A Native Decision Support System for Textile Industry using Hybrid Meta-heuristic Optimization Technique

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Abstract— Decision Making and Optimization of Resources at each level of development is a hard optimization problem, especially where selection based on real time workflow and available resources. Textile Industry is one of the prominent area where optimization problems occur due to mutation, uncertainty of yarn stock, and diverse fashion trends in market. Machine Learning and Mathematical Optimization Algorithm provides the combine solution for optimization problems related to textile industry. This paper proposed a novel Hybrid Meta-Heuristic Optimization Algorithm (HMHOA) to solve fabricators, labours and resource optimization problem at each phase of development and also help to recognize occurrence of real time interrupts. Proposed algorithm provides optimize list of fabricators & labours on various factors like cost cf(xn), production capacity prd(xn), wastage wf(xn), and quality of service qos(xn). All these would help to recognize and filter appropriate tasks at each level of development.

Keywords— *Decision Making; Optimization; Hybrid Meta-heuristic; Machine Learning; Textile Industry.*

I. INTRODUCTION

Decision Making and Optimize Solutions are key demands in native era of technology evolution, especially in field of manufacturing and production based industries. Almost every industry adopts the optimization criteria, but still textile industry has lack of optimization solutions, especially in small scale textile industries. Major consideration to prefer outsourcing their work in textile industry generates knowledge gap between outsource fabricators and final production textile companies. To overcome this problem, we need to generate flexible and powerful optimization solutions, which helps to fill this knowledge gap.

Sugawara & Fujita [5], have focus on the appropriate task selection for worker based on workflow is often changed by occurring interruption due to assignment of external activity to the worker, which strongly need to apply the approach of weighting to generate best optimize results. Sugawara & Fujita [6], have further extends criteria of harmony search space to generate better results, which actually overcome the restriction generate by local optima. This study recommends to increase more accurate subjective attributes with weights to generate best solution to the decision making for adaptive task selection.

Yu et al. [7], have simulate the textile manufacturing process by using Petri net and ExSpect tools and focus to isolate possible tasks and execute them cumulatively to achieve manufacturing process acrimoniously. Leena & Balaji [4], have discussed about the decision making and focus to use more accurate factors in diverse working environment to generate better prediction, which is appropriate for textile industry heterogeneous environment. Nguyen et al. [3], focus to co-evolve the backbone rules to enhance the effectiveness of heuristic approach, which help to generate fast and efficient results in real-time environment with parallel heuristic approach.

Liu Ruoqian et al. [2], have proposed prune search approach by reducing the search region of optimization techniques with the power of knowledge base meta-heuristic approach, which significantly reduce computational time by reorder of search space. This study need to extend machine learning factors to generate optimize results, which close to global optima and avoiding local optima by reducing search region.

Alam et al. [1], have presented a need of parallelism in heterogeneous space to generate better result swiftly in real time environment by using various distinct parameters, those are co-evaluate to generate best predictive results. Zhang et al. [8], have proposed a seamless integration of the concept of optimal computing budget allocation into Particle swarm optimization (PSO) to improve the computational efficiency of PSO for stochastic optimization problems, which is helpful for textile fabricators and workflow optimization.

Key purpose of the study is to provide extended and scientific decision making power to textile management authorities, so they can easily choose, which outsource body is best for them as per production requirement. This study generates good results, with the co-ordination of production company management and outsource fabricators management, because lack of co-ordination between them generates knowledge gap. To fill this gap, we are developing combine tool of Data Acquisition System and Decision Support System with the consolidation of advance machine learning algorithms, which helps the textile industry management to launch new products, increase productivity, increase sale and profit of Textile Industry.

II. METHODOLOGY

Knowledge Gap occurs when two isolated bodies co-relate to achieve the target. In textile industry, this gap is generated due to the co-relation of manufacturing company and outsource fabricators. To fill this knowledge gap, first of all we need to create data acquisition system as per textile industry needs and requirements.

