W4.1

High resolution ortho photos; can the GIS community handle it?

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Caveat Emptor

Professionals working in the digital age, using powerful computer systems to view and display map and image information at a high resolution, are in danger of forgetting the rules associated with conventional surveying and photogrammetric work, which still very much apply.

This paper will discuss the growing trend to acquire high-resolution photographic imagery at up to 12 cm ground resolution, but is this imagery true 12cm data and how useful is it for practical GIS study and analysis. We will examine the association of photographic scale; scan resolution and files sizes to identify optimum flying heights for different resolutions of ortho image.

There is no denying that the increase in computer performance against decreasing prices, together with software development has enabled many GIS professionals to desire ever complex datasets to improve their work activity. Digital ortho-imagery is an example of the growing need for high quality, high-resolution terrain rectified imagery, geo-referenced to the national map base. However, although precision photogrammetric film scanners can digitise photography to centimetre resolutions, the relationship between photography and image output resolutions must be understood, if high-resolution imagery is to be used effectively.

Table 1 shows the relationship between photographic scales, scan resolutions and ground pixel size. Based upon the traditional surveying and mapping rule of photographic scale being four to five times map scale.

Scan Resolution			
DPI	1200	1000	600
Microns	21	25.4	42.5
Original Photo Scale	Ground Resolution in metres		
1:4000	0.08m	0.10m	0.17m
1:5000	0.10	0.13	0.21
1:6000	0.13	0.15	0.26
1:10 000	0.21	0.25	0.43

Orrthokork (metric units)

When specifying ortho rectified photography, it is important to define the final output resolution, which is dependant upon the size of features, which the user wishes to see in the dataset. As a guide, the user should consider features and their size, ie if 12.5 cm resolution imagery is required, it should be possible to identify stop-values and manholes in the dataset, therefore the associated photographic scale should be sufficiently large to identify these features. If photography at too small a scale is used for high-resolution data, such features are not discernable and the user has acquired a large image file, which is difficult to manipulate and shows no more information than smaller scale photography. To identify features of 12.5

cm in size, the base photography should be at the very least that used for 1:1,000 scale mapping, or 1:4,000 scale photography acquired from an altitude of 2 000 feet.

N18 Ireland Demo

In addition to output resolutions, an important factor in accurate ortho rectification is the digital terrain model (DTM) used to rectify the imagery, reprocessing the image in order that each pixel is in its true geographic position. As photographic and output scale increases, the accuracy of the DTM becomes ever more important to ensure that the pixels are correctly re-processed. Errors in the DTM will cause displacements in feature position and distort linear features such as roads, railways and bridges.

Generally, a DTM at ground level will produce an accurate ortho image, however, in some special cases such as elevated roads, railways etc., the ground level DTM will not ortho-rectify features properly. In these cases, a second ortho, generated from a DTM which captures the elevations of the feature should be produced. This second ortho will now be geometrically correct and can be mosaiced into the original ortho, using specialised ortho mosaic tools.

QE 2 Bridge

25cm ortho photos for GIS Base mapping

MAPS® is the only nationwide project supplying precision ortho photo's to the GIS professional. As a true ortho at ground level, MAPS® is designed to provide high levels of positional accuracy, at ground level, to comply with existing geographic data in a GIS, such as Ordnance Survey LandLine®.

Employing a technique that uses a second elevation model for national coverage would be unfeasible, as well as unnecessary. Flying at 5,000 ft, with a 6inch lens, it is high enough to negate the need for a building elevation model in most areas. In metropolitan areas this effect is further reduced by flying even higher, 10,000 ft using a 12-inch lens, and maintaining focal ratio and scale.

