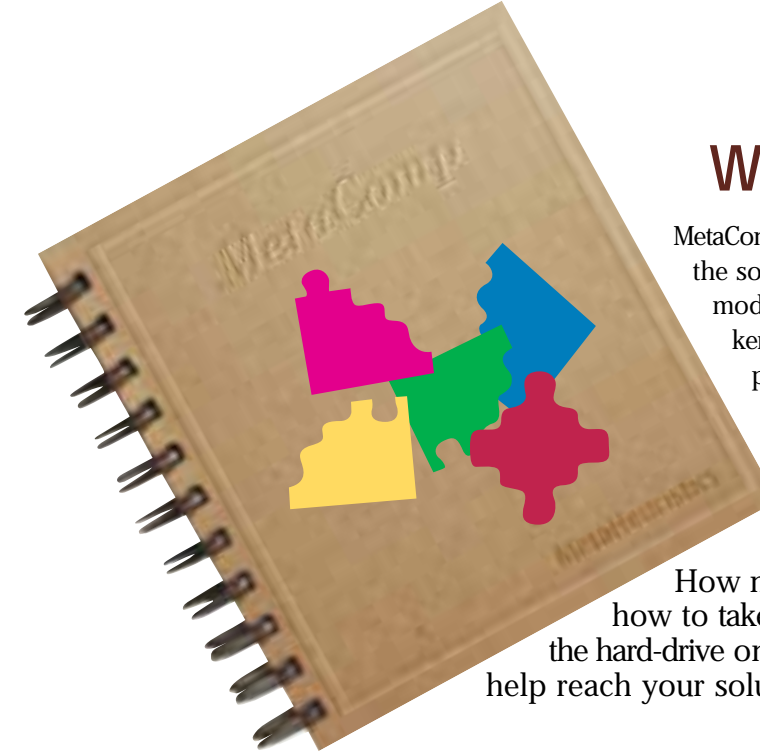




MetaHeuristics
209 W. Alamar, Suite A
Santa Barbara
California, 93105
U.S.A.

Tel: +1 -(805) 569-0347
Fax: +1 -(805) 569-6014
e-mail: mhstaff@gte.net



What Is MetaComp:

MetaComp is a suite of computer programs that provides the software to analyze databases for the purpose of modeling and optimization. The data processing kernel uses state-of-the-art developments in signal processing, neural and fuzzy computations to process existing data sets and build models that can be used for control, optimization, maintenance, fault diagnostics and development of operating procedures.

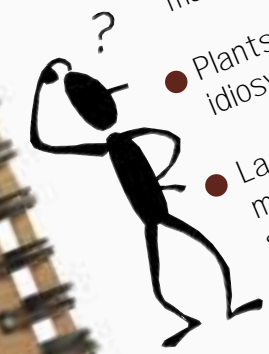
How many times have you wondered about how to take the best from that big database sitting in the hard-drive on your desk? Well, MetaHeuristics can help reach your solution!

Who Are We:

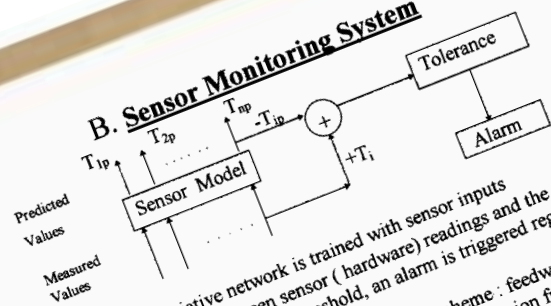
We are a team of engineers, scientists and software professionals. We have developed a powerful package to find hidden patterns in data, for process and systems modeling, and for optimization. Our expertise and software will help you to understand and run your plants, and processes, better.

Why Heuristics — The Art of Empirical Problem Solving?

