Analysis of Noise Exposure from Different Machines by Graph-Based Clustering Method

[1]Amitava Kar, [2]Pintu Pal

[1, 2] Department of Computer Applications, Asansol Engineering College, Vivekananda Sarani, Asansol, West Bengal, India.

Abstract - This paper refers to a study of noise, emitted from different press machines of a press shop in West Bengal. Different noise parameters such as L_{Aeq} (equivalent continuous A-weighted sound level), L_{AE} (sound exposure level), L_{AV} (average sound level) and TWA (Time weighted average level) are taken. The most negative effects are caused by noise exposure and this may cause permanent deafness. So it is necessary to develop mathematical models and identification of similar noise producing machines. For this, Graph-Based Clustering method is applied. Clustering is a popular data mining technique for partitioning a dataset into a set of clusters (i.e. segmentation). The Euclidean distance of the different machines in terms of noise exposure parameters, as mentioned above, is calculated. With the help of different values of this parameter a connected graph is made. Then a minimal spanning tree is constructed using Prim's Algorithm and then the edges which are too long as compared to the other edges are deleted to construct clusters. The result implies grouping of similar noise producing machines. Then attempts are made to rank the clusters in terms of emitting of noise.

***Keywords* - Graph-based clustering, minimum spanning tree, edge, edge-length.**

1. Introduction

In his paper, Prim [1] described a method to construct a minimal spanning tree from a connected graph. Later, Augustson et al. [2] depicted an analysis of some graph theoretical clustering techniques. At the same time, Zahn[3] also described graph-theoretical methods for detecting clusters. He described three techniques to form clusters using graph theory and statistics. In their paper, Raghavan et al.[4] described a comparative study of the stability characteristics of some graph theoretic clustering methods. Later, Barrow et al.[5], Asano et al. [7] and Forina et al. [8] emphasized different clustering algorithms based on minimum and maximum spanning trees. Then Varma et al.[9] and Peter et al. [10] described different types of clustering algorithms and their comparative studies using minimum spanning trees. Recently, Bhattacharjee et al.[11] and Kar et al.[12] worked on different clustering algorithms to minimize noise using Karnaugh map technique and analysis of noise emitted from different mechanical machines. In this paper, an analytical study of noise exposure from different machines has been described by graph-based clustering methods. In our work, the data are taken from the paper [11] which is given in Table 1.

Table 1: Noise Parameters for various Mechanical Machines

Machines	L_{Aeq}	L_{AV}	L_{AE}	TWA
Machine 1	98.2	128	98	73.4
Machine 2	99.9	120.6	97.6	57.9
Machine 3	111.5	126.5	108.5	59.4
Machine 4	100.6	128.7	100.3	72.9
Machine 5	98	117.5	97.2	55.5
Machine 6	96.2	125.2	95.9	70
Machine 7	98	127	97.7	71.9
Machine 8	97.6	127.3	97.2	72.4
Machine 9	98.5	128.1	98.5	73.5
Machine 10	91.6	117.1	91.5	59.8

2. Methodology of Classification

The logical distance from machine1 to machine2 can be calculated as follows

Distance (1-2) $= \sqrt{(98.2-99.9)^2 + (128-120.6)^2 + (98-97.6)^2 + (73.4-57.9)^2} \approx 17.2644$

Similarly, the logical distance of each machine from the other is calculated and given in Table 2.

Table 2: Edges with corresponding Weights

Edges	Weights
1-2	17.2644
1-3	22.0316
1-4	3.4337
1-5	20.7687

1-6	5.2735
1-7	1.8385
1-8	1.5780
1-9	0.6000
1-10	19.7378
2-3	17.0420
2-4	17.2740
2-5	4.3749
2-6	13.5702
2-7	15.5106
2-8	16.1428
2-9	17.3891
2-10	11.0436
3-4	19.3168
3-5	20.1532
3-6	22.5144
3-7	21.3399
3-8	22.1481
3-9	21.6880
3-10	27.81241
4-5	21.0848
4-6	7.7058
4-7	4.1725
4-8	4.5629
4-9	2.8931
4-10	21.5548
5-6	16.5671
5-7	18.9594
5-8	19.5400
5-9	20.9356
5-10	9.5969
6-7	3.6510
6-8	3.7175
6-9	5.7193
6-10	14.4972
7-8	0.8660
7-9	2.1587
7-10	17.9950
8-9	2.0857
8-10	18.2014
9-10	20.1321

