A Real Time System for CCD Image Acquistion and Visualization

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ABSTRACT. E' stato realizzato un sistema *real-time* per gestire l'acquisizione di immagini astronomiche con un ricettore CCD e permettere il loro *quick-look*, sia nel caso di osservazioni in sito che remote.

Tutte le parti del sistema sono connesse tramite un VMEbus con sistema operativo PDOS.

L'immagine raccolta col CCD viene letta e compressa con perdita per mezzo di una rete di transputer. La visualizzazione locale è gestita da un TRAM (modulo a transputer) grafico.

Il sistema potrà venire ulteriormente sviluppato per ottenere migliori rapporti e tempi di compressione, nonchè per fornire possibilità di calibrazione *on-line* e di analisi interattiva delle immagini.

1. Introduction

The Astronomical Observatory of Trieste (OAT) has developed a real-time system to simulate remote observing operations of CCD image acquisition and processing.

This work is connected to the activities of OAT within the "Galileo Project" for the Italian 3.5m Telescope. For this reason its base structure is identical to that of the Galileo Telescope and it is developed on a VMEbus with PDOS operating system. The scheme of the system is shown in fig. 1 (Cumani, 1993): the VMEbus controls CCD image acquisition, while the real-time processing is managed by a set of six transputers, one of which - a transputer on a graphic module - permits the image on-site display. In the case of remote observations, the six transputers are also responsible for the compression of the images that are then transmitted to the remote site, where an analogous transputer set allows the data decompression.

2. System hardware

A VMEbus controlled by an EUROCOM-6 68030 CPU Board was used to connect the instruments and to control acquisition, processing and display operations.

The Photometrics Series 200 Camera System with VME controller was used for image acquisition control. It comprises a CH250 Camera Head with a 1024 x 1024 Thomson 7896A CCD, a LC200 Liquid Circulation Unit for CCD cooling, a CE200A camera Electronics Unit and a VME200A Camera Controller Board which is installed in the VMEbus. Fig. 2 is a block diagram of data and command paths (camera system user's manual, 1993).

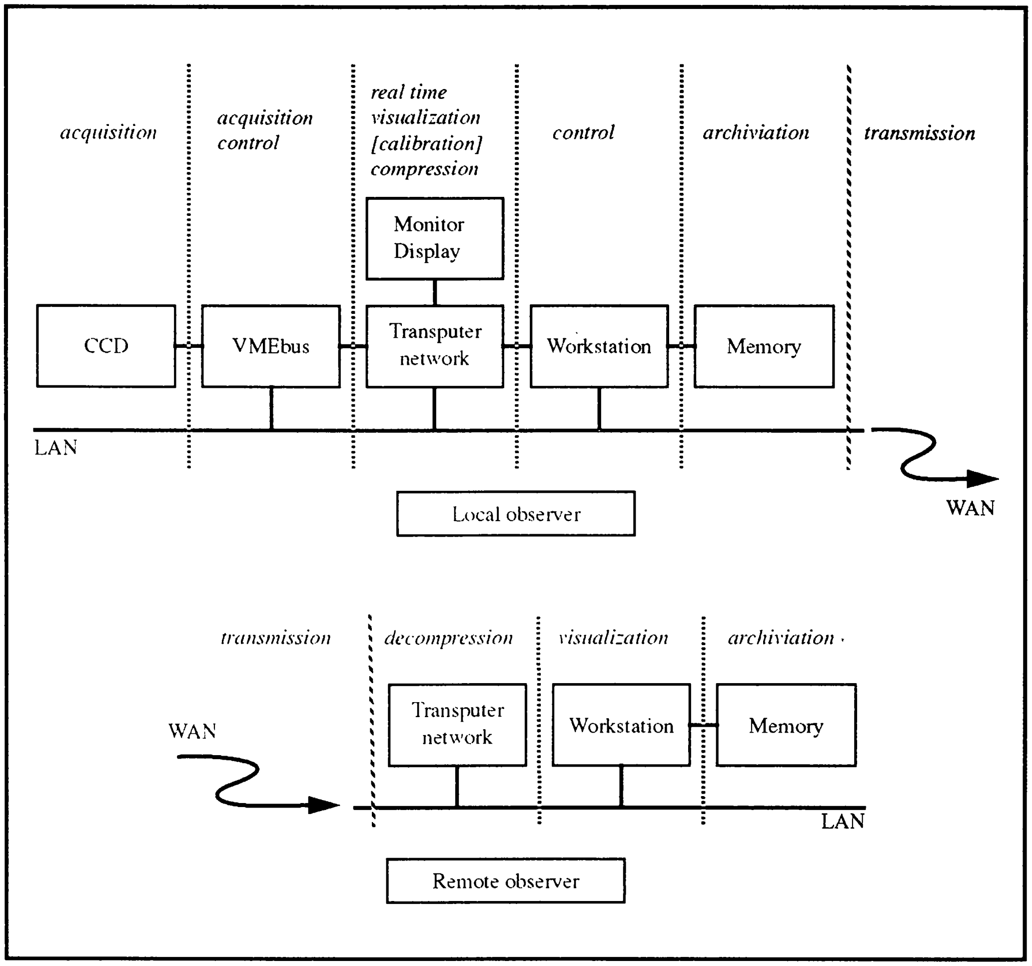

Fig. 1. Scheme of the system: operations in the local observatory and in the remote site.

