TURLI CHEGARALANISHLI HOL UCHUN П STRATEGIYANING QURILISHI HAQIDA

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Annotasiya: *Ushbu maqolada П strategiyaning geometrik chegaralanish, integro – geometrik chegaralanishli holatlar uchun qurilishi yoritilgan. П strategiyaning qurilishi turli chegaralanishli hol uchun quvish – qochish maslasining yechimlariga uzviy bog'liqligi isbotlangan.*

Kalit so'zlar: *П strategiya, geometrik chegaralanish, integro – geometrik chegaralanish.*

О ПОСТРОЕНИИ П – СТАТЕГИИИ ДЛЯ РАЗЛИЧНЫХ ГРАНИЧНЫХ СЛУЧАЕВ

Аннотация: *В статье описано построение П стратегии для геометрически ограниченных, интегро-геометрически ограниченных случаев. Доказано, что построение П-стратегии неразрывно связано с решением задачи погони-убегания для различных предельных случаев.*

Ключевые слава: *П стратегии, геометрическое ограничение, интегро - геометрическое ограничение*

ON THE CONSTRUCTION OF П STRATEGY FOR DIFFERENT BOUNDARY CASES

Annotation: *This article describes the construction of strategy P for geometric bounded, integro-geometrically bounded cases. It has been proved that the* *construction of P strategy is inextricably linked to the solutions of the chase-escape problem for different limiting cases.*

Keywords: *П strategy, geometric limitation, integro - geometric limitation.*

Differensial o’yinlar nazariyasida chegaralanishlar uchun П strategiya muhim ahamiyatga ega. Har bir chegaralanish uchun alohida П strategiyalar mavjud. Quyida ularni har birini ko’rib chiqamiz.

Fazoda P va E obyekt harakatlanyapti

$$P: \begin{cases} \dot{x} = U \\ x(0) = x_0 \end{cases}$$

(1)

$$E: \begin{cases} \dot{y} = V \\ y(0) = y_0 \end{cases} \qquad (2)$$

1. **Geometrik chegaralanish :**

$a)\ |U| \le \alpha\ ;\ \ |V| \le \beta\ ;\ \ |U| = \sqrt{U_1^2 + \cdots + U_n^2}\ ; |V| = \sqrt{V_1^2 + \cdots V_n^2}$

$b)\ U = (U_1; U_2) \rightarrow |U_1| \le \alpha_1\ , |U_2| \le \alpha_2$

$V = (V_1; V_2) \rightarrow |V_1| \le \beta_1\ , |V_2| \le \beta_2$

П strategiya : $U(v) = v - \lambda_G(v)\xi_0\ ,\ \xi_0 = \frac{x_0 - y_0}{|x_0 - y_0|}$ bu yerda

$$\lambda_G(v) = < v, \xi_0 > + \sqrt{< v, \xi_0 >^2 + \alpha^2 - |v|^2}$$

$\alpha > \beta$ da tutish masalasi yechiladi ; $\alpha \le \beta$ da qochish masalasi yechiladi .

2. **Integro – geometrik chegaralanishli xol :**

a) $\int_0^\infty |U(s)|^2 ds \le \rho_0,$ (3)

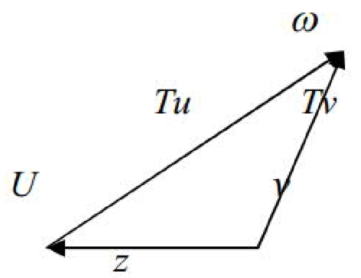
$|v| \le \beta$ (4)

b) $\int_0^t |U_1(s)|^2 ds \le \rho_{10},\ \ \int_0^t |U_2(s)|^2 ds \le \rho_{20}$

