

1995 Annual Report - Technical Commission V "CLOSE RANGE TECHNIQUES AND MACHINE VISION"

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TERMS OF REFERENCE

- Close-range and microrange measurements
 - Recording and monitoring of objects in motion and under deformation
 - Optical and integrated close-range sensor systems
 - Digital systems and time constrained solutions in close-range applications
 - Image analysis and image synthesis algorithms in close-range applications
 - Object related processing techniques in automatic, semi-automatic and manual mode in close-range applications
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STATE OF SCIENCE AND TECHNOLOGY OF COMMISSION V TOPICS

The use of still video (sometimes called digital) cameras continues to grow at an ever-increasing rate. Users from disciplines and fields of scientific endeavour previously remote from photogrammetry are discovering the efficiency of these devices, but in so doing are often "re-inventing" photogrammetric principles and may not fully understand the strict mathematical error analyses which professional photogrammetrists routinely undertake. The need for photogrammetrists, especially those with an understanding of modern electronic equipment, to publish widely across disciplines has never been more pressing.

One area where photogrammetric measurements are making a large impact and much new research has been reported from around the world is in the area of dentistry. The measurement of teeth, gums and dentures, especially for the elderly, is an area of research which is attracting a lot of attention as the populations of the developed countries grow increasingly older and health workers realise that they have very little data on this aged sector of the population. In fact, as will be seen in the following report of Working Group V/5, there is much renewed interest in Biostereometrics in general, and dental photogrammetry in particular.

Another area of global interest is in the recording of some of man's oldest work ... rock-art. Carvings, engravings and paintings on rock faces, caves and shelves are one of the oldest signs we have of our forebears' beliefs, lifestyles and inspirations. Until a concerted effort was begun this year, many of these 'works of art' have been left

neglected and have been slowly eroding away under the pressures of our modern world. Photogrammetry, in all its forms from the conventional stereo to analytical to digital analyses and reproduction in the form of printed, plotted, computer-enhanced and even set to ethnic music on a CD-ROM, is playing a leading role in the recording and preservation of this global resource. Look out for more exciting news on this topic in Vienna in July 1996!

The XVIII ISPRS Congress in Vienna will portray this increased emphasis on still- and moving-video technology in the close range environment. At the time of writing this report, abstracts are arriving every day which detail new applications which have been discovered for video-photogrammetry. They are very exciting and represent the leading edge of this developing technology. One question which now arises is whether the existing range of photogrammetric journals adequately cover these new developments? Is this the time for ISPRS to launch a new information service or dedicate more of its journal to close-range video theory and applications?

ACCOMPLISHMENTS OF COMMISSION V DURING 1995

The past year has been an active one with several Workshops and Symposia organised by various Working Groups (WGs) and individual Chairmen. Notable amongst these was the Workshop "From Pixels to Sequences" held in Zurich, Switzerland in March 1995. The wide diversity of the audience was noteworthy, as were the leading edges of technology which were discussed. The reports from the individual WG Chairs describe in greater detail the specific activities with which they have been involved.

WORKING GROUP ACTIVITIES DURING 1995

- **WG V/1 - "Knowledge Based Vision Metrology"** by Chairman:Prof. Kam W. Wong (USA)
Co-Chairman:Dr. Sabry El-Hakim (Canada)

State of Science and Technology of WG V/1 Topics

- *General Comment*

Monitoring trends in the topics of this WG, and Commission V in general, has become increasingly difficult using existing photogrammetric journals. Most have been concentrating their issues on remote sensing and GIS. We have become almost entirely reliant on workshops or conferences organized by the WGs, many in cooperation with other societies, to find the new trends. Is it time for new Journal? It may also be a good opportunity for the **ISPRS Journal** to fill the void.

- *Systems for close range metrology*

For off-line target-based applications, high-resolution digital still cameras have become the sensor of choice. For on-line applications,

more precise analogue cameras and frame grabbers are becoming available and at lower costs. Combined with the computer power that is increasingly available, hardware issues are becoming of less concern for close-range digital photogrammetry.

- *Human-machine interface*

The use of Virtual Reality (VR) techniques for computer interaction with environments is an emerging trend. The 3-D environment or site (for example a historical site or a dangerous environment such as nuclear waste site) can be created using photogrammetric techniques and interfaced with VR tools for use in many new applications.

Integration of other sensors, mainly active sensors, with traditional intensity-based CCD cameras has become important for many applications. Obtaining complete, accurate, and fast description of a 3-D object or environment may not be possible without such integration. Methods for data registration and various sensor calibrations are important issues now being addressed in research. Techniques for modelling of objects and environments from the 3-D points obtained by various sensors are also required for convenient analysis, display, and manipulation by computers.

