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Modelling of HCHS System for Optimal E-O-L Combination Section and Disassembly in Reverse Logistics

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Abstract: We propose a novel strategy for the multi period disassembly in reverse logistic. The proposed system combines the natural-inspired cuckoo search with the artificial inspired harmony search algorithms for disassembly of end of life products. The new strategy is tested by considering a test case and its performance is compared with the conventional optimization techniques. The obtained results are validated based on the cost, disassembly time, and execution time. It is shown that the performance of proposed technique outperforms the conventional technique. Hence the proposed hybrid metaheuristics approach is suitable for the real time reverse logistics management.

Keywords: Disassembly to order, reverse logistics, end of life product, reverse logistics, hybrid cuckoo harmony search

1 Introduction

In the recent decade, perhaps the emerging technology is important to every nation. In particular the product and Technological developments, in the field of product and process of technologies are taking place at a very fast pace [1]. Shortening of life span of product, development of innovations and inventions and increase in product demands are the indicators to the fast changing manufacturing scenario. Thus the hidden and enlargement of these development trends are rapidly changing the technological environment. These developments can lead the manufacturer in trouble and they need to produce new technological product within the short period [2].

Organizations need to work continually for building up more concepts and ideas which are cheap and updated of their competitors, that create long-term competitive advantages [3]. The technology upgrade is a major solution for the impacts of organization and it helps them to leads in the market for long term. In some situation the manufactures can also leads the market just by updating the types of product and with fast implementation and delivery in production [4]. In order to speed up the production process the manufactures are planned to gather the end of life (E-O-L) products and which are dismantled to accomplish the component requirement. Disassembly is a challenge task, it should properly handled and scheduled to achieve maximum yield [5,6]. Thus the heuristic approaches are employed to achieve this disassembly management task [7,8,9,10,11,12].

A study proposed by Chunguang Bai et al. [13] have proposed an adjusted inversion methodology which was divided in to agent execution and key adaptabilities. Mahdi Mahmoudzadeh et al. [14] have remarkably propelled an imaginative technique for portraying the assembling is considered in regard of unmistakable circumstance. Tyler R. Morgan et al. [15] have examined structure and performance of the resource commitment to SCM. Based on the analysis, extended the technique and suggested a future SCM technique. Ankit Mahindroo et al, [16] have made an effort to create a structural contact between IS constructs and economic and operational performance measures. In this paper a novel hybrid meta heuristic approach is proposed for the disassembly management in E-O-L reverse logistics. The rest of the paper is organized as follows; The description on the proposed HCHS approach is given in section 2. The performance analysis and implementation results are given in section 3. The conclusion to the paper is given in the subsequent sections 4.

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2 Proposed HCHS System

Metaheuristics algorithms plays major role in many engineering applications to solve some difficult problems. The metaheuristics algorithms are mostly inspired from natural process. The natural-inspired algorithms such as Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Cuckoo Search (CS) etc., providing better performance in various fields of engineering. One the other hand the artificial algorithms also proving its essential in some fields. Some of the notable artificial metaheuristics algorithms are Evolutionary Programming (EP), Earmony Search (HS) etc.

In most of the application the hybrid algorithms are formed by combining two or more natural-inspired algorithms. The combination of two or more natural-inspired algorithms consume high execution time. Because, the imitation of natural process takes many iteration to solve a problem. But these natural-inspired algorithms can provide accurate results. On the other hand the artificial inspired algorithms can execute fast and it require less iteration t. The proposed work motivate to propose hybrid metaheuristics algorithm for the optimal E-O-L product selection in reverse logistics. In the proposed system the cuckoo search is combined with harmony search. In conventional cuckoo algorithm the update and discard of any solution is based on swarm rule and probability value. The update rule is also referred as mutation of cuckoo, which is replaced by the harmony search process to speed up the optimization. The step by step procedure of proposed HCHS system is given as follows;

Step 1: Initial Solution

In the proposed hybrid system, the cuckoo begins the optimization so the candidate is initialized to the cuckoo. Each candidate in the population has N eggs, among them N-1 eggs represent the features or components of the E-O-L products and the Nth egg represents the cost value. The sample candidate representation is given in the fig 1.