This data acquisition system need to full-fill the requirement of data mining by best modular design, which helps to understand the current situation of textile industry. After finalizing of outsource fabricators data along with evaluation factors, our proposed hybrid machine learning algorithm is applied, which combines the power of heuristic and meta-heuristic approach to boost the evaluation along with best predictive results. This proposed algorithm is also able to handle the interruption of various factors, those occur during co-relation of both companies, these factors are chosen by industry expertise.

A. Theoretical Framework (Hybrid Meta-Heuristic Approach)

Fabrication outsourcing, and yarn stock allotment optimization problem occur in textile industry. This is a very complex NP-Hard Problem, which needs to be solved by scientific approach. We understand the situation and business logic of Ludhiana small scale textile industries, and finally proposed a suitable solution in form of novel decision support system based on Hybrid Meta-Heuristic Approach. This decision support system helps management, to launch new products, increase productivity, increase sale and profit of Textile Industry.

TABLE I. SAMPLE DATA SET PARAMETERS

Parameter	Description
ID	Fabricator Identification
Name	Fabricator Name
Cost Factor [cf(Xn)]	Per Piece Cost of Manufacturing
Production Capacity Factor [prd(Xn)]	No. of pieces manufactured by one unit/machine.
Wastage Factor [wf(Xn)]	How much thread is wastage per piece in grams unit?
Feedback Rating [qos(Xn)]	Quality Star Rating out of 5, based on previous data and experience of management.
Optimal Score [os(Yn)]	Score Set after merging optimize results into final result set.

B. Proposed Hybrid Meta-Heuristic Optimization Algorithm (Local/Global Minima Approach)

Algorithm: Textile Matrix's Hybrid Meta-heuristic Optimization Algorithm with Local/Global Minima Approach.

Input: A List x of n elements, non-optimized and rCapacity is required capacity.

Output: A List y or y* of n elements, optimized.

Step 1: Calculate length of x.

$$len(x) : length\ of\ list\ x$$

Step 2: Calculate current capacity of input list x, where prd(x_n) is productivity factor function.

$$\mathbf{cCapacity} = \sum_{k=0}^{n} prd(x_n) ; n = 0, 1, 2, \dots, len(x)$$

Step 3: If cCapacity <= rCapacity than set y = x and move to step 14.

Step 4: Calculate threshold value from list x, where ef(x_n) is evaluation factor function.

$$\mathbf{th}(\mathbf{x}) = \sum_{k=0}^{n} ef(x_n) / _n ; n = 0, 1, 2, \dots, len(x)$$

Step 5: Apply heuristic function h(x) to find y list.

$$h(x) = \begin{cases} y \subseteq \mathbf{x} : len(x) > 0 \\ ef(x_n) \leq th(x) : ef(x_n) > 0 ; n = 0, 1, 2, \dots, len(x) \end{cases}$$

Step 6: Calculate current capacity of list y, where prd(y_n) is productivity factor function.

$$\mathbf{cCapacity} = \sum_{k=0}^{n} prd(y) ; n = 0, 1, 2, \dots, len(y)$$

Step 7: If cCapacity < rCapacity and len(y) < len(x) than move toward to meta-heuristic approach else move to step 14.

Step 8: Calculate extended threshold value to skip the local minima, towards global search.

$$th^*(x) = \begin{cases} \sum_{k=0}^{n} ef(x_n) / _n ; n = 0, 1, 2, \dots, len(x) \\ ef(x_n) \geq th(x) : ef(x_n) > 0 ; n = 0, 1, 2, \dots, len(x) \end{cases}$$

Step 9: Set th(x) = th*(x).

Step 10: Apply Meta-heuristic function to get y* list.

$$mh(x) = \begin{cases} y^* \subseteq \mathbf{x} : len(x) > 0 \\ ef(x_n) \leq th^*(x) : ef(x_n) > 0 ; n = 0, 1, 2, \dots, len(x) \end{cases}$$

Step 11: Calculate current capacity of list y*, where prd(y^*_n) is productivity factor function.

$$\mathbf{cCapacity} = \sum_{k=0}^{n} prd(y_n^*) ; n = 0, 1, 2, \dots, len(y^*)$$

Step 12: Repeat steps 9 to 12 until cCapacity < rCapacity and len(y*) < len(x).