- Often difficult to write down accurate first principle models for many processes
- Plants have their own idiosyncrasies
- Large mathematical models are time consuming to solve, hence difficult to use for real-time analysis, control, and optimization



B. Sensor Monitoring System



- An autoassociative network is trained with sensor inputs
- If the difference between sensor (hardware) readings and the sensor models' output exceeds a threshold, an alarm is triggered regarding sensor failure
- Examples of sensor monitoring/validation scheme: feedwater flow rate monitoring in nuclear power plants, NOx emission from gas-fired boilers etc.

C. Neuro-controllers

- I. Direct Control: Using current state of the plant and the desired next state of the plant, a feedforward ANN provides the desired control action to the controller
- II. Indirect Control: A feedforward ANN is used as a nonlinear model of the plant. Given the current state and the proposed control action, the network predicts the next state of the plant which then can be used in Model Predictive Controller.

D. Neuro-Fuzzy Controller

- I. Simple rule based design. Rules can be selected using genetic optimization technique
- II. Neuro-Fuzzy controllers suppress overshoot condition such as those associated with ramping temperatures
- III. Such controllers can adapt to gradual changes in environment

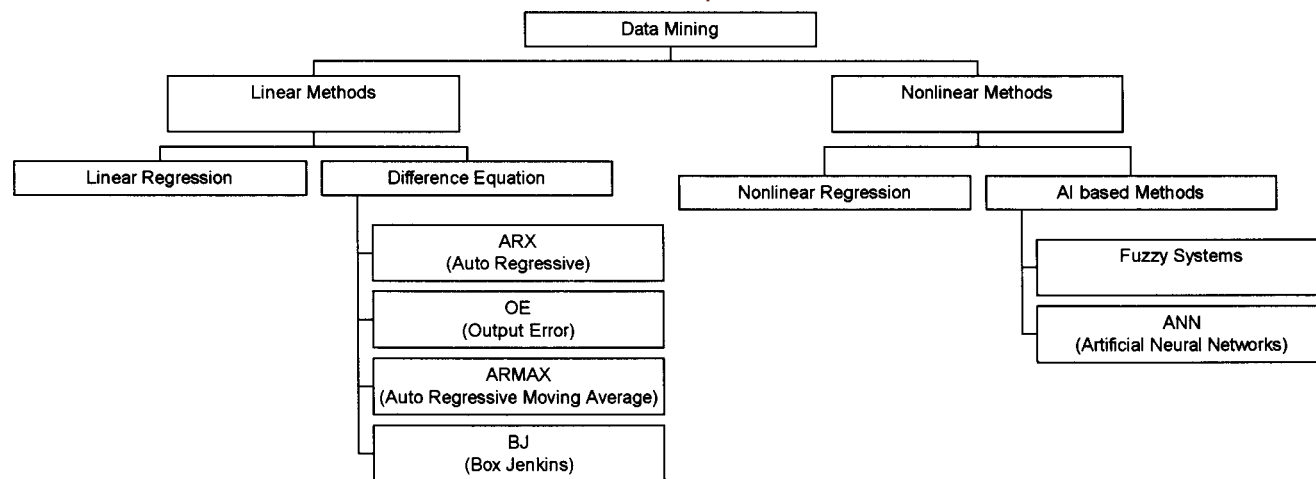
In a world where computational platforms are ever-changing, as engineers we believe that software has to be modular and portable, to best utilize available resources. MetaComp is structured as a library of modules that can either be called independently or through an easy-to-use graphics interface. The kernel has been powered with Java, a platform independent language that allows easy interfacing of MetaComp with diverse database software. Also, multimedia capabilities of Java enhance the visual analysis of results.



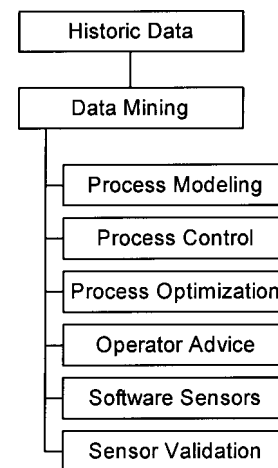
History

Our interest in AI based computational techniques arose while developing non-linear models for complex chemical and metallurgical processes, sensor validation and fault diagnostics. We have combined our skills in computational dynamics with traditional modeling techniques to make an AI based package which is fast, robust, and is specifically designed for engineering application.

