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The human-based viewshed: a new approach to measuring impacts on our scenic vistas

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Background

My background as a researcher is primarily focused on the development of decision-making tools that can help us understand how we relate to and are affected by the environment around us. GIS has provided me with a foundation for approaching my research through a spatial lens, proving to be one of the most effective ways to learn about and share findings of how we can plan for a better, more sustainable future. My background is well-suited to the development of spatial planning tools. In 2002, I earned dual Bachelor's degrees in Computer Science and Business Administration, and then completed my Master's of Science in Forestry at UBC five years later. I have been the Teaching Assistant and Instructor for Conservation GIS at UBC over the past four years. I currently hold a NSERC Canada Graduate Scholarship, and was one of only two doctoral students in Canada to be awarded the scholarship in the field of Forest Engineering in 2009. In the same year, I was awarded one of the nation's 80 NSERC Michael Smith Foreign Study Supplements, which provided for a five month research trip to Brazil this past spring where I continued developing methods for automating the delineation of Permanent Preservation Areas in the country. I am now in the final year of my Ph.D. in Forestry.

Introduction

GIS has played a key role in interpreting and quantifying how global land-use change impacts the earth's environment. A whole suite of informative and powerful GIS tools have been developed, which provide measures tailored to help us understand our impacts and how to better manage our resources. Recently, researchers have begun exploring how to use GIS to help measure or model the *social* implications of land use changes at large scales. This represents a shift in the way GIS will be used in the future. As this shift progresses, GIS will need to evolve from the strict geographical-based view of space to include tools that implement a human-based view of space as well. It will mean providing measures that help us understand the implications of land use changes to us. The research in this paper provides a clear demonstration of how we might begin thinking about land use changes from a social level and how this can be applied to a variety of landscapes.

Viewshed is employed in this paper to demonstrate these two different views of space. My research takes this ordinary Spatial Analysis tool and transforms it into something wholly different. Viewshed has been used extensively in research and applied fields of landscape planning, highway design, and forestry. The function of a viewshed in ArcGIS is quite simply to identify what is visible from a given location. This exemplifies the geographical-based view of space. Rather, the human-based view of space would require that viewshed measure the magnitude of what is seen. It would need to differentiate the significance of one visible cell from another, because unlike the geographical-based view, not every $10m^2$ space on earth is created equally.

British Columbia is a perfect test-bed for these kinds of questions as they relate to scenic vistas. BC is home to some of the most beautiful landscapes in the world, yet, these landscapes are constantly undergoing changes as we mine, harvest and modify the landscape so that we have access to minerals, timber and space for community development. At the same time, those modifications impact the landscape's beauty, valued by residents and tourists alike, even if those impacts are noticed only temporarily. The importance of our landscape on the tourism industry, land values and health (recreational, sense of place, etc.) is deeply embedded in our culture. Therefore, finding ways to easily measure and model current and future impacts would help us to better manage our visual resources as well.

Objective

The objectives of this research are to: 1) demonstrate an applied example of a human-based assessment of space by 2) providing a way to efficiently calculate the visible or perceived impacts to land use change using a custom-coded visibility analysis. The outcome of the presented research is a GIS tool which has been coded from scratch to calculate the impacts of land use change to the viewshed and provide a simple 2D planning layer in ArcGIS which contains information about the impacts as experienced in 4D. The study scenario is a simulated ferry trip through the Inside Passage of British Columbia.

Methods

The visibility analysis developed for this research is based on two distinct methods for measuring visibility. It adapts Xdraw, an efficient viewshed algorithm, to determine those cells which are visible. For those cells, it uses a concept of Visual Magnitude (VM), which calculates the amount a cell is visible in perspective view. VM provides the human dimension to visibility, and Xdraw provides an unmatched efficiency in visibility analysis. The two are fused together to provide an efficient viewshed algorithm capable of calculating the relative importance of a particular area (or cell) on the earth's surface as it would be experienced by a person. Xdraw calculates viewshed in time squared compared to the method in ArcGIS, a necessary step in producing multi-dimension, high-resolution, large scale results.

Since the important separation from the common viewshed has to do with the calculation of VM, it will be clarified here. VM is calculated by using two 3D vectors: the perspective vector and the surface vector. Each vector contains a slope and aspect value. The perspective vector is the viewing slope and direction of an individual as they look at a single space on the landscape. The surface vector is composed of the slope and aspect of the surface, as would be available in ArcGIS Spatial Analyst. VM is the difference of these two vectors, and includes a distance function as it would pertain to limitations of the human eye. Figure 1 illustrates these three components (slope, aspect and distance). Figures 2 and 3 provide examples of the outcome of the new viewshed from a single viewpoint.

VM was combined with Xdraw in order to simulate a ferry trip through the Inside Passage, by calculating a cumulative *perspective view* viewshed from over 2,500 locations along the ferry's route. This represents a sampling for every 30m along an 85 Km route. Although this viewshed is cumulative, it should not be confused with *cumulative viewshed* which simply adds the results of many analyses together. Rather, the new viewshed provides a weighting of the magnitude of each cell across all viewpoints. The terrain model used in this analysis was developed using Arcgen files with an overlay from the DFO to ensure a flat ocean surface. Its size is roughly 2100 x 2500 cells (63 x 75Km).

Results and Discussion

The result of the analysis is one seamless layer (Figure 4) which provides a measure of importance for each visible cell in the landscape, across the entire route. The output (completed in just 3 hours) reveals the subtleties of the terrain as experienced by a person. With this information it becomes easy to locate those areas that would cause less visual disturbance when modified, even if they are visible. One of the derived benefits of this research is the ability to calculate the percent of modification of the landscape in perspective view. In forestry, it is required that companies provide this information and meet strict guidelines in order to harvest in areas of scenic importance. The layer provided can be used to calculate this requirement by identifying the magnitude of all visible cells of a clear cut and its percentage in the visible landscape. This innovative use of VM coupled with an efficient viewshed, demonstrates how GIS can be used to help measure the impacts of land use change as they would be experienced by us – the critical human-based view of space necessary to understand social implications of management plans.

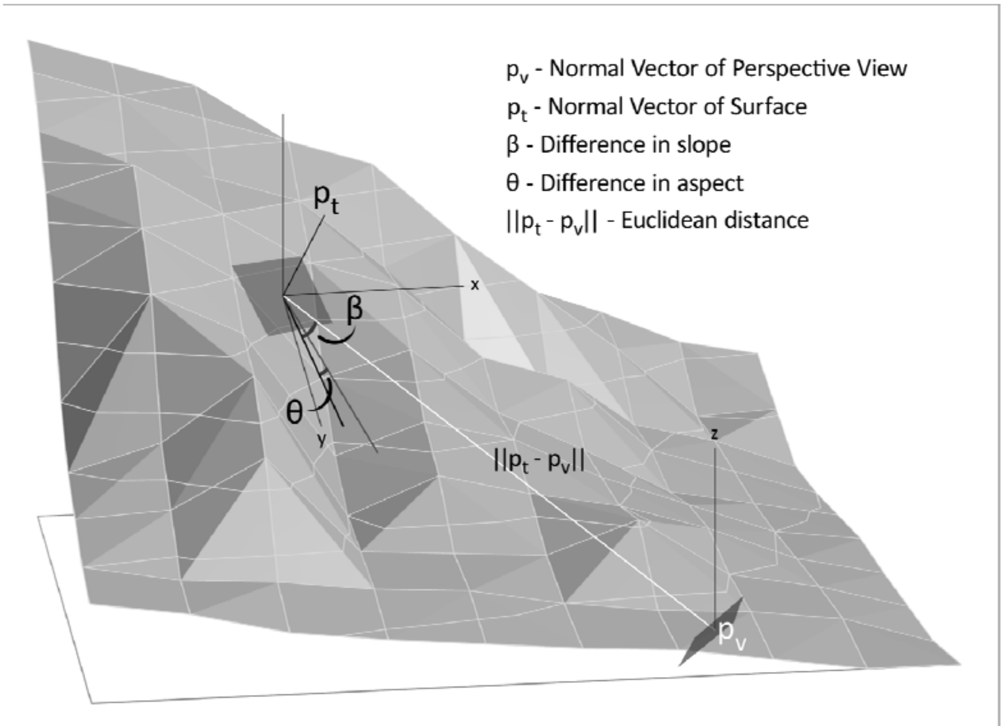

Figure 1: Demonstration of the components (slope, aspect and distance) necessary to calculate VM.

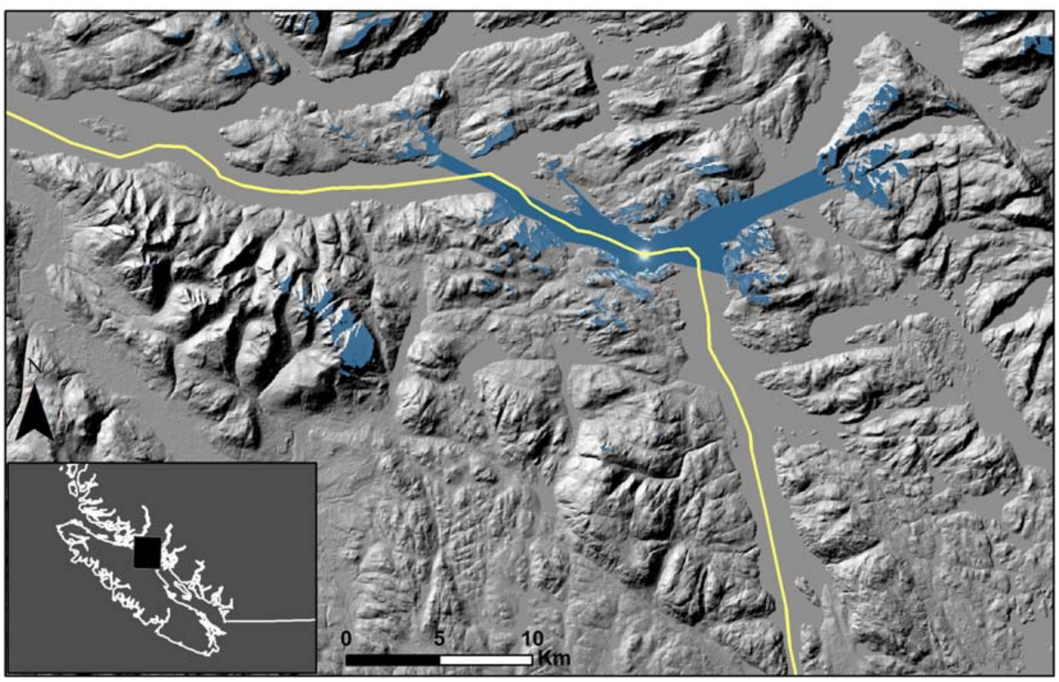

Figure 2: Plan-view representation of the new viewshed (blue gradient) as calculated from a single viewpoint and overlaid onto a 30m hillshade of a portion of the Inside Passage. The yellow line represents the ferry route; the center of the bright white spot is the viewpoint. The lighter the gradient, the more significant that cell is within the viewer's line of sight.

