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Evaluation of three inverse problem models to quantify skin microcirculation using diffusion-weighted MRI

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Abstract. Skin microcirculation plays an important role in diseases such as chronic venous insufficiency and diabetes. Magnetic resonance imaging (MRI) can provide quantitative information with a better penetration depth than other noninvasive methods, such as laser Doppler flowmetry or optical coherence tomography. Moreover, successful MRI skin studies have recently been reported. In this article, we investigate three potential inverse models to quantify skin microcirculation using diffusion-weighted MRI (DWI), also known as $\boldsymbol{q}$-space MRI. The model parameters are estimated based on nonlinear least-squares (NLS). For each of the three models, an optimal DWI sampling scheme is proposed based on D-optimality in order to minimize the size of the confidence region of the NLS estimates and thus the effect of the experimental noise inherent to DWI. The resulting covariance matrices of the NLS estimates are predicted by asymptotic normality and compared to the ones computed by Monte-Carlo simulations. Our numerical results demonstrate the effectiveness of the proposed models and corresponding DWI sampling schemes as compared to conventional approaches.