MURAKKAB TUZILISHDAGI ARALASH MAKSIMUMLI DIFFERENSIAL TENGLAMALAR SISTEMALARI UCHUN CHEGARAVIY SHART.

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Annotatsiya : Ushbu maqolada chiziqli bo'lmagan tenglamalar, aralash maksimumli differensial tenglamalar sistemalari uchun chegaraviy shart masalalarini qaraymiz.

Kalit so'zlar: Differentsial tenglama, chegaraviy shartlar, chegaralangan yopiq to'plam, , Inter jarayoni , segment, boshlang'ich shart.

КРАЕВОЕ УСЛОВИЕ ДЛЯ СИСТЕМ СМЕШАННЫХ МАКСИМАЛЬНЫХ ДИФФЕРЕНЦИАЛЬНЫХ УРАВНЕНИЙ СЛОЖНОЙ СТРУКТУРЫ.

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Аннотация: В данной статье рассматриваются задачи о граничных условиях для систем нелинейных уравнений, смешанных уравнений с максимальной дифференциальной точностью.

Ключевые слова: Дифференциальное уравнение, граничные условия, ограниченное замкнутое множество, , Межпроцесс, отрезок, начальное условие.

BOUNDARY CONDITION FOR SYSTEMS OF MIXED MAXIMAL DIFFERENTIAL EQUATIONS OF COMPLEX STRUCTURE.

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Abstract: In this article, we consider boundary condition problems for systems of nonlinear equations, mixed maximum differential equations.

Keywords: Differential equation, boundary conditions, bounded closed set, , Inter process, segment, initial condition.

Ushbu maqolada chiziqli bo'lmagan tenglamalar ko'rib chiqiladi

$$x'(t) = F(t, x(t), \max\{x(r) \mid r \in [t \mid \sigma(t, x(t))]\}), t \in [0; T]$$

$$0 \leq \sigma(t, x) \leq t \qquad T^2 \equiv \left[\overset{*}{t}; T\right] \overset{*}{t} > 0 \tag{1}$$

Chegara sharti bilan

$$\begin{cases} x(0) = \varphi_0 \\ x(T) = \varphi_T \end{cases} \qquad (2) \text{ va } (3)$$

Bu yerda $x \in X \subset R^n$ o'suvchi vektori , X chegaralangan yopiq to'plam, og'ish $\sigma(t, x(t)$ -qo'shimcha ravishda kerakli funksiyaning o'ziga bo'g'liq $x(t)$.

$0 \leq \sigma(t, x) \leq T$ ning $T^1 \equiv \left[0; \overset{*}{t}\right]$ va $t \leq \sigma(t, x) \leq T$ ning birinchi qismida $T^2 \equiv \left[\overset{*}{t}; T\right]$ ning ikkinchi qismida bunday $\overset{*}{t} > 0$ shart mavjudligini ko'rib chiqamiz.

Teorema:

1. $0 \leq \sigma(t, x) \leq t$ da $t \in T^1$ (4)
2. $F(t, x, y) \in C\left(T^1 \times X \times X\right) \cap Bnd(M_1) \cap \left(L_{1\,x,y}\right)$ (5)
3. $\sigma(t, x) \in C\left(T^1 \times X\right) \cap Lip\left(L_{2x}\right)$ (6)

$C\left(T^1 \times X\right)$ sinfda (1) boshlang'ich shartga ko'ra (2) tenglama yagona yechimga ega bo'ladi.

Isbot. T^1 segmentda biz ketma-ket yondoshuvlar yordamida (2) shartga ko'ra (1) tenglama yechimini quydagicha tuzamiz

$$\begin{cases} x_0(t) = \varphi_0 \qquad t \in T^1 \\ x_{m+1}(t) = \varphi_0 + \int_0^t F\left(\theta, x_m(\theta), \max\{x_m(r) \mid r \in [\sigma(\theta, x_m(\theta)); \theta]\}\right) d\theta \end{cases} \tag{7}$$

Jarayonni farqini (7) orqali baholaymiz.

(5) va (7) ga ko'ra, birinchi farq $x_1(t)-x_0(t)$ uchun quydagi baholash o'rinli

$$\|x_1(t)-x_0(t)\|\le M_1 t,\qquad t\in T^{(1)} \tag{8}$$

(5) ga ko'ra $x_2(t)-x_1(t)$ farq quydagicha

$$\|x_2(t)-x_1(t)\|\le L_1\int_0^t(\|x_1(\theta)-x_0(\theta)\|+$$

$$+\left\|\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}\right\|-\left\|\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta\,|\,x_0(\theta))]\}\right\|)d\theta \tag{9}$$

(9) ning o'ng tomonidagi ikkinchi qismini quydagicha yozamiz

$$\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}=$$

$$\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}+$$

$$+\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}$$

(10)

