Applied GIS

ISSN: 1832-5505

Vol-10 Issue-02 July 2022

H-PSO Routing Optimization Model for Zoomlion Ghana Limited

K SATYA NARAYANA, PROFESSOR, mastersatya08@gmail.com
C CHAITANYA LAKSHMI, ASSISTANT PROFESSOR, chaithanyalakshmi216@gmail.com
D MADHUSUDANA REDDY, PROFESSOR, madhuskd@gmail.com
Department of Mathematics, Sri Venkateswara Institute of Technology,
N.H 44, Hampapuram, Rapthadu, Anantapuramu, Andhra Pradesh 515722

Introduction

One of the pressing worldwide issues vying for more funding in many nations' national budgets is waste management. Ghana is no different. Like many other African nations, Ghana spends enormous sums of money annually on waste management and sanitation upkeep as part of its "keep Ghana clean" strategy [1]. Because more people are moving to these metropolitan regions in search of greener pastures and because more people live in a given area, more garbage is produced there than in rural areas, urbanisation is the primary reason of the growth in waste production in urban areas in Africa [2]. It is anticipated that urbanisation would keep rising in the near future [3].

The rate at which waste is produced in Ghana's cities is extremely concerning. The situation still remains a major challenge to the nation's sanitation problem despite the government's best efforts to reduce it by supporting the services of waste management companies like Zoomlion Ghana Limited, FG Plastic Recycling Ghana Limited, TrashSmart, etc. These companies' pertinent issues continue to plague the country [4]. It is anticipated that the percentage of Africans living in cities would rise from 40% in 2010 to roughly 57% in 2050, which means that garbage production will undoubtedly continue to rise in these places [5]. To address that, urban regions must have an appropriate waste management plan in place in order to control the situation.

Even if technology has transformed how companies are run these days, certain components the business today has not been replaced by any technology yet and that is routing [3]. Numerous businesses, such as mail delivery services, laundry services, travelling salesperson problems (TSP), etc., rely on routing for their everyday operations [6]. To advertise in their everyday operations, many companies require a daily route plan with multiple stops. Sadly, a lot of them are unaware of how crucial route optimisation may be to raising their operating profits and efficiency [7].

The technique of identifying the most economical collection of routes is known as route optimisation [8]. It involves more than just figuring out the quickest route between two locations, and it's rarely that easy: You need to take into consideration all pertinent variables, including the quantity and locations of all stops along the route, the time difference between arrival and departure, efficient loading, etc. [9, 10]. For businesses that heavily rely on routing to deliver services to customers, route optimisation is a way to solve vehicle routing issues (VRPs) [11]. The Vehicle Routing Problem (VRP), on the other hand, involves creating an ideal route plan that connects all routes from the depot to a range of destinations, each with constraints unique to the business, including time constraints, cost controls, vehicle limitations, and resource limitations related to the depot's loading process [12]. Serving clients along a predetermined route map with the goal of ensuring that each customer or service location is visited once is the notion [13]. The travelling salesman problem (TSP), which dates back to the early 1800s and gained popularity when door-to-door salesmen began promoting vacuum cleaners and encyclopaedias, is the first example of a classic VRP [14].

Ghana produces more trash in its cities than in its rural areas. A wide range of these wastes, including solid, chemical, liquid, construction, and industrial wastes, are created in metropolitan areas [3]. The three main types of garbage are construction, industrial, and household solid waste. While some of these wastes are transferred to dumpsites, the bulk find their way into streams, drains, and open areas [15]. The majority of these wastes are disposed of through uncontrolled burning, open dumping, and
at landfills, burning and tipping. Due to the overwhelming amount of solid and liquid waste management in many towns and cities, this has resulted in a serious sanitation issue [13]. Due to inadequate waste management, several parts of urban areas have an extremely offensive stench. There is significant room for improvement in the way garbage is currently managed. Less than 30% of urban inhabitants have access to a suitable home lavatory, and less than 40% receive solid waste collection services [16]. Concern over the lack of an integrated approach to waste management in the nation is developing as a result of the failure of the previously used methods of handling wastes and the ensuing contamination of land and water [14].

Despite the high cost of collection, waste recycling has emerged as a feasible economic option in the nation [17]. Waste recycling methods are being used by certain sectors to reduce their requirement for raw materials, energy, and water by avoiding the need for treatment, discharge, and disposal of significant volumes of waste [17]. Certain sectors have discovered that recycling garbage can significantly boost the competitiveness of their products in the market. For instance, a portion of the income of Guinness (Ghana) Limited, Kumasi, comes from the sale of yeast and leftover grain that is fed to animals [18]. Scavenging is an essential part of trash recycling, although it has historically been seen as an impediment to municipal garbage disposal operations

[19]. It is important to give careful thought to how scavengers might be formally included in municipal garbage management operations. As an illustration, they might receive training, status advancement, and official used-materials merchant designation [20].

