

Strong duality with a

unique saddle point

 $\phi_{\gamma}(x) = \min_{x} f(x, y_{\gamma}^{*})$ $s.t.y_{\gamma}^* = \arg\min_{y} \tilde{g}(x,y) + \gamma h(x,y)$

Theorem Y

Theorem X $\mathcal{L}_{\lambda,\gamma}(x) := \min_{\mathbf{v}} f(x,y) + \lambda \left(g(x,y) + \gamma h(x,y) - g_{\gamma}^{*}(x) \right)$ where $g_{\gamma}^*(x) := \min_{y} g(x, y) + \gamma h(x, y)$

 $\nabla_{x} \mathcal{L}_{\lambda, \gamma}(x) = \nabla f(x, y_{\lambda}^{*}) + \lambda \left(\nabla_{x} g(x, y_{\lambda, \gamma}^{*}) - \nabla_{x} g(x, y^{*}) \right)$