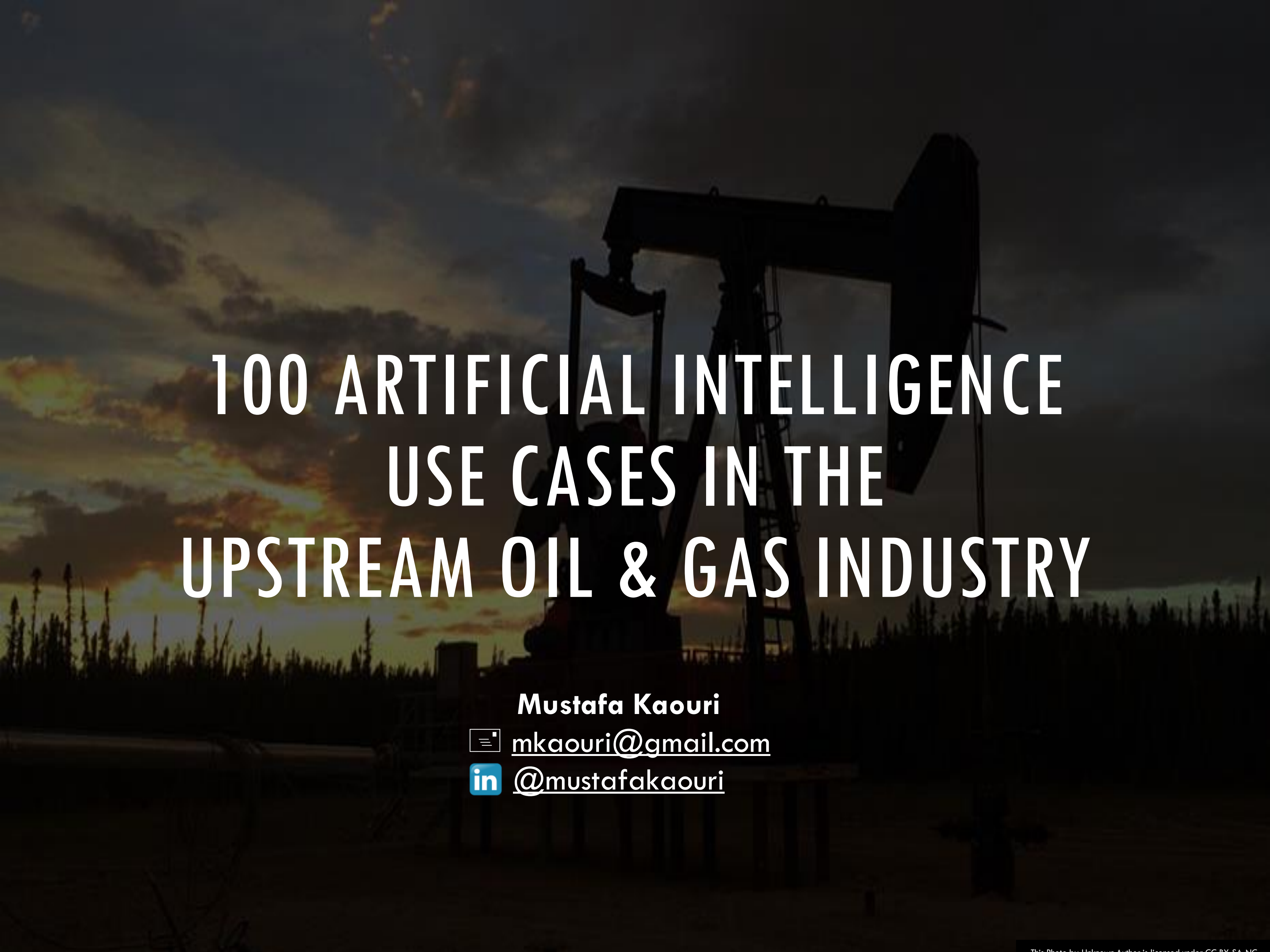

100 ARTIFICIAL INTELLIGENCE USE CASES IN THE UPSTREAM OIL & GAS INDUSTRY

Mustafa Kaouri
mkaouri@gmail.com
@mustafakaouri

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#1: AUTOMATION OF ROCKS CLASSIFICATION

Activity: Geology

Challenge:

The description of rocks is one of the most time-consuming tasks in the everyday work of a geologist, especially when a very accurate description is required.

Solution:

AI application of methods based on color distribution analysis and feature extraction. A new approach to the automated classification of rocks can help geologists reduce the time spent on core description. The best ANN architectures are GoogLeNet and ResNet.

#2: ESTIMATION OF P-AND S-WAVE IMPEDANCES

Activity: Geology

Challenge:

P- and S-wave impedances are accounted as two significant parameters conventionally inverted from seismic amplitudes for evaluation of gas and oil reservoirs. They may not be the final goal of interpretation studies; however, they play an essential role in many methods such as reservoir characterization, rock physical modeling, geostatistical simulation, fluid detection.

Solution:

Deploy adaptive network-based fuzzy inference system (ANFIS) based on SCM to establish a predictive paradigm for P- and S-wave impedances vital for different tasks such as reservoir characterization, fluid detection, and rock physical modeling.

#3: IDENTIFICATION OF FRACTURES IN RESERVOIR

Activity: Geology

Challenge:

Many types of research have been conducted on fracture identification. Still, due to the firm heterogeneity of reservoirs and complicated seepage characteristics caused by fractures, precise identification of fractures remains a crucial problem waiting to be solved. Furthermore, the identification process is complex because the reservoir contains natural, artificial, and induced fractures and the parameters involved mainly rely on logging data.

Solution:

The application of AI in the identification of fractures is a new and reliable research method. The seismic data has the advantage of continuous observation in space, so the fractures may be detected more accurately by combining seismic data with logging data. Optimize and enrich the AI algorithm to improve the identification accuracy to achieve dynamic identification.

#4: INTERPRETATION OF SPONTANEOUS POTENTIALS (SP)

Activity: Geology

Challenge:

Spontaneous potentials (SP) are usually caused by charge separation in clay or other minerals due to the presence of a semi-permeable interface impeding the diffusion of ions through the pore space of rocks or by the natural flow of a conducting fluid through the rocks. Spontaneous potentials are often measured down boreholes for formation evaluation.

Solution:

Deploy ANN to interpret spontaneous potential (self-potential) anomalies related to simple geometric-shaped models for estimating the parameters of different simple geometrical bodies.

#5: PREDICTION OF TOC IN SHALE GAS RESERVOIR

Activity: Geology

Challenge:

Total organic carbon (TOC) is essential in reservoir evaluation, exploration, and source rock characterization. An increase in TOC indicates the presence and extension of source rock, while a reduction in TOC would be interpreted as a lack of hydrocarbon sources. TOC also determines the geophysical characterization of shale gas resources, which impacts the response from organic-based rocks.

Solution:

Employ RBF model to predict the TOC of a shale gas reservoir considering neutron log, density log, acoustic log, deep induction log, and gamma-ray as input parameters. Deploy an extreme learning machine (ELM) method to estimate TOC values from well-log data. Employ ANN model to estimate TOC using well-log data considering gamma-ray, bulk density, resistivity, and sonic transit time as input parameters.

#6: SPEEDUP GEOLOGICAL MODELING

Activity: Geology

Challenge:

The output of the petrophysical interpretation from well log data is used to refine seismic interpretation. Experts extrapolate the acquired properties from near-wellbore zones into the seismic cube, saturating the 3D segmented cube with porosity, permeability distribution, and values of fluid saturation. This interpolation is probably the most time-consuming.

Solution:

If adequately trained on multiple manually conducted extrapolation exercises, generative architectures of deep neural networks can accelerate the process. Thus, although geologists and decision-makers may accept the automatically generated 3D geological model as the absolute truth, the automation with deep learning is an excellent opportunity for suggesting the expert-independent and fast variant for further fine-tuning and decision-making.

#7: PREDICTION OF ANOMALIES IN MINING GEOCHEMISTRY

Activity: Geochemistry

Challenge:

Geochemistry is one of the essential branches of exploration engineering. It aims at explaining the mechanisms behind critical geological systems by applying the principles and tools of chemistry. The gained results from this science provide invaluable guidance for multidisciplinary exploration tasks. However, due to the expensive cost of the analyses needed for generating geochemical maps and data to employ during the exploration tasks, researchers have shown an increased interest in the application of intelligent techniques to build accurate predictive/classification paradigms based on gathered information from prior geochemical investigations.

Solution:

Employ neuro-fuzzy technique for identifying anomalies in mining geochemistry. Apply intelligent models, including AdaBoost, SVM, and random forest (RF), to distinct porphyry Cu-related geochemical anomalies. These models can be trained with borehole and surface rock samples from drilled zones. Then, these models can be utilized to generate a classified map illustrating abnormal areas in the undrilled parts of the district.

#8: AUTOMATION OF SALT BODIES IDENTIFICATION

Activity: Geophysics

Challenge:

A crucial task in seismic interpretation is to identify the salt bodies in the subsurface environment. Visual picking of the salt/sediment boundaries is the standard way of performing salt identification in conventional workflows. However, this is a time-consuming manual process, which may be affected by individual bias.

Solution:

Advanced CNN-based classification, along with residual learning, has demonstrated high precision in delineating salt bodies. Furthermore, the results from these CNN-based algorithms show good agreement with manually interpreted salt bodies. Such results indicate the potential of applying CNN for automated salt identification.

