



INTELLIGENT SOLUTIONS, INC. PRESENTS:

ISI SHORT COURSE SERIES

APPLICATION OF ARTIFICIAL INTELLIGENCE IN THE OIL INDUSTRY

COURSE TITLE:

SURROGATE RESERVOIR MODELS (SRM); GETTING MAXIMUM RETURN ON THE RESERVOIR MODELING INVESTMENT

INSTRUCTOR:

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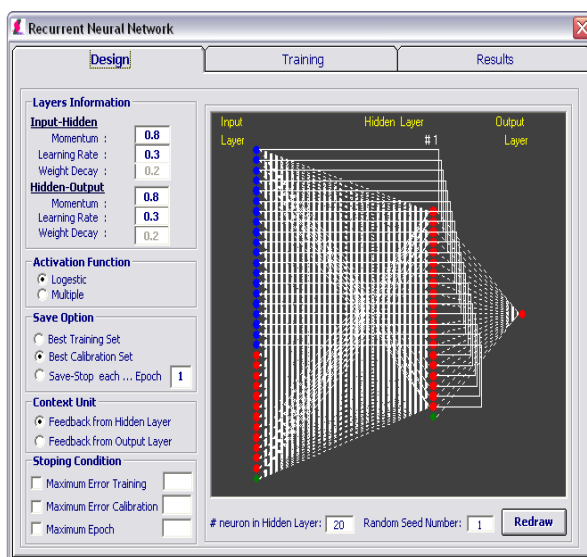
INTENDED AUDIENCE:

GEOLOGISTS, PETRO-PHYSICIST, GEO-PHYSICISTS, RESERVOIR ENGINEERS AND ASSET MANAGERS. THIS COURSE IS BENEFICIAL FOR THOSE WHO ARE INVOLVED IN ALL ASPECTS OF RESERVOIR SIMULATION AND MODELING.

COURSE DESCRIPTION:

Intelligent Solutions, Inc. introduces a revolutionary and innovative solution for fast track, comprehensive reservoir analysis (solving both direct and inverse problems) using existing reservoir simulation models. Named Surrogate Reservoir Models; SRM is defined as *replica*¹ of the full field reservoir simulation model that runs and provides accurate results in real-time (one simulation run takes only a fraction of a second). SRM mimics the capabilities of a full field model with high accuracy.

Surrogate Reservoir Model: SRM is developed to address the ever growing need in the oil and gas industry to perform accurate, but high speed simulation and modeling. Unlike conventional geo-statistical approaches (response surfaces, proxy models ...) that require hundreds of simulation runs for development, SRM is developed only with a few (from 10 to 30 runs based on the size of the model and number of wells) simulation runs. SRM can be developed regularly (as new versions of the full field model become available) off-line and can be put online for real-time processing to guide important decisions.



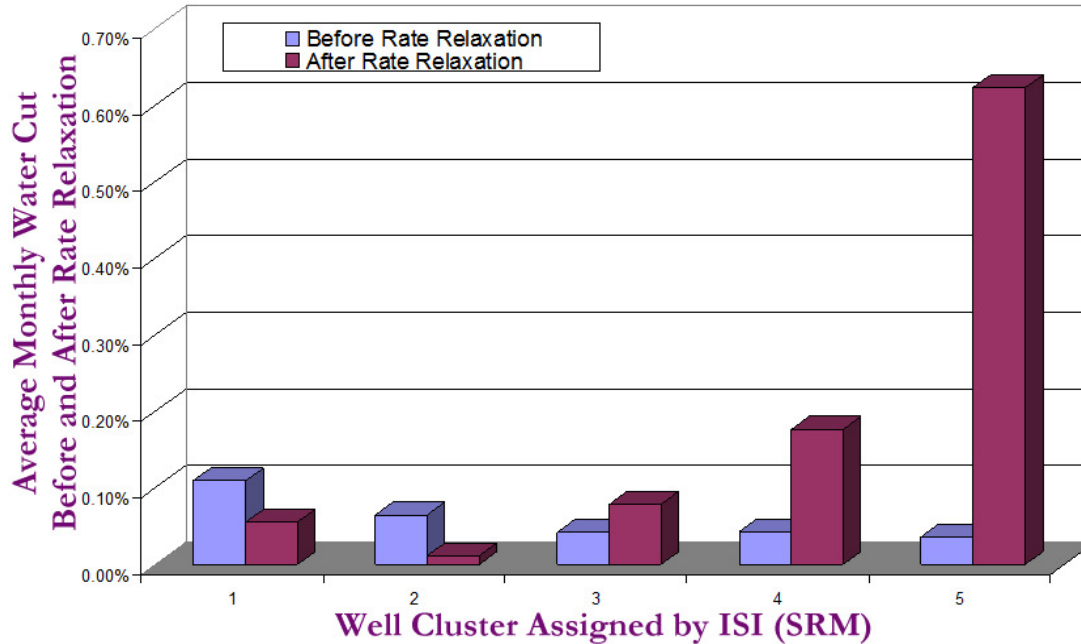
SRM has proven its value in the field. An SRM was developed for a giant oil field in the Middle East. The model included about one million grid blocks with more than 160 horizontal wells and took ten hours for a single run on 12 parallel CPUs. Using only 10 simulation runs, an SRM was developed that was able to accurately mimic the behavior of the reservoir simulation model. Performing a comprehensive reservoir analysis that included making millions of SRM runs, wells in the field were divided into five clusters. It was predicted that wells

