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Implementation of Machine Part Cell Formation Algorithm in Cellular Manufacturing Technology Using Neural Networks

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Abstract

The machine-part cell formation problem explains the topics surrounding the creation of part families based on the processing needs of the components, and the classification of machine groups based on their capacity to process exact part families in manufacturing. Allocate the specified machines and parts into cells so that the grouping efficiency is maximized. The objective of the paper is to cluster the parts based upon self-organizing map (SOM). After clustering, Minkowski distance is used to sort the machines and some bottlenecks are introduced during the clustering process which can be removed manually by rearranging. We are going to implement self-organizing map (SOM) which is a type of artificial neural network technique to solve this problem. The proposed Minkowski distance approach produced solution with a good group efficiency.

Keywords*: Self-organizing map (SOM), Minkowski distance, neural network.*

1. Introduction

Now-a-days each and every business focuses their interest particularly on swiftness for answering to their customers' desires. As a result of which they want to amplify response times. Group technology is one of the best strategies to tackle response time in the field of manufacturing, which concentrates on cellular manufacturing. Cell formation is problem refers to the procedure for arranging the part families and machine groups. Cellular manufacturing technique is a substitute to batch-type manufacturing, where dissimilar parts are formed alternatively in small lot sizes. Cellular manufacturing Technology is an application of clustering technology in manufacturing field, where similar parts are grouped together forming part families and for the ease of manufacturing and design similar machines are clubbed to form machine cells

The benefit of cellular manufacturing includes lower handling cost of materials, lower setup time and faster work, the other benefits such as improved operator and tool control, better scheduling and reduction in flow time. Even though cellular manufacturing offers huge profit but it is very complex to design cellular manufacturing system for real life problems. Here the cell formation problem and group efficiency is calculated for grouping parts and machines according to SOM techniques and Minkowski distance. First we are using the input machinepart matrix with SOM technique using neural networks to clusters the parts. After

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that we calculate the Minkowski distance for each machine to sort them out with parts to form the final output. And calculate the group efficiency of the system.

2. Literature Survey

Cell formation includes the method of evaluating parts of machines, clustering those parts with analogous design into families, and forming the related machines into cells. There has been widespread work completed in this field, Attila Körei [1] gave a solution method using the tools of formal concept analysis. They described the extent partitions of an object set that can be used for determining machine cells based on formal concepts. Miin-Shen Yang, Jenn-Hwai Yang [2] proposed a modified ART1 neural learning algorithm; they introduced modified ART1 method in which the vigilance parameter can be basically calculated by the data. It is more well-organized and consistent than [3] Dagli and Huggahalli's method for choosing a vigilance value. The algorithm proposed by author is vigilance parameter-free and very efficient to use in Cell Formation with a large range of machine/part matrices. M. Murugan, V. Selladurai [4] in their research proposed an Art Modified Single Linkage Clustering approach to resolve cell formation problems in Cellular Manufacturing. Here they included an [7] ART1 network with Modified Single Linkage Clustering to explain cell formation problems. For the performance measures, Grouping Efficiency Machine Utilization and Percentage of Exceptional Elements are considered. The steps that are included are a cell formation is constructed by heuristic ART1 Modified Single Linkage Clustering and then the solution is refined using Modified Single Linkage Clustering heuristic. There are two types of clustering methods- hierarchical and non-hierarchical methods. The drawback of the hierarchical method is chaining effects and a predetermined cluster number is needed for nonhierarchical clustering.

The research projects a piece of clustering algorithm that is based on an artificial ant clustering model [5]. The algorithm applies the features of ants, randomness and congregation to avoid grouping outcome from being limited during clustering processes and to decrease the noisy data property. Fabrice Rossi, Brieuc Conan-Guez and Aicha El Golli in their research stated how to cluster functional data using [8, 10] SOM algorithm , in that the first step is to compute the winning neuron fixed as the one which reduces the distance between its prototype vector and the input vector. This procedure is grounded on the norm on the vectorial space. The next step is to revise the form of the winning neuron and of its neighbors by the successive revise method: $p_t+1 = pt + \eta(y - p_t)$, where pt = prototype vector and = input vector.

3. Methodology

Our system is divided into three modules. The first part is used to cluster the parts that are to be machined by a specific machine .Second part machine grouping is done where we have used the Minkowski distance, in this second module there is a chance of bottleneck to be introduced. The final module is used to rearrange the machines to avoid the bottle neck which is show in Figure -1.