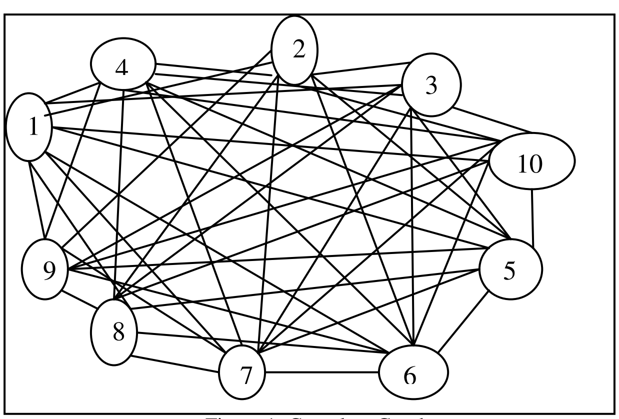

Figure 1: Complete Graph

Table 3: Minimum Spanning Tree

M/C	1	2	3	4	5	6	7	8	9	10
1	0.0000	17.2644	22.0316	3.4337	20.7687	5.2735	1.8385	1.5780	0.6000	19.7378
2	17.2644	0.0000	17.0420	17.2740	4.3749	13.5702	15.5106	16.1428	17.3891	11.0436
3	22.0316	17.0420	0.0000	19.3168	20.1532	22.5144	21.3399	22.1481	21.6880	27.8124
4	3.4337	17.2740	19.3168	0.0000	21.0848	7.7058	4.1725	4.5629	2.8931	21.5548
5	20.7687	4.3749	20.1532	21.0848	0.0000	16.5671	18.9594	19.5400	20.9356	9.5969
6	5.2735	13.5702	22.5144	7.7058	16.5671	0.0000	3.6510	3.7175	5.7193	14.4972
7	1.8385	15.5106	21.3399	4.1725	18.9594	3.6510	0.0000	0.8660	2.1587	17.9950
8	1.5780	16.1428	22.1481	4.5629	19.5400	3.7175	0.8660	0.0000	2.0857	18.2014
9	0.6000	17.3891	21.6880	2.8931	20.9356	5.7193	2.1587	2.0857	0.0000	20.1321
10	19.7378	11.0436	27.8124	21.5548	9.5969	14.4972	17.9950	18.2014	20.1321	0.0000

From the complete graph, minimum spanning tree is constructed using the Prim's algorithm. The underlined cells of Table 3 form the edges of the minimum spanning tree.

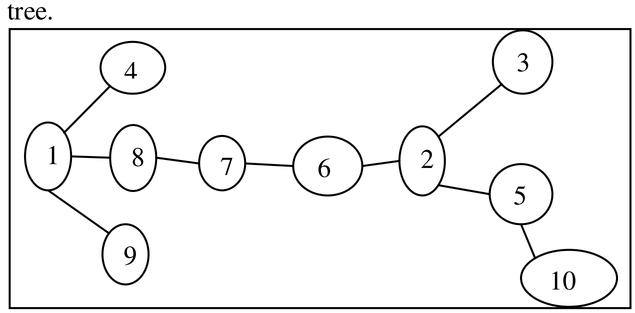

Figure 2: Minimum Spanning Tree Drawn from the Complete Graph

The edges and their weights of the minimum spanning tree are given as under:

Table 4: Edges and their weights

Edges	Weights
1-9	0.6000
1-8	1.5780
1-4	3.4337
2-3	17.0420
2-5	4.3749
5-10	9.5969
6-2	13.5702
7-6	3.6510
8-7	0.8660

2-3 is the longest edge. If edges are plot against edge-weights then the curve thus obtained is given in Figure 3.

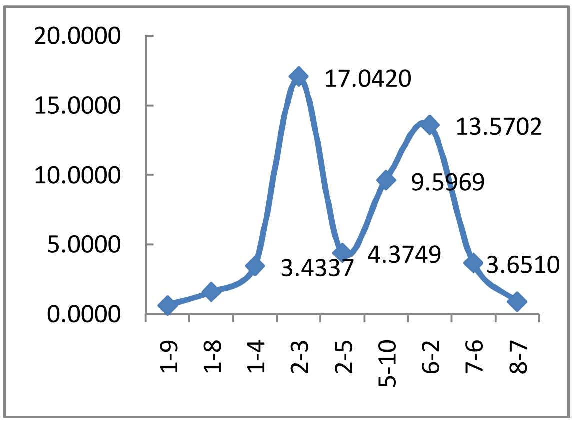

Figure 3: Edges plot against Edge-Length with Edges in the Horizontal Axis and Edge-Length in the Vertical Axis

From Table 4, it is evident that edge rises abruptly from 3.4337 to 17.0420 and then falls to 4.3749. If the edge 2-3 is deleted then a smooth curve around its neighboring points is obtained. Hence, the longest edge, 2-3 is removed.

