AN EFFICIENT SHEEP FLOCK HEREDITY ALGORITHM FOR THE CELL FORMATION PROBLEM

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ABSTRACT

CM (Cellular Manufacturing) is an essential GT (Group Technology) application that has been used in several real-world industrial applications. The problem of cell formation is considered as the first most important criteria in the design CMS (Cellular Manufacturing Systems) in order to minimize lead time and setup time to maximize productivity. In this paper, an efficient SFHA (Sheep Flock Heredity algorithm) is suggested for problem solving where the number of cells is not fixed a priori. To assess the effectiveness of the proposed algorithm, a set of 10 benchmark problems is used; the results are then compared with other methods by considering Grouping Efficacy parameter. From the results we can say that algorithm which is proposed has performed well on the standard problems.

Keywords: group technology, cell formation, grouping efficacy, lead time, productivity, sheep flock heredity.

1. INTRODUCTION

Since many years a lot of study has been done on the CF (Cell Formation) techniques in the CM (Cellular Manufacturing). One of the applications in Group Technology is Cellular Manufacturing from which identical parts are identified which is clustered in one to have advantage of its identical views in the M&D (Manufacturing and Design). Cellular Manufacturing is most similar to the terms such as cell system, cellular production system, group technology. In Cellular Manufacturing machines are divided into cells and components are divided into same number of families. This division is done in such a way that all the components in each family can be completely processed by a particular cell. There are three stages in design in Cellular Manufacturing (CM) namely arrangement of parts and components into cells, allotting areas within shop floor to the machine cell and machines layout within each cell. There are many metaheuristic algorithms in cellular manufacturing regarding cell formation out of which Sheep Flock Heredity is discussed in this paper.

2. LITERATURE SURVEY

SFHA (Sheep flock heredity algorithm) is initially suggested in Nara, K., Takeyama, T., & Kim, H. [1]. In a research article by Chandramouli Anandaraman, ArunVikram, Madurai Sankarand and Ramaraj Natarajan [2] one can get some knowledge regarding scheduling optimization using two different algorithms in which SFHA is one, which has been concluded saying SFHA shows best results. By performing change in the traditional SHFA there two referred articles published by G. Vijay Chakaravarthy, S. Marimuthu, S.G. Ponnambalam and G. Kanagaraj [3] and G. Vijaychakaravarthy, S. Marimuthu, A. Naveen Sait [4]. In another article loop layout problems are optimised using SFHA by M. Saravanan & S. Ganesh Kumar [5]. A text book 'Innovative Computational Intelligence A Rough Guide to 134 Clever Algorithms' [6] was referred to know about SFHA and another text book 'Operations Management Research and Cellular Manufacturing Systems' [7] is also referred for details of SFHA.

3. SHEEP FLOCK HEREDITY ALGORITHM

In the early stages SHFA (Sheep Flock Heredity algorithm) was refined by Hyunchul and Byungchul (2001). This algorithm was initiated to solve very large scale problems on scheduling over a time of several consecutive years. Than simple genetic algorithm it is referred as multi-level genetic operations can obtain good solutions. This algorithm was generally based on the natural change of sheep in the flock.

Let us consider some of the flocks of sheep which are separated are in a field as in Figure-1.

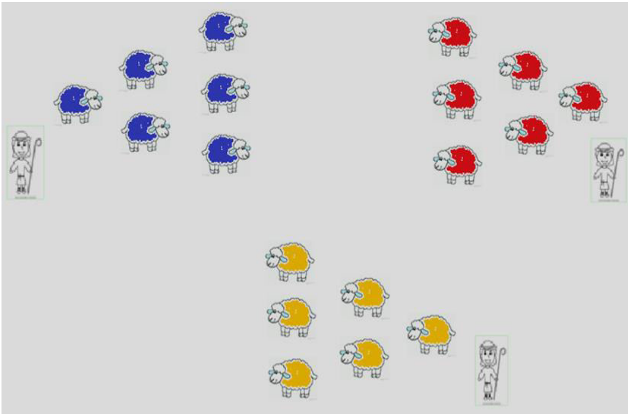

Figure-1. Flocks of sheep in field.

Generally, sheep will live inside their flock under the control of shepherds. So, all kinds of genetic inheritance happen inside the flock as it were. We can also say that some of the special properties in any one flock are developed inside the same flock only due to heredity phenomenon, and the sheep of higher fitness properties will be breeding in their environment.

