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USING THE CHAOTIC GENETIC ALGORITHM METHOD TO PREDICT OIL WITH AN APPLICATION

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Abstract:

Interest in the area of prediction has risen in recent years, leading to the development of advanced and contemporary methods, namely artificial intelligence techniques. Among these methods is the chaotic genetic algorithm, which has proven its quality in this regard, as the chaotic genetic algorithm expands the search space due to its strength and effectiveness in solving many complex nonlinear optimization problems. Our current study aims to shed light on the chaotic genetic algorithm method in predicting future oil production and prices in Iraq. The results showed that the chaotic genetic algorithm (CGA) method performs much better than the genetic algorithm (GA) method in terms of accuracy, reducing the number of iterations in optimization problems, and avoiding local convergence to reach the optimal level in predicting Iraqi oil until the year 2035.

Keywords: Chaotic genetic algorithm, chaotic sequence, slowly convergence, Local level, prediction.

Introduction

Oil is the main source of national income for many countries in the world, and occupies an increasingly important strategic place in the world. Oil stands out as one of the most significant discoveries of the twentieth century, emerging as the primary source of energy and a cornerstone of modern industrial production. It is irreplaceable and integral to contemporary industry. Iraq, with its substantial reserves, is a leading oil producer, holding a prominent position among both Arab and global oil-producing nations. The oil sector is a crucial pillar of the Iraqi economy, serving as a major foundation for national economic development. Despite the great potential that was enhancing Iraq's ability to become one of the richest countries, wars and conflicts have left severe traces of suffering and poverty. Currently, institutions in Iraq rely on artificial intelligence to make

administrative decisions, with the aim of predicting strategic plans that may affect the short, medium, or long term. [2]

Predicting future behavior is a crucial topic in statistical science because it plays a significant role in the future planning of a country's economic sectors. Many researchers have proposed several methods for predicting oil to increase the accuracy of performance. Among these methods are traditional statistical methods that included (Box-Jenkis) models and moving average models (ARIMA), multiple regression, exponential smoothing models, Bayesian estimation models, as well as intelligent methods such as artificial neural network (ANN) technology. These methods were characterized by weak appropriateness, so it is difficult to predict oil using these methods. Our current study highlights the use of a chaotic genetic algorithm in predicting future oil production in Iraq until 2035 to obtain more accurate and highly efficient results. [5]

Reference review: Given the great importance of forecasting using advanced methods, we list some studies that addressed the subject of the current study, as follows:

- A study was conducted (Xiaohui et al, 2002) examined the use of a chaotic genetic algorithm for short-term generation scheduling in hydropower systems. The study introduced an integration of chaotic sequences and genetic algorithms with a novel self-propagating error backpropagation operator. This new approach addresses the limitations of previous methods, enhancing convergence. Simulation results demonstrated that the chaotic genetic algorithm is both feasible and effective for practical applications. [14]
- The study (Wenchuan et al, 2009) used the Muskingum flood channelization model as a common flood control method for planning and managing water resources. Parameter estimation is a global optimization challenge focused on determining the optimal values for model parameters. To enhance the accuracy of flood routing, the Hybrid Chaotic Genetic Algorithm (HCGA) was introduced, which combines chaotic sequences with genetic algorithms to estimate parameters for the Muskingum model. Experimental results demonstrated that the HCGA significantly outperforms other methods, delivering superior results in practical tests. [12]
- The study (2018, Milad et al) aimed to develop a hybrid model for image encryption. This model incorporates a chaotic genetic algorithm. Initially, the method generates several encrypted images using the original image and a chaotic function. In the subsequent stage, these encrypted images serve as the initial set for the genetic algorithm. The results of experiments carried out using chaotic genetic algorithms in image encryption were of a high level of accuracy. [13]

Genetic algorithm: [6][9][11]

Algorithms are a series of sequential mathematical and logical steps to solve a specific problem. Recently, researchers have used algorithms inspired by nature and their development to solve and improve many complex engineering and mathematical problems in their research to obtain the best solution. There are many algorithms inspired by nature, and each algorithm has its own advantages and method of use. Among these algorithms is the genetic algorithm, which is considered one of the first algorithms to appear, and the basis of its work is by applying random variables and dealing with them. Genetic algorithms are used to take advantage of their speed in giving results and bypassing many stages in the solution that cannot be bypassed using other traditional methods to reach the optimal solution. The Genetic Algorithm (GA), or as it is called the Genetic Algorithm, is embodied in the technique of improving the inputs provided by researchers based on the algorithm's working mechanism, as Holland, in 1970, was the first to develop this algorithm, and its goal is to survive for the best, that is, it is considered the engine for creating the best solution or solution. optimum.

