Visibility Analysis in Archaeology Using Digital Elevation Model Produced from SRTM

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Abstract

A visibility analysis was performed with ERDAS Imagine Ver. 9.2, using Digital Elevation Model (DEM) produced from SRTM. Digital elevation models (DEMs) were already widely used and play an increasing important role in geomorphology, hydrology, soil erosion and many related geo-analysis fields. Visibility analysis did not really become popular in archaeology until the late of 1980's. There were a number of ways that visibility analysis could be applied to archaeological problems. Frequently archaeologists were concerned with whether one site was visible from another site. View shed depends on the height of the viewing point. The alteration of this height brings alteration of the view shed.

Keywords: Visibility, ERDAS, Archaeology and DEM.

تحليل مدى الرؤية في علم ألآثار باستخدام موديل ألارتفاع الرقمي المنتج من SRTM

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الخلاصة

تم أنجاز تحليل مدى الرؤية ضمن برنامج ERDAS ألنسخة 9.2 باستخدام موديل ألارتفاع الرقمي (DEM) المنتج من SRTM . استخدمت موديلات الارتفاع الرقمي بشكل موسع لكونها تلعب دور مهم و متزايد في الجيومورفولوجي، الهيدرولوجي، تعرية التربة، وعدة حقول جيوتحليلية ذات العلاقة. لم يكن تحليل مدى الرؤية شائع في علم ألآثار حتى أواخر عام 1980. وجدت عدة طرق لتطبيق تحليل مدى الرؤية في المشاكل التي تواجهة الدراسات ألآثاريه. لكون علماء ألآثار يهتمون فيما أذا كان بالإمكان رصد موقع ما عن موقع أخر و هذا يعتمد مدى الرؤية على ارتفاع نقطة الرصد ، و إن تغيير الارتفاع يؤدي إلى تغيير في مدى الرؤية.

الكلمات المفتاحيه: مدى الرؤية ، أيرداس ، علم ألآثار ، موديل ألارتفاع ألرقمي.

Introduction

Remote sensing is a term that refers to the remote viewing of our surrounding world, including all forms of photography, video and other forms of visualization. Satellite remote sensing has added advantage of being able to see an entire landscape at different resolutions and scales on varying satellites imagery datasets, as well being able to record data beyond the visible part of electromagnetic spectrum (Lillesand and Kiefer 1994). The field of *satellite* remote sensing, like archaeology, will always advance, becoming broader as satellite technology improved and the general public becomes more aware of its existence. The major benefits of remote sensing to archaeology provides a regional outlook of archaeological sites and features, relatively rapid procedure, nondestructive and multi-spectral (Henderson and Lewis 1998). The SRTM (Shuttle Radar Topography Mission) provides 3D global elevation data without charge to any user. Flown on the Space Shuttle Endeavor during an 11-day mission in February of 2000, NASA collected the data through a specialized radar system on board the shuttle. The mission represented a joint project between NASA, the National Geospatial-Intelligence Agency, and the German and Italian Space Agencies (Bamler *et al*. 2003) ; (Rabus *et al.* 2003). The mission was flown as part of the X-SAR/SIR-C mission. Furthermore, there is global 30 and 90 m pixel resolution elevation data, with 1–10 m elevation data for the USA.

Materials and Methods

SRTM data was employed in many archaeological projects due to its cost and applications to a wide range of archaeological questions. Archaeologists can import the data into either a remote sensing program or a GIS, and then layer additional satellite data on top of it. Having a good understanding of the Earth's topography was important to the geosciences, especially geology and hydrology, and was an essential part of cartography. Good digital elevation models (DEMs) also had numerous military and civilian applications, in addition to archaeological applications, as they all rely greatly on landscape reconstruction and visualization (ERDAS 1994), (Adam *et al.* 1981). Prior to the launch of the SRTM system, no consistent, global topographic map existed. Data for the SRTM was collected through the Shuttle Interferometry SAR, or In SAR, acquired by dual antennas with a small base-to-height ratio as shown in figures 1 and 2. As the radar signals were returned to the satellite, the measurements recorded according to a consistent reference coordinate system. Where there was dense surface vegetation, the SRTM data will reflect its surface and not the ground cover. Rough water, rocky ground, and scattered areas of vegetation were the ground types best recorded with the SRTM data; flat sand or still water can be incorrectly recorded. SRTM data offers archaeologists many advantages. Archaeological teams used SRTM data to model past landscapes (Adam *et al.* 1981).