$|v_1| \le \beta_1,\qquad\qquad |v_2| \le \beta_2$

P: $\dot{x} = U(t), x(0) = x_0 \rightarrow x(t) = x_0 + \int_0^t U(s)ds$

E : $\dot{y} = V(t)\ y(0) = y_0 \rightarrow y(t) = y_0 + \int_0^t V(s)ds$



Tutish masalasi : $\forall t^* : x(t^*) = y(t^*)$ (5)

Qochish masalasi : $x(t) \neq y(t)\ ,\ t \geq 0$ (6)

$z + Tu = Tv\ ,\ Tu = Tv - z\ ,\ u = v - \frac{z}{T}$ (7)

$\int_0^T |U|^2 ds = \rho, T|U|^2 = \rho, |U|^2 = \frac{\rho}{T}$ (8)

Quyidagicha belgilash kiritib olamiz : $\frac{|z|}{T} = \lambda \Rightarrow U = v - \lambda\xi, |U|^2 = \lambda\frac{\rho}{|z|}$

$$\begin{cases} |U|^2 = |v|^2 - 2\lambda\langle v, \xi\rangle + \lambda^2 \\ \lambda\frac{\rho}{|z|} = |v|^2 - 2\lambda\langle v, \xi\rangle + \lambda^2 \end{cases} \Rightarrow \lambda^2 - 2\lambda(\frac{\rho}{2|z|} + \langle v, \xi\rangle) + v^2 = 0$$

(9)

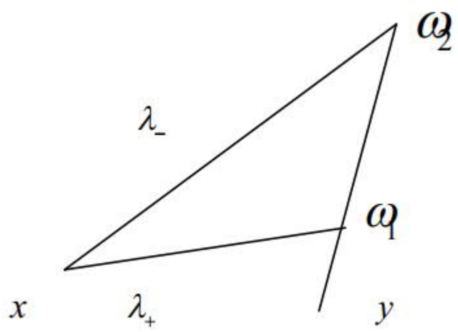
$$\lambda_{1.2} = \frac{\rho}{2|z|} + \langle v, \xi\rangle \pm \sqrt{(\frac{\rho}{2|z|} + \langle v, \xi\rangle)^2 - |v|^2}$$

(10)

λ_1 va λ_2 ham musbat . Savol tuo‘iladi qaysi λ ni olamiz ?

$\lambda_1, \lambda_2 > 0$ agar , $\frac{\rho}{2|z|} + \langle v, \xi \rangle \succ 0$ bo‘lsa yechim mavjud bo‘lishi uchun ildiz osti

aniqlangan bo‘lishi kerak ya’ni $D = \left\{ (\rho, z, v) : (\frac{\rho}{2|z|} + \langle v, \xi \rangle)^2 - |v|^2 \geq 0 \right\}$



Integro – geometrik holda quvlovchini parallel yaqinlashtirish orqali (ω_1, ω_2) oraliqda tutish mumkin bo‘lar ekan . Biz bitta quvlovchi bitta qochuvchi bo‘lgan holda ko‘ramiz ya’ni λ_+ni olamiz . Shuning uchun (10) ga yechim sifatida λ_1 ni tanlaymiz . Natijada hal qiluvchi funksiya deb,

$$\lambda(\rho, z, v) = \frac{\rho}{2|z|} + \langle v, \xi \rangle + \sqrt{(\frac{\rho}{2|z|} + \langle v, \xi \rangle)^2 - |v|^2} \tag{11}$$

funksiyani olamiz . n o‘lchovli fazoda $2n+1$ ta yechimi bor. (11)- funksiyani aniqlanish sohasini tahlil qilamiz $D = \left\{ (\rho, z, v) : (\frac{\rho}{2|z|} + \langle v, \xi \rangle)^2 - |v|^2 \right\}$