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Now, let us take that two such flocks of sheep are combined without the knowledge of the shepherds in Figure-2.

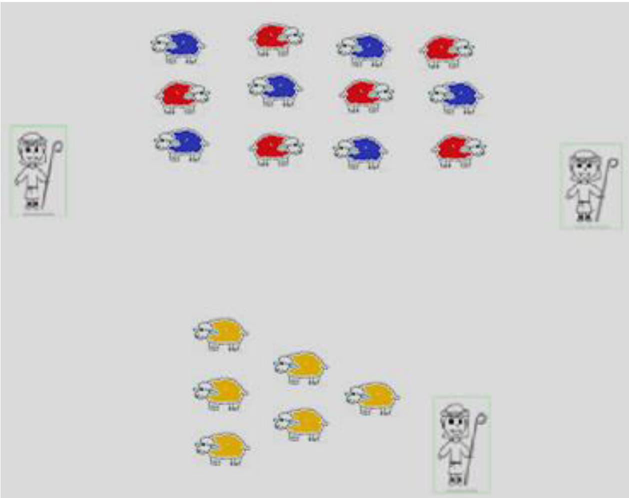


Figure-2. Mixed sheep flocks.

Now, shepherds of each flock move towards the combined flock and divided the sheep as they were before getting mixed up. After separation shepherds cannot differentiate their owned sheep because all the sheep are same in the appearance.

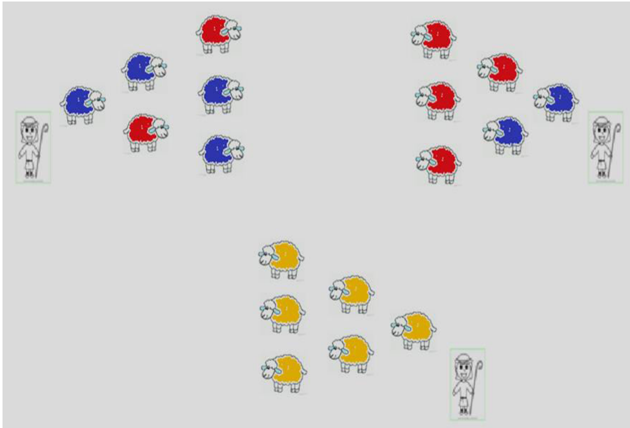


Figure-3. New flocks formed after separating the mixed flock.

As shown in Figure-3, the sheep are unavoidably combined with other sheep flocks and thus, the properties of the sheep in other flocks can be inherited. At that point, flock having great fitness to nature breeds the most.

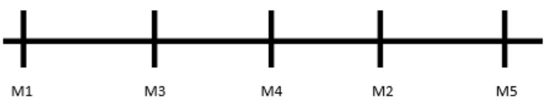
4. ALGORITHM STATEMENT

Steps:
1: Initializing the population of sheep Flock.
2: Performing Sub Chromosomal Crossover for the parent problem.
 2.1: Performing Inverse Mutation.
 2.2: Performing Pair-Wise Mutation.
3: Performing Chromosomal Crossover for the parent problem.
 3.1: Performing Inverse Mutation.
 3.2: Performing Pair-Wise Mutation.
4: Verifying the condition of termination.

4.1. Algorithm Applied to Cell Formation Problem
Problem Source: J. R. King, V. Nakornchai (1982)
Problem Size: (5 Machines × 7 Parts)
Problem Data Set:

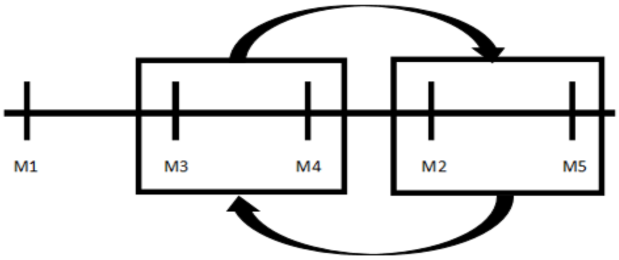
M/P	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6	Part 7
Machine 1	0	1	0	1	1	1	0
Machine 2	1	0	1	0	0	0	0
Machine 3	1	0	1	0	0	1	1
Machine 4	0	1	0	1	0	1	0
Machine 5	1	0	0	0	1	0	1

Step 1: Generating a random Machine sequence.



