

DIGITAL MAPPING TECHNIQUES 2014

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Geologic Traverse Generator

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Introduction

There is a perpetual need to conduct geological surveys in the field where geologists may interact directly with the rocks and structures in which they are interested. Many circumstances create the need for such surveys to continue, such as advancements in geologic theory and field techniques (Compton 1985), lack of necessary geologic detail (Passchier and Exner 2010), or simply to acquire answers to specific geological questions (Ernst 2006). While in the field, the geologist is often guided by predetermined regions and topics of interest, pursuing evidence to help them confirm or refute working hypotheses. For practical reasons, the geologist is guided, too, by topographic and anthropogenic factors in the field, i.e. viewsheds, water barriers, steepness of slopes, mine sites, developed roads and paths, etc. While it is common to think broadly and critically about their work in the field, geologists often give less consideration to how they navigate *through* the field. A more calculated approach in determining how to traverse a study area may provide opportunities to save time and visit additional sites.

The Geologic Traverse Generator (GTG) uses a GIS, specifically Esri's ArcGIS, to strategically delineate traverses for field geologists. From geologic, topographic, and anthropogenic factors we produce a weighted overlay surface upon which proposed traverse path(s) that connect a series of "must visit" sites are automatically generated. The weighting of the individual factors and sites to be visited are up to geologist's discretion; the resulting traverse paths, which include measures of distance and difficulty, help focus cost-benefits for the day, in advance. Of course, the geologist may still choose to abandon any traverse on the basis of discoveries in the field.

We demonstrate GTG with an illustrative example of a structural geological study in the Franklin Mountains near El Paso, Texas. This study uses existing surveys and imagery to delineate regions of geological interest and several "must visit" sites. It is these delineated features that largely determine the position of the final traverse paths generated. The GTG is well suited to projects with compressed timelines, specific sampling campaigns, reconnaissance in poorly known areas, or planning for traverses by autonomous vehicles, such as are used in planetary sciences.

Weighted Overlay Surface

Shown diagrammatically below, and in specific detail for the Franklin Mountains (Figure 1), is GTG operating with four factors: Regions of particular geologic interest, Viewsheds affording geologic perspective, established Paths, and topographic Slope, all expressed in raster form. Regions and Viewpoints are sketched by the geologist on an evolving photogeologic map. Paths and Slope come directly from satellite imagery and a DEM, respectively. The weighted overlay surface is a linear combination of these factors, as prioritized by the geologist ($Wt_R = 8$, $Wt_V = 4$, $Wt_P = 2$, and $Wt_S = 6$ in this case).

$$S = Wt_R * Region + Wt_V * Viewpoint + Wt_P * Paths + Wt_S * Slope$$

Visitation points are similarly marked and optionally ranked by the geologist on the evolving photogeologic map.

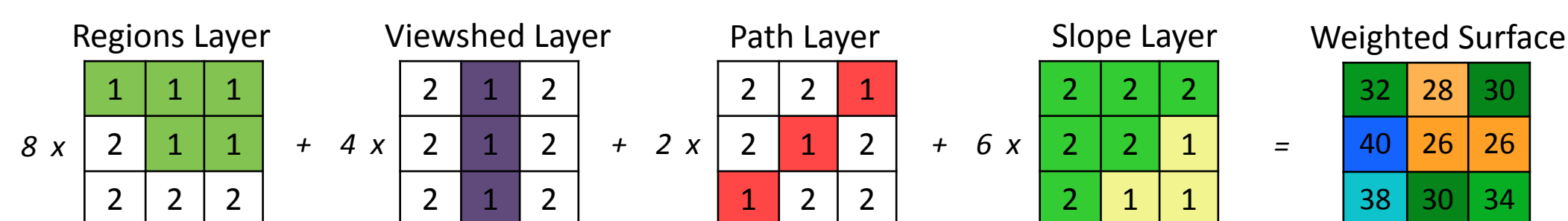


Figure 2. Example of how each raster layer is combined and the resulting weighted surface raster.

Table 1. Range and classification used for the raster factors and the values by which those factors were multiplied during the overlay procedure. The classification of Desirable means that it is likely beneficial for a geologist to travel through that cell.

Factor (GIS Layer)	Regions	Viewshed	Path	Slope	Weighted Surface
Range	1, 2	1, 2	1, 2	1, 2	20 - 40
Classification	1 = Desirable 2 = Not Desirable	1 = Desirable 2 = Not Desirable	1 = Desirable 2 = Not Desirable	1 ≈ 0 - 12° 2 ≈ 12 - 65°	From: 20 = Desirable To: 40 = Not Desirable
Multiplication Value	8	4	2	6	-

Illustrative Example in the Franklin Mountains

In this example, the objective was to generate traverses for fieldwork focused on constraining the structural geological history of a small segment of the Franklin Mountains.

