Research on hilly mountain tractor based on adaptive

Mingxi Shao¹, Xiumei Zhang² and Zhe Xin¹,*
¹College of Engineering, China Agricultural University, Beijing, China
²University of Science and Technology, Beijing, China

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

Abstract. Finite element method is an effective numerical analysis method developed to adapt to the use of computer [1]. Its role in engineering practice has been extended from analysis and verification to optimization design, and it has become a computer aided by computer aided design (CAD) Engineering (CAE) an important part. With the increasing complexity of engineering practice problems, the application of finite element method and error analysis method in one of the adaptive finite element method is becoming more and more popular. The adaptive finite element mesh which reflects the physical and geometric characteristics of the structure is the necessary part of applying the adaptive finite element method. With the trend of the development of tractors in the direction of intelligent, lightweight, the application of electronic technology and micro-control technology to tractors is an inevitable way. In this paper, based on the traditional tractor hydraulic suspension system, a tractor system with force adjustment function is designed. Compared with the traditional tractor hydraulic suspension system, the system uses the electronic control technology to realize the deep displacement adjustment and force regulation, control the chip acquisition force sensor and the position sensor real-time feedback signal to raise or lower the hanging rod.

Introduction.

Keywords: adaptive finite element method; force adjustment; finite element grid; hydraulic suspension system

1. Introduction

Since the 1970s, many scientists have been researching and working hard, and the finite element method has become a common way to solve many engineering problems [2]. One of the basic premise of applying the finite element method is to separate the solution domain representing a structure or continuum into several finite subdomain units, that is finite element mesh and connect them through the boundary nodes, and use such an assembly to simulate or approximate the solution area. The finite element method is an approximation method. The degree of approximation of the solution and the solution of the real solution of the problem depends on the number of elements, the shape of the element, and the position of the node. The size of the unit and the position of the node have a considerable effect on the accuracy of the solution. Reducing the cell size and increasing the number of nodes will generally improve the accuracy of the solution, but this will also increase the cost of the solution, memory footprint.
In order to be able to get a higher precision solution in a short time, it is necessary to balance and adjust the number of elements and nodes, the position of the node and the precision of the solution. This requires that the grid generation program be able to adaptively generate finite element meshes based on the geometry of the target domain or the results of the last analysis, that is, the larger parts of the curve that require fine delineation, such as curves and surfaces [3]. The grid generated by the stress concentration region should be denser, and the other parts with smaller curvature and relatively uniform stress can be relatively sparse. This can improve the accuracy of the solution without increasing the node and satisfy the practical analysis need. Quantitative analysis of thermo-hydraulic process mechanism is one of the difficulties to investigate the spalling of SCC. A lot of previous research focus on the pore pressure development of ordinary concrete and high-strength concrete exposed to electric heating. The similar study on SCC during fire exposure is very limited. This paper will present an experimental study on pore pressure development in fiber reinforced self-consolidating concrete during fire exposure. Steel fiber, micro polypropylene fiber, macro polypropylene fiber and their hybridizations reinforced self-consolidating concrete were investigated. Steel fiber, micro polypropylene fiber, macro polypropylene fiber and their hybridizations reinforced self-consolidating concrete were investigated.

Mesh generation is a key step in the finite element method, and since the birth of the finite element method, there have been many scientific work that is devoted to the study of this algorithm. Now this technology has been more mature, and many commercial computer-aided engineering software has a corresponding module [4].

Tractor is an important power machine that is indispensable to realize agricultural mechanization and modernization. Over the past decade, the rapid development of electronic control technology and intelligent transportation in the application of the car led to the application of electronic control technology in the tractor, the modern new tractor products increasingly in the direction of automation and intelligent development. With the new technology, the China's tractor industry accelerate the digestion and absorption of foreign products, mechanical and electrical integration of the results and experience and go as soon as possible with the world's advanced level of the same industry level. In this paper, the research on the comprehensive control technology of mountain tractor force based on adaptive nonstructural finite element is carried out in this background.

