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Using *vedute* to source geospatial information: data flowline and accuracies

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Summary:
An introduction is given to the methods by which spatial data integration exercises can use information from a wide range of sources. The nature of landscape paintings, and their possible use as such a source, is discussed. The measurement of planimetric coordinates from *vedute* paintings, using standard projective geometry tools, is described. Tests are undertaken to determine whether such paintings, which can present true visual perspective, allow for spatial fidelity to be 're-engineered'.

Introduction

The intention of this paper is to explore one aspect of the science of comparative cartographic analysis, as defined by Boutoura and Livieratos (2006). The aim is to determine the extent to which perspective views can be used to elucidate geospatial information about a scene, and how accurately data from such views can be integrated with standard topographical survey data.

Tasks for comparative cartographic analysis

Comparative cartographic analysis involves the evaluation of a number of geospatial data sources, usually in the form of maps, for a range of purposes. Interest in such comparisons is long-standing, although it has varied in intensity over many centuries (Livieratos, 2006). Such comparisons are initiated for a number of reasons, including the tasks of integrating geospatial data. Contemporary attempts, for example, to create authoritative spatial data infrastructures (SDI) at regional or national level, involve the merging of geospatial data from a range of sources, with associated variability in a range of characteristics. The conventional parameters which one might bear in mind might include the source scale of the data, its currency, consistency and completeness of data, the reliability and accuracy (assessed using a range of possible methods), the cost and copyright of the data etc. If such characteristics exhibit variability, the end result of the data integration exercise will be flawed.
In some cases such a data integration exercise will involve the consideration of historical data, including old maps. These can also be used for other tasks which rely on comparative cartographic analysis, such as reconstructing environments and scenes for virtual reality, or assessing environmental change (for example river channel change (Downward, 1995)), in addition to exercises dedicated to measuring the accuracy of historical maps and the techniques used to create them. Jenny (2006), quoting Blakemore and Harley, gives a number of reasons for analysing historical map accuracies, and has developed a valuable tool, MapAnalyst, for the precise measurement and visualisation of such quality (which has also be applied to studies of contemporary map distortion).

Incorporating vedute into comparative cartographic analysis

The integration and accuracy testing exercises mentioned so far can be undertaken using both maps and digital geospatial databases. A wider range of possible data sources can be identified, however, which

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can contribute to a reconstruction of past landscapes. Amongst this range the role of perspective views can be examined.

The small project described in this paper, therefore, extends the range of geospatial data sources to historical perspective views, notably the *vedute* paintings of the 17th and 18th centuries. Tice, Steiner, Ceen, and Beyer (2008) have suggested that there were two means for historical workers to make landscape observations permanent before the era of photography: recording pictorially as a series of more or less realistic scenes using perspective (the *vedute*), or cartographically, as an abstract drawing in plan that required scaled measurements. In fact, there is probably a continuum between these two types of rendering of space. The possible linkages and contrasts between the former and the latter have been of interest to a few authors.

For example, Fairbairn (2009) has suggested that because *vedute* paintings have often relied on the skills of the artist to render perspective accurately, they are not really <u>art</u>: their reliance on the <u>craft</u> of transforming space into an image (and the often mechanical nature of effecting such a transformation), along with a corresponding lack of emotional input, means that such *vedute* paintings are more akin to engineering drawings, enjoying the geometric rigour of a map.

Godlewska (2003), on the other hand, contends that landscape artists (her example is Bagetti) can tend to distance themselves from cartography: "most interesting is his [Bagetti's] determination to distinguish landscape painting from cartography and its concerns with mathematical and geometric accuracy and empirical data collection. Bagetti's consistent aim seems to have been to carve out a realm of creativity and peace for representational art" (p.22).

