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Active mirror alignment control system for the MACE telescope

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Abstract : The conceptual design of an active mirror control system for the MACE telescope, being set up by the Bhabha Atomic Research Centre at Mt. Abu, is described. Preliminary results obtained from recent laboratory trials are also described.

Key words : MACE telescope-Cerenkov technique-active optics.

1. Introduction

The MACE (Major Atmospheric Cerenkov Experiment) telescope deploys a 240m^2 light collector with a high resolution imaging camera at its focus. A schematic diagram of the proposed MACE system is shown in Fig. 1. The large area light collector will be made up of 1m^2 panels each of which will have four 50cm x 50cm spherical mirrors prealigned on them. The 17m aperture and focal length of the light collector along with the large weight of the imaging camera located at its focus results in gravity induced deflections of both the mirror panels and the support structure holding the imaging camera. The deflections cause a shift in the position of the focal point of the light collector. A system for correction of this shift on the focal plane of the MACE has been devised.

2. System design

Active Mirror Alignment Control System is being developed to implement on-line correction for the gravity induced deflection of the MACE telescope structure. Each of the 240 mirror panels is supported on a single ball joint and 2 actuators. A pre-aligned laser diode is fixed on each mirror panel and 3 LEDs are fixed on the focal plane of the telescope at locations which are equidistant from the centre of the focal plane. In the vertical position the light from the laser diodes fixed on each mirror panel gets focused at the centre of the focal plane equidistant from the 3 reference LEDs. At all other zenithal angles the laser beam focuses away from the centre. The shift in position of the light spot is monitored and is converted to the direction and magnitude of movement of the two actuators of the mirror panel. Movement of the mirror panel by this computed value aligns its optical axis with the centre of the focal plane. The Active Mirror Alignment Control System consists of a CCD camera with a field of view of 4° mounted near the optical centre of the light collector and looking towards the focal plane. The camera is part of a PC based Image Processing system.

3. Image acquisition and processing

Image processing is concerned with making quantitative measurements from an image to produce a description of it. This quantitative information can be used for providing feedback to enable making

decisions or controlling complex machines like robot , aircraft or telescopes. A PC-based IMAGE PROCESSING SYSTEM is developed to monitor the shift in position of the laser light spot to compensate for the deflection of the laser beam. Figure 2 shows the block diagram of PC based Image Processing System The Image Processing System consists of ½ inch CCD camera with a 110 mm lens, a Windows 95/98 P-III PC with a video Frame Grabber card on its PCI slot and the application software. The camera is based on PAL format with interlaced scanning speed of 25 frames per second. The lens is selected to meet the requirements of Field of View, Focal Distance and the Sensor Size of the camera.

4.Image acquisition and analysis software

The PCI Frame Grabber enables to acquire the data from the camera to the host PC system memory with a maximum resolution of 760x570x24 bits. The industry standard Peripheral Component Interface Bus can transfer 32-bit wide data at 33 MHz i.e. with maximum throughput of 132 Megabytes per second.

The software is developed using VC++ 6.0 under Windows 98 . It transfers data from an area of interest of the image from screen memory to system memory and segments the image so as to include only the objects of interest in the foreground. It further extracts the centroid positions of the objects i.e. the reference LEDs and the laser diode spot. The centre position of the focal plane is calculated from the LED positions and deviation is calculated in both magnitude and direction.

The alignment of the optical axis of the mirror panel with the centre of the focal plane involves 3 major steps, i.e., determination of the deflections of the laser spot from the centre of the focal plane, collection of this deflection data and application of correction for the deflections.

The operation of the system starts with switching on the reference LEDs on the focal plane. Then the diode laser on a particular mirror panel is switched on. The image of the laser light spot and the 3 reference LEDs is acquired and transferred to the PC. This image is processed and analysed by the software to calculate the deviation and the laser spot for the mirror panel is switched off. The diode laser on the next panel is then switched on and the procedure is repeated for all the 240 panels and the deviation data for all the panels are stored in a known format. The deviation data is further converted into the direction and magnitude of the two actuators of each of the mirror panels. Movement of each of the mirror panels by corresponding value aligns the optical axis with the centre of the focal plane.

The image processing and analysis software processes the Region of Interest of the image and generates a segmented image after appropriate thresholding.It locates the blobs corresponding to LEDs and laser diode and calculates the centroids of all the blobs.The deviation of the centroid of the laser spot blob from the centre of the reference LED blobs is calculated and stored. These control operations are summarized as follows:

- Switch on LEDs.
- Switch on Diode Laser on Panel 1.
- Acquire and transfer image of the laser spot and 3 LED's.
- Process and analyse image
- Measure deviation
- Repeat for all 240 panels
- Switch off LED's and laser diode

