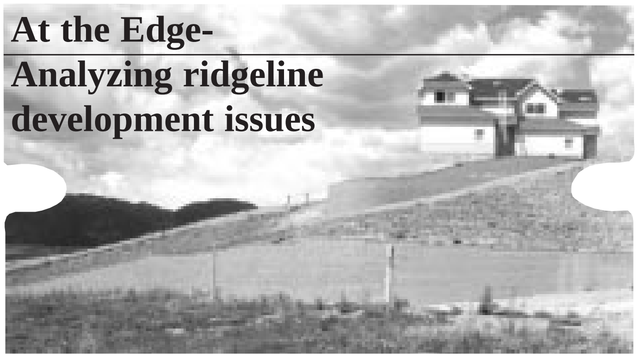
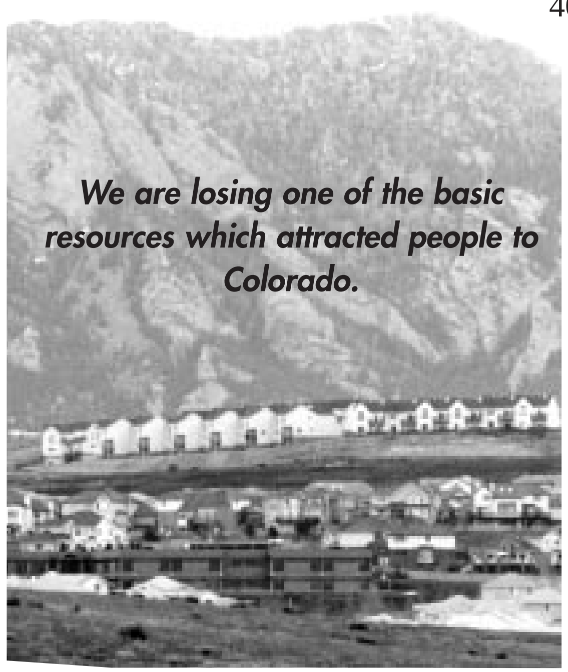
Eclectic GIS

Innovative GIS from Computer Terrain Mapping, Inc.
Issue 1, 1998

At the Edge- Analyzing ridgeline development issues



Regions that are near the skyline are particularly sensitive from a visual standpoint. Structures that break the skyline from a scenic viewing locale tend to be very conspicuous, and development in skyline areas can significantly erode the rural flavor of an area.

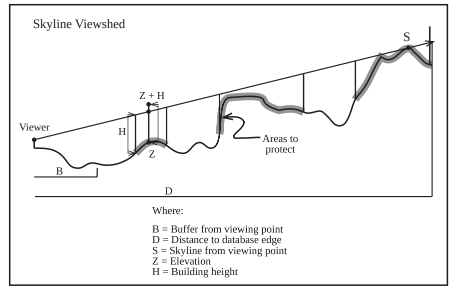


Unfortunately, commercially available visual analysis programs are not useful for determining regions where buildings or other structures will break the skyline when viewed from some set of locations. This is because most software determines simple visibility from a viewing location, usually called a viewshed map.

Figure 1 shows how visibility algorithms work. A viewer is positioned some height above ground level. The routine then attempts to draw the line-of-sight from the viewer to each point along an elevation profile. If the point can be connected with an uninterrupted line-of-sight, then the location is considered to be visible; otherwise, the location is not visible.

Figure 2 shows the important elements for a skyline analysis, which is actually a two-pass process. On the first pass, the elevation angle to each point in the profile is determined. The maximum elevation angle occurs at the skyline location. Now, how do we determine if a structure of some predetermined height - for example, 40 feet - breaks the view to the skyline? To determine this, the second pass recycles through the profile, adding the structure height to the ground elevation at each point. If the elevation angle to the new structure plus ground height is greater than the elevation angle of the skyline, then that structure would break the skyline. Areas where this occurs are indicated as "areas to protect" in figure 2.

Figure 2



Skyline viewshed shows areas where structures of a given height (H) will interrupt the view to the skyline.