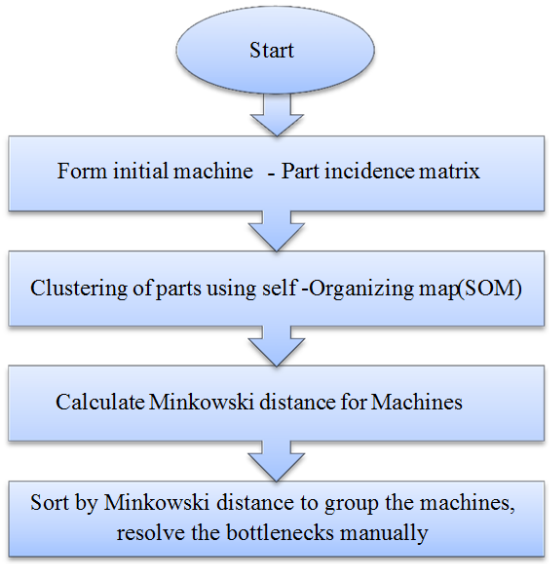

Figure 1. Steps for Solving Cell Formation Problem

3.1. Form Initial Machine-part Matrix

To form the initial machine part matrix, we are takings rows as machines and columns as parts. Matrix is formed by 1's and 0's entries, which indicates a part is used or not used by a machine for a production. An entry A_{ij} is defined as follows -

A_{ij} = 1 if part j is used by machine i.

A_{ij} = 0 if part j not used by machine i. Where, i =machine index (i =1, 2...M) j = part index (k =1, 2... P)

M =number of machines

P =number of parts

Table 1. Initial Machine-part Matrix

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
M1	0	0	1	0	0	0	1	0	0	0
M2	1	0	0	1	0	1	0	1	0	1
M3	0	1	0	0	1	0	0	0	1	1
M4	0	1	0	0	1	0	0	0	1	0
M5	1	0	0	1	0	1	0	1	0	0

M 6	0	0	1	0	0	0	1	0	0	0
M 7	1	0	0	1	0	1	0	1	0	1
M 8	0	1	0	0	1	0	0	0	1	1

3.2. Clustering Parts using Self Organizing Map Technique

After the first step apply the Self Organizing Map technique which is an artificial neural network technique to group the parts. There many clustering algorithms like K-means, Bayesian, genetic algorithms, fuzzy logic, ant-colony, neural-networks etc. We are using Self Organizing map Neural Networks technique for better efficacy as shown in Figure - 3.

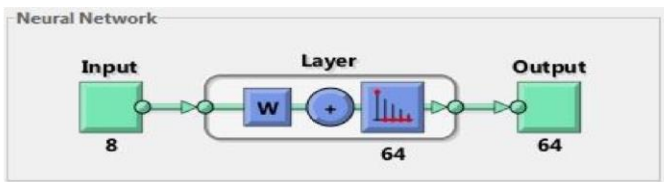

Figure 2. Working of Neural Network

We have input layer with 8 neurons, 64 hidden layers and output of 64 individual plots. Where four clusters are formed where first cluster having four parts, second three, third two and forth having one parts respectively as shown in Figure- 4 .

The group formed is:
G1= P1 P4 P6 P8
G2= P2 P5 P9
G3= P3 P7
G4=P10

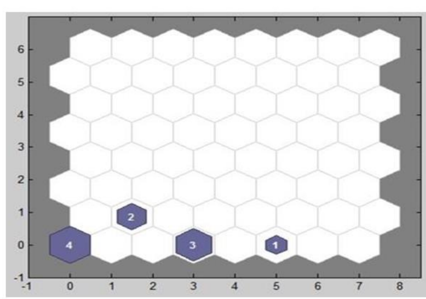

Figure 3. Neural Network SOM Sample

3.3. Calculate Minkowski Distance for Machines

It is defined between two machines and a clustering algorithm is used to group machines into machine cells. The similarity coefficient between two machines is defined as the number of parts visiting both machines divided by the number of parts visiting either of the two machines. Minakwoski distance is shown below,

$$d_{st}=\sqrt[p]{\sum_{j=1}^{n}|x_{sj}-y_{tj}|p}$$

Where x_{Sj} and y_{tj} vectors.
$p \geq 1$, the Minkowski distance is a metric which is a result of the Murkowski. For $p < 1$, it is not - the distance between (1, 1) and (0, 0) is $2^{1/p} > 2$, but the point (0, 1) is a distance 1 from both of these points. Minkowski Distances are:

17.4161
21.1607
19.0232
18.4500
20.5875
17.4161
21.1607
19.0232

3.4. Sorted by Minkowski distance

After clustering of parts using SOM technique, re-arrange the column to cluster the same machines that are used to process the parts .Then re-arrange the rows to cluster the machine according the part clusters to form final clusters. Final result shows us the grouping of parts and machines to solve the machine cell formation problem.

