Current trends in Artificial Intelligence (AI) Application to Oil and Gas Industry

Authors *Marco Cocchi – Researcher – Campus Bio-medico University of Rome*
Leone Mazzeo – Researcher – Campus Bio-medico University of Rome

1 Introduction

In recent years, artificial intelligence (AI), in its many integrated flavors from neural networks to genetic optimization to fuzzy logic, has made solid steps toward becoming more accepted in the mainstream of the oil and gas industry.

On the basis of recent developments in the field of Oil & Gas upstream, it is becoming clear that petroleum industry has realized the immense potential offered by intelligent systems. Moreover, with the advent of new sensors that are permanently placed in the wellbore, very large amounts of data that carry important and vital information are now available.
To make the most of these innovative hardware tools, an operator intervention is required to handle the software to process the data in real time. Intelligent systems are the only viable techniques capable of bringing real-time analysis and decision-making power to the new hardware.

An integrated, intelligent software tool must have several important attributes, such as the ability to integrate hard (statistical) and soft (intelligent) computing and to integrate several AI techniques. The most used techniques in the Oil and Gas sector are:

- **Genetic Algorithm (GA)**, inspired by the biological evolution of species in natural environment, consists of a stochastic algorithm in which three key parameters must be defined:
    1. Chromosomes, or better, vectors constituted by a fixed number of parameters (genes).
    2. A collection of chromosomes called genotype, which represents the individuals of a population.
    3. The operations of selection, mutation, and crossover to produce a population from one generation (parents) to the next (offspring).
- **Fuzzy Logic (FL)** is a mathematical tool able to covert crisp (discrete) information as input and to predict the correspondent crisp outlet by means of a knowledge base (database) and a specific reasoning mechanism. To achieve such goal, the crisp information is firstly converted into a continuous (*fuzzy*) form, secondly processed by an inference engine and at least re-converted to a crisp form.
- **Artificial neural network (ANN)** is constituted by a large number simple processing units, characterized by a state of activation, which communicate between them by sending signals of different weight. The overall interaction of the units produces, together with an

external input, a processed output. The latter is also responsible of changing the state of activation of the units themselves.

The techniques described above have been adopted in the Oil and Gas field since 1989. Relatively to O&G industry, Figure 1 shows the number of applications of AI.

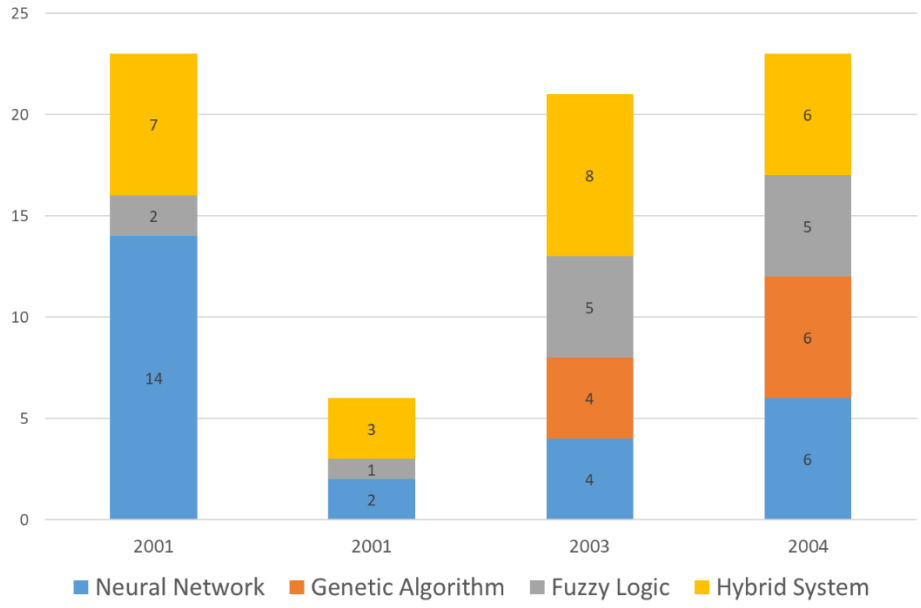

Figure 1 Artificial intelligence (AI) applications in the Oil and Gas industry during the years.