#9: CLASSIFICATION OF FACIES DISTRIBUTION

Activity: Geophysics

Challenge:

Facies can be understood as a class of rock with distinct characteristics. Therefore, understanding facies distribution in an oil and gas reservoir can help identify the regions, which are more likely to have oil and gas producing rocks.

Solution:

Applying deep neural networks has shown reasonable accuracy in classifying facies based on the petrophysical properties from the Well logs and at random points of interest away from the wells.

#10: DEALING WITH GEOPHYSICAL PARAMETER INVERSION

Activity: Geophysics

Challenge:

A geophysical inversion is a tool that we can use to recover the subsurface distribution of physical property from field-collected data. Each type of geophysical data may be inverted using one or more inversion algorithms. However, geophysical inversion does not recover the exact distribution of a physical property. Therefore, it is up to the user to set appropriate starting parameters for the inversion.

Solution:

Apply a three-layer feed-forward neural network (FNN) to deal with the geophysical parameter inversion task. First, train it using 5 and 10 numerically modeled records of the vertical component, then a three-layer transverse isotropic model to test the network.

#11: ELIMINATING MULTIPLE REFLECTIONS IN SEISMIC DATA

Activity: Geophysics

Challenge:

Identifying and removing multiple reflections in seismic data to separate the numerous wavefield from the primary wavefield and suppress it to create a multiple-free seismic section.

Solution:

Utilize multilayer perceptron (MLP) neural network for identifying and eliminating multiple reflections in seismic data. The neural network is trained with modeled data generated from well-log information and then applied to the areas between the boreholes. Input to the neural network is either the seismic trace itself or several selected, representative attributes computed from the seismic trace.

#12: ENHANCING INTERPOLATION OF SEISMIC IMAGES

Activity: Geophysics

Challenge:

Acquisition of high-resolution, regularly sampled seismic data is often hindered due to physical or financial constraints. This leads to under-sampled seismic data sets. Also, data quality issues, such as bad or dead traces, introduce additional challenges in the exploration and production activities that depend on high resolution and high-quality seismic images. Addressing these challenges can enable geoscientists, reservoir engineers, and other industry professionals to improve the predictive capability of their models.

Solution:

Employing generative adversarial networks (GAN) to interpolate seismic images helps reconstruct the bad and dead traces. It may also be used as a resolution enhancement tool for seismic data. The results of seismic interpolation using a generative adversarial network make it an interesting alternative to classical methods

#13: FAULTS DETECTION OPTIMIZATION

Activity: Geophysics

Challenge:

The traditional approach of manually picking faults and horizons on sections can be qualitatively enhanced by incorporating seismic attributes to highlight the fault structure within a seismic dataset; however, there are cases when standard attribute analysis disappoints. One of the problems with the established attribute analysis is noise from poor signal quality, which gives unclear or disappointing results in traditional fault detection.

Solution:

AI can be closely aligned with an interpreter's way of working. Allowing for tightly coupled interaction as appropriate for the dataset and the individual interpreter's workflow, an integrated deep learning environment can be created to work alongside traditional fault-picking methods. This bridges the gap between an interpreter's understanding and expertise, emphasizing the interpreter via a limitless workflow.

#14: GENERATING GEOLOGICAL STRUCTURES FOR SEISMIC INVERSION

Activity: Geophysics

Challenge:

The process of seismic inversion transforms seismic data into quantitative rock property estimates describing the reservoir.

Solution:

GAN has been combined as an a priori model for creating subsurface geological structures and their petrophysical properties. The generated structural and properties information can be used for assisted seismic inversion.

#15: MODELING SYNTHETIC GRAVITY DATA

Activity: Geophysics

Challenge:

Synthetic gravity data were computed for 3D forward modeling of salt bodies interpreted from Prestack Depth Migration (PSDM) seismic images.

Solution:

Employ radial basis function (RBF) neural networks (RBFNN) to model synthetic gravity data considering the depths, density contrasts, and location of the structures as input parameters.

#16: PREDICTING SHAPE FACTOR, DEPTH, AND AMPLITUDE COEFFICIENT

Activity: Geophysics

Challenge:

Predict the shape factor, depth, and amplitude coefficient parameters related to simple geometric-shaped models.

Solution:

Employ the feedforward neural network (FNN) to predict the shape factor, depth, and amplitude coefficient parameters related to simple geometric-shaped models.

#17: RESERVOIR CHARACTERIZATION BASED ON SEISMIC DATA

Activity: Geophysics

Challenge:

Characterization of hydrocarbon reservoirs is based on various techniques: lithoseismic, geomodeling, geostatistics, evolutionary algorithms, and petrophysics. Seismic information is first used to describe the reservoir structure, but then its relationship with facies description is a difficult task.

Solution:

Utilize adaptive neuro-fuzzy inference system (ANFIS) algorithms and a pseudo-forward equation to characterize a Reservoir based on seismic data. The ANFIS models can be established using different clustering schemes, namely, grid partitioning, subtractive clustering method (SCM), and fuzzy c-means clustering.

#18: SPEEDUP FAULT INTERPRETATION ON SEISMIC IMAGES

Activity: Geophysics

Challenge:

Fault interpretation is an essential step in seismic interpretation. Faults are formed by different mechanisms of subsurface movements, which result in a structural discontinuity. Therefore, certain operational decisions need to be taken after considering the presence of faults in the region of interest. In conventional workflows, fault interpretation is a time-intensive process.

Solution:

Convolutional Neural Networks (CNN) may be instrumental in formulating and solving fault interpretation as a computer vision problem. However, it may not always be possible to generate large amounts of labeled data representing seismic images and corresponding fault locations to train the CNN models. Accordingly, recent research has established methodologies for training advanced CNN variants with minimal training datasets while providing highly accurate pixel-by-pixel prediction of the fault locations in the provided seismic images.

#19: AUTOMATION OF WELL LOG INTERPRETATION

Activity: Petrophysics

Challenge:

Petrophysicists use Well logging data for their interpretation routine, including rock typing, estimation of porosity, permeability, and relative fluid saturation along the wellbore. However, this interpretation is a time-consuming process, and the result of the interpretation depends strongly on the expert.

Solution:

An automated interpretation algorithm based on the AI model, trained on historical Well logging data, can be applied to the data from new wells. AI interpretation can reach about 1000 times faster than the manual.

#20: DETERMINATION OF SHALE LITHOFACIES FROM WELL LOGS

Activity: Petrophysics

Challenge:

Accurate investigation of geo-mechanical properties plays a crucial role in adequately characterizing unconventional reservoirs, namely, organic-rich shales. Determination of lithofacies is among the main challenges in studying shale reservoirs.

Solution:

Apply SVM with optimization techniques, including grid searching, GA, and particle swarm optimization (PSO) to recognize shale lithofacies from well conventional logs. The gathered results from this information are primordial for hydraulic fracture stimulation and give an insight into organic matter and gas concentration.

#21: ESTIMATION OF PRECISE RESERVOIR PROPERTIES

Activity: Petrophysics

Challenge:

The process of defining different reservoir properties is referred to as reservoir characterization, which is a significant part of any reservoir simulation and modeling study. Porosity, permeability, fluid distributions, and pore/grain size distribution are among the major characteristics of a hydrocarbon reservoir. These parameters are conventionally calculated using seismic surveys, production data, Well tests, well logs, and core data. Rock samples (cores) are usually available for a limited well location, which makes the determination of reservoir characteristics a complex problem.

Solution:

AI techniques are being applied to precisely estimate these parameters. Various applications of ANNs and fuzzy sets to model different parameters such as prediction of mineral, lithology, porosity, permeability, and fluid saturation distribution. Most of that applications used well logs as the inputs of the models. A hybrid model, namely, integrated neural-fuzzy-genetic-algorithm (INFUGA), was used to predict the permeability of an offshore oil reservoir.

#22: GENERATING 2D/3D MODELS OF PETROPHYSICAL PROPERTIES

Activity: Petrophysics

Challenge:

Petrophysical modeling is critical for understanding the structure and properties of zones of oil and gas deposits in a reservoir.

Solution:

Neural networks have been successfully applied to create a detailed representation of petrophysical property distributions in the oil and gas reservoirs, sometimes called neural kriging. In addition, AI deep neural networks have been applied for generating detailed 2D and 3D models of petrophysical properties.

#23: IDENTIFICATION OF LITHOLOGICAL FACIES FROM WELL LOGS

Activity: Petrophysics

Challenge:

Determining different lithofacies to characterize a reservoir is traditionally performed using core samples taken from underground formations. However, technical and financial barriers exist to the number of cores and the depth interval from which the cores can be taken. Well logs are good alternative candidates for reservoir characterization, but manually reading and interpreting well logs can be cumbersome.

Solution:

Employ recurrent back-propagating neural networks to identify lithological facies from Well logs. Use back propagation-based neural networks to predict facies from Well logs, gamma rays, resistivity, neutrons, and density logs. Develop a workflow for preprocessing and cleanup of core data and facies prediction using PNN. Apply fuzzy logic inference method to predict lithological facies from well log data.

#24: IDENTIFICATION OF RESIDUAL OIL DISTRIBUTION

Activity: Petrophysics

Challenge:

The factors influencing residual oil distribution could be divided into two types, namely, the geological factors and development factors. The synthetic effects of these factors lead to the diversity of residual oil distribution. In addition, the displacement mechanisms for different residual oil types are other, which set barriers to excavate residual oil and improve oil displacement efficiency.