Notice the difference between the visible areas in figure 1 and the areas to protect in figure 2. Many visible areas are of no concern from a skyline standpoint. More

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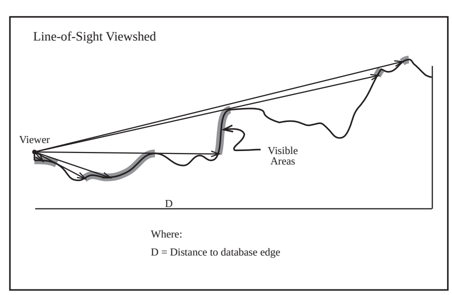
Figure 1



Line-of-sight viewshed shows visible areas from viewing location.

Beyond a Shadow of a Doubt

On a recent December day, I was tip-toeing over icy patches on a sidewalk just to the north of a tall building. After a couple of near falls, a light bulb went off in my head: cross the street! The sidewalks on the other side were beyond the reach of building's shadow, at least for a significant portion of the day.

This got me thinking about how uncommon shadow-casting capabilities are in most software packages. Shadows are not often calculated by GIS or mapping software because they are computationally intensive. While slope or aspect equations require access only to regions adjacent to the calculation point, shadows may be cast from objects distant from the current area of interest. This places a far greater burden on the program, forcing it to access the entire database in order to perform shadow calculations.

Latitude, local topography, structure height (if any), time of year and time of day all play an important role in determining the spatial extent and shape of a shadow. A computer simulation of shadows and their effects needs to include all these factors. Several examples (at right) have been given to show how this type of modeling can be used.

Figure 1 shows a shaded relief map of a region with footprints for proposed buildings. How will these buildings impact the surrounding area? One way to assess their impact is to look at a specific scenario, i.e., look at shadows on a specific date and time of day. Figure 2 shows how shadows will be cast at 3 pm on Dec 21, assuming building heights of 60 feet.

This just presents a snapshot of what the situation will be at that time on that day. Is this representative of the overall impact the buildings will have on incident solar energy? To get a better handle on "the big picture", let's assess shadows for the Dec 21 from 8 am to 4 pm. Figure 3 shows the results. Here, areas in white are never in the shadows during this time interval. The other color breakdowns represent the amount of time (in 1 hour intervals) that a particular location will be in