Data Processing Techniques



Empirical Problem Solving



For example, using operational data of a gravity-fed tank overflow conditions arising in transients were predicted using a feed forward artificial neural network (ANN). The output from the ANN was then used to extract the rules for deciding the unsafe combinations of initial inlet velocity and tank fluid level that lead to overflow. The knowledge of such rules, in more complicated plant conditions could avoid maneuvers leading to production losses.

MetaComp also provides the possibility of combining existing knowledge of the process with heuristic modeling methods. Phenomenological models can be solved using MetaPhen and the results can be incorporated in system simulation. For instance, when modeling leak detection in long pipelines, compressibility effects become important. The pressure measurements along the pipeline are affected by the changes in flow rate that occur at the inlet. A system based only on ANN would confuse these changes with the presence of a leak. If instead, a differential model of the pipeline is solved, spurious effects can be filtered and a very effective leak detection system can be built using ANN.

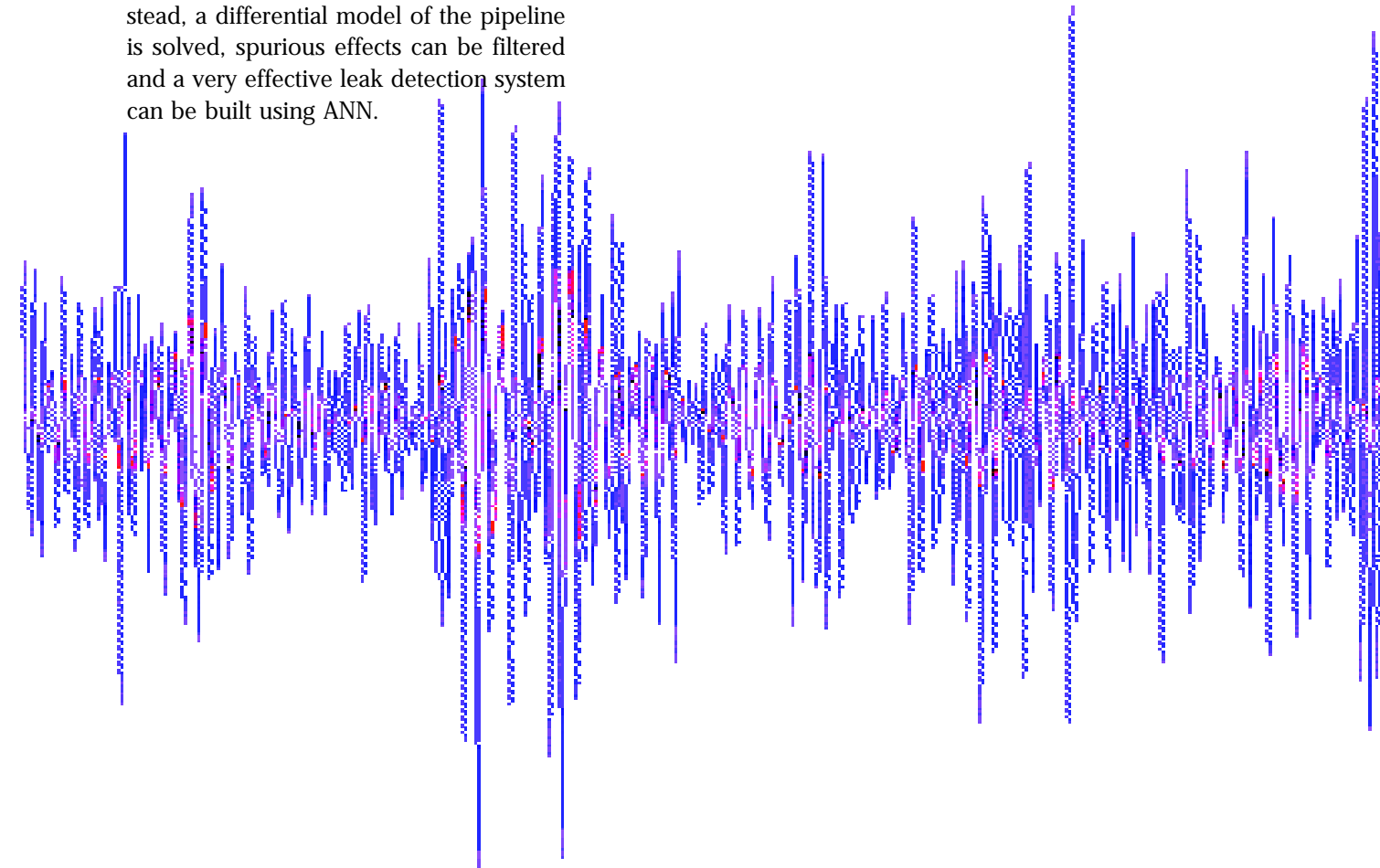
Applications of Neuro/Fuzzy System

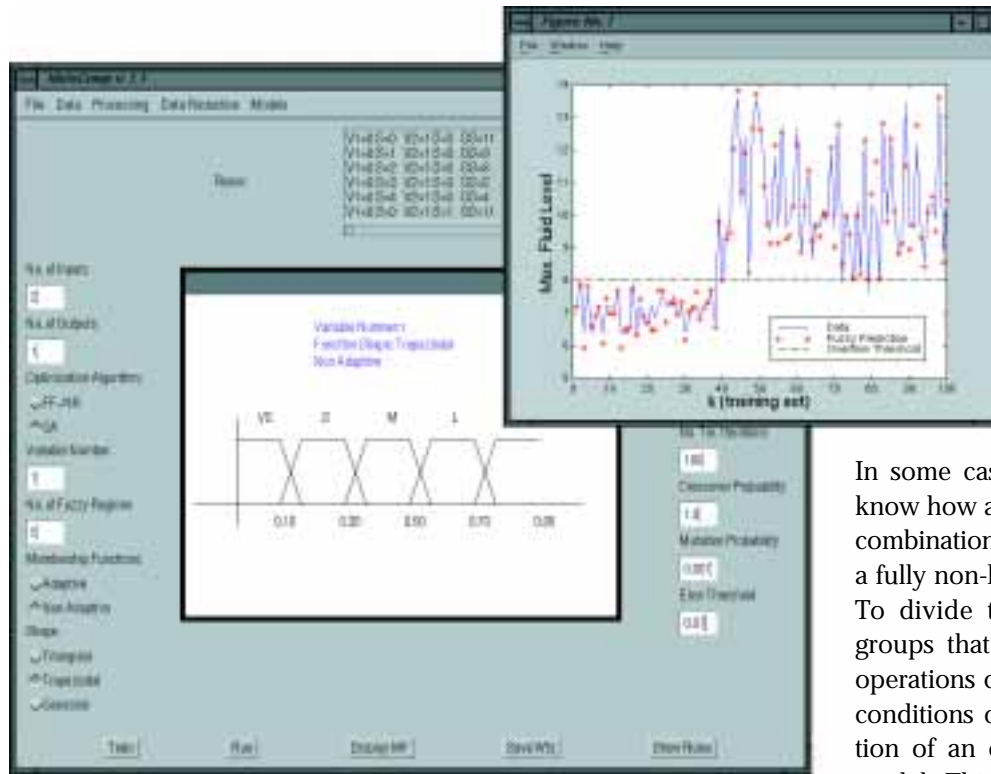
A. Soft Instrumentation

The software based instrumentation is achieved by ANN based forward prediction of the measurement device. Given the availability of historic data on the inputs to a device, and its output(s), an accurate model of the process is constructed using MetaHeuristics' fast solver. The ability of this solver to handle complex time series results in easy handling of systems with large time lags between inputs and outputs. Various step involved in the modeling process are as follows

- Select a configuration of feedforward neural network using genetic algorithm
- Select important process variables using Data Reducer
- Train the network using historic plant data
- These models can then be used at various locations in the plant after proper validation

