

# A Minimax Theorem with Applications to Machine Learning, Signal Processing, and Finance

---

*S.-J. Kim and S. Boyd*

*SIAM Journal on Optimization*, 19(3):1344–1367, November 2008.

Shorter version appeared in *Proceedings IEEE Conference on Decision and Control*, pp.751–758, 2007.

- [minimax\\_frac.pdf](#)
- [minimax\\_frac\\_cdc.pdf](#)

This paper concerns a fractional function of the form  $x^T a / \sqrt{x^T B x}$ , where  $B$  is positive definite. We consider the game of choosing  $x$  from a convex set, to maximize the function, and choosing  $(a, B)$  from a convex set, to minimize it. We prove the existence of a saddle point and describe an efficient method, based on convex optimization, for computing it. We describe applications in machine learning (robust Fisher linear discriminant analysis), signal processing (robust beamforming, robust matched filtering), and finance (robust portfolio selection). In these applications,  $x$  corresponds to some design variables to be chosen, and the pair  $(a, B)$  corresponds to the statistical model, which is uncertain.