The requirement for an ideal route plan to enable the garbage trucks to reach the waste bin centres in the least amount of time is one of the issues waste management firms are dealing with [21]. This would assist the businesses in increasing productivity, providing prompt service to a large number of clients in a short amount of time [22]. In order to prevent the vehicles from having to visit any waste bin centre more than once while in operation, the goal of this study is to discover the shortest set of routes connecting all the waste bin centres using MATLAB simulations using PSO and GA. The hybrid HPSO will be used for the study, with the shortest set of routes connecting all bin centres being the main emphasis [18].

Related research work

Numerous optimisation algorithms, including Simulated Annealing, Genetic Algorithm, and Particle Swarm Optimisation, have been used in numerous studies on truck routing. [23] states that PSO has been used to numerous optimisation issues, with superior results in many cases. Additionally, GA, with its operators crossover and mutation, has consistently offered a faster simulated process. When PSO and GA performance were compared, it was found that GA performed better. In contrast, PSO is simpler to use and yields far superior results than GA.

- **Contribution to knowledge**

Numerous VRPs have been resolved using various optimisation techniques. Numerous of these issues use these algorithms in isolation, arriving at a conclusion based on their own stopping criteria. This study presents a new hybrid optimisation algorithm that solves routing problems by combining crossover and mutation with particle swarm optimisation. It advances our understanding of a speedier, more dependable, and more reliable optimisation approach.

• Methodology

- **Source of data**

Zoomlion Ghana Limited, Sekondi Takoradi Branch, provided the data. January 30, 2021, was the date of data generation. It details the quantity of trash cans positioned at different viewpoints across the city as well as the separation between each waste can. The analysis was done with MATLAB. The Sekondi Takoradi map is displayed in Figure 1. Sekondi is the capital of the metropolis, which has a land area of 219 km2.

HQ for administration. Situated on the western shore, it is crossed by the Trans-West African Highway. The Metropolis is situated in Ghana's southwest, some 242 kilometres west of the country's capital, Accra. Additionally, it is almost 280 km away from the western border of La Cote d'voire [24]. Consideration is given to 160 public trash cans spread across several municipalities within the Sekondi Takoradi metropolitan area.

ISSN: 1832-5505
Vol-10 Issue-02 July 2022

Fig. 1. The Map of Sekondi Takoradi Metropolis

- **Particle Swarm Optimization (PSO)**

One component of the hybrid approach employed in this paper is Particle Swarm Optimisation. The goal of this method is to reduce the search space to an ideal search space. The algorithms adhere to the subsequent structure: Particle position and velocity updates, fitness value computation, and initialization. The routes are encoded into arrays during the initialization phase, accounting for the position, velocity, and

ISSN: 1832-5505
Vol-10 Issue-02 July 2022

optimal locations of each particle

$$x_i = (x_{i1}, x_{i2}, x_{i3}, \dots, x_{in})$$

$$v_i = (v_{i1}, v_{i2}, v_{i3}, \dots, v_{in})$$

$$P_i = (P_{i1}, P_{i2}, P_{i3}, \dots, P_{in})$$

[7]:(1)

•

The fitness value of each particle determines the strength of each particle in the search space. During each iteration, the velocity of each particl v_{it} moves the particle x_{it} towards a new velocity $v_{i(t+1)}$ based on the previous velocity value $v_{i(t-1)}$. The objective function for the fitness value is defined as $\sum^n$ x_{ij} where n is the number of bin centers [17].

After the fitness value the velocity and position of each particle was updated using the following equations:

$$v_{it} = v_{i(t-1)} + c_1 \times r_1 \times (pbest - x_{i(t-1)}) + c_2 \times r_2 \times (gbest - x_{i(t-1)})$$

•

And the equation for updating the position of each particle is

$$x_{i(t+1)} = x_{it} + v_{i(t+1)})$$

The PSO model algorithms is stated below:

Decision variables:

$$x = \{x_1, x_2, x_3, \dots, x_n\}$$

Objective:

$$mikimize \sum_{i,j \in N}^{n} x_{ij}$$

i.e., the distances between the waste in centers,

Subject to: equations (4) and (5) above

Fig. 2 presents the order of the implementation of particle swarm optimization algorithm. The number of iterations depends on the stopping criteria by the researcher. The iteration repeats after the update of the position and velocity of the particle.