In the following sections some of the application of AI in the O&G sector will be analyzed with a particular focus on the *Drilling operation* (Exploration & Production).

2 AI applications in Oil and Gas industry

2.1 Exploration & Production (E&P) sector

Most of the resources in the Oil and gas field is centered in drilling operation in which artificial intelligence finds natural application. Drilling success and safety are related to an accurate prediction of the likely performance of different factors such as:

- Pre-drilling settings (rig, logistics and associated drilling risks)
- Drilling equipment (casing and tubing pipes, drilling mud)
- Downhole machinery behavior (vibrations, torque limits)

The development of models, implemented by AI systems, permits to avoid the necessity of disposing of real-time data and to produce smart outcomes in order to quickly re-establish optimum operating conditions.

An example of AI application in the exploration and production (E&P) sector, is in the ***well planning*** phase. The following Figure 2 resumes all the steps of well planning in which AI was adopted.

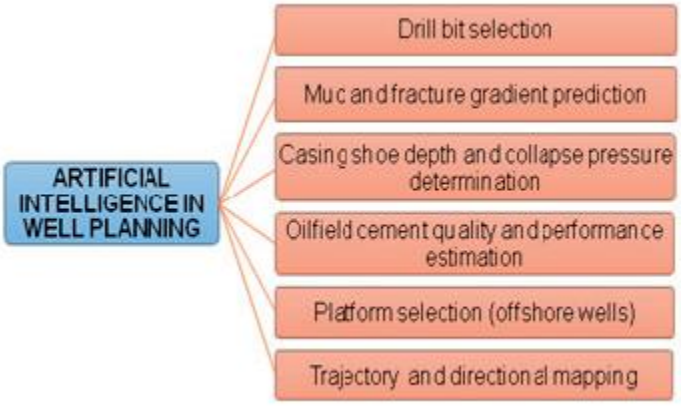

Figure 2 Potential applications of AI in well planning sector[1]

Relatively to the *selection of Drill bits*, trained artificial neural networks (ANNs) have been used: they are able to suggest the best drill bit to select (roller cone, diamond insert or a hybrid) analyzing a user defined database. The latter should include information relative to the IADC bit codes correlated with specific geological data.

Neural and network system (commonly GRNNs) gave accurate results in the *prediction of mud the fracture gradient*. As input parameters to the model, the depth of the well, the overburden gradient and the Poisson ratio must be provided. It is important to keep in mind that the results will strictly depend upon the range of the data set, and that extrapolations may loss in accuracy.

In the planning stages of a well, drilling engineers are responsible for the establishment of the different depths at which the well must be cased to ensure an overall desired perforation depth. To avoid *casing collapse*, a neural network approach adopting a BPNN based spreadsheet program can be used. Back-propagating neural networks (BPNN) are constituted by a defined number of "layers". Each layer is interconnected with the other: in particular, the input layer is connected with hidden layers which are in turn connected to the output layer. This neural net, provided of an historical well archive, is fed (input layer) with specific data of the well under consideration (i.e. location, depth, casing strength). Furthermore, the BPNN is able to estimate an "experienced" casing case probability.

[1] https://www.degruyter.com/downloadpdf/j/jaiscr.2015.5.issue-2/jaiscr-2015-0024/jaiscr-2015-0024.pdf

