WORKING GROUP IV/3 REPORT
AND REVIEW OF PROGRESS IN MAP AND DATABASE REVISION

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ABSTRACT

The Chairman presents his report on Working Group activity during the session 1992-96, including an overview of papers submitted for this Congress as well as relevant reports on practice and research published earlier in the Session. He outlines the present status of map and database revision : the inevitable move from analytical to digital techniques for routine production work has only just begun, with the adoption of digital mono-plotting by several respected organisations. Meanwhile research efforts continue towards the automation of the processes of change detection and feature extraction. However, apart perhaps from small scale map revision in remote or forested areas, practical realisations are still awaited. In the course of these discussions the author points towards how practice may develop over the coming four years, under the influence of possible technical changes such as high resolution digital imagery from commercial satellites, airborne digital cameras, orthophotos with all features correctly positioned (not just those at ground level), and the evolution of pen computers into digital photogrammetric workstations in the hands of field surveyors. In view of the overlap of interest between many of the Commissions and Working Groups of ISPRS, it is certain that much material relevant to map and database revision will be found in the sessions and archives of other Groups; it is hoped that this will lead to pressure from participants for a more convenient ISPRS structure in the future.

RÉSUMÉ

Le président du Groupe de Travail présente son compte rendu des activités pendant la session 1992-96, ci-inclus un panorama sur les articles offerts à ce Congrès et sur des publications pertinentes pendant ces quatre dernières années. Il offre un tour d'horizon sur la situation actuelle de la mise à jour de cartes et de bases de données : le changement inévitable de la photogrammétrie analytique vers les procédés entièrement numériques vient de commencer, avec l'introduction de stations de travail monoscopiques au sein de plusieurs organismes de cartographie officielle. En même temps, des études continuent vers l'automatisation des procédés de la détection des changements sur le terrain et de la saisie de données sur les objets topographiques. Pourtant, jusqu'ici on attend des réalisations pratiques de l'automatisation, sauf peutêtre en matière de la révision des cartes aux petites échelles des forêts et d'autres régions éloignées. Au cours de son exposé, l'auteur suggère l'évolution dans la pratique pendant les quatre prochaines années, sous l'influence des progrès techniques tels que les images satellitaires de haute résolution, les photographies numériques aériennes, les orthophotographies à géométrie correcte (même sur les toits!), et l'évolution de l'ordinateur portatif vers une station de travail photogrammétrique utilisable sur le terrain. Vu le chevauchement entre plusieurs des Commissions et Groupes de Travail de la SIPT, il en est certain que beaucoup d'articles pertinents à la révision se trouveront dans les sessions et les archives de ces autres groupes. On espère que, enfin, une structure plus utile sera requise par les adhérents de la SIPT.

1. INTRODUCTION

The period from 1992 to 1996 has been a fruitful one for developments in both the techniques and the management of map and database revision. The revolution in photogrammetry as a whole, founded on the transition from silver halide to digital or softcopy images has proceeded apace (Welch, 1992, Heipke, 1995). Meanwhile the importance of database update as the main task of mapping organisations for the future has been widely recognised and the management of this activity has evolved accordingly. Relevant aspects of digital photogrammetry which were ready for production have been adopted in practice. Some progress has also been made in the more difficult aspects of digital photogrammetry involving image understanding, which may eventually lead to practical procedures for change detection and feature extraction.

Due both to personal circumstances and to my judgment that in the prevailing economic conditions the market for technical meetings was already saturated, no Working Group meetings have been held during the present session except for the Commission symposium in 1994 and the present Congress. However very considerable support for the Working Group has been displayed in responses to circular letters, with some 80 respondents registering their interest over the four-year period. The lack of intervening meetings has led to very strong programmes for both the symposium and the Congress. It seems likely that the Working Group could support at least one Workshop devoted specifically to Map and Database Revision during the next session. Potential organisers should note that similar groups exist within other international or regional organisations such as ICA, CERCO and OEEPE so cooperation is clearly desirable and joint meetings should be considered.