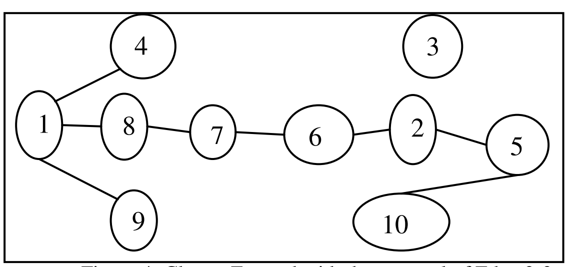

Figure 4: Cluster Formed with the removal of Edge 2-3

Figure 4 shows the formation of two clusters

Table 5: Edges and their weights

Edges	Weights
1-9	0.6000
1-8	1.5780
1-4	3.4337
2-5	4.3749
5-10	9.5969
6-2	13.5702
7-6	3.6510
8-7	0.8660

Table 5 also shows that 6-2 is the longest edge. Edges are plot against edge-weights then the curve thus obtained is given in Figure 5.

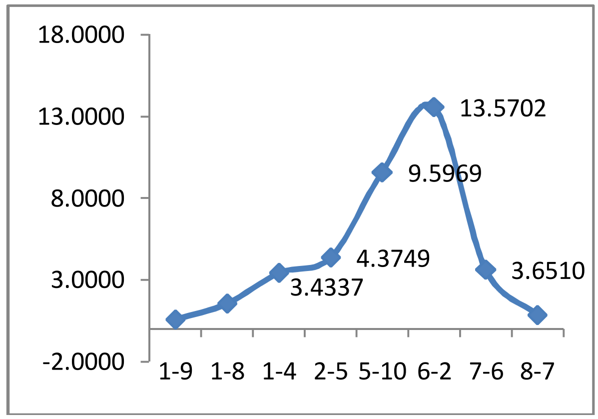

Figure 5: Edges plot against Edge-Length with Edges in the Horizontal Axis and Edge-Length in the Vertical Axis

The longest edge is 6-2. The edge rises from 9.5969 to 13.5702 and then again falls to 3.6510. The edge 6-2 may be removed.

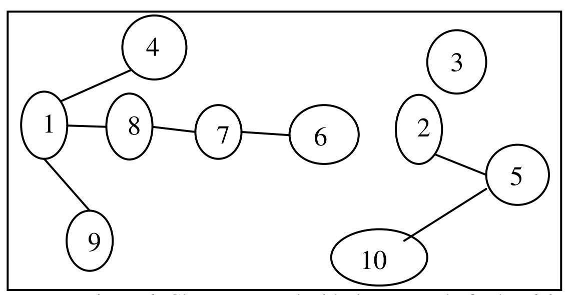

Figure 6: Cluster Formed with the removal of Edge 6-2

This resulted to the formation of three clusters which is shown in Figure 6.

Table 6: Edges and their weights

Edges	Weights
1-9	0.6000
1-8	1.5780
1-4	3.4337
2-5	4.3749
5-10	9.5969

IJCAT International Journal of Computing and Technology, Volume 1, Issue 2, March 2014
ISSN : 2348 - 6090
www.IJCAT.org

7-6	3.6510
8-7	0.8660

Then edges are plot against edge-weights and the curve thus obtained is given in Figure 7.

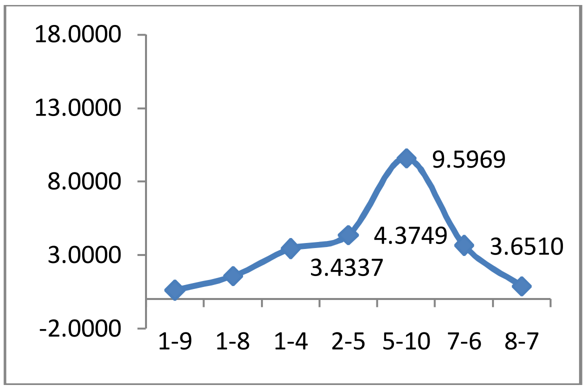

Figure 7: Edges plot against Edge-Length with Edges in the Horizontal Axis and Edge-Length in the Vertical Axis

Now, the longest edge is 5-10. The edge rises from 4.3749 to 9.5969 and then falls to 3.6510. Thus the edge 5-10 may be removed.

