Legacy Data: The Longer the Base-line, the Richer the Survey

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This conference has dwelt exclusively on wide-field surveys that have been carried out recently, or are being planned, by exploiting modern technology: highly sensitive CCDs with rapid readouts that feed the time domain as never before, or multiobject spectrographs that can multi-task. But we must not forget that wide-field astronomy has been a topic of research for longer than any astronomers in this room can remember, and longer even than the IAU itself. The (in)famous *Carte du Ciel* commenced in 1887 with the objective of monitoring the whole sky and searching for changes in position or brightness, and while we need not necessarily emulate some aspects of the way that project was carried out we *do* do well to remember that not all objects will conveniently do their thing within the relatively brief time-spans of modern observing and surveys, and that the only – the *only* – handle we can ever have soon on those very numerous oddities is through studying our legacy data. Old technology they may be, but our photographic plate stores contain images that will never be repeated in every detail, and are thus a vital adjunct to modern images and modern research.

When a photograph is exposed, an image of the object falls on the emulsion, which consists of light-sensitive elements. Once the emulsion is "fixed" through developing it, the information within each element becomes permanent, and the challenge is to "read" it in a way that is completely faithful, by transforming it correctly into a digital signal and recording it in an electronic format. The chief pitfalls are (1) positional fidelity, requiring that the digitizing equipment be stable, and (2) correct handling of the response which the emulsion has to incident intensities of differing strengths. That response is non-linear, so auxiliary *calibration* information has to be included along with the photograph itself.

All this has been standard knowledge for nearly 130 years; what Hurter & Driffield (1890) worked out then has been accepted globally as the definitive explanation and the basis of intensity calibrations. However, an important aspect of those calibrations is their strong dependence upon the treatment of each emulsion: its age, storage conditions, exposure time, exposure type, any hypersensitization (e.g., baking), details of its development, and physical measurements of the equipment used to create the auxiliary information upon which the calibration relation rests. This information should be available in the relevant log-books, or wherever the plate metadata are stored. But the individuality of each exposure or emulsion *must* be respected; the quality of the output depends on doing so; there can be no short cuts.

The equipment originally built in the 1970s by PDS (= Photometric Data Systems) to digitize photographic observations was designed to cope correctly with those basic challenges. It yielded very reliable results, and PDS scanners were common throughout astronomy's research world. The regular ones (the 10–10 model) could handle plates measuring up to 10 × 10 inches; the less common, larger one (the 20–20 model, usually on a granite base rather than a metal stand) could manage correspondingly larger plates, and was principally intended for astrometric series. The 10–10 was used mostly for scanning spectra, which it could do well. However, since the PDS was designed to measure the throughput from each pixel sequentially, a serious limitation was the speed with which it could work. Spectra – even high-dispersion coudé ones – took only a number of minutes at maximum speed, but a direct 10 × 10-inch plate took over a day to be scanned entirely, constituting an overhead that could be hard to accommodate.

On the other hand, abandoning those older – if somewhat megalithic – machines for the expedience of a commercial flat-bed scanner is *not* the answer, as they do not satisfy either of two basic requirements. Flatbed scanners are designed to produce a "picture", as opposed to a scientific image, of the information in a sample. In order to make a scan rapidly, the sample is flooded with light and the whole, or sections of it, imaged onto a CCD. Large and unquantifiable amounts of light are thereby scattered into different parts of the output. Moreover, the scanner itself is not as rigid a construction as is needed to be capable of high-performance positional precision and repeatability.

New technology can go some way to meet the two requirements of speed and photometric precision, as exemplified by (i) the instrument built at Harvard (*DASCH*) for scanning its archive of 500,000 direct plates within 5 years (http://dasch.rc.fas.harvard.edu/project.php), and (ii) a newer machine constructed in Shanghai (Yu 2017) for scanning China's collated archive of direct images. In both cases, and in view of the potential (and limitations) of the respective plates in question, making certain approximations to cope with the intensity calibrations were considered less serious than the positional fidelity. However, high-quality spectra should still be digitized with a PDS, of which Canada astronomy owns two that could be used.

The results obtained, in particular by *DASCH* (which has been producing output for several years now) are exciting, fascinating and surprising, and suggest the huge wealth of information which is still untapped in astronomy's plate archives. Now is therefore an excellent time to gather up those with knowledge of, and interest in, scanning the plates in order to comb them for new information about variables or planetary system objects. Time is short; the plates themselves are ageing but – barring accidents and natural hazards – the ageing is relatively slow. Of greater concern are human attitudes; the data are not accessible, and the task of scanning a plate at an observatory that lacks both equipment and expertise is enough to deter most researchers, and someone in authority is likely to declare a plate collection "unwanted" and thence dispose of it on the grounds that it has not been used very recently. Furthermore, those with relevant expertise are getting fewer and memories are vanishing.

These concerns have been recognized. At its recent General Assembly the IAU adopted a new Resolution (B3 2018) which encourages efforts to digitize our plate archives and to make the output and the associated metadata fully accessible to the community. It accepted the need to act before it is too late, and it anticipated the need for astronomers to give priority to these efforts on behalf of the whole community. In relation to the kinds of budgets which new telescopes require, the scanning of plate archives can be accomplished with much lesser sums, particularly if the new scanners can be cloned and their working parts shipped to observatories, where installation and working procedures could be supervised and taught, and would thus not require the R & D which has already been carried out. The small group presently urging this project forward welcomes your support.

References

Hurter, F., & Driffield, V.C., 1890. J. Chem. Soc. Ind., 9, 455
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