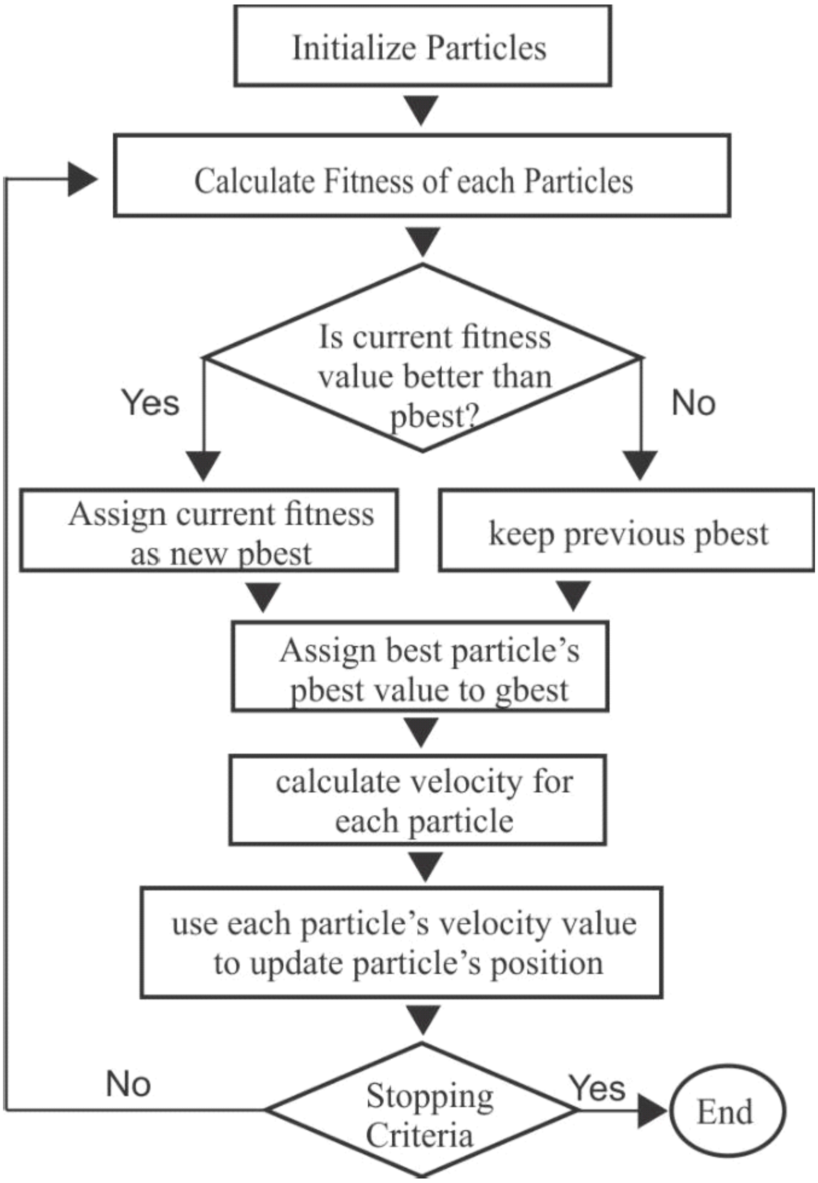


Fig. 2. The framework of particle swarm optimization

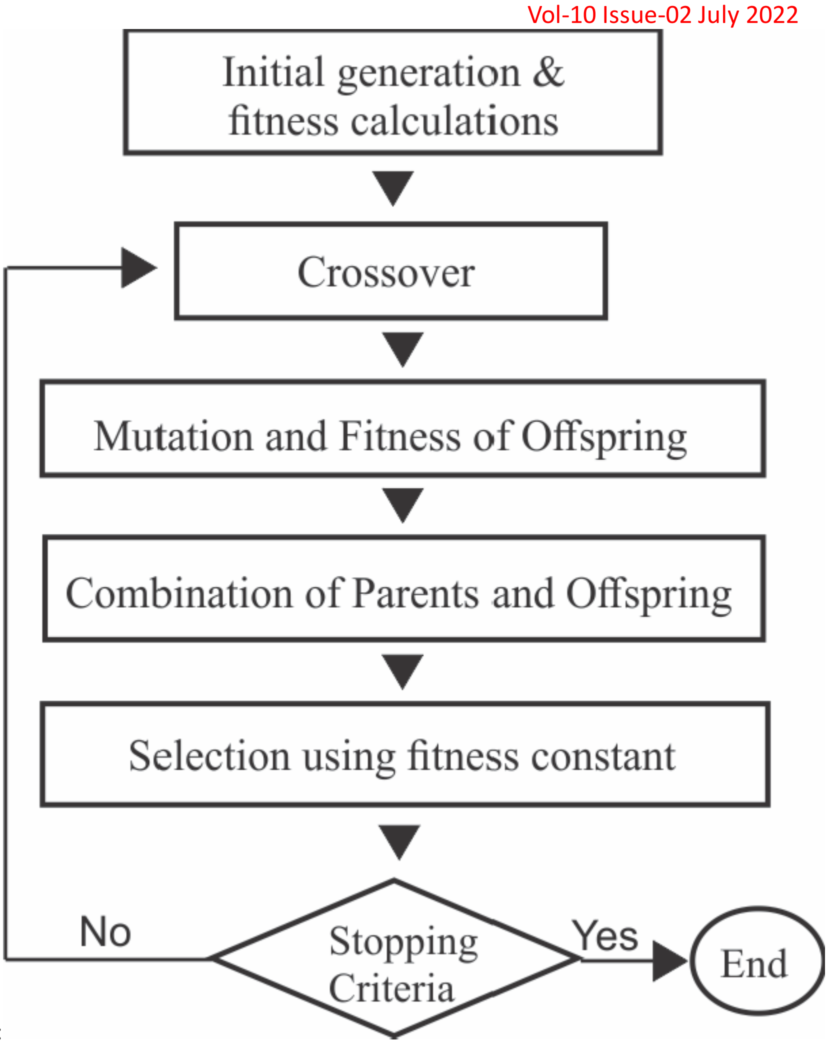
- **Genetic algorithms**

Charles Darwin's theory of natural evolution served as the inspiration for the genetic algorithm, a type of search heuristic. The process of natural selection, in which the most fit individuals are chosen for reproduction in order to create offspring of the following generation, is reflected in this algorithm [5].

The selection of the fittest members of a population is the first step in the process of natural selection. They give birth to children who will join the next generation and carry on their parents' traits. Offspring of fitter parents will outperform their parents and have a higher probability of living [11].

GA is divided into five stages: initialization, fitness assessment, crossover, mutation, and selection. The implementation order is shown in Fig. 3. Before selection, crossover, and mutation operators are used, the routes are encoded into the population, chromosomes, genes, and alleles.

ISSN: 1832-5505
Vol-10 Issue-02 July 2022



The following defines the GA Model:

- **Hybrid algorithms**

Fig. 3. The framework of genetic algorithm

The crossover and mutation operators of GA are combined with PSO in the hybrid algorithms. In this paper, this was used. After converting the routes into arrays, MATL's algorithm B was used to perform the simulation. The combination

Initialization, Fitness computation, Update of a particle's position and velocity, Crossover, and Mutation are the processes that algorithms go through [8].

