Research on Airport Foundation Settlement Deformation Monitoring Based on Gene Expression Programming

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Abstract. As the carrier of the aviation industry, the airport is developing rapidly with the rapid development of the national economy and the overall progress of the society. With the aviation industry as the first industry in Jiangxi’s strategic emerging industries, Jiangxi is giving full play to the foundation and advantages of the aviation industry to make the aviation industry better, stronger and bigger. Currently, Jiangxi is vigorously constructing the third-phase expansion project of Nanchang Changbei International Airport, Ruijin Airport, Yingtan Airport, Fuzhou Airport, etc. During the construction of these airports, the geological conditions are relatively complex, and a large number of excavation and filling works are required, and the height of the excavation and filling body is relatively high. As a result, it is difficult to control the settlement and differential settlement of the foundation after construction, which brings great difficulty to the construction of the project. The foundation engineering under the complex environmental conditions of the airport is a complex system engineering, and its foundation settlement and stability are affected by many factors. This article will take the third-phase expansion project of Nanchang Changbei International Airport as an example, using gene expression programming technology to predict the settlement and deformation of the airport foundation, and relying on training data to obtain high-precision prediction models with high intelligence and rapidity.

1. Introduction

With economic development, more and more new airports will be built in the future. They will inevitably face the problem of airport foundation settlement during the construction process. They must monitor the deformation of the airport foundation, predict the trend of foundation deformation, and provide support for the safe construction of the airport.

During the construction of the airport, the geological conditions are relatively complicated, and a large number of excavation and filling works are required. The foundation engineering under the complex environmental conditions of the airport is a complex system engineering, and its foundation settlement and stability are affected by many factors, such as the original foundation soil layer distribution and geotechnical characteristics, foundation treatment methods and effects, and rock filling materials. Soil characteristics, compaction density, filling rate, engineering measures and drainage measures, etc., these factors together constitute the factors affecting the settlement and stability of the airport foundation. The airport foundation settlement project is a systematic engineering, which not only considers the deformation and stability control of the foundation itself, but also considers the complexities such as terrain, drainage, earth and stone material characteristics, pavement structure, construction bid section division, construction technology and changes in the external environment.
2. Gene Expression Programming
Gene Expression Programming (GEP) was first proposed by Portuguese scholar Candida Ferreira in 2000, and published the first monograph in 2002. GEP is developed on the basis of genetic algorithm (GA) and genetic programming (GP), and is a new genetic algorithm based on genotype and phenotype. At present, GEP has become a research hotspot in the field of evolutionary computing, and has been applied in many fields and industries such as medicine, chemistry, electric power, management, economics, mining, surveying and mapping.

The basic genetic operators of GEP mainly include selection, duplication, mutation, transposition and recombination. These genetic operators are usually executed in order, but the order of operations between mutation, transposition, and recombination will not affect the results of GEP. What affects the results of GEP is the position of various operators on the chromosome. In addition, in order to ensure that the individuals produced after these genetic operations still meet the coding requirements of GEP, it is stipulated that in each evolution, except for mutation operations, any other genetic operator cannot perform multiple operations on a chromosome.

Gene expression programming has its own distinctive characteristics: First, it has the ability to solve complex problems with simple coding. Due to the unique individual coding method of gene expression programming, it overcomes the loss of function due to the fixed chromosomes of genetic algorithms in the course of evolution. Weakness of complexity. It also avoids that in genetic programming, individuals are represented by non-linear entities with different sizes and shapes. In order to ensure the effectiveness of entities, the limitations of new changes are generated. This unique encoding method first encodes the individual as a linear string of fixed length in the form of expression, and then expresses the individual as a nonlinear entity with different sizes and shapes, so as to realize the use of simple encoding to solve complex problems. Secondly, genetic manipulation does not lose the number of chromosome individuals, and chromosome individuals are likely to lose chromosomes during genetic operations such as insertion, deletion, crossover, and mutation. To solve this problem, gene expression programming divides the chromosome into two parts: "head" and "tail". The head of a gene is composed of function sets or variables, and the tail of a gene can only be composed of variables. This mechanism will ensure that all chromosomal individuals survive the evolutionary process.

