



Decompositions of two player games: potential, zero-sum, and stable games

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We introduce several methods of decomposition for two player normal form games. Viewing the set of all games as a vector space, we exhibit explicit orthonormal bases for the subspaces of potential games, zero-sum games, and their orthogonal complements which we call anti-potential games and anti-zero-sum games, respectively. Perhaps surprisingly, every anti-potential game comes either from the Rock-Paper-Scissors type games (in the case of symmetric games) or from the Matching Pennies type games (in the case of asymmetric games). Using these decompositions, we prove old (and some new) cycle criteria for potential and zero-sum games (as orthogonality relations between subspaces). We illustrate the usefulness of our decomposition by (a) analyzing the generalized Rock-Paper-Scissors game, (b) completely characterizing the set of all null-stable games, (c) providing a large class of strict stable games, (d) relating the game decomposition to the decomposition of vector fields for the replicator equations, (e) constructing Lyapunov functions for some replicator dynamics, and (f) constructing Zeeman games -games with an interior asymptotically stable Nash equilibrium and a pure strategy ESS.

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