The premature convergence problem with Particle Swarm Optimisation is eliminated by the hybrid methods. Additionally, it stops the rapid information transfer between particles, which typically leads to the production of comparable

particles that raise the likelihood of being stuck in local optima. Additionally, HPSO makes sure that the issue dependency connected to PSO's stochastic technique is removed [14].

- **Parameter used**

A total of 200 population size (waste bin centers) were used. A maximum iteration of 10,000 was used with crossover percentage of 0.8%, mutation percentage of 0.3%. the mutation rate is 0.02. two different selection approaches were used: Roulette wheel and tournament selections.

ISSN: 1832-5505

Vol-10 Issue-02 July 2022

• Results and Discussion

MATLAB simulation was performed on the data collected from Zoomlion Ghana Limited, Sekondi Takoradi branch and the result are presented below. The distances between the waste bin centers were run separately in MATLAB using Particle Swarm Optimization algorithm, Genetic Algorithm and hybrid algorithms. A stopping criterion of 10,000 iterations was set for all algorithms. The results are presented below.

• Result of particle swarm optimization

Fig. 4 present the result of the PSO after the distances between 160 waste bin centers were run in MATLAB. The total iteration that produced this result was 10,000. The duration for this simulation was 2432.594 seconds. At the end of the iterations, the optimal route distance was 81.6 km. the stopping criteria set here was a maximum of 10,000 iterations.

