New image capture system for high rep-rate image acquisition in the CLF high power laser experimental areas

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Introduction

This report details the development of a new image capture system which capitalises on new camera technology for the benefit of Astra and Vulcan experimental operations. Many different systems currently exist within the target areas but can be difficult to operate or rely on obsolete hardware. Therefore, to address this need a new image capture system was developed to run new digital CCDs in a flexible and user friendly manner. The cameras used for this project allow for almost all aspects of their operation to be controlled programmatically by a PC and so offer a significant advantage over previous systems. This development allows greater potential for automating control systems based on image acquisition (such as the automatic beam alignment system in Astra).

Main features

The development supports two distinct camera technologies. These are IEEE1394 FireWire (for which the Allied Vision Technologies Marlin F033B camera has been incorporated), and Gigabit Ethernet (Basler Scout Series cameras). A separate system is provided for each camera type which includes a PC with the relevant interface card.

Current capabilities common to both interfaces are:

Eight Channels – Up to 8 cameras can be operated simultaneously from one PC which the option of displaying 1, 4 or 8 channels on the monitor.

Internal/External Trigger – Acquisitions can be synchronous with the laser pulse.

Free-run/Single Shot – Cameras can be configured either to take a single shot or to keep acquiring images which can be externally triggered.

Auto save – Images can be saved automatically to a user specified location. Filenames have a user specified prefix to which is added the time (24hr HHMM), the channel number and an automatically incrementing shot number.

Settable Acquisition Attributes – Exposure time, gain, brightness, and trigger delay can be controlled by the PC.

Hardware

The FireWire cameras are powered from the PC through the FireWire cables. The GigE (Gigabit Ethernet) cameras come with separate power supplies. GigE cameras have an advantage that they can easily be placed tens of meters apart whereas FireWire cables can only be 4.5m long and so require signal repeaters to achieve a greater range than this. Hubs are needed to connect multiple cameras to the systems and trigger cables terminating in a female BNC connection are provided for each camera.

Software

The user interface has been developed in Labview 8.2.1 with the Vision Acquisition Software module. An executable form of the program will be installed on each PC along with the required run-time engines. The Vision Acquisition run-time engine requires a valid license, which is also provided with each system.

Figure 1 shows a screenshot of the main panel on the interface when displaying the full eight channels. One or four channels can be displayed instead to give a larger display of the camera images.

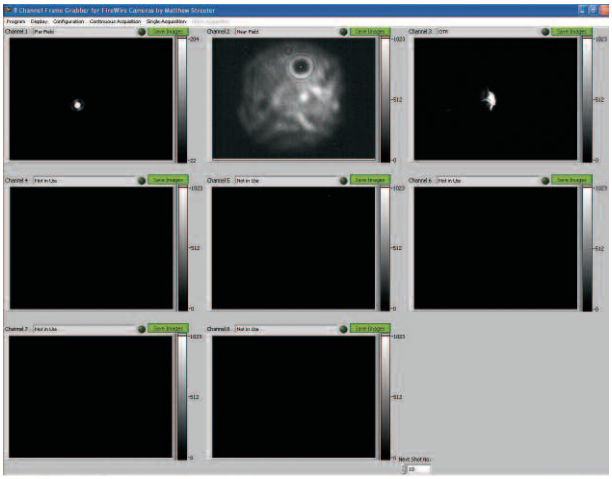

Figure 1. Screenshot of the Image Acquisition Program.

A menu bar on the top of the screen allows the user to switch between display modes and to select the triggering method. It also allows the user to configure the cameras by bringing up a second panel (figure 2) from which all detected cameras can be configured and displayed on a chosen channel. It also can set the look-up tables for the channel displays and a file location for all recorded images. All settings on this panel can be saved to a configuration file which can then be loaded at any time to restore previous settings.

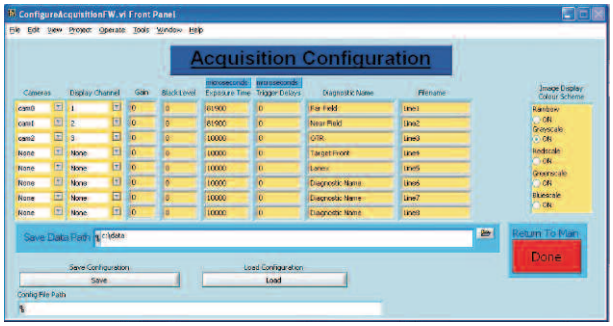

Figure 2. Screenshot of the configuration screen.

On the main panel there are two buttons on the menu bar to start the acquisition – one for single shot and one for continuous acquisition. When either is pressed the 'Abort Acquisition' button becomes active which ends the acquisition.

When an acquisition has begun in externally triggered mode the software continuously checks the first active channel for an acquired image when one is detected it downloads this image and moves onto the next active channel and does the same. This continues for all cameras but at any time the user has the option to skip a particular channel or abort the acquisition altogether. This is particularly useful when a camera fails to respond correctly as it allows all the other channels to be processed. In the continuous mode it will skip a camera if it fails to acquire an image when one of the other cameras has received a trigger so as not to stop the process completely for one failed acquisition.

Use in experiments

So far the FireWire system has been used to collect data on several Astra TA2 and Astra Gemini experiments. This has been useful for the experiments but has also served as testing for the system allowing many upgrades and fixes to the software. The GigE version is to be made available to Vulcan TAW and TAP and support will be made available to ensure that they work correctly and that more improvements can be made.

Future work

The software development is ongoing and all systems will be regularly updated to fix any problems encountered. Also user feedback on what improvements should be made will be acted on to give the best system possible.

Specific improvements which are already planned are as follows:

Integrating the two interfaces – A single version of the software which can support both FireWire and GigE cameras will streamline the use and development of the systems and will also allow for both types of camera to be used from one PC.

Allow settings to be configured during acquisitions – This will allow the gain, exposure time, trigger delay and black level parameters to be easily set while displaying the results.

Image analysis – Options to be provided for instantaneous analysis of images such as spot size, intensity, line outs, centroid, etc.

Program rationalization – Make the program conform to Labview standards so that maintenance of the systems can be carried out by any trained personnel.

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