Step 2: Fitness Estimation

The objective of the proposed system selects the most suitable combination of E-O-L products for disassembly. The selected products should require less cost and time in the reverse logistics process. Sometime, to fulfil the required parts, the parts need to buy from the outside providers. In case the overall accrued non-distractive component is less than the required quantity for the new product production. Then the balance component should procure from the outside seller. In another situation the yield is higher than the desire; the excess segments need to arrange. Along these lines, the part is far minimum or more extraordinary than it makes adversity for the E-O-L reverse logistic operation.

The aggregate time required for the dismantling of the destructive path and the aggregate time required for the dismantling of the non-destructive segment can distinguish by utilizing the accompanying eqn. (1) and eqn. (2) individually [17, 18].

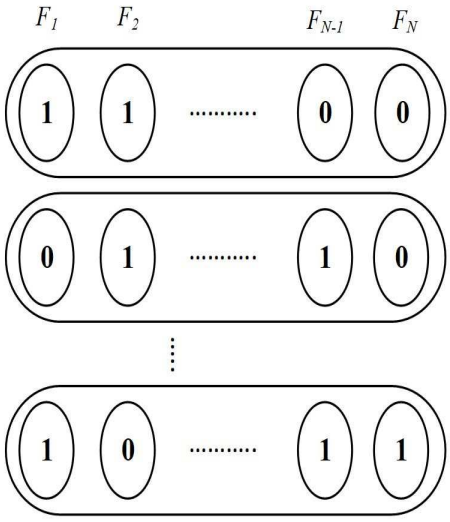

Fig. 1: Initial Candidate Representation

$$T_{Di} = \sum_{i=0}^{N} \left(\left(EP_i - NDY_i \right) \times t_{DM\_j} \right) \tag{1}$$

$$T_{Ni} = \sum_{i=0}^{N} \left(\left(NDY_i \right) \times t_{NM\_j} \right) \tag{2}$$

Step 3: Harmony Search based mutation

Then the initial solution is mutated or updated based on the fitness value. In the proposed technique the salutation is updated using harmony search algorithm. The steps includes in the harmony search algorithm for the solution update are given below.

- *Initialize the harmony memory:* Based on the dimension of solution need to update, the initial memory for the harmony is generated and is stored in a matrix.
- *Improvise New Harmony:* In this phase based on the PAR value the new harmony will be crated.
- *Update Harmony memory:* Then the fitness of initial and new harmony is compared if the best fitness solution is updated as the optimal solution by the harmony search algorithm.

The solutions updated by the harmony memory search is considered as the best solution. Then the iteration is repeated by the cuckoo.

Step 4:Termination criteria

After the successfull execution of previous steps, the iteration is checked for the termination. The process is repeated from fitness estimation till to reach the termination criteria. The pseudocode for the hybrid cuckoo harmony search algorithm is given in fig 2.

```
1. Input: Divide the dataset in to training data set and testing data set
2. begin Generate Initial population of host nest n with f eggs:
3. while max iterations is not reached do
4.     Calculate the fitness for each nest fi using Naive Bayes Classifier
5.     Update each nest using cuckoo levy flight,
6.     x_ji(t)=x_ji(t-1)+α ⊕ Levy( λ)
7.     In hybrid approach, PAR operator is applied for r mutating the updated solution.
8.     For(j=1 to n)
9.         if(∈1<HMCR)      //∈1
10.            x_ji(t)=y * x_ji(t)
11.            if(∈2<PAR)  //∈2
12.                x_ji(t)=x_ji(t)+bw*(2 * rand –1)
13.            End if
14.        Else
15.            Keep the existing solution
16.        End if
17.    End for
18.    Eliminate the worst nest with probability Pa
19.    Pass the best nests to next iteration
20. End
```

