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Displaying Drift Scanning Images from Multiple CCDs in Real-Time During Data Acquisition

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Displaying Drift Scanning Images from Multiple CCDs in Real-Time During Data Acquisition[1]

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Abstract. Drift scanning images from the Sloan Digital Sky Survey's 54 CCD camera are displayed on eight screens in real-time during data acquisition. This real-time visual feedback provides an observer the means to quickly check data acquisition and telescope operations. The hardware and software used to accomplish this display are presented.

1. Introduction

The Sloan Digital Sky Survey[2] (SDSS) will carry out a digital photometric and spectroscopic survey over a large fraction of the sky (10,000 deg^2) in the north Galactic Cap. The SDSS data acquisition system (DA) was developed at Fermilab to support various data acquisition roles with run-time configuration: handling multiple CCD and single CCD cameras (such as the Drift Scan Camera on the ARC 3.5m telescope at Apache Point Observatory, New Mexico (Nicinski, et. al. 1994)), drift scanning and staring, etc.

SDSS imaging is done by drift scanning along great circles with a 54 CCD camera. The 30 photometric CCDs are 2088×2048 pixels in size; the 24 astrometric CCDs are 2088×400 pixels in size. Each pixel is digitized to 16 bits. These are displayed in real-time during data acquisition on eight color monitors, the Scrolling Displays (SCDs).

2. Modularizing Data Acquisition Hardware

Data is acquired with a VMEbus-based system consisting of ten Instrument Control Computers (ICCs) in three crates. Each ICC, a 33 MHz Motorola MC68040 single board computer, handles up to six CCDs. At the Survey's drift rate, each ICC acquires data up to 935KBytes/sec. (for an aggregate rate over 8MBytes/sec. for all CCDs and ICCs). During acquisition, each ICC displays in real-time on an SCD a portion of its acquired pixel data from all its CCDs.

The basic data acquisition components necessary for display are (Figure 1a)

- VCI+. A Fermilab developed board which collects and buffers pixel data from up to six CCDs over a fiber optic link.

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[2]http://www-sdss.fnal.gov:8000/

- ICC. The single board computer which reads pixel data from the VCI+, stores the data, and displays it on an SCD in real-time.

- Vigra MMI-250. The video control board with 4MBytes of VRAM: 2048 × 2044 8-bit pixels.

- SCD. The 1280 × 1024 pixel color monitor.

Because the system is modularized, it is easily expanded to handle more than six CCDs by duplicating the basic components (Figure 1b). To handle the SDSS imaging camera's 54 CCDs, the system is further expanded across three VMEbus crates with their backplanes interconnected.

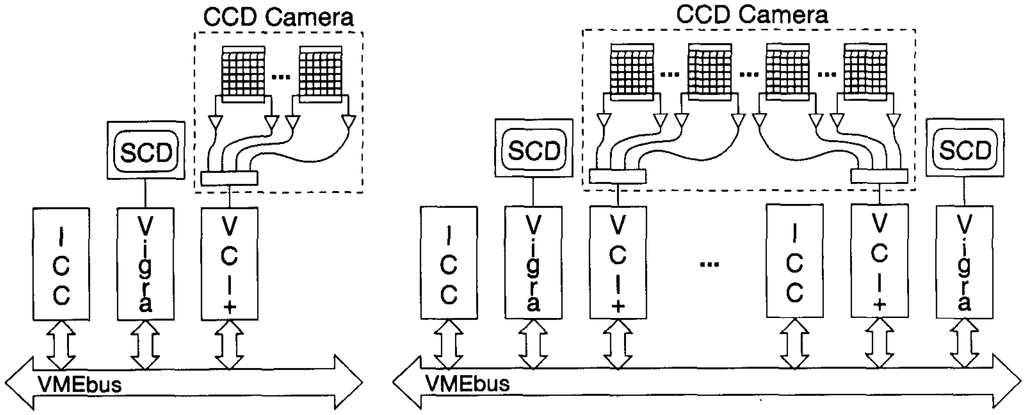

Figure 1. **a.** Basic DA Components **b.** Expanded DA System

3. The Life of a Pixel (with Respect to being Displayed)

For each CCD it handles, an ICC buffers incoming pixels from the VCI+ into a row. These are assembled into a "Frame" (akin to a FITS image) and written to magnetic media. Various jobs are performed between and at Frame boundaries, some dealing with the real-time display of pixel data.

3.1. Depth Reduction

Each 16-bit CCD pixel to be displayed is depth reduced (scaled) down to the SCD's 8 bits. The CCD pixel value indexes into a 64K entry (16-bit range) depth reduction table to obtain the 8-bit SCD pixel value, which in turn indexes into the video controller's color lookup table (CLUT). Visual limits can be set on CCD data, where pixels below a threshold value or above a saturation value are displayed in selected colors. CCD pixels within the greyscale range (of size *scdReduceSize*) are rendered as shades of grey. This results in threes areas within a depth reduction table (Figure 2).