The convergence of *vedute* and cartographic products is considered in the ongoing project ImagoUrbis, developed by Tice, Steiner, Ceen and Beyer (2008). In a project whose ultimate aim is to re-construct the urban environment of 18th century Rome, the influence of *vedutiste* Giuseppe Vasi and the work of cartographer Giambattista Nolli are presented. "Because it was topographically based, the tradition of the *vedutisti* could intersect the cartographic tradition, the *volo d'ucello* or bird's eye view, being an important type where both the pictorial and plan view are conceptually united in a single work" (op.cit). According to the authors, "the reciprocity between Vasi's views and the Nolli map enables one to enter into, and examine Rome in detail, including many neglected corners of the *Settecento* city. Passing from map to view and from view to map, one can reconstruct 18th century sites that have since changed completely or entirely disappeared."

Other examples consider the uncertain common approach of those who, in the past, produced high oblique bird's eye views - neither orthographic nor viewed from the landscape itself. Filter (1994) considers the 1729 work of Ludovico Ughi which presents a bird's eye view depicting Venice from a high oblique angle, enabling him as a cartographer to convey the vertical dimension of the buildings and architectural features of the city, while at the same time retaining a horizontal dimension, which relies on perspective rather than true scale. In fact, this map is <u>supplemented</u> on the same document by 16 small low oblique (ground level) *vedute* incorporated around the edges.

Balletti (2006) has examined the geometric properties of another example of such pictorial representation, the high oblique view of Venice created by de Barbari in the year 1500, showing, by using both a perspective projection and finite elements analysis, that it does not possess true uniform perspective.

When positioned within the landscape (rather than theoretically above it, as in the de Barbari 'map view') and intent on producing faithful and accurate representations, there is, of course, every temptation for the *vedutiste* to use tools to improve the rendering of perspective. The use of mechanical devices to aid in the work of landscape painting dates from the earliest investigations of perspective by 15th century Florentine artists and architects. From Brunelleschi's famous demonstrations of perspective geometry in 1415, through the northern European traditions of urban scene painters such as Vermeer (17th century), to the universally commissioned 18th century work of Canaletto and his talented nephew Bellotto, *vedutisti* have embraced devices to improve their transformations of space.

Practical testing of *vedute*/map interaction

The practical work described here examines methods of 'reverse engineering' such transformations and attempts to determine whether there is scope for using perspective views to enhance and supplement our geospatial knowledge of the landscape, most notably in extracting accurate coordinate information.

Clearly, traditional photogrammetric techniques based on stereo photography form the standard method for extracting measured coordinates of scenes for both mapping and re-engineering of environments and 3D displays. The restriction of using only one single image, such as a *vedute* painting, limits the possibilities of obtaining coordinates, but the embedding of projective transformations in readily available software such as PhotoModeler and ShapeCapture (Patias, 2004) offers some potential. Such software has been applied to a large number of projects which have involved the extraction of quantitative information from single photographs. This single-image process allows all points on a plane to be addressed, provided that plane has been calculated. Thus, an important assumption is that one is working with a plane, a flat surface. The primary applications of such projects are in architecture and archaeology, and they are characterised by the measurement of building facades and other vertical features which are perpendicular to the angle of view of the terrestrial camera taking an image of the scene.

For the possible extraction of planimetric coordinates, there is a requirement to examine the ground plane, and reconstruct the projective geometry of the land surface. Once that has been done, theoretically, it should be possible to obtain two-dimensional (x,y; easting,northing) coordinates of position on the flat ground.

The striking image by Canaletto of the Duke of Northumberland's London property, Syon House, was painted in 1749, during the artist's long stay in England. The property, which still stands, occupies a flat river-side site with little variation in elevation, and it is surrounded by open parkland (*Figure 1*). The base corners of this regular building are therefore easy to identify on the painting, and they share the same height above sea level. Instead of creating, therefore, a plane surface representing a facade of the building - a plane which is virtually perpendicular to the artist's view - the intention was to concentrate on the plane surface of the base of the house (and, by extension, the continuously complete ground surface around it which is at the same height above sea level).

