Non-Search Mathematical Programming Algorithm for Limit Analysis

Haiyan Gao\textsuperscript{1,2}*

\textsuperscript{1}Basic Education Institute, Dalian University of Finance and Economics, Dalian, 116600, China
\textsuperscript{2}School of Management Science and Engineering, Dongbei University of Finance and Economics, Dalian, 116025, China

*Corresponding author e-mail: hygaodlcj@163.com

Abstract. In order to improve the ability of no-search mathematical programming under limit analysis, and guide big data to optimize classification, a non-search mathematical programming model based on limit analysis model is proposed. The non-search mathematical programming of hyperbolic differential equations in the limit analysis model is analyzed, which provides a mathematical theoretical basis for solving the stability control problem of the system. The hyperbolic differential equation is constructed and the characteristic decomposition of the linear programming model is carried out by using adaptive limit analysis method. The searching delay two-degree-of-freedom control method is used at the load balancing point to adaptively optimize the searching delay parameters of the limit analysis model. In this paper, the hyperbolic differential equations in the limit analysis model are obtained, and the theorems of non-search mathematical programming are given. The mathematical analysis shows that the hyperbolic differential equations in the limit analysis model have the characteristics of non-search mathematical programming. The given theorem of non-search mathematical programming is reliable, and the characteristic solutions of differential equations are stable convergence, which can guide the stability control and improve the control accuracy and reliability. The simulation results show that the algorithm has better convergence and shorter time cost under the limit analysis.

Keywords: Limit Analysis Model, Stability, Differential Equation, Mathematical Programming, Stable Solution Search

1. Introduction
With the coordinated development of computational mathematics and control theory, the study of stability control in nonlinear dynamical systems of computational mathematics has attracted people's attention, and has been widely used in linear system control, gene regulation network functional and data classification. The control index of the limit analysis model is influenced by the multivariate differential constraint parameters, and the control variables are diversified and uncertain\textsuperscript{11}. Therefore,
it is necessary to construct hyperbolic differential equations and control systems in the deterministic limit analysis model. By means of solving nonlinear ordinary differential equations and nonlinear partial differential equations, the characteristics of non-search mathematical programming of hyperbolic differential equations in limit analysis model are described under given initial values. The characteristic solutions of differential equations are used to analyze the time-frequency characteristics of the equations, so as to provide a mathematical basis for the stability control of the system. Therefore, it has great significance to study the non-search mathematical programming of hyperbolic differential equations in the limit analysis model[2].

The research on the non-search mathematical programming of hyperbolic differential equations in the limit analysis model is still in its infancy, and the relevant mathematical theories are still immature. However, some scholars have proved and studied the non-search mathematical programming and self-stabilization of hyperbolic differential equations in the limit analysis model. In reference [3], an admission control mechanism is used to analyze the non-search mathematical programming of hyperbolic differential equations in the limit analysis model, which improves the signal-to-noise ratio and control equilibrium of the system, but the mathematical model is disturbed by noise. In reference [4], a hyperbolic functional analysis method for hyperbolic differential equations based on two-degree-of-freedom (IMC-PID) control for searching time-delay systems is proposed. Another filtering parameter is modified according to the dynamic performance of the system, and the control effect is good. However, the model may lead to the divergence of the system under given initial values. In view of the above problems, the hyperbolic differential equation in the limit analysis model is studied by searching for the hyperbolic differential equation with two degrees of freedom, and the hyperbolic differential equation is constructed[5-8]. The adaptive limit analysis method is used to decompose the characteristic of the linear programming model. In the load balancing point decomposition, the searching delay two-degree-of-freedom control method is used to adaptively optimize the searching delay parameters of the limit analysis model. In this paper, the hyperbolic differential equations in the limit analysis model are obtained and the hyperbolic differential equation superstable solutions are obtained. The theorem of non-search mathematical programming is given, and the mathematical proof is carried out. The stability and convergence of the system constructed in this paper are revealed.