3. Overview of the Phase III Expansion Project of Nanchang Changbei International Airport
Nanchang Changbei Airport started construction on October 20, 1996, and was completed and put into use on September 10, 1999. In February 2004, Nanchang Changbei Airport passed the inspection and acceptance of foreign aircraft ports and was promoted to an international airport. In 2006, the second phase of the reconstruction and expansion project of Nanchang Changbei International Airport broke ground and was put into use in 2009. On May 23, 2011, the T2 terminal of Nanchang Changbei International Airport was officially opened.

The third-phase expansion project of Nanchang Changbei International Airport officially started construction on December 24, 2019. It mainly includes: a new 250,000 square meter T3 terminal building that can take off and land the 4F class East 1 of the world’s largest civil aviation aircraft. Runway, 28 near stand, 34 far stand, air traffic control, jet fuel and other facilities. Introduce Changjiu high-speed rail and subway to build a modern comprehensive passenger transportation hub that integrates civil aviation, high-speed rail, subway, public transportation, hotel and commerce into a "seamless connection and zero transfer". The estimated investment is about 21.4 billion yuan. The main construction contents are: expansion of the terminal building of 34,700 square meters; new facilities such as 16 near stand, 1 isolated stand, and 3 remote stand. The T1 terminal building renovation project takes 2030 as the target year. It will be transformed to meet the requirement of 2 million international passenger throughputs per year. The original international and domestic terminal building will be changed to an international terminal building. The total project estimate is 373 million. yuan. After the renovation, the building area of the terminal building reached 28,200 square meters. The main content of the renovation includes: the terminal building structure renovation, reinforcement, overall decoration, water supply, power supply, HVAC, weak current, fire protection and other systems and process
equipped are all updated. The apron is adjusted, and the facilities are repaired and updated. In addition to the first introduction of the self-service customs clearance system and the first activation of the face recognition system, the T1 terminal also introduced intelligent systems and equipment such as energy management, dual-view X-ray machines, and WIFI full coverage to achieve panoramic monitoring. The lighting system in the building uses LEDs Light source and realize automatic control. There are 28 entry and exit passages for border inspection, 6 entry and exit passages for customs and health and quarantine each, 8 security inspection passages, 13 check-in counters, 1 baggage claim carousel, and 3 boarding bridges.

During the construction of the project, for the airport foundation, the damage caused by the settlement of the foundation is not just as simple as ground damage. Especially for my country’s airports, most of my country’s airport grounds use rigid cement concrete pavements. Compared with asphalt pavements, it does have the advantages of higher strength, greater rigidity, and low overall cost, but its disadvantages are also very obvious. Mainly because of its poor adaptability to uneven settlement. Under the effect of uneven ground settlement, the cement concrete pavement is prone to damage in the form of plate sinking, arching, and warping, which reduces the flatness of the pavement, affects the stability of the aircraft during taxiing, and reduces passengers’ Comfort will also affect the pilot's interpretation of instruments and control of the aircraft. What’s more serious is that the damage of the foundation causes the fragmentation of cement concrete slabs. The resulting fragments have huge ribs on the fuselage and engine of the aircraft. Once sucked into the engine, it is very likely to damage the blades and cause a flight accident.

