

Algorithmic game theory — Homework 2¹

Nash equilibria

assigned 31.10.2019, deadline 14.11.2019

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Homework 1. Show that the following linear programs from the proof of the Minimax Theorem are dual to each other.

(a) For a matrix $M \in \mathbb{R}^{m \times n}$, [2]

	Program P	Program D
Variables	$y_1, \dots, y_n$	x_0
Objective function	$\min x^\top M y$	$\max x_0$
Constraints	$\sum_{j=1}^n y_j = 1,$ $y_1, \dots, y_n \geq 0.$	$\mathbf{1}x_0 \leq M^\top x.$

(b) For a matrix $M \in \mathbb{R}^{m \times n}$, [2]

	Program P'	Program D'
Variables	$y_0, y_1, \dots, y_n$	$x_0, x_1, \dots, x_m$
Objective function	$\min y_0$	$\max x_0$
Constraints	$\mathbf{1}y_0 - M y \geq \mathbf{0},$ $\sum_{j=1}^n y_j = 1,$ $y_1, \dots, y_n \geq 0.$	$\mathbf{1}x_0 - M^\top x \leq \mathbf{0},$ $\sum_{i=1}^m x_i = 1,$ $x_1, \dots, x_m \geq 0.$

You may use the recipe for making dual programs from the lecture.

Homework 2. Use the Lemke–Howson algorithm and compute a Nash equilibrium of the following bimatrix game [2]

$$M = \begin{pmatrix} 1 & 3 & 0 \\ 0 & 0 & 2 \\ 2 & 1 & 1 \end{pmatrix} \quad \text{and} \quad N = \begin{pmatrix} 2 & 1 & 0 \\ 1 & 3 & 1 \\ 0 & 0 & 3. \end{pmatrix}$$

Start the computation by choosing the label 1.

Homework 3. [Sperner's Lemma] Let S be a given subdivision of a triangle T in the plane. A legal coloring the vertices of S assigns one of three colors (red, blue, and green) to each vertex of S such that all the three colors are used on the vertices of T . Moreover, a vertex of S lying on an edge of T must have one of the two colors of the endpoints of this edge.

Prove that, in every legal coloring of S , there is a triangular face of S whose vertices are colored with all three colors.

Hint: Use a reduction to the END-OF-THE-LINE problem. [3]

¹Information about the course can be found at <http://kam.mff.cuni.cz/~balko/>