Table 2. Output for Machine Cell Formation

	P1	P4	P6	P8	P2	P5	P9	P10	P3	P7
M1	0	0	0	0	0	0	0	0	1	1
M6	0	0	0	0	0	0	0	0	1	1
M4	0	0	0	0	1	1	1	0	0	0
M3	0	0	0	0	1	1	1	1	0	0
M8	0	0	0	0	1	1	1	1	0	0
M5	1	1	1	1	0	0	0	0	0	0
M2	1	1	1	1	0	0	0	1	0	0

M7	1	1	1	1	0	0	0	1	0	0

3.5. Group Efficiency

In large cell formation problems, grouping efficiency is important to evaluate the quality of the final solution. Grouping efficacy is one of popular measures for comparison of quality of final solution. The formula of grouping efficacy is

$$\mu=\frac{N_{1}-N_{1}^{out}}{N_{1}-N_{0}^{in}}$$

Where,
N_1=total number of 1's in matrix;
N_1^{out}= total number of 1's outside the diagonal block
N_0^{in}=total number of 0's inside the diagonal block for better grouping, the efficacy should be closer to 1.
Here for our calculation group efficacy is 96.4%.

4. Conclusion

Our system implemented successfully parts and machines for cell manufacturing problem using self-organizing map technique in Neural-network. And provide good results for group efficiency. Some bottle necks are forming that we have to fix manually but there are so many sorting techniques available, those techniques may fix these bottle necks. And the bottlenecks can be removed using automation technique.

References

[1] A. Korei, "Applying formal concept analysis in machine-part grouping problems", Applied Machine Intelligence and Informatics (SAMI), 2013 IEEE 11th International Symposium on, **(2013)** January 31-February 2, pp. 197-200**.**

[2] [2] Miin-Shen Yang, Jenn-Hwai Yang, "Machine-part cell formation in group technology using a modified ART1 method", European Journal of Operational Research 188 **(2008)** 140–152.

[3] C. Dagli and R. Huggahalli, "Machine-part family formation with the adaptive resonance theory paradigm", International Journal of Production Research, vol. 33, **(1995)**, pp. 893– 913**.**

[4] M. Murugan and V. Selladurai, "Formation of Machine Cells/ Part Families in Cellular Manufacturing Systems Using an ART-Modified Single Linkage Clustering Approach – A Comparative Study", Jordan Journal of Mechanical and Industrial Engineering, ISSN 1995-6665, vol. 5, no. 3, **(2011)** June, pp. 199 – 212**.**

[5] C. Dimopoulos and N. Mort, "A hierarchical clustering methodology based on genetic programming for the solution of simple cell formation problems", International Journal of Production Research, vol. 39, no. 1, **(2001)**, pp. 1-19**.**

[6] J. Bao, L. Wang, F. Wang and N. Xie, "Ant Colony Optimization with an Application in Cellular Manufacturing", 5th IEEE Conference on Industrial Electronics and Application, **(2010).**

[7] P. Venkumar and A. Noorul Haq, "Manufacturing cell formation using modified ART1 networks", Int. J. Adv. Manuf. Technol., vol. 26, (**2005**), pp. 909–916, © Springer-Verlag London Limited, **(2004).**

[8] F. Rossi, B. Conan-Guez and A. El Golli, "Clustering Functional Data with the SOM algorithm", Published in ESANN'04 Proceedings. Available at http://apiacoa.org/publications/2004/som-esann04.pdf**,(2004).**

[9] Malakooti, B. Ziyong Yang, "An unsupervised neural network approach for machine-part cell design", Neural Networks, IEEE World Congress on Computational Intelligence. 1994 IEEE International Conference **(1994).**

[10] N. Ampazis and I. Minis, "Design of cellular manufacturing systems using latent Semantic Indexing and Self Organizing Maps", Computational Management Science © Springer-Verlag, **(2004).**