2. A sub Generic grid generation method

In engineering applications, finite element grid is mainly two kinds:
A grid is a structured grid. In a structured grid, all internal nodes have the same number of neighboring nodes and the same number of neighboring cells, that is, all internal nodes have the same degree. The cells in the structured grid are all quadrilateral elements of a two-dimensional plane or a three-dimensional surface or a hexahedral element. The structured grid generation method is used to generate a structured grid. The representation of this method is the mapping method. The advantage of the mapping method is that the algorithm is simple and fast, the unit is of good quality, and the density can be controlled. It can generate quadrilateral cell grid and generate hexahedral element grid. Mapping method can directly deal with single-connected domain problem, but for complex multi-connected domain problem, it is necessary to first decompose the region to be segmented into a mapable sub-region by geometric or automatic method, and then apply the mapping in each sub-region law. However, there are still several difficulties in practice that need to overcome such as how to automatically decompose complex mappable segments into simple sub-regions that can be mapped to meet the requirements of some of the physical problems for grid density transition meet the grid compatibility requirements between subdomains.

Another grid is an unstructured grid. In unstructured meshes, the connection and distribution of nodes are relaxed, allowing any number of cells to intersect at one node, the degree of all internal nodes may be different. Although the quadrilateral element and the hexahedral element can also form unstructured meshes, the triangular elements and tetrahedral elements are practically used in unstructured grids. One of the salient advantages of the unstructured grid generation method is that it can adapt to complex geometries, which is not related to the shape of the geometry. Combining certain control methods can
produce high-quality elements, and the use of unstructured networks the grid generation algorithm can automate the generation of regional grids. The main problem of unstructured grid generation is the design and operation of data structures, which is a key issue for all unstructured grid generation algorithms. It should be pointed out that the triangular element and the tetrahedral element are not the only choice of the unstructured finite element mesh. The finite element grid composed of the quadrilateral element or the hexahedral element is different from the degree of the node. Still unstructured grid. Typical and generalized unstructured finite element mesh generation methods are based on the grid method, the triangulation method, the method of advancing the wavefront method and the file-based grid generation method.

2.1. Adaptive grid generation method
There are three main methods of adaptive finite element mesh generation, which are p method, r method and h method respectively. The p-method improves the accuracy of the solution by increasing the polynomial interpolation order of the element. The method does not improve the interpolation order of the unit and does not change the total number of nodes. It is the purpose of changing the position of the nodes to reflect the structural features. This method serves as the grid smoothing process and h method of the grid generation post-processing stage Common use can achieve very good results. The h method achieves the goal of improving the accuracy of the grid by changing the number of nodes and the cell size. These three methods can be used in the process of adaptive finite element mesh generation, but they are mainly h method. When the h method and p method combination, known as hp method, such as h method and r method combination, said hr as a method. Here we mainly discuss the hr method, that is, by increasing and decreasing the number of nodes and units and by changing the position of the nodes to produce a mesh with uniform dimensional gradients. When the h method is combined with the p method, we call the hp method, such as the h method combined with the r method, we call the hr method. Here we mainly discuss the hr method, that is, by increasing and decreasing the number of nodes and units and by changing the position of the nodes to produce a mesh with uniform dimensional gradients. The most important step in generating an adaptive grid with this uniform gradient is to specify the size and shape of the mesh in the split domain. Dimensional function and Riemannian method are two commonly used methods. The Riemannian method can also be regarded as a spatial transformation method, which transforms the target space into Riemann space first, and makes a unit network in Riemannian space Lattice, that is, in the case of Riemann metric, the length of each edge in the grid is close to 1. As the Riemann metric not only can control the size of the unit, but also can control the direction of the unit, and almost become a standard grid adaptive control. The adaptive source is also multifaceted, mainly by geometry (such as the curvature of the curve surface, the subordinate relationship between the geometric elements in the segment), the result, and the user specified. The adaptive finite element mesh generation method is closely related to the adaptive finite element analysis, which is an important part of the adaptive finite element analysis. For the calculation of adaptive, based on the error criterion of the calculation result, the key question is how to establish the relationship between the finite element analysis precision and the density of the finite element mesh. The core is the error criterion of the finite element analysis result. This part of the work is largely related to the work of the finite element analysis program, which is representative of the research work.

When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper.