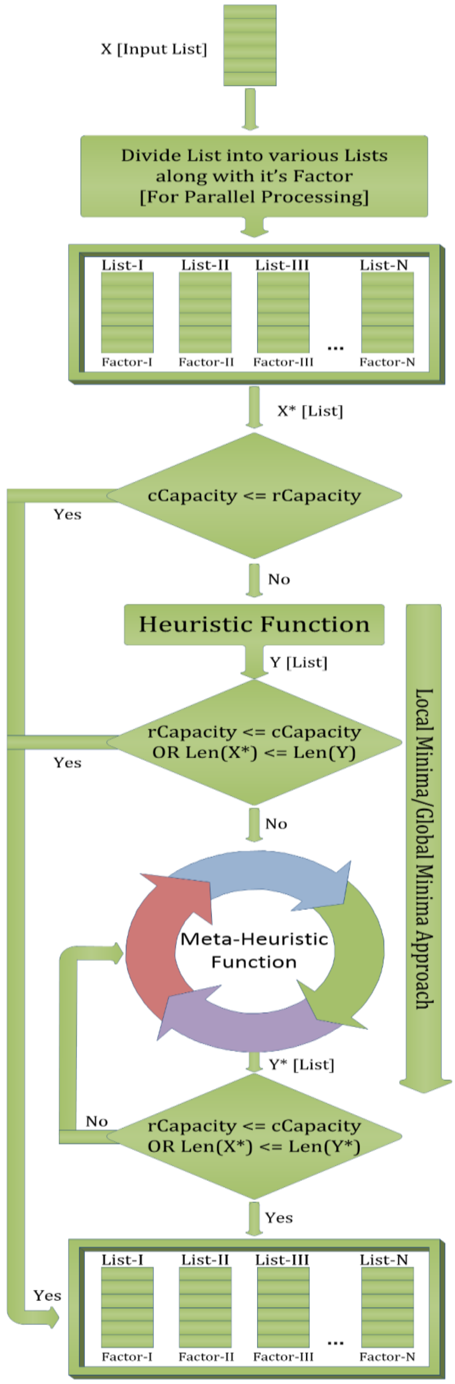

Figure 1: Block Diagram of Proposed Meta-Heuristic Algorithm (Local/Global Minima Approach)

C. Proposed Hybrid Meta-heuristic Optimization Algorithm (Local/Global Maxima Approach)

Algorithm: Textile Matrix's Hybrid Meta-heuristic Optimization Algorithm with Local/Global Maxima Approach.
Input: A List x of n elements, non-optimized and rCapacity is required capacity.
Output: A List y or y* of n elements, optimized.

Step 1: Calculate length of x.

$$len(x) : length\ of\ list\ x$$

Step 2: Calculate current capacity of input list x, where prd(X_n) is productivity factor function.

$$\text{cCapacity} = \sum_{k=0}^{n} prd(x_n)\,;n = 0,1,2,\dots,len(x)$$

Step 3: If cCapacity <= rCapacity than set y = x and move to step 14.

Step 4: Calculate threshold value from list x, where ef(X_n) is evaluation factor function.

$$\mathbf{th(x)} = {\sum_{k=0}^{n} ef(x_n)}/_{n}\,;n = 0,1,2,\dots,len(x)$$

Step 5: Apply heuristic function h(x) to find y list.

$$h(x) = \left\{\begin{array}{c} y \subseteq x : len(x) > 0 \\ ef(x_n) \geq th(x): ef(x_n) > 0;\ n = 0,1,2,\dots,len(x) \end{array}\right.$$

Step 6: Calculate current capacity of list y, where prd(Y_n) is productivity factor function.

$$\mathbf{cCapacity} = \sum_{k=0}^{n} prd(y)\,;n = 0,1,2,\dots,len(y)$$

Step 7: If cCapacity < rCapacity and len(y) < len(x) than move toward to meta-heuristic approach else move to step 14.

