifications

- Display (QVGA LCD) : TFT
- Bandwidth : 70 MHz
- Channels : 2
- External trigger input : Included
- Sample rate on each channel : 1.0 GS/s

Figure 2.10: Tektronix (TDS-2002C)

2.2 Software Specifications

2.2.1 CamExpert - TELEDYNE DALSA

CamExpert is bundled with Sapera LT, easy to use camera configuration utility to create new or modify existing camera configuration files. We use this software to operate the camera and check specific details like the exposure time of the camera in order to get a good results as the moving parts is in operation as well.
Sapera Vision Software offers field proven image acquisition, control and processing and analysis functions to design, develop and deploy high-performance machine vision applications.

Features

- Supports image acquisition from GigE Vision®, Camera Link®, parallel digital and analog cameras.
- Field proven image acquisition, processing and analysis software tools offer over 400 functions.
- Integrated prototyping environment with intuitive user interface.
- 64/32-bit platforms leverage multi-core CPU to turbo charge program execution.

Chapter 3

Study of Camera And Lens Features

3.1 Camere Features

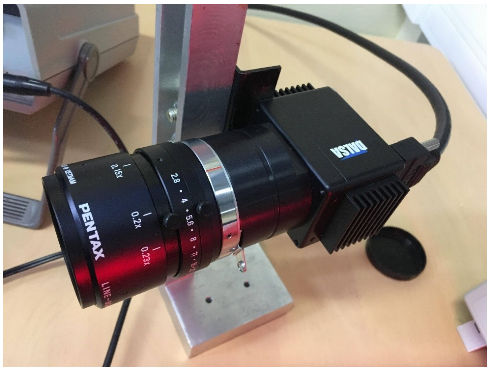

Figure 3.1: Camera Positioned

3.1.1 Sensor

A sensor within a camera captures light that comes through the lens to create an image. It is an analog device whose charge needs to be converted into a signal that is amplified and then converted into a digital form. The digital form of the image appears in the form of pixels with each pixel having a number. The DALSA S2-1X-02K40 has a CCD sensor of size 28mm which are known to offer the best image quality as compared to CMOS sensors. The sensor device of the camera used in this experiment was Dalsa IL-P3-2048.

3.1.2 Resolution

The resolution of a camera is said to be the amount of detail that a camera can capture and is measured in pixels. The higher the number of pixels in a camera, the more details it can capture and the larger the image captured can become without blur, noise or grains. The DALSA camera used has a resolution of 512, 1024 and 2048 pixels.

3.1.3 Shutter speed

This is the length of time the sensor within the camera is exposed to light during the capture of an image. This is proportional to exposure time. The shutter speed of the DALSA S2-1X-02K40 was set in the CamExpert software during the configuration of the camera before capturing the images.

3.2 Lens Features

3.2.1 Focal length

This describes the distance between the lens and the image sensor when the camera is in focus. The Pentax YF5028A-02 has a fixed focal length of 50mm.

3.2.2 Aperture

The aperture of a lens is the hole within a lens that allows a specific amount of light to enter a lens and create an image on the sensor of the camera. Aperture works hand-in-hand with the focal length of a length and every lens has a unique aperture with which it can function. the smaller the aperture, the darker the image is for a given exposure time. In combination with the shutter speed of the camera, they regulate the amount of light that reaches the sensor. A fast shutter speed requires a large aperture to obtain a good image and a slow shutter speed requires a small aperture to obtain a good image. The diameter of the aperture is controlled by a diaphragm which is measured in F-stops. An F-stop is the ratio of the focal length to the effective aperture diameter. The Pentax lens has an aperture with a range of F2.8 - F22.

3.2.3 Focus

This refers to the point where light rays from an object converge on a lens in order to produce the best image of the lens with any blur. This is usually achieved when the shutter speed, distance and aperture have been well adjusted on both the camera and its lens. The focus of the Pentax lens can be manually controlled within the ranges of 356mm to 471mm. At 471mm it has a magnification of 0.15 and a viewing angle of 39°30 and at 388mm it has a magnification of 0.20 and a viewing angle of 37°13.

