Research Inventy: International Journal of Engineering And Science
Vol.11, Issue 12 (December 2021), PP 26-31
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Selection and Evaluation EOR Method Using Artificial Intelligence

Akpoturi Peters
Department of Petroleum Engineering
Federal University of Petroleum Resources Effurun

Abstract
Recently, the theory of Artificial Neural Network has found a worldwide approval from those who are concerned with the research in the field of petroleum and natural gas engineering this may be due to the neural network potentialities in solving problems to which the network is designed, depending on the gunned experiences of some similar problems joined with their solutions. This theory has been found to give high possibilities with amazing results as applied and tested in petroleum engineering.
A model composed of two neural networks was designed to work in series in order to perform the task of EOR project selection through the first network (Technical network), and then evaluate the selected project economically using the second network (Economics network) As the model, with the two networks, performs its task successfully, it is then tested with data seeded with certain level of error affecting the parameters given to the model in the test features in order to determine the power of the model and its ability to overcome what we call noisy data.
Keywords; *Artificial intelligence, neural network, Reservoir, EOR, Primary mechanism, gas injection , porosity, and permeability.*

Date of Submission: 12-12-2021 Date of Acceptance: 26-12-2021

I. INTRODUCTION

Typically, the use of the natural stored reservoir energy may not produce more than 50 percent of the original place during the usage of the primary mechanisms. As these energies are exhausted programs of water flooding or gas Injection may then be applied to the reservoir during the secondary recovery phase. In order to maintain the energy of the reservoir.

The term enhanced oil recovery (EOR) covers all reservoir treatment processes designed to recover the stranded fraction of oil in place. Namely the fraction that has not been able to move under the natural effect of the pressure gradient and expansion of the dissolved gas, pressure maintenance by water or gas Injection.

These processes, which may be applied to improve the petroleum recovery from existing reservoir, have gamed more attention as a result of increasing costs of exploring new oil fields and reducing opportunities for discovery of new oil reservoir high reserve and good quality. Since the production of oil by any means of EOR process is a rather difficult, risky, and need huge capital cost, the proper selection Of the EOR methods for a certain reservoir is important. In attaining a successful and profitable project. The most difficult that faces reservoir engineers and experts is how to select the most appropriate method to enhance the oil production based on technical and economical factors. To achieve this mission, many reservoir factors must he studied carefully such as reservoir depth, reservoir area, reservoir temperature, porosity, permeability, oil gravity, and oil viscosity, and also how these factors may affect each other.

Shindy et al. , developed a knowledge based expert system for the selection of the EOR method in oil reservoirs. An analytical method based on statistical evaluation was used to produce the rules used in the expert system formulation. These may solved the problem of technical selection of EOR techniques for different application. No solution for the economical selection of EOR project was presented in their paper.

The choice of any improved oil recovery method is based on technical and economical criteria. The main problem faced by the petroleum engineer is to identify technically, and evaluation economically the enhanced recovery processes - applicable for the oil reservoir.

In our study, both the technical and economical EOR selection problem has been solved using the neural network approach. This approach is as efficient and flexible as the previous developed expert system However, the economical analysis for the EOR selection which was not solved by the previous expert system, has now solved in the present work.

The classification of the selected EOR projects was carried out using the artificial neural network as an intelligent classifier. The architecture of the neural network used is the multi-layer feed-forward neural network trained by the back-propagation algorithm. The programs are written using neural network toolbox in MATLAB 5.3 software.

Neural Network System

Artificial neural network ' is that technology that grew from the challenge to obtain a full understanding of some ideas and aspects about how biological systems work, especially the human brain. A system is composed of a basic element called the artificial neuron, or simply the neuron. This neuron receives some input signals from other neurons, each signal is multiplied by a certain value called weight, then the resulting sum of the weighted signals is activated through a non-linear function to determine the neuron output This basic element. with its features, repeals itself vertically designing the layer which in turn design the whole network as it is repeated horizontally many times with only three types' Input layer (only one layer), hidden layer (could be more than one layer), and finally output layer (only one layer).