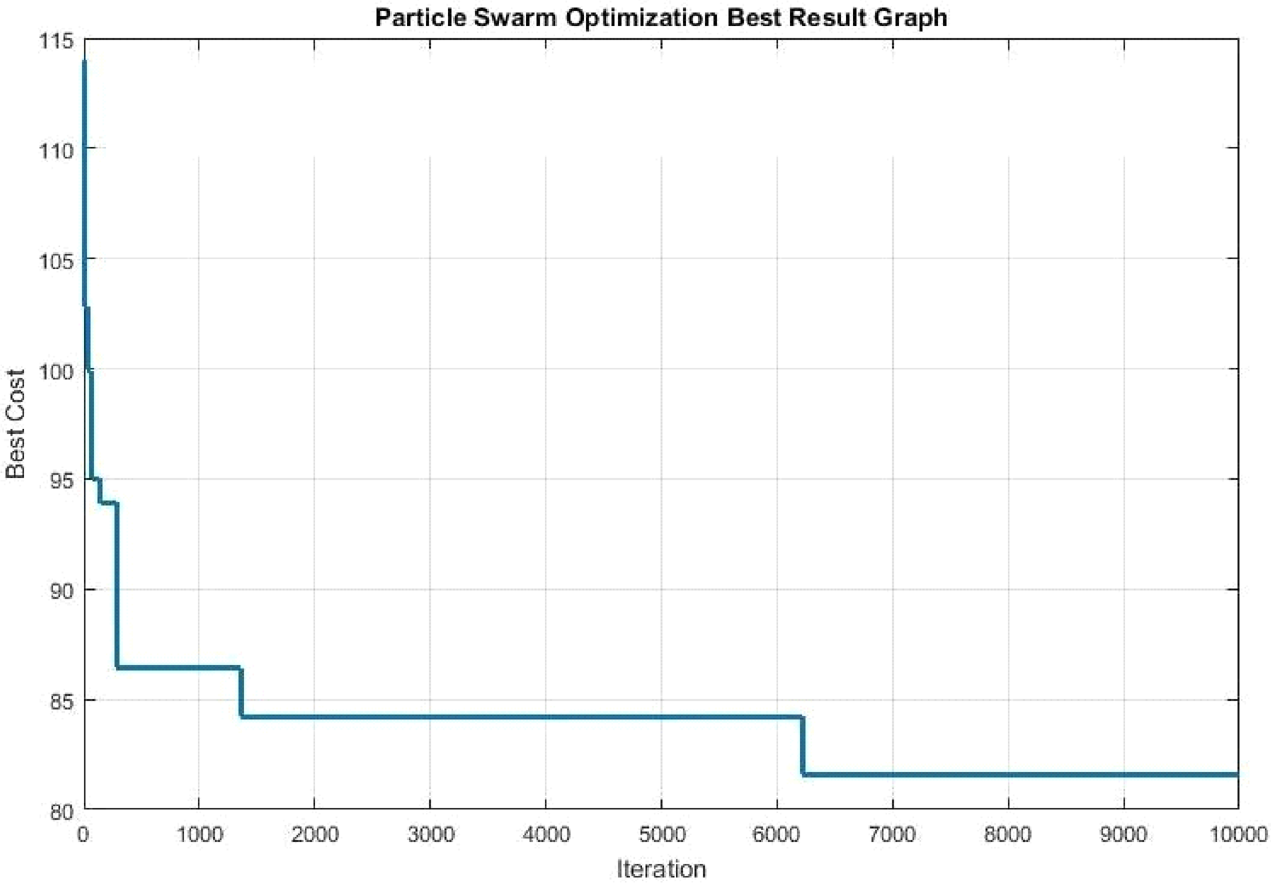


Fig. 4. PSO results after 10,000 iterations

• Result of genetic algorithm

Fig. 5 present the result of the GA after the distances between 160 waste bin centers were run in MATLAB. The total iteration that produced this result was 10,000. The duration for this simulation was 259.4684 seconds. At the end of the iterations, the optimal route distance was 88.9 km. the stopping criteria set here was a maximum of 10,000 iterations.