The VME200A is a CCD camera control peripheral. Its main constituents are a 56001DSP microchip which controls the camera, a 68HC11 microchip functioning as a sequencer interfacing between the DSP and the host computer and a VMEbus interface connecting the 68HC11 and on-board DRAM to the VMEbus.

The DRAM on the VME200A appears on the VMEbus as ordinary memory and can be written to, or read from, the VMEbus host. The DRAM is dual ported with the ability to support incoming camera data with concurrent host read or write accesses.

All of the host communication with the VME200A controller passes through a set of dual-port "*mailboxes*", 8-bit registers which can be written to and read from either the VMEbus or 68HC11.

Image data is processed by a set of transputers.

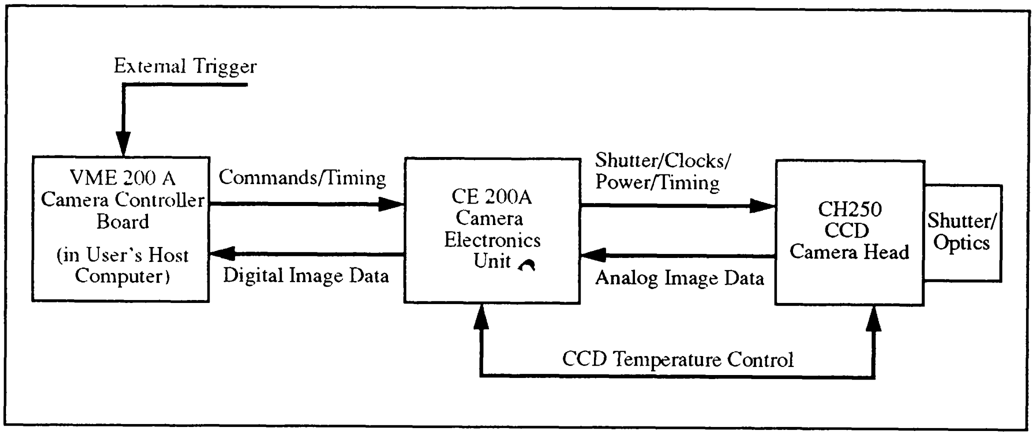

Fig. 2. Photometrics Series 200 data and command paths.

Transputers (from "*transistor computers*") are a class of VLSI chips developed by INMOS (Bristol) and first marketed in around 1983. They are fundamentally low cost microcomputers, i.e. chips with processor, FPU and memory, with channels (links) to enable rapid comunication (up to 20 Mbits/s) with other transputers (Transputer Databook, 1989). Six transputers were used: three IMS T805 and three IMS T800.

In particular, one IMS T805 is assembled on a graphic TRAM (*TRA*nsputer *M*odule (Transputer Applications Notebook, 1989)) and allows real-time on-site display of the CCD images.

All the transputers are mounted on Transtech TMB14 motherboards which are connected to the VMEbus. By TMB14 it is possible to connect the transputers in different parallel architectures. The problem lies in the fact that this motherboard cannot access to VMEbus shared memory and so it is impossible to connect the transputer network to the Camera Controller Board VME200A DRAM to read CCD image in real-time mode. Consequently, an IMS B016 VME Master Board was used to permit the transputers to read the DRAM data.

The diagram of the system hardware is shown in fig. 3.

3. Software developed

On the basis of software provided by Photometrics, several functions were developed to manage the CCD camera: timer and waiting functions to permit the user to read and to write mailboxes in correct times; setup functions that define default CCD camera parameters or allow them to be modified; functions for repeated exposures and dark acquisitions, functions that allow the modification of internal 68HC11 registers to change Camera Controller Board DRAM addresses, function to clear this DRAM.

A program was written for real-time display of CCD image by the graphic TRAM, which can directly read the Camera Controller Board DRAM while pixel data is being transferred into it from the camera.