Solution:

Integrate AI into the identification of residual oil. To estimate the residual oil saturation quantitatively, develop a time-lapse seismic interpretation method that uses the ratio of amplitude attributes extracted from the baseline and monitoring seismic data. Then the residual oil distribution can be calculated with the proposed method that matches the production logs.

#25: PETROPHYSICAL METRIC PREDICTIONS

Activity: Petrophysics

Challenge:

Predicting permeability, water saturation, and effective porosity of oil and gas reservoir sections from Well log data is a necessary task because core data is typically unavailable for all wells drilled or complete reservoir sections.

Solution:

A data matching algorithm can be developed to evaluate data from multiple well-log curves. It provides accurate petrophysical metric predictions and extensive data mining insight to the lithological units it evaluates. Expressing the well-log data in a standardized well-log representation and evaluating that network with the data-matching algorithm provides permeability, water saturation, and effective porosity prediction from datasets that combine standard Well logs curves with lithofacies and stratigraphic information.

#26: PREDICTION OF FLOW ZONE INDEX

Activity: Petrophysics

Challenge:

A flow unit is a particular reservoir layer in which the petrophysical and geological properties do not significantly change, and fluid flow can be defined uniformly. Fluid flow properties within hydraulic flow units can be used to obtain a better characterization of a reservoir. Permeability data is the most important source of flow unit definition. Permeability data can be obtained by taking cores and well logs of the reservoir. However, these tasks are generally time-consuming and expensive.

Solution:

Employ neural networks to predict permeability values from well log data, using the reservoir's production history and combined neural network and statistical methods to characterize flow units and estimate permeability values. Apply GA-based formula to predict flow zone index (FZI). Develop ANNs and linear regression to develop a relationship between seismic data and FZI.

#27: PREDICTION OF PERMEABILITY

Activity: Petrophysics

Challenge:

Permeability is challenging to evaluate in reservoir petrophysics property, especially in low porosity–permeability reservoirs. The conventional permeability estimation model establishing the regression relationship between permeability and porosity is not applicable. This regression hypothesis based on the correlation between porosity and permeability (logarithm) is not available in low porosity–permeability reservoir. It remains a challenging problem in tight and heterogeneous formations' petrophysical interpretation.

Solution:

Utilize Neural Network with a Levenberg-Marquardt learning algorithm to predict Well log response, considering the Well log data from different offset wells to predict permeability.

#28: PREDICTION OF POROSITY AND PERMEABILITY ALTERATION

Activity: Petrophysics

Challenge:

Characterizing the rate of salts in cores and alteration of porosity and permeability after reservoir desalination due to drilling mud or water injection, which geoscientists usually define due to special laboratory analysis.

Solution:

Apply a predictive model based on RCA results and data on coring depth and top and bottom depths of productive horizons. A two-hidden-layer neural network can demonstrate the best predictive ability and generalizability for different rock characteristics. This approach allows predicting the alteration of porosity and permeability during desalination in porous rocks and evaluating salt concentration without direct measurements in a laboratory.

#29: PREDICTION OF ROCK BRITTLENESS FROM WELL LOGS

Activity: Petrophysics

Challenge:

Brittleness is another vital information for properly screening hydraulic fracturing candidates in unconventional reservoirs such as tight oils and shale gas. This parameter can be modeled based on mechanical parameters and mineralogical data.

Solution:

Apply ANN, MLP, and RBFNN, for predicting rock brittleness by exploiting conventional Well logs as inputs.

#30: PREDICTION OF SHEAR WAVE VELOCITY FROM WELL LOGS

Activity: Petrophysics

Challenge:

Shear wave velocity is an important parameter that can give an accurate description of rocks' mechanical properties. This parameter is rarely recorded during drilling processes and is usually measured from cores in the lab. However, core sampling from lengthy reservoir layers is cumbersome and expensive.

Solution:

Employ ANNs, fuzzy logic, and neuro-fuzzy logic to predict shear wave velocity from well log data. Develop ANN and gene expression programming models to predict shear wave velocity of an earthquake-recording site considering site-to-source distance, spectral accelerations, peak ground acceleration, and the magnitude of the recordings as input parameters. Employ empirical correlations and AI techniques to estimate shear wave velocity from the Well log data using different correlations and AI techniques of backpropagation neural network and SVR. Combine extreme learning machine (ELM) with the mean impact value (MIV) technique to estimate the shear wave velocity values of a shale gas reservoir from well log data.

#31: PREDICTION OF WATER SATURATION AND POROSITY

Activity: Petrophysics

Challenge:

Petrophysical properties evaluation of shaly sandstone reservoirs is a challenging task in comparison to clean sand reservoirs. Logging derived porosity in shaly sands requires shale correction, and Archie's formula cannot be used in shaly sands to determine water saturation.

Solution:

Employ ANN to predict water saturation and porosity and to identify the lithology of a sand reservoir. Use density and resistivity logging data and gamma ray data to develop ANN intelligent models for predicting water saturation and porosity.

#32: DETECTION OF NATURAL OIL SEEPS IN OCEAN FLOOR

Activity: Reservoir Engineering

Challenge:

Natural seeps occur when oil escapes from rock found on the ocean floor. An estimated 60 percent of oil underneath the earth's surface in North America is due to natural seeps.

Solution:

Robots with the ability to navigate these oceanic regions and detect oil seeps can protect the ecosystem and serve as indicators for robust energy resources. Apply AI to boost its natural seep detection capabilities.

#33: FORECASTING OF OIL PRODUCTION

Activity: Reservoir Engineering

Challenge:

Production forecasting helps in the estimation of available reserves and economic evaluation. Traditionally numerical simulations and decline curve analysis (DCA) techniques are extensively used for production forecasting. However, these techniques require knowledge of the reservoir behavior and lack flexibility for modeling complex physics.

Solution:

AI methodologies using feedforward neural networks and recurrent neural networks have demonstrated their effectiveness and accuracy in a production forecast of single and multiple wells. These AI approaches make the forecasting process efficient and accurate for the assets with or without significant operational history information.

#34: OPTIMIZATION OF HISTORY MATCHING

Activity: Reservoir Engineering

Challenge:

The most crucial task in oil and gas development is to predict future development based on the existing data and make a reasonable development plan. Therefore, history matching is needed to facilitate the subsequent numerical simulation before prediction. However, due to the complexity of actual oilfield development, multiple factors simultaneously interfere, which increases the difficulty of history matching with conventional methods.

Solution:

With the development of AI, it has been proven feasible to apply a neural network to the history matching of oilfield development. The history matching and training of the existing data can effectively capture the nonlinearity of problems with fast matching speed and good precision and further become a new history matching method. Artificial neural network (ANN) is commonly utilized to conduct training and history matching oilfield development. In addition, genetic algorithm (GA) is often combined to optimize and improve the matching speed and accuracy.

#35: PREDICTION OF ACCURATE PVT PROPERTIES

Activity: Reservoir Engineering

Challenge:

It is essential to accurately determine the pressure-volume-temperature (PVT) properties of oil and gas due to their high significance for material balance calculations. In addition, these parameters directly affect reservoir performance and evaluation and production operation and design. PVT correlations and equation of state (EOS) are two approaches to estimate PVT properties when the experimental PVT data is unavailable.

Solution:

To overcome the shortcomings of empirical correlations, intelligent models were developed to predict the PVT properties more accurately. Artificial neural networks (ANNs) to estimate the bubble point pressure (Pb) and oil formation volume factor (Bo) in the area of PVT properties prediction. Also, support vector machines (SVMs) could accurately predict the Pb and Bo. Application of genetic algorithms (GAs) can be employed to predict the viscosity of crude oils.

#36: PREDICTION OF ASPHALTENE PRECIPITATION

Activity: Reservoir Engineering

Challenge:

Asphaltenes are very complex molecular compounds that exist as a heavy fraction in petroleum. Asphaltenes have the potential to damage the oil-bearing formation and production equipment considerably. Asphaltene precipitation and deposition can lead to catastrophic formation damage problems in terms of pore throat plugging and wettability alteration during different phases of field development (drilling, production, and injection). Therefore, it is essential to predict this phenomenon so that preventive precautions can be made.

Solution:

Employ the MLP-ANN technique to predict the weight percent of precipitated asphaltene considering P, API gravity, the molecular weight of the precipitant, the dilution ratio, and the ratio of asphaltene as input parameters. Employ the SVM, FCM, ANFIS, and LSSVM modeling techniques to predict the precipitation of asphaltene about the conventional input variables temperature, type of precipitant, and the dilution ratio. Utilize the RBF network to estimate the reduction of asphaltene precipitation due to the presence of inhibitors as a function of molecular weight and concentration of inhibitors, API, oil asphaltene content, and the number of carboxylic, hydroxyl and circular structure groups. Employ the LSSVM and the RBF NNs to predict the amount of asphaltene precipitation considering paraffin type, crude oil colloidal stability index, and the dilution ratio as the input variables.

#37: PREDICTION OF FORMATION DAMAGE

Activity: Reservoir Engineering

Challenge:

Formation damage is an inevitable and undesirable problem during the oilfield development and production processes. Many controllable and uncontrollable factors that can cause the disturbance of the existing equilibrium inside a porous medium may potentially be considered a cause of formation damage. In addition, formation damage can severely reduce reservoir permeability and well performance. Therefore, accurate prediction of formation damage before its occurrence can significantly contribute to the petroleum industry.

