Heliyon 8 (2022) e10638

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

A new hybrid Artificial Intelligence (AI) approach for hydro energy sites selection and integration

F. Chen Jong [a], Musse Mohamud Ahmed [a,*], W. Kin Lau [a], H. Aik Denis Lee [b]

[a] Department of Electrical and Electronic Engineering, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia
[b] Department of Grid System, Sarawak Energy Berhad, Kuching, Sarawak, Malaysia

ARTICLE INFO

Keywords:
Fuzzy logic operation
Genetic algorithm
Hydro energy sites
Mixed integer-linear-programming
Travelling salesman problem

ABSTRACT

The increase of energy demand in this era leads exploration of new renewable energy sites. Renewable energy offers multiple benefits; hence it is suitable to be harnessed to meet power needs. In Sarawak, exploitation of hydro energy is a very feasible potential due to the abundant river flows and high rainfall volume. Thus, in this paper, 155 potential Hydro Energy Sites (HES) are identified and divided into six districts using a raw and unprocessed data provided by Sarawak Energy Berhad (SEB). Since there are no similar researches previously done for identification and integration of hydro energy sources, in this paper, two stage complex data management was built using 155 HES locations in Sarawak. New spatial mapping technique were used for the first stage. From the new spatial mapping technique, the mapped data were categorized into groups, analysed and created new accurate mapping locations on the Sarawak map in terms of the districts using GIS Spatial tools. Their exact geographical locations were identified, and their coordinate systems have been retrieved as complete final data with geo-referencing technique in QGIS with ID numbers. Moreover, the power capacity of each location of all the 155 HES was quantified. By employing this data, the identified locations have been integrated into the already created 155 HES sites. For the second stage, a new two-part AI hybrid approach has been proposed and applied to improve optimal transmission line routing for each district to locate transmission line paths. The first part of hybrid AI implemented in this paper was TSP-GA and second part implemented in this paper was based on improved fuzzy logic with TSP-GA together. To ensure the optimal results are reliably achieved, both first part of TSP-GA and second part of improved fuzzy TSP-GA are utilized to generate the transmission line routing. These two approaches are required to obtain the minimal values of total distance and total elevation difference of each HES. Based on the benchmarking results, fuzzy TSP-GA successfully improved 12.99% for Song district, 7.52% for Kapit district, 3.71% for Belaga district, 1.54% for Marudi district, 18.01% for Limbang district, 11.00% for Lawas district when comparing against the ordinary TSP-GA approach.

1. Introduction

Renewable energy is receiving significant attention nowadays. It is because renewable energy possesses clean, omnipresent, and infinite properties. It has also been gradually replacing the usage of fossil fuels [1]. In Sarawak, various types of renewable energy sources are worthy for implementation. Since Sarawak is blessed with high rainfall about 4600 millimetres annually and abundant river flows, harnessing hydro energy is an excellent option due to these local geographical characteristics [2]. In Sarawak, the longest river is in the northwest of Borneo in Malaysia, and a prominent hydroelectric plant was constructed. It is Malaysia's most extensive and tallest hydroelectric power station, with which the head dam is approximately 160 m and named Bakun Hydro-Electric Dam [3]. It has the highest power generation capacity of 2400MW in Sarawak. In addition, some other hydroelectric dams, such as Batang Ai (108MW) and Murum HEP (944MW), generate electricity for domestic usage. Meanwhile, many remote areas still do not have electricity accessibility [4]. To solve this problem, proper identification and integration of new locations of HES are necessary [5].

* Corresponding author.
E-mail address: mamusse@unimas.my (M.M. Ahmed).

https://doi.org/10.1016/j.heliyon.2022.e10638
Received 11 February 2022; Received in revised form 27 June 2022; Accepted 8 September 2022