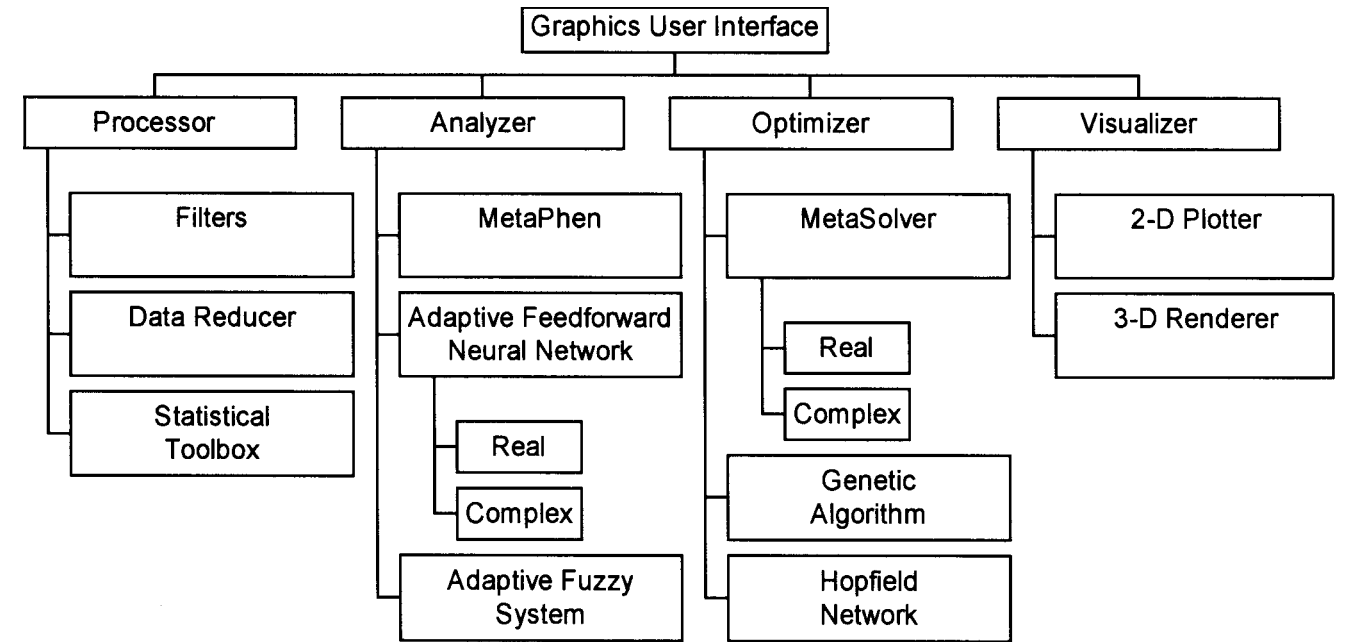
Soft instrumentation are cheap and they also provide crucial insights into the mechanisms in the process being modeled.





In some cases it is more important to know how a system will react to a given combination of parameters, than to have a fully non-linear model of the process. To divide the input parameters into groups that lead to safe, or less safe, operations can be a faster check on the conditions of the process than calculation of an output from a complicated model. This can be achieved with the Fuzzy System toolbox in MetaComp. Fuzzy System toolbox can be combined with the modeling and optimization techniques to extract simple rules for operator advice.

MetaComp v. 1.1



Advantages of Fuzzification

- Compatibility with human thinking process
- Reduction in the complexity of problem
- Noisy signals can be usefully processed
- Results can be interpreted in terms of simple rules, helping in decision making and effective advisory systems
- In combination with optimization techniques like ANN's and genetic algorithms, the rules can be interpreted according to their relative importance

$$7 + 7 = 3$$

Stages of Data Mining

- Select appropriate functions for statistical analysis
- Compute using historic data
- Analyse the results to identify patterns
- Use the information for process/sensor models, advisory information, control, optimization, to improve plant efficiency etc.