This paper is confined to reviewing only the Congress papers offered to this Working Group, although some relevant material published elsewhere during the period is naturally also cited. It is certain that there will be many contributions to other working groups, especially in Commissions II and III, which are of lively interest to the members of WGIV/3. Indeed the present "horizontal" Commission structure, with layers of activity from initial data capture onwards, requires those who are interested in a particular "vertical" theme (for example the whole of topographic mapping from sensor to user) to be involved in the affairs of almost all of the Commissions. This is unduly expensive even for those with institutional support and prohibitive for those without sponsorship; thus it is certain that even the chairman of this working group has overlooked numerous relevant contributions during the past eight years. The structure is also inefficient in terms of the exchange of ideas and of the cross-fertilisation between researchers, theoreticians and practitioners which in my view was the main justification for the continued survival of the vertical Commission structure of ISPRS. It is hoped that the inevitable overlaps in this Congress programme, the impossibility of one delegate attending all of the sessions relevant to his interests, and the dispersal of related papers among numerous volumes of the archives, will stimulate the reopening of the debate on future ISPRS structure which yielded inconclusive results in the 1988-92 session.

2. REVIEW OF CONTRIBUTIONS TO THIS CONGRESS

At the time of writing, the detailed programme for the Congress is not yet available, but I have seen all of the extended abstracts offered for this Working Group and have advised on how they should fit into the programme.

The first session, whose proposed title is "Map Revision : Where are we now ? (Progress and Practice 1992 - 96)", readily embraces papers from a range of national mapping or similar organisations: van Asperen (The Netherlands), Armenakis (Canada), Müller (Germany) and Krishna (India) are all using or proposing softcopy approaches. The emphasis from the Netherlands is on management, rather than technicalities, to ensure efficient routine operations. The emerging consensus is that mono-plotting, from a digital orthophoto, is the cost effective way forward. Peled (Israel) reports on developing national mapping procedures as well as his own research towards semi-automated revision based on the intelligence embodied in the existing database. Meanwhile Sehnalek (USA) reports from the private sector on procedures which closely follow those reported in earlier years by this author (Newby, 1990).

The theme of automation is taken up in earnest in our second session "Change at the Millennium : Is automation possible ? (Ongoing developments, with total automation the ultimate goal)". In his invited paper, Woodsford (UK) offers us a thoughtful and thought-provoking discussion of update philosophy and paradigms, with special emphasis on the importance of maintaining database integrity. Two papers from Germany, offered by Englisch *et al* (Munich) and Anders *et al* (Stuttgart) report on important research into automated feature extraction, the former emphasising medium scale (topographic) data (ATKIS) and the latter very large scale (cadastral) data (ALK). Steps towards the automation of change detection or feature extraction for various themes or scales are also reported by Masaharu (Japan), Shi and Shibasaki (Japan), Johnsson (Sweden) and Lin (China).

There are also numerous contributions which fit well into a possible third session: "Graphic Revision and Digital Update - Field, Office and User. (Diverse needs, diverse processes : where should photogrammetry fit in ?)" Mills (UK) breaks into true digital airborne imagery (as opposed to scanned conventional aerial photography), in experiments using a very small format digital camera for local map revision. This offers the prospect of a shift in the balance between field and photogrammetric surveys for change on small sites. Grozdeva (Russia) follows the same principle as Mills but proposes appropriate technology of conventional small format photography taken from a microlight aircraft for the revision of small towns, presumably in a country where there is no official bar on the use of microlights for business purposes. Other varied contributions cover combinations of aerial imagery with SPOT (Naithani, India) or with terrestrial photography (Crosilla, Italy), both of which are presumably more feasible in the digital era than in the past. Solutions at varying levels of technology are also proposed by Julia (Argentina) and Ramirez (USA). Standards, a topic neglected by ISPRS WGs, are addressed by van den Heuvel (The Netherlands). Finally I will cite Tempfli (The Netherlands) whose discussion of scale, resolution and scanning parameters may help users to ensure that digital image technology matches the performance to which we are accustomed. Along the way he gives a notable demonstration of the benefits of stereo imagery, a point possibly yet to be fully appreciated by the proponents of digital mono-plotting.