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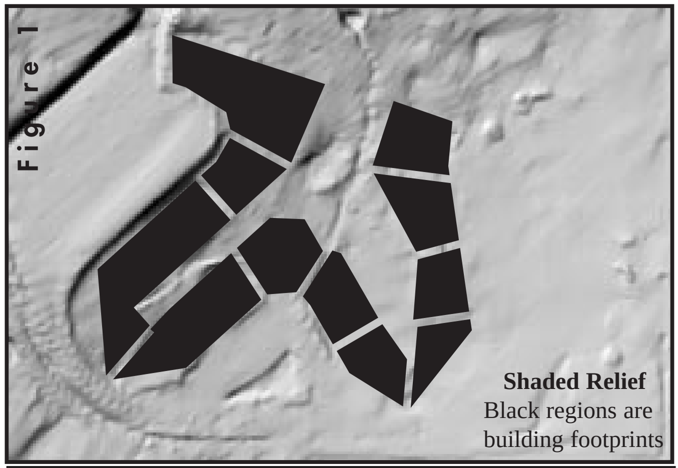
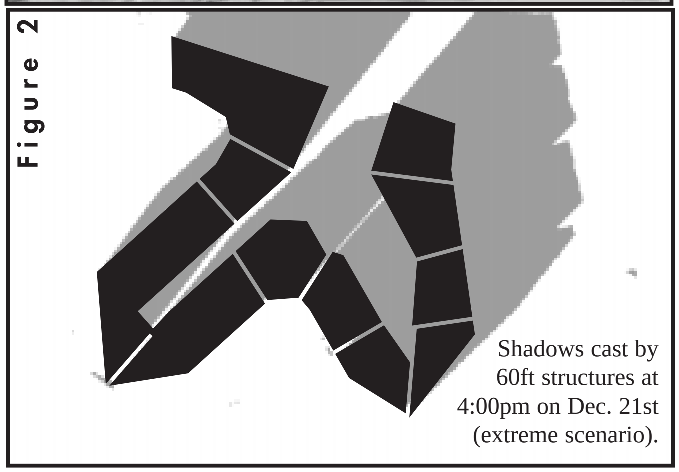
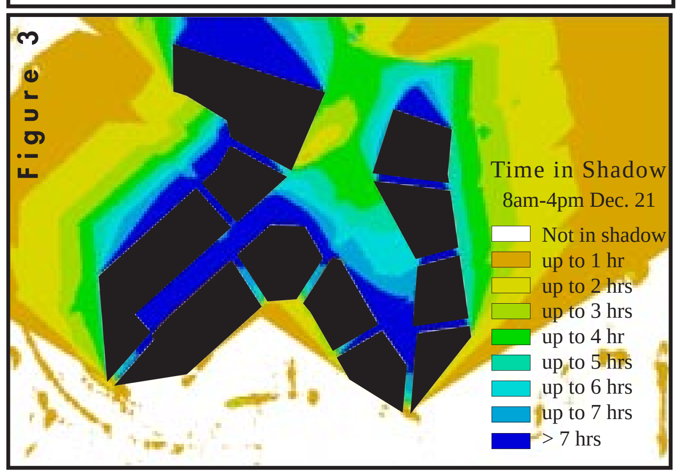
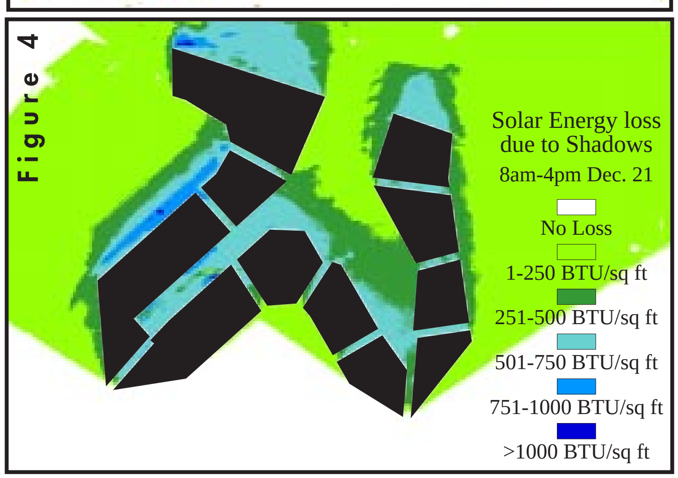








shadow. Areas in dark blue are in shadow for at least seven hours. Obviously, these areas will be significantly impacted by the structures. This sort of image gives a “time lapse” representation of shadow effects during the day.

One point worth emphasizing is: extreme cases - early morning or late afternoon - are often used to draw conclusions on the effects shadows will have. While these cases are indicative of shadows at their greatest lengths, they’re usually poor predictors of average effects. The “time lapse” pictures, showing hours in shadow for different regions, are better overall predictors of impact.

Finally, we can estimate changes in incident solar energy for various locations. Incident or direct solar energy is the amount of the Sun’s energy which reaches the Earth at a given location. Figure 4 shows the loss of direct solar energy due to shadows between the unbuilt landscape and the landscape with 60 foot structures. The color breakdowns are in increments of 250 BTU/sq ft Those areas in deep blue see losses of incident solar energy in excess of 1000 BTU/sq ft over the eight hours.