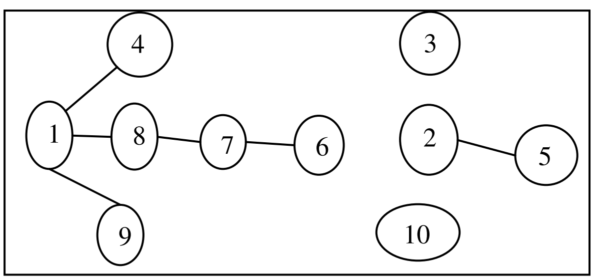

Figure 8: Cluster Formed with the removal of Edge 5-10

Figure 8 shows the formation of four clusters.

Table 7: Edges and their weights

Edges	Weights
1-9	0.6000
1-8	1.5780
1-4	3.4337
2-5	4.3749
7-6	3.6510
8-7	0.8660

Now, the longest edge is 2-5. But there is no abrupt change of slope. So the edge 2-5 is not removed. The corresponding curve is shown in Figure 9.

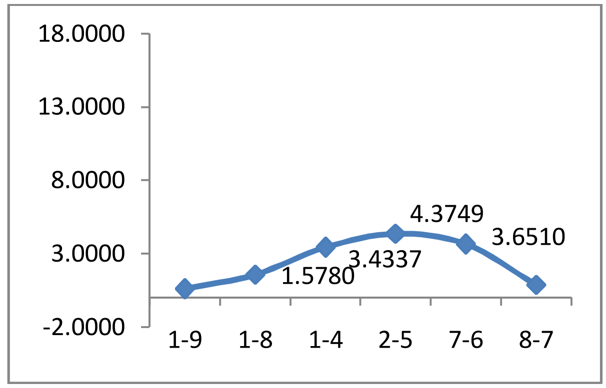

Figure 9: Edges plot against Edge-Length with Edges in the Horizontal Axis and Edge-Length in the Vertical Axis

The curve obtained from Figure 9 is almost smooth. The slope of this curve almost converges with the X-axis which is given in Figure 10.

This is termination criterion of the iterations.

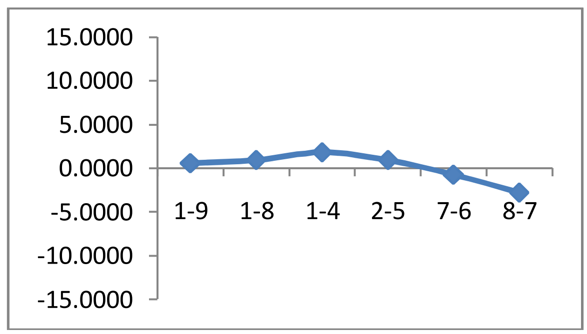

Figure 10: Slopes plot against Edge with Edges in the Horizontal Axis and Edge-Length in the Vertical Axis

3. Ranking of the Clusters

There are four clusters. They are denoted by A, B, C and D. Cluster A consists of the machines 1, 9, 4, 8, 7 and 6. Cluster B contains machine 2 and machine 5. Cluster C contains machine 3 and Cluster D contains machine 10. Now it is to find the machines that make maximum noise. Considering that the points are plot in a 4-axes coordinate system, the distance of each machine from the origin (0, 0, 0, 0) is calculated. Logical distance of A from origin is $\sqrt{}(98.2 - 0)^2+(128 - 0)^2+(98 - 0)^2+(73.4 - 0)^2$
= 197.5507.

Likewise, the distances of all other machines from the origin may be evaluated and are given in Table 8.

Table 8: Logical distance of each machine from the origin

M/C	Distance
1	202.531

2	193.3974
3	209.1294
4	205.0818
5	189.5741
6	197.5507
7	201.1166
8	201.0489
9	203.0181
10	184.5298

The minimum and maximum distance of the origin from each cluster is given in Table 9.

Table 9: Logical distance of each cluster from the origin

Cluster	Minimum	Maximum
A	197.5507	205.0818
B	189.5741	193.3974
C	209.1294	209.1294
D	184.5298	184.5298

Table 10: Logical distance of each Cluster from the origin in descending order

Cluster	Minimum	Maximum
C	209.1294	209.1294
A	197.5507	205.0818
B	189.5741	193.3974
D	184.5298	184.5298

From Table 10, it is evident that cluster C is the maximum noise producing i.e. machine 3 makes the maximum noise. It is followed by cluster A i.e. machines 1, 4, 6, 7, 8 and 9. Then comes cluster B i.e. machines 2 and 5. Last comes cluster D i.e. machine 10.

