Data Article

Data on optimization of the Karun-4 hydropower reservoir operation using evolutionary algorithms

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A B S T R A C T

This article describes the time series data for optimizing the hydropower operation of the Karun-4 reservoir located in Iran for a period of 106 months (from October 2010 to July 2019). The utilized time-series data included reservoir inflow, reservoir storage, evaporation from the reservoir, precipitation on the reservoir, and release of water through the power plant. In this data article, a model based on Moth Swarm Algorithm (MSA) was developed for the optimization of water resources. The analysis showed that the best solutions achieved by the MSA, Genetic Algorithm (GA), and Particle Swarm Optimization (PSO) were 0.147, 0.3026, and 0.1584, respectively. The analysis of these datasets revealed that the MSA algorithm was superior to GA and PSO algorithms in the optimal operation of the hydropower reservoir problem.

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1. Data

Water is a vital resource for socio-economic development in many parts of the world. Reservoir operation is an essential element in water resource planning and management. In the present study, Karun-4 hydropower reservoir operation is considered in terms of careful water demand management. The time series meteorological and hydrological dataset consists of reservoir inflow, reservoir storage, evaporation from the reservoir, precipitation on the reservoir, and release of water through the power plant for a period of 106 months (from October 2010 to July 2019). The utilized data are shown in Fig. 1.

Reservoir inflow is the volume of water inflow to the Karun-4 reservoir, which is measured in million cubic meters (MCM). Reservoir storage is a volume of water storage of the Karun-4 reservoir at the beginning of each period, which is expressed in MCM. Evaporation from the reservoir is a depth of evaporation from the area of the Karun-4 reservoir at each period, which is expressed in millimeter (mm). Precipitation on the reservoir is a depth of precipitation in the area of the Karun-4 reservoir at each period, which is expressed in millimeter (mm). The release of water through the power plant is a volume of water outflow from the power plant of the Karun-4 reservoir at each period, which is expressed in MCM.

Fig. 2 shows the location of the Karun-4 dam in the Karun basin. Table 1 gives the main characteristics of the Karun-4 dam reservoir. Table 2 displays the values of used algorithms parameters for the hydropower operation problem. Table 3 describes the objective value of objective functions and the average CPU run time obtained by each algorithm for the Karun-4 hydropower reservoir problem. Fig. 3 represents the convergence rate of applied algorithms in reaching the optimum value for 1000 iteration. Fig. 4 depicts the water release pattern for the operation of the Karun-4 hydropower...
reservoir for a period of 106 months (from October 2010 to July 2019). Finally, Fig. 5 shows the water storage pattern for the operation of the Karun-4 hydropower reservoir for this period.

2. Experimental design, materials and methods

In this data article, using the time-series dataset, a model based on Moth Swarm Algorithm (MSA) was developed for optimal hydropower operation of the Karun-4 Reservoir. The details of the MSA algorithm were provided by Mohamed et al. (2017) [1]. The MSA algorithm was compared with other well-known developed evolutionary algorithms, including GA and PSO algorithms [2–4]. It is noteworthy that all the studied metaheuristic algorithms were coded in MATLAB software.

2.1. Experimental design

The simulation optimization model for producing a time-series dataset of the highest amount of energy of the Karun-4 reservoir was structured in a monthly time step during the period 2010–2011 to 2018–2019. Objective functions and constraints of the Karun-4 reservoir are as follows:

\[
\text{MinF} = \sum_{t=1}^{T} \left( 1 - \frac{P_t}{PPC} \right)
\]

\[
P_t = g \times e_t \times \left( \frac{RP_t}{PPF} \right) \times \left( \frac{\bar{H}_t - TW_t}{1000} \right)
\]

\[
\bar{H}_t = (H_t + H_{t+1}) / 2
\]

\[
H_t = a_0 + a_1 S_t + a_2 S_t^2 + a_3 S_t^3
\]
Fig. 2. Location of the Karun-4 dam in the Karun basin (southwest of Iran).