Other WG topics, particularly the use of Artificial Intelligence (AI) techniques, have not gained much interest. However, research on using neural networks for camera and system calibration is gaining popularity in computer vision. Nevertheless, the need to develop expert systems or AI to computerize some of the routine decision-making functions of photogrammetrists continues to impede wide spread acceptance and applications of metric vision systems.

Accomplishments of WG V/1 During 1995

The main activity for WG V/1 was organizing the SPIE conference "Videometrics IV" held 23-26 October 1995 in Philadelphia, USA. The conference included 38 papers from 15 countries and produced **SPIE Proceedings Vol. 2598** (about 400 pages). The trends mentioned above are evident in the proceedings. The next Videometrics is planned for July 1997 in San Diego, USA, as part of the SPIE Annual meeting.

The Future

In order to refocus the WG to match the emerging trends, it should be renamed to: "Integrated Systems for Modelling Objects and Environments (Sites)."

- **WG V/2 - "Close Range Imaging Systems and Their Performance"**

by Chairman: Dr. Horst A. Beyer (Switzerland)
Co-Chairman: Volker Uffenkamp (Germany)

State of Science and Technology of WG V/2 Topics

This WG was one of the main organisers of the Inter-Commission Workshop "From Pixels to Sequences" held in Zurich during March 1995. Some of the topics covered included:

- Performance in Algorithms
- Advances in Imaging Technology
- Calibration of Optical Systems
- Performance in Applications

Some quite interesting presentations were given, and reading the proceedings of the Workshop is very worthwhile. The papers clearly indicated that the basic research and developments are undergoing an optimisation process with regard to user friendliness.

A highlight was the relatively new technology of still-video cameras, which have come onto the market within the last couple of years. They allow an acquisition of digital images without the necessity of a permanent linkage between camera and computer. With a commercial resolution of up to 3000 x 2000 pixels now available, these cameras offer format and accuracy comparable to film-based middle-sized format cameras. They are on the way to revolutionise the daily practical work of close-range photogrammetry and demonstrate a certain gain in performance.

Accomplishments of WG V/2 During 1995

The Workshop "From Pixels to Sequences - Sensors, Algorithms and Systems", was held from 22-24 March 1995 in Zurich, Switzerland. Common workshops were also planned together with "Videometrics IV," 22-26 October 1995, Philadelphia, USA and "Optical 3-D Measurement Techniques," 2-4 October 1995, Vienna, Austria.

The WG V/2 chairmen have met several times in the period of March to October 1995 to discuss WG affairs. The publishing of the Zurich workshop proceedings besides the distributed invitation sheets using personal contacts and the evaluation of invited speakers have been the main topics. The remainder of 1995 will continue this theme, including the session planning for the XVIII Congress in Vienna.

- **WG V/3 - "Structural and Industrial Measurements with Consideration of CAD/CAM Aspects"**

by Chairman: Dr. Clive S. Fraser (Australia)
Co-Chairman: Prof. Heinz Ruther (South Africa)

State of Science and Technology of WG V/3 Topics

Rather than addressing each Term of Reference of the WG separately, we will provide a general review which implicitly considers all of them. In regard to digital close-range photogrammetry, or vision metrology, for industrial measurement, 1995 was a watershed year. Over the past 12 months or so, we have witnessed a true commercial acceptance of single- and multi-sensor

vision metrology for high-precision 3-D coordinate determination, primarily in the aircraft/aerospace manufacturing sector, but also in shipbuilding and the nuclear industry. The impetus for the growing application of vision metrology, apart from the fact that the photogrammetric research in this area is reasonably mature, is attributable to two factors, one photogrammetric and one not so. The first is the successful configuring of large-area CCD cameras into on-line, real-time measurement systems, and the second is the burgeoning use of still-video technology for single-sensor vision metrology systems.

In the multi-sensor, real-time systems we see innovations such as fully automated exterior orientation and the introduction of different forms of trackable measurement probes. Moreover, CAD analysis is finally being incorporated as an integral component of these systems, although primarily for application at the measurement analysis stage and not so much at the design or image mensuration phase. With due attention to calibration, and with strategies for automated monitoring and updates of calibration and exterior orientation, these systems are now yielding to object space positioning accuracies of 1:50,000 and better.