Solution:

Deploy the CSA-LSSVM model to predict the permeability reduction factor (Kd/Ki) regarding the injection rate, the volume of injected water, T, ΔP, Ki, and solution ionic components after seawater injection as input parameters. A predictive model based on quantum NNs estimates the severity of aqueous phase trapping (a formation damage mechanism). The input parameters are initial water saturation (Swi), IFT between oil and water, φ, gas permeability, and average pore diameter. Develop a GEP algorithm for evaluating the formation damage owing to mixed sulfate deposition.

#38: PREDICTION OF INTERFACIAL TENSION (IFT)

Activity: Reservoir Engineering

Challenge:

Interfacial tension (IFT) and minimum miscibility pressure (MMP) are among the most critical two-phase properties of reservoir fluids. The significance of IFT is well understood since it has an essential role in many industrial and engineering processes.

Solution:

An artificial neural network (ANN) model can predict the IFT value of pure hydrocarbon and water systems over temperature and pressure. Furthermore, the Common Scrambling Algorithm (CSA) can optimize the model and apply the radial basis function (RBF) kernel function.

#39: RECOGNIZING RESERVOIR MODEL THROUGH WELL TESTING DATA

Activity: Reservoir Engineering

Challenge:

Identifying well test interpretation models and estimating reservoir parameters are two essential parts of a Well test analysis process. The information provided by Well tests is also necessary for estimating the productive reservoir capacity and average pressure. The analysis of reservoir performance and predicting its future production is based on having appropriate information about the reservoir properties and circumstances.

Solution:

Employ a recurrent ANN to categorize the reservoir models based on pressure transient data. The three optimization algorithms, namely, PSO, DE, and covariance matrix adaptation evolution strategy, can predict various reservoir parameters such as drainage radius, wellbore storage coefficient, skin factor, and reservoir permeability in different reservoir models (fractured, radial composite, and homogeneous reservoirs) through well test data. Employ an MLP ANN or PNN to recognize the reservoir model through well-testing data. Also, you can use the GRNN and MLP for predicting the reservoir permeability, wellbore storage coefficient, skin factor, and storativity ratio.

#40: SPEEDUP RESERVOIR MODELING

Activity: Reservoir Engineering

Challenge:

Computations done with conventional reservoir modeling tools perform numerical solutions of partial differential equations describing the physics of reservoir flows. However, these computations are lengthy, limiting possible runs and the optimization ability for proper field development planning.

Solution:

Modern reservoir models with a new computation engine based on AI deep neural networks compress the mathematical problem dimensionality and approximate the time derivatives promise 100–1000 times the conventional models' speedup while keeping similar functionality.

#41: SPEEDUP UPSCALING IN RESERVOIR MODELING

Activity: Reservoir Engineering

Challenge:

Many reservoir engineers use tricks to perform manual upscaling (i.e., bringing information gained from various scales of geophysical studies to a single geological and then hydrodynamical reservoir models) in a way that seems correct to themselves. This upscaling process introduces a strong bias to the reservoir model.

Solution:

Summing up the multiple experiences with a deep learning algorithm trained on multiple cases of manual upscaling would increase objectiveness and increase the speed of the upscaling process.

#42: PREDICTION OF MMP AND CO2 STREAMS

Activity: Enhanced Oil Recovery

Challenge:

Minimum miscibility pressure (MMP) is an essential two-phase property of reservoir fluids. In miscible gas injection processes, the injection pressure should be high enough (higher than MMP) to make the injected gas miscible in the reservoir fluid. Otherwise, the injection process is considered as an immiscible gas injection. The miscibility can be attained through first contact or multiple contact processes. The lowest pressure at which the injected gas can achieve miscibility with the reservoir oil is called MMP.

Solution:

To estimate the MMP of pure and impure CO2, use the GMDH scheme to develop accurate correlations. Consider the T, Ppc, and Tpc of injected gas, the ratio of volatile-to-intermediate oil fractions, and MW of C51 fraction as input variables. A new model, namely, AdaBoost SVR, predicts the MMP of pure and contaminated CO2 streams through reservoir temperature, pseudo critical temperature of injected gas, mole fractions of volatile and intermediate fractions, and MW of C51 oil fraction.

#43: PREDICTION OF RECOVERY FACTOR (RF) AND OIL RATE

Activity: Enhanced Oil Recovery

Challenge:

After the primary and secondary oil production phase from reservoirs, two-thirds of the original oil in place will be left behind inside the porous media. The main reasons for such recovery efficiency may be macroscopic and microscopic heterogeneities, different fluid characteristics (densities and viscosities), various Interfacial tensions (IFTs) and wettability, and other driving forces.

Solution:

Employ AI techniques in enhanced oil recovery (EOR) processes to predict the RF and oil production rate in CO2-foam flooding processes. Two models were considered: a multilayer perceptron (MLP) and a radial basis function (RBF) NN. The RBF and MLP models predicted the recovery factor (RF) and oil rate as functions of surfactant type, rock porosity, permeability, core pore volume (PV), initial oil saturation, and injected PV of foam.

#44: ANALYZING WELLBORE STABILITY TO SUSTAIN WELL INTEGRITY

Activity: Drilling and Completion

Challenge:

The focus of artificial intelligence has not evaded the difficulties faced in maintaining a stable wellbore while drilling due to complex lithology and abnormal pore pressure values. In many instances, these discontinuities and stressed conditions lead to many wellbore issues such as lost circulation, downhole kicks, wellbore leakages (drill string or casing), and even stuck-pipe situations.

Solution:

To assist in sustaining the well integrity, AI tools such as Artificial Neural Networks (ANNs) and fuzzy reasoning can be employed to analyze the stability of the designed / being-drilled wellbore in a particular in-situ stressed environment having a specific geological order and rock strengths, a definite hydrostatic and fracture gradient, assigned drilling fluid properties and distinct configuration of a drill string (parameters taken as input feed).

#45: AUTOMATED EVENT RECOGNITION IN DRILLING PROCESS

Activity: Drilling and Completion

Challenge:

Daily drilling reports (DDR) have been the source of truth for describing a detailed log of key operations and events occurring at the rig site; however, they are subject to human bias and use inconsistent text formats and terminology. With the inclusion of downhole sensors and telecommunication capabilities, there is a broad spectrum of real-time data collection processes during drilling and completion operations. The current challenge is to identify events from real-time data and derive insights to prevent non-productive time (NPT) and Invisible Lost Time (ILT).

Solution:

AI methodologies can be proposed to automatically identify and classify drilling events by detecting the changing trend of drilling parameters when the events happen. Drilling events are extracted from massive daily drilling reports (DDR) and real-time drilling databases using defined expert rules, thresholds, and criteria, as well as regression and classification methods. The objective of automated event recognition and classification is to pinpoint and rectify problems in the drilling process and within a time frame that enables optimum and safe drilling operation.

#46: AVOIDING DS VIBRATIONS TO OPTIMIZE DRILLING PROCESS

Activity: Drilling and Completion

Challenge:

Drillstring (DS) vibrations (axial, lateral, and torsional) are a frequent problem hindering smooth and optimum drilling conditions. The interaction of drill bit and Bottom Hole Assembly (BHA) with the borehole walls results in bit bounce, backward/forward whirl, and over-torqued joints, causing damaged BHA parts, increased non-productive time, and a significant decline in the drilling rate. However, monitoring drilling parameters influencing the growth of vibrations can help the driller improvise on base control parameters (RPM, WOB, TOB, etc.) as necessary to avoid vibration conditions, optimize the drilling procedure, and maintain the rate of penetration (ROP).

Solution:

An understanding of the interaction of various drilling parameters generating DS vibrations and the case-specific influence of different parameters in their intensification requires means of recognizing complex behaviors, patterns, and relationships between control parameters. This is where ANNs have been successful in the ROP modeling and predicting the behavior of control parameters towards the possible accumulation of vibrations. Introduction of control parameter (Surface and downhole RPMs, WOB, DS formulation, TOB, static and dynamic downhole friction components, formation UCS, Poisson ratio, and elastic modulus) values in a system trained to identify complex patterns to determine the probability of DS vibrations can not only be used to model the vibrations in well-planning phase but also to manage them in real-time and maximizing the ROP. The system can be trained by analyzing vibration data from historical cases or running simulations on an experimental setup.

#47: COMPUTER VISION FOR RIG LOCATION INSPECTION

Activity: Drilling and Completion

Challenge:

Drilling operations on land can cover large areas involving many rigs and industrial facilities. Monitoring and inspecting these locations can involve extensive amounts of travel, which is inefficient and could lead to problems being missed.

Solution:

Automate this monitoring and inspecting workload with the help of computer vision AI to recognize specific events and send reports to field managers, allowing them to assess whether a site inspection needs to be made. This technology can significantly reduce the need for time-consuming visits whilst maintaining high levels of vigilance across large-scale drilling operations.

#48: ESTIMATION OF DOWNHOLE CONDITION IN REAL-TIME

Activity: Drilling and Completion

Challenge:

Determining the state of the drilling system to optimize the drilling efficiency by evaluating the condition of the drilling components (drillstring, drill bit, surface equipment, mud, etc.) concerning the formation being drilled and control parameters (WOB, RPMs, and mud flow rate) in place (either real-time or modeled).

Solution:

A drilling equipment condition recognition tool that is based on the comparison and intelligent detection of the input data from a wide range of datasets and comparisons between the fed data and the information from previous case histories to estimate the downhole condition in real-time.

