GROUND BASED DEVELOPMENTS - REDUCTION SYSTEMS

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ABSTRACT

The reduction of Schmidt plates is divided into scanning the plates, processing the data, and analyzing the results. At least two new measuring machines for analyzing Schmidt plates are being designed which will increase the total throughput to over 10 plates per day. The developments of microprocessors and mass storage open new possibilities for faster and cheaper processing of these large amount of data. Finally, the introduction of DataBase Management and Table Data systems will make it easier for astronomers to analyze the extracted informations. With these new developments the aim to make a detailed analysis the plates at the same rate at which they are obtained can be achieved within this decade.

1. INTRODUCTION

The reduction of Schmidt plates can be divided into the three subsequent steps, namely : digitizing the plates, locating and classifying objects on them, and finally analyzing these data in order to obtain astronomical results. The main difference in analyzing Schmidt plates compared with data from other area detectors is the amount of data. A 30 cm * 30 cm photographic plate contains approximately 1 Gpixel being equivalent to 5000 standard CCD frames or 400 images from the Space Telescope Wide Field Camera. Since several such plates are taken per night the total amount of data coming from Schmidt telescopes is orders of magnitudes larger than that obtained from other astronomical image detectors. As a result only a small fraction of the Schmidt plates available have been studied fully by means of digital technichs. Thus, the main aim for the future development of reduction systems for this type of data is simply to analyze this material properly at the same rate at which they are obtained. Several recent advances in hardware and software technics have made it possible to achieve this goal within the present decade. These new

M. Capaccioli (ed.), Astronomy with Schmidt-Type Telescopes, 571–575.

technics and their impact on the three reduction steps are discussed below.

2. MEASURING MACHINES

The first step in the reduction of a Schmidt plate is to digitize its photographic information. Important properties of this process are the range of densities which can be measured correctly, and the rate with which it can be done. Estimates of these two quantities assuming a 10 micron squared aperture are shown in Figure 1 for a number of measuring machines. Due the large differences between the machines the data given should only be regarded as an indication of their performances within an order of magnitude.

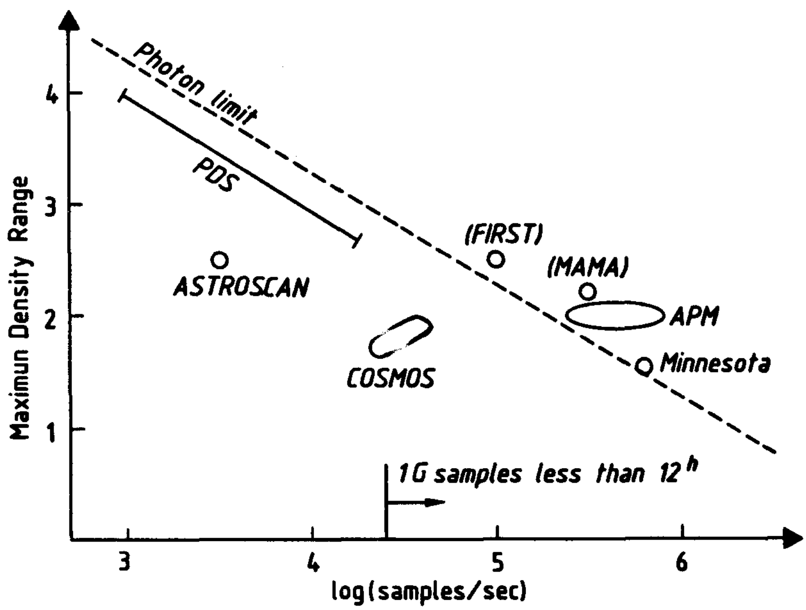

Figure 1 : Maximum density range as a function of sample rate for measuring machines (see text for explanation).

The two machines written in parentheses (i.e. FIRST in ESO-Garching and MAMA in Paris) are being designed and constructed at present. In the diagram the line 'Photon Limit' gives the possible location of a single aperture microdensitometer with a numeric aperture of 0.167 and a standard halogen lamp as light source assuming a sampling time of 0.1 times the sample interval and a maximum density deviation of 0.01. The position of the line will be shifted if a different set of parameters is chosen. Two of the four machines placed over the line are using lasers for illumination (i.e. APM and Minnesota) while the other two have array detectors (i.e. FIRST and MAMA). The maximum density range

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for these machines is limited rather by stray light than by photon statistics.