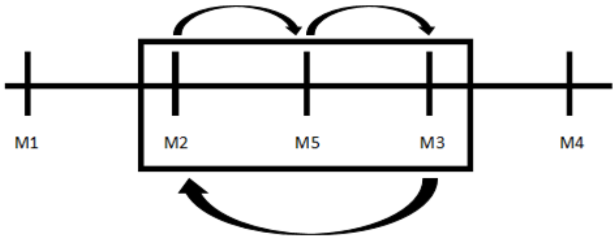
Step 2: Similarly a random Part sequence is also generated after machines are randomised.

Step 3: Performing Sub Chromosomal Crossover on above generated Machine sequence.



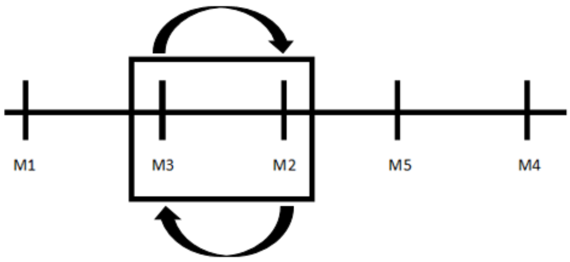
Step 4: Similarly Sub Chromosomal Crossover is performed for random Part sequence generated.

Step 5: Performing Inverse Mutation on the above obtained Machine sequence.



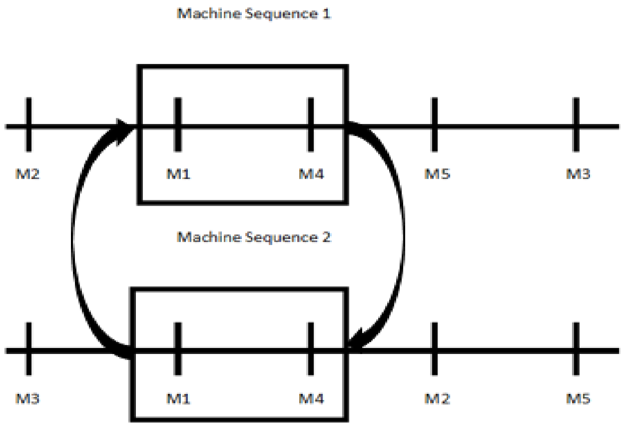
Step 6: Similarly Inverse Mutation on the above obtained Part sequence.

Step 7: Performing Pair-Wise Mutation for the above obtained Machine sequence.



Step 8: Similarly Pair-Wise Mutation for the above obtained Part sequence.

Step 9: Now two random sequences are generated and Chromosomal Crossover process is done for the Machines.



Step 10: Similarly two random Part sequences are generated and Chromosomal Crossover process is done.

Step 11: As specified in step 5 apply Inverse Mutation for both Machine and Part Sequence obtained in previous step.

Step 12: As given in step 7 apply Pair-Wise Mutation for both Machine and part Sequence obtained from the previous step.

Solution Obtained by using Proposed Sheep Flock Heredity Algorithm is mentioned below and voids (0's) are eliminated here which are shown above.

M/P	Part 3	Part 7	Part 1	Part 5	Part 4	Part 6	Part 2
Machine 2	1		1				
Machine 5		1	1	1			
Machine 3	1	1	1			1	
Machine 4					1	1	1
Machine 1				1	1	1	1

Cells formed along with machine and parts data shown below:

	Machines	Parts
Cell-1	2,5,3	3,7,1
Cell-2	4,1	5,4,6,2

Number of Exceptional Elements are 2

5. COMPARISON OF PROPOSED ALGORITHM WITH WELL-KNOWN APPROACHES BASED ON GROUPING EFFICACY

To verify the quality of solution, GE (Grouping Efficacy) that takes the number of operations and void elements inside and outside BDF into consideration can be computed formulae shown below suggested by Kumar and Chandrasekhar an.

Grouping Efficacy = $\frac{(1-\Psi)}{(1+\Phi)}$) x 100 %

Where,

$$\Psi = \frac{(Number of operations (1's) outside the Cells)}{(Total Number of operations (1's))}$$

$$\Phi = \frac{(Number of zeros (0's) inside the Cells)}{(Total Number of operations (1's))}$$

A set of 10 benchmark issues taken from the literature are solved to assess the execution of the proposed calculation. The sources of benchmark problems and their sizes are shown in Table. The suggested algorithm was coded in JAVA and run on a PC with Intel Core i5 CPU with 6 GB RAM. To compare performance of the suggested method with other approaches, we took Grouping Efficacy as Performance Parameter for 10 benchmark problem sets.