The vast majority of applications performed by artificial neural network have been trained by supervised training. In this technique both input data and corresponding desired output data are given to the network (data of training phase). As the network start training, the input layer reseives the input signals, then processing the data through the hidden layers until reaching the output layer yielding the resulted outputs. These outputs are then compared with the desired out puts compute the error which is back propagated through the system causing it to adjust the Weights, which control the network. The weights are randomly given small values the beginning of training the network. The process of training is repeated stopping only when the system has attained the desired accuracy. In the testing phase, the trained network is tested with new data not included in the network training phase to check the ability of the designed network.

Data Sources and Preparation

The data used in training and testing the networks was extracted from production reports published by the Oil and Gas journal [10 11]. These sources deal with three categories of EOR projects: planned EOR projects producing EOR projects and completed/terminated EOR projects.

Data was collected from the second and third categories covering seven parameters, which were classified into four classes rock parameters (porosity, permeability Initial oil saturation at beginning), fluid parameters (API, oil viscosity), Ranges of all these parameters are given in Table I. Due to the great variation in some parameters, the Mean arithmetic average Was calculated for all parameters and tabulated in Table 2. Finally, each value in certain parameter was divided by Its corresponding mean arithmetic average, and then forwarded to the neural network. Table 3 gives the new ranges for the parameters used.

TABLE 1- RANGE OF THE PARAMETERS USED FROM EOR METHODS

Parameters	Unit	Min. value	Max. value
Reservoir Area	Acre	3	49900
Porosity	%	2	40
Permeability	md	1.3	5000
Depth of the Reservoir	Ft	200	11300
API Gravity	Dimensionless	11	57
In-situ Oil viscosity	Cp	0.097	10000
Initial Oil Saturation	%	17	98

TABLE 2 ARITHMATIC AVERAGE VALUES FOR PARAMETERS USED FROM EOR METHODS

Parameters	Arithmetic Average
Reservoir Area	3590.544444
Porosity	21.93422222
Permeability	1160.636667
Depth	4419.611111
API Gravity	27.41
In-situ Oil viscosity	1214.731733
Initial Oil Saturation	63.93444444

TABLE 3- NEW RANGE OF FRE PARAMETERS
USED FROM EOR METHODS

Parameters	Min. value	Max. value
Reservoir Area	0.000835528	13.89761551
Porosity	0.091181724	1.823634485
Permeability	0.001120075	4.307979153
Depth of the Reservoir	0.045252851	2.556786106
API Gravity	0.401313389	2.079533017
In-situ Oil viscosity	0.000079853	8.232268517
Initial Oil Saturation	0.265897379	1.532820183

II. RESULTS AND DISCUSSIONS

Two separate networks are designed one has the goal to select the project that is technically successful to be applied in the reservoir under consideration. Then the project will be tested for economics by applying the second network to check whether the project will be profitable or not.

I - Technical Network

The network was trained with 107 projects, Table 4 gives the number of each type of EOR project. tested with 15 projects. The network is successfully trained to select between the projects.

TABLE 4- EOR PROJECTS CLASSIFICATIONS

EOR Projects	Number
Combustion	15
Steam	30
Polymer	20
Hydrocarbon Miscible	25
Co_2 Miscible	17

The output of the neural network was designed such that each project has a separate output, i.e. the number of output layer nodes equal to five nodes. For the selected project type, the network was designed to produce I or positive value in the neuron corresponding to the project, and all other neurons produce —l or any negative value near-I.

The neural network used was a multi-layer network with four layers. The input layer has seven neurons. The output layer has five neurons, Two hidden layers are used and the optimal number of hidden neurons, which gives the optimal network performance, were found to be 17 hidden neuron in the first hidden layer, and 15 hidden neurons in the second hidden layer. The hyperbolic tangent sigmoid function was used as the activation function in the first hidden layer, while log sigmoid function was used in the second hidden layer, and finally pure linear function with the output layer. The optimal performance of the neural network was obtained by training the network many times with different number of hidden layers, hidden neurons. and activation functions until the weights of the network were calibrated to give minimum error of the training set.