From the Table 10, it can be seen that

$Cluster(\mathrm{C}) > Max\ (Cluster\ (\mathrm{A}))$ -------------- (i)
$Min\ (Cluster\ (\mathrm{A})) > Max\ (Cluster\ (\mathrm{B}))$ ----- (ii) and
$Min\ (Cluster\ (\mathrm{B})) > Cluster\ (\mathrm{D})$ ------------- (iii)
The three results given in (i), (ii) and (iii) made the classification quite simple.

4. Concluding Remarks

In this work, the machines are classified into four categories on the basis of the noise produced by them. Machine 3 makes the maximum noise. The workers working on that particular machine should have the maximum protection in their ears. Machine 1, machine 4 and machine 6 to machine 9 falls under next category. The workers working on these six machines should have protection in their ears but not up to that level as that of machine 3. Machine 2 and machine 5 form another group. The workers working on these machines may have less protection in their ears. Machine 10 comes under the fourth group. The workers working on this machine may have very little protection in their ears in comparison to the rest categories.

References

[1] Prim, R., “Shortest connection networks and some generalizations” Bell System Technical Journal, Vol. 36, pp. 1389-1401., 1957.

[2] Augustson J.G., Minker J., “An analysis of some graph theoretical clustering techniques”, J. ACM Vol.17, 4, pp. 571-588., 1970.

[3] Zahn, C.T., “Graph-theoretical methods for detecting and describing gestalt clusters” IEEE Transaction on Computers, C20: 68-86., 1971.

[4] Raghavan V.V., YU C.T., “A comparison of the stability characteristics of some graph theoretic clustering methods”, IEEE Trans. Pattern Anal. Mach. Intell. 3, pp. 3-402., 1981.

[5] Barrow, J.D., Bhavsar, S.P., Sonoda, D.H., “Minimal spanning trees, filaments and galaxy clustering” In Monthly Notices of the Royal Astronomical Society, 216:17-35., 1985.

[6] Jain, A.K., Dubes, R.C., “Algorithms for Clustering Data”, Prentice-Hall advanced reference series, Prentice-Hall, Inc., Upper Saddle River, NJ., 1988.

[7] T.Asano, B.Bhattacharya, M.Keil and F.Yao. “Clustering Algorithms based on minimum and maximum spanning trees”. In Proceedings of the 4th Annual Symposium on Computational Geometry,Pages 252-257, 1988.

[8] Forina, M., Oliveros, C., Concepcin M., Casolino, C., Casale, M.,“Minimum spanning tree: ordering edges to identify clustering structure” In Analytica Chimica Acta, 515: 43-53., 2004.

[9] Varma, S., Simon, R., “Iterative class discovery and feature selection using Minimal Spanning Trees” BMC Bioinformatics, Vol. 5, pp. 126-134., 2004.

[10] S. John Peter & S. P. Victor “A Novel Algorithm for Informative Meta Similarity Clusters Using Minimum SpanningTree”. International Journal of Computer Science and Information Security vol. 8 no. 1 April, 2010.

[11] P.K. Bhattacharjee, T.Sen, D. Banerjee and B.Sarkar, “Minimize Noise Dose Exposure by Karnaugh Map Technique for a Small Scale Manufacturing Industry in West Bengal of India”, International Journal of Environmental Science and Development, 2(2), 2011.

[12] A. Kar, T. Sen and D. Banerjee, “Analysis of Noise Emitted From Electrical Machines by Clustering

Method", International Conference on Ergonomics and Human Factor, 2013.

Amitava Kar received his Master of Computer Applications from West Bengal University of Technology in the year 2004 and then did his M.Tech in Operations Research from NIT, Durgapur in 2008. He has about 10 years of teaching experience and is presently working as Assistant Professor in the Department of Computer Application in Asansol Engineering College. His research interest includes Data Mining, Image Processing, and Robotics etc.

Pintu Pal received his Master of Computer Applications from North Bengal University in 1996. He did his Ph.D. in Engineering from Jadavpur University in 2012. He has several publications in reputed National and International journals. He is also reviewer of several journals like Information Science of Elsevier. He has about 15 years of teaching experience and is presently working as Assistant Professor in the Department of Computer Application in Asansol Engineering College. His research interest includes Genetic Algorithms, Particle Swarm Optimization, Data Mining, Robotics etc.