STATUS OF A VERSATILE VIDEO SYSTEM AT PITZ, DESY-2 AND EMBL HAMBURG

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Abstract

The market for industrial vision components is evolving towards GigE Vision (Gigabit Ethernet vision standard). In recent years, the usage of TV systems and optical readout at accelerator facilities has been increasing. The outlined Video System, originated in the year 2001, has overcome a huge evolution over the last years. Being real-time capable, lossless capable, versatile, well-documented, interoperable, and designed with the user's perspective in mind, use cases at PITZ, HERA-e and DESY-2 (with an eye toward PETRA III) at DESY in Zeuthen and Hamburg as well as the EMBL Hamburg have been implemented to great success. The wide use range spans from robotics to live monitoring up to precise measurements. The submission will show the hardware and software structure, components used, current status as well as a perspective for future work.

INTRODUCTION

The origin of the outlined Video System is the **P**hoto **I**njector **T**est Facility **Z**euthen (PITZ). PITZ is a test facility at DESY for research and development on laser driven electron sources for Free Electron Lasers (FEL) and linear colliders [1, 2, 3]. The optimisation of an electron gun is only possible based on an extended diagnostic system including a video system. The goal is to measure the electron beam position and the profile of the beam at different places and by different diagnostic tools along the beam line [4, 5].

The whole Video System includes a rich set of components starting from a wide hardware base over the grabbing and image taking software, the control software, the connection and transport protocols as well as tools, interfaces for user applications and a complete Video Client application for analysis and data taking.

KEY FACTS

Based on initial PITZ hardware setup and demands of measurement intentions, three basic principles are maintained throughout the whole system.

- provide lossless video data for measurements
- ability of real-time live scene view
- readout and transport of luminosity signal

Based on the requirement of video-based measurement of characteristic parameters, the digital video content should remain unchanged. This implies unchanged video data or the ability to restore original scene data at the client end of data transport. Moreover, the sequence of video images must be preserved - no video image should be dropped. In addition, the adjustment of properties at analogue image acquisition level is important to preserve the image quality up to the point of digitization.

A live scene view, available at real-time speed, supports the physicist in his work. For instance, when performing a solenoid scan, the magnet current that deflects the electron beam is changed over a defined interval. A prompt view of the changing shape of the beam image can outline problems in beam transport and deliver valuable information for optimisation.

For live-view, analysis and measurements it is satisfactory to provide video data that contains the luminosity signal of the scene.

HARDWARE

Starting in the year 2002 with 6 analogue JAI M10 RS cameras and two framegrabber cards [6], the Video System has been widely extended over the years driven by increasing demands for video diagnostics. Based on the initial PITZ setup, analogue video signal integration is supported using the DALSA PC-Vision framegrabber card. A secondary analogue interface card was integrated into the system for monitoring tasks at the **E**uropean **M**olecular **B**iology **L**aboratory (EMBL) Hamburg. Special support was created for the analogue camera model JAI M10 RS and it successor, JAI M10 SX, both widely used at PITZ. A video multiplexing device, specifically an RS232 terminal controllable video crossbar with integrated galvanic isolation, gives free choice when connecting a large amount of cameras to a limited set of framegrabber cards.

As industrial vision world is moving towards an agreed interface called Gigabit Ethernet Vision (GigE Vision), steps were made to integrate such cameras into the Video System. Cabling, electronics and software integration effort is substantially smaller than using analogue cameras. The Prosilica camera GE 1350 and its compact model GC 1350 were chosen to apply new technologies and supporting measurements by increasing the longitudinal resolution from 8 to 12 bit.

For the near future, support for Directshow-based hardware and a digital Basler camera named “Scout” is in preparation. Having a Directshow interface, it is easy to integrate cheap imaging hardware like Web cameras in order to tryout the mentioned software or to monitor instrumentation mounted at remote locations.