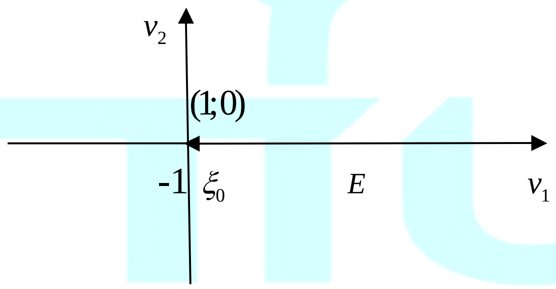
$(\frac{\rho}{2|z|} + \langle v, \xi \rangle + |v|)(\frac{\rho}{2|z|} + \langle v, \xi \rangle - |v|) \geq 0$ demak ,

$$\frac{\rho}{2|z|}+\langle v,\xi\rangle-|v|\geq 0 \qquad (12)$$

bo'lishi kerak . (12) tengsizlikning geometrik mohiyati (v ga nisbatan):

$a^2=\frac{\rho}{2|z|}$, $a^2+v_1\xi_1+\ldots+v_n\xi_n-\sqrt{v_1^2+\ldots+v_n^2}\geq 0$ figura hosil bo'ladi .

Soddalashtirish uchun tekislikda ko'raylik . $a^2+v_1\xi_1+v_2\xi_2-\sqrt{v_1^2+v_2^2}\geq 0$

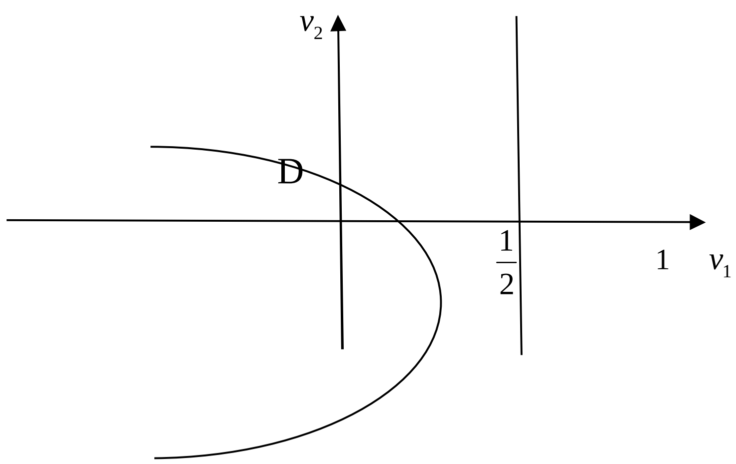


$\xi_0=\frac{x_0-y_0}{|x_0-y_0|}, x_0=(0;0), y_0=(1;0); \xi_0(-1;0), \xi_1=-1, \xi_2=0$

$a^2-v_1-\sqrt{v_1^2+v_2^2}\geq 0$, $a^2\geq v_1+\sqrt{v_1^2+v_2^2}\geq 0$, $a=1$desak , $v_1+\sqrt{v_1^2+v_2^2}\leq 1$,

$\sqrt{v_1^2+v_2^2}\leq 1-v_1$

$1-2v_1+v_1^2\geq v_1^2+v_2^2, 1-2v_1\geq v_2^2, v_1\leq\frac{1-v_2^2}{2}$



D sohamiz parabolaning ichi ekan . Uch o‘lchovli fazoda ko‘rsak , paraboloid bo‘lib qolar ekan . Agar $a \neq 1$ bo‘lsa uchi $\frac{a}{2}$ da bo‘lar ekan tekislikda .

$\xi_0(-1,0,0)$; $a^2 - v_1 - \sqrt{v_1^2 + v_2^2 + v_3^2} \geq 0, a^2 - v_1 \geq \sqrt{v_1^2 + v_2^2 + v_3^2}$

$$a^4 - 2a^2 v_1 + v_1^2 \geq v_1^2 + v_2^2 + v_3^2, a^4 - 2a^2 v_1 \geq v_2^2 + v_3^2, v_1 \leq \frac{a^4}{2a^2} - \frac{v_2^2 + v_3^2}{2a^2}, v_1 \leq \frac{a^2}{2} - \frac{v_2^2 + v_3^2}{2a^2}$$

$\beta \leq \frac{a^2}{2} = \frac{\rho}{4|z|} \Rightarrow \rho \geq 4\beta|z|$. Demak , xulosa (11) $\lambda(\rho, z, v)$ funksiya $\rho \geq 4\beta|z|$ bo‘lganda $\forall |v| \leq \beta$ uchun aniqlangan .