(4) va (8) ni hisobga olgan holda tenglikning birinchi farqi (10) uchun quydagi baholash o'rinli

$$\left\|\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}\right\|\le$$

$$\le\left\|\max\{(x_1(r)-x_0(r))\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}\right\|\le M_1 t,\quad t\in T^1$$

(7) ga binoan , tenglikning ikkinchi farqi uchun (10) olamiz

$$\left\|\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}\right\|=0$$

U holda (9) tengsizlik quydagicha

$$\|x_2(t)-x_1(t)\|\le L_1\int_0^t 2M_1\theta d\theta=2L_1M_1\frac{t^2}{2},\quad t\in T^1 \tag{11}$$

Endi (6) va (11) ga ko'ra $x_1(t)-x_0(t)$ farqiga kelsak,

$$\|x_3(t)-x_2(t)\| \le L_1\int_0^t (\|x_2(\theta)-x_1(\theta)\|+$$

$$\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}+$$

$$+\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}\,d\theta \le$$

$$\le L_1\int_0^t (2+L_2M_1)\|x_2(\theta)-x_1(\theta)\|d\theta \le$$

$$\le 2L_1M_1\left[L_1(2+L_2M_1)\right]\frac{t^3}{3!} \quad t\in T^1$$

Xuddi shunday davom etmoqda ushbu jarayon usuli to'liq $x_{m+1}(t)-x_m(t)$ farq uchun matematik induksiyani quydagicha olamiz

$$\|x_{m+1}(t)-x_m(t)\| \le 2L_1M_1\left[L_1(2+L_2M_1)\right]^{m-1}\frac{t^{m+1}}{(m+1)!} \qquad t\in T^1 \tag{12}$$

(12) dan kelib chiqadiki, $\{x_m(t)\}$ ketma-ketlik t bo'yicha T^1 segmentda tekis yaqinlashadi. Shuning uchun (1) tenglamaning sistemasi (2) boshlang'ich shart bilan T^1 segmentda $x(t)$ yechimga yaqinlashadi, bunda $x\in C^1(T^1;X)$.

Keling , ushbu yechimning yagona ekanligini ko'rsataylik. $C^1(T^1;X)$ sinfidagi (1) Sistema ham xuddi shunday (2) boshlang'ich shartga ega bo'lgan boshqa $z(t)$ yechimga ega bo'lsin.

$z(t)$ ni va $x_0(t), x_1(t), x_2(t),\ldots$ yaqinlashishlarini solishtiramiz.

(5) ga binoan quydagicha baholaymiz

$$\|z(t)-x_1(t)\| \le L_1\int_0^t \|z(\theta)-x_0(\theta)\|+$$

$$+\left\|\max\{z(r)\,|\,r\in[\theta\,|\,\sigma(\theta;z(\theta))]\}-\max\{x_0(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_0(\theta))]\}\right\| \le$$

$$\le 2L_1M_1\int_0^t \theta d\theta = 2L_1M_1\frac{t^2}{2!}$$

(6) va keying farq uchun quydagi tengsizlikni olamiz

$$\|z(t)-x_2(t)\| \le L_1\int_0^t \|z(\theta)-x_1(\theta)\| +$$

$$+\|\max\{z(r)\,|\,r\in[\theta\,|\,\sigma(\theta;z(\theta))]\}-\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}\|+$$

$$+\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}-\max\{x_1(r)\,|\,r\in[\theta\,|\,\sigma(\theta;x_1(\theta))]\}d\theta\le$$

$$\le L_1\int_0^t (2+L_2M_1)\|z(\theta)-x_1(\theta)\|d\theta\le$$

$$\le 2L_1M_1\int_0^t (2+L_2M_1)\frac{t^3}{3!},\qquad t\in T^1$$

Xuddi shunday

$$\|z(t)-x_3(t)\|\le 2L_1M_1[L_1(2+L_2M_1)]^4\frac{t^4}{4!}$$

Va hokozo

Ushbu bahodan ko'rishimiz mumkinki $m\to\infty$ da $\|z(t)-x_m(t)\|\to\infty$

T^1 segmentda t bo'yicha tekis yaqinlashadi.

Shundan kelib chiqqan holda (1) tenglama yechimi (2) boshlang'ich shart bilan $\{x_m(t)\}$ ketma-ketlikka ko'ra $C^1(T^1;X)$ sinfda yagona yechimga ega

ADABIYOTLAR:

1. Sidorov N., Sidorov D., Dreglea A., Solvability and bifurcation of solutions of nonlinear equations with Fredholm operator. Symmetry. 2020. 12 (6), ID 920, 1-21.

2. Rojas E.M., Sidorov N.A., Sinitsyn A.V, A boundary value problem for noninsulated magnetic regime in a vacuum diode. Symmetry. 2020. 12 (4), ID 617 14 pp.

3. . Assanova A. T., Bakirova E. A. and Kadirbayeva Z. M. Numerical solution to a control problem for integro-differential equations, Comput. Math. and Math. Phys., 2020. Vol. 60. No. 2. P. 203-221