International Association for Pattern Recognition, Inc
An affiliate member of the International Federation for Information Processing

NEWSLETTER

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From the Editor's Desk

This issue sees, by popular demand, the return of the summary of forthcoming conferences, workshops, *etc.* — see the back page. If you are organising, or merely know of, meetings that may be of interest to the readership, please let the editor know. A fax or brief e-mail message is all that is needed.

The restoration of imagery from the Hubble Space Telescope is currently an active research topic in the astronomical community, including IAPR TC-13; an article on this subject is presented in this issue by the Chairman of TC-13, Dr. Fionn Murtagh.

Also in this issue is the call for nominations for the King-Sun Fu Award, to be presented at the 11th ICPR next year. Please note the deadline for receipt of nominations by the Committee Chairman, Dr. Saburo Tsuji.

The Editor

Articles for inclusion in the *Newsletter* are always welcomed, and may be on any subject likely to be of interest to the IAPR community. They should be submitted, preferably electronically, directly to the editor at the above address.

HST Image Restoration: A Short Overview

THE HUBBLE Space Telescope (HST) was launched from the Space Shuttle Discovery on 24$^{\underline{\text{th}}}$ April 1990. HST, with a 2.4m primary mirror and six scientific instruments on board, is a joint NASA-ESA observatory in low-Earth orbit with an expected life-time of 15 years. On June 21, 1990, it was announced that proper focussing of the telescope was prevented by a flaw in the optics, now known to be spherical aberration in the primary mirror. Refurbishment Shuttle missions to upgrade instruments were foreseen from the beginning, and the first such mission in 1993 will install correcting optics in the optical path at the same time as upgrading one of the instruments. In the meantime, image restoration techniques have assumed very great importance in efforts to remove some of the degradation due to spherical aberration. Image restoration methods have for a long time played a central role in synthetic aperture mapping in radio astronomy. In optical astronomy, including near-optical infra-red and ultra-violet wavelengths, restoring images blurred by atmospheric turbulence ("seeing") has been less widely practised, for understandable reasons.

HST image restoration is made both difficult and challenging for reasons such as the following.

- The point spread function (PSF) — the instrument response to a distant point source, characterising the deformity of the image — can be large relative to the image dimensions, even though the frame dimensions are up to 1600×1600 pixels.
- The PSF is richly structured (Figure 1), with significant response at spatial frequencies up to the diffraction limit.
- Depending on the instrument, the PSF can be space-variant, and it is dependent on wavelength at which the object is viewed.
- Noise is signal-dependent and therefore non-stationary.
- Point sources, which exhibit high contrast, could be said to be "edge only" objects. Edges are known to be difficult to restore. Correlations between adjacent pixels are quite different in the case of extended objects — galaxies and jets, for example.
- Theoretically, the PSF can be modelled from a physical understanding of the total optical path, except (so far) at far ultraviolet wavelengths. This is advantageous from the point of view of restoration.
- Known instrumental distortions require calibration, which has very adverse effects on the high frequency part of the optical transfer function, as well as on the noise properties of the images to be restored.
- Finally, the astronomer requires quantitative evaluation, including error analysis of image data. This also holds true for restored images.

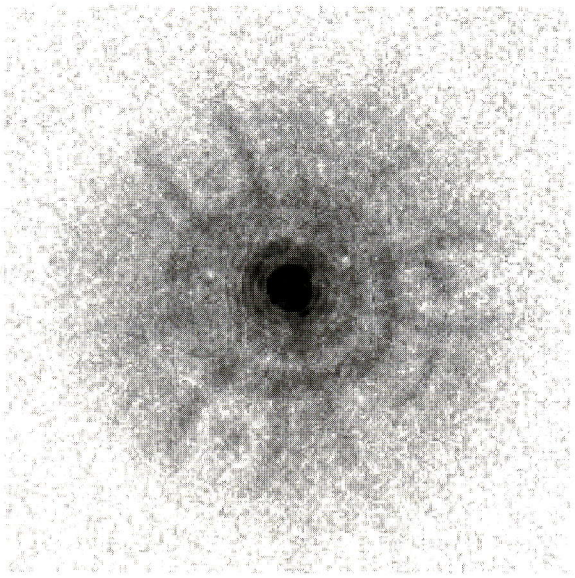

Figure 1: A Faint Object Camera Point-Spread Function. All images are scaled logarithmically in intensity.

