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# Towards integrated image-based systems for aerial photographs

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## *Introduction*

Aerial photographs are a well established source of geo-referenced information. They are used extensively in map compilation and revision, for the collection of inventory data, morphological and vegetation studies and for monitoring landuse and environmental change. They are also used to provide a pictorial backdrop to more traditional map data.

Traditional photogrammetric methods remain important for deriving highly accurate spatial data in two and three dimensions. The development of analytical plotters and, more recently, digital photogrammetric workstations (Dowman *et al.*, 1992) can be seen as building blocks which introduce photogrammetry into a more integrated GIS framework.

The role of photo interpretation is gaining credence within GIS circles as an alternative approach to certain types of data collection. Typically such information has been manually extracted to meet the particular needs of individual studies, with little or no consideration of the wider use of such data. The introduction of viable digital solutions for photo interpretation studies increases the potential for using data, which might otherwise not be collected. The number and range of such studies is increasing, bringing aerial photographs out of the cupboard where they have traditionally resided, unused except by the specialist.

The trend is for more frequent and extensive aerial surveys. The development of high quality and relatively low cost colour aerial photography has convinced many of the value of such imagery. Photographs are establishing a complementary role as both a source of spatial data and a contextual tool on which to overlay other geo-referenced information. Colour imagery is increasingly used to provide geographic context for GIS display. The developments in GIS technologies and more recently in image-based systems presage a new revolution in the use of aerial photography across the UK in the 1990s.

## *UK aerial photography in 1991*

During a census year there is a laudable desire to link the collected statistics with

concurrent imagery thus giving an integrated socio-economic and landuse dataset. This desire in turn leads to an increase in commissioned aerial surveys. Despite prevailing economic conditions, 1991 proved to be no exception.

Large areas of the UK were flown over during the year. GEONEX UK Ltd completed aerial surveys of some 14 counties, all of which were in colour, at scales ranging from 1:5 000 for areas such as West Glamorgan to 1:25 000 for East and West Sussex.

A relatively complete and current aerial survey exists for the whole of the UK at a variety of scales ranging from 1:3 000 to 1:25 000 and flown by a number of aerial survey firms. The ownership and marketing rights to these surveys varies, depending on the commissioning agent and the survey company involved. The time of year at which the surveys were undertaken also varies, and much of the imagery is still black and white. The result is a customer or task specific library collected on an *ad hoc* basis. There is surely a case to be made for a regularly updated national aerial survey to be used as the aerial photographic archive from which the growing body of users could purchase imagery as required.

A recent agreement between the Ordnance Survey and the main UK aerial survey companies has led to the establishment of a national information service on the availability of aerial photography. The National Air Photo Library, NAPLIB was launched in October 1991 as a successor to the long defunct air photo register maintained by the OS. Details on the available photography are supplied to OS as coverage diagrams by the six main UK aerial survey companies and OS operate a query service on aerial photo availability through the Air Photo Sales Office (contact number 0703 792584).

Recent improvements in the photographic films used in aerial cameras has extended the range of flying options, making it possible to conduct surveys in poorer weather conditions and at different times of year while still retaining image quality. Added to this is the introduction of a new generation of aerial survey cameras such as the Carl Zeiss RMK TOP. These have computer-supported control systems with forward motion compensation, high performance lenses and filters and integrated navigation instruments for automatic navigation and overlap control. The result is improved image quality and feature definition even from small scale photography.

## *Integrated photogrammetric solutions*

Survey standard aerial photography flown to a high order of precision is designed for the accurate collection of geo-referenced data using photogrammetric techniques. In particular the three dimensional model created in the photogrammetric plotter provides an alternative method to ground survey for the collection of precise planimetric and heighting data.

Photogrammetry is used not only for traditional map compilation and revision but also for a wide range of specialist application studies. Examples include detailed contouring for coastal defence planning and the heighting of buildings in urban areas for determining telecommunication transmission blind spots. Such projects involve considerable photogrammetric expertise and are expensive to complete. There must be a well justified case for adopting a purely photogrammetric solution to data capture but where high accuracy is critical it is often the preferred solution, for example in creating a digital elevation model for coastal zone planning.

Increasingly aerial photographs are being used in digital form within integrated image management systems. These draw together the hitherto distinct strands of photogrammetric data collection, image analysis and image-based map compilation. In addition, aerial photographs are becoming available as digital orthophotos, or photographs which have been geo-corrected by removing all the inherent distortions due to aircraft movement and ground height variation. The advantage being the ability to overlay photos directly with map data.

Examples of such image management systems are the Carl Zeiss PS1 PhotoScan and PHIPS system and the Intergraph ImageStation 6187 which have a conceptually integrated approach to GIS and photogrammetry. The PS1 PhotoScan scanner for the digitization of photographs is a joint venture between Zeiss and Intergraph. This high resolution scanner has a pixel size of 7.5 microns, a scanning rate of 2 megapixels per second that will capture a 230mm square colour image in about 20 minutes.

The PHIPS system is a Photogrammetric Image Processing System, designed as the data processing kernel of a digital data manipulation suite of products. It will digitally produce orthophotos for use in application studies based on orthophoto mosaics. PHIPS can run in a multi-processor environment in order to satisfy the high computing demands required for the manipulation and management of such large digital images.

The ImageStation 6187 incorporates image processing capabilities. It combines raster and vector data for simultaneous viewing and manipulation on a single screen. In addition, photogrammetric data extraction can be undertaken by viewing overlapping images which are digitially offset through polarized glasses giving the operator a three dimensional model on the computer screen. The acceptance of this approach to large scale photogrammetric projects over more traditional optics on analytical plotters could revolutionize photogrammetric data capture but much depends on the availability of suitable computing platforms and how operators adjust to the glasses. The ImageStation 6187 is a fully compatible solution within the Intergraph RISC Workstation range of GIS products.

Digital photogrammetric workstations require a high level of computing power. The ImageStation 6187 typically might operate with 60Mb RAM running at 120Mhz (although this is not a minimum configuration). Single black and white aerial photographs require in the order of 30 to 40 Mb of storage at 30 micron resolution, while colour images are three times as large. The stereo viewing capability doubles the storage requirement.

This is not an exhaustive review of such systems. In the UK for example, GEC Avionics market a range of digital stereo image and photogrammetric workstations produced by Helava Associates Inc., a subsidary of General Dynamics. It does however serve to demonstrate the recent developments in this type of high cost solution to handling digital aerial photographs.

## *Low cost photo-interpretation systems*

Not all users of aerial photographs can justify the use of such solutions; for many an alternative approach needs to be considered. The needs of the professional photo-interpreter and the more casual user of imagery are much less constrained by high accuracy requirements. Their need is for large area coverages from which data, often only interpretable from aerial photographs, is collected as map overlays with lower orders of accuracy. Typically the importance of the photos is to provide a geographical context for the data being collected, before it is transcribed to map based overlays (Young, 1992).

The technological requirements of such users are contradictory. Large geographical areas are wanted, usually comprising many tens or hundreds of frames, which have to be high quality photographs displayed and stored on low cost computer platforms and associated storage devices.

One approach to this problem has been the GEO-DAS system. Based on Apple Macintosh with an additonal 24 bit colour graphics board, the system displays partially corrected, geo-referenced photo tiles that are still of an acceptably high quality. These tiles are extracted from the original images to form edgematched blocks which create a "seamless" photo world. The images are displayed together with a transparent map layer and user defined layer on which photo extractions may be compiled using a standard range of graphic tools (Cassettari, 1991).

The contrast in this approach to that of the digital image workstation is highlighted by the image file size. A single tile is displayed in the GEO-DAS six-inch image window at a resolution of 72 dpi. Each colour photo is stored as a 24 bit image but only requires of the order of 650k storage, uncompressed, which can be reduced by up to a factor of 10:1 with current compression techniques. Uncompressed the photo, map and user layer require less than 1mb of storage. While the image quality is good, the resolution does not allow image enlargement without the pixel structure becoming apparent.

In order to capture large areas cost effectively the images undergo a simple linear transformation but are not orthophotos. Hence they still contain some of the distortions inherent in any raw aerial photograph.

While the digital photogrammetric workstation may be regarded as the "professionals tool", GEO-DAS is aimed much more at increasing the awareness and widening the use of colour aerial photography through photo interpretation studies. It is not too difficult to conceive of future solutions combining the benefits of the orthophoto and stereo model with large "seamless" photo coverages on relatively low cost platforms. The continuing reduction in computer costs, coupled with increased power and storage capabilities over the next five years are likely to provide the impetus for such developments.

## *Increasing the use of aerial photographs*

The development of GIS concepts is increasing the use of geo-referenced information within a consolidated decison-making structure. Aerial photographs in tandem with maps form a very valuable graphic element to the visualization of geographic data. GIS is only one part of the information revolution currently underway, however. Potentially the development of multi-media technologies and their integration within spatially referenced information systems has enormous implications for the wider user of aerial photographs.

It is already possible to buy atlases and small scale map data for the whole world on CD-ROM for use on the average PC with the appropriate player. Sony have launched their home CD collection for the PC environment and Kodak will be providing CD formatted home photography. Alternatively videodisk technology can be used to store large numbers of still pictures as analogue TV frames, offering enormous capacity and fast retrieval; for example one side of a double sided disk can store 54 000 8-bit digital images of 640 by 480 pixel resolution. Retrieval times would be in the order of three seconds.

Aerial photographs linked to text information, ordinary photographs and sound have enormous potential. Add to this moving images, including video from aircraft, and a wide range of applications become possible, such as the development of local atlases and guides and many image-based inventory systems, all of which use the geo-referenced aerial photograph as the index. However, to be truly effective such integrated datasets will normally require an element of user interaction. Software solutions need to be added which allow the user, in the office or at home, to scroll around the photo world, add his or her own graphics, sound or images and call up information in any form, including video, based on the geo-referenced index.

Assuming that the market predictions made by Sony and Kodak are realised, CD-ROMs will be part of every computer and home TV system in the very near future. Aerial photography is potentially an important component within such systems. The critical elements are the simplicity of the software and the development of more intuitive user interfaces. The World Wide Fund for Nature's SATCOM project is an example of a well structured approach to multi-media technology with a central geographical focus, developed for the purposes of environmental awareness in schools. There are many others.

The wider use of aerial photography has implications for those commissioning and flying the surveys. Wider use of photography increases the copyright fees, giving the commissioning organization a greater return on investment. This may in turn lead to more frequent flying of certain areas and the availability of various scales flown at different times of year, thereby meeting the disparate needs of those interested in leaf cover, soil moisture, crop type and such like. The development of time series coverages is of increasing interest as a method of monitoring change and thus modelling future developments within a GIS environment.

## *Integrated approach*

It is clear that the flying of aerial photography has continued across the UK during the early 1990s, given new impetus by the availability of colour imagery. The development of integrated digital photogrammetric and othophoto systems is part of the move to establish photogrammetry as a key component in data capture processes, linked directly into integrated geo-information systems. Likewise the development of low cost archive and management systems developed for a different range of users is addressing the same issue but from a different perspective. The continuing downward trend in computer cost for increasing capability will draw these two approaches together. At the same time the development of multi-media technology is likely to provide a wider market for map and graphic information. The aerial photograph has a particular role to play in this development.

A clear objective over the next few years is the increased awareness of the potential of aerial photographs as a source of data, both highly accurate and less stringent in positional terms, and as a means for deriving geographic context. The aerial photograph has the potential to complement the traditional map as a means of communicating geographical information.

## References

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