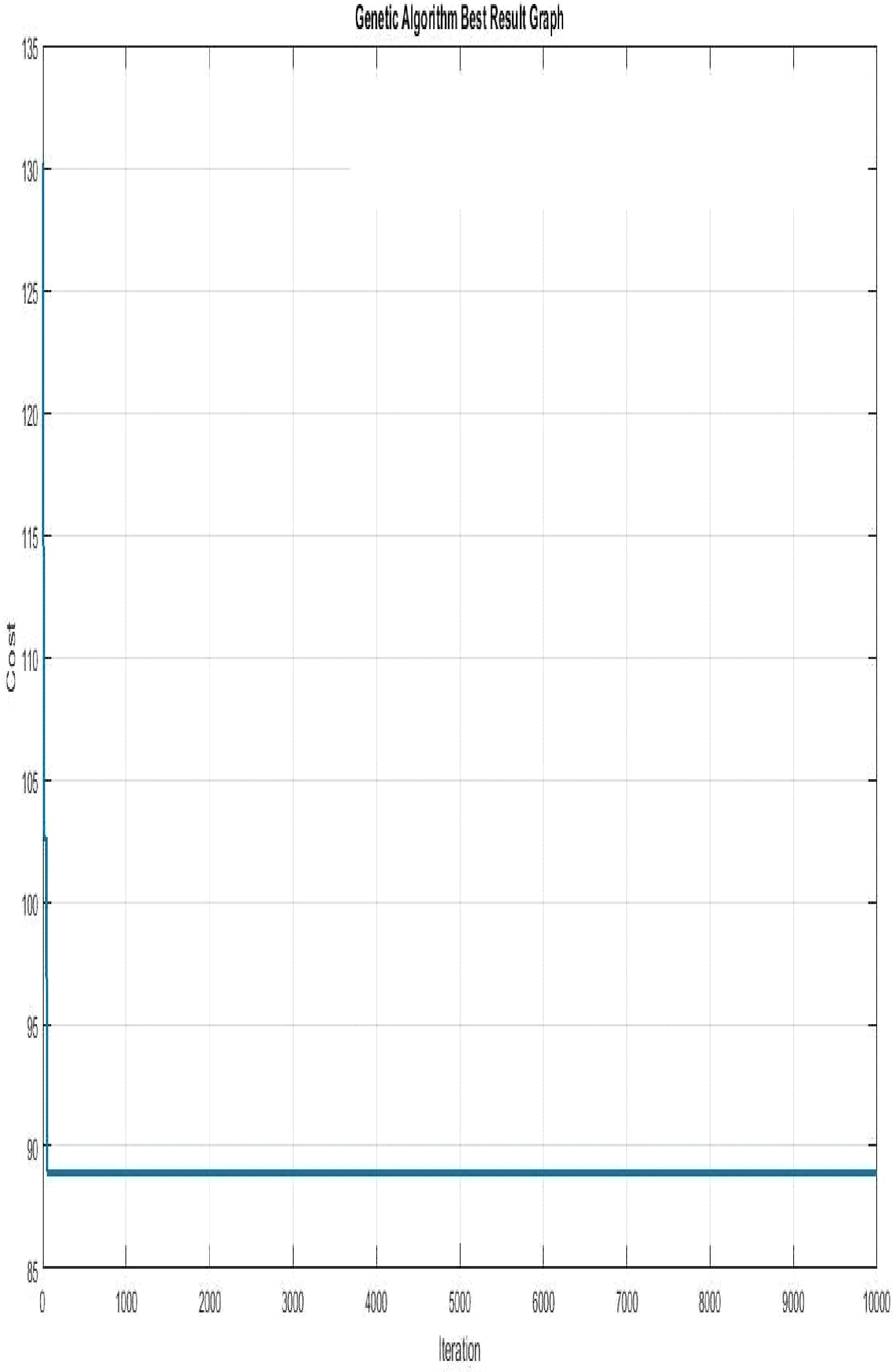


Fig. 5. GA results after 10,000 iterations

- **Result of hybrid algorithm**

Fig. 6 present the result of the Hybrid algorithm after the distances between 160 waste bin centers were run in MATLAB. The total iteration that produced this result was 10,000. The duration for this simulation was 2855.1353 seconds. At the end of the iterations, the optimal route distance was 79.7 km. the stopping criteria set here was a maximum of 10,000 iterations.