During the construction of the airport foundation, due to the formation loss caused by the construction, the disturbance of the surrounding rock mass and the reconsolidation of the remolded soil, the construction surface deformation was caused. At the same time, the airport foundation was changed due to the airport foundation construction during the formal operation of the airport. The surrounding geological environment, surrounding rock stress field and groundwater conditions, etc., have accumulated over a certain period of time to cause deformation of the airport ground surface. The main reasons for this deformation include: stratum compression, stratum loss-of-water consolidation, and improper excavation and support of airport foundations. According to the prediction theory of random medium, foundation settlement and deformation are caused by stratum loss. The so-called formation loss refers to the difference between the volume of the soil actually excavated in the construction of the airport foundation and the volume of the completed airport foundation. The volume of the completed airport foundation also includes the volume of the pressed slurry wrapped around the airport foundation. The formation loss is the result of many factors. The soil of the excavation surface moves into the airport foundation, and the construction section of the airport foundation converges, which can cause formation loss. The deformation of the airport foundation lining will also cause a small amount of formation loss. When airport foundation construction is carried out in a water-bearing stratum, it may cause changes in the internal pore water pressure of the surrounding soil, causing surface settlement caused by drainage and consolidation of the stratum, and the creep of the soil may also cause a certain amount of surface settlement. There are many factors that affect the deformation of the ground surface, and its size is not only related to the buried depth of the airport foundation, section size, construction method, and support method, but also affected by the ground conditions. Therefore, no matter what method of subway and airport foundation construction is adopted, it will inevitably cause more or less surface deformation.

4. Airport foundation settlement and deformation monitoring
The monitoring data obtained by different monitoring technologies have different formats. In order to be better applicable to the prediction model based on gene expression programming technology, the data of different formats should be processed in a unified standard format. The forecasting idea based on gene expression programming technology is to find the law of data changes over time from one-dimensional time series data without prior knowledge. In order to keep confidential work requirements, this article first performs certain processing on the original data obtained, and the processed data is as follows:
Table 1: Airport foundation settlement and deformation monitoring data

| Number | X     | Y     | Z     |
|--------|-------|-------|-------|
| 1      | 214.7 | 166.7 | 65.9  |
| 2      | 237.2 | 167.2 | 64.2  |
| 3      | 228.6 | 167.2 | 61.2  |
| 4      | 226.9 | 168.5 | 56.8  |
| 5      | 216.4 | 169.7 | 52.4  |
| 6      | 226.6 | 165.2 | 48.3  |
| 7      | 225.3 | 167.3 | 48.9  |
| 8      | 224.2 | 163.1 | 46.1  |

This article uses the C# programming language, the installed memory is 8.00G, the system type is a 64-bit operating system, and the Windows version is a Windows 7 family ordinary version of the desktop computer. The gene expression programming program is obtained, and the program is used for deformation prediction. The obtained prediction curve is as follows:

![Gene expression programming prediction model for prediction of airport foundation settlement deformation](image1)

According to the above figure, it can be obtained: The airport foundation settlement deformation monitoring programming prediction model based on gene expression programming technology performs well in actual application, and the predicted value of the model basically matches the actual monitoring value. The gene expression programming prediction model has better prediction performance than the GM(1,1) gray prediction model. The effect of predicting the settlement and deformation of the airport foundation has reached the expected requirements and met the accuracy requirements.

5. Comparison of three models of gray GM(1,1) and gene expression programming

Gray GM(1,1) and gene expression programming model were used to monitor the deformation of the airport foundation settlement. By predicting the same original data, the prediction result shown in Figure 2 below is obtained. Through data analysis, the gene expression programming model has smaller prediction errors than the GM(1,1) gray prediction model. The airport foundation settlement deformation prediction model based on gene expression programming technology has obvious advantages in the accuracy of prediction, and its speed is faster. Experimental results show that the gene expression programming model is a better model for predicting the settlement and deformation of airport foundations.
6. Conclusion
This article describes the background and significance of gene expression programming in the prediction of airport foundation settlement deformation, analyzes the mechanism of airport foundation settlement deformation, and summarizes the advantages and disadvantages of commonly used prediction methods. Based on the basic principles of the gray system and gene expression programming, the gray GM(1,1) model and the gene expression programming model were established on the Windows 7 family ordinary desktop computer using C# software; through the study of gene expression programming algorithms, the modeling process is determined as the selection of function set and terminator set, population initialization, chromosome decoding, fitness evaluation, genetic manipulation, and based on this, the modeling work of gene expression programming is completed. By comparing and analyzing the two models of GEP and GM(1,1) to predict the settlement and deformation monitoring data of airport foundations, it is obtained that the gene expression programming model has higher prediction accuracy and faster prediction speed. Therefore, gene expression programming is a better model for predicting the settlement and deformation of airport foundation than the gray system model.

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