Figure 3.2: Lens attached to the Camera

3.3 Grabbing Images

First the settings of the camera were set in order to obtain a satisfactory or the best image. After setting the camera using the software on the computer we were required to set the lens in order to obtain a good image. To achieve this three main things were considered, namely

- Lens focus
- Lens aperture
- Distance of the camera from moving industrial part

The satisfactory image will be got by modifying the following parameters:
➜the distance between the camera and the moving part,
➜the aperture of the lens
➜the focus.

So we grab several images by changing the parameter before we got the one we consider as the best one where we can see the sample.

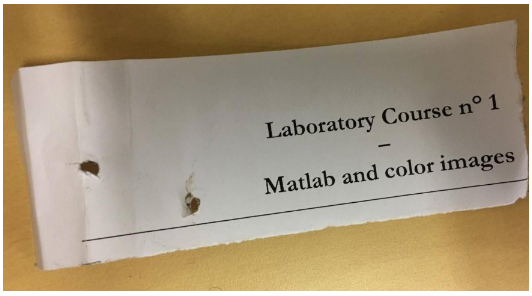

Figure 3.3: Sample to be captured

3.3.1 Configuration

For the configuration of the software, we choose the " Teledyne DALSA " ➜part1-Free Running-8bits

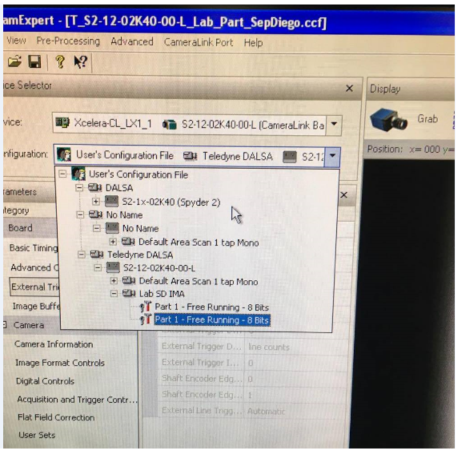

Figure 3.4: CamExpert Setting

Thus we took several distances, apertures and focuses. At each distance, we grabbed an image of the moving industrial part by triggering the camera using the CamExpert software. At each of the various settings of the lens we obtained different results of the image. We thus selected the focus, aperture and distance that gave us the best or the clearest image that was in focus. The results of this can be seen in the table below.

FOCUS (amplification)	APERTURE (f-stop)	DISTANCE (cm)	OBSERVATION
0.23x	22.0	30	The image was too blurry and could not be seen
s	16.0	30	The image remained blurred with only a few features visible
1.50x	5.6	30	A few details of the image could be seen however parts of it remained blurred
0.15x	5.6	36	The image was fully in focus with no blur.

3.3.2 Results

Figure 3.5: distance=30cm, aperture=22, focus=0.23x

Figure 3.6: distance=30cm, aperture=16, focus=0.23x

Figure 3.7: distance=30cm, aperture=5.6, focus=1.5x

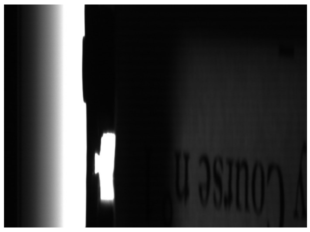

Figure 3.8: distance=36cm, aperture=5.6, focus=0.15x

Therefore we decided to choose the focus of 0.15x, aperture of 5.6 and the distance of 36cm of the camera from the industrial moving part as our setting of the camera to grab the images throughout our experiment.

3.4 Camera Applications

This camera can be used in a variety of applications, a few of which are highlighted below:

- Web inspection (multi-cam and narrow web) : It can be used in industry as a web inspection system to scan a production line in order to detect defects or problems that might be present. It is used to inspect or scan materials such as paper, film, metal foil, or textiles that are being processed.
- Pick and place : It can be used in robotic machines or surface mount technology (SMT) component systems which are used to place surface-mount devices (SMDs) onto a printed circuit board (PCB).
- Document scanning : In this process the camera takes images of information in various forms such as paper, etc. By doing so the information is converted into a digital file which has a lot of uses in industry.

