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Detecting Enervated Signal Zones – A Fuzzy Based Approach

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Abstract: In this methodology detection of enervated signal zones is boiled out by using the Amalgamated clustering technique, which is carried out by cooking out a hard clustering technique followed by a soft one. Here a blend has been made extracting ideas from the working principles of Minimum Distance Segmented Method and fuzzy based Two-Phase Method. The intention behind making such a blend is to enhance the level of compactness. The area having the maximum distance, with respect to its near-by mobile tower will have the lesser signal strength compared to the one which is closer to it The proposed technique works in two subsequent steps. Firstly, Amalgamated clustering technique identifies the suspicious points which may suffer from low signaling problem and in the second step, among those suspicious points, which are really victim, are found and suitable location for setting up new tower is suggested to overcome the problem.

***Index Terms* – Enervated Signal Zones, Amalgamation, Minimum Distance Method, Two-phase method, Fuzzy based method**

I. Introduction

With the boon of mobile communication, the universe is gradually being turning to a global town. As the days progresses, the mobile communication network is expanding in a very hasty-fasty pace, however, one of the major question in this communication process is,"Does everyone get uniform service by this communication network"? The answer is "NO". This disadvantage continues to peek through as the years went and may continue, if no proper action is taken up. One of the suitable technique to get recovery from such problem is proper selection of the locations for setting up of new mobile towers and a lot of attention should be paid in such kind of selections. While deciding these proper positions for setting up new towers, attention is given to the fact that on an average, how far the signal strength of such tower can reach. Setting up mobile towers without planning can lead to critical network errors such as signal interference, frequent disconnections, low-signal strength and so on. To maintain a mobile communication network that will not only be error free but also provides strong signal strength, is very challenging nowadays. The technique proposed in this chapter aims at minimization of all such troublesome. To accomplish this task, the following two factors are taken into account —

• The distance between the mobile towers and entire area under consideration.

• The mobile signal strength received by the problematic areas, on an average, for twenty four hours.

The above two factors are analyzed on the basis of suitable and appropriate data (signal strength received by a particular area), provided by different mobile operators. These two factors discussed here, could be granted as the backbone of the proposed work. Detection of enervated signal zones is boiled out by using the Amalgamated clustering technique, which is carried out by cooking out a hard clustering technique followed by a soft one. Here a blend has been made extracting ideas from the working principles of Minimum Distance Segmented Method and 2nd phase of Two-Phase Method. The intention behind making such a blend is to enhance the level of compactness. The above two factors bulleted, is sufficient enough to depict out the problematic areas since the mobile signal strength of an area is inversely proportional with the distance between that considered area and the considered near-by mobile tower. As such, the area having the maximum distance, with respect to its near-by mobile tower will have the lesser signal strength compared to the one which is closer to it. Then why the proposed technique has been cooked out by blending the ideas of two different proposed clustering techniques? The reply is pretty simple – there would be an increment in the level of time consumption if the clustering techniques are not involved. Since in such case, the number of suspicious areas would be more compared to the number of such areas evoked out after carrying out the clustering techniques and thus, the clock counting would be much more for feeding the signal strength for twenty four hours with respect to all such problematic suspicious areas. Thus, in a summarized form it can be said that, the proposed technique works in two subsequent steps. Firstly, Amalgamated clustering technique identifies the suspicious points which may suffer from low signaling problem and in the second step, among those suspicious points, which are really victim, are found and suitable location for setting up new tower is suggested to overcome the problem.

The organization of this chapter is as follows. Section II illustrates the methodology incorporated for detection of enervated signal zones. Comparison of the proposed method with Minimum distance Method and Fuzzy c-Means (as the essence of the working strategies of these two are sensed in the proposed method) has reflected in section III and finally concluding remarks are there in section IV.

II. METHODOLOGY

To illustrate the process of detecting enervated signal zones, it is required to consider a map, populated with mobile users. For the present purpose, the map of northern half of Barrackpore (22°46′, 88°23′) (situated at West Bengal, in India), has been considered. This area is quiet well populated with mobile users, having three existing mobile towers. The considered map is depicted in figure 1.

Fig. 1: Map of Northern part of Barrackpore (West Bengal, India)

At very beginning, the proposed technique digitizes numerous random points on the considered map. The location of the towers been also digitized. The outcome of which has depicted in figure 2, where the red points are the digitized points.