In PhotoModeler, such plane reconstruction needs four known points. Therefore the British National Grid coordinates of the three visible corners of the house, along with a knowledge of the height of one of the towers (giving the coordinates of a fourth point), were entered and the geometry was solved (*Figure 2*). In effect, PhotoModeler reconstructs the scene (it is invariably used with photographic, rather than artistic imagery) assuming the image was obtained using a camera with a particular focal length and image size. If used by Canaletto, mechanical optical devices such as *camera obscura* and primitive pinhole cameras would equate to such a device.

Once the ground plane of the building has been reconstructed it is re-projected onto the painting, and it should be possible then to obtain the coordinates of any point on that plane, or the extrapolation of that plane outside its edges. Tests showed, however, that this exercise was almost impossible to achieve with the painting used. In *Figure 3* a line has been drawn successfully from the diagonal of the house (the longest edge of the calculated plane) towards the control point at the front corner of the central tower. The line was then continued successfully outside the calculated surface, but as it moved towards the edge of the image - indeed it was drawn to finish on the control point at the bottom of the right-hand tower - the accuracy of the points became increasingly erratic, as can be seen in the orthogonally viewed 3D scene in *Figure 3*.

Figure 1. Syon House, London (photograph, Microsoft Virtual Earth and map, Ordnance Survey).

The major reason for the lack of accuracy in recording the coordinates is the poor geometric condition of the calculated plane. It is a very thin, poorly conditioned triangle with unfavourable geometry, which makes identifying and calculating the positions of points troublesome. The ground surface plane is difficult to create and use because of the low oblique angle of Canaletto's painting position. Identifying any individual point relies, in effect, on 'grazing rays' which travel from the viewpoint to intersect the ground plane at an acute angle.

