GEOMETRIC RECONSTRUCTION IN BIOLUMINESCENCE TOMOGRAPHY

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Resumo/Abstract:

Bioluminescence tomography is a novel technique to image cells in a living organism (in vivo). To this end DNA of a luminescent protein (so-called luciferase) is infiltrated into the target cells (e.g. tumor cells). These cells will emit photons triggered by luciferin which has to be injected prior to imaging. From the observed photon flux over the organism's surface one has to recover location and intensity of the photon source. This inverse source problem is ill-posed: it suffers not only from strong instability but also from non-uniqueness. To cope with these difficulties the source is modeled as a linear combination of indicator functions of measurable domains leading to a nonlinear operator equation. The solution process is stabilized by a Mumford-Shah like functional which penalizes the perimeter of the domains. For the resulting minimization problem existence of a minimizer, stability, and regularization property are shown. Moreover, an approximate variational principle is developed based on the calculated domain derivatives which states that there exist smooth almost stationary points of the Mumford-Shah like functional near to any of its minimizers. This is a crucial property from a numerical point of view as it allows to approximate the searched-for domain by smooth domains. Based on the theoretical findings numerical schemes are proposed and tested for star-shaped sources in 2D: computational experiments illustrate performance and limitations of the considered approach.