To compare the proposed approach, we compare the Grouping Efficacy values obtained by the following methods:

- ZODIAC
- GRAFICS
- ROC
- MD-based

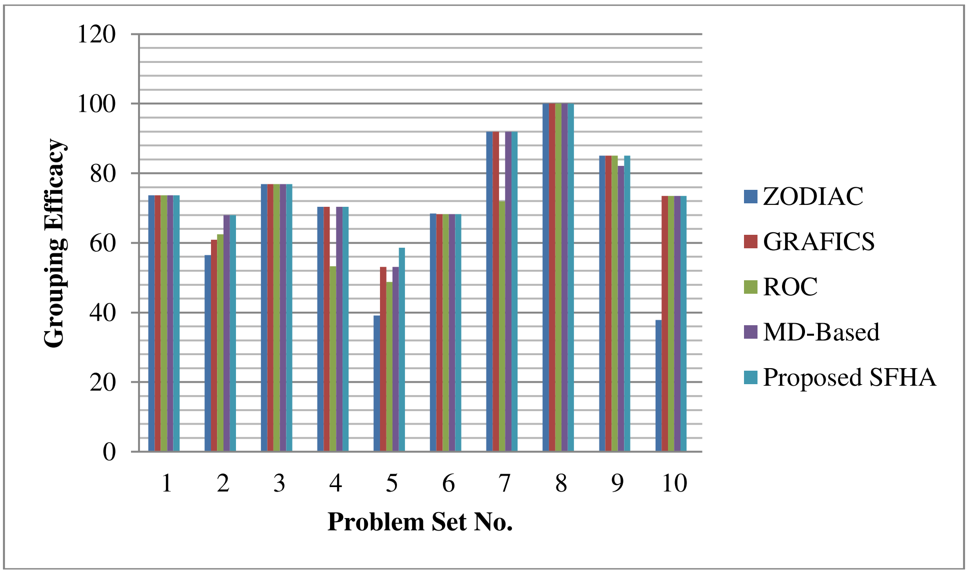
Table-1. Sources of 10 Standard problems and their sizes.

Problem No.	Problem Source	Size (MxP)
1	J. R. King, V. Nakornchai,(1982)	(5x7)
2	P. H. Waghodekar, S. Sahu, (1984)	(5x7)
3	A. Kusiak, M. Cho (1992)	(6x8)
4	F.F. Boctor (1991)	(7x11)
5	A Kusiak, W.S. Chow (1987)	(7x11)
6	H .Seifoddini, P.M. Wolfe (1986)	(8x12)
7	H.M Chan, D.A. Milner (1982)	(10x15)
8	M.P. Chandrasekharan, R. Rajagopalan (1986)	(24x40)
9	M.P. Chandrasekharan, R. Rajagopalan (1986)	(24x40)
10	M.P. Chandrasekharan, R. Rajagopalan (1986)	(24x40)

Table-2. Comparisons of percentage of grouping efficacy of proposed SFHA with different methods.

Problem No.	Methods				
	ZODIAC	GRAFICS	ROC	MD -Based	Proposed SFHA
1	73.68	73.68	73.68	73.68	73.68
2	56.52	60.87	62.5	68	68
3	76.92	76.92	76.92	76.92	76.92
4	70.37	70.37	53.33	70.37	70.37
5	39.13	53.12	48.78	53.13	58.64
6	68.4	68.3	68.29	68.3	68.3
7	92	92	71.93	92	92
8	100	100	100	100	100
9	85.1	85.1	85.11	82.11	85.1
10	37.85	73.51	73.51	73.51	73.51

Table-3. Graphical representation of comparisons of proposed SFHA with other methods.



The above Tables 2 & 3 shows the grouping efficacies of above methods and the method proposed by us for 10 benchmark problems. The results reveal that the performance of the proposed method taking the grouping efficacies into consideration and comparing with the existing algorithms is either improved or comparably best for most of the problems.

6. CONCLUSIONS

The main intention of this paper is to generate optimal machine and part cells by using Sheep Flock Heredity Algorithm in cellular manufacturing systems to maximize Grouping Efficacy. Computational results of suggested algorithm and comparison with well-known existing methods for 10 benchmark problems are presented. This shows that the suggested algorithm gives better results for most cases among existing algorithms.

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