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Producing Image Map of Thebes Necropolis Cultural Heritage Site: The Mortuary Temple of King Ramses III at Habo Luxor, Egypt

Ahmed Ibrahim Ramzi

National Authority for Remote Sensing and Space Sciences (NARSS), Cairo, Egypt

Correspondence should be addressed to Ahmed Ibrahim Ramzi, Ahmedasi@hotmail.com

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Abstract In the recent past, archaeologists used in their study traditional methods. Now, remote sensors have become essential equipment in archaeology studies, either used on board satellites in space or on airborne. Producing modern maps for the archaeological sites is very essential for develop and protect it. The Orientation of ancient Egyptians constructions is still surprising among astronomers and scholars in the world to find out how ancient Egyptians oriented the axis of their constructions with high accuracy. Main research objective is using remote sensing data and techniques to assess producing image map and to determine the direction of the axis of Heritage site. The Mortuary Temple of King Ramses III at Habo Luxor, Egypt has been selected as study area. The study area covered with QuickBird 0.6m resolution slandered pansharped images. A coarse digital elevation model DEM has been used release the topographic relief. Also, ground control points GCPs and check points CPs have been used for geometric correction and image map accuracy assessment. The proposed methodology involves many steps included geometric correction of QuickBird satellite imagery using an appropriate mathematical model and asses the scale of the produced image map. After that, the direction of the main axis of the heritage site has been determined. A comparative study has been performed between traditional method based on direct GPS measurements and the suggested method. The obtained results of the study showed that the accuracy of the produced image map using second order polynomial function gives TRMS 4.288m which satisfies theoretical large scale mapping of 1: 10 000. The difference between axis direction of the temple from the produced image and from GPS direct measurements was ± 0 deg 59 min 7 sec.

Keywords *Image Map; Heritage Site; Archaeology; GIS; Remote Sensing*

Research Objectives

- To produce image map from QuickBird Pansharpened images with 0.6 meter resolution using ground control points and check points.
- To establish a practical methodology for calculation the azimuth or the whole circular bearing of the main axis of the ancient Egyptian temple based on QuickBird Images.
- To assess the geometric accuracy of pansharped QuickBird images using selected mathematical model.
- To compare the results obtained from traditional methods (field measurements and from remote sensing techniques.