#49: ESTIMATION OF FRICTIONAL DRAG IN HORIZONTAL SECTIONS

Activity: Drilling and Completion

Challenge:

The induction of extensive friction torque can lead to grave issues such as unscrewed joints, broken or damaged bottom hole assembly (BHA) sections, or even helical buckling of the drill string, which might be complicated to unbuckle. Estimation of frictional drag in horizontal sections during the Well planning phase or even in real time before reaching the target section can help evade expensive trips to replace BHA tools or rectify a locked-up drillstring.

Solution:

The application of Artificial Neural Networks (ANNs) has proved helpful for accurately predicting frictional drag and drillstring contact force during slack-off load transmission. For example, a two-hidden-layer BPNN with adequate training can determine the bottom contact force and frictional drag as a function of radial clearance (between the string and hole wall), slack-off load, and bending stiffness drillstring, and other elasticity parameters.

#50: ESTIMATION OF MUD AND FLOW RATES DURING DRILLING

Activity: Drilling and Completion

Challenge:

A kick is an event where gas suddenly starts to seep in from the formation into the wellbore. As gas enters the wellbore, it starts ascending to the surface. The upward movement of gas shows up as the increased volume of mud at the surface, accompanied by increased mud flow rate out of the well. Kick is a dangerous event, and remedies to the aftereffects of such events prove to be expensive. Traditional alarm systems either suffer from many false alarms or are ineffective at identifying a kick accurately.

Solution:

The application of AI algorithms provides accurate estimates of mud volumes and flow rates during the drilling process. It also significantly reduces the frequency of false alarms. The earlier a kick is detected, the sooner the crew on the drilling rig can take necessary corrective actions.

#51: ESTIMATION OF PRESSURE LOSS OF DRILLING FLUIDS

Activity: Drilling and Completion

Challenge:

Pressure loss is an inevitable occurrence in every piping system due to friction, elevation changes, and turbulence caused by sudden changes in direction. Pressure loss calculation has always been an essential practice in Well control or drilling operations. In addition, inaccurate estimation of pressure losses can cause a variety of drilling difficulties, including inappropriate selection of required power supply and mud pump system, kicks, lost circulation, and stuck pipe. An accurate prediction of flow patterns (FP) leads to a reduction in formation damage, an increase in the rate of penetration (ROP), and production improvement.

Solution:

Utilize a Support Vector Machine (SVM) model to predict the pressure loss of fluids. Employ an MLP neural network model to estimate the pressure loss of drilling mud considering the liquid flow rate, yield stress, consistency index, flow behavior index, the eccentricity of the annulus, and diameter ratio as input parameters. Apply a General Regression Neural Network (GRNN) in estimating the pressure loss of drilling fluids. Employ RBF neural networks in estimating the FPL of two-phase drilling fluid in deviated wells.

#52: IDENTIFYING ROCK TYPE AT DRILLING BIT

Activity: Drilling and Completion

Challenge:

Directional oil well drilling requires high precision of the wellbore positioning inside the productive area. However, due to the specifics of engineering design, sensors that explicitly determine the type of the drilled rock are located farther than 15m from the drilling bit. As a result, the target area runaways can be detected only after this distance, which leads to a loss in Well productivity and the risk of the need for an expensive re-boring operation.

Solution:

Identifying rock type at the drilling bit based on AI classification methods and data mining on sensors readings to examine extra features coming from mathematical modeling of drilling mechanics. Use AI for identifying lithotype at the drilling bit based on MWD data.

#53: MONITORING OF DRILL BIT COMPATIBILITY WHILE DRILLING

Activity: Drilling and Completion

Challenge:

Rate of penetration (ROP) improvement is essentially related to keeping the drill bit parameters compatible with the formation geology and the borehole conditions. To enhance downhole bit hours and improve the overall ROP efficiency, it is crucial for the rig-site drilling engineers to make well-informed decisions based on a combination of both live well feed and offset well data.

Solution:

To achieve this, an Artificial Neural Network (ANN) bit usage optimization system can be developed to check bit compatibility with the formation and to manage control parameters based on real-time data to ascertain the maximum possible bit running length at the highest feasible drilling rate. Such a tool can help attain extended bit and BHA tool life and lesser NPT by reducing trips. The input rock, DS, and bit parameters for the tool development can be chosen based on the Well feed and offset log information on downhole lithology and conditions. The tool can be trained for the current bits' (selected during the planning phase) specific structure, material, geometry, and wear rate.

#54: OPTIMIZED SELECTION OF DRILL BITS

Activity: Drilling and Completion

Challenge:

Selection of drill bits for a particular drilling environment, whether a Polycrystalline diamond compact (PDC), roller cone, diamond insert, or a hybrid.

Solution:

Artificial neural networks (ANNs) can be used for decoding data, categorizing the empirical relationships and optimized bit selection based on a user-defined database that include the International Association of Drilling Contractors (IADC) bit codes for typical rock formations, rock strength data, geology, compaction characteristics and conventional ROP values corresponding to the rocks. Hence after the user input on the data, the ANNs can correctly learn the codes and numerical values and select the suitable bit.

#55: OPTIMIZING SELECTION OF SUITABLE WELL TO SIDETRACK

Activity: Drilling and Completion

Challenge:

Infill drilling refers to additional drainage locations selected in a later stage of the field development cycle to increase the well-reservoir contact area. The objective of infill drilling is to accelerate or improve recovery factors from wells, which might have bypassed oil and gas reservoirs in their drainage area. Selecting infill well candidates requires a careful analysis to verify, quantify, and locate such bypassed reservoir locations.

Solution:

AI methods can be developed to forecast production for potential sidetracks providing a set of criteria to select the most suitable well to sidetrack, leveraging all associated uncertainties and linking to stochastic economic analysis.

#56: OPTIMIZING SELECTION OF HOLE-CLEANING PROCEDURE

Activity: Drilling and Completion

Challenge:

The selection of feasible drilling procedures (underbalanced, overbalanced, jet drilling etc.) and submethods in terms of improved production, reduced costs, time saving and technical compatibility is always critical to the final well condition and requires in-depth consideration of many drilling parameters beforehand. One of such decisions is drilling in unconsolidated sandstone reservoirs (foam, air, or wash-back) to avoid the undesirable flow of loose sand particles into the well and cause the pump jamming.

Solution:

Applied case-based reasoning (CBR) to aid in the selection of the optimum hole-cleaning procedure in shallow unconsolidated sands. For reasoning model training, a database containing detailed information on production operations and well interventions is required.

#57: PREDICTING CEMENT PERFORMANCE IN WELL CONSTRUCTION

Activity: Drilling and Completion

Challenge:

Quality and performance of oilfield cement slurries can be estimated in terms of composition, particle size distribution, and thickening time (neat and retarded) using the Diffuse Reflectance Infrared Fourier Transform (DRIFT) spectrum of cement powders.

Solution:

Artificial neural networks (ANNs) for prediction on cements slurry performance. The base idea is to have a database that establishes an infrared spectrum of the cement powder as a signature of its behavior. The spectrum can then provide precise and refined information about the nature and state of the cement that is not provided in API tables.

#58: PREDICTION OF DIFFERENTIAL PIPE STICKING

Activity: Drilling and Completion

Challenge:

The stuck pipe has always been a worldwide concern in the drilling industry since it can cause extra costs and time to the drilling operations. Stuck pipe refers to a situation in which the drill string's movement or/and rotation is suddenly frozen or restricted. A severe stuck pipe case leads to the loss of the drill string or complete loss of the well. This occurrence is influenced by diverse parameters such as differential pressure, accumulation of cuttings, improper mud design, inappropriate drilling properties, and poor hole cleaning.

Solution:

Build a fuzzy logic-based model to predict pipe sticking considering various parameters such as initial gel strength, YP, PV, WOB, and RPM as the inputs parameters, and probability as the model output. Employ SVM and ANN algorithms to predict stuck pipe considering minimum WOB, nozzle size, initial gel strength, salt concentration, and temperature filtrate loss as input parameters. Employ an artificial probabilistic neural network (PNN) to predict the differential pipe sticking considering depth, differential pressure, filtrate viscosity, and hole size as input parameters.

#59: PREDICTION OF DRILLING FLUID PROPERTIES

Activity: Drilling and Completion

Challenge:

Drilling fluid or mud is one of the most important parts of a drilling operation. Drilling fluid is an oil-based or water-based fluid that plays several significant roles such as cleaning the bottom hole, transporting the cuttings to the surface, cooling down the bit and drilling pipes, lubricating the well, controlling the formation pressure to prevent from kick and blowout, and stabilizing the well. Hence, knowing the mud properties and its related issues is essential to drill a well successfully.

Solution:

Utilize the least-squares SVM (LSSVM) and MLP neural network models to calculate brine density considering concentration, temperature, and pressure as the input variables. Employ ANNs to predict the rheological properties of drilling fluid. Apply ANN and SVM techniques to predict the viscosity of non-Newtonian fluids. Employ a radial basis function (RBF) neural network to predict the mass flow using the levels from an ultrasonic scanning array. Apply SVM, FL, and ANN algorithms to estimate the fluid flow rate considering the time series of the levels from the array of ultrasonic level sensors as the input of the model.

#60: PREDICTION OF DRILLING RISK IN REAL-TIME

Activity: Drilling and Completion

Challenge:

Real-time drilling risk indication is a key factor in pre-estimating possible drilling incidents, determining their root causes, evaluating the level of risk associated, suggesting prevention or control measures, and modifying control parameters as necessary to evade the situation.

