PDS MICRODENSITOMETER AT INDIAN INSTITUTE OF ASTROPHYSICS

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The PDS (Photometric Data System) microdensitometer (Perkin-Elmer model 1010 M) is a self contained free-standing flatbed scanning photodigitizer. It is designed to take accurate readings on very small areas of a photographic plate or film (hereafter called specimen) at precise locations. The system is made up of a Micro-10 Microdensitometer, a terminal, a magnetic tape system, a strip chart recorder and a D1010 A photographic playback system. Fig.1 is the block diagram of the system. Essentially, it consists of three systems: One to measure the density or transmission information, the second to move the stage in either or both orthogonal (X and Y) directions and the third to generate the precise information on stage position. The optical diagram of the microdensitometer is shown in Fig.2. Incandescent light is projected through a source aperture and focussed on to the emulsion of the photograph to be digitized. This pre-aperture minimizes stray light in the optical system by restricting the area of the emulsion being illuminated. The light from the illuminated portion of the specimen, after passing through another sample-defining aperture (called sensor aperture), is imaged on to a photomultiplier tube. The size of the sensor aperture, divided by the overall microscope magnification determines the size of the picture element used in digitizing the specimen. Photomultiplier tube, in turn, converts the light intensity into a voltage signal which is proportional to the transmittance of that area of emulsion defined by sampling aperture. After being amplified by a logarithmic converter, the resultant voltage represents the specimen density and is expressed as:

$$\text{Density} = \text{Log } 10\ (1/\text{Transmission})$$

When the specimen is moved, an analog signal is generated due to variations in the transmittance of the photographic emulsion. This signal is sampled and digitized as a function of the stage position, thus creating a numerical image which can be stored on magnetic tape for subsequent processing. The microdensitometer output consists of stage positional information and pixel transmittance, optionally in units of density, covering a density range of 5.11. The digitized data can, on