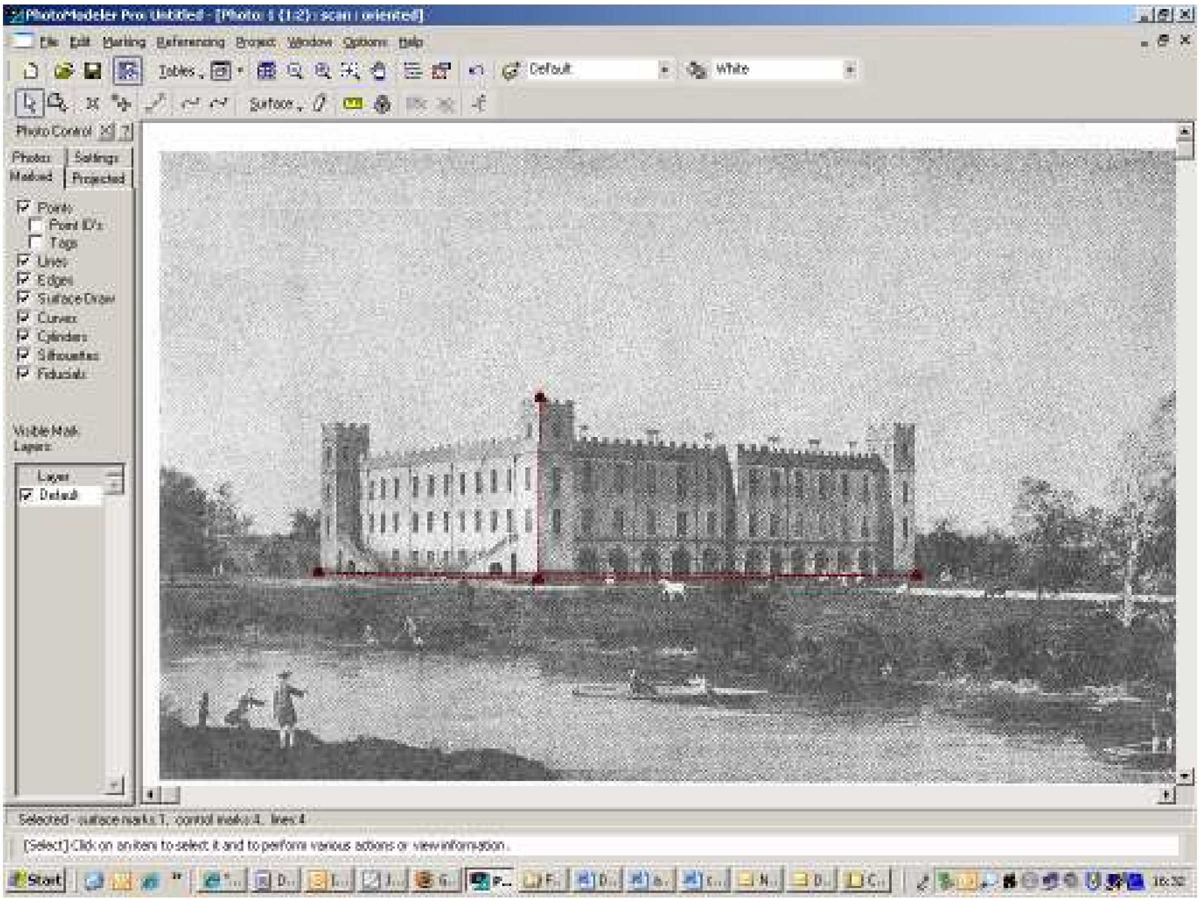

Figure 2. Using Photomodeler software to capture the projective geometry of Canaletto's 1749 painting 'Syon House'

