THE LOCAL GRADIENT METHOD SUPPORTED BY ARTIFICIAL NEURAL NETWORK IN GRANULAR IDENTIFICATION PROBLEMS

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1. Introduction

The identification problems belong to inverse problems and concern the determination of mechanical systems by finding same material, shape and topology parameters and boundary conditions from the knowledge of the responses to given excitations. Such problems are mathematically ill posed.

One of the well known optimization methods are the gradient methods: (i) steepest descent method, (ii) conjugate gradient method, (iii) variable metric gradient method and etc. This methods in the previous stages of investigation were used.

This paper describes a new conception of application of the local gradient method supported by artificial neural network in granular identification problems. The following systems are considered as the granular models (i) interval numbers, (ii) fuzzy numbers and (iii) random variables. The proposed local method was examined for testing bench-mark. Next, the algorithm was applied for identification problem in mechanical structures. The paper presents the application of the algorithm in finding the shape, material coefficients and boundary conditions of the granular mechanical structures.

2. The formulation of granular identification problem

Consider an elastic body which occupies the domain Ω bounded by boundary Γ. The body is restrained by granular boundary conditions and loaded by granular forces. The material parameters are also assumed as the granular numbers. The body can contains some defects described by granular parameters also. The number, shapes and sizes of the defects are unknown.

The aim of the identification problem is to find the parameters described the set of defects. The identification problem is expressed as the minimization of the special minimizing function. The function contains the physical values which can be measured in the special selected sensor points. The sensor points are located on the surface of the body. As the measured values means here: (i) displacements under static loading, (ii) displacements under dynamical loading, (iii) eigenfrequencies and etc.

3. The local gradient method supported by artificial neural network

The proposed local optimization method is a combination of the classical gradient method and the artificial neural network. In the first step of the algorithm a set (cloud) of points in the function domain is generated. In the aim of realize the optimization process the network is constructed.

In each iteration of the optimization algorithm a few steps are performed.

In the first step the set of training vectors of the network is created. In the first iteration the set is created on basis of the cloud of points. The coordinates of points play the role of the input values of the network, the fitness values in points play the role of output value of the network.

In the second step the network is trained.

In the next, third step, the optimization process is carried out. The gradient method of optimization is used. The network as the fitness function approximation is used. The gradient of the fitness function on the basis of the artificial neural network is computed also.

For a point, which is a result of optimization (found in step 3), the actual fitness function is computed.

In the last step the stop condition is checked. In the case, in which the condition is true, the point is treated as the result of the optimization process. If this condition is false, this point is added to the training vector set and the next iteration is carried out (go to step 1).

This approach for deterministic problems (testing bench-mark and mechanical identification problems) was used.

In the present paper the artificial neural network is used as the computation tool of the sensitivity analysis of the granular fitness function.

4. Conclusions

An effective intelligent technique based on the gradient methods, artificial neural networks and granular approach has been presented. This approach in the granular optimization problems in mechanical structures can be applied. The following granular problems were solved in the identification of the (i) defects, (ii) boundary conditions and (iii) material parameters.

The results were satisfactory.

In future the influence of the parameters on the sensitivity of the algorithm (the number of the trainign vectors, number of the layers and number of the neurons in the hidden layers) should be tested.

In future presented algorithm will be connected with the granular evolutionary algorithm. This idea for deterministic problem was applied. Due to fussion evolutionary algorithms with the gradient method supported by artificial neural network the optimization time was decreased even to 50%.

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6. References

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