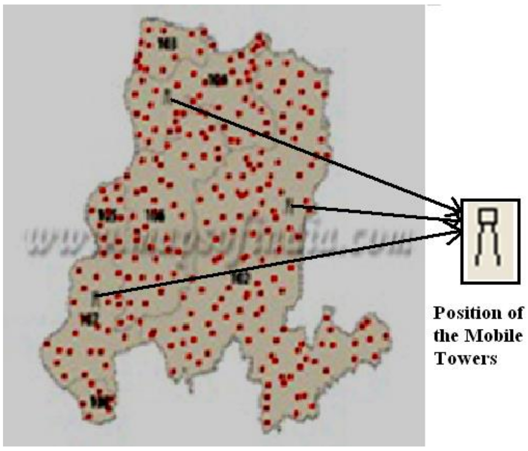

Fig. 2: Map after digitization

For clustering of the digitized points, the proposed Amalgamated Technique works in two consecutive phases. The first phase, which is basically a type of hard clustering, calculates the minimum distance between each digitized points and the tower points (the point at which the tower is situated). Here the Minimum Distance Method (section 4.3) has been used for clustering. The tower positions are considered for the initial positions for cluster centroids.

This operation is accomplished by using the Manhattan distance formula mentioned below:

$$\text{Distance} = |A0 - A1| + |B0 - B1| \qquad (1)$$

where, (A0 , B0) is the coordinate position of any digitized point and (A1 , B1) is the coordinate position of any tower point. The points are clustered into n number of clusters, where n is the number of existing towers and for this initial clustering, Manhattan distance is considered as the basic clustering parameter; since the signal strength depends on the distance. More is the distance from the mobile tower, poorer is the signal strength. Thus, this step is based on the first factor bulleted under section I. The outcome of this step, after clustering the points into three different clusters, each under one tower position, is demonstrated in figure 3.

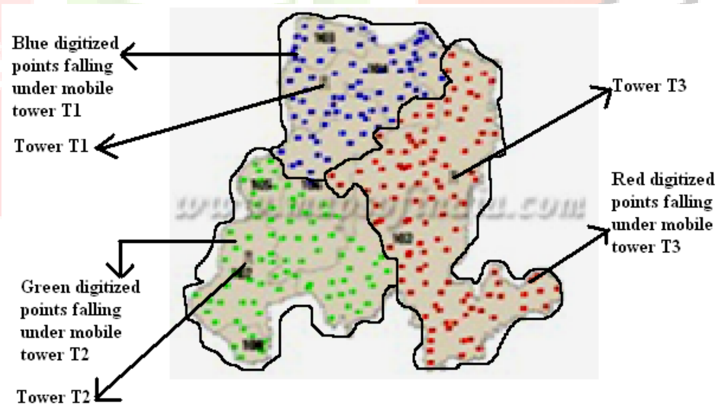

Fig. 3: Clusters formed on execution of the first phase of Amalgamated clustering technique (Here, T1,T2 and T3 are three considered mobile towers)

The next trail in the proposed technique is to execute the second phase of the Amalgamated clustering technique, which is basically a soft clustering part. For this purpose, 2nd phase of the Two-Phase Method (section 3.4) been used. This step is taken into account to increase the level of compactness. To accomplish this soft clustering technique, membership values are assigned to each digitized points based on the outcome of the previous step. More a digitized point is closer to its respective mobile tower; more is its membership value towards that considered tower. The following equation has taken up for carrying out this task.

$$\eta_{AP} = \frac{1}{\sum_{\alpha=1}^{\delta}\left(\frac{ZAp}{ZA\alpha}\right)2/q - 1}$$

Z_{Ap} represents the Manhattan distance (equation 9.1) between Ath digitized point and p^{th} tower point. Actually here the main objective is to minimize:

$$S(U,V) = \sum_{i=1}^{n} \sum_{i=1}^{\delta} (\eta_{AP})^{q} \parallel x_i - \omega_p \parallel^2 \qquad (2)$$

The aftermath of this step is portrayed in the figure 4.

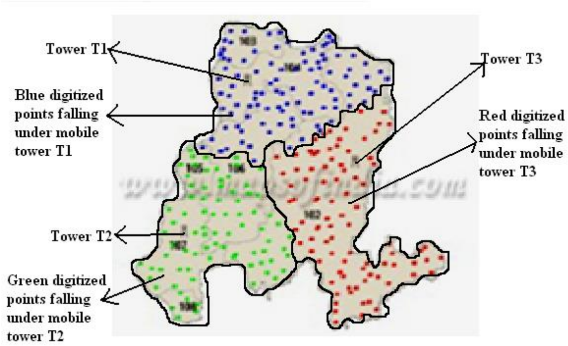

Fig. 4: Clusters formed after execution of the second phase of Amalgamated clustering technique (Here, T1,T2 and T3 are three considered mobile towers)

The basic objective is to figure out the low signal points; for which the exterior points belonging to each cluster are found by applying the conditions:

$(|\ xi - xk| + |\ yi - yk|) > 1.5 \times Mk$ . . . . . . Condition 1

Here $M_k = \frac{Dk}{n}$ and

$D_k = \sum_{k=1}^{m} \sum_{i=1}^{n} (|\ xi - xk| + |\ yi - yk|)$

Where, k = 1 . . . m, the number of clusters, i.e. towers; i = 1. . . n and n is the number of digitized points lying in a particular cluster. (xk,yk) is the co-ordinate of the existing tower in that cluster. These exterior points are marked as black points in figure 5, where these regions been encircled for better understanding.

