Performance Evaluation of CMOS Detector using GigE vision Framework

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Abstract - *As the detector is key element in image generation, in the last few years, innovative solutions for the realization of these large area detectors are required especially for advanced biomedical systems with integrated detector electronics. Detector should be able to communicate high-speed video and related data to host over network. GigE Vision is an interface standard for high-performance industrial cameras/detectors. It provides a framework for transmitting high-speed video and related control data over Ethernet networks.*

***Key Words*: GigE vision, CMOS, CDD, Detector, X-ray imaging, High Speed, Biomedical application, Simulator**

1. INTRODUCTION

Modern medical imaging systems require advanced technologies for the imaging sensor and detector to build an integrated system. The high-speed image and video processing is becoming increasingly important in many applications, detector should be able to handle such huge data efficiently. Communication between Image detection and Correction unit and detector is also major factor for high speed. GigE-Vision compliant CMOS detector bridge this gap. Gigabit Ethernet, will deliver sufficient bandwidth over normal network connections to meet the high bandwidth. Which is demand in many image processing applications. Also, there should be generic framework of detector technology which will make it easier to exchange hardware. Which will lead to shorter design cycles, lower development costs and thus, greater opportunities in the market. [1].

1.1 X-Ray Imaging

X-ray based methods of medical imaging include conventional X-ray, computed tomography (CT) and mammography. X-ray imaging uses an X-ray beam that is projected on the body. When passing through the body, parts of the x-ray beam are absorbed. This process is described as attenuation of the X-ray beam. On the opposite side of the body, detectors capture the attenuated X-rays, resulting in an image. In conventional radiography, one 2D image is produced. Sometimes the detector is rotated around the body during the examination so that multiple images can be acquired, resulting in a 3D visualization. As the detector is key element in image generation, detector should be able to communicate high-speed video and related data to host software over ethernet networks.

1.2 Detector Technology

CCD (charge coupled device) and CMOS (complementary metal oxide semiconductor) image sensors are two different technologies for capturing images digitally. We will compare CCD and CMOS detector in biomedical application.

Parameter	CDD Approach	CMOS Approach
Pixel	Charge generation and charge integration	Charge generation, charge integration and charge-to-voltage conversion.
Array Readout	Charge transfer from pixel to pixel	Multiplexing of pixel voltages: Successively connect amplifiers to common bus
Sensor Output	Output amplifier performs charge-to-voltage conversion	Assorted options Possible: -no further circuitry (analog output) -add. Amplifiers (analog output) -A/D conversion (digital output)

Table -1: CDD Approach vs CMOS Approach

2. GigE Vision FRAMEWORK

The GigE Vision is a new standard developed by a committee of the Automated Imaging Association (AIA), for high performance machine vision cameras. [2] The GigE vision standard includes the hardware interface standard (Gigabit Ethernet), communication protocols, and standardized camera control registers which are based on a command structure called GenI cam. GenI cam provides a generic camera description file for all camera types, regardless of the interface technology they use (i.e. GigE, Firewire, Camera Link, etc.)

GigE Vision has four main elements:

1. **GigE Vision Control Protocol (GVCP):** How to control and configure devices.

2. **GigE Vision Stream Protocol (GVSP):** Covers the definition of data types and the ways images can be transferred via GigE.

3. **GigE Device Discovery Mechanism:** Provides mechanisms to obtain IP addresses.

4. **XML description file:** Allows access to camera controls and image streams.

It provides a framework for transmitting high-speed video and related control data over Ethernet networks. With help of GigE framework, we can implement CMOS detector technology which will be generic for all camera types, regardless of the interface technology they use.

3. DESIGN

The basic idea was to create detector simulator, which we will able to mimic the all functionality original detector. This simulator will help us to perform various operations without working on actual detector. The CMOS detector simulator was implemented in CPP using following steps.