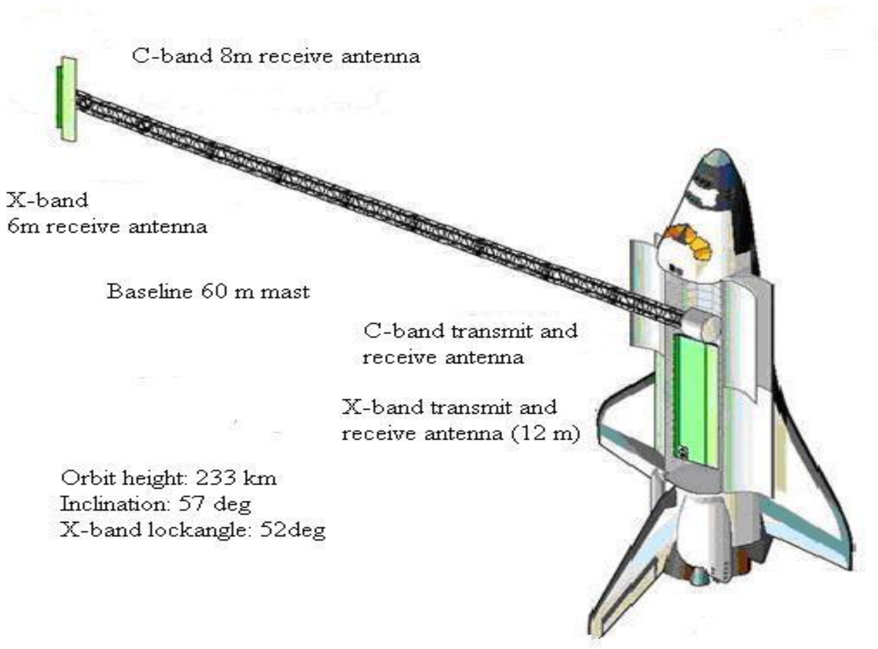

Figure (1) Shuttle Radar Topography Mission

Radar imagery had many advantages and disadvantages for archaeological use (Elachi 1982). Radar imagery was used to detect a wide range of sites and features ranging from natural to human-made, including trails, roads, and canals. For a low cost, archaeologists could obtain high-quality imagery, but the limited coverage of radar imagery was an issue. SRTM data, allows archaeologists to model landscapes in 3D. It had found a wide array of applications. SRTM data used for purposes as diverse as hydrological modeling, vegetation surveys, reconstruction of prehistoric water bodies, and mapping of glaciers and detection of ancient settlement sites.

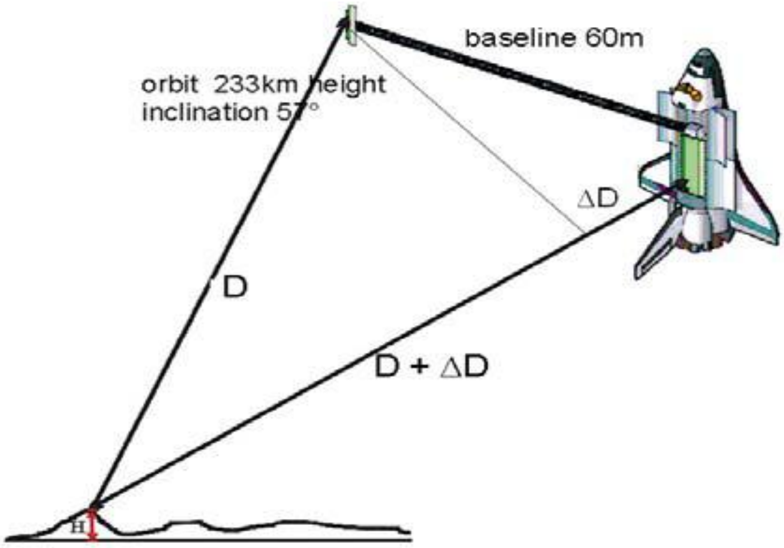

Figure (2) In SAR configuration.

Visibility analysis

Visibility analysis did not really become popular in archaeology until the late 1980's. There were a number of ways that visibility analysis could be applied to archaeological problems (Kim *et al.* 2004). Let us take a general look at the various kinds of visibility analysis that could be done.

1. Single Location: One could compute the view shed of a particular site.

Line of Sight between points: Once could examine the inter visibility between two points in the landscape as shown in figure 3.

