Research on the High-Speed Highway Bridge Stability Analysis Model Based on Particle Swarm Optimization with Gradient Descent Algorithm

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Abstract.

In this paper, we conduct research on high-speed highway bridge stability analysis model based on particle swarm optimization with gradient descent algorithm. Road and the bridge construction technology management and the quality control is the key to guarantee the quality of the project construction, prevention is the focus of the construction quality common fault occurs, the scientific implementation of help enterprises to reduce the quality common fault management cost that will improve economic efficiency of the enterprises. To enhance the quality of the traditional structure, in this paper, we propose the new particle swarm optimization with the gradient descent algorithm based method for enhancement which achieves the satisfactory result.

Keywords: highway bridge, stability analysis, particle swarm optimization, gradient descent.

Introduction

Road and bridge construction project is an important part of the project construction, with the rapid development of the transportation industry in our country the highway bridges become an important transport infrastructure, and that the national investment in highway bridges are also growing. Our country's construction industry overall has the good development momentum. With the continuous development of construction enterprise, although the current number of road and bridge engineering construction present a rising trend, but also has brought more construction problem, especially in the construction of road and bridge engineering of subgrade pavement construction issues.

Road and bridge engineering in the construction of the roadbed during the construction of the common problems mainly include the following three aspects. (1) Luqiao engineering construction of roadbed damaged condition. In the long process of rolling, subgrade and pavement may appear many cracks or fine lines, and on long-term sunlight and rain erosion of subgrade and pavement concrete, asphalt is likely to will be damaged or even split, resulting in the bridge service life greatly shortened, but also to people's life and property safety threat. (2) There is an uneven problem in the middle of the Luqiao project construction. Once appear uneven road and bridge pavement, put into use after the vehicle on the road there will be bumpy, the tire caused serious wear and tear, resulting in the process of driving the appeared a lot of uncertain factors and unsafe factors, pose a threat to the safety of the people's lives and property. (3) Luqiao engineering construction in the presence of roadbed collapse, bump car and so on. The reasons of the problems such as the roadbed collapse and the bump at bridge head are mainly included: the compaction degree of backfill material is not in conformity with the standard, the drainage of Luqiao is not strong, which leads to the reduction of the load capacity of the Luqiao. Under normal circumstances, soft soil shear strength and bearing capacity is not high, water content is relatively large so in the construction process of soft soil subgrade and pavement to pay more

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attention to the improvement of soft soil foundation, prevention and treatment of subgrade and the pavement appear collapse. For dealing with the issues, we should consider some countermeasures.

Particle swarm optimization algorithm as a global optimization evolutionary algorithm based on population search strategy has the characteristics of concept is simple, easy to implement, in the early evolutionary convergence speed, less need to adjust the parameters. PSO has become a hot current research in the field of basic optimization algorithm that has been successfully applied to functions optimization, image processing, load forecasting, industrial process control, etc. In the standard PSO algorithm, with the increase of evolutionary iteration times, particles gradually gathered to the global optimal value, the diversity of the population is reduced the speed of the particles has been reduced. Once the particles into an extreme value range, the population of particles will be difficult to move again, the algorithm convergence to find the optimal solution at present. If the search to the extreme value gbest is an optimization problem of local minima, the algorithm will appear the phenomenon of the premature convergence. The standard particle swarm optimization algorithm provided no escape from the strategy of local solution, namely the standard particle swarm of exploring ability is weak. For better use of the algorithm, we should optimize it. Firstly, we demonstrate the basic features of the PSO in the following figure one. In the later sections, we will discuss the issues in detail.

![Figure 1. The Visualized Demonstration of the Particle Swarm Optimization (PSO).](image)

**Our Proposed Methodology**

The **Particle Swarm Optimization Algorithm.** Biological group in the social behavior has been attracting the attention of the researchers. The researchers try to biological groups (such as birds and fish) social behavior modeling, and simulation in the computer. R as B flock model is put forward. In this model, R set the behavior of birds follow these rules: 1) to avoid collision, the individual should avoid collisions and nearby companions; 2) speed matching, that is, the individual must be consistent with individual near speed; 3) concentrated to the center, that is, an individual must fly toward the center of the neighborhood. B model is successfully demonstrated the flight behavior of real birds, and have been successfully applied to the graphics, virtual reality, and many other fields.

In Kennedy after local version of particle swarm optimization algorithm is put forward and many scholars in order to improve the performance of the proposed PSO algorithm of the topology model. Studied the extensive study of particle swarm optimization algorithm (CLPSO) in essence is to use a dynamic topology model, the evolution of the fixed intervals algebraic topology model of random change of particles. CLPSO algorithm at the same time there is also the important differences and other improved PSO algorithm while each particle of each dimension is independent learning. For the optimization procedures, we should firstly consider the following conditions.
The hidden wall: allow the particles fly out of the search space, however, this time the search boundaries don’t calculate the fitness value of particles.

Absorption wall: when the particles in a dimension to the border of the search, the speed of the particles in this dimension to 0, particles in this dimension for the boundary at the same time. This means that the wall absorbs the energy of particles tried to break through search space.

Reflection wall: when the particles in a dimension to the border of the search, take back the speed of the particles in this dimension, size remains the same. At the same time, the particles bounce back to the original locations of the search space.