Chapter 4

Camera Triggering By External Signal

In this section of the experiment we had to trigger the camera using an external signal instead of the CamExpert software or internal signal of the camera. To achieve this, we first had to change the configuration on the software by enabling the external trigger parameter.

The external signal that was to be used was to be created using a signal generator. We connected the signal generator to an oscilloscope in order to view the waveform of the signal, and connected it also to the camera and the PC.

4.1 Performing Task

The camera and lens settings from the previous experiment were maintained. Therefore camera focus was 0.15x, aperture was 5.6f and the distance from the industrial moving part was kept at 36cm. To trigger the camera using the external signal the following steps were taken.

1. We started the CamExpert software and changed the configuration setting to enable an external trigger.

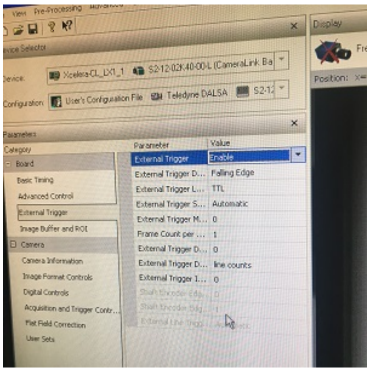

Figure 4.1: External Trigger being enabled

2. After changing the configuration setting, we powered on the industrial part.
3. We triggered the first external signal with the signal generator by starting at the lowest voltage of 1V . This triggered the camera and an image was taken.
4. We saved the image taken and it can be seen below :
5. Using the signal generator, we generated another signal at 10V. This triggered the camera to grab another image.

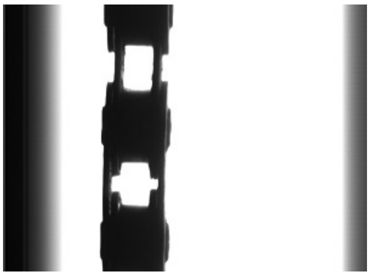

Figure 4.2: First image of signal triggered externally at 1V

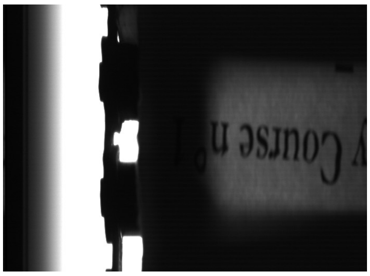

Figure 4.3: First image of signal triggered externally at 10V

6. Again we generated a third signal at 100V, and this also triggered the camera to grab an image of the moving part.

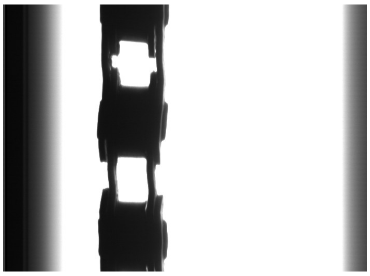

Figure 4.4: First image of signal triggered externally at 100V

7. We generated a fourth signal at 1kV from the signal generator, however the camera was not triggered to grab an image. This was because the 1kV signal generated an external trigger that was faster than the frame rate. Therefore the camera was unable to trigger.
8. All other signals that we generated above 100V did not trigger the camera.

4.2 Applicaion of Such Configuration

Camera triggering by external signal are used in various sectors of industrial purpose. One being in food manufaturing indutry where foods which are damaged in the cause of manufacturing are noticed by external triggering and later inspected. Another example is being in mining sector for effective use during production.

Chapter 5

Conclusion

We completed all the necessary tasks asked in this report. We were able to perform triggering externally and inetrnally also by using the provider software. Moving objects imaging is mostly used in manufacturing industries.

This tutorial was basically on a line scan camera applications. We were able tp learn line scan cameras output only has a single line of pixels per exposure and therefore require much less time to transfer the sensor image information into the readout register than area array cameras. This is initiated by the application of a trigger pulse to the camera. The trigger pulse signals the end of the exposure period and the start of the readout period for the current line.

We will go further with future findings to enable us to be well equipped with this area of moving object imaging.

References

1. **[1]Xcelera-CL LX1 Base, Teledyne DALSA**

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3. **Sensors**

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