Fig. 2: Pseudocode for the hybrid cuckoo harmony search

Table 1: Parameter Setting

Parameters	Values
No of Nests	100
pa	0.5
α	0.2
λ	1.5
HMCR	0.9
PAR	0.1

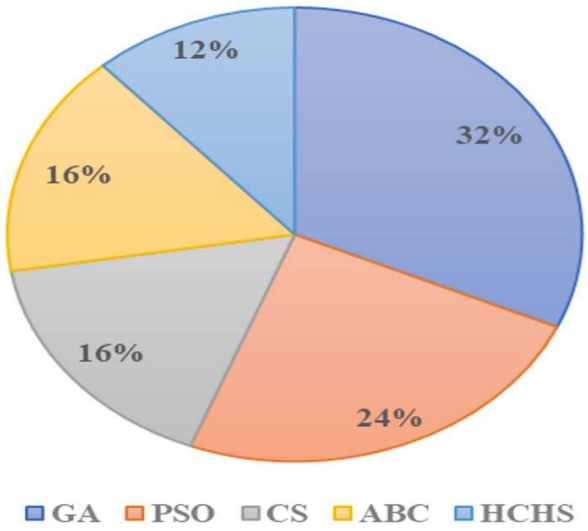

Fig. 3: Comparison of various optimization technique for product selection

3 Results and Discussion

The proposed procedure for the ideal D-T-O in E-O-L reverse logistic in light of the novel B2CS method is investigated and actualized by MATLAB 2017a, with the framework setup; Intel Core i3 processor, 8GB RAM and windows 10 working framework. In this reproduction, thinking about 100 item and every item contains most extreme of 9 parts.

The sort of item considered in our work is (pc) and their parts are numbered in the vicinity of 1 and 9. The parts detail and relating procurement and transfer cost are portrayed in Ref. [17, 18]. The initial parameter for the proposed hybrid cuckoo harmony search algorithm is given in the table 1.

The number of E-O-L products selected by various optimization techniques is given in the fig 3. The comparison chart clearly proves that the HCHS technique selecte only 12% of products. But the GA selecte maximum of 32% products.

The case considered in this paper for the trial execution is to make 20 new products from the accessible 100 E-O-L products. So as to fabricate 20 new products requires 180 segments. The quantity of 20 segment sort is required to fulfill the necessity. In this manner most extreme of 55 E-O-L products (estimated) is taken. To choose the most helpful compound which diminishes the general cost and dismantling time the proposed HCHS algorithm is employed.

The accomplishment of the normal approach is contrasted and past procedures like adaptive genetic algorithm (AGA), and simulated honey bee state algorithm (ABC) based planning. In the past chapter thought to diminish the dismantling time of the E-O-L products, so that an ideal planning structure in view of ABC algorithm is proposed. This chapter, focused both choice and planning of E-O-L products so that the general profit get increment. By and large the normal time taken by the different machines is given in the Table 2 [18].

Table 2 gives the dismantling machine required more time for dismantling non-destructive machine than the destructive machine. Since non-destructive dismantling need to stay away from harm of parts. The most extreme normal time required for the dismantling of the non-destructive part is 40seconds and least required time is 33 seconds for the given products. Then again for the dismantling of the destructive segment machine require most extreme of 14 seconds and least of 9 seconds. The

Table 2: Average time taken by the various machines

Non-destructive Machine	Time(Sec)
NM_1	33
NM_2	36
NM_3	35
NM_4	40
NM_5	32
DM_1	11
DM_2	9
DM_3	13
DM_4	14

disassembly time of the proposed work is compared with the existing techniques and is given in Table 3.

Table 3: Comparison on disassembly time for the 47 products

No of E-O-L Products	HCHS	ABC	GA	EP
47	175	223	247	280

The dismantling time of the different system for the D-T-O of 47 products got from the past work is given in Table 3. The total time required for the dismantling of 47 products by the proposed HCHS procedure is 175 seconds and by utilizing alternate strategies like ABC, GA and EP is 223, 247 and 280. It is unmistakably demonstrating that the proposed strategy system can be a superior choice for the dismantling of E-O-L products in brief time.

Table 4: Comparison on total cost for the 47 products

No of E-O-L Products	HCHS	ABC	AGA	GA	EP
47	465	498	525	591	614

In Table 4 the total cost required for the D-T-O of 47 products is given. The total cost required for the dismantling of 47 products is 614, 591, 525, 498 and 465 by utilizing EP, GA, AGA, ABC and B2CS. The table 2 and 3 demonstrates that the utilization of time and cost for the dismantling of 47 products is better and low by utilizing the proposed HCHS system.

The Fig 4 the dismantling time examination of different procedures at various no. of E-O-L products is given. It plainly demonstrates that the time required by the proposed strategy is lower than alternate strategies.

The execution examination diagrams given in Fig 4 and 5 unmistakably demonstrates the adequacy of the proposed system for the E-O-L item in the reverse logistic operation.