Step 8: Calculate extended threshold value to skip the local minima, towards global search.

$$th^{*}(x) = \left\{\begin{array}{c} {\sum_{k=0}^{n} ef(x_n)}/_{n}\,;n = 0,1,2,\dots,len(x) \\ ef(x_n) \leq th(x): ef(x_n) > 0;\ n = 0,1,2,\dots,len(x) \end{array}\right.$$

Step 9: Set th(x) = th*(x).

Step 10: Apply Meta-heuristic function to get y* list.

$$mh(x) = \left\{\begin{array}{c} y^{*} \subseteq x : len(x) > 0 \\ ef(x_n) \geq th^{*}(x): ef(x_n) > 0;\ n = 0,1,2,\dots,len(x) \end{array}\right.$$

Step 11: Calculate current capacity of list y*, where prd(Y^*_n) is productivity factor function.

$$\mathbf{cCapacity} = \sum_{k=0}^{n} prd(y^{*}_{n})\,;n = 0,1,2,\dots,len(y^{*})$$

Step 12: Repeat steps 9 to 12 until cCapacity < rCapacity and len(y*) < len(x).

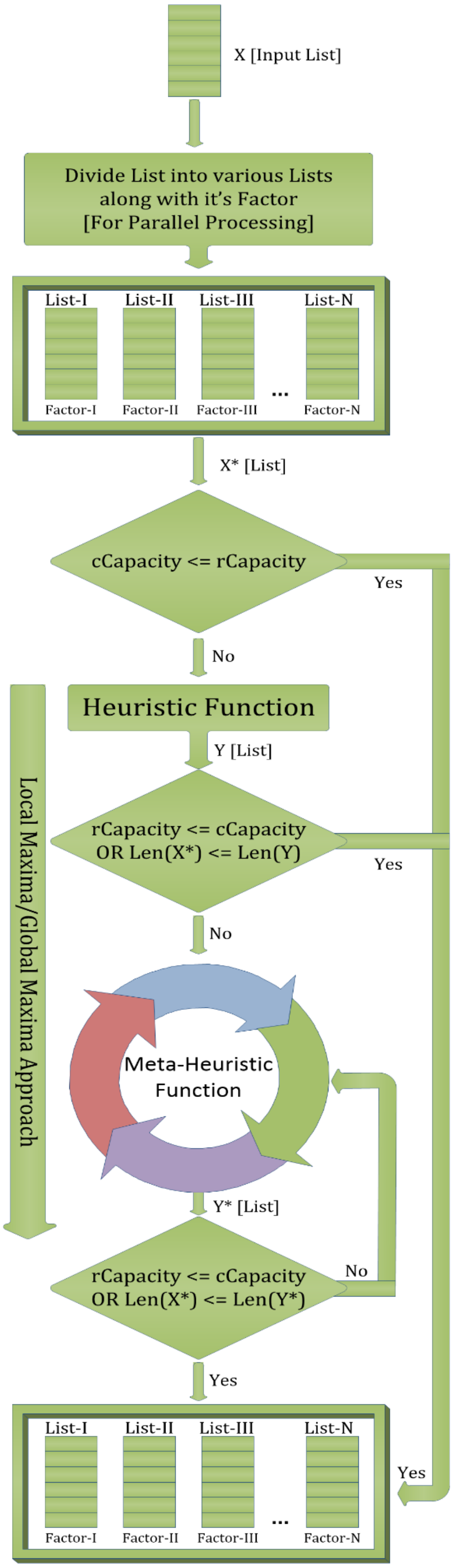

Figure 2: Block Diagram of Proposed Meta-Heuristic Algorithm (Local/Global Maxima Approach)

D. Proposed Hybrid Meta-heuristic Final Collective Optimization Algorithm

Algorithm: Textile Matrix's Hybrid Meta-heuristic Final Collective Optimization Algorithm.