II- Network for Economics

The network used was also a multi-layer network with three layers. The input layer had seven neurons. The output layer has single neurons. Several trials were done to select the optimal number of hidden layers, number of hidden neurons and activation function, that yields the optimal performance of the neural network. It was found that one hidden layer with 21 neurons performs the task accurately. The log sigmoid activation function was used in the hidden layer while the tangent sigmoid activation function was used for Output layer. The network was trained with around 107 projects and tested with the projects. For a certain project, the network was designed to produce I or a positive value in the output neuron if the project is profitable, and —I or any negative value near -I if not. 2)

III- Noise Test

As the network trained and tested successfully, the error affecting the data in the test phase was examined through a random noise test. The magnitude of noise was selected (10% for example) and applied negativity and positively to all the data of the tested projects in order to generate two boundaries for each parameter in all test features, among which a set of 15 numbers are randomly generated. This means that, fifteen random projects are driven out from each project in the set.

III-a- Technical Network and Noise Test

A set of 225 random projects was developed from the base test set and entered into the network as a new rest set. II was found that, for up to 15% noise, the network gave classification efficiency of 100%. This means up to 15% error in the data characterizing the project, the network can overcome this error and give right selection of which project could be applied in this reservoir. The network was tested up to 40% noise. The noise level and resulting efficiency is tabulated in Table 5, and given graphically in Fig. 1.

TABLE 5- EFFICIENCY OF TECHNICAL NETWORK AGAINST NOISE TEST

% of Noise	% of efficiency
15%	100%
20%	98.22%
30%	96%
40%	91.1%

III-b- Response of Economics Network to Noise Test

The noise test was performed using a set of 165 random driven projects. The output proved that, the network is able to overcome noisy error up to 6% and yield classification efficiency of 100%. Then the network was tested with noisy error up to 20%. The noise level and resulting efficiency is given in Table 6. Fig. 2 presents the results graphically.

TABLE 6- EFFICINENCY OF ECONOMICS NETWORK AGAINST NOISE

% of Noise	% of efficiency
6 %	100%
8 %	98.18%
10 %	96.36 %
15 %	94.55 %
20 %	91.1%

Application of the Designed Model

With the two networks trained and tested successfully, it was then recommended to apply the two networks as a one model working in series to some other known reservoirs, and check the model response. The three fields that were prepared and entered into the networks as test features were,

A. Intisar Field
B. Kelly Snayder Field
C. Willington Field

Case Study 1 Intisar "A" Field

Intesar reservoir was discovered in 1987, in Libya. Depth of the reservoir was found to be around 10000 ft, with oil found in carbonate reefs. Primary recovery from the reservoir was low, so that a water flooding project was established for while before starting hydrocarbon miscible flooding as a recommended EOR project for the reservoir 2.

The technical neural network detect the best method for this reservoir as hydrocarbon miscible flooding project, as already exist in the field Also, the economical neural network displays that the project is profitable.

Case Study 2 Kelly-Snyder Field

Located in Texas, USA, this field is the largest field producing oil by carbon dioxide miscible flooding since 1982.

The field was discovered in 1968 with 13 billion bbl of oil in place. The field was produced with fluid expansion and gas in solution as primary mechanisms Due to the rapid drop in pressure resulting in low recovery factor, a water injection program began in 1954 and by 1971. the oil produced were 771 million bbl before starting the EOR project.

The technical network was tested with this held and it selected carbon dioxide miscible project as the recommended project, and the economic network predicted that it will be profitable.

Case Study 3: Wilmington Field

The field is located in California, USA, and it is now produced with carbon dioxide immiscible flooding as an EOR project. The oil in place was 6946 bbl in the project area, and total oil produced was around 23.27% of original oil In place before the project began.

Even though carbon dioxide immiscible flooding in one of the five selected methods used in designing the two networks, these data was given to the system as a test - feature. The technical network select in-situ combustion as a recommended project for the field, while the economical network predicted that the project would be unprofitable one in this field.

This example gives other evidence for the power and intelligence of the model designed.