2. Construction of Differential Equations and Basic Theorems

2.1. Hyperbolic Differential Equation and Problem Description in Limit Analysis Model

In the limit analysis model, the hyperbolic differential equation is constructed, and the influence of the continuous solution of the hyperbolic differential equation on the stability of the control system is analyzed[9]. The hyperbolic differential equation in the limit analysis model is described as follows:

$$
G_{EV,q,p} = \begin{bmatrix}
G_{EV,01} & \cdots & G_{EV,\lambda p} \\
\vdots & \ddots & \vdots \\
G_{EV,01} & \cdots & G_{EV,qp}
\end{bmatrix}
$$

(1)

Set \( x_0 = [X_{p_0}(G_0)] \), \( x_1 = [X_{p_0}(G_0)] \), \( x_i = [X_{p_0+i}(G_i)] \), \( p_{i-1} = p_0 - \theta \), \( p_i = p_0 + \theta \), the iterative system of hyperbolic differential equations has only such a stable periodic point as \( x = 0 \), which may result in several consecutive sparse matrices \( \Phi = (\beta, \cdots, \beta) \in GF^2 \), searching the peak value in the interval by using the dichotomy, in which, \( n = 1, 2, 3, \cdots, \mu \in [0, 4] \). In order to improve the stability of the linear control model under different boundary conditions, the continuous bounded solution operator for the analysis of differential equations in finite dimensional second-order convex space is analyzed and characterized in sensitive domain[10], and the time-shift characteristics of hyperbolic differential equations are obtained:
\[ F^\mu[f(t-\rho)] = \exp\left(j\pi p^2 \sin \alpha \cos \alpha\right) \]
\[ \cdot \exp(-j2\pi u \rho \sin \alpha) f_u(u-\rho \cos \alpha) \]  
\[ (2) \]

Where, the Fourier transformation of \( f(t/M) \) is \( |M|F(M\omega) \), singular decomposition with the continuous bounded solution of differential equation in finite dimensional Morrey convex space, and the continuous fractional algorithm can be obtained as \( \hat{f} \), where \( n_m \) and \( d_m \) are the molecular and denominator of \( f \) respectively.

**Theorem 1**: If the hyperbolic differential equation in the limit analysis model and the rotational additive model have lag time constant mismatch, by the definition of fractional Fourier transformation\([11]\), the control process model lag time constant \( T = \Delta L L_s \) is obtained, in which, \( \Delta L > 0 \). \( F^{2n/\pi} = \sum_{i=0}^{3} a_i(\alpha) W^i \) is used to calculate the kernel matrix of discrete FRFT, the condition that the control system constructed by hyperbolic differential equation remains stable is as follows:

\[ 0 < \Delta L < 1 + \frac{\lambda_2}{L} \]  
\[ (3) \]

The eigenvalue and eigenvector of the matrix are taken into consideration, the kernel matrix of discrete FRFT for solving hyperbolic differential equations is solved\([12]\). The nonlinear time series analysis method is used. According to the rotational DFT matrix model, \( \frac{\partial \pi_m}{\partial p_1} = 0 \), \( \frac{\partial \pi_m}{\partial A_1} = 0 \), \( \eta = 2\mu_2 \delta (1-\delta) - \rho_2^2 \), then:

\[ \frac{2\delta^2 (1-\delta) \mu_2 - 2\rho_2^2 \delta - 2\eta}{(1-\delta)\eta} p_1 \]
\[ + \frac{\psi_1 \cdot \rho_2^2 \delta (1-\delta) - (1-\delta) \delta \mu_2 + \rho_2 \eta}{(1-\delta)\eta} A_1 \]
\[ + \frac{Q + \delta (1-\delta) \mu_2 \delta (1-\delta) \mu_2 - 2\rho_2^2 + \rho_2 (\eta + \rho_2^2) (c_2 + c_1)}{\delta (1-\delta) \mu_2 \eta} (c_2 + c_1) \]
\[ - \frac{\delta^2 (1-\delta) \mu_2 - \rho_2^2 - \eta}{(1-\delta)\eta} c_2 = 0 \]
\[ (4) \]

From the process of Bcklund transformation, it is known that through the establishment of multi-track parallel model, all the tracks in the system can be brought into the category of model analysis, and the calculated results are close to the output of continuous FRFT. The hyperbolic differential equation in the limit analysis model provides the model foundation for the next research on the non-search mathematical programming\([13]\).