2. View shed from Multiple locations: One could compute the view shed from multiple locations to see if a set of sites was in a location where all points of interest (perhaps mountain tops) can be viewed.

3. Comparison of Visibility between distributions.

a. between time periods: was there a change in the nature of visibility through time.

b. between site types: was there a difference in visibility that related to site function.

c. Between observed and expected: was there a difference in the nature of visibility between site and non-site locations (Kim *et al.* 2004, Maloy and Dean 2001).

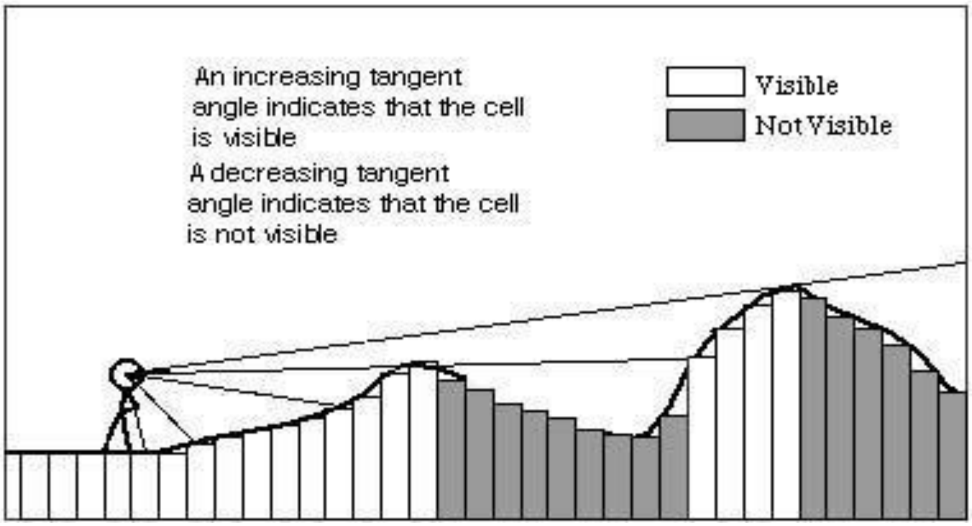

Figure (3) Line of Sight.

Results and Discussion

Figure (4) represents the study area chosen for visibility analysis. The region lies to the west of Al Razzaza Lake in Karbala Governorate. The produced DEM from SRTM data is shown in figure (5)

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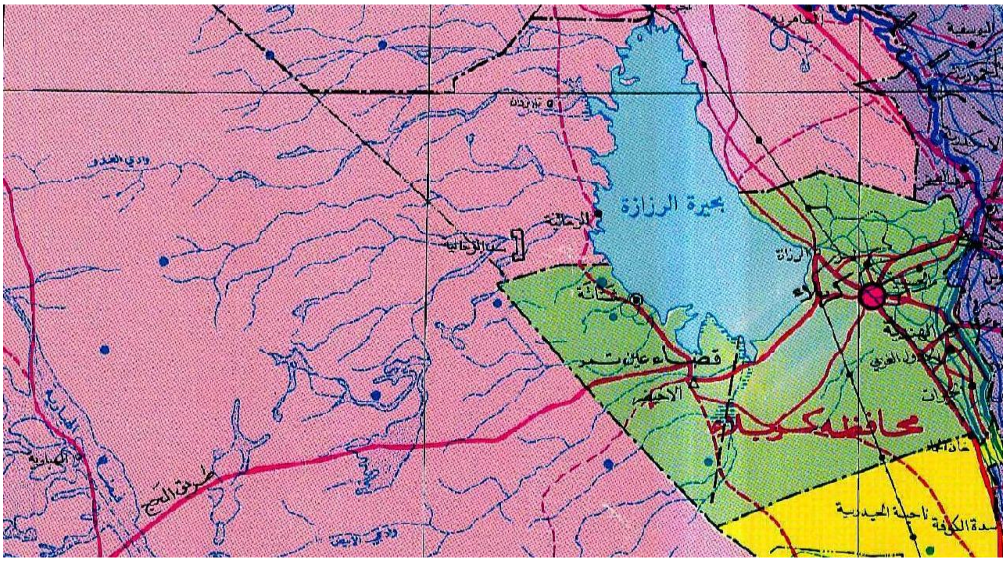

Figure (4) The study area lies west of Al Razzaza Lake.

Figure (5) The image represent the elevation data of the study area.

