Mapping Science - Georeferencing

This report aims to provide a detailed description and analysis on the process of georeferencing the provided image, and conclude upon the results of this process. Figure 1 displays the location of this study, of central London. Figure 1a - the Ordnance Survey Mastermap layer, and Figure 1b – the satellite image provided.

Figure 1: Location of study area.

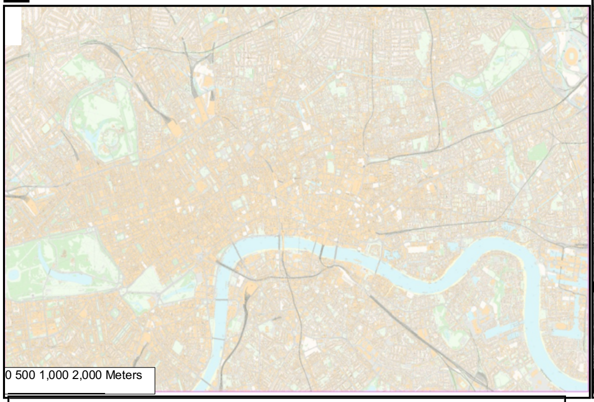

Figure 1a: Ordnance Survey Mastermap, derived from EDINA Digimap

Figure 1b: Satellite image provided. @Crown Copyright and Database Right 2017. Ordnance Survey (Digimap Licence)

A significant amount of unprocessed geographic data such as aerial photographs and satellite imagery, are particularly limited in their integration with other GIS data, this is because the images do not include geospatial scales and characteristics (Georeferencing and Digitizing Image/Map, n.d.). This can be demonstrated by central perspective projection (figure 2), where the aerial photographs and satellite images provide a view from the centre of the image, therefore the extremities of image are often stretched and distorted (Tate, 1998).

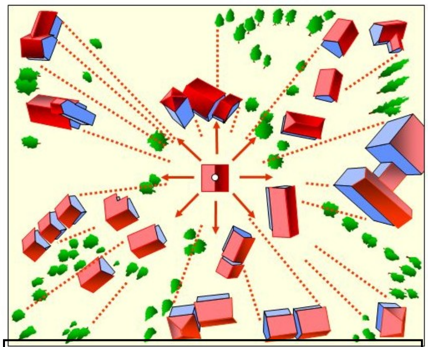

Figure 2: Sijmons, K. (n.d.). image showing change in spatial data on extremities of image.

In order to create a scaled Ortho-image with accurate geospatial characteristics, the image must first be georeferenced. Georeferencing involves the process of geospatially correcting unreferenced data to align (location and rotation) with an existing data that has been geographically referenced to a coordinate frame. Rectification (georeferencing) is performed by collating locations within the unreferenced data with the reciprocal locations within the already geographically referenced data and then implementing a transformation. (Verhoeven et al., 2012; Georeferencing and Digitizing Image/Map, n.d.)

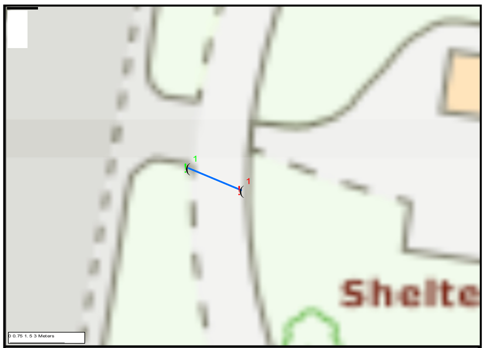

Figure 3: GCP-1 displayed on OS Mastermap

In this study, Ground Control Points (GCP) were used as geographic reference points. The GCP's were implemented manually using visual techniques to find corresponding features at the same geographic location. In the interest of continuity and accuracy in the results, the GCP's used in this study conformed to parameters stated in literature (Georeferencing and Digitizing Images/Map, n.d.). The parameters included; easily identifiable geographic locations, to be distributed comprehensively throughout the entire image, and using geographic features at ground level. Figure 3 shows the displacement a transformation can cause upon a GCP. Within figure 3, the green circle represents the initially selected geographic feature to place the GCP, in comparison, the red circle represents the displaced GCP once a transformation is performed.