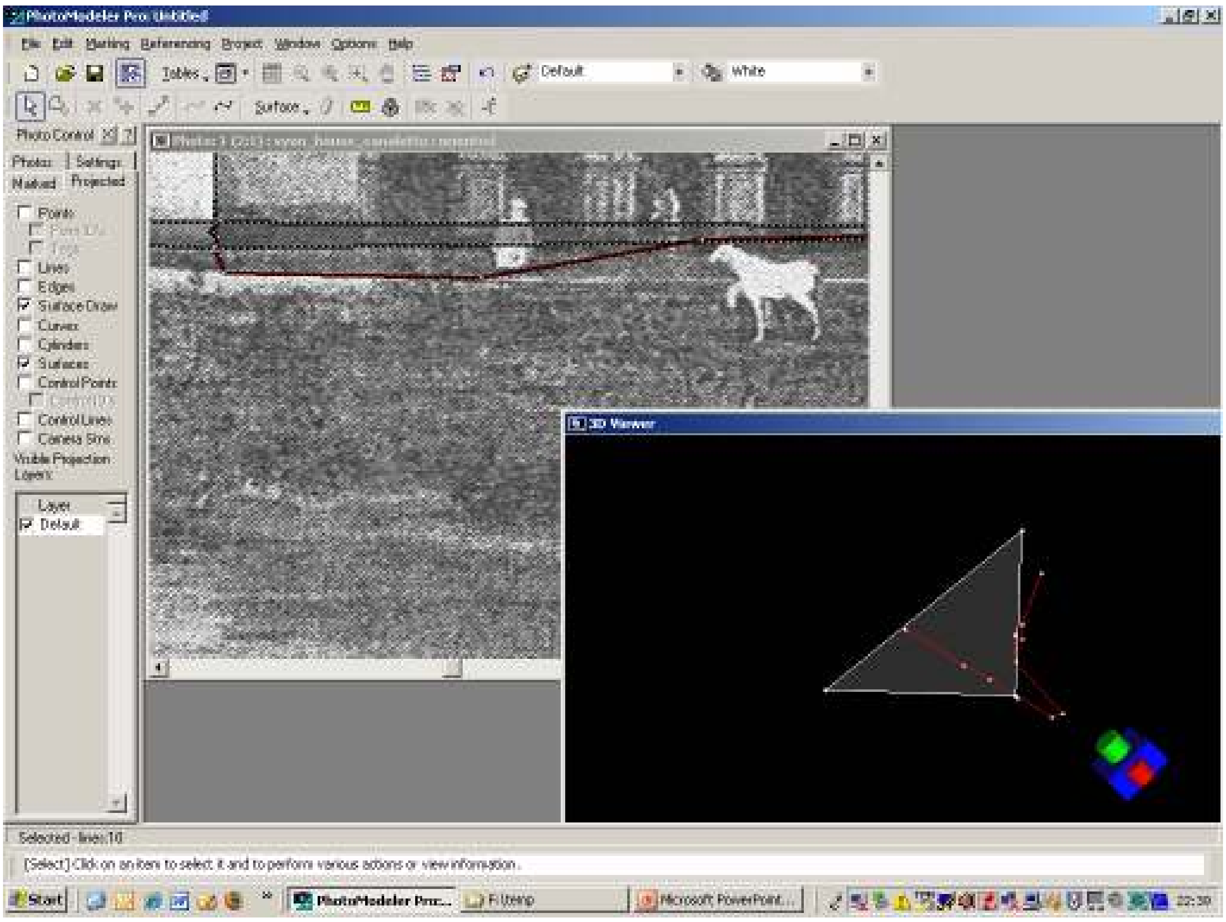

Figure 3. Attempting to re-construct the plan view of the east façade of Syon House using Photomodeler**.**

Further testing using Google SketchUp

Notwithstanding this lack of success, a further attempt was made to re-construct the geometry using the software package Google SketchUp, which appears to have significantly more flexibility in data handling, than the more traditional photogrammetrically-sourced tools.

In this case, fewer control points are needed initially, but constraints in the form of parallel lines are drawn in perspective to help reconstruct vanishing points and the horizon (*Figure 4*). For Google SketchUp, the origin is placed, at the beginning of the exercise, in a standard location at the centre of the scene (in this case the bottom of the central tower). No further coordinated control information is needed at this stage, although it will be introduced in later processing. The scale is applied either directly by measuring a known distance on the image, or by adjusting the height of the resident avatar ('Bryce') who can be made to match the scale of the other characters in the Canaletto painting. Using similar techniques to PhotoModeler, but with considerably greater control over rotating and zooming the resultant ground plane, detail was extracted and exported in .DXF format (*Figure 5*).

The ground plan was then inserted into AutoCAD as a block, allowing for the one control point specified - the origin (0,0) at the base of the central tower - to be transformed to its true British National Grid coordinates. One further control point was needed in order to calculate the angular rotation of the block, but it was clear that there were advantages in terms of number of control points required, and ease of transformation of coordinates, in this flowline.

Unfortunately, once more accuracy did not appear to be high. *Figure 6* shows an overlay of the GoogleSketchUp derived house side (in blue) on top of the contemporary MasterMap data (in red). Further, an historical map of Syon House from 1894 has been included to indicate the mismatch between mapping of different periods, along with the mismatch between *vedute*-derived data and the mapping.

