Genetic algorithm and neural network methods for inverse problems of coupled models using topological derivative

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ABSTRACT

In the paper we compare two methods based on genetic algorithm and neural network for finding the location of small holes in the domain, in which the coupled boundary value problem is defined. The initial domain consists of two components, linear and nonlinear, connected by the transmission conditions defined at the interface boundary. Both methods: genetic algorithm and neural network calculate the location of one, two or three holes located somewhere in the linear part of the domain based on input data coming from the exterior part of the domain.

We consider a coupled model described by the domain bounded in $\mathbb{R}^2$ and decomposed into two subdomains Ω and ω in such way, that the interior part ω is surrounded by the exterior subdomain Ω. In the interior subdomain the physical phenomena are described by the linear partial differential equation and in the exterior subdomain the processes are governed by nonlinear partial differential equation subject to some external function. Here, the nonlinear boundary value problem is coupled through transmission conditions with the linear boundary value problem. As an example of such system one can consider a gravity flow around an elastic obstacle. Such situation have numerous physical interpretations, for example the water flow around submarine or gas flow inside the jet engine. For real life models the coupling conditions are still a subject of research [1].

Our goal in this paper is to compare two methods. First method is a combination of genetic algorithm and information given by the topological derivative. In this method the location of small hales in the interior domain is approximated by the genetic algorithm which uses the probability density in random selection for the initial population of single holes, pairs of triples, and also to supplement the population in consecutive generations. The probability density is evaluated based on the values of the topological derivative calculated in the interior subdomain ω for a given shape functional defined in the exterior subdomain Ω. Second method applies an artificial neural network which calculates the locations of one, two or three holes in ω the linear component of the domain. The information comes from Ω the exterior part of the domain and is represented as a Fourier series expansion of a solution of the nonlinear partial differential equation and calculated at the interface between two subdomains.

REFERENCES

[1] Ignatowa, M., Kukavica, I., Lasiecka, I. and Tuffaha, A. *On well-posedness for a free boundary fluid-structure model*, Journal of Mathematical Physics, 53 (2013).