Input: Bunch of Hybrid Meta-heuristic optimize lists of n elements and rCapacity is required capacity.

Output: A List y* of n elements, final collective optimized list.

Step 1: Sort All Hybrid Meta-Heuristic optimize Lists in ascending order from Top to Bottom, based on respective evaluation factor $ef(X_n)$.

Step 2: Calculate mid value of respective evaluation factor $ef(X_n)$ for all lists.

Step 3: Generate single list Y* with distinct Ids and corresponding values along with merge weights. If ID not available in any list, than use mid value of respective factor from list.

Step 4: Sort list Y* with respect to merge weights.

Step 5: Initialize index value.

$$index = 0$$

Step 6: Calculate length of list Y*.

$$len(Y^*) : length\ of\ list\ Y^*$$

Step 7: Calculate current capacity of optimize list Y*, where $prd(Y^*_n)$ is productivity factor function.

$$cCapacity = \sum_{k=0}^{n} prd(Y^*_n) ; n = 0, 1, 2, \ldots, len(Y^*)$$

Step 8: Repeat steps from 9 to 13 until rCapacity <=rCapacity else move to step 14.

Step 9: Push(Y*[Index]) in to Y* List.

Step 10: Increment index value by one.

Step 11: Add push element capacity to current capacity.

$$cCapacity \mathrel{+}= pushElement(capacity)$$

Step 12: Final output Y* optimize list is generated.

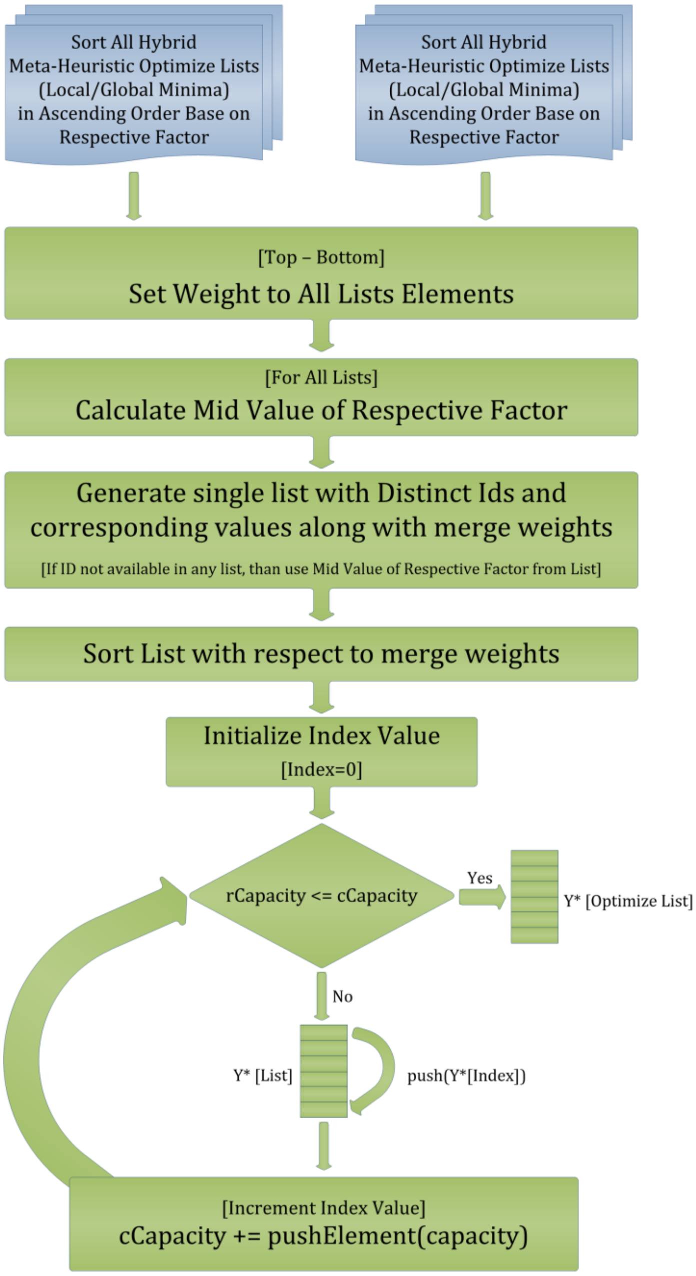

Figure 3: Block Diagram of Proposed Meta-Heuristic Final Collective Optimization Algorithm