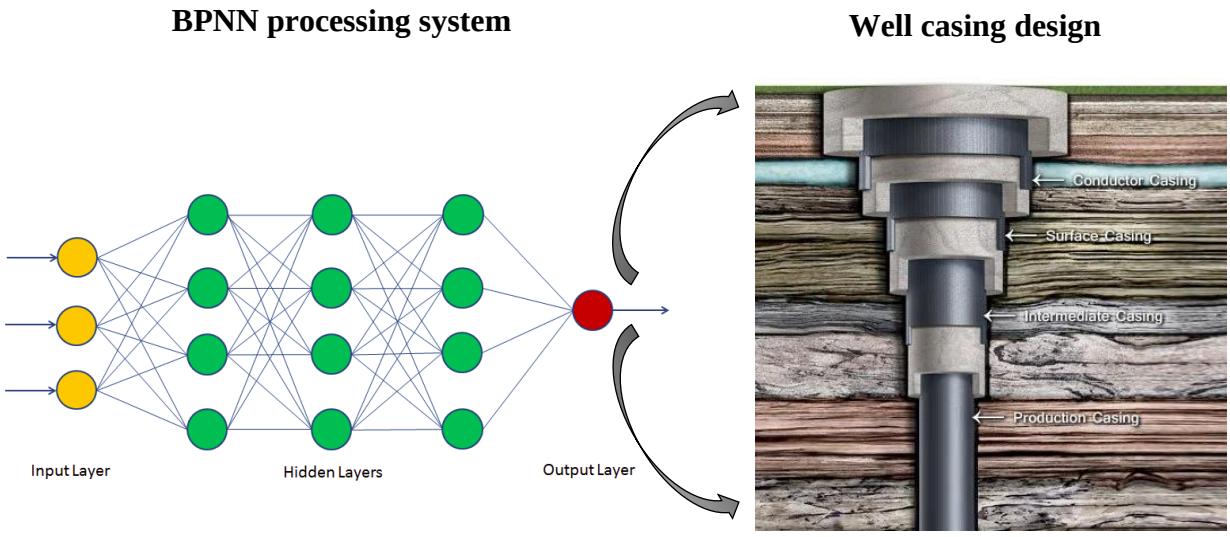

Figure 3: An BPNN graph showing the hidden layers interconnection and well casing structure designed by BPNN

Another example of AI application is given by the ***real time drilling optimization*** in which artificial intelligence system are adopted to improved monitoring of downhole parameters optimizing the drilling operation. The following Figure 4 resumes all the steps of real time drilling optimization in which AI was used.

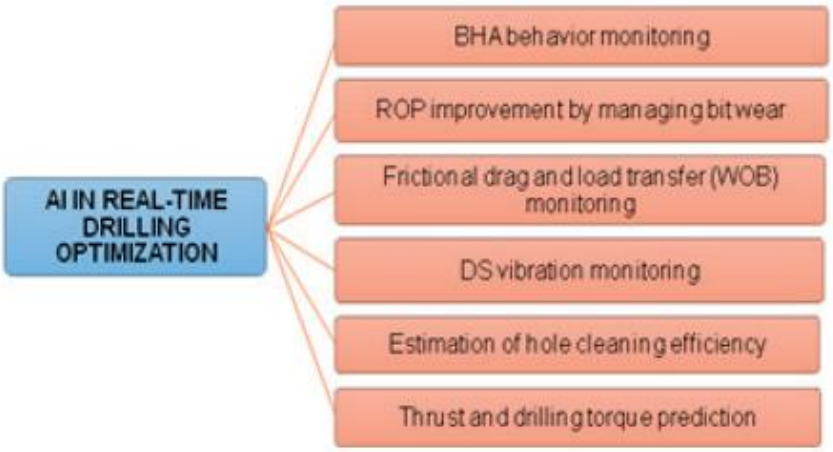

Figure 4 Important applications of AI in drilling optimization

A crucial real-time operation is the Estimation of ***hole cleaning efficiency*** in terms of *cutting concentration*. During the drilling process, the wellbore is filled with many rock fragments (cuttings) generated by the mechanical action of the drill bit. In order to remove those cuttings from the well, a drilling fluid, or drilling mud, is pumped from the drill bit and exits from the wellhead: the cuttings are lifted and carried on the top of the well. According to this, the cutting

concentration (expressed as a %) is the residual amount of rock fragments into the well after the cleaning action of the mud (Figure 5 gives a visual idea of the situation described). Inefficient removal of the drilled cuttings may lead, in some severe cases, to the loss of the well due to stuck pipe.