Several of the papers cited above will receive their exposure in the Congress Poster Sessions, along with many more which bring fresh perspectives to the same themes. I will allow all of these authors to speak for themselves through their presentations in Vienna and through the Congress Archives, but now offer a commentary on the current status of map and database revision and on work published earlier in the 1992-96 session of ISPRS.

3. THE FRAMEWORK FOR DEVELOPMENT

I was recently asked to contribute a paper on "digital images in the map revision process" for the special Commission IV issue of the International Journal of Photogrammetry and Remote Sensing (Newby, 1996).

For considerably more detail on the current status of map revision than can be included here, readers are referred to that article, which was designed to set the scene for this Congress. However, since that paper is also in large part a review of Working Group progress during this session, many of the points made there should also be emphasised here.

In the digital photogrammetric revolution, as in all revolutions, forces of reaction are also at work, based in this case on sound economic and practical grounds. In the real world of routine production, all technical processes stand or fall by their cost effectiveness. This is especially the case with entirely new developments such as softcopy photogrammetry because of the high initial investment involved, not only in research and development and in capital equipment (including the scanner as well as workstations), but also in staff training and (most importantly for database revision) in integration with existing systems. Unless on taking all of those factors into account digital photogrammetry can do a better, cheaper or quicker job than existing methods, the latter must be retained. To justify the change, at least one, but preferably two or three of those comparisons must be proved to be favourable. Moreover, the needs and wishes of map and data users must be both recognised and embedded into the implementation of any technical change. It is encouraging that several of the contributions to this congress do emphasise these points, when discussing progress towards their goal of automation. If these matters are fully appreciated we can move on to consider current directions in research, and their antecedents.

It is developments in computer science over the past forty years which have provided the driving force for development in surveying and mapping, including (or indeed especially) in photogrammetry. We have moved from totally analogue optical and mechanical processes, through the first steps in analytical aerial triangulation in the 1950s and 1960s, to the late-80s situation in which the misleadingly named "analytical plotter" had become a photogrammetric workstation at which a human operator, assisted by one or more computers, could capture or edit three-dimensional geometric, topological and semantic data about the world from collections of high quality two-dimensional graphic images and record it in digital databases (Bonjour & Newby, 1990).

Meanwhile our colleagues developing the newly emerging discipline of remote sensing were obliged generally to use digital images transmitted from satellites. Developments in computer science parallel to those exploited by surveyors and mappers allowed them to learn to handle such images. Image processing and computer vision developed independently of photogrammetry for the simple reason that photogrammetrists retained the major advantage of working with graphic images of very high geometric and radiometric quality; only very recently have developments in computer graphics made digital images worthy of the attention of photogrammetrists. Now there is a most welcome convergence between photogrammetry and remote sensing, image processing and computer vision : for it is clear that photogrammetry can benefit from existing expertise in digital image processing, while contributing traditional strengths in the rigorous understanding and manipulation of the geometry of image formation.

Benefiting from this convergence, numerous system vendors now offer softcopy systems capable of handling many photogrammetric tasks. However the papers at this Congress demonstrate that database update is a considerably more complex task than database creation. Vendors, even if they have grasped this distinction, are not yet providing ready-made solutions to the update problem, but it is those who are willing to work closely with users to integrate revision systems into existing technical and management structures who will be most successful in this fundamental future activity.

4. SCANNERS, SENSORS AND WORKSTATIONS

In the present structure of ISPRS it is clear that developments in image capture and manipulation belong to other Working Groups in other commissions. However, such developments will naturally influence the directions taken by their eventual users. Thus a review of aspects of digital photogrammetry relevant to map and database revision is necessary here. For more detail, again refer to Newby (1996).