E. Required Capacity of Production (rCapacity)

Required Capacity of Production is calculated based on the following formula as in (1):

$$rCapacity = \frac{requiredPieces}{availableProductionHours} \quad (1)$$

III. RESULTS AND DISCUSSION

A. Input Data Set (X)

Instance of Fabricators Data Set is generated using classification based on Large Front Manufacturer's parameter. Input Data Set gather from various Fabricators, Hosiery, Knitwear and Textile Industries located in Ludhiana City. This Data Set include id, fabricator name, cost of manufacturing, production capacity, wastage of raw material and quality feedback.

TABLE II. INPUT LIST OF FABRICATORS ALONG WITH EVALUATION FACTORS

ID	Name	Evaluation Factors ef(Xn)			
		cf(Xn)	*prd(Xn)*	*wf(Xn)*	*qos(Xn)*
1	Banke Bihari Fabrication	20	4	9	4.7
2	Davinder Fabrication	22	3.5	8.5	4.4
3	Ravi Fabrication	22.5	4.5	9.5	4.2
4	Raju Fabrication	20.5	4	8.5	4.5
5	Parteek Fabrication	22	3.5	9.5	4.2
6	Radha Vallabh Hosiery	21	5	8.5	4.7
7	J. P. Knitwear	21.5	4.5	10	4.4
8	Brij Mohan Fabricator	20	4	9.5	4.2

B. Input Data Set (X)

Optimize Results (Y*) are generated after applying proposed Hybrid Meta-Heuristic Algorithm based on Local/Global Minima/Maxima Approach (Minima and Maxima approach vary based on evaluation factors). Cost Factor cf(xn), Wastage Factor wf(xn) used Minima Approach and Production Capacity prd(xn), Feedback Rating/Quality of Service Factor qos(xn) used Maxima Approach. Optimization Results generate based on various evaluation factors set efs(xn) are following:

rCapacity for current context, from equation (1):

$$rCapacity = \frac{8600}{176} = 48.86$$

TABLE III. OPTIMIZE LIST (Y*) ON EFS({PRD(XN)})

ID	Name	Evaluation Factors ef(Xn)	
		prd(Xn)	*os(Yn)*
1	Radha Vallabh Hosiery	5	1
2	J. P. Knitwear	4.5	2
3	Ravi Fabrication	4.5	3
4	Brij Mohan Fabricator	4	4
5	Raju Fabrication	4	5
6	Banke Bihari Fabrication	4	6
7	Parteek Fabrication	3.5	7
8	Davinder Fabrication	3.5	8
9	Radha Vallabh Hosiery	5	1
10	J. P. Knitwear	4.5	2
11	Ravi Fabrication	4.5	3
12	Brij Mohan Fabricator	4	4

TABLE IV. OPTIMIZE LIST (Y*) ON EFS({CF(XN)},{PRD(XN)})

ID	Name	Evaluation Factors ef(Xn)		
		cf(Xn)	*prd(Xn)*	*os(Yn)*
1	Radha Vallabh Hosiery	21	5	5
2	Brij Mohan Fabricator	20	4	6
3	Banke Bihari Fabrication	20	4	7
4	J. P. Knitwear	21.5	4.5	7
5	Raju Fabrication	20.5	4	8
6	Ravi Fabrication	22.5	4.5	11
7	Davinder Fabrication	22	3.5	14
8	Parteek Fabrication	22	3.5	14
9	Radha Vallabh Hosiery	21	5	5
10	Brij Mohan Fabricator	20	4	6
11	Banke Bihari Fabrication	20	4	7
12	J. P. Knitwear	21.5	4.5	7