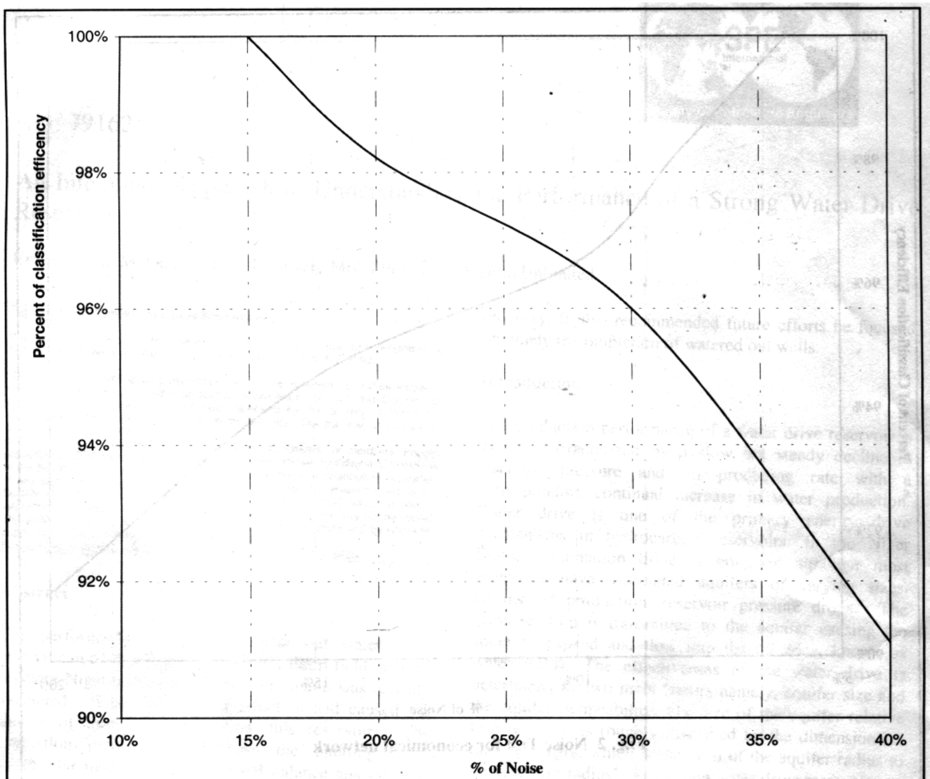
III. CONCLUSIONS

1. A multi layer network with 4 layers was applied to select the EOR project The input layer has 7 neurons. output layer has 5 neurons first hidden layer has 17 neurons with hyperbolic tangent sigmoid transfer function, while the second one has 15 neurons with logarithmic sigmoid transfer function. Pure me transfer function was applied to the output layer. The network is trained by 107 samples and tested with 15 samples. This network was successfully trained to select between five projects. Noise test was then applied to the network, and it was found that the network can withstand till 15% force in the parameters input to our model and still attain an efficiency of 100%.