It is not feasible to enter digital photogrammetry half-heartedly. To justify the investment in a scanner to convert photographic hard copy images into softcopy it is necessary to plan to make use of its full capacity. I would expect one scanner to be able to supply four to six digital photogrammetric workstations (DPWS) although there is not yet much practical experience to quote in this connection. It remains an open question whether it is necessary to spend the large sums required for a top quality scanner designed expressly for photogrammetry, or whether much lower cost systems can give acceptable results. Certainly it is now recognised that not all scanners are the same, that even very expensive scanners may not provide perfect results, and that the complete digital photogrammetric flowline will depend on this single crucial component. The importance of this issue led to the formation of a joint OEEPE-ISPRS working group on the analysis of photo-scanners.

This group has examined not only the technical requirements of geometry, resolution, image noise, dynamic range and so on, but also comfort and convenience aspects such as the level of automation of the process and the use of original roll film negatives, as well as engineering points involving the satisfactory solution of classical problems of aerial imagery such as optical distortion, image flatness, vibration and the avoidance of artefacts. Above all, the results of scanning must aim to be as good and cheap as a diapositive! (Kölbl *et al*, 1994).

This makes it quite hard for digital photogrammetry to compete. Photogrammetric operators are now accustomed to recent improvements in photography such as forward motion compensation (FMC). FMC not only allows photography to be flown under conditions which would in the past have been considered marginal (a major factor for time-dependent map revision) but it also encourages the use of slower and therefore less grainy films. Meanwhile film manufacturers also claim to have improved their emulsions. Thus all recent trends have encouraged photogrammetrists to expect sharper, better images than ever before. Moreover, for the surprisingly demanding task of detecting and surveying change while minimising the need for subsequent field completion, reducing the scale of photography has not proved to be a sensible way of exploiting the improved geometric accuracy of modern photography and measuring systems. Instead, ease of interpretation has become the dominant requirement. Throwing all of this away in exchange for the privilege of viewing lower resolution pixel-based images on a computer screen requires an act of faith or a dramatic cost advantage. Nevertheless Stirling (1995) has reported that users of digital systems do get used to the comparatively fuzzy screen images and that the loss of information is not severe.

This introduces the question of the trade-off between pixel resolution and data volume which affects the cost of capture, storage and transmission of data. The standard was set by the Zeiss/Intergraph PhotoScan, which allows a smallest pixel size of 7.5 μm. This implies about 600Mb of data per aerial image. Much discussion of the minimum practical resolution has ensued, without a firm consensus yet emerging. However it seems likely that most users will eventually settle for pixels in the 15 to 25 μm range, or some 100Mb per image. Whether or not the next generation has difficulty with the storage volumes involved (terabytes per year for the national mapping of a medium sized country), processing speeds and transmission rates will certainly be critical, as will the disciplines of managing such quantities of data.

Until very recently the idea of replacing the conventional aerial camera with a digital system in the aircraft seemed ludicrous. Such sensors have now already flown. IGN (France) has been seeking collaborators for further development of their experimental digital camera. Meanwhile in North America systems are in use for environmental monitoring and are producing images which show some potential even for urban map revision (Monday et al, 1994). At the same time several long-heralded commercial satellite-borne high-resolution imaging systems may be launched in 1997 and will then yield results for discussion at the next round of ISPRS symposia. With planned pixel sizes of one to two metres on the ground these will certainly be of interest for small scale map revision. They will surely not replace airborne imagery for the update of large scale databases, although some contribution to automated change detection, even for large scale work, may be foreseen.

5. HARDWARE AND SOFTWARE FOR DPWS

At its most basic level the DPWS has monocular viewing only, of a single image whose geometry is corrected by a good DTM. This is the solution now being adopted by several respected organisations. However, any monocular system deliberately discards one of the most crucial benefits of photogrammetric surveying, namely stereoscopic viewing. Of course this serious disadvantage may be outweighed by the obvious simplicity and economy of monoplotting systems. If not, it will be necessary to wait for the hand-held field computer to combine monocular photogrammetry with the surveyor's eye view at ground level before the loss of stereoscopy will be tolerated by most photogrammetrists.