In the single-sensor environment, still-video imagery has had a profound effect, to the point where film-based systems are now obsolescent for all but the relatively few applications demanding accuracies exceeding, say, 1:150,000. Although commercial progress has been strong, much scientific research interest remains in vision metrology, especially in the still undeveloped area of precision object reconstruction in the absence of artificial target points. The perennial question of sensor calibration still poses some vexing problems as does the development of fully automated orientation and object measurement/reconstruction procedures which are sufficiently robust for industrial use. The role of CAD is potentially very important in this regard, and this remains an area worthy of further scientific enquiry.

Accomplishments of WG V/3 During 1995

Although many of the terms of reference of WG V/3 appeared in themes for a number of conferences and technical meetings throughout the year (e.g. "Videometrics IV," Philadelphia, USA; "Optical 3-D Measurements III," Vienna, Austria; and the US-based meeting of the Coordinate Measurement Systems Committee), our WG was only formally involved as a sponsor for one conference. This was the very successful "Photogrammetry in Engineering Surveying" which was organised by Prof. H. Richter and held in Cape Town, South Africa during 7-10 February 1995, in conjunction with the "International FIG Symposium on Deformation Analysis and Engineering Surveying". Among the many international visitors attending this meeting was the Commission V President, Prof. John Fryer.

The long-noticed characteristic of limited formal activities by `members' of this WG between ISPRS Congresses and Inter-Congress Symposia continued in 1995, as did the notable fact that the WG draws a very strong interest when it comes to hosting presented papers at major conferences. The XVIII ISPRS Congress in Vienna in July 1996 looks likely to again re-enforce this trend.

WG V/3 News

All energies of the WG V/3 are now focussed on the Vienna ISPRS Congress, where the WG has twenty-five abstracts submitted for the technical and poster sessions.

- **WG V/4 - "Photogrammetry in Architecture and Archaeology"**

by Chairman:Cliff L. Ogleby (Australia)

Co-Chairman:Dr. Andreas Georgopoulos (Greece)

State of Science and Technology of WG V/4 Topics

This WG continues its consolidation of research directions with respect to the use of CAD to aid in the visualization of ancient monuments. Research has continued into appropriate surface modelling routines to best define surfaces derived from photogrammetric measurements. The development of photogrammetric systems on portable personal computers for the use of architects and archaeologists has been pursued with vigour. Several of these activities have taken place in close liaison with WGs of CIPA.

One area where considerable new development has taken place concerns the use of E-mail and the World Wide Web (WWW) Internet service. A WWW Home Page for the Australian Rock Art Research Association has been established. Rock art, and its recognition as a major cultural heritage, is an important emerging trend for CIPA and this WG. The Rock Art Home Page may be inspected at:

<http://sunspot.sli.unimelb.edu.au/aura/Welcome.html>

The CIPA Home Page is also worthy of inspection and can be found at:

<http://www.p.igp.ethz.ch/cipa/cipa.html>

WG V/4 News

Considerable energies of WG V/4 are now focussed on the July 1996 Vienna ISPRS Congress, where the WG has 40 abstracts submitted for the technical and poster sessions and will be responsible for part of the organisation of a special session devoted to CIPA.

- **WG V/5 - "Biostereometrics and Medical Imaging"**

by Chairman:Dr. Thomas Leemann (Switzerland)

Co-Chairman:Dr. Harvey L. Mitchell (Australia)

State of Science and Technology of WG V/5 Topics

Changes in the various established technical approaches to biostereometrics do not appear to have come about in the past year, (nor indeed in the life of this WG). Medical measurement continues to involve from both film and images from electro-optical cameras, and it also continues to see widespread use of

structured light techniques. However, the co-chairs continue to seek out papers which are notable because they:

- a. report photogrammetry which has attained genuine medical use in clinical or surgical applications (see e.g. **Photogrammetric Record 1995**)
- b. signify developments in medical photogrammetry and in other measuring techniques beyond institutions whose members are associated with ISPRS and published in journals not connected with ISPRS. Such publications can indicate interesting achievements of which ISPRS members are not aware, or they can indicate development work which may not be benefitting from input by photogram-metrists. Indeed, it is one of the problems of medical photogrammetry to keep up with relevant publications in journals such as **Medical & Biological Engineering and Computing** , **Spine** , and many others.

Papers in both these groups continue to appear. The paper by Adams et al., "Stereophotogrammetric Pointing Device for Neurosurgical Use, **Medical & Biological Engineering and Computing** , **33** : pp 212-217, 1995, is mentioned here because it fits both categories above. However its photogrammetric significance is less than its medical significance.

A paper by one WG co-chair reviewed progress in digital image usage: Mitchell, H.L., "Applications of Digital Photogrammetry to Medical Investigations," **ISPRS Journal of Photogrammetry & Remote Sensing** , 50(3): pp 27-36, 1995.