In many ways, there is a good understanding of the imaging process, including noise. Prior knowledge, *e.g.* the non-negativity constraint, is available. One could also maintain that there is limited complexity in most astronomical scenes. Some of these issues will be further touched on in the remainder of this note.

The PSF has the now-familiar appearance of a "squashed spider" (Figure 1). Being indicative of how light is distributed, a well-chosen PSF is pivotal for good restoration. Using physical models of the optical path, simulations of PSFs constitute one way to obtain PSFs for a given instrument, configuration, filter combination, wavelength of observed source, and other varying physical and environmental properties. Alternatively, and what has been primarily done to date, an empirical PSF is availed of, which matches as nearly as possible the properties of the imaging chain at the time of the exposure. For fields of fairly isolated stars, which approximate ideal point sources, such an empirical PSF can be selected carefully, or averaged from a number of stars.

The two cameras among HST's instruments present quite different characteristics from the restoration point of view

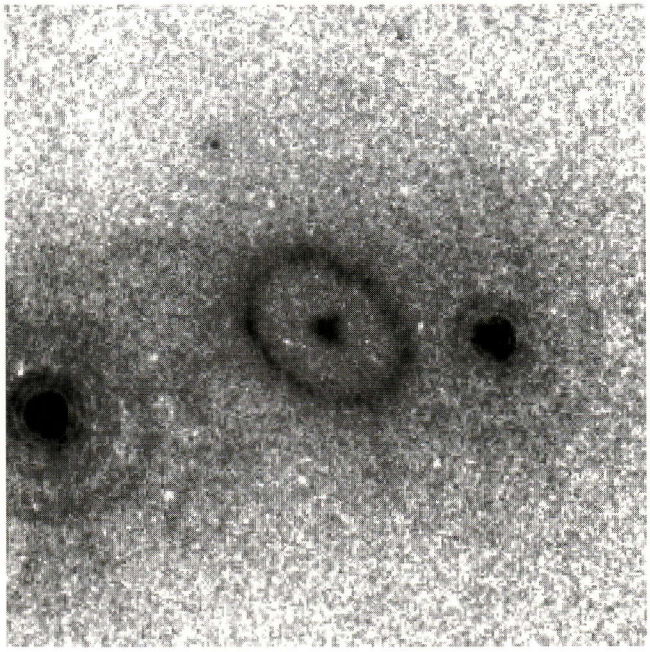

Figure 2: Original FOC (composite) image of supernova 1987a. Reseaux marks (in white) are visible. The cores of the two very bright stars, and of the supernova within the ring, show geometric distortion.

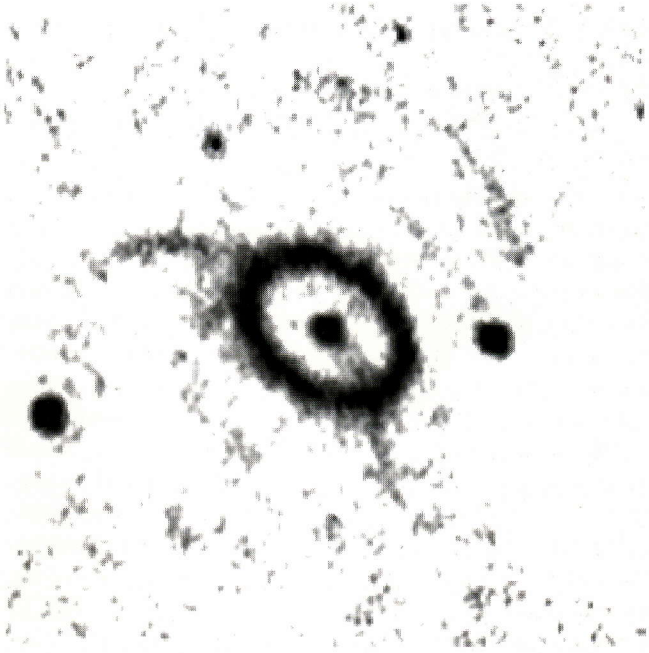

Figure 3: Richardson-Lucy restoration (40 iterations) of image in Figure 2.