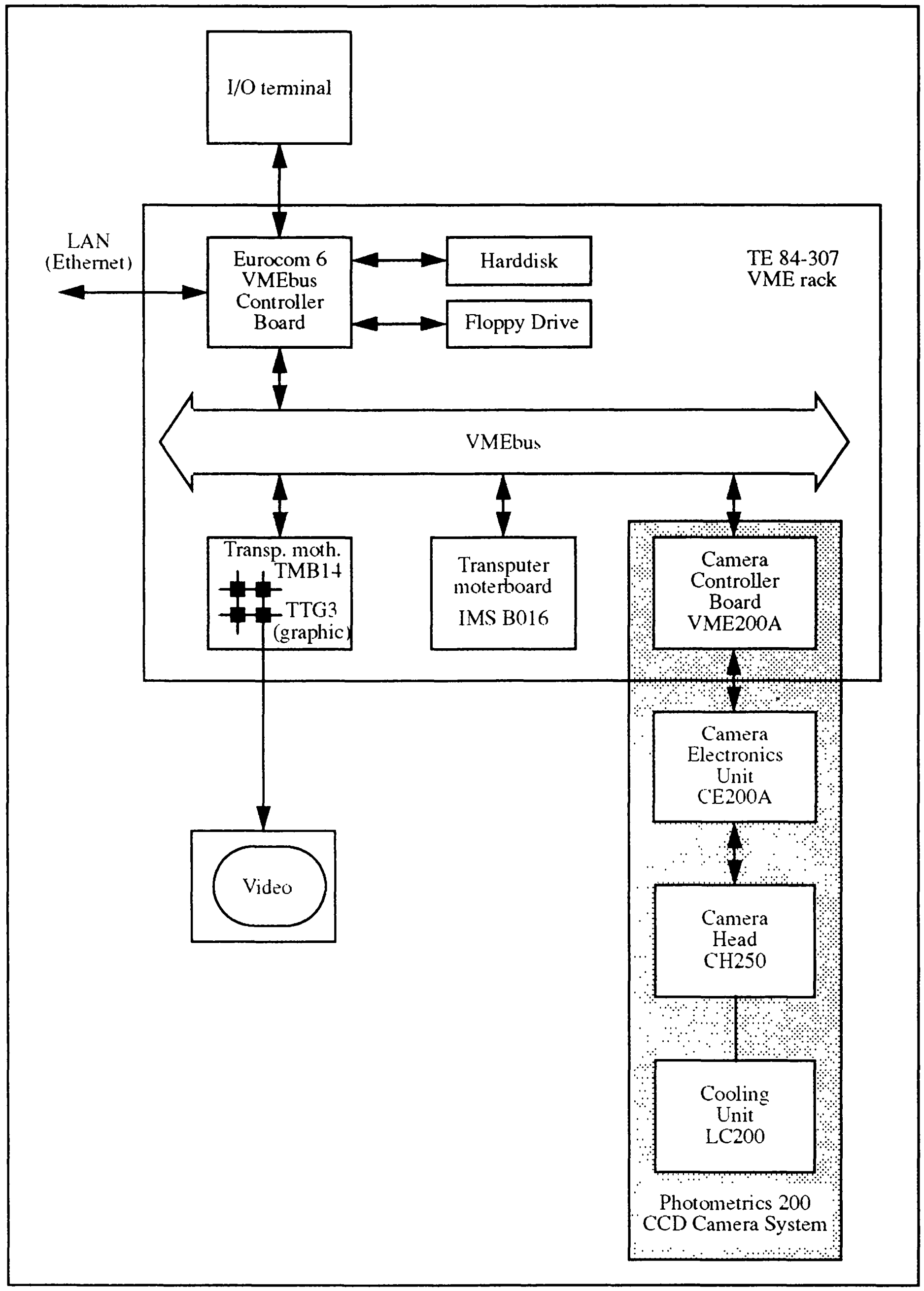

Fig. 3. Diagram of the system hardware.

Software for remote quick-look was also developed. Quick-look's function is to provide the astronomer with the possibility of understanding if an image is satisfactory or not (if the field is correct, if there is manifest over or underexposition and so on). This requires the transmission of only the relevant data. Thus lossy compression has been used.

An occam algorithm based on Discrete Cosine Transform was produced and lossy compression is now managed by the network of transputers.

Geometric and farming parallel architectures were tested. Compression ratios from 20 to 120 have been obtained, according to process images with great or small entropy. The compression of a 512x512 image took from about 3 to 7 seconds, both in geometric and in farming architecture (for DCT algorithm and test results description see Balestra et al., 1993).

4. Conclusions

A real-time system to simulate remote observing operations of CCD image acquisition and processing has been developed at OAT. This system allows CCD images real-time on-site display and compression for remote quick-look.

The system is open to further developments:

1) CCD management can be improved to allow interactive operations such as histograms, image analysis, etc.

2) higher compression rates can be achieved using refinder DCT algorithms;

3) faster algorithms can be obtained by optimizing parallel architectures;

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References

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