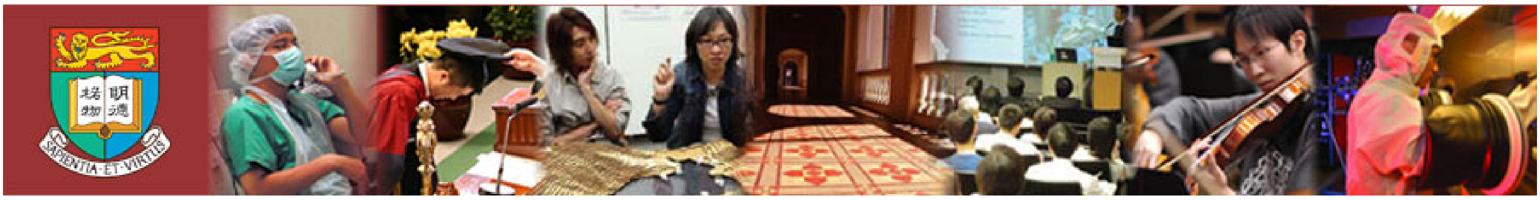

Title	HTS coil design using artificial neural network and fuzzy interference system
Author(s)	Hui, P; Shen, GG
Citation	International Society for Magnetic Resonance in Medicine (ISMRM) 11th Scientific Meeting & Exhibition, Toronto, Canada, 10-16 July 2003, p. 2380
Issued Date	2003
URL	http://hdl.handle.net/10722/99489
Rights	This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

HTS Coil Design using Artificial Neural Network and Fuzzy Interference System

P. Hui[1], G. X. Shen[1]

[1]Dept. of EEE, The University of Hong Kong, Hong Kong

Abstract

The design of High Temperature Superconducting (HTS) RF coil highly relies on the computer simulation because HTS materials are very expensive and the coil fabrication requires high accuracy. Normally, the simulation for the HTS coil design is time consuming and not straightforward. In this paper, two novel approaches for HTS coil design, the electromagnetically (EM) trained artificial neural networks (EM-ANN) and the electromagnetically trained fuzzy inference systems (EM-FIS) are presented. These two models can simplify the normal simulation and speed up by millions of times. Therefore, the difficult tuning procedure of HTS coil can be easily simulated before its fabrication.

Introduction

HTS coils can significantly improve SNR for some MRI applications, however, they have not been very popular so far, mainly because their materials are very expensive, and their design procedure and accurate fabrication are complicate. Unlike traditional RF coils, HTS coil does not include lumped capacitors because these capacitors can not operate properly under very low temperature (4k –77k). The capacitance required for the resonant circuit is created by its own distribute parameters. Without the lumped variable capacitors for tuning and matching, the adjusting of the resonant frequency becomes very difficult and highly relies on the accuracy of the coil fabrication.

Methods

Two methodologies for accurate modeling of HTS coil, electromagnetically (EM) trained artificial neural networks (EM-ANN) and electromagnetically trained fuzzy inference systems (EM-FIS) are presented. EM-ANN and EM-FIS can both model linear and complex nonlinear system without knowing how it functions behind, but only with sufficient input and output pairs. Thus, to determine the relationship between the input and output is just like a simple nonlinear mapping. When the model is chosen, the output can be found out instantly once the input data are entered.

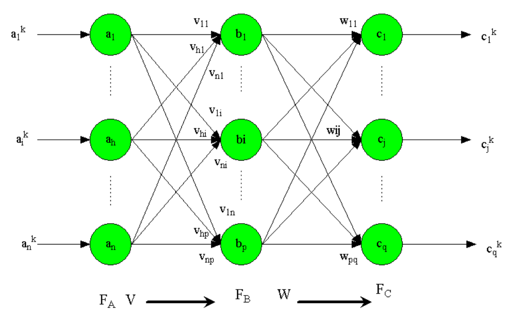

Fig.2. The architecture of an ANFIS.

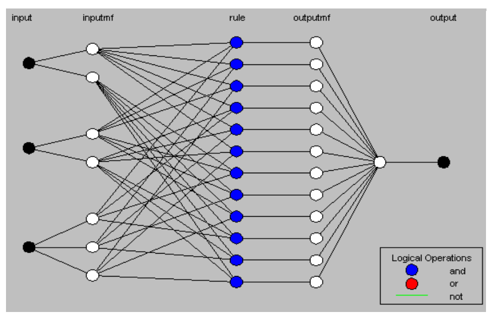

Fig.1. The architecture of an EM-ANN.

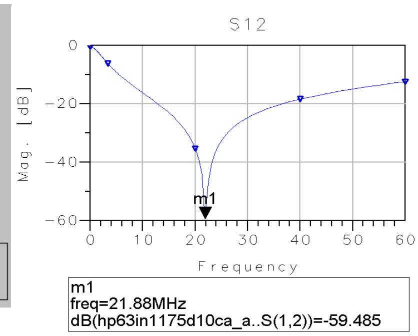

Fig.3. S12 of a 6-turn spiral coils.

These methods make the HTS design highly flexible and interactive. In order to verify these two models, a commercially available EM simulator (HP-momentum) is used firstly to test an existing THS coil, though this simulation is very time consuming. Then, the simulation data from this verified EM simulator to form the training set and the testing set of the ANN and the FIS models. In this paper, we use a special type of back-propagation algorithm, the Levenberg-Marquardt algorithm [1] and a special type of radial basic network, the generalized regression neural network (GRNN) for the neural network models and use a special fuzzy inference system for the adaptive neuro-fuzzy inference system (ANFIS)[2] which is usually used for Input/Output data modeling.

Result

The results and percentages of errors for two models, EM-ANN and ANFIS were listed in Table1. Where, **W** is the thickness of the superconducting stripe, **S** is the separation between the adjacent turns, **dielectric** is the dielectric constant, **s-f(MHz)** is the simulation resonance frequency by the HP-Momentum simulator. **LM(18)** are the results from the LM-BP network with 18 neuron in the hidden layer. **BR(18)** are result from LM-BP networks with Bayesian Regulation. **LM(25)** are the results from the LM-BP network with 25 neuron in the hidden layer and **tri(2 2 3)** is the data generated from the ANFIS using triangular type membership function with 2 membership function for **W** and **S** and 3 membership function for the input resonance frequency.

Table 1. Results and percentage of errors for EM-ANN and ANFIS models

Input parameters			Momentum	LM (18)		BR (18)		LM(25)		tri(2 2 3)	
W (mm)	S (mm)	Dielectric	s- f (MHz)	Result	Error (%)	Result	Error (%)	Result	Error (%)	Result	Error (%)
0.045	0.045	14.5	20.83	21.11	1.33	20.75	0.09	14.22	1.89	30.41	1.35
0.055	0.045	30	15	14.77	1.51	14.71	1.90	29.22	2.58	30.42	1.39
0.06	0.05	11.25	25	24.59	1.63	24.51	0.86	10.97	2.46	10.73	4.61
0.03	0.05	21.45	17.5	17.71	0.78	17.29	0.57	21.38	0.33	21.53	0.37

Conclusion

The measured data are well agreed with the simulation using these two models. The simulation time normally using HP-simulator can be reduced by a factor of millions, thus very complicated HTS simulation becomes very flexible and easy to be interfered at any time by different input data. HTS coils can be designed with very high accuracy before their fabrications. These methods can also be extended to micro-strip RF coil design.

Reference

[1] Matlab manual for Neural network toolbox, Release 12.2.
[2] Matlab manual for Fuzzy logic toolbox, Release 12.2