[11]. The Faint Object Camera (FOC) is a photon-counting device; Poisson noise characteristics therefore predominate. The FOC full-frame image dimensions are 1024×1024 pixels. In one of its three focal ratio configurations, the PSF fills almost the entire field of view. The limited dynamic range of the FOC means that bright stars near the object of interest will be saturated (Figure 2). The FOC also suffers from significant geometrical distortion.

The Wide Field and Planetary Camera (WF/PC) uses 8 charge-coupled device (CCD) chips as detectors, with Gaussian noise properties in addition to the Poisson noise of the incoming signal. The usual WF/PC image dimensions are four quadrants, each of 800×800 pixels, yielding 1600×1600 image frames. An added complication with WF/PC restoration is that the PSF varies over the field of view, due to obscurations in the WF/PC repeater optics. Saturation in the WF/PC may also cause charge in the CCD to "bleed" into adjacent pixels. Cosmic ray hits — either direct or as secondaries produced from the instrument housing — can be very numerous, and if not removed or allowed for as bad pixels in the restoration, can wreak havoc with the result obtained. All of these detector characteristics have to be borne in mind, and parried or pre-empted where possible.

Image undersampling is common to the FOC and the WF/PC: in the WF configuration, pixels are almost twice as big as the core of the PSF. This severe undersampling makes resampling of a recorded image very problematic; and it limits the extent to which reconstitution of a desirable image is possible through image restoration. On the other hand, the possibility of super-resolution through image restoration presents an interesting opportunity here.

The astronomer wants quantifiable information from an image — relative positions and photometric magnitudes of stars, luminosities of galaxies, and quantitative assessment of the presence or absence of image features and artifacts. On top of detector non-linearities, the use of more powerful non-linear restoration techniques makes it more difficult to provide quantitative statements related to such aspects of the image. It is clear, though, that visual clarity in the interpretation and assessment of image data is of vital importance, and this can be considerably aided by restoration techniques.

The principal methods used at present [10, 1, 2] are linear methods, the Richardson-Lucy iterative method, and variants of the maximum entropy method. Linear transformations [5] such as the inverse or the Wiener filters provide quick restorations at the expense of ringing around bright objects, and severe background mottling. The Richardson-Lucy method [7, 6, 8] has quickly gained reputation in the optical astronomy arena (see Figure 3). Being an iterative technique, which converges to the maximum likelihood solution in the case of Poisson-distributed data, it provides visually-acceptable solutions at a reasonable cost in machine and in human (image preparation) time. It preserves flux globally. The method is fairly tolerant of imperfections in the PSF used. In the case

of the spatially-invariant PSF (discussed above), the convolutions involved in this method can be implemented as Fourier transforms. In the case of spatially-variant PSFs, experimentation to date has mainly concentrated on assuming spatial invariance in subimages.

A method presenting long-term promise is the versatile maximum *a posteriori* method with an entropy prior [4]. A recent innovation in the framework of maximum entropy-based restoration is the use of "multiple channels", defined by the use of intrinsic correlation functions [9]. These play the role of goal PSFs, and are used to take inter-pixel correlations in the signal into account. The conjoint use of differing input image data frames raises the appealing prospect of making use of all relevant images, even images from ground-based and space-borne instruments, for an improved restoration. Other methods and techniques which could play a role in the future include: locally-adaptive restoration techniques; the use of the wavelet transform as a generalisation of the Fourier transform; the projection-onto-convex-sets (POCS) approach; and "hard modelling" as described by [3].

References

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The First Israel–Italy Symposium on Computer Vision

THE FIRST ISRAEL–ITALY SYMPOSIUM on Computer Vision was held on 31st of May, 1991 in Capri (Italy). It was chaired by Prof. Shmuel Peleg of the Hebrew University of Jerusalem and Prof. Leila De Floriani of the University of Genova. This event was organised by the IAPR and the IMA/CNR, and sponsored by the NCRD and the CNR. During the Symposium, relevant activities being carried out in the two countries in the fields of computer vision, image analysis and machine vision were illustrated. The two scientific delegations agreed to set up a cooperation between universities and research institutions in Israel and Italy. The Israeli and Italian chapters of the IAPR will also exchange information concerning scientific activities, and will promote and organise joint activities.