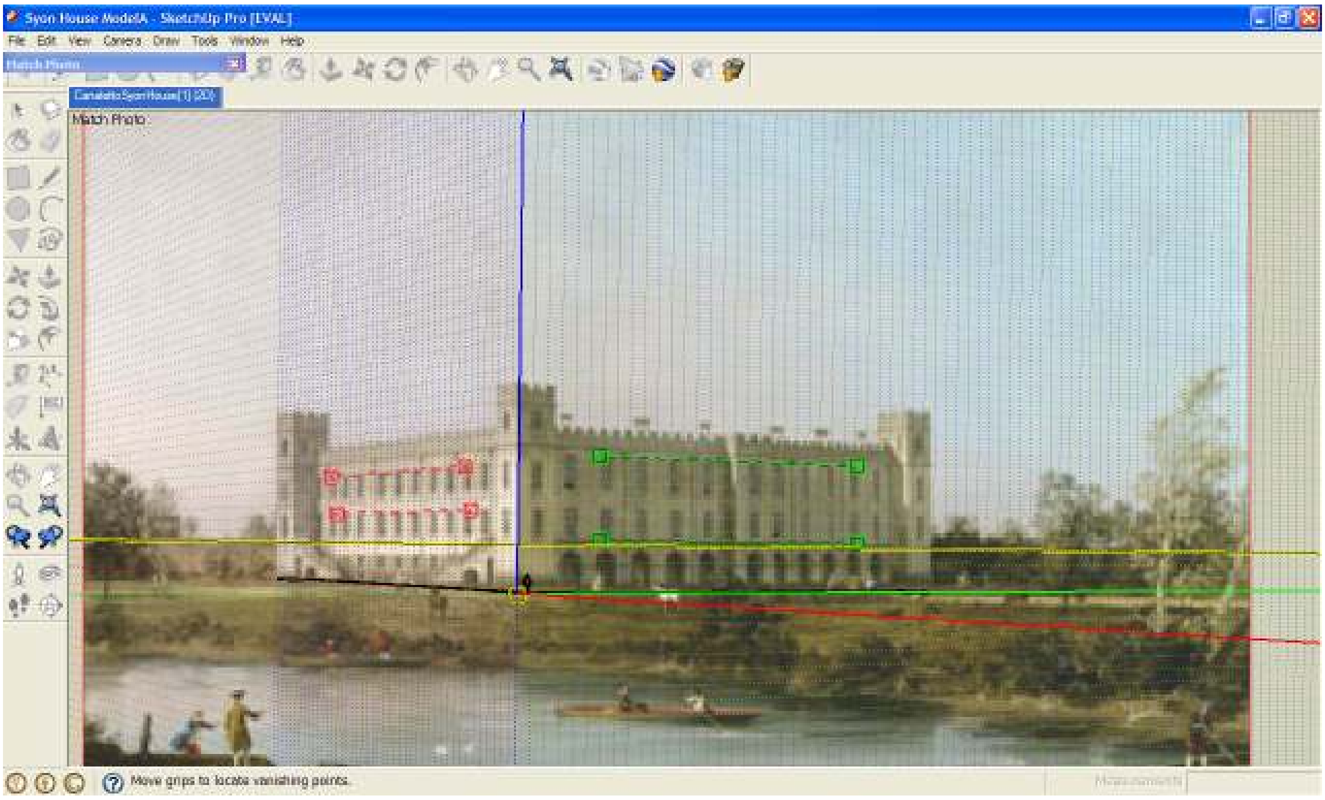

Figure 4. Using Google Sketchup to capture the projective geometry of 'Syon House'.