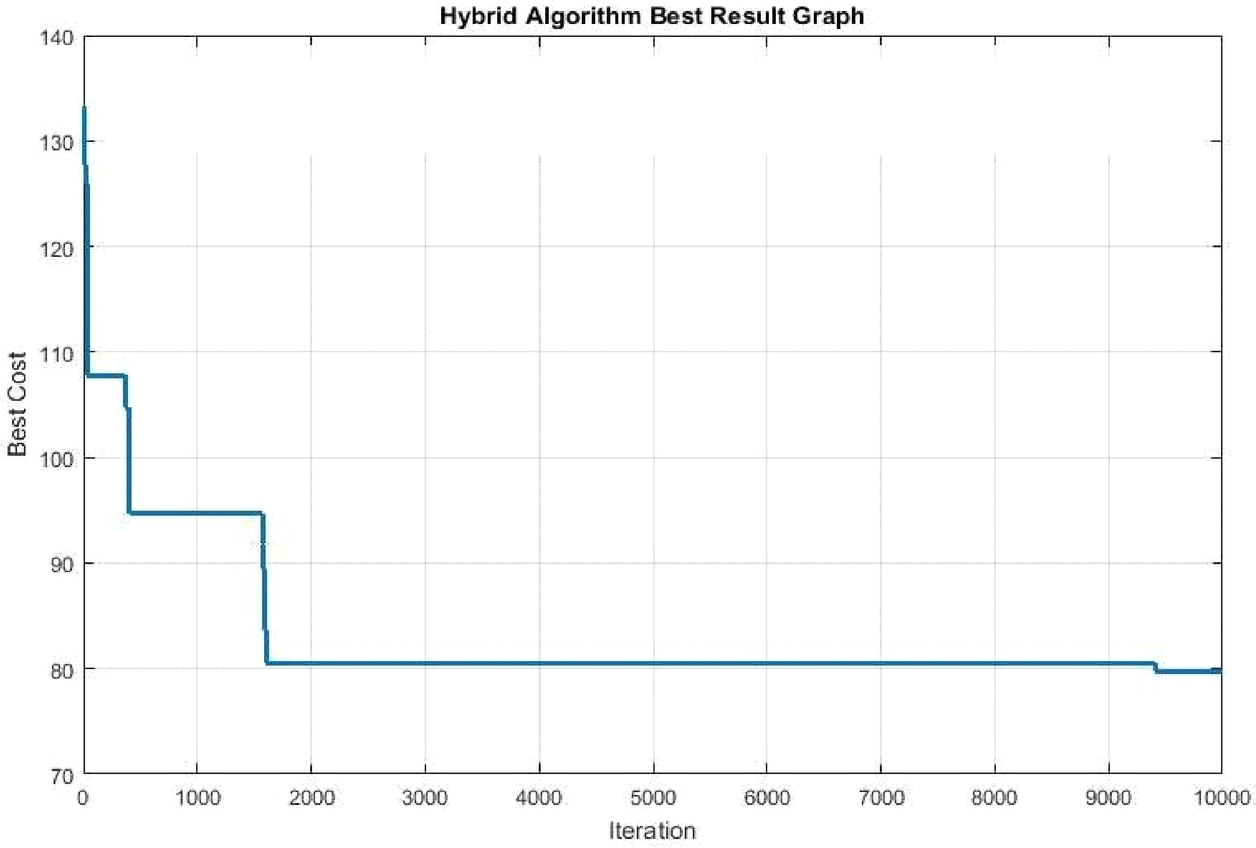


Fig. 6. GA results after 10,000 iterations

- ## Discussion

The algorithms, iterations, durations, and optimal route outcomes of the simulation are summarised in Table 1. Despite being simpler to implement than GA, PSO is notorious to converge to the local optimal state too soon. An ideal distance of 81.6 kilometres was reached in 2432.594 seconds following 10,000 repetitions. In 259.4684 seconds, GA produced 88.7 km in the same amount of repetitions. This demonstrates that while PSO produces far more optimal results than GA, GA's crossover and mutation operators enable the algorithm to operate more quickly. After 10,000 iterations in 2855.1353 seconds, the hybrid algorithm that combines crossover and mutation with PSO yielded a minimal optimal outcome of 79.7 km. It's clear that combining the two operators lengthens the iteration time, but the outcome was superior to using PSO and GA independently.

Table 1. Summary of algorithms, iterations, durations and optimal result

Algorithm	Iterations	Duration	Optimal distance
PSO	10,000	2432.594 secs	81.6 km
GA	10,000	259.4684 secs	88.9 km
Hybrid	10,000	2855.1353 secs	79.7 km

- ## Matlab Code Structure

The genetic algorithm (GA) and particle swarm optimisation (PSO) codes are combined to run the hybrid algorithm. First, random data is initialised from the sample data via the hybrid code. Next, it determines each particle's fitness value and chooses the ones with the lowest values. It is constantly updating the particle positions and recalculating the fitness values. At this stage, a second set of particles are chosen, and the second section of the code that uses GA starts. At this stage, crossover and mutation code start, and the preset stopping criteria are used to determine the ultimate best solution.

- **Conclusion**

This work established a hybrid algorithm that combined PSO with the crossover and mutation parameters of GA. An ideal path measuring 79.7 km was reached after 10,000 iterations measuring the distances between Zoomlion Ghana Limited's 160 garbage bin centres in the Sekondi Takoradi branch. This demonstrates that the hybrid algorithm outperformed the individual PSO and GA algorithms in achieving the desired outcome. By solving route optimisation problems with a faster and more dependable optimisation technique, this study advances our understanding.

Competing Interests

Authors have declared that no competing interests exist.

References

M. Schneider, G. Desaulniers, F. Errico, S. Irnich. Accurate methods for electric vehicle routing issues with time windows. Operations Research, 2016; 64(6): 1388–1405.