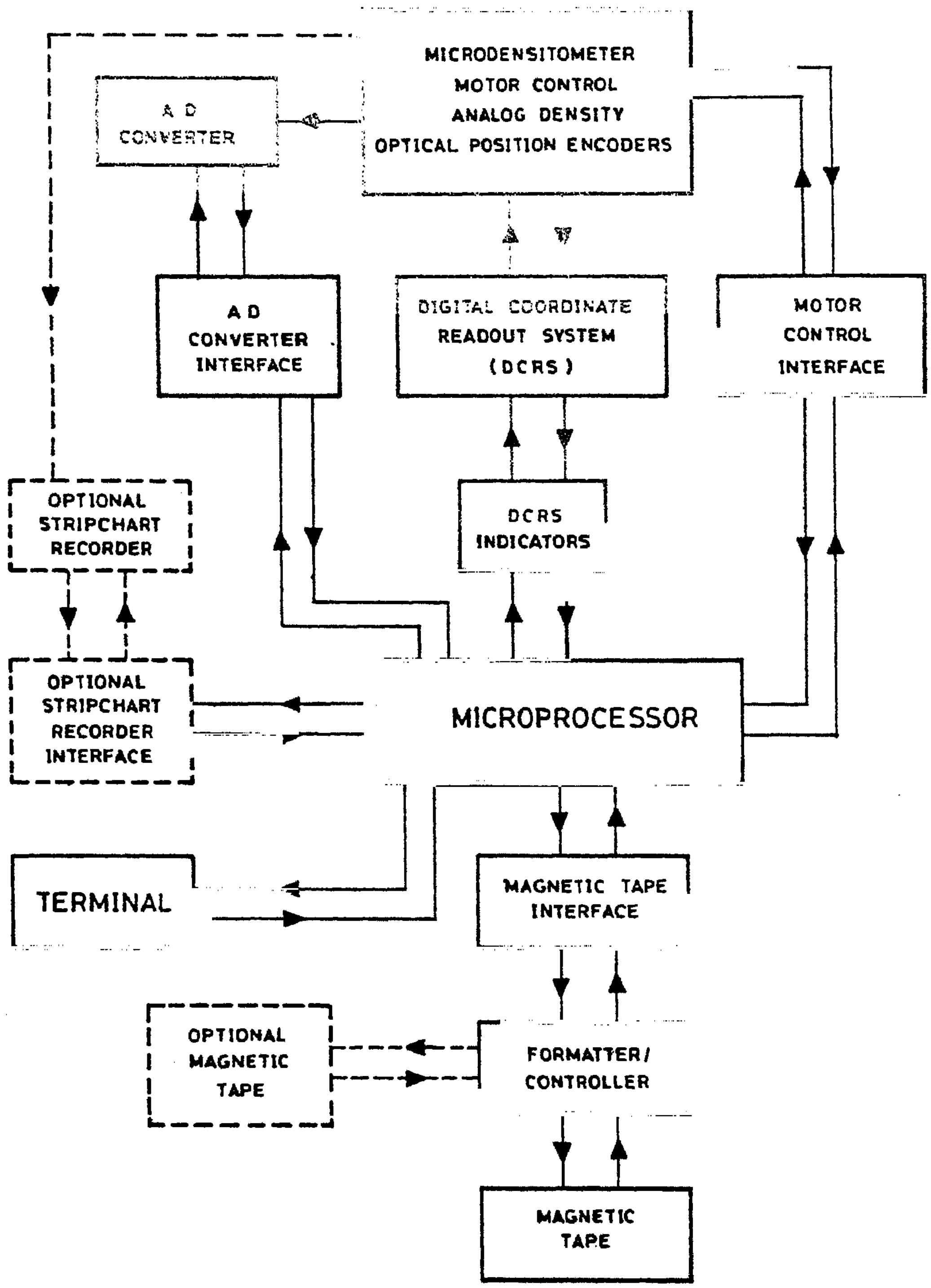

FIG.1 – THE MICRO – 10 SYSTEM BLOCK DIAGRAM

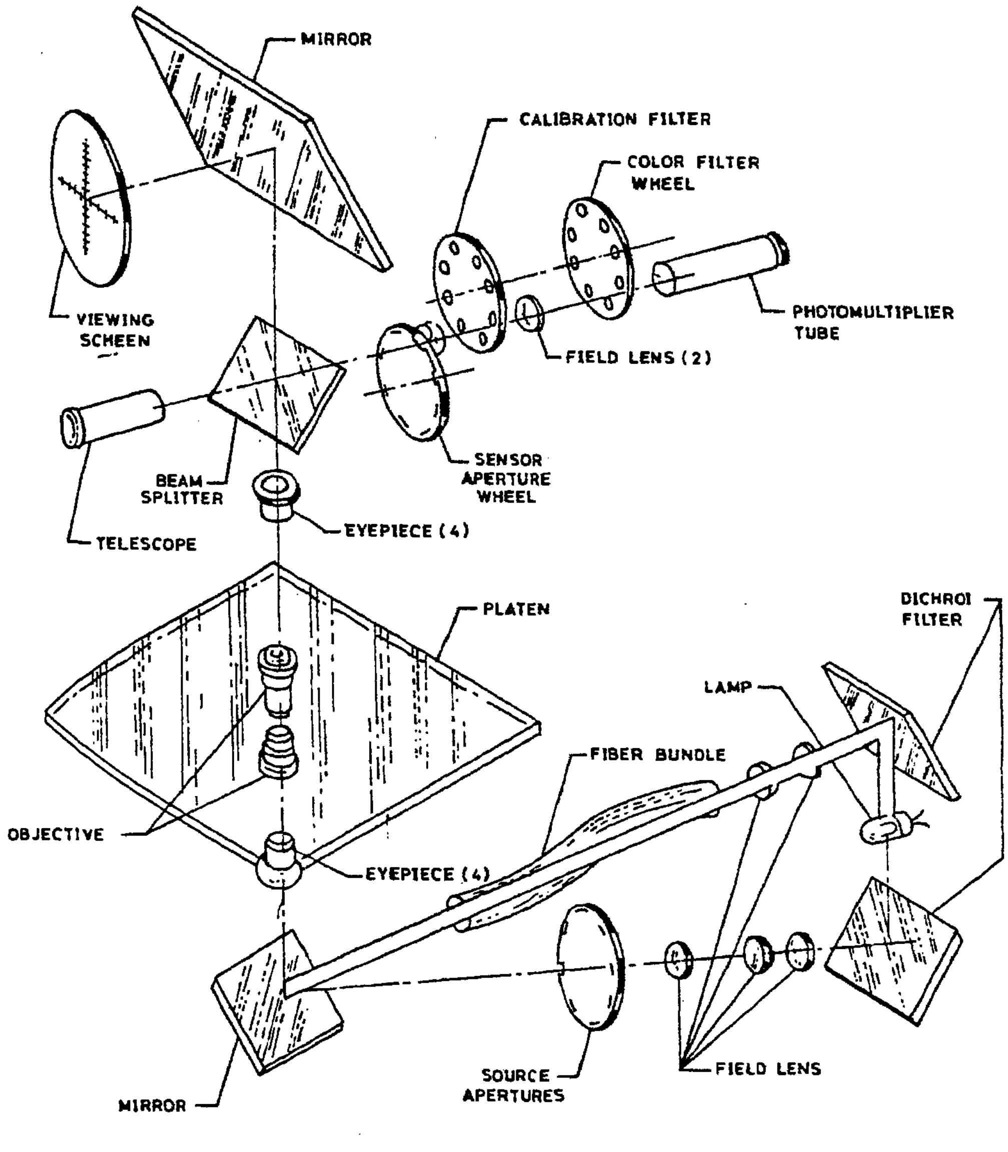

FIG.2 - LIGHT PATH IN FULL FIELD POSITION

command, be stored on magnetic tape, plotted on a strip chart recorder or printed out at the console terminal.

Low inertia D.C.Servo motors are used to move the stage in the X and Y direction. Linear optical encoders are used to determine the precise location of the stage.

The model D1010 A photographic playback system provides the facility to generate photographic image from digital images stored on the magnetic tape. A red LED (light emitting diode) light source is used to expose the film or plate on the microdensitometer stage.

SPECIFICATION OF THE MACHINE

The PDS can accommodate and digitize a maximum area of 25cm x 25cm at a maximum scan velocity of 50mm per second. The glass plates on which the specimen is fastened can be rotated manually through 360 degrees, thus facilitating an accurate alignment of scanning direction. The stage position along each axis is monitored with a precision of 1µm using linear optical encoders. The overall positioning accuracy is 5µm over the full 25cm of travel. Eight selectable aperture and four selectable magnifications provide 32 different pixel shapes and sizes over a range of 5 to 400µm (See Table 1). A set of neutral-density filters help in the selection of the optimal range of light level at the photomultiplier for a given size of sampling aperture, and the range of densities of interest. A set of colour separation filters are also available. Table 2 lists the other specifications of the microdensitometer.

USERS PARAMETERS AND OPERATION OF THE MACHINE

To set up the microdensitometer for scanning the following steps should be followed:

1. Fasten the specimen to the stage platen; adjust the scanning direction by rotating the platen and select the scanning area by moving the stage in X and Y direction.

2. Choose size and shape of the sampling aperture and accordingly adjust the sampling and source aperture wheels, optical magnification, and then focus the upper and lower microscopes. The choice of pixel size and shape depends upon the particular photodigitizing application involved. A square is the optimum shape for covering a two-dimensional area. There are no gaps and equal resolution is obtained in each axis. Rectangular apertures are used where the informational content of a specimen lies in one dimension only, as in spectragraphic lines. The advantage of the slit aperture in such a case is that high resolution can be obtained in the axis of interest while more light can be passed through the system, reducing noise. Circular apertures are used mostly for granularity studies and for statistical analysis. The spatial resolution of a digital image is solely a function