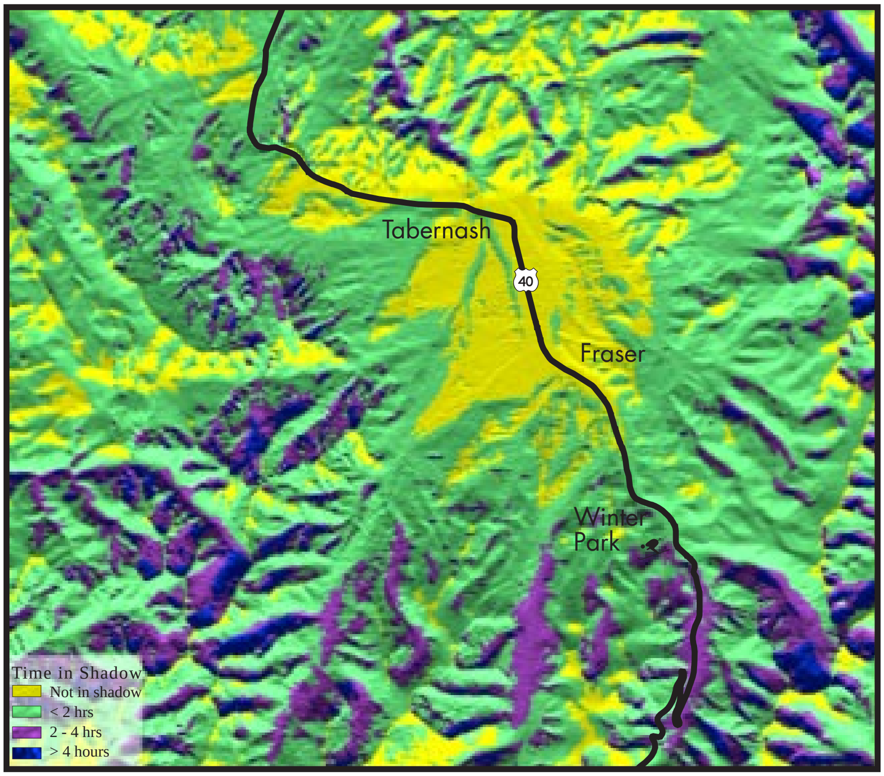
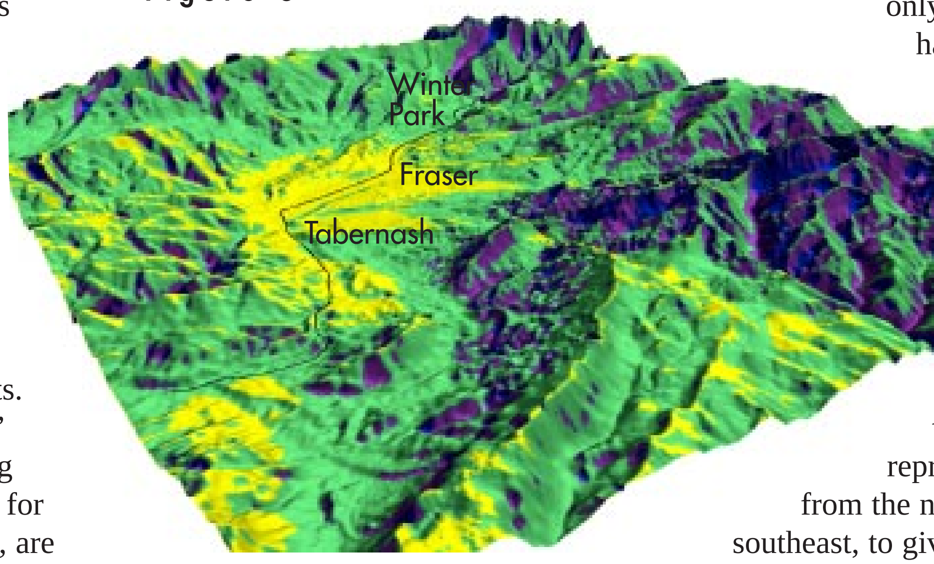


Figure 5

The examples above concentrated on the impact of shadows from buildings. Obviously, the same sorts of analyses can be run on terrain-only databases. Figure 5 shows the “hours in shadow” calculation for the Winter Park, Colorado area. Here, only four breakdowns have been used: never in shadow (yellow), in shadow two hours or less (purple), in shadow two to four hours (green) and in shadow more than four hours (cyan). Figure 6 shows a three-dimensional representation, viewing from the northwest to the southeast, to give a better feel for the distribution of shadows.