2.2. Riemann metric in two-dimensional space
In the adaptive subdivision of two-dimensional adaptive meshes and three-dimensional surface parameters, a metric matrix is usually used to represent the size and shape of a certain grid. This metric matrix is called Riemann in differential geometry measure. The Riemannian metric of the point P in the two-dimensional space Ω can have a control ellipse to represent that the control ellipse is determined by three quantities of the long axis h1, the short axis h2 and the angle θ as shown in Figure 1:
\[ M(P) = R^T R = \begin{bmatrix} \cos \theta & -\sin \theta & \frac{1}{h^2} & 0 \\ \sin \theta & \cos \theta & 0 & \frac{1}{h^2} \\ \end{bmatrix} \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \\ \end{bmatrix} \]  

(1)

M (P) is a real symmetrical array, can also be expressed as:

\[ M(P) = \begin{bmatrix} E & F \\ F & G \end{bmatrix} \]  

E > 0, G > 0, \( EG - F^2 > 0 \)  

(2)

The two eigenvalues of M (P) are: \( \lambda_1, \lambda_2 > 0 \). Let \( \lambda_1, \lambda_2 \) corresponding eigenvector is \( e_1, e_2 \) are:

\[ M(P) = \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} [e_1, e_2]^T = [e_1, e_2] \begin{bmatrix} \frac{1}{h^1} & 0 \\ 0 & \frac{1}{h^2} \end{bmatrix} [e_1, e_2]^T \]  

(3)

The Riemannian metric of all points constitutes a Riemannian field, also called Riemann space e. In the case of isotropy, the Riemannian metric of point P can be simplified as:

\[ M(P) = \frac{1}{h^2} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = \lambda I \]  

(4)

At this point, the control ellipse of Figure 1 degenerates into a circle with a center at P, radius h.

**Figure 1.** The Riemannian metric determines the control ellipse

**Figure 2.** Anisotropic Riemannian interpolation
All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your paper. Please keep a second copy of your manuscript in your office. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper.

3. System design

3.1. Traditional hydraulic suspension system

Traditional tractor suspension unit is mainly composed of hanging tools, suspension and hydraulic parts, as shown in Figure 3. The working parts in which the farm implements the farm work are connected to the tractor by means of a suspension mechanism[5]. According to the farmer in the tractor mount position is different, which can be divided into front suspension, rear suspension and side suspension three. The hanging mechanism is a number of rod mechanisms for connecting farm implements. The hydraulic system consists of oil millet, oil rainbow, dispenser and others. The main executive part of the traditional hydraulic suspension is the distributor, through the mechanical putter device to adjust the position of the distributor to control the flow of oil and flow, so that agricultural tools in different working positions. Figure 3 Traditional hydraulic suspension system diagram

![Figure 3. Traditional hydraulic suspension system diagram](image)

The suspension and descent control of the farmer in the conventional suspension system is mechanical. By the driver through the manipulation of the handle and a set of bar body in the form of displacement of the input signal, the output is by playing yellow, cam and force, bit adjustment lever mechanism converted into the amount of displacement, in order to achieve the main control valve Position adjustment [6]. Mechanical control of the hydraulic suspension system with rod and elastic components, the structure is more complex, elastic components of the hysteresis, mechanical friction and the expansion and contraction of the bar will affect the regulation performance. After entering the century, the tractor to the high power, low fuel consumption, light emissions, intelligent, sealing and
comfort direction, mechanical control system in the structural layout and performance has not adapted to the requirements of modern agricultural development [7].

3.2. Adaptive unstructured finite element control force joint control technology electronic control hydraulic suspension system overall design

In this paper, it is based on adaptive non-structural finite element force integrated technology electronic control hydraulic suspension system to replace the original mechanical hydraulic control system. The improved design is based on the original tractor mechanical hydraulic control system. Tractor electronic control hydraulic suspension system consists of: suspension mechanism, hydraulic suspension system, micro-controller, hydraulic load system, sensor, control panel.

The suspension mechanism uses the three-point suspension in the rear suspension, which can be used directly with the original suspension of the tractor.

The hydraulic suspension system will replace the original mechanical manipulator of the tractor with the electro-hydraulic ratio for the replacement, and then the design of the power source can drive the suspension to work.