Prof. H. Yeshurun (President, Israeli IAPR chapter)
Prof. V. Di Gesú (President, Italian IAPR chapter)

IAPR Executive Committee Meeting

THE IAPR Executive Committee (ExCo) held a meeting at the *International Workshop on Visual Form* (a very nice workshop indeed!) on 28th May 1991 in Capri, Italy. A number of things were discussed and decided at this meeting. This report is an extract from the official minutes.

The treasurer's report showed that the IAPR economy is satisfactory.

Prof. Takagi, the Technical Committee (TC) committee chairman, reported on TC activities. The activity level in the different TCs is very varied; workshops were held in 1990 — or are planned for 1991–92 — by TC-1 (Statistical Pattern Recognition Techniques), TC-2 (Structural and Syntactical Pattern Recognition), TC-6 (Special Purpose Architectures), TC-7 (Applications in Remote Sensing), TC-8 (Applications in Industry, new chairman Prof. J. Sanz), TC-10 (Map and Line Drawing Processing), TC-11 (Applications in Text Processing), and TC-13 (Pattern Recognition in Astronomy). TC-5 (Benchmarking and Software) is making a survey of software systems in the IAPR area of interest. TC-10 has compiled a bibliography of papers relevant to document image analysis, which is available from either `kasturi@cmpe.psu.edu` or `log@research.att.com`. The rest of the TCs, sadly, had no activity to report, or did not report what they are doing.

The procedure for getting IAPR sponsorship for a meeting was discussed and it was generally agreed that the current procedure is too complicated. There will in future be two kinds of sponsorship: general approval and general approval with financial help (normally a loan). It was suggested that the procedure should be different in the two cases. The following procedures where outlined:

1. The organisers send a request for sponsorship, together with relevant material, to the Conferences and Meetings chairman (presently Prof. S. Levialdi). He then checks that the meeting complies with IAPR standards and with its Constitution and Bylaws. He also checks that the local governing board (GB) member(s) approves of the meeting. If no financial support is requested the C&M committee then decides on sponsorship or not, and notifies the organisers and the Secretary of the result.

2. If financial support is requested, this decision must be taken by the ExCo. The C&M chairman should present the case to the committee, after discussion with the treasurer. After the decision is taken, he notifies the organisers.

3. All IAPR-sponsored meetings should be announced in the *Newsletter* one year ahead. After the meeting, the organisers must write a note on the meeting for the *Newsletter*.

4. In each *Newsletter*, a list of all forthcoming IAPR-sponsored meetings will appear. This list will be prepared by the Secretary.

Gunilla Borgefors, IAPR Secretary

For those of you organising a meeting I would like to remind you of the ways to get in contact with the Conferences and Meetings Chairman:

Prof. Stefano Levialdi
Scienze dell' Informazione,
Università degli Studi "La Sapienza",
I-00198 Roma,
Italy.
Tel: +39 6 8841962 or +39 6 8841967
Fax: +39 6 8841964
Email: `levialdi@astrom.lbl.bitnet`

As you read in a recent Newsletter, Prof. V. di Gesù has suggested the formation of a European IAPR chapter, consisting of the 18 local IAPR societies. The meeting decided that further work is necessary before any decision can be taken. It was suggested that di Gesù should prepare a ballot to the GB, consisting of some questions on their opinion on this matter. Based on the result of this ballot, a proposal can be prepared for the GB meeting in The Hague. Prof. di Gesù welcomes all comments on this, both from European and non-European members.

Dr. M. Ejiri has prepared a number of proposals for improvement of the IAPR contacts with industry. These were

also published in a recent Newsletter. He has unfortunately not received many comments on these proposals. The meeting thought that most of the suggestions were good. The president asked Dr. Ejiri to prepare a proposal for the GB meeting in The Hague, based on the original proposals and the comments.

The membership committee chairman (me) reported tentative contacts with a number of countries that are, or could be, interested in IAPR membership. At least one or two new societies are expected to join us at the next GB meeting. (All suggestions and information on suitable societies are welcome!)