Depth reduction can be static or dynamic. For the static case the threshold and saturation CCD pixel values are set explicitly. The dynamic case is more

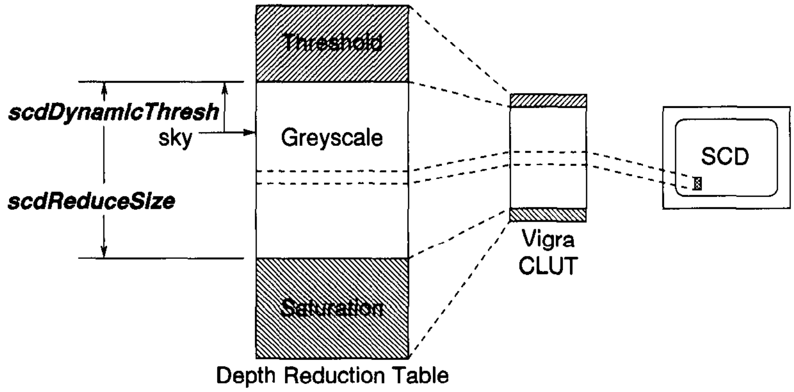

Figure 2. Dynamic Depth Reduction of a CCD Pixel

interesting as the threshold is offset (by *scdDynamicThresh*) from the background "sky" value.[3] The saturation point is then offset from the threshold by *scdReduceSize*. The threshold and saturation points follow the sky value, necessitating adjustments to the depth reduction table (at Frame boundaries).

3.2. Updating Depth Reduction Tables

Each CCD has one or two depth reduction tables associated with it, depending on whether readout is from one or two amplifiers. Thus, an ICC may handle up to 12 tables. To conserve space *and* time, one larger "slide" table contains all depth reduction tables (Figure 3):

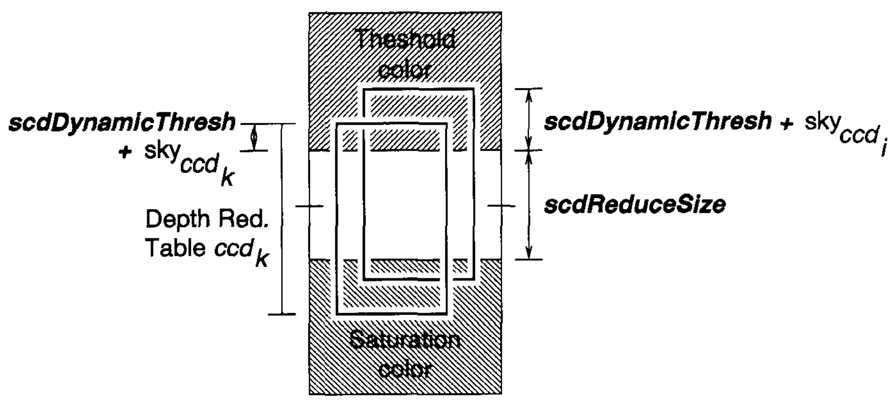

Figure 3. Slide Table with Two Dynamic Depth Reduction Tables

A depth reduction table is potentially adjusted at each Frame boundary. Usually it slides up or down in the slide table to track a new sky value (if dynamic depth reduction is done). By simply changing the pointer to the start of a particular depth reduction table, this adjustment is inexpensive. The slide

[3]The background sky value is the n^{th} lowest unique value sampled from incoming CCD pixels. It is either sampled by the SCD code or supplied by independent online analysis code.

table needs to be only twice the size of a depth reduction table to accommodate all depth reduction tables.

Adjustments are also inexpensive when the threshold value is changed (relative to the sky value), as long as the range of CCD pixel values reduced to greyscale (*scdReduceSize*) remains the same (the saturation point also moves as it is pegged to the threshold value).

3.3. What the User Sees

Besides viewing CCD pixels reduced to a greyscale, a banner is displayed for each Frame. It identifies the Frame, the CCDs being displayed and their corresponding background sky values. Multiple CCDs are displayed vertically on one SCD (with inter-CCD borders). Various colors are used to provide additional information.

Besides specifying the range of CCD pixels to be reduced to greyscale, users have considerable run-time control of the SCD displays. For example, images can be panned; CCDs can be not displayed; and pixels can be decimated (every n^{th} pixel is displayed).

4. Spreading the Load

CCD pixels are not necessarily displayed immediately after their acquisition. The DA prioritizes tasks to accomplish its goals effectively. All SCD related activities are done by an SCD task. It receives pixel information through messages from the acquisition task. During periods of intense action within the DA, such as at Frame boundaries, the display of CCD pixels or the adjustment of depth reduction tables is delayed. But, the delay is small and there is no visual discrepancy.

5. Results

The SCD subsystem's purpose of providing immediate visual feedback to an observer has been successfully accomplished. The depth reduction and table adjustments are efficient, only 4% of an ICC CPU is used without impacting data acquisition or online analysis.

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