University of Tabriz

Journal of Civil and Environmental Engineering
Volume 51 (2022), Issue 4 (Winter), 31-43

EXTENDED ABSTRACT

Optimum Design of Water Distribution Networks Utilizing Optimization Krill Herd Algorithm

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Received: 29 August 2018; **Accepted:** 21 May 2020

Keywords:
Metaheuristic algorithm, Hydraulic constraints, Matlab, Epanet.

1. Introduction

An effective way to achieve an economical design of water distribution networks (WDNs) is to utilize the metaheuristic optimization algorithms profited by swarm intelligence. In this research, Krill Herd (KH) Optimization algorithm was applied to obtain the optimum design of water distribution networks (WDNs). For this purpose, the KH algorithm was linked with EPANET hydraulic software (Rossman 2000) in MATLAB. The capital cost was considered as the objective function in Kadu and Khorramshahr WDNs herein. The obtained optimum design cost for two WDNs was compared with the solutions published using other approaches.

2. Methodology

2.1. Objective function

The overall objective function was formulated as:

$$\text{Minimize: } C_t = \sum_{i=1}^{N_i} c(D_i, L_i) + \vartheta * \left(\sum_{j=1}^{N_j} v(P_j) + \sum_{i=1}^{N_i} v(V_i)\right) \tag{1}$$

Where $v(V_i)$ and $v(P_j)$ are penalty functions for violation of velocity and pressure constraints, respectively, and ϑ is the violation factor. Herein C_t is computed with calibrated $\vartheta = 100{,}000{,}000$, and penalty functions are considered as below:

$$\text{If } P_j > P_{max} \quad \rightarrow v(P_j) = Max\,(0, P_j - P_{max}) \tag{2}$$

$$\text{If } P_j < P_{min} \quad \rightarrow v(P_j) = Max\,(0, P_{min} - P_j) \tag{3}$$

$$\text{If } V_i > V_{max} \quad \rightarrow v(V_i) = Max\,(0, V_i - V_{max}) \tag{4}$$

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If $V_i < V_{min} \quad \rightarrow v(V_i) = Max\,(0, V_{min} - V_i)$ (5)

2.2. KH algorithm

The Krill herd algorithm performs based on the herding behavior of krill individuals (Gandomi & Alavi, 2012). The position of an individual krill at each time is governed by three factors involves movement induced by other krill individuals, foraging activity and random diffusion. A sensing distance (ds) should be considered around each krill individual to find the neighbors (Fig. 1). The main steps of the KH algorithm are as follows:

I) Defining the problem and KH parameters and initial krill herd population, etc.
II) Evaluating all krill individual fitness based on its current position.
III) Calculating motion for each krill based on the position of other individuals, foraging motion and physical diffusion.
IV) Implement the mutation and crossover operators.
V) Updating the krill individual position in the population.
VI) Going to step III and repeating the steps until termination criteria are met.

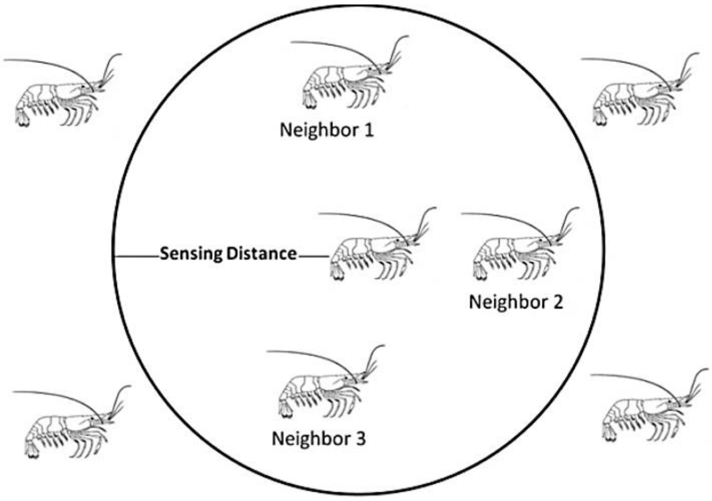


Fig. 1. A schematic of the swarm krill individual behavior in typical decision space