At the 10th ICPR in Atlantic City, some concern about the safety of arranging a conference in Jerusalem was voiced. The recent Gulf War has again raised this issue. It was agreed that it is in nobody's interest to arrange a meeting to which many scientists will hesitate to come. However, it was also felt that the situation had not changed significantly from that when the decision on the venue was taken. The meeting concurred that a final decision on change of the venue can be taken *no later than the end of 1991*. After that, no change will be made. This is to avoid any repetition of the situation that ended in the regrettable and late change of venue for the 9th ICPR. If you have any strong feelings on this subject, please report them to the President or me as soon as possible.

The result of the ballot for appointing the Nominating committee was reported by the Secretary (me again). Some 28 'yes' votes have been received regarding the President's suggestions; there are no 'no' votes, and 9 have not voted. Thus we have the following nominating committee: M. Levine, Canada (chairman); H. Niemann, Germany; M. Pietikäinen and S. Tanimoto, USA; J.-I. Toriwaki, Japan.

Gunilla Borgefors
IAPR Secretary

Book Review

Interpretation of Visual Motion: A Computational Study by M. Subbarao. Pitman, London. ISBN 0-273-08792-4

IT WAS A GREAT PLEASURE for me to read this book. I consider it an excellent introductory text for all those who are interested in working on structure and shape from motion. The book is concise and gives a clear insight to the meaning and nature of the image flow equations and their solutions. All the mathematical details are contained in ten appendices that constitute about a third of the book.

The basic idea is to infer the structure (slope and curvatures) of a rigid object, and the velocity with which it moves, from the information obtained by the image velocity field arising from the projection of the motion of the object on the image plane. We learn that this is unambiguously possible only for curved surfaces, while for planar surfaces there is a two-fold ambiguity.

There are two ways of resolving this ambiguity: the first is the spatial consistency requirement where one considers two or more planes rigidly attached to each other. Such planes will have different orientation parameters, but they will move with the same velocity. The second way to resolve ambiguity is the temporal consistency requirement that the plane orientations at a certain instant in time should be consistent with the plane orientations at the immediately proceeding instance in time plus the motion information at that time.

The use of temporal information seems to be important: One can trade off the calculation of noisy second order derivatives of the flow field with the calculation of the first order temporal derivatives.

Towards the end of the book, the rigid body assumption is dropped and the general formulation of the problem is given. It is shown there that the solution of the image flow equations will always be an underdetermined problem: the more equations we incorporate by considering higher order terms in the Taylor series expansion of the velocity field, the more unknowns we introduce. So, there is always a need for extra constraints.

I found the book fascinating for its clarity and the insight it gives. It was very interesting to see how an estimate of the upper limit of the velocity of an approaching object can be inferred from the first order derivatives of the velocity field of the image. "Thus an organism can, in principle, quickly evaluate the potential danger of an approaching object from only coarse information."

The book concludes pessimistically, or maybe optimistically, depending on your point of view: many problems remain unsolved in the field. So, if you get excited by the subject, go ahead, there is plenty of work to be done and reading this book is a good starting point!

Maria Petrou
University of Surrey

Missing Societies Alive and Well

AFTER MY ENQUIRY in the last issue of the *Newsletter* about hard-to-contact member societies, I quickly heard from both the Israeli society (which has had major problems with e-mail) and the Portugese society (which has changed officials). They ask me to ensure everybody that they are alive and well — and growing, with 120 and 50 members respectively.

Gunilla Borgefors
IAPR Secretary

Nominations for the King-Sun Fu Award for 1992

THE INTERNATIONAL ASSOCIATION for Pattern Recognition (IAPR) is pleased to call for nominations for the 1992 **King-Sun Fu Award** in honour of Professor King-Sun Fu. Dr. Fu was instrumental in the founding of the IAPR, served as its first president, and is widely recognised for his extensive contributions to the field of pattern recognition.

This biennial award will be given to a living person in recognition of an outstanding technical contribution to the field of pattern recognition, and will consist of a suitably inscribed and framed certificate and a cash amount, the costs of which are borne by interest income from a special fund created for this purpose.

The award recipient is to be selected by the King-Sun Fu Award Committee, with the selection subject to approval by the IAPR Governing Board.

The award recipient shall be selected by the Award Committee, subject to approval by the IAPR Governing Board, upon nomination by a member of a national member society of IAPR and by endorsement of at least five members, representing at least two member societies different from that of the nominator.