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SERVER

The scope of the server side is to acquire raw images from supported hardware, to provide a structured way to access and control the hardware and to provide image streams for client side. Based on meaningful distribution of tasks, three server applications are provided in order to interface, control and readout the hardware.

GrabServer2

The image acquisition and delivery to the client side is done by GrabServer2, a successor of the initial video grabbing software at PITZ. Its main purpose is to acquire greyscale images from any supported image source, pre-process image data, compress images using supported formats (JPEG and Huffman-based lossless compression) and to provide platform-independent image streams for client side. In addition, control connections are implemented for status readout and controlling the application.

These mechanisms are provided per instance of the program. Having multiple instances, distributed as necessary across industrial PC hardware, multiple image streams can be provided to client side. Naturally, this depends on support of hardware and API.

To transfer 768 • 574 pixels per video frame up to 10 times per second from server to client side (initial requirement of PITZ) is a heavy task for control system protocols. At the time of initial implementation, dedicated TCP socket connections were the only answer. In case of multiple client connects, the required bandwidth is multiplied by the number of clients, as each client has a dedicated connection to the server. Lossless Huffman-based compression was used to tear-down demands on 100 Megabit networking infrastructure and to fulfil lossless, in time delivery of each video image.

At initial revision, **T**hree-fold **I**ntegrated **N**etwork **E**nvironment (TINE) protocol [7] was chosen for basic control system connections. Based on increasing use of the Video System and availability of TINE multicast transfer mode, multicast transmission was integrated as a frame-transfer method. TCP socket connections remained as a backup solution.

Asynchronous notification, a feature of TINE protocol, provides an efficient way of transferring huge byte sets. Unless having a static polling rate which defines the maximal update rate of data sets, asynchronous notification permits to stream out data to connected consumers on event basis with minimal time delay. Having asynchronous notification and multicast support combined, TINE is fit to stream huge video images in time to a virtually unlimited number of clients.

Today, image feeds are provided to the client side using TINE protocol. Various choices of data transport are available: Multicasting, Unicast UDP, TCP and shared memory.

Slow Control Server (RS232)

At PITZ, multiple analogue cameras are used for measurement purposes. To optimize image quality at the camera level, it is necessary to have a defined control interface to adjust camera settings like gain, black level and shutter speed. The Slow Control Server (RS232) is used as an interface to access the RS232 connection provided at camera level. An interface to the control system is provided using TINE control system protocol.

Video System Control Service

Having installed a widely branched Video System, a defined place for settings, lookup and control can minimize redundancy of information distributed. Human-readable and editable configuration files behind the server provide an easy way to change settings and structure without additional dependencies. In addition, assignment of cameras to servers is done via this service. For example if there are four digital Prosilica cameras installed in the Video System but only two GrabServer2 instances are enabled in order to provide Prosilica digital images, a mechanism to attach and revoke camera assignments is necessary in order to be able to watch images from all connected cameras if required.

CLIENTS

Video Client 2

The Video Client 2 is a versatile video display and analysis tool used to monitor, take and analyse video data that is produced by image sources which are installed along a beamline. Various tools, provided inside the application, make it easy to

- monitor what is going on (e.g. see electron beam, see laser beam, see dark current, see diagnostic devices in the beam pipe)
- do online-analysis of the beam images (spot size, position, shape, ...)
- optimize the beam image quality before data is taken and stored permanently
- do manual data-taking
- do semi-automatic data-taking (beam images and backgrounds by control of laser shutter)
- correlate behaviour between spot-size, position and shape and changing experiment parameters (Online-DAQ)

In the last few months, remote shifts have been established at PITZ under certain conditions. The Video Client 2 is, via integration of DirectDraw for drawing video data, instantly able to deliver its whole GUI in time via Remote Desktop Protocol (RDP). Having a broadband internet connection like DSL is enough to display live images from readout positions at the accelerator.

