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Quadratic Penalty Methods for Shape from Shading

Stefania Bellavia, Lapo Governi, Alessandra Papini and Luca Puggelli
Department of Industrial Engineering, University of Florence,
Florence, Italy
stefania.bellavia@unifi.it,lapo.governi@unifi.it,
alessandra.papini@unifi.it,luca.puggelli@unifi.it

Abstract

"Shape from shading" (SFS) denotes the problem of reconstructing a 3D surface, starting from only one image showing a shaded representation of the surface itself. Minimization techniques are commonly used for solving the SFS problem, where the functional that must be optimized is a weighted combination of the brightness functional plus one or more regularization terms. A critical role in this context is played by the weights used in the functional, which markedly affect the possibility of obtaining a good reconstruction. However the choice of these weights in not trivial.

In this work we present a quadratic penalty method where an a-priori choice of the weights is not needed. In this approach the SFS problem is formulated as a constrained minimization problem, where the objective function is given by a term accounting for the smoothness of the reconstructed surface, and the constraints consist of the image irradiance equation (representing how well the reconstructed surface reproduces the original image) and of an integrability term.

Using a quadratic penalty strategy the original constrained problem is replaced by a sequence of unconstrained subproblems, which are solved by a Barzilai-Borwein method. The results obtained on a set of case studies show the effectiveness of the proposed approach.

Key words: Shape from shading, equality constrained minimization, quadratic penalty methods, Barzilai-Borwein method.