Accomplishments of WG V/5 During 1995

Responses continued to be received in 1995 from the WG Questionnaire which was sent to:

- o the full WG mailing list;
- o most Commission V correspondents from ISPRS member countries;
- o ISPRS office bearers;
- o a number of ISPRS members known to have medical imaging experience; and
- o a number of non-ISPRS colleagues and contacts known to have medical imaging experience.

A WG Newsletter was circulated in May 1995 and covered the following topics:

- o WG Questionnaire responses (see above);
- o announcements relating to the Vienna Congress;
- o announcements of two medical (i.e. non-ISPRS) meetings of photogrammetric interest.

WG V/5 News

The major effort of the WG has been a report on the state of medical photogrammetry which is being prepared for the July 1996 Vienna ISPRS Congress. The report concerns itself primarily with promotion of use in clinical or surgical applications of medical photogrammetry and the development of measuring techniques in institutions whose members are not associated with ISPRS and published in journals not connected with ISPRS. The first draft of this report, titled "The State of Medical Photogrammetry in the Digital Imaging Era" has been completed, and circulated to all those who had responded to survey and selected others on the WG mailing list, and E-mailed to others with E-mail address. Reactions from WG members were invited but so far only four have been received, even though questionnaire response was over 50 replies.

As a result of contact with the International Research Society for of Spinal Deformities, the WG should be a cooperating participant in the next IRSSD meeting to be held in Stockholm in 1996. Formal approval has not yet been received from the IRSSD executive, but approval to have it included as an ISPRS event will then be sought.

The Future

The WG V/5 emphasised issues of implementation in medical photogrammetry, rather than technical matters of limited interest to diverse medical photogrammetry studies. The ordeals of communication in medical photogrammetry continue with e.g. the apparent demise of the UK Medical Photogrammetry Group, and the apparent discontinuation from of the longstanding Biostereometrics series of meetings, the last being held in 1990.

WG V/5 has recognised the need to communicate the difficulties of implementing, rather than developing, medical photogrammetry, and the importance of going beyond ISPRS membership for both input and information. No change is seen to be likely in these matters unless the WG report to be distributed at the Vienna Congress can have its desired aim of improving communications in the broad field of medical photogrammetry, well beyond ISPRS.

- **Inter-Commission WG V/III - "Image Sequence Analysis"**

by Chairman: Dr. E. Baltsavias (Switzerland)

Co-Chairman: Dr. H. H. Baker (USA)

State of Science and Technology of Inter-Commission WG V/III Topics

In general there is an increase of dynamic applications and processes involving imaging sensors and digital photogrammetric techniques. These developments refer almost exclusively to close-range. In the algorithmic point of view there was no spectacular development in 1995. There are however new technological developments (e.g. in imaging and navigation sensors) and also new applications and systems.

Applications and systems can be found in the traditional areas of robotics, industrial inspection, medicine, sports etc. A significant number of

contributions were in the field of particle tracking in fluid flows and related tasks. Particle Tracking Velocimetry using imaging sensors has now reached a state of maturity and can provide accurate results with high spatial and temporal resolution.

Other applications that are attracting a lot of interest are navigation of vehicles and mobile mapping systems. The first case includes autonomous navigation of vehicles on natural terrain, mainly for military purposes (see the UGV project of ARPA in USA) but also for planetary exploration (relevant research work is done at JPL, Pasadena and CMU). It also includes Intelligent Highway Vehicle Systems that find a lot of attention in N. America and autonomous driving on highways (see also the European project Prometheus). Autonomous driving over long distances at about 90 km/h has been successfully demonstrated.

Several mobile mapping systems have been developed in USA, Canada and in Europe and are starting to find a use in practical applications. Their aim is to map roads, railway tracks etc. and their environment (e.g. traffic signs and lights, neighboring objects of interest etc.). Autonomous vehicles and mobile mapping systems usually employ several sensors such as multiple CCD cameras, GPS, INS, odometers, and in some cases barometers, laser scanners, etc. Thus, a major issue is the synchronisation and integration of these sensors, and the integrating data processing.

Other emerging applications that have not found a big interest in ISPRS include the entertainment industry, digital video, multimedia and human machine interfaces. As an example systems have been developed for tracking of the human eyes as an interface in multimedia systems, or accepting commands by hand movements in multimedia systems or for giving commands to a TV instead of using a remote control. Other applications relate to visualisation, e.g. imaging buildings all around with ground based systems and constructing a detailed 3-D geometric and textural representation of them.