Figure 6



These examples have been chosen to illustrate the usefulness of these shadow-casting capabilities. Other potential uses include layout of ski runs and siting of houses or solar collectors. Now there’s no longer any reason to wonder about shadow effects, this computer modeling tool can answer your questions - beyond a shadow of a doubt!

Those Vexing Vectors

Digital aerial photography and satellite imagery are useful resources which can supply information on vegetation, water resources, geomorphology and general landscape patterns. Combining these images with line (vector) data - roads, for example - is common practice in GIS and mapping applications. Unfortunatly, getting a vector database to properly align with the digital imagery can be a vexing challenge.

Misaligned vector information can be caused by several factors. The most common causes are registration problems during digitizing or, when derived from aerial photographs, photographic image displacements. The resultant vector data, in either case, display varying degrees of distortion.

Some vector distortions can be corrected by simple polynomial-based transformations. These transformations work best for displacements which are fairly uniform in nature. For non-uniform displacements, using a piecewise triangle-based transformation is much more effective.

Triangle-based piecewise transformations
CTM has developed a piecewise transformation algorithm that reconstructs a digital file in "patches" between ground control points. These patches are triangles that form an irregular mesh covering most or all of the data. All ground control points are geographically "anchored" as triangle vertices. A ground control point exerts influence only on those triangles in which it is a vertex. While each triangle will have a different transformation function, adjacent triangles will share the same transformation function values at their common edge. This makes the piecewise transformation continuous across the digital data so that the transition from one triangle to another becomes seamless.

In practice, the algorithm steps through each point in an arc or polyline, and determines the triangle that contains that point. The output (x,y) coordinate is calculated based upon the distances to each triangle vertex. It is possible that adjacent points along a polyline may fall into different triangles and consequently have different transformation functions. As stated above, however, these transformation functions will have identical values at the boundary of these triangles.

The key element needed in any transformation is accurate ground control points. These points are used to create a mathematical relationship between the true locations and the distorted locations. It should be mentioned that this algorithm is particularly sensitive to poorly placed control points. Unlike polynomial transformations that may average a bad control point, this piecewise transformation will adjust the vectors to match the spurious locale.

Example
Figure 2 shows the results of the piecewise transformation on a subdivision . Figure 2a shows the original parcel map data overlaying an orthorectified airphoto of the region. Obvious misalignments occur. Using points that are identifiable in both the airphoto and the parcel map (figure 2b), the parcel data were transformed. Figure 2c shows the results.

If your vectors are vexing you, this may be just the solution you need!

Figure 2a. Original alignment

Figure 2b. Original alignment with control points

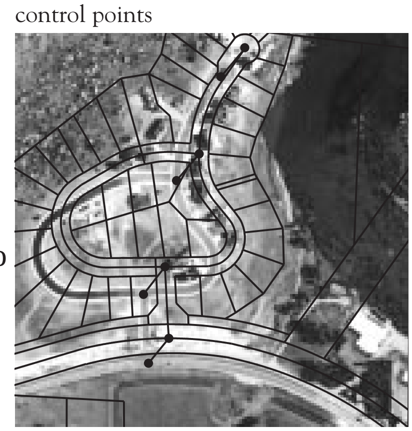


Figure 2c. Vector alignment after warping

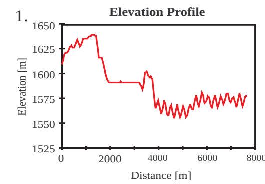
Spatial Bytes

Identifying and removing systematic errors in USGS DEMs

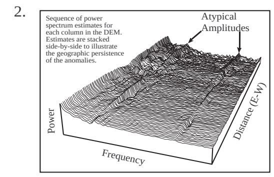
Manually profiled USGS Digital Elevation Models (DEMs) are prone to systematic errors which are often referred to as "striping:. Striping can be described as successive ridges and troughs, usually oriented approximately E-W, that run though the elevation model. Though these DEMs conform to national map accuracy standards, they cause great frustration to researchers who try to use these data for applications such as slope analysis, watershed delineation, water flow patterns, or landscape rendering. As of April, 1994, over 13,000 USGS DEMs have been produced with the manual profiling process.