Solution:

Based on fuzzy or case-based reasoning method, a base comparison of real-time feed of data with the database reference sets and prompt indication on deflection between the actual and reference function values can estimate drilling risk in early time and even be applied for live downhole monitoring of control parameters. Even a base comparison with such reasoning system, having a vast database with a wide range of incident-prone values of control parameters (hook load, WOB, downhole torque, RPMs), can provide continuous average risk values with occasional peaks and compare it with maximum and minimum base references for accurate and reliable drilling risk detection.

#61: PREDICTION OF HOLE CLEANING EFFICIENCY WHILE DRILLING

Activity: Drilling and Completion

Challenge:

Hole-cleaning predictions in underbalanced drilling techniques (air drilling, foam drilling, etc.) are aimed to minimize formation damage, bit and stabilizer issues, and other drilling problems.

Solution:

Estimating hole cleaning efficiency in cutting concentration in the wellbore annulus can be made using back-propagating neural networks (BPNNs) or Multiple Linear Regression (MLR) methods as a function of parameters.

#62: PREDICTION OF LOST CIRCULATION IN DRILLING PROCESS

Activity: Drilling and Completion

Challenge:

Lost circulation is a significant problem encountered in the drilling process and is defined as the unwanted loss of the whole or a portion of drilling mud into a formation. This occurrence can lead to severe problems, including pipe stuck, formation damage, blowout, and wellbore instability, leading to an increase in time and cost of the operation.

Solution:

Utilize Artificial Neural Networks (ANNs) and GA to find the relations of parameters corresponding to lost circulation, to determine the optimum flow rate, pump pressure, and mud weight, respectively. Employ decision trees (DT), ANFIS, ANNs, and GA-MLP to predict the amount of lost circulation. Apply ANNs and SVM algorithms to predict the lost circulation solution in the case of both deviated and vertical wells considering mud weight, weight on bit (WOB), azimuth, loss rate, circulating pressure, and rate of penetration (ROP) as input parameters.

#63: PREDICTION OF FRACTURE GRADIENT

Activity: Drilling and Completion

Challenge:

Drillers must, as far as possible, avoid kicks, wellbore instability, and loss of circulation through fractures, usually by selecting an appropriate mud weight. Knowledge of formation pore pressure and fracture gradient is essential for selecting a safe range of mud weights.

Solution:

The Neural Network GRNNs can be trained to predict the approximate gradients as a function of depth, overburden gradient and Poisson ratio. The neural network model takes all this data as input and plots the predicted fracture gradient for the data set.

#64: PREDICTION OF RATE OF PENETRATION (ROP) IN DRILLING

Activity: Drilling and Completion

Challenge:

Drilling rate or rate of penetration (ROP) is a measurement of a drilling operation efficiency. Drilling time and costs are highly affected by ROP. To improve drilling efficiency, ROP should be optimized. ROP depends on many factors such as WOB, formation type, bit type, and RPM.

Solution:

Employ LSSVM to predict the rate of penetration (ROP) considering measured depth, bit size, mud weight, flow rate, standpipe pressure, rotary torque, RPM, and WOB as input parameters. Utilize random forest algorithms to predict the ROP. Employ PSO-MLP and PSO-RBF models to predict ROP considering WOB, RPM, shear wave velocity, pore pressure, pump pressure, pump flow rate, gamma-ray, and density log as input parameters.

#65: PREVENTING STUCK PIPE EVENTS DURING DRILLING

Activity: Drilling and Completion

Challenge:

In specific scenarios during the drilling operations, the drill pipe may get stuck inside the wellbore. Once the drill pipe gets stuck, drilling operations are put on hold until a remedy is performed. Stuck pipe problem is one of the biggest contributors to non-productive time during drilling operations.

Solution:

To predict the nonlinear behavior surrounding the stuck pipe events, artificial neural networks optimized by particle swarm optimization algorithm have shown high accuracy in predicting the possibility of a stuck pipe event ahead of time. Predictions obtained from this AI approach, together with sound engineering judgments, have the potential of preventing stuck pipe events.

#66: REDUCTION OF NPT IN DRILLING

Activity: Drilling and Completion

Challenge:

There are three types of sensors in modern drilling. First are the sensors on the surface that record the mechanical parameters of the drilling process in real-time. Second are the logging-while-drilling (LWD) sensors, recording physical parameters of the formation behind the drilling bit. Third are mechanics-while-drilling (MWD) sensors recording mechanical data from the bottom hole assembly. All the sensors generate a time series that can be used to manage the drilling itself and update the oilfield's geological or reservoir model.

Solution:

With the development and implementation of AI-aided drilling support systems working with real-time drilling telemetry for making the drilling process faster, safer, and more precise, you may expect a significant reduction of the non-productive time down to 20–40% on average, with a considerable decrease in failures down to 90%.

#67: DETECTION OF DRILL BIT DEFECTS

Activity: Drilling and Completion

Challenge:

The physical inspection of the drill bits by providing drill bit wear analysis and defects detection is time-consuming and expensive, so there's a need to optimize the drill bits condition monitoring process.

Solution:

Apply AI and visual recognition algorithms to detect drill bit defects in the images captured by the cameras and provide recommendations on required drill bit replacement and maintenance. The algorithms preprocess an image and analyze it to recognize blades a, singleut individual cutters, asand Employ object detection neural network relying on the Hough Circle Transform method to identify cutters. A convolutional neural network can be applied for image recognition, used to perform cutter state classification, and a separate Mask R-CNN, an algorithm for object instance segmentation, applied to perform blades' surface segmentation and detect blade surface defects. The results of the analysis can give wear percentage and recommend an optimal date for drill bit replacement.

#68: DETECTION OF FAULTS IN PIPELINE SYSTEMS

Activity: Production Engineering

Challenge:

Pipelines are the most economical and efficient means of oil and natural gas transportation over long distances in different environments; however, they are subjected to corrosion and degradation. Pipeline accidents result in vast economic losses as well as catastrophic environmental effects such as oil spills. Natural hazards, mechanical, operational, corrosion, and third-party activities are the most probable causes of oil pipeline failure.

Solution:

An ANN to locate and detect the leaks in liquified gas pipelines based on the pressure and flowrates at the inlet and outlet of the pipeline. Apply ANNs to classify the pipe weld defects using magnetic flux leakage signals. ANNs to detect faults in pipeline systems based on stationary and nonstationary status. Utilize the FL model to predict the rate of corrosion regarding T, flowrates of gas and liquid, pH, P, and CO_2 partial pressure. Use SVM with Artificial Bee Colony (ABC) to detect leaks in pipelines. Employ the ANN and FL techniques to predict pipe failure based on the type of product carried by the pipeline, land use, pipeline age, pipeline location, and pipeline diameter. Develop an MLP network trained through the ICA algorithm to predict the drag reduction in petroleum pipelines as a function of temperature, type of pipe, Reynolds number, and type and concentration of drag-reducing agents (DRAs).

#69: ESP FAILURES PREDICTION USING PCA APPROACH

Activity: Production Engineering

Challenge:

The electrical submersible pump (ESP) is widely used for artificial lift, making it critical to ensure continued oil production from the wells. Despite being among crucial equipment in the upstream operations, ESPs exhibit significantly high failure rates. These failures are often random and result in lost oil production from the wells. It is estimated that ESP failures lead to hundreds of millions of barrels of lost or deferred oil production each year.

Solution:

A principal component analysis (PCA) approach is used to detect ESP failures and predict the remaining useful life of the equipment before failure by using complete historical data. Combining these predictions from the AI-based models with engineering principles to detect problems with ESPs, long before they occur and prescribing preventive actions can have a significant economic impact.

#70: OPTIMIZATION OF GAS-LIFT PROCESSES

Activity: Production Engineering

Challenge:

Gas lift works by injecting gas into the Well tubing through gas lift valves to reduce the hydrostatic pressure on the fluid column below the fluid pressure in the reservoir formation.

Solution:

Utilize ANNs and GAs to predict the efficiency of long-time gas-lift processes. Employ GAs to optimize the gas-lift allocation problem considering the instability phenomenon as a constraint. Employ SVM technique to optimize the natural gas lift process.

#71: OPTIMIZATION OF OILFIELD DEVELOPMENT PLAN

Activity: Production Engineering

Challenge:

It is challenging to evaluate an oilfield development plan's performance with one production index due to the mutual influence of technical, economic, and social indicators in the adjustment and optimization of that plan.

Solution:

AI applications in developing plan optimization mainly improve production or its rate with the consideration of economic factors. The most used method for oilfield developing plan optimization is the Artificial neural network (ANN) and the genetic algorithm (GA) models. Combining geological background, historical matching, dynamic monitoring, and economic benefit to optimize dynamic development plan.

#72: OPTIMIZING PRODUCTION OPERATIONS IN REAL-TIME

Activity: Production Engineering

Challenge:

The objective of production optimization is to manage and ensure asset goals profitably using all available information up to that point to predict outcomes with confidence and to make decisions that produce optimal results and implement such decisions until the next decision-making point in time.

Solution:

The increasing availability of real-time downhole measurements and remotely activated valves in the oilfields has made field-wide operations optimization in real-time a distinct possibility. With more real-time data and measurements, it's possible to build AI models, which could be updated with the availability of new data to optimize production in real-time.

