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Using flow analysis to accelerate the Frank-Wolfe method

The Frank-Wolfe (FW) method is popular in sparse constrained optimization, due to its fast per-iteration complexity. However, the tradeoff is that its worst case global convergence is comparatively slow; without line search or specialized steps, the vanilla method converges at a rate of $O(1/k)$, even if the objective is strongly convex. However, we show that when the method is viewed as an Euler discretization of an underlying flow, the flow rate itself may be arbitrarily fast, reaching $O(1/k^c)$ for *any* $c > 0$. Therefore, the slowdown of the FW method can be attributed directly to discretization error, which we show can be mitigated using two strategies: multistep methods, and weighted averaging. In the latter approach we prove an overall global convergence rate of $O(1/k^p)$, where $0 \leq p \leq 1$, which accelerates empirically to $O(1/k^q)$ once the sparse manifold has been identified, for $q \geq 3/2$. In practice we also observe that the method achieves this accelerated rate from a very early stage, suggesting a promising mode of acceleration for this family of methods.