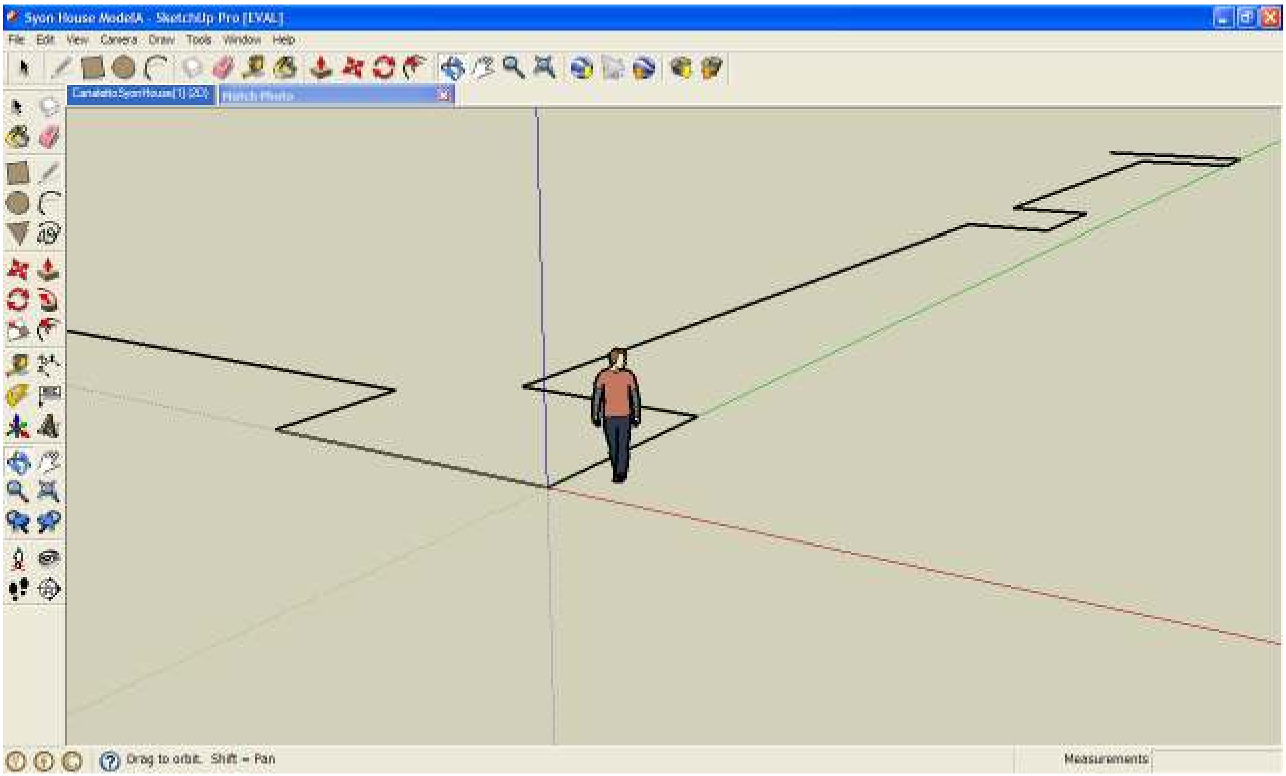

Figure 5. Extracting the east side of Syon House using Google SketchUp.