#73: OPTIMIZING SELECTION OF OPTIMAL COMPLETION PARAMETERS

Activity: Production Engineering

Challenge:

Completion is a term to indicate the hardware deployed inside the wellbore to ensure production lifting from the reservoir to the wellhead. Optimal completion strategy requires the proper understanding of reservoir potential and the production requirements (i.e., rate targets and wellhead pressure). Traditionally, production engineering models, such as nodal analysis Well models, are good enough to provide accurate predictive performance relationships for successful completions.

Solution:

In the cases of unknown well failure or uncertain reservoir phenomena, data-driven models provide much better predictions than pure engineering models. AI methods assist operators in selecting optimum completion parameters, which have a positive effect on production and are advantageous to lower unit costs, such as stage intensity, plug-and-perforate cemented-well designs, injection rate, and proppant mass per lateral foot, and fluid volume per lateral foot.

#74: PREDICTION OF CASING COLLAPSE OCCURRENCE & DEPTH

Activity: Production Engineering

Challenge:

Well integrity is a crucial aspect that must be maintained through the lifecycle of a well, and one component of which, the casing, must be able to withstand all the internal and external loads. These loads include the invariable factors in the geothermal environment, such as high-temperature, high-strength rock, highly-fractured formation, corrosive fluid, and under-saturated pressure. Thus, in the casing construction process of setting depth and design of a geothermal production well, these factors needed to be taken into account based on the environment where the Well is located to ensure that casing collapse does not happen.

Solution:

A back-propagating (BP) network of user-defined number of internal (hidden) layers can be connected to input and output layers to provide an 'experienced' estimate on casing collapse depth for the wells to be drilled. The data layer can have a number of inputs such as location, depth, pore pressure, corrosion rate, casing strength, etc., to analyze and provide feed on expected collapse depth and probability of casing collapse.

#75: PREDICTION OF ESP LIFESPAN

Activity: Production Engineering

Challenge:

Electric submersible pump (ESP) repairs are a costly issue. Identify the key drivers behind ESP failures and determine if they could predict an ESP's lifespan accurately.

Solution:

Use predictive model techniques such as linear regression, decision trees, and high-performance random forests (HP Forest). The best prediction model is the HP Forest model, which can predict ESP lifespans within approximately five days. The top variables of importance when predicting ESP lifespan are metrics related to ESP shutdowns.

#76: PREDICTION OF MULTIPHASE FLOW RATES

Activity: Production Engineering

Challenge:

Several sensors can provide measurements of temperature and pressure downhole a well. The problem is how oil, gas, and water flow depends on these measurements: i.e., the function that describes the multiphase flow rates.

Solution:

Capture the thermodynamics and fluid dynamics of the multiphase flow of oil, gas, and, water from the production well to generate lots of simulated training data for an AI model. By generating large amounts of training data from the physics-based model, we can teach the AI model the physics of the problem. A trained AI model can use just the sensor measurements from the physical Well, i.e., pressures and temperatures, to predict the oil, gas, and water rates simultaneously. More importantly, it can make these predictions within a fraction of a second, making it ideal for running on real-time data from the production wells.

#77: PREDICTION OF PRESSURE GRADIENT IN WATER-OIL PIPELINES

Activity: Production Engineering

Challenge:

The precise determination of the pressure gradient parameter is complex because it results from the frictional effects between fluids and pipe wall and the interfacial effects between the fluids themselves.

Solution:

Employ LSSVM and the RBFNN models to predict the pressure gradient in water-oil pipelines considering oil and water slip velocity, pipe diameter and roughness, and oil viscosity as input variables.

#78: PREDICTION OF PRODUCTION INDEX

Activity: Production Engineering

Challenge:

Production dynamic analysis methods (oilfield numerical simulation method, characteristic curve method, production decline method, material balance method, analogy method, empirical formula method, chart method, etc.) have been applied in oilfield production for years. However, they still have apparent limitations due to complex factors affecting the production index dynamic prediction.

Solution:

Combining a neural network with a fuzzy logic algorithm to accurately predict production index to reach an excellent fitting accuracy, with static and dynamic production data involved.

#79: PREDICTION OF PRODUCTION POTENTIAL OF NEW WELLS

Activity: Production Engineering

Challenge:

During the field development planning, reservoir engineers use data from the existing wells. Based on the analysis of data from existing wells, they may decide the placement of new wells. Specifically, this is a standard practice in the development of unconventional oil and gas resources. The challenge is to predict the production potential of that new proposed wells.

Solution:

One such approach used dimensionality reduction by applying principal component analysis (PCA), followed by regression methods to predict the production potential of new proposed wells. The analysis based on AI methods has also demonstrated the capability of uncovering hidden patterns, which are not easily noticed in a high-dimensional space. By identifying these patterns, it's been shown that the wells expected to behave similarly can be identified. Further analysis can reveal common properties of wells exhibiting similar behavior, the underlying reasons for poor performance in the Wells not behaving satisfactorily, and measures to avoid similar poor performance in the new wells.

#80: PREDICTION OF TWO-PHASE IPR IN VERTICAL WELLS

Activity: Production Engineering

Challenge:

Well Inflow Performance Relationship (IPR) has many applications in both applied and theoretical sciences, especially in petroleum production engineering. For example, an accurate prediction of well IPR is crucial to determine the optimum production scheme, design production equipment, and artificial lift systems.

Solution:

Employ GP and ANN techniques in predicting the two-phase IPR in vertical wells considering flowing bottom hole pressure, average reservoir pressure, maximum oil flow rate, bubble point pressure, oil formation volume factor, solution gas-oil ratio, and gas viscosity as the inputs of the models and oil flow rate as the output.

#81: PREDICTION OF WAX DEPOSITION THICKNESS

Activity: Production Engineering

Challenge:

Wax deposition is a significant problem in the oil and gas industry that can lead to catastrophic situations such as oil production reduction, pipeline plugging, and formation damage. Wax precipitation is a concern in crude oil and gas condensate fields when the temperature falls below a specified temperature known as wax appearance temperature.

Solution:

Employ ANN, CSA-LSSVM, RBFNN, or ANFIS techniques toward predicting the amount of wax precipitation considering oil composition and SG, pressure, and temperature of the system as input parameters. ANNs to predict the wax disappearance temperature (WDT) considering molar mass and pressure as input variables. Utilize ANFIS and ANN techniques to predict the wax deposition thickness as a function of Reynolds number, wax content, oil and pipeline temperature, and deposition time. Employ RBF-ANN and LSSVM-CSA techniques, respectively, to predict the wax deposition rate.

#82: PREVENTION OF JUNKED WELLS

Activity: Production Engineering

Challenge:

Junked wells were mainly caused by maintenance activities that went wrong, leaving running tools, wires, plugs, and other materials abandoned and often jammed in the well. Failures often occurred in tubing or casing due to corrosion, erosion, thermal stress resulted in the collapse of casing which could lead to flooding of wells. Junked wells also frequently occurred when the wells were converted from producers to injectors. Mobile rock formations such as salts and shales were some of the likely causes, too.

Solution:

Data from well logs, tubing stress analysis and service providers profile can be fed into AI algorithms to produce accurate models to predict the probability of encountering junked wells before any decisions to convert the wells from producers to injectors. This approach may help oil companies and service providers to better arrive at decisions to prevent junked wells from taking place.

#83: PREVENTION OF WELL CLOGGING

Activity: Production Engineering

Challenge:

Detecting when Wells is about to clog or predict Well events can lead to costly production deferrals or safety concerns.

Solution:

AI models can be developed by combining physics-based modeling with specific sensor data to recognize patterns that indicate the beginning of clog in the wells, allowing engineers to intervene before any real risk occurs.

#84: PUMPS PREDICTIVE MAINTENANCE

Activity: Production Engineering

Challenge:

Many of the pumps, including electric submersible pumps, pumps for injection wells, hydraulic fracturing, and other Well treatment pumps, are equipped with a high number of sensors measuring pressures, temperatures, vibrations, flow rates, etc.

Solution:

AI applications for various pumps to implement predictive maintenance and select the optimal operation regimes concerning operational costs vs. production. There are many examples when an entirely data-driven or a hybrid model containing physics-driven and data-driven math helps optimize the regimes, prevent unexpected failures, and save on maintenance-on-schedule.

#85: WELL TREATMENT RECOMMENDATION

Activity: Production Engineering

Challenge:

The investments to the costly well treatment campaigns are always at high risk because of two things. The first relates that physics-driven models for predicting the Well treatment produce very rough estimates due to the lack of precise knowledge of the near-wellbore formation's physical properties. The second relates to the experts' bias in figuring out the final selection of the Well treatment procedures for a particular set of wells.

Solution:

There is an excellent opportunity to reduce the investment risks by accumulating data from already produced well treatment jobs and then predicting the efficiency of hydraulic fracturing jobs and AI-based analysis of injectivity issues. Also, the development of algorithms based on optimization math and programming will enable full-scale recommending systems. The recommending systems will help select the particular well treatment design for a specific Well and plan the Well treatment campaigns.

#86: PREDICTING VALVE FAILURES IN RECIPROCATING COMPRESSORS

Activity: Production Engineering

Challenge:

The reciprocating compressor is one of the most widely used compressor technologies in today's oil and gas industries. It can compress various gases and has a wide range of applications, high compression efficiency, and stable working pressure. However, due to its complicated structure and many vulnerable parts, it will bring huge losses once a failure cannot be detected and eliminated in time.