1. Introduction

The use of remote sensing technology offers the archeologist the opportunity to detect these impacts. The usefulness of satellite images for identifying and analyzing archaeological sites is now available from satellite borne sensors such as Spot-5, Ikonos, Quickbird, GeoEye, Worldview and LIDAR that provide even greater potential for investigating archaeological sites. Roman landscape at Butrint has been studies using aerial photographic data and computational routines for identifying linear landscape features conforming to specified alignments, within a spatially extensive and complex data set (Neubauer et al., 2002). Large areas of land can be investigated using satellite remote sensing; allowing archaeologists to get a better sense of spatial distribution, size, scale and discover unknown sites (Sarah Parcak, 2004). Real photogrammetric survey of an archaeological site of the Tartessic epoch in Southern Spain has been studies using light aerial platforms or unmanned aerial vehicle (UAV) systems (Mozas-Calvache et al., 2012). Multispectral and hyperspectral instruments mounted on orbiting and sub-orbital platforms have provided new and important information for the discovery (Marco J. Giardino, 2011), 3D modelling of Pinchango Alto, Peru, based on a combination of image and range data. Digital photogrammetry and laser scanning allow archaeological sites to be recorded efficiently and in detail (Karsten Lambers et al., 2007). Free available satellite images viewed in Google Earth and historic aerial photographs was used to identify anomalies in a 25,000 km^2 macro region encompassing 13 river valleys along the Peruvian coast on the Central Coast of Perú (Margaret Brown Vega et al., 2011). Ground Penetrating Radar (GPR) is the only near-surface geophysical tool that can make three dimensional maps and images of the subsurface at archaeological sites. By using GPR and geophysical methods, it is possible to detect the underground presence of structures such us walls, foundations, floors, roads, kilns, hearths, tombs, graves, pits cavities, mounds and filled ditches; (Conyers et al., 2002, Goodman et al., 2004, Neubauer et al., 2002). Researcher and studies has been approved that ancient Egyptian temples had certain orientation: (1) Astronomy (solar, lunar and stars); (2) Topography orientations (Nile direction and hills) and (3) Both astronomy and topography orientation. Reasons for changing orientation of ancient Egyptians Constructions: (1) Era or construction date; (2) Change in the religious beliefs of with time and (3) Influence of the royal power. Many pyramids and other important buildings in Mesoamerica (Olmécs, Maya...) were oriented by means of a magnetic compass (Klokoèník et al. 2007; Charvátová et al., 2011). Astronomical orientation of temples not easy to study because it needs the right constructions dates to check them out. High accuracy software RedShift (archaeoastronomical simulations), has been used to calculate the astronomy orientation at the construction dates. Many ancient ruins demonstrate that the people who constructed them had not only a special regard for celestial bodies and mathematics, but also a spot-on accuracy. Four previous orientation studies of Egyptian Temples studies have been found: First, Shaltout and Belmonte used traditional method for checking the azimuths were based on prismatic compass readings, which the authors claim are accurate to within ± ½° (Shaltout et al., 2007; Belmont and others, 2008;) hereafter papers 1, 2, 3 and 4, respectively. Second, David Furlong studied the direction of the axis of Egyptian temples using satellite imagery which available free in Google Earth (David Furlong, 2007). Third, Amanda-Alice Maravelia and Muslim Shaltout studied the axis direction of three Egyptian temples Karnak, Luxor, and Hatshepsut at Thebes using also satellite imagery which available free in Google Earth also without doing any geometric correction (Amanda-Alice Maravelia and Muslim Shaltout, 2010). Fourth, Shaltout and Ramzi Method used QuickBird 0.6 m resolution pansharped slandered images which radiometric and geometric corrected by venders without using any additional ground control points GCPs and check points CPs (Shaltout and Ramzi, 2012). So, this research will focus in remove distortion from satellite images. There are generally two types of mathematical models used to correct the distortions of satellite imagery: physical models and non-physical models. Physical models reflect the physical reality of the viewing geometry (platform, sensor, Earth and sometimes map projection). The major advantages of physical modeling over empirical modeling is mainly due to the fact that the mathematical functions correspond to the physical reality of the viewing geometry and take into account all the distortions generated in the image formation, while empirical model parameters do not have any physical meaning (Madani, 1999; Dowman and Dolloff, 2000; Aguilar et al., 2005; Toutin, 2004; Toutin et al., 2005; El-ghazzali, S.S., 2005). Non physical models are the most widely used models in remote sensing that transform the coordinates from the images coordinate to the object coordinate systems and vice versa (Jacobsen, 2005; Mohamed, L.K., 2006). Ground control points (GCPs) and check points (CPs) are necessary for the evaluation and acceptance of the geo-referencing/rectification process (Nicola Georgiev et al., 1998; Elghazali, S.S., 2005; Elmanadili, Y.S., 2007). In this research geometric correction of satellite image using different number and distribution of GCPs will be carried out also image rectification using digital elevation model (DEM) will be carried.

2. Study Area

Temple of King Ramses III located at Habo City in the west bank of Luxor city, Egypt. It located in the far south of group of temples commemorate the Pharaohs. The Temple built near the Nile and on the edge of the desert in the west of Thebes. In ancient times Madinat Habo or Habo city was known as Djanet and according to ancient belief –the place was Amun first appeared. Both Hatshepsut and Tuthmosis III built a temple dedicated to Amun here and Later Rameses III constructed his larger memorial temple on the site. King Ramses III was the second in the King family dynasty 20, and Okhrhakm the great era of the modern state. Fought three times during his reign was successfully repel the invasions of the Sea Peoples and the Libyans, who tried the first time the invasion of Egypt during the reign of Ramses II. Wars brought great wealth to Egypt and built many new temples were built in the Medinet Habo., temple at Thebes huge and also added Khonsu Temple of Amun at Karnak temple complex. The Temple of Medinat Habo or Habo city is one of the largest memorial Temples in Egypt. It measures 320m in length (East to west) and about 200m in width (North to South). Figure (1) shows location map of the study area “the Mortuary Temple of King Ramses III at Habo City Luxor, Egypt”. Figure (2) shows Mortuary Temple of King Ramses III at Habo City Luxor, Egypt. This Temple basically consists of a huge gate, a huge mud brick enclosure wall surrounds it, temple entrance, Migdol I, mortuary booths, the first pylon, the first court, the second pylon, the second court, the hypostyle hall, holy of hogties, stores and administrative buildings, royal place, Chapels of the divine Adoratrices, entrance to the western portico, and outer wall and temple of Amun.