Defensive village locations are in places where there was a "commanding view" of the bay for example, so that villagers had time to prepare defenses against an attack. On a generally flat terrain, past peoples were more likely to settle on a raised area to give them a defensive position in times of conflict. Each culture will have varying relationships with their landscapes. Understanding how past peoples interacted with their topographies allows better archaeological analyses to take place. Frequently archaeologists were concerned with whether one site was visible from another site. Figures 6 and 7 represented a 3D view of the study area, derived from the DEM.

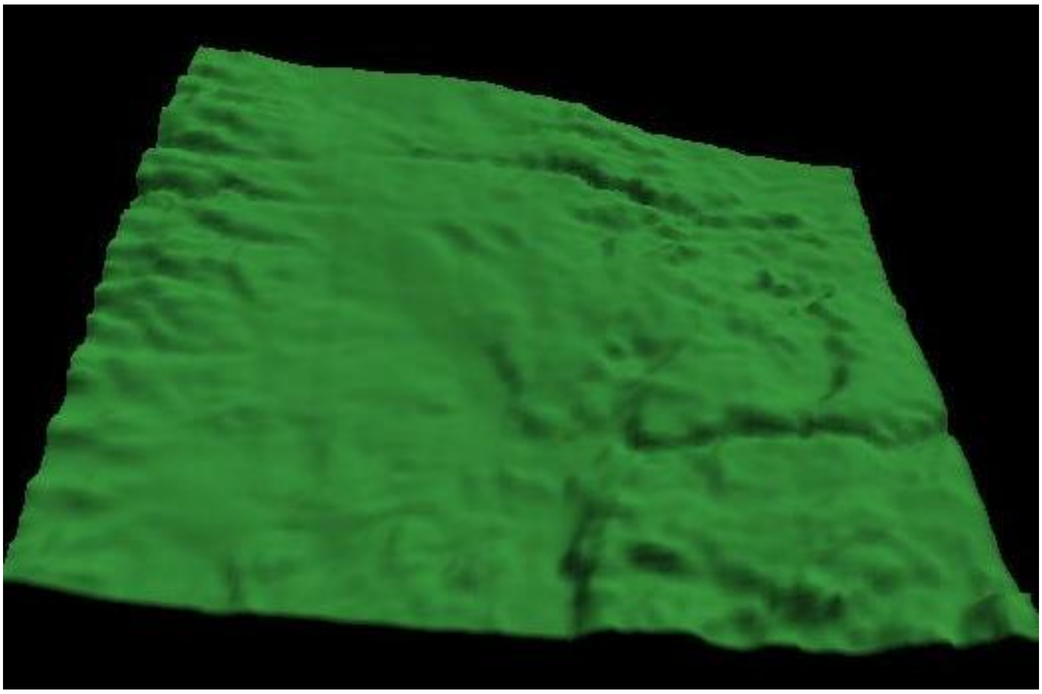

Figure (6) 3D view of the region.