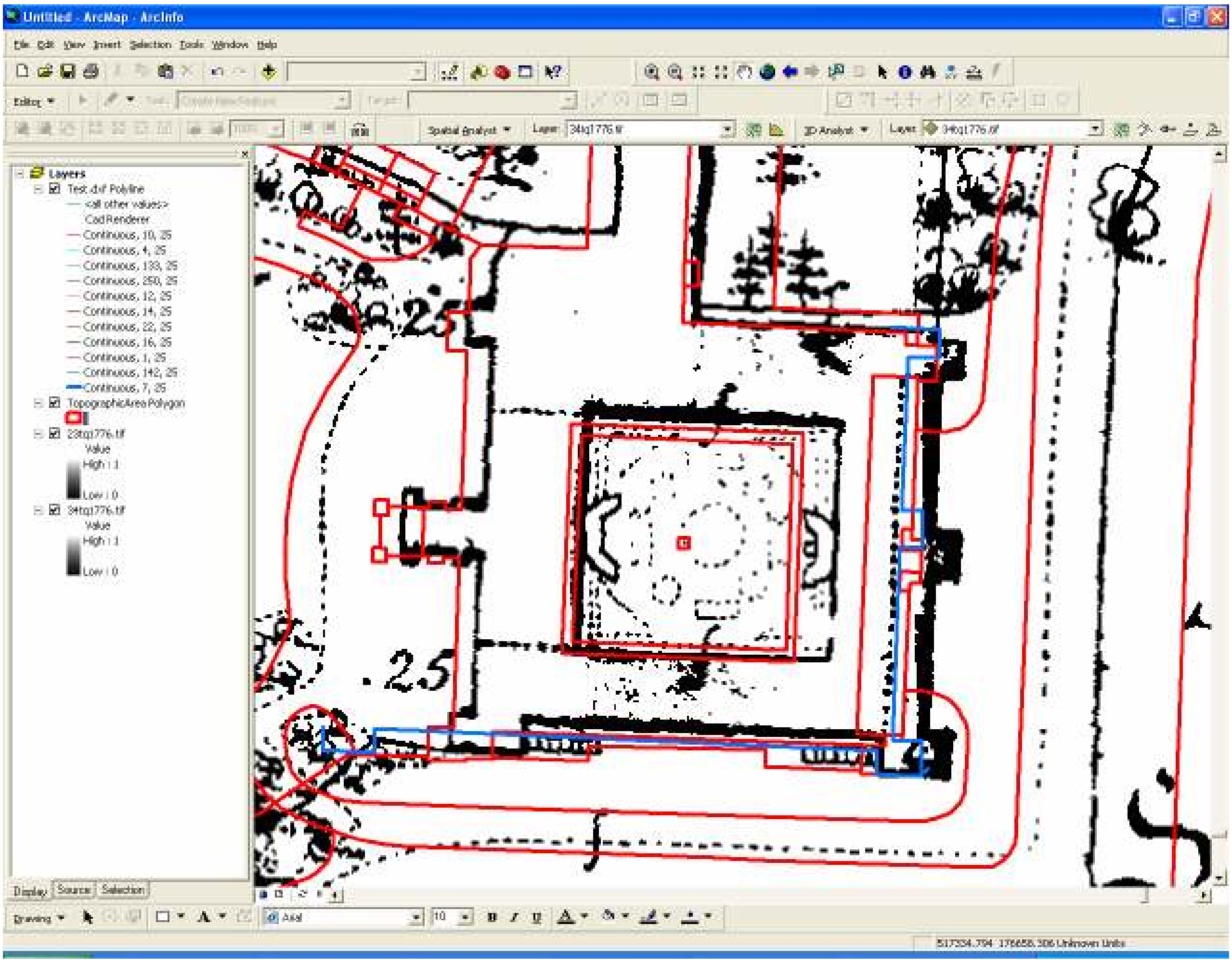

Figure 6. Overlay of contemporary MasterMap topographic data, historical mapping (date 1894) and plan view obtained from Google Sketchup.

Conclusions and further work

It is clear that the accuracy of coordinate positions derived from the *vedute* is low. There is a number of possible reasons why this might be so. Firstly, the artists themselves, even if they have used mechanical perspective devices, may well have introduced 'artistic licence', modifying the view for particular purposes, imposed by their patron or from their own artistic interpretation. Secondly, it is unlikely that the image produced by *vedutisti* would match the lens based image of a contemporary camera, with its associated focal length and restricted image size. The calculation of the focal length, which is inherent in the initial processing of the scene in PhotoModeler, may have little relevance in the context of a *vedute* painting. Further, once the geometry has been successfully re-engineered, the low oblique perspective displayed by the vast majority of *vedute* painters leads to significant problems in accessing good quality positional data due to the foreshortening of the ground plane.

PhotoModeler, and other image handling software of its type, are able to handle multiple, convergent, images to give more accurate results than the single images used here. It would be of interest to use a set of paintings of the same scene (e.g. the large number of Canaletto paintings of St. Mark's Square) and undertake multiple point matching for the purposes of re-mapping that area. In some cases, *vedutisti* were able to obtain a high point of view for their paintings, so such high oblique artworks could yield more accurate results.

The comparisons made in this project have been purely visual, on a very limited set of data. For larger projects, the type of accuracy measurement using mathematical means, such as that done by MapAnalyst, could be usefully applied. Further mathematical rigour could be introduced by examining ways of dealing with non-planar ground surfaces, for example using a digital terrain model, and adjusting the projective geometry calculations to that, rather than a plane surface.

This small project has shown that there is some potential in the extraction of geospatial data from *vedute* paintings, but that there are many barriers to their use in truly accurate reconstructions of the historic environment.

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