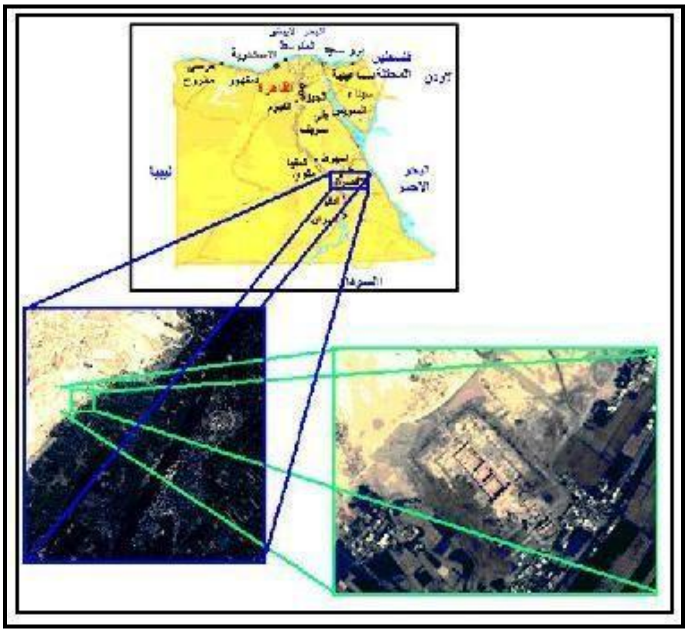

Figure 1: *Location Map of the Study Area "the Mortuary Temple of King Ramses III at Habo City Luxor, Egypt"*

Figure 2: *Image of the Mortuary Temple of King Ramses III*

3. Data Set

The study area covered with QuickBird 0.6m resolution, slandered pansharped images. A coarse digital elevation model DEM has been used release the topographic relief. Also, ground control points GCPs and check points CPs have been used for geometric correction and image map accuracy assessment.

4. Methodology

The new method proposed to perform geometric correction of QuickBird satellite imagery using an appropriate mathematical model and asses the scale of the produced map. After that calculation of the direction of the temple axis and determine the percentage of error on it by comparing the results with measurements from field with GPS has been performed. The following steps have been used: The proposed methodology from very high resolution satellite images involves many steps to get the final results.

These steps are:

1) Data collection "Remotely sensed data "VHRS images and maps covering the study area".
2) Acquisition of the ground points (control/check) coordinates X, Y.
3) Geometric correction of satellite image using different number and distribution of GCPs using second order polynomial (non-parametric model).
4) Image(s) rectification /orthorectification using digital elevation model (DEM).
5) Obtaining the image coordinates of x, y of ground points, ground control points (GCPs) and check points (CPs) from the rectified images.
6) Accuracy assessment of GCPs and CPs, calculation of residuals in x and y directions and RMSE.
7) Evaluating the produced image map.
8) Defining the main axis of the temple on the rectified images. Fix point at the back of the temple (point A); move forward to a second position on the axis of the temple and fix it, then measured the co- ordinates of point (A) and (B). It is then possible to calculate accurately the bearing between these two points.
9) Calculating the azimuth or the whole circular bearing of the main axis of the temple from image map.
10) Calculating the azimuth or the whole circular bearing of the main axis of the temple from direct GPS measurements in the field for points on the axis of the temple.
11) Comparative study between traditional method and remote sensing method.
12) Conclusions and Recommendations

5. Results and Discussion

The proposed methodology has been applied step by step. Used Coordinates System: Projection: UTM, Zone 36 North, and Datum: WGS 84. Used software was ENVI 4.8. Rectified image or image map has been produced using, 6 GCPs, 2-D polynomial function first and second order models and DEM. The best results came from Second order 2-D Polynomial Function. After the geometric correction, checking the accuracy is very important. In order to check the accuracy of the geometric correction on GCPs and CPs the discrepancies has been calculated. The results showed that: RMS error in X direction in 6 GCPs = 1.235m, RMS error in Y direction in GCPs = 1.562m and TRMS error in X and Y direction in 6 GCPs = 1.991m. The results showed that: RMS error in X direction in 12 CPs = 2.053 m, RMS error in Y direction in 12 CPs = 3.765m and TRMS error in X and Y direction in 12 CPs = 4.288m. The results will be evaluated according to the American specifications in production and updating of maps as per American National Map Accuracy Standard (NMAS). The allowable error according to (NMAS) can be computed from the following formula:

$$\text{Allowable error} = 0.50 \text{ mm} \times (1/ \text{map scale})$$

From the obtained results the produced image map meets map scale 1: 10 000 or greater according to the specifications. Figure (3) shows produced photo map scale 1:10 000 of King Ramses III temple in Habo city. Photos of some main parts of King Ramses III temple has been taken to explain it in more details which are presented in Figures from 4 to 21. Figure (4) shows Scared Lake. Figure (5) shows Lake and Nilometer. Figure (6) shows Temple of Ramses III. Figure (7) shows Chapels of The Divine Adoratrices. Figure (8) shows First pylon. Figure (9) shows Mud Brick Wall. Figure (10) shows Second pylon. Figure (11) shows Second courtyard. Figure (12) shows Royal Palace. Figure (13) shows Entrance to the western portico. Figure (14) shows Entrance & Migdol. Figure (15) shows Small temple. Figure (16) shows Storage and administrative buildings. Figure (17) shows Scene above the doorway entering the 2nd Courtyard. Figure (18) shows Scenes from the rear of the temple of Ramesses III at Medinet Habo. Figure (19) shows Hypostyle, chapels & shrine. Figure (20) shows the south side of the 1st pylon (the back). The scene is of a wild bull hunt in the marshes with column of Egyptian soldiers. Figure (21) shows Reliefs and inscriptions on the front of the towers record the military victories of Ramses III--over the Libyans and Asians. To calculate the azimuth or the whole circular bearing of the main axis of the temple from the rectified map, several points has been identified on the axis of the temple their coordinates have been measured. Axis direction of the temple from the produced image was 131 deg 5 min 57 sec. Figure (22) shows main axis of the temple on the produced image map scale 1:10 000. Calculate axis direction of the temple from direct GPS measurements in the field for the points on the axis of the temple. Seven points on the axis of the temple of Ramses III of point No. 676 to No. 682 point was the use of a handheld GPS device to measure the coordinates of the it, taking into consideration the number of the observed satellites and increase the monitoring time until one get the highest possible accuracy. Figure (23) seven points located on the axis of the temple its coordinates measured with handheld GPS. When drawing the seven points should be located straight line represents the axis of the Temple of Ramses III, but did not fall in a straight line as a result of errors, according to the theory of the sources of errors are nature, Instrumental and personal. First 2 points have been canceled due after that a linear regression model (equation 1) has been developed with 95% confidence which represent the best fitting for the measured data. Figure (24) shows best fitting of five measured GPS points X and Y coordinate.

So, axis direction of the temple from GPS direct measurements for points on the axis of the temple from field was: 130 deg 6 min 50 sec

$$Y = -1.18696650292295X + 3390663.02392538 \qquad \text{(equation 1)}$$

Axis direction of the temple from the produced image was 131 deg 5 min 57 sec. Axis direction of the temple from GPS direct measurements for points on the axis of the temple from field was: 130 deg 6 min 50 sec. Therefore, the difference between them was ± 0 deg 59 min 7 sec.