Integration of User Applications

Continuously increasing demands on specialized client software and export to remote locations at DESY-2 and the EMBL Hamburg lead to a constrained design of an easy to use library / component to access the video system. Taking live video images for dedicated analysis is the most important point. Saving and loading image file formats and certain basic algorithms are also important. This functionality is provided through the Videokernel library, which is currently available for Linux and ROOT (both 32 and 64 bit flavours), Windows (32-bit), Visual Basic and Labview. Interfaces for MATLAB and Java are in preparation for the future. The finishing of this library resulted in many dedicated client programs written for special purposes and made the specialized GUIs at DESY-2 and EMBL Hamburg possible.

Basic Control Toolset

In order to support the work with Video Client 2 and dedicated clients, supplementary GUIs have been developed. The Camera Switching Panel is used to provide an easy way for camera-server assignment. The Slow Control Client (RS 232) is used to adjust the analogue camera properties. Prosilica Slow Control is a tool to adjust camera properties on Prosilica Gigabit Ethernet cameras. A display and control panel of server side status properties was integrated into the Control System at PITZ.

INSTALLATION AT DESY-2

The Video System was introduced at DESY Hamburg Accelerator Control Room (BKR). It was used in the past for HERA-e and is used at the moment for DESY-2. For real-time monitoring, alignment and threading of particle beams, a stable live view of the beam position and shape at certain positions is very important. The Video System is used as a backend to provide live video images from image sources along the beamline. Using a Visual Basic (VB) interface to the Videokernel library, operators have written their own GUIs, supporting specialized tasks depending on operational area.

INSTALLATION AT EMBL

The European Molecular Biology Laboratory (EMBL) has a site situated at DESY Hamburg. Synchrotron beams of DESY are used to perform experiments. In order to support biology sample changing in controlled areas, which are not physically accessible during processing, the Video System was introduced at EMBL Hamburg for remote sample changing and centring. In order to support Labview, used at EMBL Hamburg for control applications, an extension of Videokernel library was provided in order to easily integrate live video images.

PERSPECTIVE

Having a Video System that fits multiple purposes, that is easy to use and to extend was a key to successful export from PITZ to other accelerator-dependant use cases like HERA, DESY-2 and EMBL Hamburg.

As the world is not standing still, bottlenecks in the current design have been identified. To resolve these, efforts are focused on an abstract, modular grabbing interface in order to be able to easily integrate new hardware parts at the image capture level. Creation of a Video Transport Layer in order to exchange and reuse components in heterogeneous TV System environments is a chance to broaden flexibility, extend use-cases and ease co-operation. Moreover, it is foreseen to integrate standard image file formats for storing and retrieval of video images and backgrounds from/to disk.

As industrial, ready-to-use cameras show inferior performance and lifetime in radiation environments, testing and integration of radiation hardened camera hardware designs, not satisfactory in the past, will continue. Another extension of the hardware base will be the integration of Directshow-based cameras.

Based on setup and operating experience at HERA-e and DESY-2, the system will be reused and extended for DORIS Synchrotron Light Monitoring and for PETRA III video applications.

REFERENCES

[1] F. Stephan et al., “Recent Results and Perspective of the Low Emittance Photo Injector at PITZ”, FEL 2004, Trieste, Italy

[2] A. Oppelt et al., “Status and First Results from the Upgraded PITZ Facility”, FEL 2005, Stanford, CA, USA

[3] S. Rimjaem et al., “Status and Perspectives of the PITZ Facility Upgrade”, FEL 2007, Novosibirsk, Russia

[4] Juergen Baehr et al., “Development of a TV Diagnostic System for the Photo Injector Test Facility at DESY Zeuthen”, FEL 2001, Darmstadt, Germany

[5] Juergen Baehr et al., “Diagnostics for the Photo Injector Test Facility at DESY Zeuthen”, DIPAC 2001, Grenoble, France

[6] S. Weisse, I. Chachkhunashvili, „PITZ Video System“, PCaPAC 2002, Frascati, Italy

[7] TINE website
http://tine.desy.de