TABLE 1.
SHAPE AND SIZES IN MICRONS OF THE PIXELS AVAILABLE FOR DIGITIZING

Sensor Apertures	Magnification			
	1(50X)	2(100X)	3(150X)	4(200X)
A	20 Dia	10 Dia	6.67 Dia	5.0 Dia
B	20 Sq.	10 Sq.	6.67 Sq.	5.0 Sq.
C	50 Sq.	25 Sq.	16.7 Sq.	12.5 Sq.
D	10 x 200	5.0 x 100	3.3 x 66.7	2.5 x 50
E	10 x 400	5.0 x 200	3.3 x 133.3	2.5 x 100
F	30 x 400	15 x 200	10 x 133.3	7.5 x 100
G	50 x 200	25 x 100	16.7 x 66.7	12.5 x 50
H	50 x 400	25 x 200	16.7 x 133.3	12.5 x 50

TABLE 2.
DETAILS OF THE PHOTOMETER, ILLUMINATOR AND OPTICS OF THE MICRODENSITOMETER

PHOTOMETER

Mamamatsu	:	R 268 PMT
Response	:	300 to 650 nm
Dark Current	:	0.2 NA
Maximum Current	:	100µA

ILLUMINATOR

150W Tungsten	:	Halogen Lamp
Colour Temperature	:	3244 K

OPTICS

Objective	:	10 x .25 NA Achromet
Resolution	:	900 L-P mm^{-1}
Depth of focus	:	+ 4.4µm
Eye Pieces	:	5x, 10x, 15x, 20x

of the pixel size because in the photodigitizer, the photon flux is integrated over the entire sampling aperture. Thus, choice of the pixel size depends upon the high or low resolution digital image. High-resolution photodigitizing generates more data than low-resolution one. This requires a longer scanning time and more data storage capacity.

3. Select the mode of machine operation i.e. either density or transmission and accordingly calibrate the photometer following the procedure described in the PDS manual.

4. Input the scanning parameters. These inputs are in the form of responses to questions displayed on the control terminal. One should input direction, increment and length of scanning for both X and Y as well as the mode, speed and starting point for scanning. There are three modes of scanning namely, Raster-mode, Edge-mode and Flip-mode. Raster mode scanning consists of back-and-forth scans in the X-axis interspersed with stepwise movements in Y. Since it allows sampling in both directions of X-travel, it provides the highest-threeput photodigitizing. However, every other scan line is reversed when the serially-acquired data are stored on magnetic tape. Edge mode scanning where the sampling is done in the same direction of X-travel, provides a properly ordered magtape record, but threeput is cut half compared to earlier one. The best of both scan types is provided by the flip-mode of scanning. The specimen is raster-scanned, but the data from every other scan line is flipped so that it resembles edge mode output. A segmented scan automatically occurs whenever the number of samples per line exceeds 15,200, the maximum buffer size. In such cases, Flip mode cannot be used.

In the automatic mode of PDS scanning, the controlling microprocessor (6802) will control all microdensitometer operations according to the inputed scanning parameters. It will continually monitor X and Y stage positions, initiate analog to digital conversions and store the desired information. The format of the stored information is described in the next section.

FORMAT OF THE DATA ON MAGNETIC TAPE

Data on magnetic tape are stored in the form of a record. A record is generated at the conclusion of each scan line, or segment thereof. It consists of informations on start of record, identification, number of samples, X and Y co-ordinates, step size in X and data values in buffer. There are interrecord-gaps and after the last record of a given scanning program, a file-mark will be written. Either 800 or 1600 bpi formats can be used for storing the data on magnetic tape. Both formats utilize 9-track magnetic tape. Eight of these tracks contain data, while the ninth holds a parity bit.

The following example will give an idea about the scanning time and amount of output data for a two-dimensional scanning. Suppose one wishes to digitize 50mm x 50mm area of the specimen using 5M square aperture; 5μm step size along both X and Y scanning time will be 2 x 10^4sec and digital output will be 100 M6.

CONCLUSIONS

The high precision and measuring speed of this machine and automatic nature of its operation make it a valuable tool for many investigations besides astronomy. Many new branches of applied science such as digital cartography, electron microscopy, medicine, radiography, remote sensing etc. are immensely benefitted by this new instrument.