Hardware developments have been noticed in the imaging sensors (higher resolution, faster frame rates, wider use of progressive scan sensors, smart sensors with native intelligence and processing capabilities) as well as in GPS (on-the-fly ambiguity resolution), INS (cheaper sensors), and in storage devices.

There is a large bibliography on the topics of the WG that can not all be mentioned here. Instead we will mention the following conferences where papers on the subject can be found (more details such as contact addresses, etc. can be found in the Calendar of the **ISPRS Journal of Photogrammetry and Remote Sensing**). These 1995 Conferences include:

- 5-10 Feb IS&T/SPIE "Symposium on Electronic Imaging"
- 22-24 Mar ISPRS Inter-Commission Workshop "From Pixels to Sequences"
- 3-5 Apr Workshop on "High Precision Navigation"
- 17-21 Apr SPIE Symposium
- 12-14 Jun IFAC Conference on "Intelligent Autonomous Vehicles" (ICCV)

- 26-28 Jun Workshop on "Automatic Face- and Gesture-Recognition"
- 3-6 Jul Conference on "Image Processing and its Applications"
- 9-14 Jul SPIE Annual Meeting
- 4-8 Sep ISPRS Inter-Commission Workshop on "Integrated Sensor Orientation"
- 6-8 Sep Conference on "Computer Analysis of Images and Patterns"
- 13-13 Sep Conference on "Image Analysis and Processing"
- 18-19 Sep Symposium on "Visualising Time-Varying Data"
- 18-22 Sep ISATA Symposium on "Manufacturing and Transportation"
- 2-4 Oct "Optical 3-D Measurement Techniques III"
- 9-11 Oct IFAC Workshop "Motion Control"
- 22-26 Oct SPIE Symposium "Photonics East"
- 23-26 Oct ICIP'95
- 225-26 Oct IFAC Workshop
- 8-10 Nov ISPRS Joint Workshop on "Integrated Acquisition and Interpretation of Photogrammetric Data"
- 9-11 Nov "World Congress on Int'l Transportation Systems"
- 20-22 Nov IEEE Symposium on "Computer Vision"
- 5-8 Dec Asian Conference on "Computer Vision"

Accomplishments of Inter-Commission WG V/III During 1995

The major event for the IC WG was the organisation of the Inter-Commission Workshop "From Pixels to Sequences - Sensors, Algorithms, and Systems", in Zurich, Switzerland, 22-24 March 1995 in cooperation with the WGs I/3 and V/2. The workshop attracted 130 scientists from 17 countries with a good blend among academia (60%) and research institutes and private companies (40%). More than half of the participants were non-photogrammetrists. The sixty presented papers are published in a 400 page volume of the **ISPRS Archives**. The income of the workshop was used to finance three Best Young Author Awards, each 2,500 SFr, for the 1996 ISPRS Congress. More details on the workshop can be found in the **ISPRS Journal of Photogrammetry and Remote Sensing, Vol. 50, No. 3**, p. 38. As a note, the WG used for the first time the WWW on the Internet with very positive results.

The IC WG V/III participated in the organisation of a mini-workshop that took place in Zurich on March 21. This workshop was co-organised by the Swiss Society of Photogrammetry, Image Analysis and Remote Sensing and the Japanese "Association for Real-Time Imaging and Dynamic Analysis" and aimed at the exchange of scientific information between the two groups. Several of the workshop talks were on topics of our WG. In addition, the IC WG V/III sent the second announcement and call for papers for the ISPRS XVIII Congress to 50 scientists that were not addressed by the Congress organisers.

Inter-Commission WG V/III News

The following activities are planned until the next ISPRS Congress:

- Evaluation and selection of the papers for the ISPRS Congress and preparation of the three WG sessions

- Evaluation of the papers for the Best Young Author Award that were sponsored by the three WGs that organised the IC Workshop "From Pixels to Sequences"
- Reformulation of the terms of reference of the WG for discussion at the ISPRS Congress

The Future

Future developments will probably move along the tracks outlined in section above on State of the Science and Technology with faster changes expected in hardware and systems and relatively little change in the algorithmic part. For certain classes of applications integrated use of sensors is mandatory and thus, improvements in the whole system design and processing algorithms will also be observed.

The field is already strongly interdisciplinary and as new applications are developed, some of them quite exotic, this trend will become stronger. This fact and the plethora of events where related topics are presented lead to a fragmentation and make a mutual exchange of information and a study of the international developments difficult. Therefore, it might be necessary for the WG to focus on certain selected subjects for the period 1996-2000 and change appropriately its terms of references.