Striping renders many DEMs worthless without filtering. CTM has written a stripe suppression program which utilizes power spectrum estimates for each column in the DEM to identify and suppress the stripes. This program works in 4 basic steps:

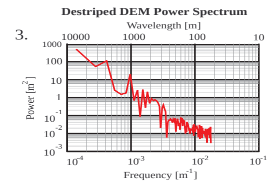
1. Convert spatial profiles into frequency (wavelength) domain on a column by column basis using Fast Fourier Transform (FFT).



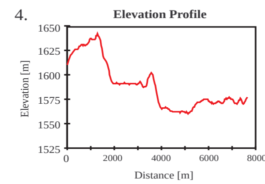
2. Identify frequency regions with anomalous amplitudes.



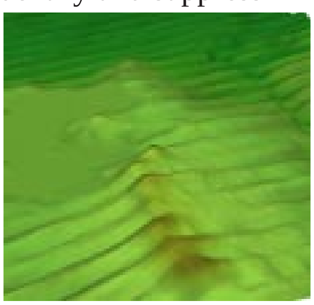
3. Reduce anomalies to background level using filter techniques.



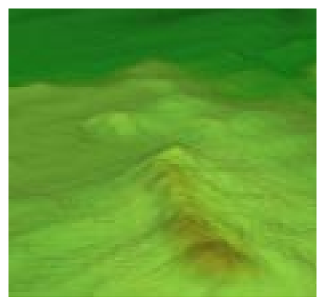
4. convert each column back to the spatial domain.



Unfiltered, plan view



Unfiltered, 3D view



Filtered, 3D view

Results after filtering DEM.

GIS and the Planning Process

Geographic Information Systems (GIS) technology allows the synthesis of information from a variety of sources and scales into a concise and understandable form. Landuse alternatives can be easily tested to maximize use potential while avoiding resource conflicts such as steep slopes, visually sensitive regions and public access issues. Using GIS results in a cost effective decision making tool.

CTM offers an innovative array of services to clients interested in using GIS to understand, utilize and communicate land resource information.

ONLINE :

CTM is now online at www.ctmap.com/ctm.

We are also maintaining a digital journal "Terra Forum" which features articles about GIS in planning applications, innovative GIS technology and the Colorado Lands Forum Newsletters. Check it out at www.ctmap.com. If you are interested in contributing to the journal please contact us by email at: ctm@ctmap.com

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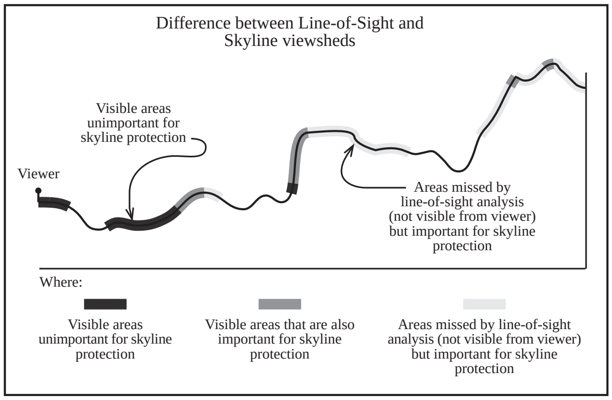
Figure 3



Difference between line-of-sight viewshed and skyline viewshed. Areas in dark grey are visible with line-of-sight analysis, but unimportant for skyline protection. Areas in light grey are missed by line-of-sight analysis (not visible), but important for skyline protection.

significantly, however, are those areas completely missed by the viewshed algorithm. Backsides of hills can be important and regions in the "visual shadow" of a feature can also be significant. Figure 3 highlights regions of difference between the two algorithms.

The skyline technique described here has been used on projects in Routt County and Douglas County, both in Colorado. The results have been enthusiastically received, and building regulations have been adopted in unincorporated Routt County near Steamboat Springs. The skyline analysis provides another tool for planners to help identify visually sensitive areas to target for protection.

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Inside View: