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Multi-directional Analytical Hill-Shading for Enhanced Cartographic Relief Presentation

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Abstract:

Multi-Directional Hill-Shading (MDHS) methods are able to restore lost or incomplete relief information from artifacts and weaknesses of usual, one source, ideally diffused Hill-Shading (HS), in order to illustrate most information possible of the shape of earth's surface. On the other hand, a dominant illumination with strong tonal contrast is responsible for the familiar, realistic character of hill-shading method, which should be properly chosen to depict most of the terrain formations. To compose these two needs and achieve maximum performance without critical discounts in the visual effect of hill-shading, the proposed framework of actions is based on three axes:

1. Implementation of a dominant HS image with optimal illumination
2. Implementation of a MDHS model
3. Selective enhancement of dominant, optimal HS with MDHS

There have been many proposals which gradually enrich illumination from a single source, from light source's local adaptation, then to combinations of different light directions and even up to simulative sky illumination models. Among them, this research focuses on the analytical solution proposed by Robert Mark (1992) -which initially referred to the term "Multi-Directional" in its Multi-Directional Oblique-Weighted (MDOW) method- as it encourages the unified use of the full range of perceptually correct illumination, originating from southwest to north directions. The research firstly deals with skepticism on the tonal equalization and consequent lagging of tonal contrast, caused by multiple illumination, by establishing visual relevance of MDHS images with the familiar character of hill-shading, after experimental evaluation of visual complexity by using eye-tracking technique.

Existing and additional, alternative models for MDHS are listed and organized in terms of the analytical weighted synthesis used, into: *global-weighted, oblique-weighted* and *incident-weighted* (that is, based on the incidence angle of illuminating source). Discussion is carried out about west to north illumination range, considered as a perceptually effective choice, as well as for terrain analysis procedures that can contribute to the determination of optimal HS direction for revealing most of ground's relief changes (e.g., diagrammatic analysis of orientation data, structural line identification, land surface generalization, morphometric classification). The final mixing between a dominant, optimal HS and MDHS images is analytically controlled by the local incidence angle of optimal illumination, so that the dark areas of the former are enhanced with multiple illumination.

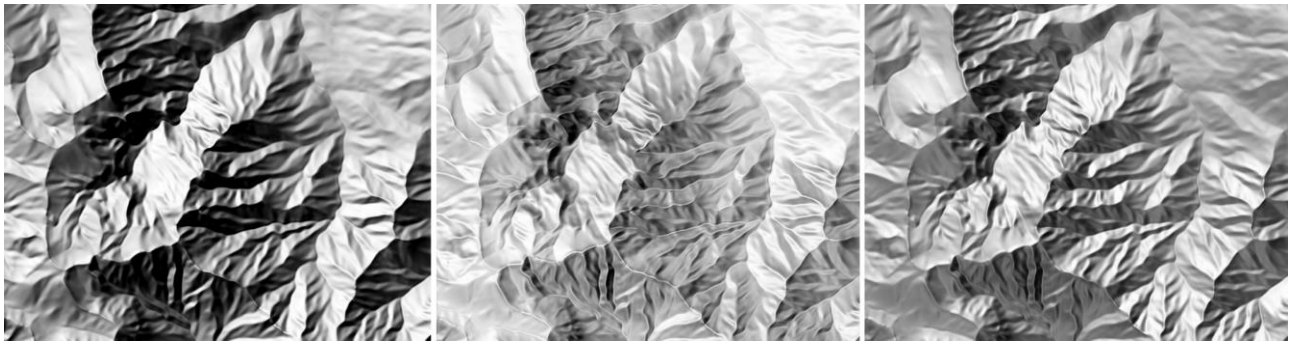

Figure 1. Optimized, one-source HS, MDOW HS and mixed, enhanced MDHS with 2m DEM at location "Zarouchla" of North Peloponnese, Greece.

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Several MDHS models and combinations are implemented as software tools (in ESRI's ArcGIS) and then they are applied on mountainous study areas. The images produced are evaluated in terms of completeness in rendering the topographic relief, through online questionnaire filled by university staff members with experience in cartographic and spatial visualizations. In addition, conclusive questions for further research are set out.

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