Chaotic genetic algorithm: [1][3][4]

The Chaotic Genetic Algorithm (CGA) is an effective tool for tackling nonlinear and complex optimization problems. Its core principle involves mapping the problem variables from the solution space to the chaotic space, and then conducting a search for solutions based on three key properties of chaotic variables: randomness, efficiency, and regularity. The genetic algorithm (GA) faces two main issues: slow convergence and the tendency to get stuck at local optima. These problems arise because maintaining the original population under selective pressure can reduce diversity, resulting in many initial solutions being weak and far from optimal. To address these issues, chaos sequencing has been combined with the genetic algorithm to improve performance and overcome these limitations, including the challenge of properly selecting mutation probabilities. The Chaotic Genetic Algorithm (CGA) operates similarly to the Genetic Algorithm (GA), but with a key difference: the length of the solution chains in CGA is variable, unlike the fixed-length chains in GA. The fundamental concept behind integrating chaotic mechanisms into the genetic algorithm is to enhance the optimization process. By combining chaotic optimization with the genetic algorithm, the Chaotic Genetic Algorithm (CGA) improves the selection of control parameters and initial values for the population. This integration reduces the randomness inherent in traditional genetic algorithms and simultaneously enhances convergence and local optimization. The CGA effectively leverages chaotic selection, crossover, and mutation to achieve these improvements.

Figure (1) shows a flowchart of the chaotic genetic algorithm. [7]

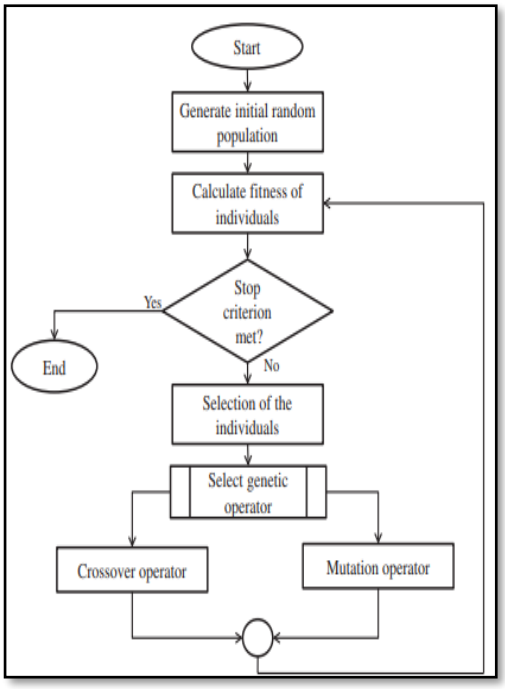

Figure 1: Shows a flowchart of the chaotic genetic algorithm.

Steps for making a chaotic genetic algorithm: [10][8]

The Chaotic Genetic Algorithm (CGA) operates similarly to the Genetic Algorithm (GA), but differs in that the length of the solution chains (or strings) is variable rather than fixed. This algorithm is also employed to tackle challenging problems due to its increased efficiency and effectiveness. It operates within a flexible system that can represent and solve problems with solution chains of varying lengths, as each chain can contain different genes. The program generates short chains that serve as partial solutions to the problem, evaluates their fitness early in the genetic algorithm process, and retains the genes that achieve above-average fitness. The fitness is above

average, after which the algorithm continues its normal operation by transitioning from one solution to another during the first epoch. As the process progresses, the length of the chains increases until the full length of the solution chains is achieved.

The steps for making a chaotic genetic algorithm are as follows:

1. **Initialization:** In the initialization step of the algorithm, the variables are determined for which the optimal values are to be found or to represent the available solutions that are being processed. After specifying the required variables, the first solution from the set of solutions is found.
2. **Identifying the individual:** It is a set of initial solutions that are randomly generated in a certain size depending on the nature of the problem, which is used to conduct the chaotic genetic algorithm process.
3. **Intersection:** After finding the first solution in the initialization step, the process of exchanging properties takes place between two new solutions that have common properties from the initial solutions.
4. **Mutation:** Mutation is implemented by replacing one or more solutions that are randomly selected among the new solutions that were generated through the crossover process.
5. **Chaos:** In this phase of the chaotic genetic algorithm, the final set of new solutions is determined using chaotic methods. The genes in the solution are selected, with each gene being set as an initial value in the function. This process generates a series of chaotic values for each gene, which are then used as genes for new solutions. By employing chaos, multiple solutions can be produced in each iteration.
6. **Selection:** After generating new sets of solutions through crossover, mutation, and chaotic processes, all the data are consolidated. The best solutions are then selected to determine the next set of solutions.
7. **Evaluation:** The final step in the chaotic genetic algorithm is evaluation. The algorithm's stopping criteria are checked, which may include elapsed time, number of iterations, or achieving the desired cost value. In this work, the number of iterations is used as the stopping criterion.

Result Discussion:

A chaotic genetic algorithm was applied as a nonlinear model according to the following relationship:

$$m(x_i) = a * \frac{e^{b*x_{1i}}}{g*x_{2i}} + d * \sin(\epsilon * x_{2i}) \quad \dots (1)$$

Whereas:

$m(x_i)$: It represents the output of the chaotic genetic algorithm, which is the export of Iraqi oil.

$(x_{2i}، x_{1i})$: The input to the chaotic genetic algorithm represents (prices and production) of Iraqi oil.

The parameters of the chaotic genetic algorithm were estimated and as shown in Table (1) the values of the estimated parameters of the chaotic genetic algorithm.

Table (1) Values of parameters estimated using the chaotic genetic algorithm.

e	d	c	b	a	Parameter
0.52185	0.16244	2.7565-	0.37922	0.083725-	Estimation using chaotic genetic algorithm

We note in Table (1) that $(0.083725 * e^{0.37922x_{1i}})$represents the exponential effect of oil production on exports, which reflects how oil production can lead to a nonlinear increase in oil exports, while the term $(\ ^{1}/_{2.7565x_{2i}})$ represents the nonlinear effect of prices, as the effect of prices on exports can be increasingly less when prices rise, while the term (0.16244*sin($0.52185x_{2i}$) represents the fluctuation in oil prices on exports, which reflects how exports can be affected by price fluctuations. The values of (MSE=0.5708421), (MAPE=0.8904147) for the chaotic genetic algorithm were also obtained.

Table (2) Main information of the chaotic genetic algorithm.

50	**Number of solutions**
100	**Number of courses**
0.1	**Mutation probability**
0.8	**Crossover probability**

We note in Table (2) that the number of solutions was (50) solutions as an initial set and that the value of the number of solutions greatly affects the performance of the algorithm. The large size may lead to greater diversity in the solutions, which increases the chance of finding better solutions, but it requires more time in calculation. The small size speeds up the calculation process but reduces diversity. We also note that the number of cycles for the algorithm was (100) cycles in which the set of solutions is improved through the process of selection, hybridization and mutations. Each cycle consists of a set of solutions that are evaluated based on specific criteria, and the importance of the number of cycles lies in improving the solutions.

We also note that the mutation probability in the algorithm was (0.1), which indicates the value that determines the probability of a random change occurring in one of the solutions in each round. Mutations are an essential part of the search process because they add diversity to the solution set. Thus, the importance of mutation probability can be in increasing diversity as it helps introduce new changes in the solutions, which enhances the diversity in the set. It also helps in exploration as it allows the algorithm to explore new areas of the solution space, which may lead to finding better solutions.

The probability of intersection refers to the value that determines the probability of merging two solutions from each cycle, which contributes to improving solutions and helps in enhancing diversity by producing new solutions and thus helps in improving the overall performance of the algorithm, which produces solutions that outperform the initial solutions. Table (3) Expected values for predicting Iraqi oil (2023-2035).

Table (3) Future forecast values for Iraqi oil exports (2023-2035).

Years	Predicting Iraqi oil export values using CGA method
2023	2.495264
2024	1.948857
2025	1.438789
2026	1.079145
2027	0.929686
2028	0.979885
2029	1.172803
2030	1.427569
2031	1.666114
2032	1.831839
2033	1.899258

2034	1.873383
2035	1.781657

Conclusions:

We conclude that the CGA method is excellent for solving a wide variety of complex and nonlinear optimization problems. The results also showed that the CGA method performs much better than the GA method in terms of accuracy, reducing the number of iterations in optimization problems, and avoiding local convergence to reach the optimal level in predicting Iraqi oil until 2035.

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