Boosting primal-dual type methods with larger step sizes for saddle point problems

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First-order algorithms are majorly used for various optimization problems arising in data science. It is often to see the dilemma that the step size of a first-order algorithm is forced to be sufficiently small for the purpose of convergence guarantee, while a small step size inevitably results in slow or even stuck convergence. In the literature, there are many heuristics that can empirically accelerate the convergence considerably but lack of rigorous theory, and some theory that can ensure the acceleration rigorously but only incrementally (on the scale of percentages). We are thus inspired to seek larger (or the largest if possible) step sizes to accelerate the convergence significantly and meanwhile the convergence is rigorously guaranteed. I will focus on the well-known primal-dual method proposed by Chambolle and Pock for saddle point problems, and show how to accelerate it with much larger step sizes by a very simple strategy. It is shown by some applications that the acceleration could be significant, sometimes more than 10 times faster.