TABLE V. OPTIMIZE LIST (Y*) ON EFS({PRD(XN)},{WF(XN)})

ID	Name	Evaluation Factors ef(Xn)		
		prd(Xn)	*wf(Xn)*	*os(Yn)*
1	Radha Vallabh Hosiery	5	8.5	4
2	Raju Fabrication	4	8.5	7
3	Ravi Fabrication	4.5	9.5	8
4	Davinder Fabrication	3.5	8.5	9
5	Banke Bihari Fabrication	4	9	10
6	J. P. Knitwear	4.5	10	10
7	Brij Mohan Fabricator	4	9.5	11
8	Parteek Fabrication	3.5	9.5	13
9	Radha Vallabh Hosiery	5	8.5	4
10	Raju Fabrication	4	8.5	7
11	Ravi Fabrication	4.5	9.5	8
12	Davinder Fabrication	3.5	8.5	9

TABLE VI. OPTIMIZE LIST (Y*) ON EFS({PRD(XN)},{QOS(XN)})

ID	Name	Evaluation Factors ef(Xn)		
		prd(Xn)	*qos(Xn)*	*os(Yn)*
1	Radha Vallabh Hosiery	5	4.7	2
2	J. P. Knitwear	4.5	4.4	6
3	Banke Bihari Fabrication	4	4.7	8
4	Raju Fabrication	4	4.5	8
5	Brij Mohan Fabricator	4	4.2	10
6	Ravi Fabrication	4.5	4.2	11
7	Davinder Fabrication	3.5	4.4	13
8	Parteek Fabrication	3.5	4.2	14
9	Radha Vallabh Hosiery	5	4.7	2
10	J. P. Knitwear	4.5	4.4	6
11	Banke Bihari Fabrication	4	4.7	8
12	Raju Fabrication	4	4.5	8

TABLE VII. OPTIMIZE LIST (Y*) ON EFS({CF(XN)},{PRD(XN)},{WF(XN)})

ID	Name	Evaluation Factors ef(Xn)			
		cf(Xn)	*prd(Xn)*	*wf(Xn)*	*os(Xn)*
1	Radha Vallabh Hosiery	21	5	8.5	8
2	Raju Fabrication	20.5	4	8.5	10
3	Banke Bihari Fabrication	20	4	9	11
4	Brij Mohan Fabricator	20	4	9.5	13
5	Davinder Fabrication	22	3.5	8.5	15
6	J. P. Knitwear	21.5	4.5	10	15
7	Ravi Fabrication	22.5	4.5	9.5	16
8	Parteek Fabrication	22	3.5	9.5	20
9	Radha Vallabh Hosiery	21	5	8.5	8
10	Raju Fabrication	20.5	4	8.5	10
11	Banke Bihari Fabrication	20	4	9	11
12	Brij Mohan Fabricator	20	4	9.5	13

TABLE VIII. OPTIMIZE LIST (Y*) ON EFS({CF(XN)},{PRD(XN)},{QOS(XN)})

ID	Name	Evaluation Factors ef(Xn)			
		cf(Xn)	*prd(Xn)*	*qos(Xn)*	*os(Xn)*
1	Radha Vallabh Hosiery	21	5	4.7	6
2	Banke Bihari Fabrication	20	4	4.7	9
3	Raju Fabrication	20.5	4	4.5	11
4	J. P. Knitwear	21.5	4.5	4.4	11
5	Brij Mohan Fabricator	20	4	4.2	12
6	Davinder Fabrication	22	3.5	4.4	19
7	Ravi Fabrication	22.5	4.5	4.2	19
8	Parteek Fabrication	22	3.5	4.2	21
9	Radha Vallabh Hosiery	21	5	4.7	6
10	Banke Bihari Fabrication	20	4	4.7	9
11	Raju Fabrication	20.5	4	4.5	11
12	J. P. Knitwear	21.5	4.5	4.4	11