Microcontrollers are based on the design of the control system, the main function is: the collection of sensor signals, control panel set the signal [8], and according to the acquisition of the signal using a certain control algorithm real-time to control the tractor working status.

The hydraulic loading system simulates the force of the suspension in the process of farming, so that the indoor simulation test is more perfect.

The sensor is used to detect tillage locations and soil resistance. The control panel is to enable the driver to control the suspension by the keys and switches to select the corresponding operating mode. The overall design of the Tractor Electronically Controlled Hydraulic Suspension System is shown in Figure 4.

3.3. Oil design of hydraulic suspension system

![Figure 4. Electrohydraulic suspension system diagram](image-url)
4. Conclusion
In this paper, the design is based on the adaptive non-structural finite element force integrated control technology. The electro-hydraulic suspension system is controlled by the electro-hydraulic proportional valve. The chip is used to realize the comprehensive adjustment of the force level by using the fuzzy control algorithm.

The system simplifies the hydraulic circuit, improve the tractor's power and economy, simplifying the complexity of the driver's operation. Advanced sensor technology and highly integrated application of the chip make the system automatically adjusted the tillage, and it achieves the suspension system and other systems between the tractor data communication, the real realization of the tractor automation and intelligence. Therefore, the tractor suspension system based on the adaptive non-structural finite element force integrated control technology has a very wide application prospect.

Acknowledgments
This work was financially supported by The National Key Research and Development Program of China (Grant: 2016YFD0700504).

References
[1] ZHENG XiaoBo,CHEN Gang,XIE XiaoPing. A divergence-free weak Galerkin method for quasi-Newtonian Stokes flows[J]. Science China(Mathematics),2017,(08), pp.1515-1528.
[2] Da-som JIN,Kwang-ho CHUN,Eun-sang LEE. Analysis of the current density characteristics in through-mask electrochemical micromachining(TMEMM) for fabrication of micro-hole arrays on invar alloy film[J]. Chinese Journal of Aeronautics,2017,(03), pp.1231-1241.
[3] ZUO Hao,YANG ZhiBo,SUN Yu,XU CaiBin,CHEN XueFeng. Wave propagation of laminated composite plates via GPU-based wavelet finite element method[J]. Science China(Technological Sciences),2017,(06), pp.832-843.
[4] Wenbo Zhao,T.Warren Liao,Lampros Kompotiatis. Stress and Springback Analyses of API X70 Pipeline Steel Under 3-Roller Bending via Finite Element Method[J]. Acta Metallurgica Sinica(English Letters),2017,(05), pp.470-482.
[5] Jianzhong ZHAO,Xingming GUO,Lu LU. Controlled wrinkling analysis of thin films on gradient substrates[J]. Applied Mathematics and Mechanics(English Edition),2017,(05), pp.617-624.
[6] Zhao Chen,Zhou Jin,Xu Yuanping,Di Long,ji Minlai. Identification of Magnetic Bearing Stiffness and Damping Based on Hybrid Genetic Algorithm[J]. Transactions of Nanjing University of Aeronautics and Astronautics,2017,(02), pp.211-219.
[7] JASC Jayasinghe,M.Hori,MR Riaz,MLL Wijerathne,T Ichimura. Conversion between solid and beam element solutions of finite element method based on meta-modeling theory:development and application to a ramp tunnel structure[J]. Earthquake Engineering and Engineering Vibration,2017,(02), pp.297-309.
[8] Yongcun Zhang,Shipeng Shang,Shutian Liu. A novel implementation algorithm of asymptotic homogenization for predicting the effective coefficient of thermal expansion of periodic composite materials[J]. Acta Mechanica Sinica,2017,(02), pp.368-381.
[9] Kyong-il KIM,Hsin GUAN,Bo WANG,Rui GUO,Fan LIANG. Active steering control strategy for articulated vehicles[J]. Frontiers of Information Technology &amp; Electronic Engineering,2016,(06), pp.576-586.
[10] Jin-yi LIU,Jing-quan TAN,En-rong MAO,Zheng-he SONG,Zhong-xiang ZHU. Proportional directional valve based automatic steering system for tractors[J]. Frontiers of Information Technology &amp; Electronic Engineering,2016,(05), pp.458-464.