Table 1
Main characteristics of the Karun-4 dam reservoir.

| Parameters                        | Unit          | Value    |
|-----------------------------------|---------------|----------|
| North latitude                    | Degree (°)    | 31° 35'  |
| East longitude                    | Degree (°)    | 50° 24'  |
| Minimum reservoir storages        | MCM           | 1405     |
| Maximum reservoir storages        | MCM           | 2279     |
| Power plant capacity (PPC)        | MW            | 1000     |
| Annual potential energy production| MWh           | 2107     |
| Efficiency                        | Percent (%)   | 80       |
\[ TW_t = b_0 + b_1 \text{Re}^\text{Power}_t + b_2 \left( \text{Re}^\text{Power}_t \right)^2 + b_3 \left( \text{Re}^\text{Power}_t \right)^3 \]  

(5)

\[ RPS_t = \text{Re}^\text{Power}_t - \text{RP}_t \]  

(6)

\[ 0 \leq P_t \leq \text{PPC} \]  

(7)

\[ S_{t+1} = S_t + Q_t - \text{Re}^\text{Power}_t - S_{P_t} - \text{Loss}_t \]  

(8)

\[ \text{Loss}_t = (E_{vt} - R_t) \times \overline{A}_t / 1000 \]  

(9)

\[ \overline{A}_t = (A_t + A_{t+1}) / 2 \]  

(10)
\[ A_t = c_0 + c_1.S_t + c_2.S_t^2 + c_3.S_t^3 \]  

(11)

\[ S_{\text{min}} \leq S_t \leq S_{\text{max}} \]  

(12)

where \( P_t \) is the electricity produced by the power plant (MW), PPC is the total power plant capacity (MW), \( T \) is the total number of hydropower operation periods of the Karun-4 reservoir. In addition, \( g \) is gravitational acceleration, \( e_t \) is efficiency of the Power plant, PF is the plant factor, \( RP_t \) is the water release through the power plant to generate power (MCM) in period \( t \), \( Mult \) is conversion factor from million cubic meters to cubic meters per second during period \( t \), \( H_t \) and \( H_{t+1} \) are reservoir water level at the beginning and end of period \( t \) (m), respectively, \( TW_t \) is reservoir tail-water level, which is assumed constant for all periods during period \( t \) (m), \( Re_{\text{Power}} \) is water release through the power plant (MCM) in period \( t \), \( RPS_t \) is the overflow volume through the power plant in period \( t \) (MCM), \( S_t \) is the reservoir storage (MCM), \( Q_t \) is the reservoir inflow (MCM), \( Sp_t \) is the spill overflow from the reservoir during period \( t \) (MCM), \( Loss_t \) is the loss from reservoir (MCM), \( Ev_t \) is the depth of evaporation from the reservoir (m), \( R_t \) is the depth of precipitation on the reservoir (m), \( A_t \) and \( A_{t+1} \) are area of the reservoir lake at the beginning and end of period \( t \) (Km²), respectively, \( S_{\text{min}} \) is the minimum storage (MCM), \( S_{\text{max}} \) is the maximum storage capacity (MCM), and \( a_i, b_i, \) and \( c_i \) are the coefficients of the Storage-Area-Depth relationships for the reservoir.

### 2.2. Analysis of datasets

The analyses of this data article showed that the best solution achieved by the MSA, GA, and PSO algorithms for the Karun-4 hydropower reservoir problem were 0.147, 0.3026, and 0.1584, respectively. The analyses revealed that the MSA algorithm was the superior algorithm in the optimal operation of the Karun-4 hydropower reservoir.

All analyses of this research for each algorithm are presented in Table 3 and Figs. 3–5.
Data availability statement

All datasets, models, or codes generated or used during the article are available from the corresponding author by request.

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**Fig. 4.** Water release patterns of applied algorithms in the Karun-4 hydropower reservoir. The figure shows the water release pattern for the operation of the Karun-4 hydropower reservoir using the MSA, GA, and PSO algorithms. The MSA algorithm was able to store and generate more energy by water releasing less for a period of 106 months. This indicates the high capability of the MSA in calculating near-optimal global solutions.

**Fig. 5.** Water storage patterns of applied algorithms in the Karun-4 hydropower reservoir. The figure shows the water storage pattern for the operation of the Karun-4 hydropower reservoir using the MSA, GA, and PSO algorithms. According to this figure, the storage of the reservoir obtained by the runs of the investigated algorithms is better than the actual storage. Also, the figure shows the superior performance of the MSA algorithm compared to other algorithms.
Conflict of Interest

The authors declare that they have no known competing for financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.105048.

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