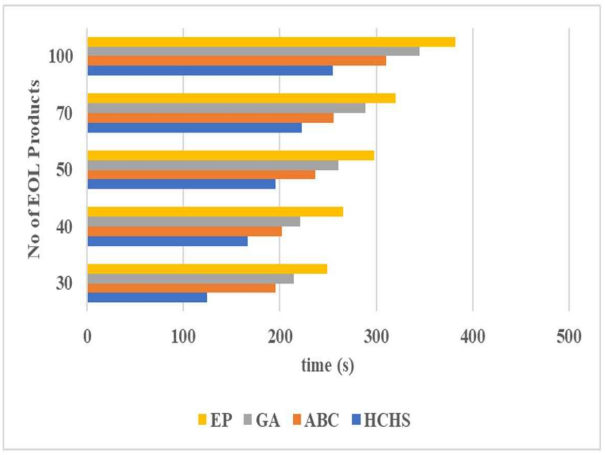

Fig. 4: Comparison of disassembly time at variable no. of E-O-L products

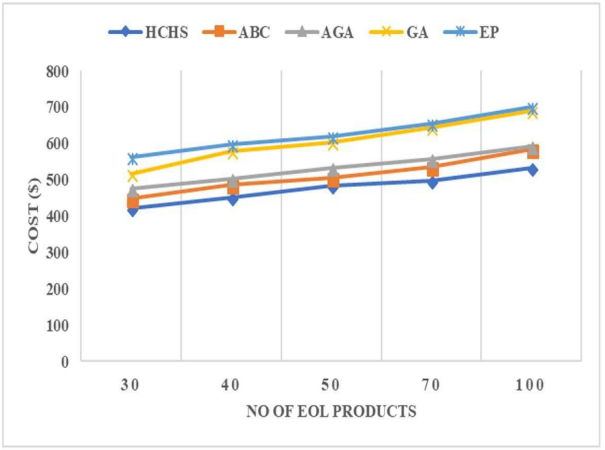

Fig. 5: Comparison of total cost at variable no. of E-O-L products

The Fig 6 gives the comparison of execution time of various optimization techniques. The execution time of proposed hybrid technique is less compared to the other hybrid technique.

The hybrid approach HCHS is proposed for the multi period dismantling in reverse logistic of end of life products. The proposed strategy combine the honey bee province algorithm and cuckoo scan algorithm for the better advancement. The goal of the proposed work is to locate the appropriate mix of products, hence its

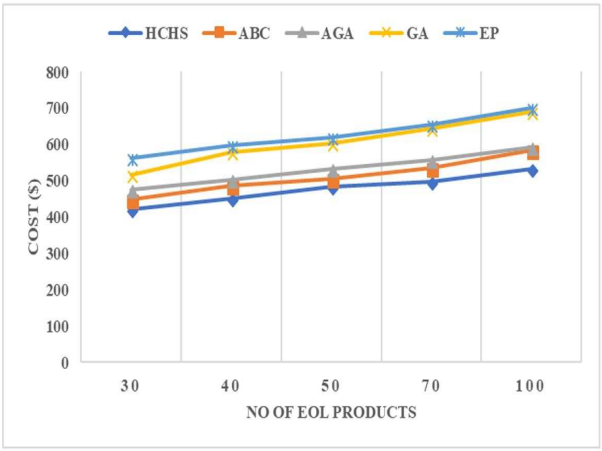

Fig. 6: Comparison of Execution time

dismantling cost and time taken to be reduced by preparing D-T-O. The normal procedure strategy is utilize a case test information, and the experiment is executed and the correlation demonstrates the viability of the proposed HCHS approach in the reverse logistic. Henceforth from the investigation and execution correlation recommend the proposed approach is one of the appropriate method for the constant usage toward the finish of life reverse logistic.

4 Conclusion

The hybrid approach HCHS is proposed for the multi period disassembly in reverse logistic of end of life products. The proposed method combines the cuckoo with the harmony search algorithm for the better optimization. The objective of the proposed work is to find the suitable combination of products, so that its disassembly cost and time taken is reduced by processing D-T-O. The expected pro method is tested using an example test data, and the performance is evaluated the performance is analysed to prove the improvement of the proposed HCHS approach in reverse logistic. Hence from the analysis and performance comparison we can suggest that the proposed approach become one of the suitable technique for the real time implementation in the end of life reverse logistic.