According to Barroso ES, De Melo AMC, and Parente E. Optimising laminated composites using a hybrid PSO-GA algorithm. 2017, volume 55, issue 6, pages 2111-2130. Optimisation in Structure and Multidisciplinary Areas. Segger MCC. A plan for significant improvements to sustainable development legislation and governance. At the Natural Resources Forum. Oxford, UK: Blackwell Publishing Ltd., 2004;28(1):61-74.

"A lesson on particle swarm optimisation" (2009, 34) by Blondin J. Here at http://cs.armstrong.edu/saad/csci8100/psotutorial you may get the PDF of the instructive.

Mallawaarachchi V. provides an overview of genetic algorithms, along with code examples. 8(07) 2017: Moving Forward with Data Science.

Deng Y, Zheng Y, and Li J. developed a model for optimising routes in a collaborative logistics network that considers a cost discount based on GATS in a mixed transportation issue. It appears in the 2019 edition of the Journal of Ambient Intelligence and Humanised Computing, volume 10, issue 1, pages 409-416.

The Gaussian swarm is an innovative method for optimising particle swarms, as proposed by Krohling RA. 2004 IEEE Conference on Cybernetics and Intelligent Systems, 1:372-376.

Klimawandel: Gender research and women's organising for sustainable development as an information resource. Dankelman I. Publication date: 2002; volume: 10, issue: 2, pages 21–29.

Genetic Algorithms: An Introduction with Example Code by Mallawaarachchi V. (2017) and 2019 (2019).

*Li L, Wv W, Sun Q, and C Ma are the authors. A discrete optimisation model and technique are used for driver planning in the periodic driver routing issue. Discrete Dynamics in Nature and Society, 2019.

Genetic algorithms: A primer for engineers and scientists (Coley, DA). Publication year 1999 by World Scientific Publishing Company.

According to Akaateba and Yakubu (2019), residents of Wa, Ghana are pleased with the solid trash collection services provided by Zoomlion Ghana Ltd. European Science Journal, 2013;9(32).

(Belfiore, Yoshizaki, and Tsugunobu, 2018). Using time windows and split deliveries as vehicle routing issues: a search and find. There are problems with the routing of vehicles. In the field of technology, 2013.

A novel hybrid algorithm that combines PSO-GA with an improved GA was developed by Shi XH, Wang LM, Liang YC, Lee HP, and Lu C. Article published in 2005 in the Letters on Information Processing, volume 93, issue 5, pages 255-261.

A study by Zhou X, Li X, and Zhao Z. optimises the transportation routing issue for perishable goods on a time-varying road network by considering the dependability of food safety and temperature control. PloS One, 2020, 15, 7, e0235950.
Improvements to a Hybrid Particle Swarm Optimisation Algorithm for Job Shop Scheduling Problems via the Use of Nonlinear Inertial Weight and Gaussian Mutation By 2020, Yu H., Gao Y., Wang L., and Meng J. will have published in Mathematics the 8th edition, issue 8, page 1355.

Maiti MK, Khan I, and Pal S. In a variety of contexts, a hybrid PSO-GA algorithm was developed for use by travelling salespeople. International Journal of Uncertainty, Fuzziness, and Knowledge-Based Systems, 2019;27(5):693-717.

Optimisation issues including restrictions and a hybrid PSO-GA approach, Applied Mathematics and Computation (Garg H. 2016; 274: 292-305).

A novel approach combining fuzzy logic with particle swarm optimisation and evolutionary algorithms is presented by Dziwiński P and Bartczuk Ł. 2019 IEEE Transactions on Fuzzy Systems, 28(6):1140-11554.

•In Brazil, Fidelis R, Komatsu AK, Antunes LC, and Marco-Ferreira A. 2020;154:104594. The article discusses the principles, practices, and future possibilities of scavengers' socio-productive engagement in municipal solid waste management. Materials, Preservation, and Reuse.

Nema AK and Gupta SK are the authors. Improving the recipe for bettering hazardous waste management systems at the regional level. public health literature19(7-8):441-451 (1999).

Khan A, Hizam H, Abdul bin Wahab NI, and Lutfi Othman M. developed a method for optimising power flow using a hybrid of firefly and particle swarm optimisation. Journal Article: 2020;15(8):e0235668; Publication: Plos One.
The paper "Particle Swarm Optimisation for the Vehicle Routing Problem with Stochastic Needs" was published in the journal Applied Soft Computing in 2013 and can be found in volume 13, issue 4, pages 1693–7004.
Turkson AJ and Wang XJ conducted a statistical analysis of the risk variables for the main epidemic illness among residents of the Sekondi-Takoradi Metropolis (STMA). The Journal of Mathematics and Statistics published the article in 2009 with the DOI number 5/3: 146.