Solution:

A modern Reciprocating compressor has installed sensors. They take periodic readings of the compressors' physical properties, including motor winding temperatures, compressor vibrations, and pressure and temperature for both suction and discharge at various compression stages. Utilize shapelets methodology and multivariate time series classification algorithm to find patterns that capturing differences between sensor data related to normal valve function versus failed valve function, considering valve sensor time series data as an input parameter. Also, you can employ a fault diagnosis model based on a one-dimensional convolutional neural network (1DCNN). This method takes the differential pressure and differential temperature of each compressor stage as the input of 1DCNN, using the characteristics of the CNN to extract the features and finally using Softmax to classify the fault.

#87: AI-ENABLED INTERNET OF THINGS (IOT) TO DRIVE SMART ACTIONS

Activity: Process Optimization

Challenge:

IoT is helping in capturing a tremendous amount of data from multiple sources. However, wrapping around the multitude of data coming from countless IoT devices makes it complex to collect, process, and analyze the data.

Solution:

AI-enabled IoT creates intelligent machines that simulate smart behavior and supports decision-making with little or no human interference. While IoT deals with devices interacting using the internet, AI makes the devices learn from their data and experience. As the data delivered from the sensor can be analyzed with AI, businesses can make informed decisions.

#88: PAPERLESS PROCESS AUTOMATION

Activity: Process Optimization

Challenge:

Manual processes such as paperwork, written processes, printed forms, and manual documentation, consume vast amounts of time from skilled critical staff.

Solution:

AI can carry out that manual paperwork with minimal oversight. As a result, it can free up scientists and engineers to make the most of their specialist skillset.

#89: PROCESS AUTOMATION TO DETECT PRODUCTION RISKS

Activity: Process Optimization

Challenge:

A Well may not be able to operate and produce satisfactorily. Identifying such Wells and performing interventional and remedial activities (also called workover) to bring the Well performance to satisfactory levels has shown significant economic impact. Expert systems have been used in the oil and gas industry for decades, with processes ranging from data integration and cleansing over problem detection to ranking candidates according to production gains, costs, risk, and net present value.

Solution:

AI and reasoning tools like Bayesian Belief Networks can be used to detect production risks with likelihoods of occurrence for various problems in wells, reservoirs, or facilities. These systems assist in differentiating root causes and prioritizing different countermeasures at hand. Furthermore, these screening logics work as a repeatable and automated process, which can be scheduled or can be executed on demand.

#90: AI-ENABLED PROCESS MINING

Activity: Process Optimization

Challenge:

In times of global economic challenges, when resources are limited and time puts pressure, it is vital to keep drilling and workover operation processes under control and operate fast and efficiently.

Solution:

Leverage AI algorithms to mine upstream industry processes and understand the actual processes in detail. Process mining can provide the fastest time to insights about as-is processes. It helps oil and gas companies understand what's going on inside their organization. Process mining helps identify bottlenecks and creates full transparency on business processes. Thus, analyzing workflows with process mining is the ideal solution to address both efficiency and risk-related problems.

#91: OPTIMIZATION OF OFFSHORE PLATFORM SELECTION

Activity: Asset Planning

Challenge:

Selecting an offshore platform requires qualified decision-making based on many different factors such as location, water depth and depth of the Well, expected production rates and costs, operator experience, and anticipated weather and tidal conditions.

Solution:

Employ back-propagating (BP) artificial neural networks for deepwater floating platform selection. An approach for case-specific selection of best suited offshore units using nonlinear back-propagating neural networks (BPNNs) with multiple input nodes and one processing (hidden) layer encompassing five model functions (technology maturity, field development time, cost, operator experience, and risk involved).

#92: RECOMMENDATION SYSTEM FOR FACILITIES PLANNING

Activity: Asset Planning

Challenge:

The application of facilities planning is based on a human knowledge model based on data and facts from historical and current oilfield conditions. There's no implementation of an artificial mental model to recommend the best scenario of optimizing facilities to achieve a production target.

Solution:

Deploy an AI recommendation model that helps recommend the best scenario of planning an optimized network of facilities that can achieve a production target by leveraging the current capacity design and actual production of the interconnected facilities.

#93: AI-ENABLED BLOCKCHAIN FOR DATA INTEGRITY

Activity: Data Management

Challenge:

There is no such thing as a perfect data storage system. As soon as someone begins to store data, whether it's on a spreadsheet, Word document, or hard drive, errors will inevitably creep in. Yet, the consequences of this lapse in data integrity can be far greater than a simple data error, with the potential to cause serious harm to the assets of the upstream industry.

Solution:

By using Blockchain and AI to verify the accuracy of data sets independently, oil and gas companies will have more control over their data. As data integrity becomes more critical, it will be essential to verify the accuracy of data used in AI systems. Blockchain and AI will be crucial to developing these technologies, allowing us to control our data.

#94: DATA MINING AND PATTERNS RECOGNITION

Activity: Data Management

Challenge:

Millions of dollars were spent on collecting, cleaning, and storing data from vast numbers of sources that left oil and gas companies with a large volume of data that they do not know what to do with.

Solution:

AI can help by automating the collection, connection, and cross-reference rules necessary to refine that significant volume of data into recognizable patterns. Those patterns can then provide insight for the same critical staff to make more informed decisions at crucial times.

#95: INFORMATION EXTRACTION FROM DIGITIZED DOCUMENTS

Activity: Data Management

Challenge:

Geoscientists spend a lot of time sifting through past drill and Well log data and seismic data to discern where they might find more oil and the structures of the rocks in which it might be located. This work is time-consuming and involves a variety of geoscience specialists whose time is limited.

Solution:

Digitizing documents and turning them into a searchable database could save hundreds of thousands on each research session and drive real revenue by discovering new oil fields faster. A search function based on natural language processing (NLP) and machine vision could make this possible. In addition, after the documents are digitized and organized in the digital database, an AI-based Information extraction tool could help geoscientists find new locations to drill based on past geolocation data the oil and gas company can access.

#96: AI-ENABLED CHATBOT FOR BETTER DECISION

Activity: Information Technology

Challenge:

Queries might involve prioritizing infill drilling locations, finding optimal well spacing. Then, autonomously run a quick modeling exercise to detect nuances such as well-to-well interference patterns.

Solution:

To avoid potential interference with an offset operator's development plan, an AI-enabled chatbot could suggest drilling a specific section sooner than planned. There are other benefits like 24/7 availability and reduced costs, as chatbots can handle more tasks as they learn more. In addition, Chatbots can understand more complicated queries as AI algorithms improve.

#97: AI-ENABLED CYBERSECURITY FOR DATA SECURITY

Activity: Information Technology

Challenge:

The digital oilfield depends more on technology than ever before. A massive amount of critical data is generated and gathered by implementing booming technologies like the Internet of Things (IoT) and cloud computing. Although data can be used to serve the oilfield needs better, cyber-attacks often pose major challenges.

Solution:

AI techniques involving machine learning and deep learning methods, natural language processing, knowledge representation and reasoning, and knowledge or rule-based expert systems modeling can be used to solve the cybersecurity issues in the oil and gas industry. The security intelligence modeling based on AI methods can make the cybersecurity computing process more efficient and intelligent than conventional security systems.

#98: AI-ENABLED PROJECT MANAGEMENT BOT

Activity: Information Technology

Challenge:

As oil and gas companies increase in size and complexity and work from home culture, a solution is needed to manage and coordinate an entire organization's portfolio of different projects. These solutions help the management shuffle between plans, workload, budgets, scope change, and resources, carefully monitor project progress and report on delivery success and lessons learned. Additionally, organizations' increased focus to promote collaborations among the workforce and boost the team's efficiency also drives the market growth.

Solution:

Deploy an AI-enabled user-friendly bot for Project Management in the upstream industry, also applicable in any industry. This solution can remove excessive information and noise, enabling project managers to focus on the most relevant and important information to derive actionable insights and strategies, ensuring that project managers are always up to date with global trends and best practices. For example, employ this AI Bot to provide estimates of the cost, duration, resource requirements for project activities based on subject matter experts and lessons learned from previous projects while ensuring no compromise on safety and quality. Also, the bot can suggest corrective action based on historical data and continuously track progress to warn the project manager when risk arises.

#99: AI-ENABLED AUGMENTED REALITY

Activity: Information Technology

Challenge:

Qualification of employees who operate technological processes directly influences the safety of production. However, the employees' qualifications cannot wholly exclude the human factor. Today, there are many technologies that can minimize or eliminate human factor impact on production safety ensuring.

Solution:

Augmented reality is an example of AI-enabled technology. The effectiveness of using augmented reality technology for servicing oil pumps provided that there is a complete description of all the actions that must be performed during maintenance. Visualization using AR gives a significant reduction in the time spent on servicing one unit of pumping equipment. Connecting to an expert through AR offers excellent results in emergencies and beyond the scope of the instructions. Expert help with AR will significantly increase the overall performance.

#100: COMPUTER VISION & PREDICTIVE ANALYTICS FOR HSE

Activity: Information Technology

Challenge:

Operations on the oilfields are risky for personnel as there are several risk factors, including heavy equipment, non-covered rotary equipment, high pressure, high-temperature operations, and aggressive chemicals. Employees in oilfields work under different temperatures, are sometimes exposed to toxic fumes, and must be aware of many moving mechanisms. Not following proper safety protocols can result in injury and financial penalties.

Solution:

Pattern recognition utilizing deep learning or computer vision on video streams recorded with cameras helps to alarm if an employee is not adequately dressed for the particular set of operations or not following safety procedures. And AI predictive analytics algorithms can alarm operators on the equipment's health state, enabling pro-active actions to prevent a catastrophe with the consequences to health, safety, and environment (HSE).

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