in cluster one & two are best candidates for rate relaxation with minimal, long term water production while wells in clusters four and five are susceptible to high water cuts.

Two years and 20 wells later, rate relaxation results from the field proved that all the predictions made by the SRM analysis were correct. While incremental oil production increased in all wells (wells in clusters 1 produced the most followed by wells in cluster 2, 3 ...) the percent change in average monthly water cut for wells in each cluster clearly demonstrated the analytic power of SRM. As it was correctly predicted, wells in clusters 1 and 2 actually

¹ Replica is defined as a copy or reproduction of a work of art, especially one made by the original artist on a scale smaller than the original. Something closely resembling another.

experience a reduction in water cut while substantial increase in water cut was observed in wells classified into clusters 4 and 5. Performing these analyses would have been impossible using the original full field simulation model.



All predictions made by SRM proved to be accurate in a field test

A DETAIL OUTLINE OF THE COURSE MATERIAL FOLLOWS.



Course Outline:

- **Part One: Virtual intelligence; Background and overview**
 - Introduction
 - Artificial Neural Networks
 - Genetic Optimization
 - Fuzzy Set Theory

- **Part Two: Reservoir Simulation and Modeling**
 - Finite Difference Calculus
 - Grid Types & Boundary Conditions
 - Solution Techniques
 - Numerical Solution of Fluid Flow in Porous Media

- **Part Three: Surrogate Reservoir Models – SRM**
 - Definition and specifications
 - SRM in the Context of Comprehensive Analysis of Solution Space
 - SRM in the Context of Smart Field
 - SRM in the Context of Real-Time Reservoir Management
 - Starting the Construction of Surrogate Reservoir Models (SRM)
 - Identification of the Objectives
 - Understanding the Reservoir Model
 - Design of Runs
 - Generating Dynamic Data Set
 - Understanding the Field Geology
 - Generating the Static Data Set
 - Compiling the Complete SRM Data Set
 - Building the Surrogate Reservoir Models (SRM)
 - Identification of Key Performance Indicators (KPI)
 - Data Partitioning
 - Training, Calibration and Validation of SRM
 - Post-Processing and Analysis of the Surrogate Reservoir Models (SRM)
 - Sensitivity Analysis
 - Single Parameter Sensitivity Analysis
 - Multi Parameter Sensitivity Analysis
 - Quantification of Uncertainties
 - Type Curve Generation
 - Field Development Strategies

➤ **Part Four: Getting Familiarity with Software Implementations**

○ **INTELLIGENT DATA EVALUATION & ANALYSIS, IDEA™**

▪ **Data Preparation**

- Getting to know your data
- Frequency Distribution
- Conventional Regression Analysis
- Dealing with Missing Data
- Dealing with Outliers
- Advance Statistical Analysis

▪ **Key Performance Indicators**

- Ranking the Performance Indicators
- Behavior of the Performance Indicator

▪ **Cluster Analysis**

- Conventional K-Mean Clustering
- Fuzzy C-Mean Clustering
- Automatic Cluster Analysis

▪ **Neural Network Model Building**

- Data partitioning
 - Intelligent Data Partitioning
 - Cluster Analysis-Based Partitioning
 - Random Partitioning
 - Pre-Determined Partitioning
- Neural Model Architecture
 - Number of Layers
 - Number of Neurons
 - Activation Functions
 - Learning Rates
 - Momentum
- Training Algorithms
 - Back Propagation
 - Generalized Regression
 - Recurrent
 - Radial Basis Functions
 - Self-Organizing Maps
- Training Process
 - Avoiding Overtraining
 - Real-time Monitoring of the Training Process

- Neural Model Analysis
 - Parameters Inter-Dependency
 - Tables
 - Functions
 - Neural Models
 - Sensitivity Analysis
 - Single Parameter Analysis
 - Combinatorial Analysis
 - Monte Carlo Simulation
 - General Model Behavior

- Neural Model Application
 - Import New Data
 - Apply Neural Model