A first-order primal-dual algorithm with linesearch

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We propose a linesearch for the primal-dual method to solve a saddle point problem. In contrast with the basic primal-dual algorithm that uses fixed step sizes during all iterations, the proposed method does not require to compute the operator norm and, in addition, allows to make larger steps. Each iteration of the linesearch requires to update only the dual (or primal) variable. Moreover, the step sizes may increase from iteration to iteration. We prove the convergence of the algorithm under quite general assumptions. In case when one of the prox-functions is strongly convex, we modify our method to get a better convergence rate. Also we show that in many important cases the primal-dual algorithm with linesearch preserves the same complexity of iteration as the standard primal-dual method does. In particular, our method, applied for any regularized least-squares problem, uses the same number of matrix-vector multiplication per iteration as proximal gradient method or FISTA (with fixed step size) do, but does not require to know a matrix norm and, in addition, uses adaptive steps. Finally, we propose the linesearch for a saddle point problem with an additional smooth term. Several numerical examples are given to illustrate the efficiency of proposed methods.