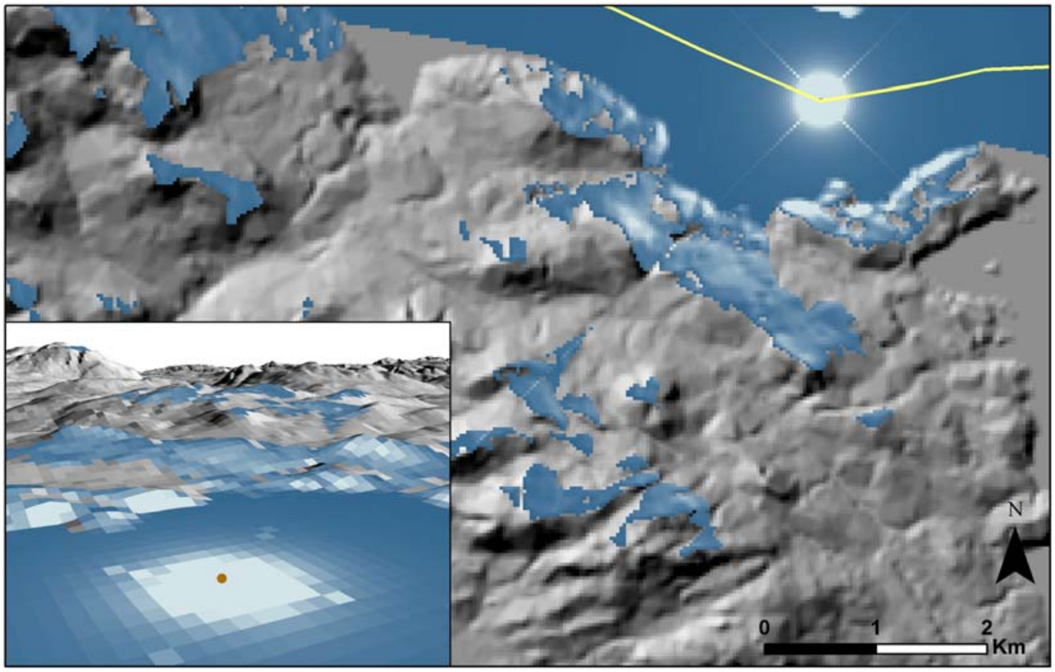

Figure 3: Close-up sample based on single viewpoint shown in Figure 2, with a 3D representation of the view looking SW from the viewpoint. The 3D representation better depicts how the subtle changes in relative slope, aspect and distance effects the magnitude of a cell within the viewer's perspective.

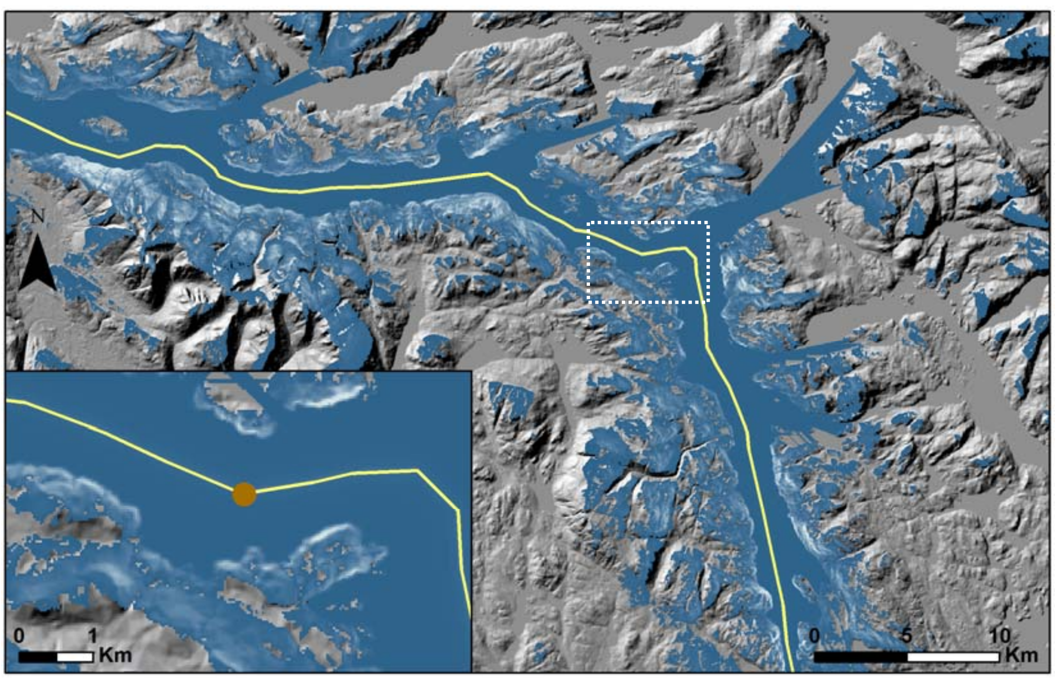

Figure 4: The final composite of the new viewshed using 2500+ viewpoints, one for every 30m, along the ferry route. Again, the lighter the gradient, the more significant that cell is within the viewer's line of sight as they experience the landscape through time. The close up, depicts the sample area in Figure 3, showing the composite viewshed which allows for a quick comparison between the differences of the single and composite outcomes. The original viewpoint is depicted as the brown dot.