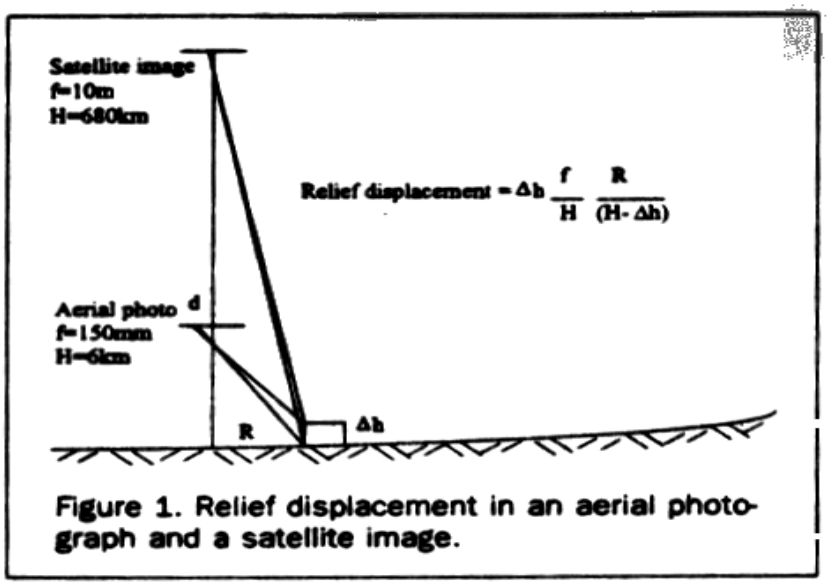

Figure 1. Relief displacement in an aerial photograph and a satellite image.

$$d = \Delta h \frac{f}{H} \frac{R}{(H - \Delta h)}.$$

Rongxing Li 1998 American Society for Photogrammetry and Remote Sensing

The MAPS® product, currently being produced nationally by UK Perspectives is derived from 1:10 000 scale photography and directly scanned to 25cm ground resolution using precision photogrtammetric scanners (DSW 300). For the purpose of an image underlay, in a GIS, the MAPS® product is ideal for the majority of desktop applications.

For entire County data sets, 25cm imagery provides enough information to meet both small and large-scale requirements. Large areas can be displayed for landuse/cover analysis, whilst containing the capacity to 'drill down' into the imagery to observe features, such as buildings, boundaries and footpaths.

For large area coverage, such as a county, 25cm resolution gives a more manageable file size that is less demanding on disk space, storage requirements and ensures rapid display times.

Full ortho rectification using a DTM (photogrammetrically generated and manually edited from aerial photography, based upon 3D GPS control) is the only rectification technique that ensures high enough positional accuracy that is suitable for use within GIS applications.

Demanding a higher resolution at what price?

As more users look to ortho photo mapping as an essential layer within their GIS there is a natural desire for ever higher resolution imagery, especially in urban areas. Local Authorities in Metropolitan areas characteristically have a smaller area of administration with higher densities of social and economic activity. On the surface ortho photos with a higher resolution of 12cm would seem the ideal solution. However a few details need to be examined before committing to a product that is often up to 10 times the price of standard 25cm ortho photo mapping.

What was the flying scale of the original photography? – As stated above if the detail is not in the photography in the first place it won't be visible in the imagery, no matter what resolution the film was scanned at.

Ever-higher pixel resolutions must go in tandem with greater positional accuracy. A higher pixel resolution does not necessarily mean greater positional accuracy! Accuracy is related to the source of the control, GPS being the most reliable for GIS applications. Ordnance Survey's 'Positional Accuracy Improvement Programme' reinforces the necessity to control ortho photos using GPS technology, otherwise many data sets which use existing LandLine® as the source of control will become redundant very quickly.

Exaggerated building lean will obscure detail on the ground – A lower flying height will intensify this effect. If no elevation model is used, and a 2D rubber sheet correction method is employed, the effect is exaggerated further.

London - waterslade data.

Conclusion

Using high-resolution ortho photo's as a base for GIS applications is important to choose a data set, which is most suited to the purpose it is being used put to. 25cm fully ortho rectified imagery is versatile enough for most desktop applications, offering good image clarity for discerning ground detail as well as excellent positional accuracy to use as a reliable layer within a GIS.

1:10,000 scale photography minimises the effect of building lean in urban areas and promotes fast and efficient use of the data. Large county data sets, for example, can be used and distributed almost effortlessly throughout an organisation.

12cm data may be suited to more project specific engineering applications. As a base map in a GIS it is too cumbersome for practical use, building lean will obscure much detail in urban areas and positional accuracy is not necessarily improved, especially if the source of control is not derived from GPS, but from existing 1:2 500/1:1 250 mapping.