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References

[1] R. Ganeshan and T.P. Harrison, An introduction to supply chain management, Department of Management Science and Information Systems, Penn State University, Vol. 3, No. 1, pp. 2-7 (1995).
[2] A. Chursin, Y. Vlasov and Yury Makarov, Innovative Development of Modern Economy: Basic Principles, In Innovation as a Basis for Competitiveness, Springer, Cham, pp. 1-36 (2017).
[3] C. Goldin and L.F. Katz, The race between education and technology, In Inequality in the 21st Century, Routledge, pp. 49-54 (2018).
[4] Q. Zhu, J. Sarkis and K. Lai, Green supply chain management implications for closing the loop, Transportation Research Part E: Logistics and Transportation Review, Vol. 44, No.1, pp. 1-18 (2008).
[5] Y. Ren, D. Yu, C. Zhang, G. Tian, L. Meng and X. Zhou, An improved gravitational search algorithm for profit-oriented partial disassembly line balancing problem, International Journal of Production Research, Vol. 55, No. 24, pp. 7302-7316 (2017).
[6] C. Prahinski and C. Kocabasoglu, Empirical research opportunities in reverse supply chains, Omega, Vol. 34, No. 6, pp. 519-532 (2006).
[7] D.S. Rogers and R.S. Tibben-Lembke, An examination of reverse logistics practices, Journal of Business Logistics, Vol. 22, No. 2, pp. 129-148 (2011).
[8] E. Grenchus, R. Keene and C. Nobs, Demanufacturing of Information Technology Equipment, Proceedings of 1997 IEEE International Symposium on Electronics and the Environment, San Francisco, California, pp. 157-160 (1997).
[9] V.D.R. Guide Jr, R. Srivastava and M.S. Spencer, An Evaluation of Capacity Planning Techniques in a Remanufacturing Environment, International Journal of Production Research, Vol. 35, No. 1, pp. 67-82 (1997).
[10] L. Moyer and S.M. Gupta, Environmental Concerns and Recycling / Disassembly Efforts in the Electronics Industry, Journal of Electronics Manufacturing, Vol. 7, No. 1, pp. 1-22 (1997).
[11] L. QuocDat, D. ThiTrucLinh, S.Y. Chou and V.F. Yu, Optimizing reverse logistic costs for recycling end-of-life electrical and electronic products, Expert Systems with Applications, Vol. 39, No. 7, pp. 6380-6387 (2012).
[12] T. Sathish and S. Karthick, HAIWF-based fault detection and classification for Industrial Machine Condition Monitoring, Progress in Industrial Ecology, An International Journal, Vol. 12, No. 1-2, pp. 4658 (2018).
[13] C. Bai and J. Sarkis, Flexibility in reverse logistics: a framework and evaluation approach, Journal of Cleaner Production, Vol. 47, No. 1, pp. 306-318 (2013).
[14] M. Mahmoudzadeh, S. Mansour and B. Karimi, To develop a third-party reverse logistics network for end-of-life vehicles in Iran, Resources, Conservation and Recycling, Vol. 78, No. 1, pp. 1-14 (2013).
[15] T.R. Morgan, M. Tokman, R.G. Richey and C. Defee, Resource commitment and sustainability: a reverse logistics performance process model, International Journal of Physical Distribution & Logistics Management, Vol. 48, No. 2, pp. 164-182 (2018).

[16] A. Mahindroo, H.V. Samalia and P. Verma, Information systems road map to enhance economic and operational reverse logistics performance, Int. J. Logist. Syst. and Management, Vol. 29, No. 2, pp. 215-240 (2018).
[17] T. Sathish and J. Jayaprakash, Meta-Heuristic Approach to Solve Multi Period Disassembly-to-order Problem of End-of-life Products using Adaptive Genetic Algorithm, Int. J. Mechan. & Mechatron. Engineering, Vol. 15, No. 3, pp. 59-67 (2015).
[18] T. Sathish and J. Jaya Prakash, Multi Period Disassembly to Order of End of Life Product based on scheduling to maximize the Profit in Reverse Logistic Operation, Int. J. Logis. Sys. and Manage, Vol. 26, No. 1, pp. 402-419 (2017).

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