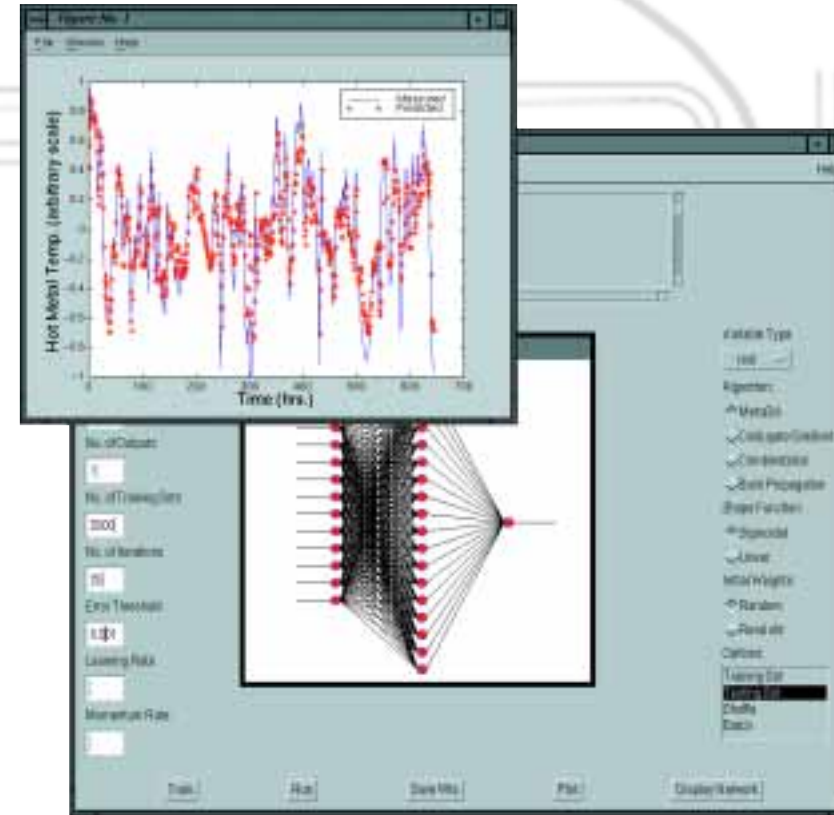
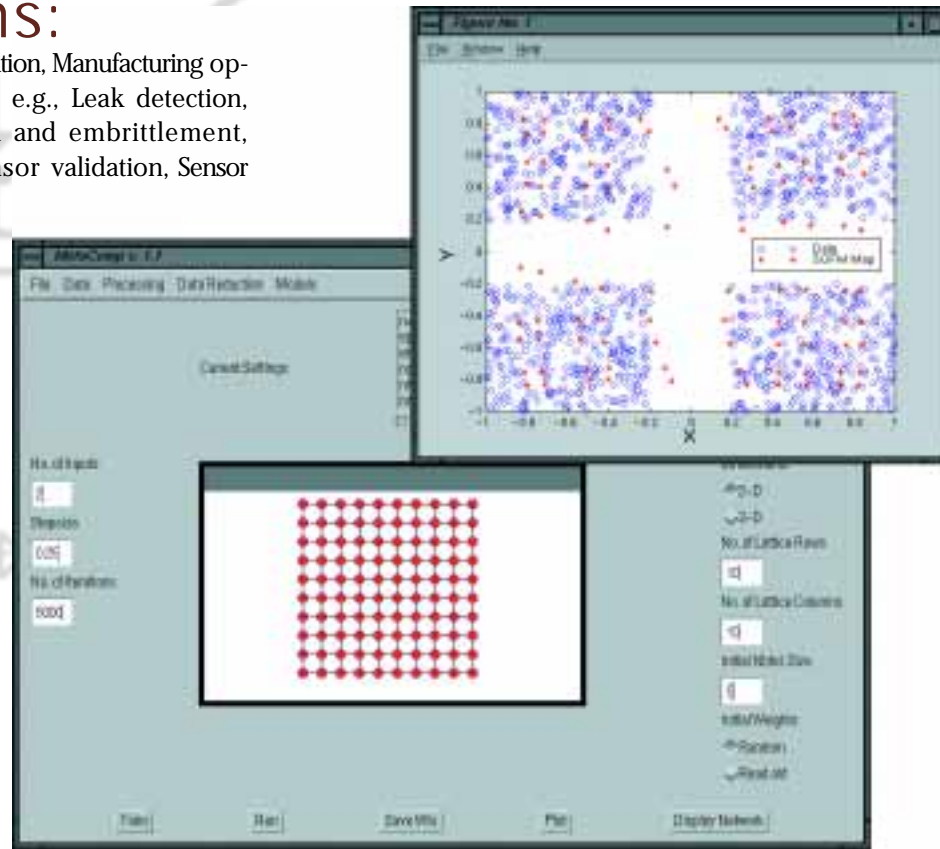