In order to improve the local search ability of the standard PSO algorithm, and avoid premature convergence as in this paper, the author on the basis of QPSO algorithm, combined with good point set theory, an improved quantum particle swarm optimization algorithm. The basic idea is in quantum particle swarm optimization algorithm, using good point set theory take the uniform distribution, the characteristics of population initialization is more uniform while improve the initial population of the ergodicity and the updated formula could be them summarized as the follows.

\[
\begin{align*}
  v_d(t+1) &= \alpha \times v_d(t) + c_1 \times n_1 \times (p_{d}(t) - x_d(t)) \\
  x_d(t+1) &= x_d(t) + v_d(t+1)
\end{align*}
\]

In the CLPSO algorithm, it was assumed that each particle randomly selected the m-D to the corresponding dimensions of Gbest study, the rest of the D, randomly selected some more dimensions to other randomly selected particle Pbest corresponding dimensions of learning, the rest of the dimensions to learn from its own Pbest corresponding dimensions as follows.

\[
\begin{align*}
  v_d &= w \times v_d + \text{rand()} \times (\text{gbest}_d - x_d) \\
  v_d &= w \times v_d + \text{rand()} \times (\text{pbest}_d - x_d) \\
  v_d &= w \times v_d + \text{rand()} \times (\text{pbest}_d - x_d)
\end{align*}
\]

Boundary constraint is a double-edged sword, it can simplify the optimization problem, to avoid invalid computation overhead, but it also brought a cross-border problems. Although the basic PSO algorithm is no guarantee that each particle any time movement within the search space, it is indisputable fact that, it is generally thought that only a few particles crossing the line.

![Figure 2. The Trending Curve of the Particle Swarm Optimization Algorithm.](image)

**The Gradient Descent Algorithm.** In order to further improve the convergence rate of stochastic parallel gradient descent algorithm, based on the SPGD algorithm based on theoretical analysis, using...
the stern hillier than as the system performance evaluation function, the wave front mirror shape and deformation influence function with the same Zernike polynomial representation, from the form of the algorithm, the convergence rate of the algorithm and cosmetic effect. As the revised suggestion, we then propose the following formula as the systematic optimization.

\[
  b_{jk} = f\left(\sum_{i=1}^{n} \left(\sum_{q=1}^{L} \xi_q^j \int_{t}^{T} (b_q(t) x_k(t)) \, dt - \theta_i\right)\right),
\]

\[
  f_k = \sum_{i=1}^{n} \eta f\left(\sum_{q=1}^{L} \xi_q^j \int_{t}^{T} (b_q(t) x_k(t)) \, dt - \theta_i\right) - d_k, F(W) = (f_1, f_2, \ldots, f_K)
\]

(3)

Consider a network weight function is a set of known functions based on process neural network model, it has equivalent information processing mechanism and basic model, is under the premise of meeting the fitting precision requirement of the weight function is expressed as the base function expansion. In applications, the only need to choose according to probability and statistics properties of nonlinear time-varying systems appropriate function basis can adopt the traditional neural network has been mature learning algorithm for system modeling and network training.

![Figure 3. The Gradient Descent Searching Algorithm.](image)

**The High-speed Highway Bridge Properties.** Road and that the bridge construction technology and management and the quality control is the key to guarantee the quality of the project construction, prevention is the focus of the construction quality common fault occurs, the scientific implementation of help enterprises to reduce the quality common fault management cost that will improve economic efficiency of the enterprises. Scientific construction technology and quality control but also can effectively guarantee quality of construction projects improve the service life of the project, in order to reduce the maintenance cost to lay a good foundation, it also on road traffic safety, to reduce the "vehicle dumping phenomenon" as cause of traffic accidents.

For the optimization of the quality, we should consider the listed issues. (1) Road & bridge construction management objectives for the development of science and technology management. Construction technology is the foundation of effective guarantee construction quality control and the management is the focus of modern road and bridge construction management work. Road and bridge construction enterprise should be aimed at technology management objective scientific development road and bridge construction technology control and the management. Before the construction of the actual conditions and contract requirements engineering science set up the technical control points, and in the construction of the technical control points for strict technical control and management, technology management goal, to provide effective guarantee bridge construction quality to avoid the happening of the construction quality common fault. (2) Road & bridge construction technology and perfect quality control system, and promote the effective implementation of technical management and
the quality control. Road and bridge construction technology and the improvement of the quality control system we should departure from the management level of enterprise itself to analysis, in view of the actual situation of the enterprise technical force and management process to build the basic management system.

Through the above theoretical analysis and mathematical modeling can scientifically resistance to overturning stability of continuous box girder bridges for qualitative analysis. In the data analysis of continuous box girder bridge box girder of longitudinal shear strength is not taken into consideration, in the case of overload box girder of the continuous box girder bridges before independence have damaged and bridge piers is closely related to the structure and the load distribution. Bridge pier due to horizontal thrust of bending damage, the Bridges occurring topple under heavy load and collapsed. Beam end road didn't appear when the vehicle is only unilateral bearing with horizontal support, if the beam end bracket horizontal limits failure or transverse limit pavement, bridge pier is not affected by horizontal force constraints, continuous box bridge from being destroyed by the bending moment of force. Continuous box girder bridge when the lateral stability of basic evaluation based on the above analysis of box girder lateral instability of the process, can be obtained for box girder lateral stability evaluation can through the cross section of the box girder itself strength, bridge pier shafts of section strength and bearing force three main influencing factors to consider. According to the above analysis, for continuous box girder bridge reinforcement, the need to increase the pier column section area, increase the intensity of the shafts of the piers. At the top of the column set torsional support, increase the main effect of torsion bar is increase the torsional rigidity of the upper box girder, control of the continuous box girder beam body prevent torsional deformation of bearing damage.

**Conclusion**

In this paper, we conduct research on high-speed highway bridge stability analysis model based on particle swarm optimization with gradient descent algorithm. Our country's construction industry overall has the good development momentum. With the continuous development of construction enterprise, although the current number of road and bridge engineering construction present a rising trend, but also has brought more construction problem, especially in the construction of road and bridge engineering of subgrade pavement construction issues. This paper analyzes the corresponding challenges to propose the new countermeasures for the issues that will be meaningful.

**References**