Two scanning modes are normally used for digitizing information from Schmidt plates, namely : search mode where objects over a large area of the plates are found, and raster scan mode where objects with known positions are measured. The sample rate is of prime importance for search mode whereas a lower maximum density can be accepted because the majority of the objects will be faint. A scanning time of 12 hours for one Schmidt plate (i.e. approx. 25 K samples/sec) is a practical limit at which it becomes feasible to analyze many plates. The fast array detector or laser scanner machines are built for this type of work but they are only marginally suited for detailed measurements of brigther objects. That can be done in raster scan mode where the limited number of object makes it more important to achieve high densities than to scan fast. This is of special interest for the newer emulsions (e.g. IIIa-J) with their very high saturation densities. Due to stray light problems it can only be done on machines having a single matched set of preslit and aperture (e.g. PDS).

Including the two machines being designed the total throughput of Schmidt plates analyzed in search mode will soon become larger than 10 per day. The production of deep exposures from Schmidt telescopes is of the same order. The measurement of plates will therefore not be the limiting factor in the reduction. It should, however, be noted that the geographic distribution of these machines is far from uniform. Also concerning the study of single bright objects an increasing amount of single aperture microdensitometers (e.g. PDS) is becoming available.

3. PROCESSING OF DATA

Only the processing of the large amount of data produced in search mode pose a problem whereas data from raster scan mode normally are so few that they easily can be handled by standard image processing systems (e.g. IHAP or MIDAS from ESO, GIPSY from Groningen, IPPS or FOCAS from KPNO, AIPS from NRAO etc.). The algorithms for detection and classification of objects on Schmidt plates are well known (see e.g. Bijaoui,1979 and Stobie,1980). The main problem is to process the data at the same rate at which they are digitized (i.e. larger than 100 KHz) in order to reduce them before they are further analyzed. The present high speed measuring machines are using special hardware to performe these computations. However, the recent development of fast 16-bit microprocessors (e.g. MC68000 from Motorola and Z8002 from Zilog) makes in possible to used such devices. Most of the operations needed for object detection and classification can be done using 16-bit integers. A comparison of three standard processors is

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shown in Table 1 for this type of operations.

Table 1: Relative performance of different processors for 16-bit integer operations.

Processor	Compiler	Optimized	Rel. performance
MC 68000	C	No	1.0
MC 68000	Assembler	Yes	2.1
HP 1000F	Fortran	No	1.0
VAX 11/780	Fortran	Yes	1.8

It can be seen that microprocessors such as MC68000 have a performance which is equivalent to that of standard mini-computers. The large difference between assembler and C code is due to an optimized use of the many internal registers in assembler. Further, the microprocessor systems are at least an order of magnitude cheaper than the mini-computers mentioned in Table 1. Since both multi-task operating systems (see Tinnon,1982) and cross-compilers for high level languages are available the use of microprocessors for detection and classification algorithms is more cost efficient also when development costs are included.

The increased capacity of mass storage will soon make it feasible to store the original digitized data directly. The storage density on optical devices has exceeded that of Schmidt plates and will in the coming years reach approx. 100 times higher value (Ohr,1983). When such densities are obtained a distribution of optical digital disks containing measured data from plates would be possible instead of reducing the data before making them available. This would have two advantages, namely : that the reductions could be done at the astronomers home institute, and that different routines optimized for the individual application could be used. By spreading the processing task to more institutes the load on the individual installation would further be made smaller.

4. ANALYSIS OF EXTRACTED DATA

The result after processing the plates is a set of data describing each of the objects found. In order to extract physical informations from these data their internal statistical properties have to analyzed, and they must be compared with other available data. Most present image processing systems do not provide such facilities to the user who therefore must do this time consuming task for his individual data. It is, however, possible to make a system which operates on table with heterogeneous data instead of images (see Ponz and Grosbøl, 1982). By defining commands which performe statistical operations and tests on the tables the user can analyze the internal distributions of his data in an efficient way. The second problem is to find other available data related to the material and to compare it with the data obtained. The bibliographic search for references and data is very normally very slow. This type of information is now becoming available in data bases at different centers. Access to these data through DataBase Management Systems will also greatly improve the efficience of final analysis. Especially, when the data found can be directly transfered to the table processing system.

5. CONCLUSION

The measurement and processing of the data from Schmidt plates will soon be able to keep up with the incoming material. The main challenge for the reduction systems is to provide flexible tools for the users to analyze their final data. First then it will be possible for the individual astronomer to obtain result from this vast amount of information in a limited time. The availability of such reduction facilities would also interest more people in doing research on Schmidt plates.

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REFERENCES

Bijaoui,A.: 1979, Image Processing in Astronomy, Eds. G.Sedmak, M.Capaccioli, R.J.Allen, Trieste, pp. 173-185.
Ohr,S.: 1983, Electronic Design Vol.31 No.17 , pp. 137-146.
Ponz,J.D.,Grosbøl,P.: 1982, Tables in MIDAS, ESO-Garching.
Stobie,R.S.: 1980, SPIE Vol.264, pp. 208-212.
Tinnon,J.: 1982, Electronics Vol.55 No.8 ,pp. 137-140.

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