(11) ko‘rinishni yuqoridagi $U = v - \lambda\xi, |U|^2 = \lambda\frac{\rho}{|z|}$ tenglikka olib kelib qo‘yamiz va quyidagi strategiyani hosil qilamiz :

$$\begin{cases} U(\rho, z, v) = v - \lambda(\rho, z, v)\xi \\ |U(\rho, z, v)|^2 = \lambda(\rho, z, v)\frac{\rho}{|z|} \end{cases}$$

(13)

(1) va (2) tenglamadan quyidagi tenglamani hosil qilamiz

$$\begin{cases} \dot{z} = U - v \\ z(0) = z_0 \end{cases} \qquad (14)$$

bu yerda $z = x - y, \dot{x} = U; z_0 = x_0 - y_0, \dot{y} = v; \dot{x} - \dot{y} = U - v$

(14) ko‘rinishdagi U ni o‘rniga (13) ni 1-qatorini qo‘yamiz natijada :

$$\begin{cases} \dot{z} = -\lambda(\rho, z, v)\xi \\ z(0) = z_0 \end{cases} \qquad (15)$$

$$\rho(t) = \rho_0 - \int_0^t |U(s)|^2 \, ds$$

(16)

(16) tenglamaga $|U|^2$ ni o'rniga (13) ni 2-qatorini qo'yamiz

$\rho(\mathrm{t}) = \rho_0 - \int_0^t \lambda(\rho(s), z(s), v(s)) \frac{\rho(s)}{|z(s)|} ds$ tenglikni hosil qilamiz . Endi har ikki tomondan hosila olaylik

$$\begin{cases} \dot{\rho}(t) = -\lambda(\rho, z, v) \dfrac{\rho}{|z|} \\ \rho(0) = \rho_0 \end{cases} \qquad (17)$$

(15) va (17) lardan quyidagi natijaga ega bo'lamiz

$$\begin{cases} \dot{z} = -\lambda(\rho(t), z(t), v(\mathrm{t})) \dfrac{z(t)}{|z(t)|} \\ \dot{\rho} = -\lambda(\rho(t), z(t), v(\mathrm{t})) \dfrac{\rho(t)}{|z(t)|} \\ z(0) = z_0, \rho(0) = \rho_0 \end{cases}$$

(18)

(18) dan (ρ, z) ga nisbatan differensial tenglamalar sistemasi hosil bo'lishi kelib chiqdi.

(18) sistema nochiziqli differensial sistema . Agar $z \neq 0$ bo'lsa bu sistemaning o'ng tomonidagi funksiya $\rho \geq 4\beta|z|$ shartda uzluksiz ((ρ, z) ga nisbatan) . Funksiya *t* ga nisbatan esa o'lchovli funksiya (ya'ni Karatedore shartlari bajarilyapti) deyiladi. Karatedore sharti bo'lishi uchun , Karatedore tenglamasining o'ng tomoni *z* bo'yicha Lipshist shartini qanoatlantirishi kerak ya'ni

$$\left| f(z_1,t) - f(z_2,t) \right| \le L \left| z_1 - z_2 \right| \qquad (19)$$

