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Edited by G. Goos and J. Hartmanis
Series: I.F.I.P. TC7 Optimization Conferences

41

Optimization Techniques

Modeling and Optimization in the Service of Man
Part 2

Proceedings, 7th IFIP Conference
Nice, September 1975

Edited by Jean Cea

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PREFACE

These Proceedings are based on the papers presented at the 7th IFIP Conference on Optimization Techniques held in Nice, September 8-12, 1975. The Conference was sponsored by the IFIP Technical Committee on Optimization (TC 7) with the cooperation of:

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SMF (Société Mathématique de France)

Université de Nice, Ville de Nice and Conseil Général des Alpes-Maritimes.

The Conference was devoted to recent advances in optimization techniques and their application to modeling, identification and control of large systems. Major emphasis of the Conference was on the most recent application areas including: environmental systems, socio-economic systems, biological systems.

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ON THE MARGINAL VALUE OF AN ANTAGONISTIC GAME

Joachim Hartung
Institut für Angewandte Mathematik
D-53 Bonn, Wegelerstraße 6

Let X and Y be the sets of strategies of two antagonistic players, and for $t \in [0,T] \subset \mathbb{R}$, $T > 0$,

$$f(x,y,t) : X \times Y \to \mathbb{R}$$

may be a payoff function in the parametric two-person zero-sum game

$$G_t := (X,\ Y,\ f(x,y,t))\ ,\quad t \in [0,T],$$

where it is to maximize over X and to minimize over Y.

Definition 1: If $v(t) = \mathrm{val}(G_t)$ is the value of G_t, $t \in [0,T]$, then the marginal value of the family of games $\{G_t\}_{t\in[0,T]}$ in the point $t = 0$ is defined as

$$v'_+(0) := \lim_{t\to+0} \frac{v(t) - v(0)}{t} \quad .$$

We consider conditions - different from that given for instance in [3], [5] - for the existence of the marginal value, which enable us to derive from the marginal value theorem a method for solving a wide class of constrained games.

Let X, Y be not empty closed convex subsets of real topological linear spaces.

Definition 2: A function $g: X \times Y \to \mathbb{R}$ is 'sup-inf compact', if the level sets $\{x \in X \mid g(x,y) \geq a\}$, $y \in Y$, $a \in \mathbb{R}$, and $\{y \in Y \mid g(x,y) \leq b\}$, $x \in X$, $b \in \mathbb{R}$, are compact.

Let X(t), Y(t) denote the sets of optimal strategies in G_t, $t \in [0,T]$.

Theorem 1: (marginal value theorem)

If (i) $f(x,y,t)$ is concave (convex) in x (in y) for $t \in [0,T]$,

(ii) $f(x,y,0)$ is upper (lower) semicontinuous in x (in y),

(iii) $f(x,y,0)$ has a saddle point on $X \times Y$,

(iv) $f'(x,y,0) := \frac{\partial f(x,y,t)}{\partial t}\Big|_{t=+0}$ exists, and

$$O(1,x) \leq \frac{f(x,y,t)-f(x,y,0)}{t} - f'(x,y,0) \leq O(1,y)\ ,\ \text{for } t \in (0,T],$$

where $O(1,x)$ is independent of y and $O(1,x) \to 0$ for $t \to +0$ and fixed $x \in X$, $O(1,y)$ is independent of x and $O(1,y) \to 0$ for $t \to +0$ and fixed $y \in Y$,

(v) $f'(x,y,0)$ and $f(x,y,t)$ for $t \in (0,T]$ are sup-inf compact on $X \times Y$,

then $v'_+(0)$ exists and

$$v'_+(0) = \max_{x \in X(0)} \min_{y \in Y(0)} f'(x,y,0) = \min_{y \in Y(0)} \max_{x \in X(0)} f'(x,y,0) \quad . \tag{1}$$

Proof:

Because of (i), (iii) and (v) the sets $X(t)$, $Y(t)$ are not empty and there exist the values $v(t)$, for $t \in [0,T]$. Let $x_t \in X(t)$, $y_t \in Y(t)$, $t \in [0,T]$, then we have

$$f(x_o,y_t,t) - f(x_o,y_t,0) \leqslant v(t) - v(0) \leqslant f(x_t,y_o,t) - f(x_t,y_o,0) \quad . \tag{2}$$

For $t \in (0,T]$ we get from (iv)

$$\bigwedge_{x \in X} \bigwedge_{y \in Y} O(t,x) + tf'(x,y,0) \leqslant f(x,y,t) - f(x,y,0) \leqslant O(t,y) + t \cdot f'(x,y,0) \quad , \tag{3}$$

and with (2)

$$\begin{aligned} t \cdot f'(x_o,y_t,0) + O(t,x_o) &\leqslant f(x_o,y_t,t) - f(x_o,y_t,0) \\ &\leqslant v(t) - v(0) \\ &\leqslant f(x_t,y_o,t) - f(x_t,y_o,0) \\ &\leqslant t \cdot f'(x_t,y_o,0) + O(t,y_o) \quad . \end{aligned} \tag{4}$$

From (v) we get

$$f'(x,y,0) \geqslant \min_{y \in Y} f'(x,y,0) =: f'(x,y(x),0) > -\infty \tag{5}$$

and

$$f'(x,y,0) \leqslant \max_{x \in X} f'(x,y,0) =: f'(x(y),y,0) < +\infty \quad ,$$

such that with (4):

$$t \cdot f'(x_o,y(x_o),0) + O(t,x_o) \leqslant v(t) - v(0) \leqslant t \cdot f'(x(y_o),y_o,0) + O(t,y_o) \quad , \tag{6}$$

which means that

$$\lim_{t \to +0} v(t) = v(0) \quad . \tag{7}$$

Dividing in (4) by t, (5) yields