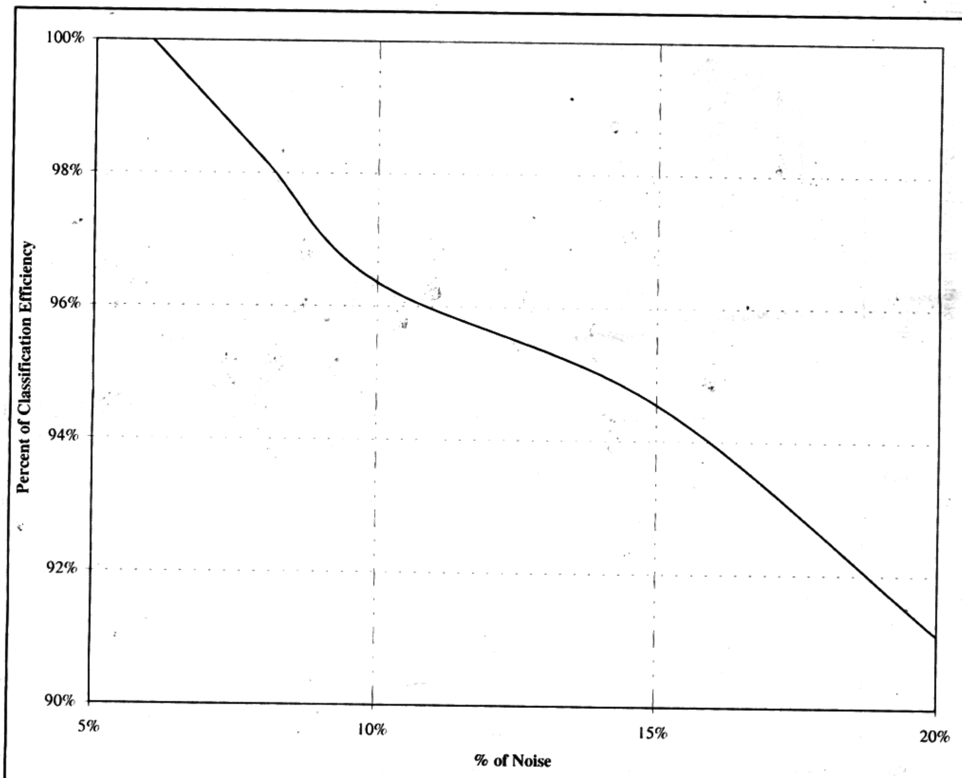
2. As a certain project is selected, it is then tested by the second network through profit point of view. The network composed of three layers. input layers with 5 neurons, output layer with single neuron activated by the hyperbolic tangent sigmoid, and only one hidden layer with 21 neurons activated by logarithmic sigmoid transfer function. The network was trained with 107 samples and tested with II samples this network was successfully trained to tell it the project is profitable or not. The noise test shows that the network can yield efficiency of 100% even with error up to 6% in the parameters input to our model.
3. Using these networks will give the right decision in a little time compared to the time required to carry out a study necessary to take the decision.
4. The networks will save a lot of money when applied by a specialist to study the selection of the project
5. Noise test prove that even with the level of error in the parameters, the network give the right selection. This gives some comfort and let the engineers be satisfied with the results. Hence, it may also lower the costs needed to gather or determine the exactness or perfectness of data.
6. Three eases studies were applied to the system with excellent results.

REFERENCES

[1]. Taber, I. S ; Martin. F. 0;. and Seright, R .S, Technical Screening Criteria Revisited," Paper SPE/DOE 35385. 2003
[2]. Lake. L W. "Enhanced Oil Recovery' Prentice Hall, Englewood Cliffs, New Jersey, 2009
[3]. Sayyouh, M 1-I.; and Al-Blehed, 0. F.. Screening Criteria for Enhanced Recovery at Saudi Crude Oils," International Journal of Energy resources, Vol. 2, No. I, P. 71 — 82, 2010
[4]. El- Batanony, M. H.; Sayyouh, M. H.; Mahgoub, I. S.; and Abdel Waly. A. A.," Screening Guides Enhanced Oil Recovery Methods Egyptian Reservoir Conditions,' J. Soc. Of Engineers. Vol. 26, No 1, pp. 12, 2012.
[5]. Shindy, A. M.; Darwich T.; Sayyouh, M. I-I - and Osman A., "Development of an Expert System for EOR Method Selection," Paper SPE 37708, 2017.
[6]. Shokir, E M. . "Neural Network Determines Shaly-Sand Hydrocarbon Saturation" Oil & Gas Journal Apr. 23 ,2011, Vol. 99. pp17.
[7]. Zurada J M., "Introduction to Artificial Neural System," PWS Publishing Company, 2005.
[8]. Mohaghegh. M., Virtual-Intelligence Application in Petroleum Engineering: Part 2- Artificial Neural Network" JPT Match 2000
[9]. Beale R.; and Jackson, T., "Neural Computing: An Introduction," Adam huger Company, 1969.
[10]. Morities, G., EOR Dips in U. S But Remains a Significant Factor," Oil and Gas Journal, Sept. 26, 2004.
[11]. Moritis, C., "EOR Whether Low Oil Prices,' Oil and Gas Journal, March. 20, 2000
[12]. Willhite, 0. P.," Waterflooding," Society of Petroleum Engineers, 2014.
[13]. Carcoana, A. "Applied Enhanced Oil Recovery,' Prentic Hall 2002.



Fi.g. 1 Noise Test for technicl network



Fi.g. 2 Noise Test for economical network

Akpoturi Peters. "Selection and Evaluation EOR Method Using Artificial Intelligence." *International Journal of Engineering and Science*, vol. 11, no. 12, 2021, pp. 26-31.