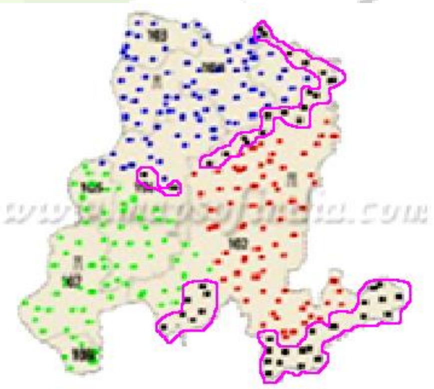

Fig. 5: Exterior Points en-marked with black dots and been encircled

In other words, these exterior ponts are the suspicious points, which may only suffer from low-signaling problem. Thus, for carrying out next step only these points would have to be considered. A signal-strength reading of 24 hours for these exterior points is needed. Among them only which satisfy the following criterion, are considered for new tower set-up. The criterion is:

$\sum_{i=1}^{24} (\frac{Value}{24}) \leq$ dBm (Decibel-milliwatts) . . . . . . Condition 2

Where $Value_i$ represents the signal strength (imparted) at i^{th} hour.

A proper measurement of signal strength at these suspicious points is very much required, because although these points situates quite a far from the respective towers, but still may receive signals from some others. Thus in gist, the method works in two steps. First, Amalgamated Clustering points out the suspicious points and the subsequent step finds the points which are real victim of low-signaling problem, among those suspicious points. Figure 9.6 depicts the zones which are real victim of enervated signal problem (found after measuring strength for 24 hours); which is a proper subset of the zones en-marked in figure 5.

Fig. 6: Actual enervated signal zones

Comparing with figure 5, it could be stated that now only two zones are en-marked, in place of four.

Since, the cost of setting up a mobile tower is huge enough, so it is never recommended to set up a tower for solving the enervated signaling problem of a very small region. Thus next, have to judge the area of the region suffering from this enervated signaling problem. Here the third condition comes onto the crease, which tells that, “If the en-marked enervated signal zone has an area more than 20% of the average area being served by the existing towers, then only a new tower is recommended." . . . . . . Condition 3

The value 20% is for demonstration purpose only and has to be fixed from proper field study. The zone, which is not satisfying condition 3, is not considered as enervated signal zone furthermore and it is merged with the nearest (in terms of centroid-to-centroid distance) cluster. after applying this condition, the upper one zone depicted in figure 9.6 is abolished; resulting only the lower zone to exist, as depicted in figure 7.

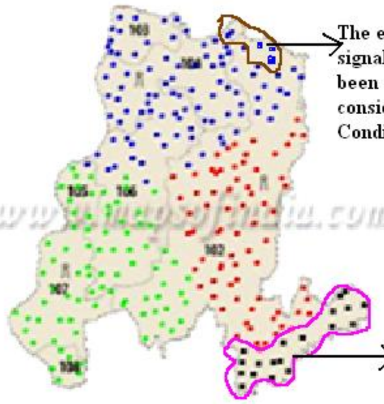

Fig. 7: Final en-marked enervated signal zones

Figure 9.7 depicts the fact that, among the two victim regions, only one (lower one) has finally targeted for setting up of mobile tower. The upper one problematic zone, due to its very small area, has been discarded. The location of the new tower is just the centroid of the enervated signal region, which could be calculated using the following equations:

$$X_T = \sum_{i=1}^{n} \frac{xi}{n} \quad \ldots.. (9.5)$$

$$Y_T = \sum_{i=1}^{n} \frac{yi}{n} \quad \ldots\ldots (9.6)$$

where, X_T and Y_T is the coordinate position of the new set up (proposed location of the mobile tower), xi and yi is the coordinate position of ith low signal points and n is the number of such points. The final outcome obtained is depicted in figure 8.