Table 1: Total RMSE values for different transformations

Transformation	Total RMS Error
1st Order Polynomial (Affine)	4.78713
2nd Order Polynomial	3.58347
3rd Order Polynomial	3.34795
Projective Transformation	4.60429

Table 1 shows the different Total RMSE (Root of Mean-Square Error) of GCP's when applying all 16 GCP's. The smaller value is considered to be more accurate. Although the Total RMSE is a good valuation for the of each transformation's accuracy. A low RMSE can often lead to an inaccurate configuration on the georeferenced layer. This can often be caused by many variables including errors in the manual output.

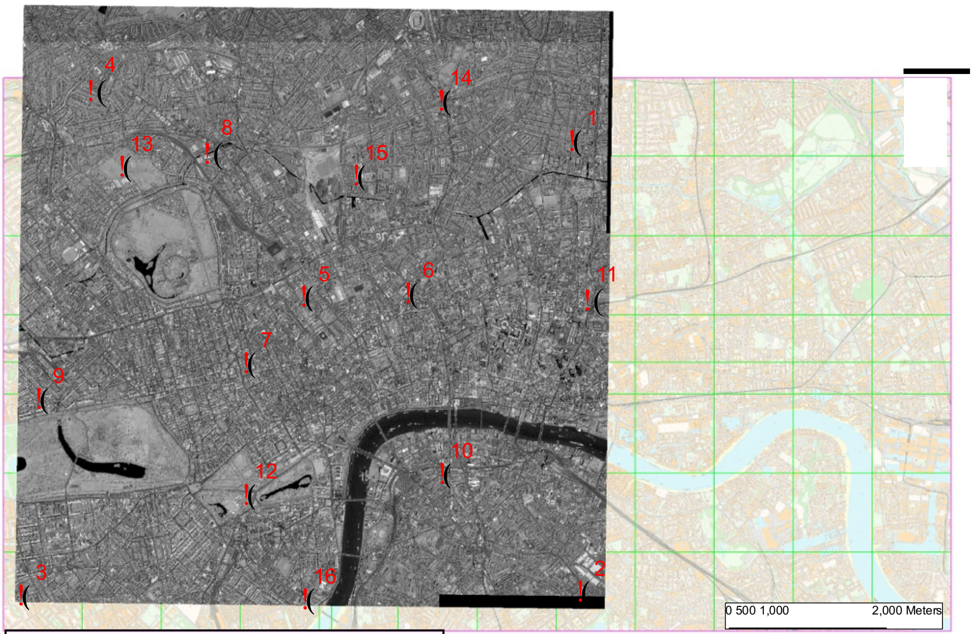

Figure 4: Overlayed map with GCP

Table 2

GCP	X Source	Y Source	X Map	Y Map	Residual_x	Residual_y	Residual
1	7065.866383	5968.843602	533292.0596	184232.8643	-2.15641	3.01606	3.70766
2	7248.115503	249.773289	533395.0297	178518.8406	1.51857	-5.6571	5.85737
3	162.595914	119.279552	526308.8614	178479.5768	-1.52977	3.46385	3.78662
4	949.582522	6531.169444	527191.8363	184858.7099	2.06647	-2.47405	3.2165
5	3693.648669	3949.331573	529893.2012	182256.6102	-1.58515	1.78038	2.38379
6	5018.802314	4009.353083	531222.6361	182299.2117	2.62905	-0.184871	2.63555
7	2978.430405	3101.825588	529169.3472	181413.6777	1.62266	-4.24254	4.54227
8	2446.469977	5749.135264	528672.1787	184072.0367	-2.5515	7.99338	8.30541
9	353.835116	2615.59051	526538.3522	180957.4355	0.677209	-5.87574	5.91463
10	5474.950457	1727.150317	531641.666	180021.4727	-1.5419	3.22771	3.42787
11	7284.73013	3947.97145	533486.6181	182207.4469	2.94423	-4.59505	5.45738
12	2999.531687	1428.871519	529163.7146	179754.4899	-0.864796	5.13882	5.21108
13	1363.656453	5575.244389	527592.3114	183896.4004	2.5544	-6.72589	7.19462
14	5397.984191	6457.473028	531632.9832	184735.6921	-1.43844	-0.676633	1.58964
15	4336.026005	5500.03294	530557.0331	183797.8895	-2.20433	4.05982	5.61966
16	3766.592859	114.863804	529911.3288	178431.8807	-0.813354	1.75184	1.93145