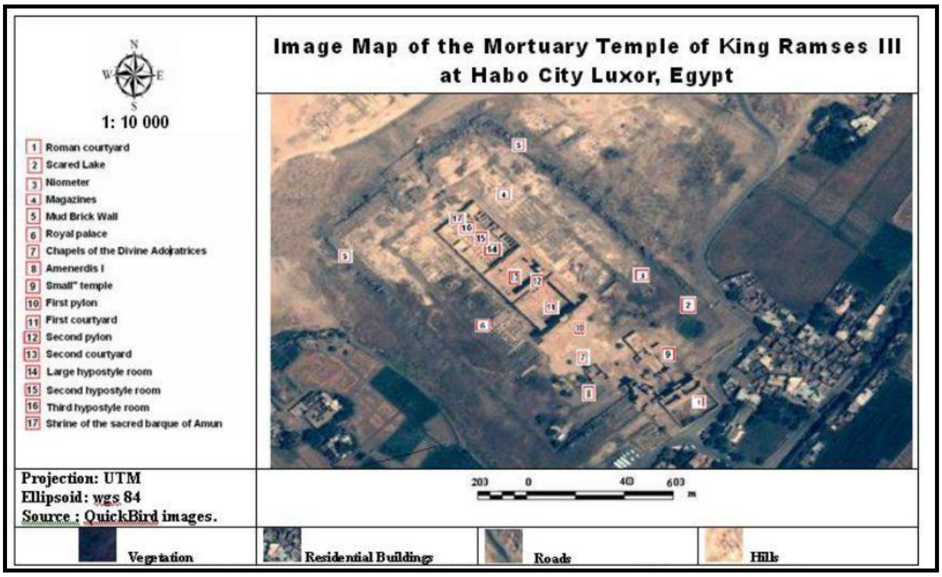

Figure 3: *Produced Photo Map Scale 1:10 000 of King Ramses III temple in Habo City*


Figure (4) Scared Lake


Figure (5) Lake & Nilometer


Figure (6) Temple of Ramses III

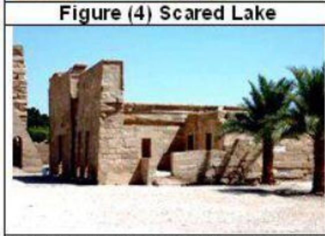
Figure (7) Chapels of The Divine Adoratrices

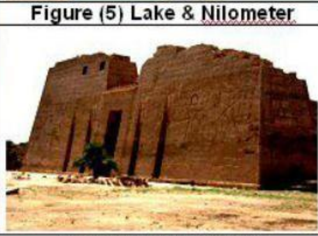
Figure (8) First pylon

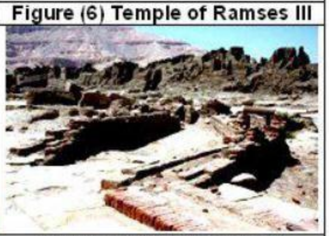
Figure (9) Mud Brick Wall


Figure (10) Second pylon

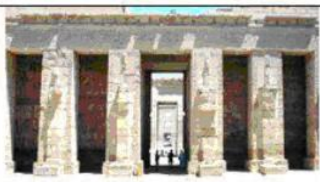
Figure (11) Second courtyard


Figure (12) Royal Palace

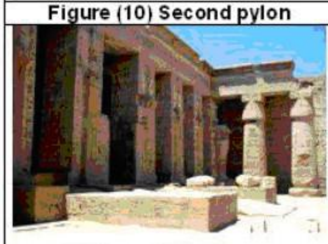
Figure (13) Entrance to the western portico


Figure (14) Entrance & Migdol


Figure (15) Small" temple


Figure (16) Storage and administrative buildings


Figure (17) Scene above the doorway entering the 2nd Courtyard.95


Figure (18) Scenes from the rear of the temple of Ramesses III at Medinet Habu.

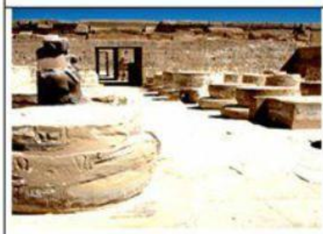
Figure (19) Hypostyle, chapels & shrine

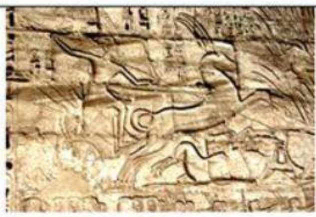
Figure (20) The south side of the 1st pylon (the back). The scene is of a wild bull hunt in the marshes with column of Egyptian soldiers.


Figure (21) Reliefs and inscriptions on the front of the towers record the military victories of Ramses III--over the Libyans and Asians.