TABLE IX. OPTIMIZE LIST (Y*) ON EFS({PRD(XN)},{WF(XN)},{QOS(XN)})

ID	Name	Evaluation Factors ef(Xn)			
		prd(Xn)	*wf(Xn)*	*qosXn)*	*os(Xn)*
1	Radha Vallabh Hosiery	5	8.5	4.7	5
2	Raju Fabrication	4	8.5	4.5	10
3	Banke Bihari Fabrication	4	9	4.7	12
4	Davinder Fabrication	3.5	8.5	4.4	14
5	J. P. Knitwear	4.5	10	4.4	14
6	Ravi Fabrication	4.5	9.5	4.2	16
7	Brij Mohan Fabricator	4	9.5	4.2	17
8	Parteek Fabrication	3.5	9.5	4.2	20
9	Radha Vallabh Hosiery	5	8.5	4.7	5
10	Raju Fabrication	4	8.5	4.5	10
11	Banke Bihari Fabrication	4	9	4.7	12
12	Davinder Fabrication	3.5	8.5	4.4	14

TABLE X. OPTIMIZE LIST (Y*) ON EFS({CF(XN)},{PRD(XN)},{WF(XN)},{QOS(XN)})

ID	Name	Evaluation Factors ef(Xn)				
		cf(Xn)	*prd(Xn)*	*wf(Xn)*	*qosXn)*	*os(Xn)*
1	Radha Vallabh Hosiery	21	5	8.5	4.7	9
2	Banke Bihari Fabrication	20	4	9	4.7	13
3	Raju Fabrication	20.5	4	8.5	4.5	13
4	J. P. Knitwear	21.5	4.5	10	4.4	19
5	Brij Mohan Fabricator	20	4	9.5	4.2	19
6	Davinder Fabrication	22	3.5	8.5	4.4	20
7	Ravi Fabrication	22.5	4.5	9.5	4.2	24
8	Parteek Fabrication	22	3.5	9.5	4.2	27
9	Radha Vallabh Hosiery	21	5	8.5	4.7	9
10	Banke Bihari Fabrication	20	4	9	4.7	13
11	Raju Fabrication	20.5	4	8.5	4.5	13
12	J. P. Knitwear	21.5	4.5	10	4.4	19

C. Recommended Priority (#) Sets of Evaluation Factors for Best Optimization Results

Recommended Sets of Evaluation Factors are suggested after comparison based on the Efficiency and Reliability Score.

TABLE XI. RECOMMENDED EVALUATION FACTORS

#	Name	Efficiency	Reliability	OS
		$\frac{\sum_{k=0}^{\|y*\|} y^*(os)}{\|efs\|}$	$\frac{rCapacity}{\|y^*\|/\|efs\|}$	
1	efs({cf(x)},{prd(x)},{wf(x)},{qos(x)})	49.5	16.27	65.77
2	efs({cf(x)},{prd(x)},{wf(x)})	50	12.22	62.22
3	efs({prd(x)},{wf(x)},{qos(x)})	49.7	12.22	61.92
4	efs({cf(x)},{prd(x)},{qos(x)})	48.3	12.22	60.52
5	efs({prd(x)},{wf(x)})	50	8.14	58.14
6	efs({cf(x)},{prd(x)})	48.5	8.14	56.64
7	efs({prd(x)},{qos(x)})	48	8.14	56.14
8	efs({prd(x)})	46	4.07	50.07

IV. CONCLUSION

Textile Industry's manufacturing process is very complex structure. Uncertainty in manufacturing process generate various optimization problems, which are very difficult to handle by Textile Industry management. To overcome this problem, a novel decision support system software is proposed, which provides optimal solutions using proposed hybrid meta-heuristic optimization algorithm. This proposed system able to work in real time environment, and it is also flexible in nature via various judgement factors those are able to modify by user to get better result as per requirement.

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