Table 2 gives a numerical representation of the Ground Control Points (GCP) throughout the georeferenced map. It can be seen the GCP points comply with the parameters previously mentioned and are distributed well. In addition to figure 1, table 2 Gives a numerical representation of the GCP location, as well giving residual values for each GCP when 16 GCP's are used. The residual x and y values (meters) represent the amount of misalignment from each of their respective actual x and y locations that was specified relative to the same GCP, using this the sum residual value can be calculated (final column in Table 2). The Total RMS Error can be calculated as the root mean square sum of all residuals. Using all 16 GCP's, the Total RMSE is given a total of 4.79m.

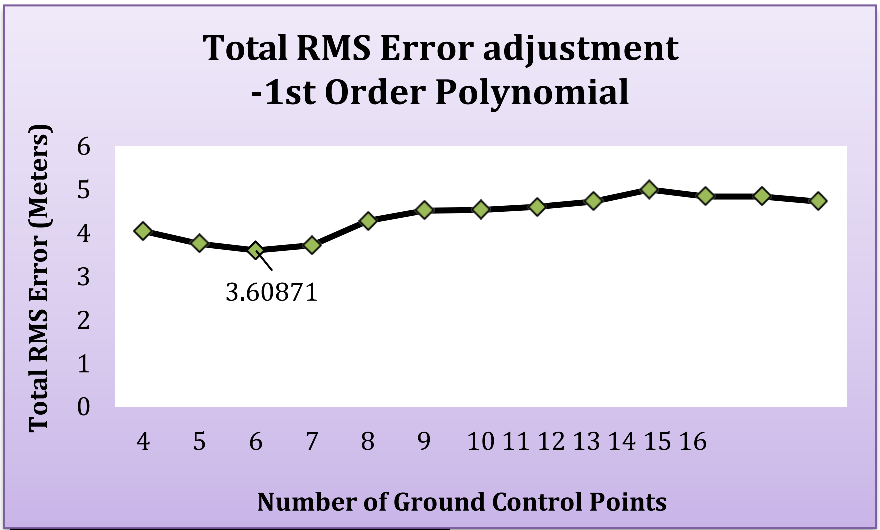

Figure 5: Total RMSE for 1st Polynomial.

Figure 5 shows the variant values of the Total RMSE's for 1st Order Polynomial transformations when adjusting the amount of GCP's including in the calculation. It can be seen that the smallest value (highest spatial accuracy) occurs with 6 GCP's in the calculation. It can also be noted that any value after 6 GCP's, displays a general increasing trend in value, representing a weaker accuracy. However, this could be as a result of an outlier in residual values for GCP-8 as can be seen in table 2 (8.30541m). It was concluded to use 6 GCP as gave the highest accuracy when using 1st Polynomial formations.

<u>References</u>

Georeferencing and Digitizing Image/Map. (n.d.). *Spatial Structures in the Social Sciences*, [online] pp.1-7. Available at: https://s4.ad.brown.edu/Resources/Tutorial/Modul2/Georeferencing%20and%20Digitizing%20%20in%20ArcGIS.pdf [Accessed 20 Nov. 2017].

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Verhoeven, G., Doneus, M., Briese, C. and Vermeulen, F. (2012). Mapping by matching: a computer vision-based approach to fast and accurate georeferencing of archaeological aerial photographs. *Journal of Archaeological Science*, 39(7), pp.2060-2070.