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MadNLP.jl : A condensed-space interior-point method for nonlinear programming on GPUs

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We present a novel interior-point method to solve nonlinear programs on graphical processing units (GPUs). The classical interior-point method solves a sequence of symmetric indefinite linear systems, or Karush-Kuhn-Tucker (KKT) systems, that are increasingly ill-conditioned as we approach the solution. Solving a KKT system with traditional sparse factorization methods involves numerical pivoting, making parallelization difficult. A remedy is to condense the KKT system into a symmetric positive-definite matrix and solve it with a Cholesky factorization, stable without pivoting. We have implemented the condensed-space interior-point method on the GPU using MadNLP.jl, an optimization solver interfaced with the NVIDIA sparse linear solver cuDSS and with the GPU-accelerated modeler ExaModels.jl. Our experiments on large-scale OPF and optimal control instances reveal that GPUs can attain up to a tenfold speed increase compared to CPUs.

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