A preconditioned forward-backward algorithm for minimizing nonconvex composite functions: Application to radio-astronomical imaging

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Over the last decade, nonconvex and nonsmooth optimisation have been instrumental tools to develop algorithms for solving high-dimensional inverse imaging problems. In particular, the forward-backward (FB) algorithm that aims to minimise a sum of a differentiable function and a nonsmooth function, has shown to be particularly flexible and robust. In this presentation, we will focus on a preconditioned version of the FB algorithm for solving the challenging case where the nonsmooth function is non-convex and results from the composition between a strictly increasing, concave, differentiable function and a convex nonsmooth function. The proposed algorithm circumvents the explicit, and often challenging, computation of the proximity operator of the composite functions through a majorize-minimize approach. Precisely, each composite function is majorised using a linear approximation of the differentiable function, which allows one to apply the proximity step only to the convex nonsmooth function. We show that the proposed approach is a generalisation of reweighting methods, with convergence guarantees. We further show that this algorithm is particularly suitable in the context of radio-interferometric imaging in astronomy. This modality aims to provide high-dynamic range images of the sky by processing terabyte-sized data obtained from radio-telescopes. The resulting problem appears to be a great playground for nonconvex nonsmooth optimisation : it necessitates the use of reweighting methods to achieve a high dynamic range, and the preconditioning enables to mainly work on image-size rather data-size. Based on this, an imaging software dubbed Africanus has been developed to handle radio-astronomical data from modern telescopes. We will show a validation of the method on terabyte-sized data from the MeerKAT telescope.

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