Figures 4 - 21

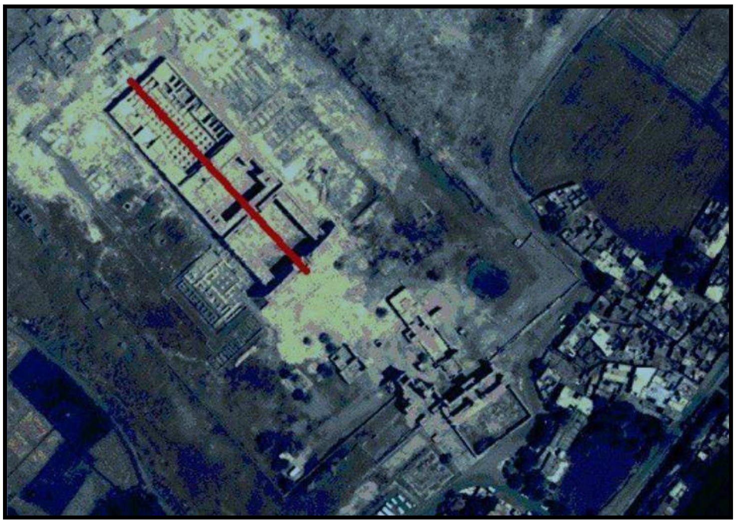

Figure 22: *Main Axis of the Temple on the Produced Image Map Scale 1:10 000*

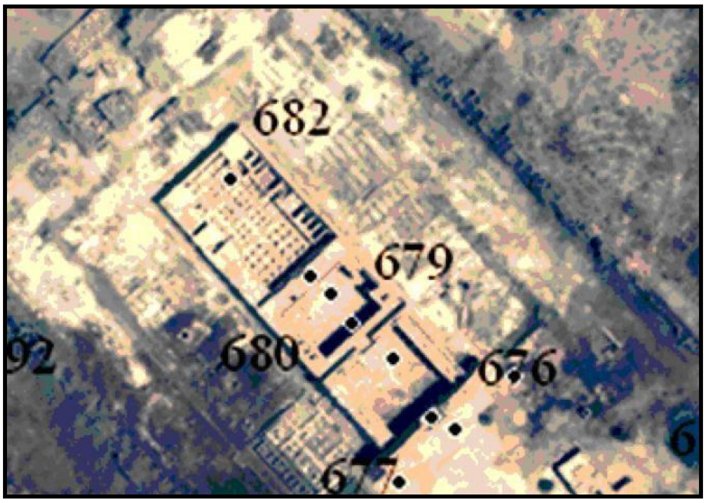

Figure 23: *Seven Points Located on the Axis of the Temple its Coordinates Measured with Handheld GPS*

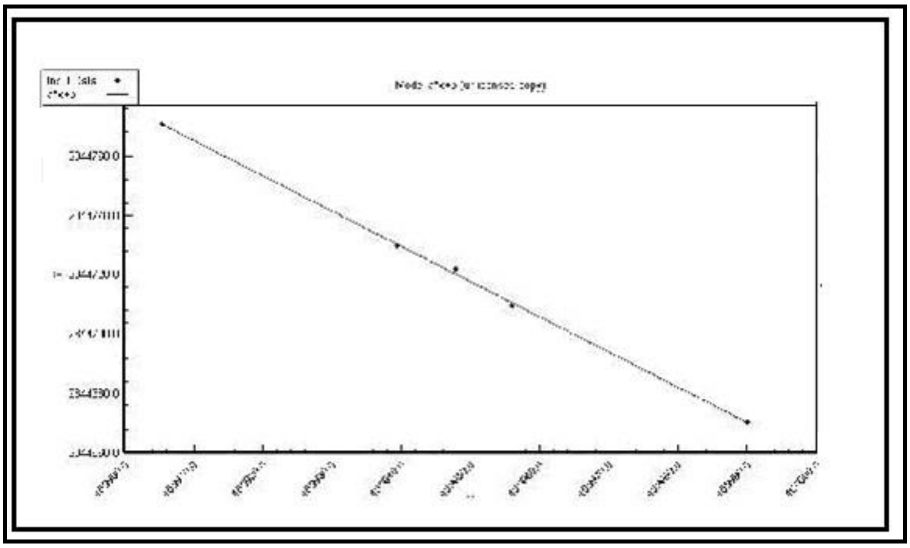

Figure 24: *Best Fitting of Five Measured GPS Points X and Y Coordinate*

6. Conclusion

Regarding the assessment of obtained results, the following conclusions are only valid for a geographic region with similar properties and covered with standard panchromatic QuickBird images within this area. The accuracy of the produced image map using second order polynomial function gives TRMS 4.288m which satisfies theoretical large scale mapping of 1: 10 000. The difference between axis direction of the temple from the produced image and from GPS direct measurements was ± 0 deg 59 min 7 sec.

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