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DISCOVERING HIDDEN CLUSTER STRUCTURES IN CITIZEN COMPLAINT CALL VIA SOM AND ASSOCIATION RULE TECHNIQUE

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Abstract

Significant revolution in different organizations chief's point of view toward customer treating and the level of product presentation or services resulted in redefining the structure of these organizations based on this point of view. The municipal services are very important as well. The strategy of "CRM" which was so successful in the private sector and has been applied as "CiRM" in the public sector of developed countries could be very useful for this achievement. The main goal of citizen management is realizing the citizen's needs and demands, improving communication through connection with citizens and optimizing it to increase the level of their satisfaction. The government agencies do it based on their idea and point of view cause the citizen are valuable assets in the planning of services and reduction of costs. This study proposes a combined data mining method to discover hidden knowledge in call citizen complaint of the municipality of Tehran. A Self-organizing map neural network was used to identify and classifying citizen needs based on RFM analysis. It also classified citizen needs into three majors. the result of classification and clustering of SOM has created a new feature to profiled call's customer to identify temporal-spatial patterns of problems by using an association rule with the Apriori algorithm. The results of this idea demonstrate that accordance of citizens call compliant in a different area and discovering hidden knowledge can facilitate the performance of human recourse in improving services to citizens.

Keywords: citizen management, data mining, RFM-SOM algorithm, Apriori algorithm, a new feature

I. Introduction

Citizen relationship management is one of the key issues in modern government and it's very important to the organization. Citizen relationship management is derived from the concept of customer relationship management which it's a general meaning in the private sector [XVIII] [XX]. Customer relationship management in the public sector is called citizen relationship management [XVII] [XIX] [XVI].

The main purpose of citizen relationship management is prioritizing and identifying needs for different groups of citizens and providing services tailored to those needs [XXI][XVIII].

Therefore, to improve the delivery of urban services because of the complexity of urban needs and problems, it is necessary to identify and prioritize the needs and problems of different groups of citizens in the first step [I]. Due to the complex needs and urban problems, therefore to improve the delivery of urban services, it is essential to identify and prioritize the needs and problems of different groups of citizens in the first step [I] [II].

In general, the goals of citizen relationship management can be explained as Citizen-centric, improved communication between government and citizens for increased satisfaction.

To express the position of the present problem, it is possible to the present study is closely intertwined with discussions of citizen relationship management and data mining. To express the position of the present problem of this study, it is possible to identify it in the context of citizen relations management issues. The present study is closely intertwined with discussions of citizen relationship management and data mining. In other words, this research deals with this problem with the knowledge discovery process and citizen relationship management which Patterns and rules were achieved in the Spatio-temporal occurrence of urban problems.

The first step in this paper to solve this problem is classifying urban needs based on a database of call compliant of the citizen to the municipality and then in the next step use this database for establishing citizen call profiles based on urban needs. The citizen call profile then was used to explain each group of categorized data and used as a tool for funding better bank service strategies. For a better understanding of our strategies, this research is organized as follows. Section 2 presents discusses related work based on the application of RFM and CiRM analysis. Section 3 shows the description of the research methodology of RFM analysis, SOM clustering and association rule mining and Apriori algorithm. Section 4 makes Analysis results of the research methodology and finally, Section 5 conclusion and acknowledgments are made.

II. Related work

In this section, we explained the related work of citizen relationship management and RFM analysis.

Application of data mining in CiRM

The first study that refers indirectly to the application of data mining techniques in citizen relationship management has been conducted by [VII], where examines the social impacts and ethical considerations of using data mining techniques. And in this article, customer relationship management is introduced as one of the most widely used data mining areas. Another application that deals with citizen satisfaction of urban services by using ARM and Apriori algorithm. The author in another research applied RFM analysis and data mining techniques in citizen relationship management. And introduced RFM features in a new model that has been called an FTiS model. And introduced as a general model where it can be used in similar cases to identify important

urban needs in the field of public services [I]. Other research used combined methods such as clustering k-means and association rules to classify urban needs. To identify the effective factors of satisfaction of the municipality, the association rule has been very useful in controlling municipal waste complaints [II]. In recent research, a new approach by using the data mining method includes association rule mining for evaluating HR performance based on CRM perspective [III]. The combined method with data mining and meta-heuristic method include k-means and Bees algorithms are used in citizen complaint systems to prioritization of urban needs and estimation of citizens' satisfaction [VIII].

Data mining in RFM analysis

Various authors used RFM analysis to solve the business problem of their scope.