At the next level of present-day development, with the addition of stereoscopic viewing, the DPWS replicates the functionality of an analytical plotter. Like the old universal analogue machines, in its most advanced form it will be able to be used for all known photogrammetric processes. All DPWS will have the facility of viewing the existing vector or raster map data, together with any new data captured from the current aerial image. Many processes will eventually be automated.

For revision purposes its capture and edit system must integrate easily with the existing database or GIS. This integration points to a major advantage of digital photogrammetry in terms of quality management : real world geometry will always be maintained, or at least departures from it will be immediately apparent.

Along the way the DPWS will be able to generate DTMs automatically and will allow them to be edited in a user-friendly way. From the DTM orthophotos will in turn be generated automatically; for them to be of serious use in urban areas for map revision or indeed any other purpose it is essential that they should show the tops, as well as the bases, of buildings in their correct planimetric positions. This obvious requirement had long been overlooked by researchers and system vendors, so it seemed a remarkable breakthrough when Meister & Dan (1994) described just such a process during the last Commission IV symposium. Within months at least one leading vendor (Leica) was including a similar procedure in a DPWS although the onus remains on the user to capture the necessary three dimensional building model manually in order to exploit this capability of the orthophoto software. Now, everyone is tackling this problem vigorously and it will soon seem incredible that it was ignored for so long. Once this "building lean" is eliminated automatically, the floodgates will open for the acceptance of orthophotos for urban mapping. Since currency is also crucial in the urban environment, this will immediately affect both expectations and methods for urban database update, perhaps ultimately even ending the dominance of the line map as the preferred portrayal of urban areas.

6. PROGRESS AND PROMISED ADVANCES IN MAP AND DATABASE REVISION

In this section I will review progress in map and database revision reported earlier in this four year session of ISPRS. I hope that speakers at this Congress will present us with real progress towards the goal of automation, which will allow this increasingly cost-conscious world to contain the cost of database maintenance in the future. Meanwhile almost all of the processes used in practical map revision today still rely on the human operator. The excellence of the human eye and brain, or what soldiers call "the Mark 1 eyeball", at tasks of image understanding and pattern recognition is even harder to reproduce in a computer than it is to understand. Nevertheless some progress reported earlier has pointed to the possibility of at least semi-automated processes reaching the production arena.

First, I will very briefly discuss the current state of development of digital map revision at the Ordnance Survey of Great Britain (OS), arguably the most experienced organisation in this field worldwide. For large areas of change on the ground, the analytical plotter with superimposition of both the corrected aerial image and the edit menu for the integral workstation has provided the most cost-effective revision method. For smaller areas of change, OS continued to use a mixture of appropriate field methods, often assisted by aerial photography. Changes in the management of revision at OS, towards extremely rapid database update for change on the ground judged to be of first importance to users, and a more frequent cycle of revision for all change (or to confirm the absence of change), have been even more important than technical developments over the past four years. However current technical developments do include both softcopy photogrammetric revision using digital orthophotos in the office, and a handheld pen computer (without any photographic assistance) replacing graphic processes in the field. Both of these have the potential to shift the economic balance between photogrammetric and field activity, thereby also affecting the management of revision. (Newby, 1994, Vincent & Logan, 1995 and Greenway, 1994). The pen computer could perhaps also ultimately incorporate a digital image backdrop, thus placing a digital photogrammetric workstation in the hands of the field surveyor and blurring historic distinctions between field and photogrammetric surveys.

A notable collaborative project by OEEPE, a regional member of ISPRS, during this period, was entitled "Updating of complex digital topographic databases". This was headed by the Ordnance Survey of Northern Ireland (OSNI) but involved the participation of up to eight European nations at various stages. The project report (Gray (editor), 1995) shows that participants made some collaborative progress, while confirming the need for individual local approaches integrated within existing data structures. The project also emphasised the retention of historic data, whether through the treatment of time as a fourth dimension in databases or by accumulating "change only" data, rather than retaining only the current version of reality on the ground.