For the estimation of the hole cleaning efficiency, artificial feed-forward neural network with back-propagation (BPNN) can be used. As input to the model all the parameters which affect the cutting concentration must be given. The latter are divided in specific parameters of the drilling (rate of penetration, inclination angle of the wellbore) or in parameters regarding the rheology conditions of the mud (viscosity, density). As it is shown in the FIG below, the implemented model is consistent in the prediction of the cutting concentration.

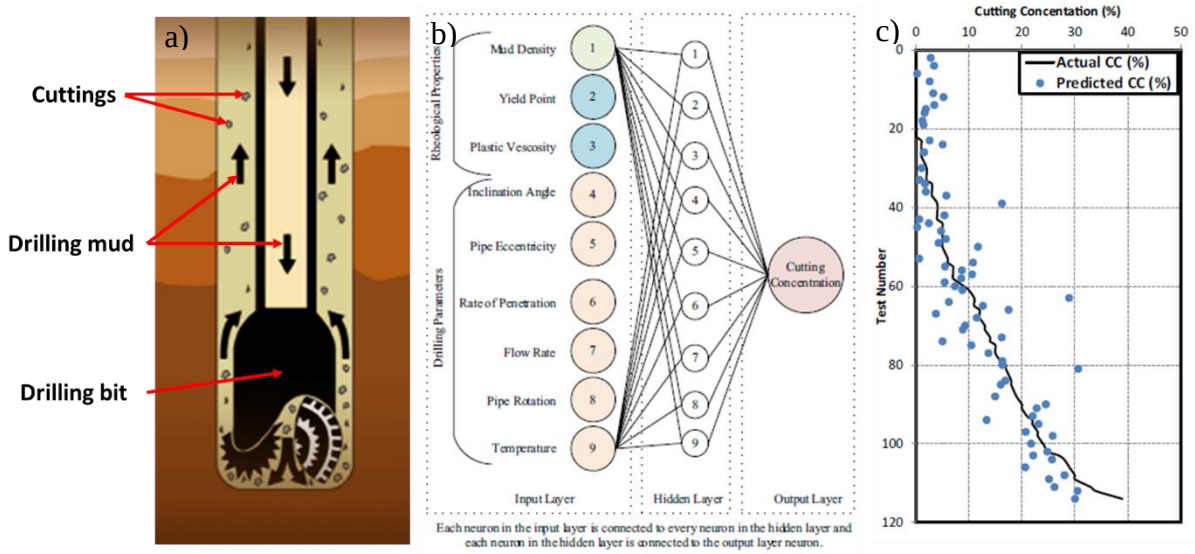

Figure 5 A sketch of the removal of cutting during drilling operation (a); artificial neural network and results of the prediction of the cutting concentration (b)-(c)[2].

2.2 Economical applications

In recent years several tools were developed for the prediction of crude oil price that, as it is known, is characterized by a complex behavior and subjected to many variations. Since the business plan of Oil companies is highly influenced by such price oscillation, the interests among this topic are rapidly increasing and have determined the introduction of AI methods for prediction purposes.

In one case, or example, the West Texas Intermediate (WTI) crude oil price was monitored and predicted by the implementation of a Genetic Algorithm (GA). As it is shown in Figure 6, which takes under consideration the time period between May 2008 to December 2011 (44 months), the oscillating trend of WTI crude oil price, expressed in $ per barrel, was reproduced. However, the predicted values have a mean absolute error of about 11%.

[2] Al-Azani, K., Elkatatny, S., Ali, A. et al. Cutting concentration prediction in horizontal and deviated wells using artificial intelligence techniques. J Petrol Explor Prod Technol 9, 2769–2779 (2019) doi:10.1007/s13202-019-0672-3