The RFM variables are performance benchmarks for customer segmentation. The analysis helps companies avoid focusing on less profitable customers and allocate their resources to profitable customers [XIV]. Some people believe that these two indicators are of equal importance [XI]. Whereas some researchers suggest that weights should be considered as five different weights, in other words, the importance weight of these indicators varies for different companies and organizations [XII, XI]. An example is the work of [XIV]. Who used these weights to indictors, and they concluded that weight for the variable improves the quality of the clustering

By reviewing previous research, can be obtained knowledge about customer and citizen relationship management by various data mining methods. Several worked on a database of call compliant of the municipality based on RFM analysis to identifying urban needs and evaluated citizen satisfaction with several algorithms of data mining. In this study to discovering hidden knowledge of the database of call compliant during the period 2013-2016, we use a self-organizing map (SOM). And after that, we create a citizen call profile by the Apriori algorithm to identify temporal-spatial patterns of problems by creating new features from the results of SOM. The knowledge obtained from this study can be very useful for the human resources of the municipality to provide better responses from accrued call complaints of the citizen.

III. Research Methodology

Considering the dataset, the combined approach in this research can be considered in three phases.

- Data preprocessing
- Segmentation of urban needs
- Build a citizen call profile of urban needs

The structure of proposed approach is shown in Figure 1.

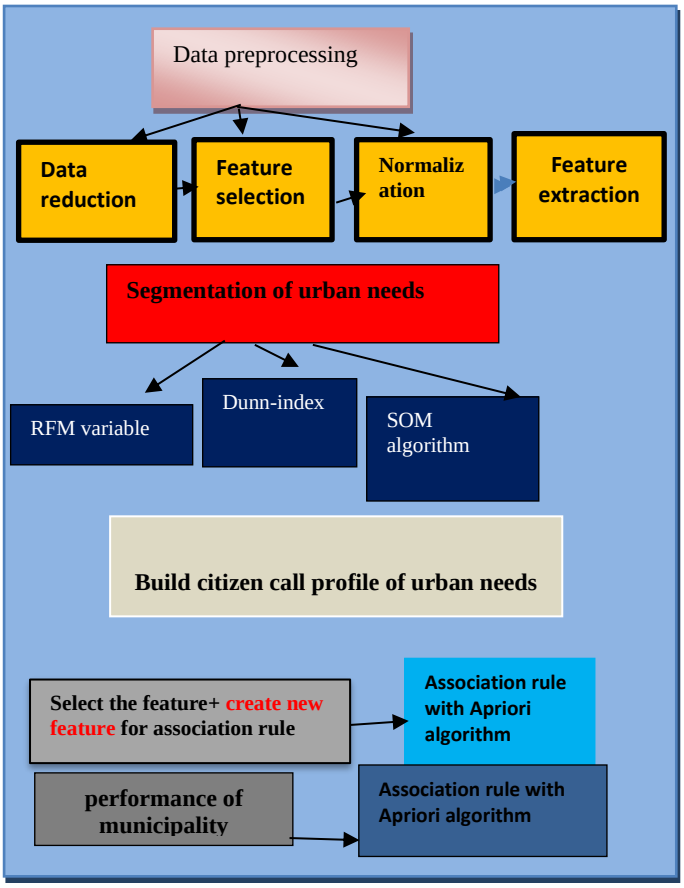

Figure 1.

Data collection and preprocessing

In this step, the data were collected from the call center of the municipality of Tehran. According to this database, the information of citizen call is stored based on message time, unit ID massage region subject ID a sample of a database is shown in table 1.

In this phase, feature selection, normalization of data for preprocessing were extracted

Table1. The sample data

Message ID	Subject ID	Message text	Message Region	Message Section	Unit ID	Last state ID	Message time	Message date	Citizen phone
43742850	15	Collection of waste and branches and waste	4	01	24	27	10.16	/1504/2013	**22311050**

Discovering customer behavior is one of the ways to create customer recognition through a variety of models. RFM model was used to detect the customer behavior. this method was first proposed by [II] and it's a good model for identifying important customers among the enormous database [IV]. RFM analysis is one of the most important ways of calculating customer lifetime value that is usually done for identifying profitable customers and improving relevant strategies for target customer selection. The analysis is based on three variables that are defined as follows.

Frequency: the number of times a customer orders or purchases over a specified period. the higher the value of this variable is represented, the greater customer loyalty.

Recency: The last time customer order or buy: This means that the customer has been recently contacted with the company and how long has it been since the last customer visit? The lower the value of this variable, leads to the higher the likelihood of a customer

Coming back and buying again [I].

Monetary: How much was the financial exchange of the clients with the company over a specified time. [I] [IV] [II]

IV. Segmentation of urban needs with RFM and SOM

SOM clustering

The algorithm is the type of artificial neural network method (ANN) that has been used as a classification analysis tool in business-related scope [XIII]. Also, SOM is the most well-known clustering algorithm.