(18) tenglamaning o'ng tomonidagi funksiyalar (ρ, z) bo'yicha $z \neq 0$ holda Karatedore shartlari o'rinli . Shuning uchun (18) sistemani yagona yechimi mavjud bo'ladi . (18) tenglamadan quyidagicha almashtirish hosil qilamiz

$$\begin{cases} \dot{z}_1 = -\lambda(\rho(t), z(t), v(t)) \dfrac{z_1(t)}{|z(t)|} \\ \dot{z}_2 = -\lambda(\rho(t), z(t), v(t)) \dfrac{z_2(t)}{|z(t)|} \\ \dots\dots\dots\dots\dots\dots \\ \dot{z}_n = -\lambda(\rho(t), z(t), v(t)) \dfrac{z_n(t)}{|z(t)|} \end{cases} \Rightarrow \begin{cases} \dfrac{\dot{z}_1}{z_1} = -\lambda(\rho(t), z(t), v(t)) \dfrac{1}{|z(t)|} \\ \dfrac{\dot{z}_2}{z_2} = -\lambda(\rho(t), z(t), v(t)) \dfrac{1}{|z(t)|} \\ \dots\dots\dots\dots\dots\dots \\ \dfrac{\dot{z}_n}{z_n} = -\lambda(\rho(t), z(t), v(t)) \dfrac{1}{|z(t)|} \end{cases}$$

endi integrallasak ,

$$\ln z_i \Big|_0^t = -\int_0^t \lambda(\rho(t), z(t), v(t)) \frac{1}{|z(t)|} ds; \; z_i(t) = z_i(0) e^{-\int_0^t \lambda(\rho(t), z(t), v(t)) \frac{1}{|z(t)|} ds}, i = \overline{1, n}$$

$e^{-\int_0^t \lambda(\rho(t), z(t), v(t)) \frac{1}{|z(t)|} ds} = h(t)$ deb olsak ,

$$z(t) = z_0 h(t) \qquad (20)$$

hosil bo'ladi . Xuddi shu kabi ,

$$\begin{cases} \rho(t) = \rho_0 h(t) \\ z(t) = z_0 h(t) \end{cases}$$

(21)

bu yerda $h(t) = h(z, \rho, v, t)$. (21) ni (11) ga olib borib qo‘yaylik

$$\lambda(\rho,z,v)=\frac{\rho}{2|z|}+\langle v,\xi\rangle+\sqrt{(\frac{\rho}{2|z|}+\langle v,\xi\rangle)^2-|v|^2}=\frac{\rho_0 h}{2|z_0|h}+\left\langle v,\frac{z_0 h}{|z_0|h}\right\rangle+\sqrt{(\frac{\rho}{2|z|}+\langle v,\xi\rangle)^2-|v|^2}=\lambda(\rho_0,z_0,v)$$

Demak , boshlano‘ich holatdagi (ρ_0, z_0) ni bilsak bo‘ldi ekan .

Ta’rif : Integro –geometrik differensial o‘yinda $\prod$ strategiya deb , quyidagi funksiyaga aytamiz

$$U(v) = v - \lambda_{IG}(v)\xi_0 \tag{22}$$

bu yerda $\lambda_{IG}(v) = \frac{\rho_0}{2|z_0|} + \langle v, \xi_0 \rangle + \sqrt{(\frac{\rho_0}{2|z_0|} + \langle v, \xi_0 \rangle)^2 - |v|^2}$

Mavzu bo‘yicha tarixiy ma’lumot : Strategiyalar quvish masalasi qadimdan olimlarni qiziqtirgan . Eramizdan 2000 yil avval Xitoy qo‘lyozmalarida “Burgut va O‘lja masalasi “ o‘rganilgan bunda burgut o‘z o‘ljasini izma –iz quvish strategiyasi orqali harakatlanib ushlash masalasi ko‘rilgan . Lekin matematika rivoji u davrda bu masalani yechishga yetarli bo‘lmagan . 1732- yil fransus gidrogrifi va matematigi Bagauer “ Tulki va Quyon “ masalasini yechadi . Bunda quyin ma’lim to‘o‘ri chiziq bo‘yicha qochib borganda tulki uni izma – iz quvish natijasida qaysi trayektoriya orqali harakat qilishi mumkinligi mαasaasi yechildi . Bu masala amerikalik olim Lokning “ Zambaraklarni boshqarish “ kitobida bafurcha tahlil qilinib yechimlari keltirilgan .

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