Members of the IAPR Executive Committee, as well as the Award Committee, shall be ineligible for award and may not serve as nominators or endorsers.

The 1992 award is intended to be presented at the *Eleventh International Conference on Pattern Recognition* The Hague, The Netherlands 30 August – 4 September 1992

Nominations should be submitted on Fu Award nomination forms, copies of which may be obtained from the Fu Award Committee Chairman:

Dr. Saburo Tsuji
Department of Control Engineering
Osaka University
Toyonaka
Osaka 560
Japan
Fax: +81 6 857 7664
Email: rsuji@ce.osaka-u.ac.jp

Nominations must be received by the Fu Award Committee Chairman no later than 1st March 1992.

Dr. Saburo Tsuji
Chairman, Fu Award Committee

Formal Methods in Shape Analysis

A special issue of the *Annals of Mathematics and Artificial Intelligence*, devoted to 2-D shape analysis, is planned for 1992–93. Papers with significant mathematical content are being solicited for consideration. Invited surveys and full-length versions of selected papers will be published.

Topics of interest include, but are not limited to, coding, data structures, segmentation, local and global properties of shape, shape invariants, morphological operators, geometric similarity, Hough transform methods, model matching, 2-D object recognition neural networks, methods based on neural networks, and parallel algorithms.

The guest editors for this special issue are Prof. Janos Csirik and Prof. Horst Bunke. Four copies of the manuscript should be submitted to:

Prof. J. Csirik
Dept. of Applied Computer Science
University of Szeged
Arpad ter 2
Szeged H-6720
Hungary
Email: h873csi@ella.hu

The deadline for submissions is 31st January 1992.

Forthcoming Conferences, Workshops and Events

Please notify the editor of any additions to this list.

DATE	EVENT	LOCATION	CONTACT ADDRESS [SPONSOR]
4–6 Sep 1991	The Sixth International Conference on Image Analysis and Processing	Villa Olmo, Lake Como, Italy	6th Int. Conf. on Image Analysis and Processing, c/o Centro di Cultura Scientifica Alessandro Volta, Villa Olmo, I-22100 COMO, Italy
17–19 Sep 1991	4th International Conference on Computer Analysis of Images and Patterns (CAIP'91)	Dresden, Germany	Scientific-Technological Society for Measurment and Automatic Control, Conference Secretariat CAIP 91, Clara-Zetkin-Str. 115–117, Berlin, Germany [IAPR]
20 Sep–2 Oct 1991	First International Conference on Document Analysis and Recognition	St Malo, France	AFCET-ICDAR 91, 156 Boulevard Pereire, 75017 Paris, France [IAPR]
23–27 Sep 1991	Second International Workshop on Frontiers in Handwriting Recognition	Bonas, France	Prof. Sebastiano Impedovo, 2–IWFHR Chairman, I.S.I. University of Bari, Via Amendola 173, 70126 BARI, Italy
24–26 Sep 1991	British Machine Vision Conference (BMVC91)	Glasgow, UK	Tanya Oliver (BMVC91), The Turing Institute, George House, Glasgow G1 2AD, UK [BMVA]
30 Sep–2 Oct 1991	First International Conference on Document Analysis and Recognition	Saint-Malo, France	Prof. Guy Lorette (Conference Chairman), Universite de Rennes, Rennes, France
4–6 Dec 1991	Digital Image Computing: Techniques and Applications (DICTA-91)	Melbourne, Australia	Australian Pattern Recognition Society DICTA-91, c/o Department of Computer Science, Monash University, Clayton 3168 VIC, Australia (aprs@bruce.cs.monash.edu.au) [APRS]
9–14 Feb 1992	Image Processing — Implementations and Systems	San Jose, California, USA	SPIE, P O Box 10, Bellingham, WA 98227-0010, USA [SPIE/IS&T]
7–9 Apr 1992	4th International Conference on Image Processing and its Applications	Maastricht, The Netherlands	IPA Secretariat, Conference Services, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, U. K. [IEE]
30 Aug–3 Sep 1992	11th International Conference on Pattern Recognition	The Hague, The Netherlands	11th ICPR Secretariat, Delft University of Technology, P. O. Box 5031, 2600 GA Delft, The Netherlands (icpr@et.tudelft.nl) [IAPR]