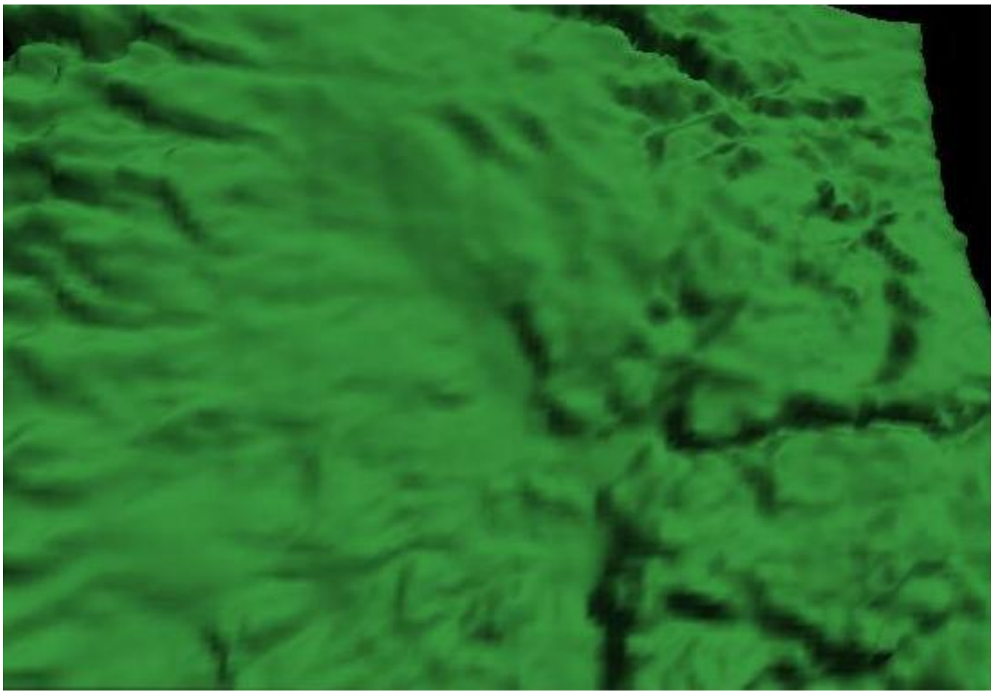

Figure (7) 3D view of the region with exaggeration.

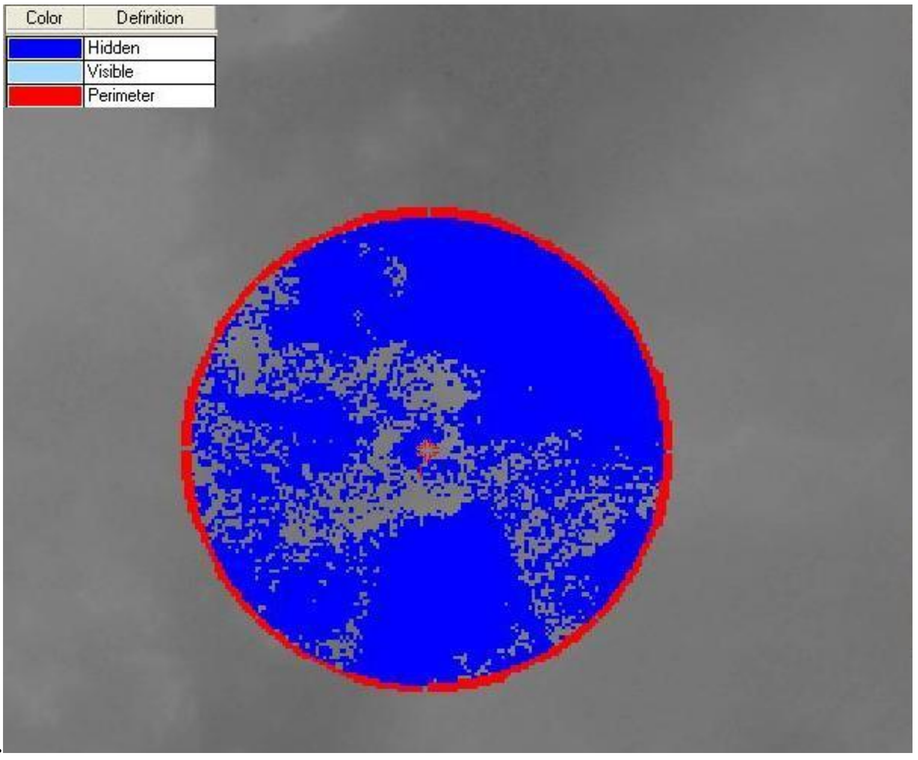

Figure (8) Visibility results for one observer.