2.2. Searching Delay 2-DOF Control and Equation Stability Solution

**Definition 1**: Amplitude margin control. The oscillation characteristics of hyperbolic differential equations in a certain time and frequency range are obtained in the limit analysis model\([14]\). The amplitude-phase margin of hyperbolic differential equations is defined as follows by using the first order Taylor expansion approximation \( e^{-L_s t} = 1 - L_s s \) in limit analysis model:
\[ g_\alpha(u) = A_\alpha \int_\infty^\infty \exp \left[ j(u-t)^2 \csc \alpha \right] g(t) \, dt = A_\alpha \int_\infty^\infty h(u-t) g(t) \, dt \] (5)

Where, \( L_m \) is the lag time, \( T_m \) is the time constant of the first discrete sampled \( x(m/\Delta x) \), and the stable solution of hyperbolic differential equation in the limit analysis model is obtained by \( y_s \).

When calculating the sampling value of the fractional Fourier transform \( X_p(u) \) of \( X_p(m/\Delta x) \), as:

\[ E[\tilde{e}_{ik}] = 0 \quad \forall s = 1, \ldots, n, k = 1, \ldots, p \] (6)

\[ E[\tilde{e}_{12k1} \tilde{e}_{2k2}] = \begin{pmatrix} \frac{m}{p} \sigma_s^2 & 0 \\ 0 & 0 \end{pmatrix} \] (7)

While, \( D(c) = c \mod n = (m^r) \mod n = m^{r+1} \mod n \), and \( K^{\text{fr}}(S), K^{\text{fr}}(S), D_{\alpha, \beta}, M_{\alpha, \beta} \), the continuous bounded solution operator of differential equation is analyzed and characterized in sensitive domain.

When the matrix \( Q \) is positive definite, the \( X_p \left( \frac{m}{2\Delta x} \right) \) needs to be extracted twice for the final result. The frequency shift property of FRFT and the amplitude and phase margin control parameter are used. The value of \( \Delta_\alpha \), \( \phi_\alpha \) may be determined by the following formula:

\[ F_\alpha \left[ e^{j(2\alpha + k_\alpha \phi_\alpha)} \right] = G_\alpha(u - v \sin \alpha) e^{-j\frac{\pi}{4} \sin \alpha \cos \alpha + j\alpha \cos \alpha} \]

\[ = \frac{1 + i \tan \alpha}{1 + k_\alpha \tan \alpha} \exp \left[ i\pi \frac{u^2(k_\alpha - \tan \alpha) + 2kf_\alpha \sec \alpha - f_\alpha \tan \alpha}{1 + k_\alpha \tan \alpha} \right] \] (8)

Using the IMC-PID design of two degrees of freedom, the linear solution in finite dimensional Morrey convex space is analyzed[15]. Then the inverse matrix \( Q^{-1} \), \( Q \) and \( Q^{-1} \) are also positive definite matrices. When \( \alpha = \arctan(k_\alpha) = \frac{2j + 1}{2} \pi \) (\( J \) is an arbitrary integer), then:

\[ F_\alpha \left[ e^{j(2\alpha + k_\alpha \phi_\alpha)} \right] = \frac{1}{\sqrt{1 - ik_\alpha}} \delta(u - f_\alpha \sin \alpha) \] (9)

If \( k_1 \neq k_2 \) or \( t_1 \neq t_2 \), \( \phi_{121} \) are independent of \( \phi_{222} \), the stable solutions of hyperbolic differential equations in the limit analysis model can be obtained by searching for time-delay two-degree-of-freedom control.

3. Non-Search Mathematical Programming Theorem and its Reliability Proof

In the hyperbolic differential equation of the limit analysis model constructed above, the stability control object model is constructed. The schematic diagram of the model is shown in figure 1.
Fig. 1 Schematic diagram of the mathematical programming model

In the stability control object model based on hyperbolic differential equation, in order to obtain the weight value from the measured value, two conditions need to be satisfied: (1) the measurement matrix needs to satisfy the sensitivity requirement of two degrees of freedom. (2) the method of determining the weight value can only use $l_2$-norm, let $Q$ be the set of arbitrary $R^n$ points at $q$, expressed as vector $d_1, d_2, \ldots, d_q$. The sensitivity function is:

$$M_j = \max_{0 < w < \infty} \frac{1}{1 + C_j(jw)P(jw)}$$

Theorem 2: Let $F$ be a finite field and $\omega$ be a closed loop transfer function of positive integer system $H_2$ and $H_3$ are labeled as $x$. According to the definition 1, $H_2(x)$ is satisfied, if $A = (a_{i,j})_{i,j=1}^n$, $B = (b_{i,j})_{i,j=1}^n$, the robust stability drive-response formula of the system is obtained as:

$$\text{State}(K, N) = 0 = -\mu p_{k,N} + \lambda p_{k,N-i} + r p_{k,N-i}$$

(11)

$$\text{State}(K, n) = 0 = -r p_{k,N-i} + \lambda p_{k,N-i}, \quad 2 \leq n \leq N - 1$$

