ECE-QE AC3-2011 - Rhea

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ECE Ph.D. Qualifying Exam

Automatic Control (AC)

Question 3: Optimization

August 2011

Question

Part 1. 20 pts

Consider the optimization problem,

maximize $-x_1^2 + x_1 - x_2 - x_1x_2$

subject to $x_1 \geq 0, x_2 \geq 0$

(i) Characterize feasible directions at the point $x^* = \begin{bmatrix} 1 \\ 2 \\ 0 \end{bmatrix}$

(ii) Write down the second-order necessary condition for x^*. Does the point x^* satisfy this condition?

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Part 2.

Use the simplex method to solve the problem,

maximize $x_1 + x_2$

subject to $x_1 - x_2 \leq 2$

$x_1 + x_2 \leq 6$

$x_1, -x_2 \geq 0.$

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Part 3. (20 pts)

Solve the following linear program,

maximize $-x_1 - 3x_2 + 4x_3$

subject to $x_1 + 2x_2 - x_3 = 5$

$2x_1 + 3x_2 - x_3 = 6$

x_1 free, $x_2 \geq 0, x_3 \leq 0.$

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Part 4. (20 pts)

Consider the following model of a discrete-time system,

$$x(k+1) = 2x(k) + u(k), x(0) = 0, 0 \leq k \leq 2$$

Use the Lagrange multiplier approach to calculate the optimal control sequence

$$\{u(0), u(1), u(2)\}$$

that transfers the initial state $x(0)$ to $x(3) = 7$ while minimizing the performance index

$$J = \frac{1}{2} \sum_{k=0}^{2} u(k)^2$$

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Part 5. (20 pts)

Consider the following optimization problem,

$$\begin{aligned} &\text{optimize} (x_1 - 2)^2 + (x_2 - 1)^2 \\ &\text{subject to } x_2 - x_1^2 \geq 0 \\ &\qquad 2 - x_1 - x_2 \geq 0 \\ &\qquad x_1 \geq 0. \end{aligned}$$

The point $x^* = \begin{bmatrix} 0 & 0 \end{bmatrix}^T$ satisfies the KKT conditions.

(i) Does x^* satisfy the FONC for minimum or maximum? Where are the KKT multipliers?

(ii) Does x^* satisfy SOSC? Carefully justify your answer.

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