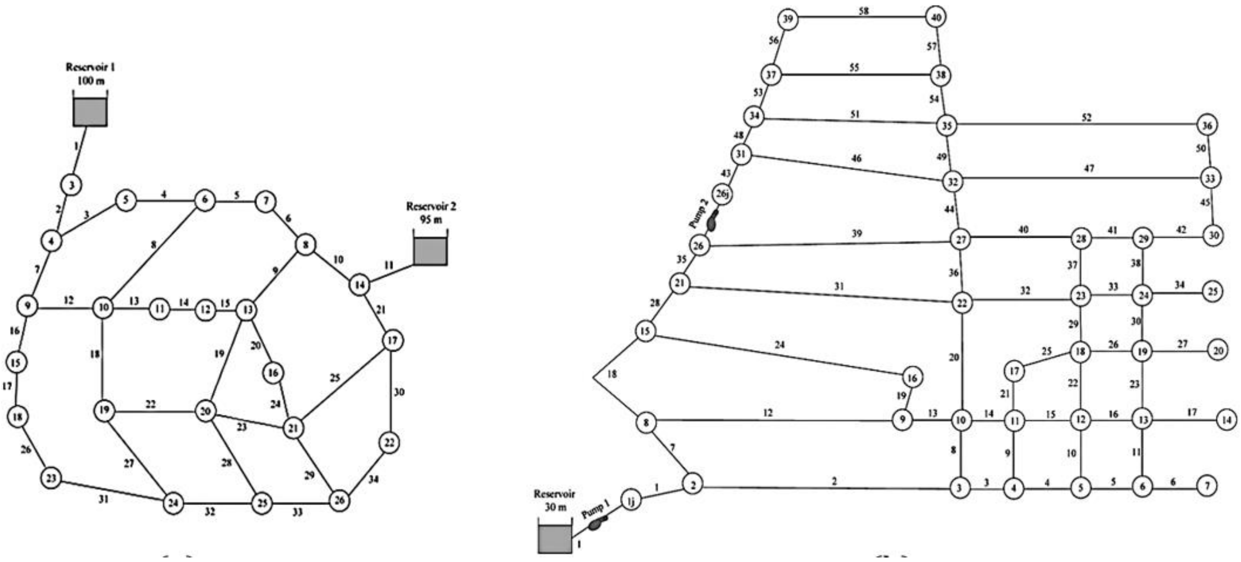


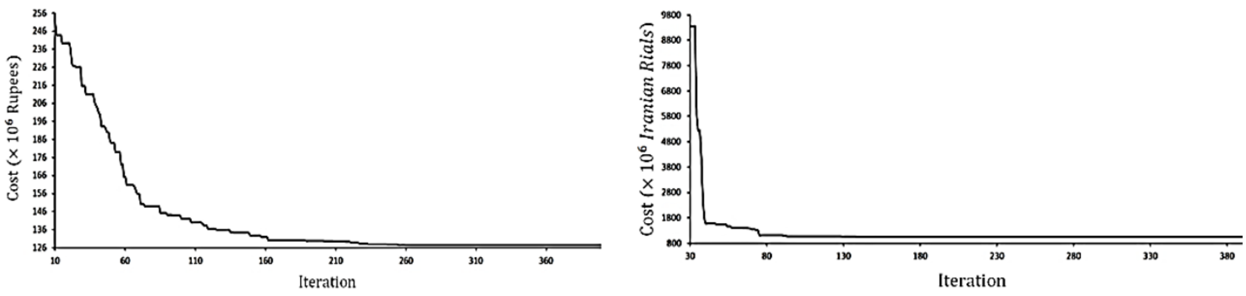
Fig. 2. Studied Networks: a) Kadu Network design, b) Khorramshahr Network design

2.3. Studied Networks

The Kadu Network is a looped WDN (Fig. 2-a) fed by two reservoirs. Further information and hydraulic constraints about the Kadu network could be found in Kadu et al. (2008). Also, the Khorramshahr network (Fig. 2-b) is a looped WDN with two booster pumps. Further information about this network could be found in Samani and Zanganeh (2010). Hydraulic constraints and further information about this network could be found in Samani and Zanganeh (2010).

3. Results and discussion

The convergence behavior of the KH methods to optimize pipes design in Kadu and Khorramshahr networks are shown in Fig. 3-a and 3-b, respectively (Regarding the huge amount of the initial 9 iteration cost values in Kadu network and initial 29 iterations in Khorramshahr network, it is decided not to show them in this figure). Here in the calibrated KH parameters are as $N_{pop} = 170$, $C_t = 0.005$, $V_f = 0.002$, $D_{max} = 0.02$, $N_{max} = 0.02$ and $\mu = 0.02$. The Comparison of the KH results for these two networks with those obtained using other optimization techniques in the literature is presented in Table 1 and Table 2.



(a) (b)

Fig. 3. Convergence behavior of KH for Studied Networks: a) Kadu network, b) Khorramshahr network

Table 1. Comparison of the solutions of Kadu network

Authors	Kadu et al. (2008)	Haghighi et al. (2011)	Moghadam et al. (2013)	Present work
Method used	GA	GA-ILP	PSO	KH
Cost (Rupees)	131,678,935	131,312,815	130,666,043	127,330,855
Evaluation	36,000	4,440	22,000	44,200

Table 2. Comparison of the solutions of Khorramshahr network

Authors	Samani and Zanganeh (2010)	Present work
Method used	LP	KH
Cost (Thousands Iranian Rials)	1,535,371	1,376,713
Evaluation	14	27,710

With regard to Table 1 the optimum cost obtained by KH for Kadu network compared with GA, GA-ILP and PSO algorithm shows an approximate improvement of 3.30%, 3.03% and 2.55%, respectively. Also, the optimum cost obtained by KH for the Khorramshahr network as compared with the LP method (Table 2) shows an approximate improvement of 10.33%.

4. Conclusions

The obtained optimum design cost for two WDNs was compared with the solutions published using other approaches. This comparison shows that the KH method is more efficient in obtaining lower piping-cost rather than other methods. It seems that this high ability of KH to find optimum solutions has come from the swarm behavior of krill herds and sharing their own global and individual information. Also, the mutation and crossover operators enhance increasing the global exploration ability and convergence velocity of this approach. So, the assessment of KH performance to select the optimum rehabilitation alternatives of WDNs is recommended for future studies.

5. References

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