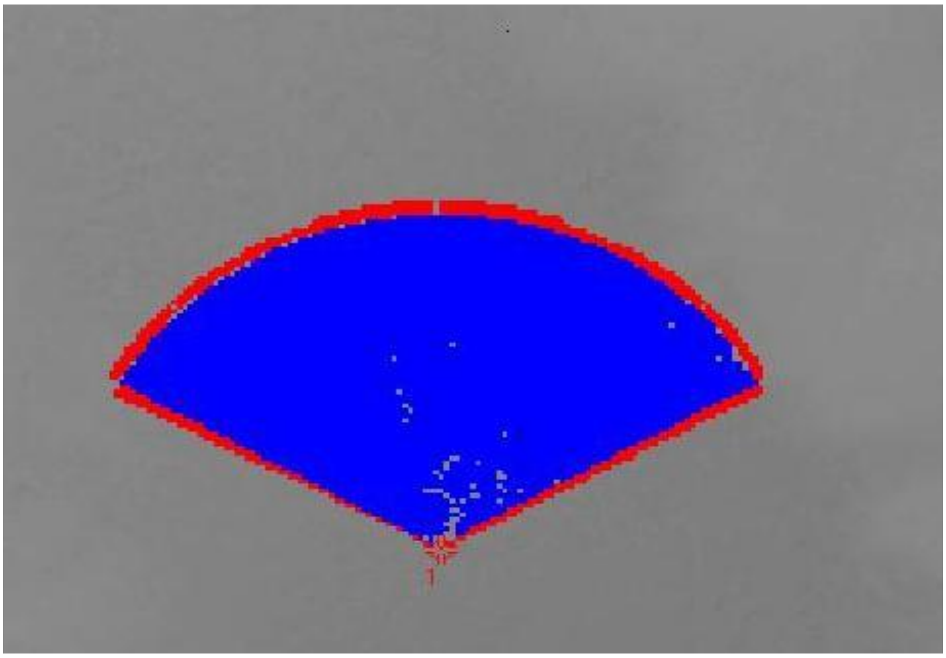

Figure (9) Visibility results for one observer with FOV 120 degrees.

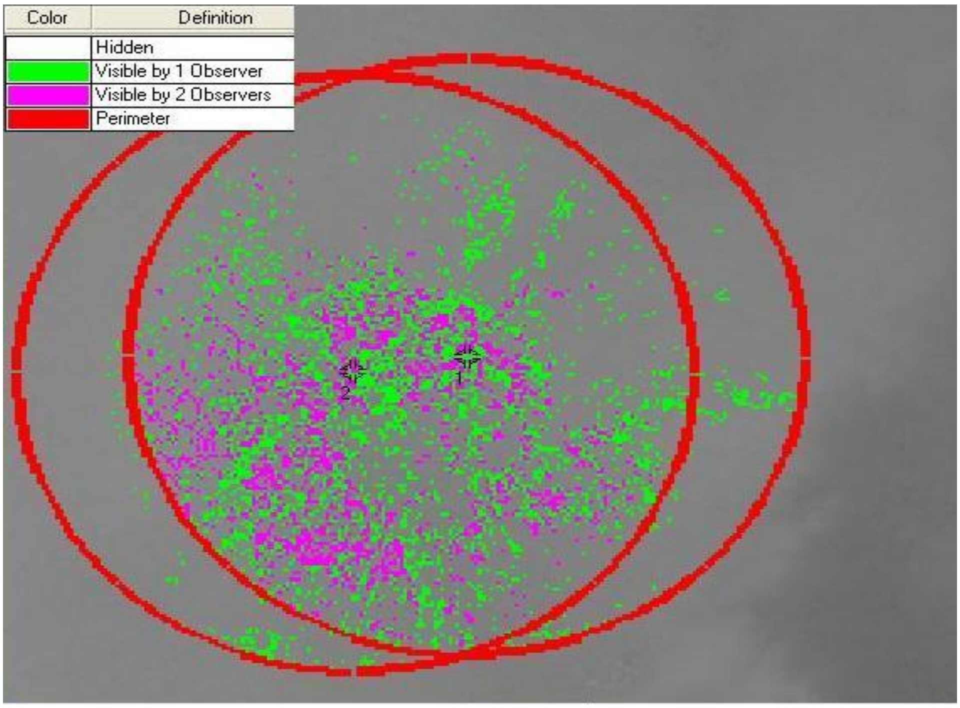

Figure (10) Visibility results for two observers.

It was concluded from this study that the principle behind visibility analysis was a simple one: the extents of an area visible from one point or a set of points were defined over a digital elevation model. The resulting grid presented the cells where a straight unhindered line-of-sight (LOS) exists between observation and target points. The heights of observation points, target points and cells between them determine if a cell can be seen from the point. Cells were considered “visible” if no elevation between either the higher observation or target points. A visibility grid presented the maximum area that can be seen from a point or set of points. The calculation of view sheds is a routine operation in GIS and was used in a wide range of applications. Many of these involved the sitting of features, such as radio masts, which were part of a network and yet the selection of sites was normally done separately for each feature. The selection of a series of locations which collectively maximize the visual coverage of an area was a combinatorial problem and as such cannot be directly solved except for trivial cases. Analysis of visibility was suggested as one of the basic analyses with digital surface models. The quality of viewshed results determined by accuracy and complexity of input data and the quality of viewshed algorithm. The input data is DEM (Digital Elevation Model), observer site and parameters of visibility (e.g. the direction of the viewshed and the search distance). In figures 8, 9 and 10 , the red circle represented the search distance , the observer lies in the center of the circle. The field of view (FOV) was 360 degrees for the observers in figure 8 and 10, while it is 120 degrees for observer in figure 9. I assume that the observer height was 1.5 meter. Increasing the height will affect the results of visibility analysis

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