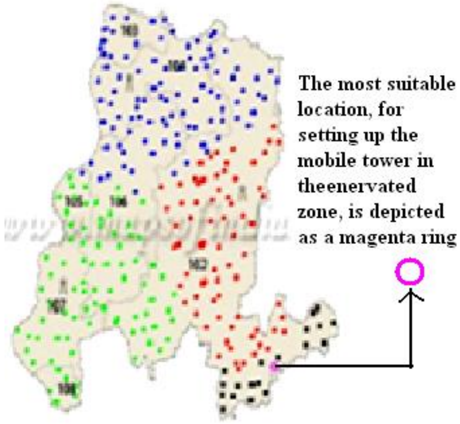

Fig. 8: Final en-marked enervated signal zones

The implementation task is executed using NetBeans(JAVA). To accomplish the implementation job, flat file system is chosen as the basis for data storage and no database is taken up for such purpose. Here first the map is loaded onto a newly created profile with significant name and the points are digitized onto the map. Next upon clicking onto the designated button the exterior points are en-marked, for which a 24 hours signal strength measure is needed and being imparted as associated attribute data. Which finally enables in prediction of the new tower locations, as already been described.

III. Comparison

This proposed Amalgamated clustering technique, which is a hybrid of both Minimum Distance Segmentation Method and second phase of Two-Phase Method; aims to solve major limitations of both the techniques of clustering and at the same time keeping the advantages of both, under consideration of the present scenario. As the working strategy of second phase of the Two-Phase Method (section 3.4) is just like popular fuzzy based soft clustering method FCM, hence comparison has been made with Minimum Distance Method and FCM. The popular and widely accepted soft clustering approach-FCM mainly faces two major problems. First one is formation of virtual clusters, where in some situations, few cluster(s) contains no real data objects, therefore has no practical implications and the second one problem is that, the clustering is only done on the basis of inter-object point distances, i.e. non-incorporation of any associated attribute data. The reason behind creation of virtual clusters are as follows. If it is desired to produce 3 clusters, C1, C2 and C3 and unfortunately at the last step in the association matrix each data member has its maximum association either with C1 or with C2 (in other words no column has its maximum value at row C3), then no member becomes part of cluster C3. In other words cluster C3 contains no real object and is treated as a cluster, which exists only virtually. This type of cluster has no practical application in GIS. Hence they must have to be avoided. In this proposed method as the first phase is creating required number of clusters, each with real objects, so no question arises here on possibility of virtual clusters. Thus the first problem gets resolved. This proposed Amalgamated Clustering technique also considers the associated attribute data (signal strength) in addition to distance for clustering, not dependent on distance only like FCM. Hence the second one demerit of FCM also been resolved. As the compactness of the clusters produced by FCM is more than the clusters generated by Minimum Distance Method, hence in this proposed technique concept of fuzziness is used to increase the compactness of the rough clusters generated by Minimum Distance Method. Table 9.1 summarize the statement of comparison. This table illustrates the fact that in this proposed Amalgamated Clustering Technique, it is possible to obtain same compact clusters, as those obtained by Fuzzy C-means (which is more than the clusters produced by Minimum Distance Method), however at the same time the possibility of occurrence of virtual clusters, a major problem of FCM, is being resolved. As here the FCM is being executed on already generated rough clusters, so it is being terminated only within a few iterations.

Table 1: Comparison between Fuzzy C-means, Minimum Distance Method and the proposed Amalgamated Clustering Method

Characteristics	FCM	Minimum Distance Method	Amalgamated Clustering Method
Formation of Virtual Clusters	May occur	No such occurrence	No such occurrence
Basis of Cluster Formation	Distance between the cluster center and the data points	Distance between the cluster center and the data points	In addition, user fed attribute data values are also considered
Compactness	Compact clusters generated	Compactness of the produced clusters are less in comparison with those produced by FCM	Compactness of the produced clusters are same as generated by FCM

IV. Conclusions

At the beginning, when mobile communication network opened its account, the network grew in a rapid speed, like a huge mighty web, in every lump of this universe. However, a lot of problems do brings out some bulky challenges in the path of this communication service. The proposed technique can surely prove to be one of the most suitable techniques for sorting out (at least minimizing) such demerits in the field of mobile communication network. The proposed system can definitely extend the helping hands out for identifying the problematic areas which are, on an average, receiving very low or weak signal strength, so that the network optimization engineers can thoroughly focuses on such places and bring out the solution for sweeping out such problems. The proposed work does stipple out the most proper and suitable location for setting up the mobile towers in the weak signal receiving zones. While doing so, the proposed technique, also keep in mind , the cost effectiveness, since setting up a mobile tower does require huge amount of capital to invest. For doing so a newer amalgamated method of clustering, which is a hybrid of Minimum Distance Method and fuzzy based clustering method, is devised. This proposed technique works with keeping the advantages of both the methods but at the same time removes the demerits of both.

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