In Self-Organized Networks (SOMs), competitive learning is used for teaching. Competitive learning in each learning step, the units compete to activate one another, At the end of a competition stage, only one unit wins, where weights are changed differently than those of other units. SOM networks have different types, but the clustering network is suitable for clustering [XIII].

The structure of the Korhonen Network is shown in Figure 2.

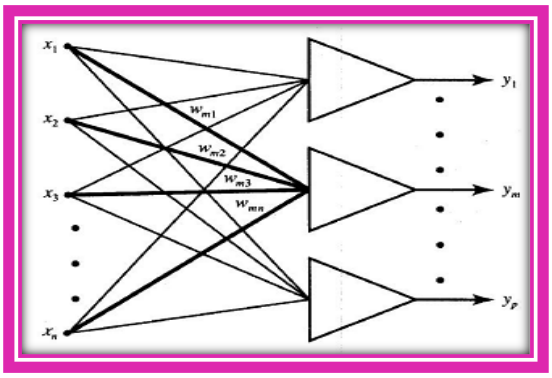

Figure 2. The structure of the Korhonen Network

In the learning phase, each unit calculates the distance of the input vector x to its weights as follows

$$I_i = \mathrm{D}(\mathrm{X}, W_i) \quad (1)$$

WhereW_i is the weight of the neuron i and D is also a distance function of measurement Any of the conventional functions can be used to measure distance, such as the spherical arc distance $D(u,v) = 1 - cos\theta$ that θ is the angle between two vectors u and v. Another example of D is the Euclidean Distance which is the case of $D(u,v) = |u - v|$. The unit will win the stage of the competition with the closest weight to the input vector [XXV]. Then the following Kuhnen's law is used to update the weight of the winning neuron.

$$W_i^{new} = W_I^{old} + \alpha\left(x - W_i^{old}\right),\ 0 < \alpha < 1 \quad (2)$$

This update rule makes the weight of the winning neuron closer to the input value. As a result, if data similar to x is applied, the likelihood of the target neuron being increased is increased. At the end of the training, the final weights represent the center of the cluster [XXV].

Clustering evaluation for obtaining optimal k:

As each clustering method yields different results, it is necessary to evaluate the efficiency of the methods used. There are different criteria for evaluating clustering algorithms that can be divided into two categories.

Unsupervised evaluation criteria (internal criteria) and criteria.

To evaluate using these criteria, it is necessary to obtain the quality of clustering operations using the information in the dataset. The most important task of a clustering algorithm is to optimally maximize and minimize the inter-cluster distance. The objectives of maximizing and minimizing intra-cluster distance are to maximize the density of each cluster and the separation between clusters, respectively. All evaluation criteria of non-observers are similar in terms of maximizing the density and clustering factors. Different indicators have been introduced to evaluate the clustering. In this study, we use the Dunn index. This index is introduced by [XII] as an internal benchmark index for evaluation clustering. The procedure of this index is as follows.

$$D = \min_{1 \le i \le} \left[\min_{i+1 \le j \le k} \left[\frac{dist(a_i, a_j)}{\max_{i \le j \le k} diam(a_i)} \right] \right]$$

Where

$dist(a_i, a_j)$ Is the internal cluster distance between cluster a_i and a_j

Where $dist(a_i, a_j) = \min_{y_{i \in a_i}, y_j \in a_j} d(y_i, y_j)$

$d(y_i, y_j)$ Is the distance between data $y_i \in a_i \ and y_j \in a_j$

$diam(a_i)$ Is the diameter of the cluster a_i

$$diam(a_i) = \max_{y_{i1}, y_{j2} \in a_i} (y_{i1}, y_{j2})$$

An optimal value of the k is one that maximizes the Dunn's index [XXV].

IV. Build a citizen call profile of urban needs with association rule mining and the Apriori algorithm

The goal of this step is to discover hidden patterns in citizen call databases to get a better understand of temporal-spatial patterns of citizen call compliant and improve new strategies to provide better responses to customer needs.

ARM and the Apriori algorithm

Association rule mining methods is a descriptive data mining method. Association rule is explained as an expression of X→Y, where X and Y are items [X]. The goal of association rule mining (ARM) is to examine the database and find a rule in the dataset [X]. ARM technique prepares worthwhile information in a significant correlation (10). ARM evaluated by to index: support and confidence. The support of an association rule at the dataset in transaction T is the probability of transaction population includes both X and Y. whereas the confidence in the transaction database contains Y given that it already includes X [III]. The important index in the evolution of ARM is the lifted index.