Moving now to the quest for automation, one of the less demanding tasks in image understanding is to recognise and follow linear features such as roads. Successful demonstrations have been given using both SPOT and aerial image data. (See for example de Gunst and Lemmens, 1991, Solberg, 1992, Sakoda, 1993, Plietker, 1994 and Peled, 1994). Comparison of a new image with the old network allows the latter to be updated. Peled outlined a plausible scenario for future progress, beginning with a semi-automatic process of subtraction of old and new images followed by noise removal, to supply the human reviser with candidate areas for his attention. Next, in what he calls "GIS-driven updating", the above process would provide the trigger for automated recognition of new detail and its extraction in a hierarchy of themes. Finally, autonomous rule-based AI systems may largely take over from the human operator. As in most aspects of image understanding, it seems unlikely that any one algorithmic approach will yield the required results, but that a combination of approaches, mimicking the human's intuitive combined tactics, may eventually be successful. Similar efforts have been reported in the detection and extraction of buildings, notably in our own Commission proceedings by Murakami and Welch (1992) as well as by Förstner, McKeown and others.

Thus far I have not distinguished explicitly between two and three dimensional databases; we may assume that our map is an attempt at a model of a three-dimensional world although until recently most GIS developers have preferred to treat it as two-dimensional. Certainly the topological structure becomes very much more complex if the third dimension is allowed to intrude. Theoreticians as well as practitioners have now started to wrestle with the question of whether time ought to be treated as a fourth dimension in a GIS or whether update merely generates a succession of states of the database (which may or may not be stored for posterity). In my opinion we should retain the latter view. This makes it easier for us to consider practical matters such as change on the ground which has not yet reached the database, change in the database as a result of improved data without any corresponding change on the ground, and the requirements of users in terms of supply of complete new versions of the database after update or merely replacement of updated features within the database. As data structures become more rigorous and complex, these matters pose formidable problems of data integrity for both supplier and customer. They are necessarily addressed in practice by national mapping organisations, but have also received theoretical attention from researchers such as Kemppainen (1994).

7. CONCLUSIONS

Map and database revision as practised today makes intensive use of analytical photogrammetry as well as appropriate non-photogrammetric methods. Digital or softcopy tools are starting to be used and will undoubtedly be adopted increasingly in future. However they must compete effectively on cost grounds in satisfying user needs, while being tailored to interact with existing database structures and practices, for this is the essence of revision as opposed to original survey. It is not just the storage but also the manipulation and transmission of the huge volumes of data entailed in digital images which will demand careful attention. The question of mono- versus stereo-viewing is an important issue today but in this author's opinion stereoscopy is a special advantage of photogrammetry which will not lightly be given up, at least until developments in data handling and transfer allow the field surveyor to hold a (monocular) DPWS in his hand, on site.

Database revision has now become a respectable discipline within the ISPRS commission structure. Technical and management aspects rank equally as worthwhile subjects for discussion. There has been perceptible and promising progress towards the long-term goals of automated change detection and feature extraction but practical solutions are still some way off. Database integrity after update is now attracting serious attention, being helped in practice by the use of the best tools and the best possible imagery as an aid to interpretation. The likely availability of so-called high resolution satellite imagery in the near future will provoke further controversy on just how good the image must be for effective and reliable work, but for large scale applications the low-flying aircraft will surely remain the vehicle of choice and will still be assisted by the surveyor on the ground. This Congress and the next session from 1996 to 2000 should disclose interesting developments in this very important practical subject.

Finally, because of the present "horizontal" ISPRS Commission structure (layers of activity from initial data capture onwards), those who are interested in a particular "vertical" theme (for example the whole of topographic mapping from sensor to user) need to be involved in the affairs of almost all of the Commissions. It is certain that many papers of interest to participants in this Working Group and worthy of inclusion in our sessions will have been submitted to other Groups, especially in Commissions II and III. I intend to join in such sessions where the Congress Programme permits, and I urge my Working Group members to do the same. Such cross-fertilisation among the present Commissions is an imperative for sensible progress in our discipline. This may also eventually persuade ISPRS to adopt a more logical "vertical" Commission structure for the organisation in the years to come.

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