SFS with DTM

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The paper first deals with the Shape-from-Shading (SFS) method mostly known from Computer Visualization. Depending on numerous, partly merely estimable geometrical and physical factors such as surface reflectance, shadows, light source distribution, image resolution, accuracy of initial elevation map, etc., SFS applied to real-world imagery is a non-trivial, generally ill-posed problem.

By exploiting additional information beyond HRSC image data, SFS first enables a distinct refinement of the photogrammetric DEM generated previously by matching. This will then be the basis for subsequent modifications of image shades towards rigorous homogenization and optimization of relief shading in the digital ortho-image maps. Then, SFS is briefly described from a methodical point of view. The Conjugate Gradient method algorithm is treated for the direct solution, elucidated by a series of examples using generated synthetic data.

In SFS research, the imaging model is specified through a image irradiance equation $E(x, y) = R(p, q)$ where $E(x, y)$ is the image irradiance at a particular point (x, y) in the image and $R(p, q)$ is the photometric reflection function, denoted reflectance map, with $p = \frac{\partial f}{\partial x}$ and $q = \frac{\partial f}{\partial y}$ being the partial derivatives of height $z = f(x, y)$. The reflectance map is given by:

$$R(p,q) = \rho \frac{-\frac{\partial f}{\partial x} \cdot cos\alpha - \frac{\partial f}{\partial y} \cdot cos\beta + cos\gamma}{\sqrt{(\frac{\partial f}{\partial x})^2 + (\frac{\partial f}{\partial y})^2 + 1}}$$

where $\bar{s} = (cos\alpha, cos\beta, cos\gamma)$ denote the unit illumination vector and ρ the surface albedo assumed constant (we consider the Lambertian model and orthographic projection with the z axis parallel to the optical axis of camera).

$E(x, y)$ is proportional to the radiance at the corresponding point on the surface imaged, as determined by the projection equation.

Our approach to shape-from-shading (SFS) is governed by the fact we can assume that the surface (so called a-priori DTM) to be operated on by SFS is already known to a certain degree of accuracy and SFS can improve or, at least, considerably refine the a-priori DTM.

For the SFS process, the a-priori DEM represents an approximate initial DTM that has to be improved iteratively to an optimal final DTM.

This will have to be followed by a suitable discretization and algorithmitization of the problem. Finally, a computer programm will have be generated and several tests with simulated and real data be performed.

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