Applications:

Process modeling and optimization, Manufacturing optimization, Fault diagnostics e.g., Leak detection, Materials corrosion, erosion and embrittlement, Physical Experiments, Sensor validation, Sensor substitution, e.g., Software sensors, Acoustic and seismic analysis, Medical Diagnostics, Econometric modeling, Demographic systems

Process Modeling:

For large systems it is useful to reduce the size of the problem at hand by identifying the most important variables. This is possible with Data Reducer which provides techniques like Principal Components Analysis, Linear Vector Quantization and Genetic Algorithms for this purpose. With this reduced set of variables the statistical toolbox can be used to test the efficacy of linear models. In many cases, however, linear models are not sufficient and one must resort to non-linear modeling techniques.



Analyzer builds non-linear models based on Neural Networks. For example, a blast furnace operation involves complex interactions between chemical reactions, heat exchange and gas flow dynamics. The resulting process is non-linear, time-variant and is characterized by a large number of input variables. For safe and low cost operation of the plant it is necessary that the hot metal temperature be within prescribed limits. Using Data Reducer the number of inputs was reduced by a factor of three and a model was constructed using feed forward neural network. The network parameters were optimized using MetaSolver, a very fast technique for function minimization.

Regression Models

Linear regression is of the form

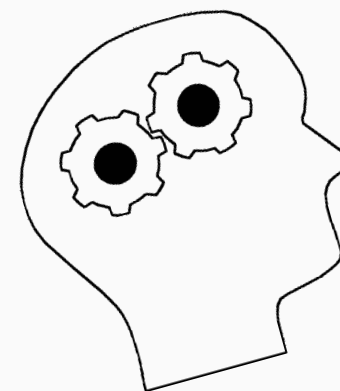
$$y = a_0 + a_1x_1 + a_2x_2 + \dots + a_nx_n$$

The coefficients a_1, \dots, a_n can be computed using least square technique from the historic plant data.

An example of nonlinear regression is an equation of the form

$$y = a_0 + a_1 \sin(a_2x_2) + \dots + \exp(a_nx_n)$$

The coefficients in this case have to be solved by iteration. However, there are no guidelines for selecting the nonlinear functions for the regression.



Advantages of AI Based Techniques

- ANNs have been shown to be universal function approximators. Hence they can be used for complicated multivariate nonlinear modeling. This removes the problems associated with nonlinear function selection in statistical regression.
- As pattern storage devices they can be used to fill in missing data
- Since they are based on biological systems, they are also robust, adaptive, highly parallel and can deal with noisy or fuzzy input
- Capable of generalizing

WHY MetaHeuristics?

MetaHeuristics Provides:

- The Choice of working in either real or complex domain
- A fast solver for both real and complex feedforward networks with 200 input variables and more than a thousand network parameters (weights)
- Fuzzy and neuro-fuzzy modeling
- Combinatorial optimization techniques for network selection and for the adaptive selection of fuzzy rules

MetaHeuristics
209 W. Alamar, Suite A
Santa Barbara
California, 93105
U.S.A.

(805) 569-0347



MetaComp