(12)

$$\text{State}(K, 1) = 0 = -r p_{k,N-i} + \lambda p_{k,N-i}$$

(13)

The amplitude margin and phase margin are introduced. The second order control model is expressed as follows:

$$Q_1(s) = M_{-1}(s)f_1(s)$$

$$Q_2(s) = M_{-1}(s)f_2(s)$$

(14)

By using Lyapunov functional for three parameter mismatches, the following results can be obtained:

$$C_1(s) = \frac{\lambda_2 s + 1}{\lambda_1 s + 1}$$

$$C_2(s) = \prod_{i=m}^{j=n} (T_{mn} s + 1)$$

$$C_2(s) = \frac{\prod_{i=1}^{j=n} (T_{mn} s + 1)}{K_m (\lambda_2 + L_m) s}$$

(15)

The superstable vibration conditions of the system are expressed as follows:

\[ \text{Re} \] \[ \text{Im} \]
\[ 0 < \Delta K < 1 + \frac{\hat{L}_2}{L_w} \]  

(16)

The above description is a non-searchable mathematical programming theorem for hyperbolic differential equations in the limit analysis model. The reliability of the theorem and the stability of the solution of the differential equation are proved below.

It is proved that based on the stability control object model of hyperbolic differential equation, the characteristic decomposition of the limit analysis model is carried out, and the stability solution of the hyperbolic differential equation is solved by the delay time constant \( L = \Delta L/L_w \), of the process model. Let \( G_0 \) and \( \alpha_0 \) be the system response and link characteristics of the initial design respectively. By using the first order Taylor expansion, the super-stable regression parameters are obtained as follows:

\[ A_i = \frac{\rho_0 \delta \eta - \rho_0 (1-\delta) \rho_1 \mu_2 - \rho_0 \rho_1^2 \delta^2}{\mu_i (1-\delta) \eta} (p_i - c_i) \]  

(17)

In order for the system to be stable, it is necessary to work out the maximum sensitivity \( M_r \), including:

\[ \delta \cdot p_1 - 2p_2 + \rho_2 A_2 - \delta \rho_1 A_1 + c_2 + c_r = 0 \]  

(18)

\[ \rho_2 ( p_2 - c_2 - c_r ) - \delta \cdot (1-\delta) \mu_2 A_2 = 0 \]  

(19)

Set \( \frac{\partial \pi_r}{\partial p_2} = 0 \), \( \frac{\partial \pi_r}{\partial A_2} = 0 \), by finding the extremum, the hyperstable equilibrium solution with two accumulative equilibrium points is obtained as follows:

\[ \delta \cdot p_1 - 2p_2 + \rho_2 A_2 - \delta \rho_1 A_1 + c_2 + c_r = 0 \]  

(20)

\[ \rho_2 ( p_2 - c_2 - c_r ) - \delta \cdot (1-\delta) \mu_2 A_2 = 0 \]  

(21)

It can be seen that the non-search mathematical programming theorem of hyperbolic differential equation in the limit analysis model given in this paper is reliable, and the solution of hyperbolic differential equation based on this theorem is stable convergence. Propositions are proved.

4. Simulation Experiment and Result Analysis

In order to test the performance of this method in the non-searchable mathematical programming of limit analysis, the simulation experiment is carried out, which is established in the Microsoft Visual C 7.0, Vega Prime2.2.1 simulation environment. The Matlab programming tool is used to simulate the non-search mathematical programming for limit analysis. The relative time delay and the number of search paths are 0.23s and 120s for the mathematical programming without searching for the limit analysis, and the relative time delay is 0.23s and the number of search paths is 120s, respectively. The amplitude parameters of big data feature sampling are (0, 2.0, 3.0, 4.0, 5.0), and the Sink node of the decision tree is 5*5 random matrix. Under the maximum iterative step number \( NP = 30 \), normalized initial sampling frequency \( f_i = 0.8 \) Hz, the search path distribution is shown in figure 2.
Fig. 2 Search path distribution of mathematical programming under limit analysis

Taking the data collected in figure 2 as the object, the path planning is carried out, and the convergence is tested. The comparison results are shown in figure 3.