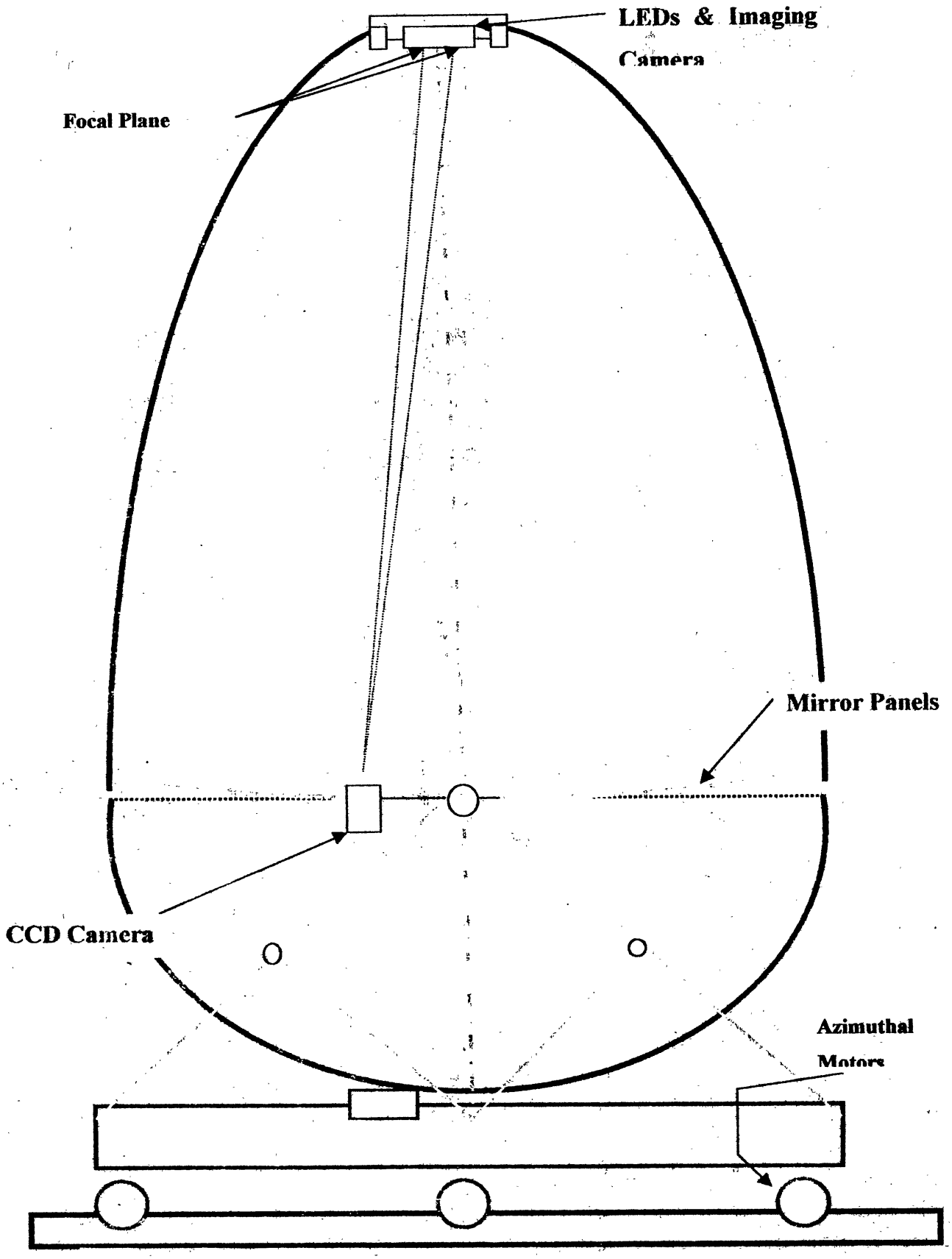

Fig. 1: Schematic drawing of the MACE telescope

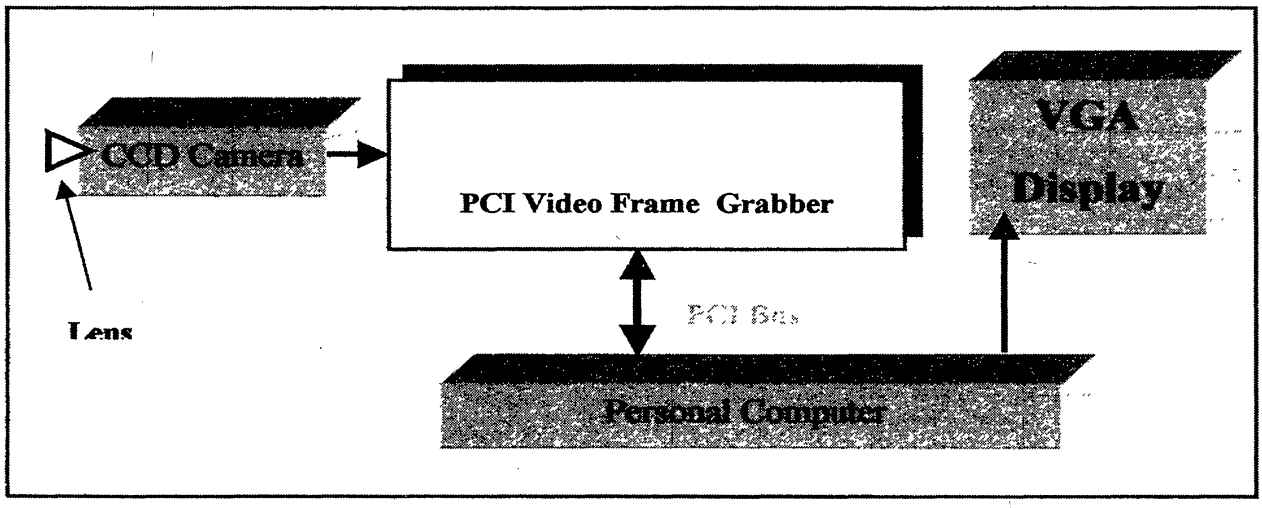

Fig.2 : Block diagram of a PC-based image processing system

Image processing and analysis software involves following sequence of operations :

Extract and transfer data from ROI.
Segmentation – thresholding.
Size filter - remove unwanted objects.
Locate LEDs and laser diode blobs.
Find centroid of all the blobs .
Determine deviation of laser spot blob.
Store the coordinates.

5. Results and Conclusions

This system has been tested at NRL, BARC, with a simulated setup consisting of single mirror panel. The total time required for image acquisition and analysis was 100m sec.