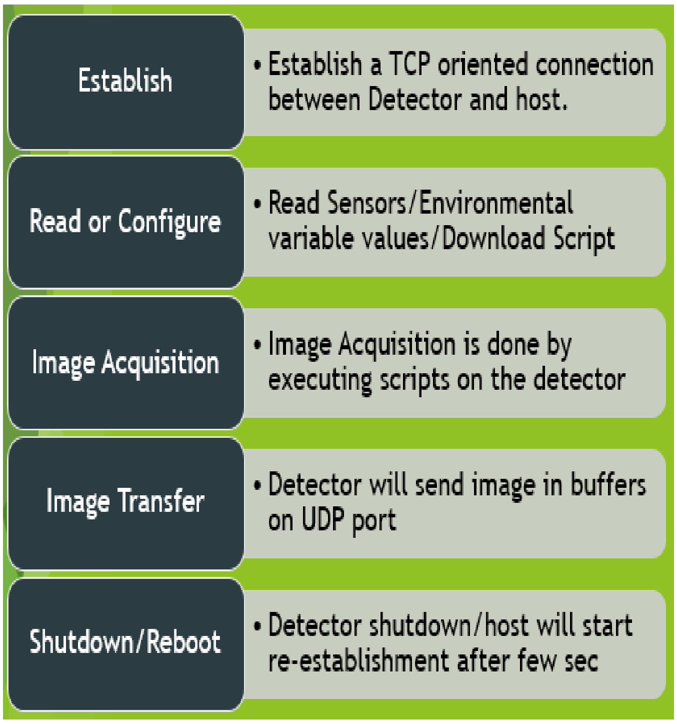

Fig -1: Communication Design

CMOS detector simulator was implemented with **GigE-Vision** framework was deployed on machine with the following specifications:

Hardware Specifications:

CMOS Detector

Processor: Intel i5-3210M CPU @ 2.50Ghz

Memory: 32GB RAM

Hard Disk: 1TB

Software Specifications:

Operating System: Helios Linux 6.x series

Programming Language: C++

Open source Software: GigE-Vision framework

4. IMPLEMENATION

The idea is to establish communication with detector to perform image readout and basic detector environmental monitoring. The GigE Vision standard including of both the hardware interface standard (Gigabit Ethernet) and the communications protocol can be utilized for controlling and communication of cameras. GigE Vision standard consists of two protocols: GVCP and GVSP which will be used for communication. Following is implementation overview for detector simulator.

Input:

1. Commands to configure detector
2. To perform image readout from detector. (Trigger mode)

Output:

Stored x-ray image based on configuration.

Communication Channels:

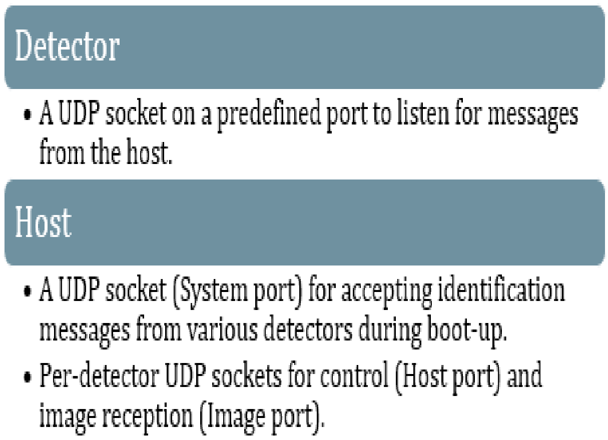

Fig -2: Communication Channels

5. PERFORMANCE ANALYSIS

Performance analysis of CMOS detector as an option in biomedical application is done using GigE vision Framework parameters. CMOS detector simulator will help us to perform various operations without working on actual detector. Analysis of 2 different detector (CDD detector, CMOS detector) are considered. These 2 detectors are integrated into biomedical application.

The parameters which are considered for performance analysis are as follows:

a. **Power Consumption:** Power consumption refers to the electrical energy per unit time, supplied to operate detector.

b. **Hardware Cost:** Detector hardware cost

c. **Image Readout:** Detector trigger modes when to read image.

d. **Noise**: Random variation in image density.

e. **Dynamic Range:** The dynamic range of detector is defined as full well capacity divided by the total noise.

f. **Image quality:** Characteristic of an image that measures the perceived image degradation.

g. **Heat generation:** Amount of heat generated during time of acquisition.

h. **Image resolution**: Resolution refers to the number of pixels in an image.

6. CONCLUSIONS

Performance evaluation of different detectors will help to increase communication speed and eliminate the hardware dependency when it comes to detector technology.

This approach can then be used in applications which require generic framework of detector which will lead to shorter design cycles, lower development costs and thus, greater opportunities in the market.

It can be used for diagnostic purpose in healthcare domain that perform detector testing or new feature implementation or improvisation in detector from remote sites, especially in case where the detector is remotely located.

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