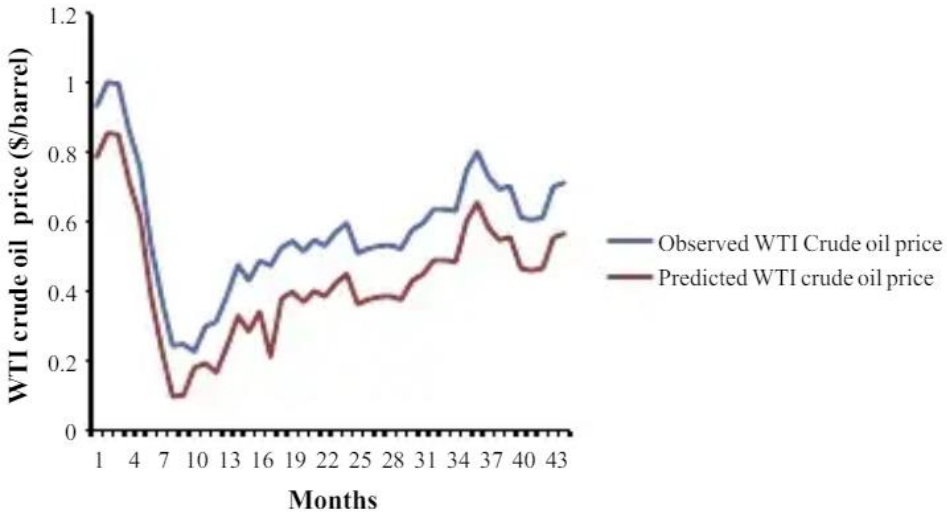

Figure 6 Comparison between observed and predicted WTI crude oil prices[3].

3 Conclusions and future trends

During this article, several applications of AI were explained and the potential of such applications was understood. Even though some of predicted results in the field of Oil & Gas sector are still affected by errors (see Figure 6), AI is considered a promising technology that will play a key role in future of Oil and Gas. According to "Value Global"[4] the market of AI in O&G will reach a value of $2.85 billion by 2022, and, according to "Mordor Intelligence"[5], such value will rise at a CAGR (Compound Annual Growth Rate) of 12.14% till 2024.
Big players of the Oil & Gas industry are already investing in AI in the fields of:

- **Exploration.** *ExxonMobile* is working together with the *Massachusetts Institute of Technology* (MIT) to develop self-learning submersible robots for ocean exploration. AI will allow the robots to change their behavior depending on their mission parameters.
  A similar project, conducted by *ENI*, led to the realization of "Clean Sea" a subsea exploration robot for offshore asset inspection[6].

[3]https://www.academia.edu/13035176/Evolutionary_Neural_Network_model_for_West_Texas_Intermediate_crude_oil_price_prediction
[4] http://www.valueglobal.net/artificial-intelligence-is-powering-the-future-of-oil-and-gas
[5] https://www.mordorintelligence.com/industry-reports/ai-market-in-oil-and-gas
[6] https://www.eni.com/en_IT/innovation/technological-platforms/safety-and-the-environment/clean-sea.page

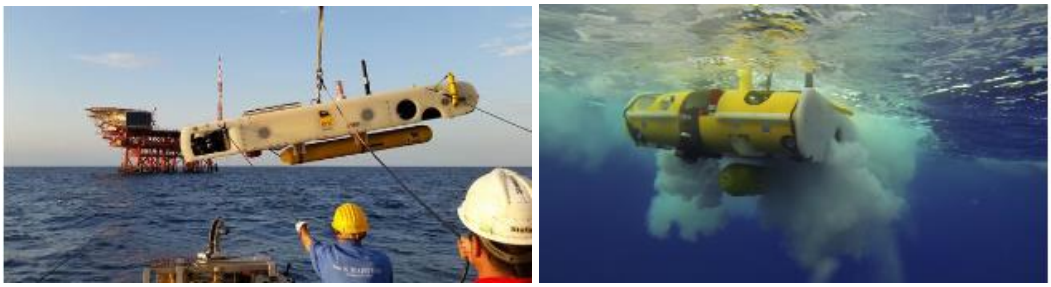

Figure 7 Clean Sea Robot Technology Developed by ENI

- **Extraction** *Royal Dutch Shell PLC*, one of the first company to integrate AI in Oil & Gas equipment, invested around $1billion in AI obtaining a boost of the extraction productivity[7].

[7] https://blogs.wsj.com/cio/2018/09/20/shell-announces-plans-to-deploy-ai-applications-at-scale/