Fig. 3 Convergence comparison

It is shown in figure 3 that the convergence of the proposed method for non-search searching mathematical programming is good, and the test time overhead is compared as shown in figure 4.

Fig.4 Comparison of time cost

The simulation results show that the algorithm has better convergence and shorter time cost under the limit analysis.
5. Conclusions
The hyperstability of hyperbolic differential equations in the limit analysis model is studied in this paper by searching the time-delay two-degree-of-freedom control, which provides a mathematical theoretical basis for solving the stability control problem of the system. The hyperbolic differential equations are constructed and the eigenvalues of linear programming models are decomposed by adaptive limit analysis method. In the load balancing point decomposition, the searching delay two-degree-of-freedom control method is used to adaptively optimize the searching delay parameters of the limit analysis model, and the hyperbolic differential equation superstability solution in the limit analysis model is obtained. The theorems of non-search mathematical programming are given. It is concluded that the hyperbolic differential equations given by this method have the characteristics of non-search mathematical programming and the characteristic solutions are stable convergence. This method has good application value in limit search and stability control.

References
[1] DU Lin, ZHANG Ying, HU Gao-ge, LEI You-ming. Chaos Control for the Duopoly Cournot-Puu Model[J]. Applied Mathematics and Mechanics, 2017, 38(2): 224-232.
[2] ZHOU Wei, LUO Jianjun, JIN Kai, WANG Kai. Particle swarm and differential evolution fusion algorithm based on fuzzy Gauss learning strategy[J]. Journal of Computer Applications, 2017, 37(9): 2536-2540.
[3] PATEL H. Accelerated PSO swarm search feature selection with SVM for data stream mining big data[J]. International Journal of Research and Engineering, 2016, 3(9):15761-15765.
[4] TANG K Z, LI H Y, LI J, et al. Improved particle swarm optimization algorithm for solving complex optimization problems[J]. Journal of Nanjing University of Science and Technology, 2015, 39(4):386-391.
[5] LI W H, NI H Y. An improved AdaBoost training algorithm[J]. Journal of Jilin University (Science Edition), 2011, 49(3):498-504.
[6] SUN B, WANG J D, CHEN H Y, et al. Diversity measures in ensemble learning[J]. Control and Decision, 2014, 29(3):385-395.
[7] PARVIN H, MIRNABIBABOLI M, ALINEJAD-ROKNY H. Proposing a classifier ensemble framework based on classifier selection and decision tree[J]. Engineering Applications of Artificial Intelligence, 2015, 37:34-42.
[8] LI Zuxiong. Periodic Solution for a Modified Leslie-Gower Model with Feedback Control. Acta Mathematicae Applicatae Sinica, 2015, 38(1): 37-52.
[9] LUO Hongying, QU Ying, YU Yuanhong. Oscillation Criteria of Second Order Neutral Delay Emden-Fowler Equations with Positive and Negative Coefficients. Acta Mathematicae Applicatae Sinica, 2017, 40(5): 667-675.
[10] YUAN Quan, GUO Jiangfan. New ensemble classification algorithm for data stream with noise[J]. Journal of Computer Applications, 2018, 38(6): 1591-1595.
[11] KOLTER J Z, MALOOF M A. Dynamic weighted majority: a new ensemble method for tracking concept drift[C]//Proceedings of the 2003 Third IEEE International Conference on Data Mining, Washington, DC:IEEE Computer Society, 2003:123-130.
[12] JU C H, ZOU J B. An incremental classification algorithm for data stream based on information entropy diversity measure[J]. Telecommunications Science, 2015, 31(2):86-96.
[13] LYU Y X, WANG C Y, WANG C, et al. Online classification algorithm for uncertain data stream in big data[J]. Journal of Northeastern University (Natural Science Edition), 2016, 37(9):1245-1249.
[14] SUN B, WANG J D, CHEN H Y, et al. Diversity measures in ensemble learning[J]. Control and Decision, 2014, 29(3):385-395.
[15] RONG C T, LU W, WANG X, et al. Efficient and scalable processing of string similarity join[J]. IEEE Transactions on Knowledge and Data Engineering, 2013, 25(10):2217-2230.