1. Gathered and examined materials relevant to the study area (i.e. geological maps and reports, DEM, and satellite imagery)
2. Used ArcGIS with satellite imagery (Google, INEGI, NAIP) in combination with georeferenced published maps (Scharman 2006 and Harbour 1972) to create a prototype geological map
3. Sketched on the prototype map Regions of geologic interest and six "must visit" sites, which act as origins and destinations in the ArcGIS Cost Distance and Cost Path tools.
4. Analyzed DEM to delineate areas of relatively high elevation and create the Viewpoints Layer
5. Analyzed satellite imagery to delineate roadways and trails and create the Path Layer
6. Used ArcGIS Slope tool to compute a Slope Layer from DEM
7. Reclassified all four layers into the range and classification shown in Table 1
8. Combined these layers with the use of the ArcGIS tool, Weighted Sum
9. Used the output from the Weighted Sum and a selected origin as inputs for the Cost Distance tool
10. Used the output from the Cost Distance and a selected destination as inputs for the Cost Path tool
11. Ran the Cost Distance and Cost Path tool within ArcGIS ModelBuilder six times, each with different selected origins and destinations, in order to create six connected traverse path segments

Future Developments and Further Research

Traverse paths are iterative: information gathered from sites visited one day change the priority of sites for the remaining days, and may suggest new sites that require visitation. Future project developments will focus on the generation of new traverses out in the field as new information becomes available. GTG would undoubtedly be most useful if it was operable on a mobile, GPS enabled device. This will likely require a more streamlined methodology and user interface where the weights of regions of interest and "must visit" sites are quickly and easily adjusted, thus resulting in traverse paths which dynamically change alongside new observations. Also, other data (e.g. geophysical, well logs, etc.) may improve the delineation of the Regions layer and "must visit" sites.

Additional research may focus on how to assign weights to the factors influencing field geology. Also, studies may be conducted to determine how strategically defined traverse paths influence fieldwork and how they compare to the more common, ad hoc approach. Having a better understanding on what increases scientific return while in the field will help ensure field geologists of the future are best utilizing advances in GIS and mobile computing technologies.



Figure 2. Photoshopped depiction of having the traverse paths available in the field, here on a Nexus 7 mobile device.

References

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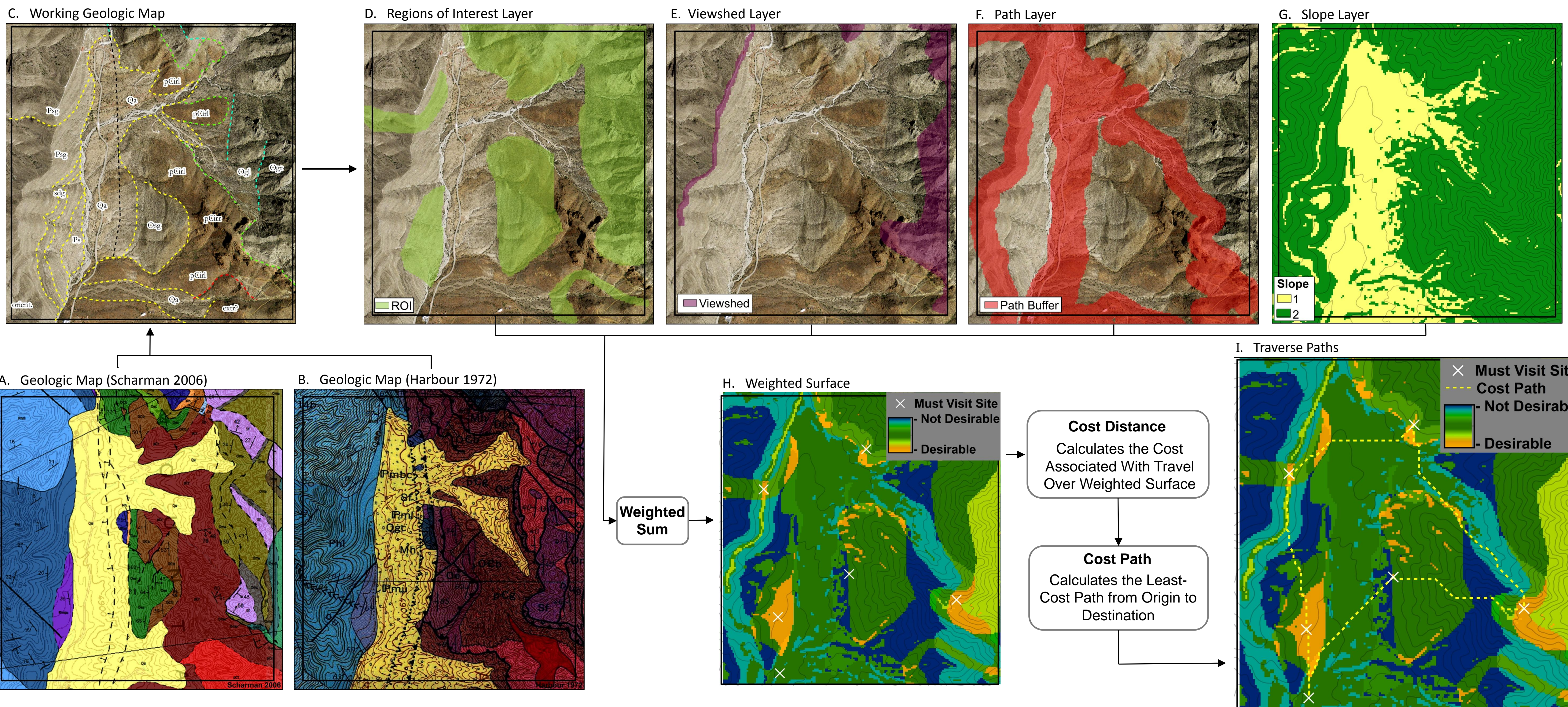


Figure 1. Published map layers (A and B) inform the evolving field map (C), with visitation sites, from which Regions of interest layer (D) is derived; this is combined in ArcGIS with topographic Viewsheds, Paths, and Slope layers (E, F, and G) using the Weighted Sum tool to produce the Weighted Overlay surface (H); finally, this is recombined in ArcGIS with visitation sites to generate proposed traverse (I) using the Cost Distance and Cost Path tools. Map scale in A through H is around 1:13 000 and in I is around 1:12 500. North is up.