The index is determined by the sector of confidence of a rule by the support of the consequent part rule, respectively [IV]. The popular algorithm of ARM is the Apriori algorithm. A method for mining item sets and generating corresponding rules [IV]. The association rules in this step to build a citizen call profile. Association rule extraction aims to discover the relationship between features of the month, section and new feature "cluster"

V. Results

To normalize the data, we used the normalization of min-max in the range of (0, 1) in rapid miner software for all values of three features. (Frequency, Recency, Time interval, and Number of days) in this study the satisfaction variable is not considered

Frequency: the number of times a problem occurs in one season

Recency: recently the problem occurred.

Tim interval: the last and the first time a problem occurs until the end of the season. This variable is expressed in terms of days [III].

Number of days: the number of different days in a month that a problem occurs

Segmentation of urban needs with SOM and Clustering evaluation

In this step first, we used Dunn-index for obtaining the best optimal number of clustering (k). The best optimal k in this research is four clusters. Therefore, four clusters are selected for the segmentation of urban needs in SOM clustering. The summary of the value Dunn-index for each and SOM clustering are shown in Tables 2and 3 and Figure 1.

Table 2. The value of Dunn-index for each cluster

cluster	2	3	4	5	6	7	8	9	10
Dunn-index	0.1231	0.1766	0.2156	0.2534	0.1645	0.1589	0.1745	0.1667	0.1478

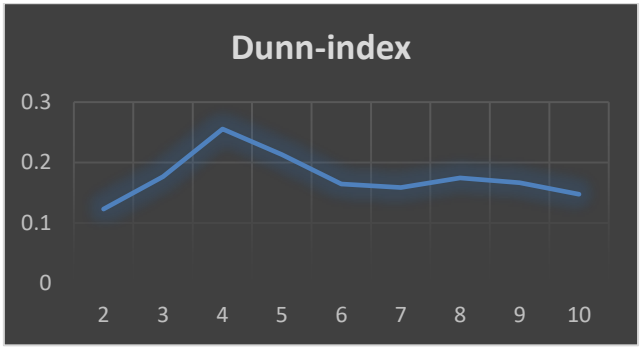

Figure.3. Clustering evaluation with Dunn-index

Table 3.the result of SOM clustering of urban problems

Cluster	Number of problems	F	R	ND
C1	79	8.77	8.34	2.76
C2	100	1287.4	75.23	56.89
C3	32	110.55	67.34	18.90
C4	16	2567.78	83.89	66.21

Explain clusters

Cluster 1: in this cluster, the urban problem is very specific problems that have rarely happened. This cluster dedicated the lowest average of (Frequency, **R**ecency, and Number of days). The average amount of frequency in Cluster 1: in this cluster, the urban problem is very specific problems that have rarely happened. This cluster dedicated the lowest average of (Frequency, **R**ecency, and Number of days). The average amount of frequency in this approximately.

Cluster 2: in this cluster, the (Frequency, Recency, and Number of days) features are very high where the 80% of problems are Waste and scrap, asphalt, collection, and installation, construction

Cluster 3: in this cluster, 90% of problems are related to Parks and green spaces and trees, installation of safety signs, washing, repair, separation and recycling, harassment and workers

Cluster 4: These clusters include problems of "collecting dirt and debris", "these passages (walkways and rides) need cleaning", "and changing location from parking or residential to commercial, office or warehouse."

To classify urban problems, a number is assigned to each cluster that indicates the degree of each cluster of urban problems.

After clustering, prioritizing the urban needs of each cluster was calculated based on an RFM model. Thus, prioritizing problems is equal to the average of the variables' value of each problem. The clusters were classified into three grades the low, medium. And high level according to their average value index. Means that the cluster where have a close average value to each other, they were assigned the same value class [I]. The segmentation of urban needs for each cluster is shown in table 4.

Table 4: The result of classifying clustering of urban problems

Number of clusters	Class code	Classification Value	Average problems index
C1	Class3	low	2.095
C2	Class1	high	2.57
C3	Class2	medium	2.134
C4	Class1	high	2.778

According to Table 4, the second and fourth clusters include Initial and immediate problems that are called Class 1. And it involves the key problems of the city where the municipality should apply appreciative strategies to solve the needs of the citizen. The third cluster is called the second category of citizen's problems and is classified as class 2 and the first cluster is classified as a third class of problem where allocated coed class 3

In this step, the association rules between 'section', 'month', 'region' and 'cluster' variables were extracted by using the Apriori algorithm has four variables were considered respectively, as input and output of this algorithm. The minimum value of support and confidence values were adjusted 2% and 80%, respectively. We also calculated the lift value for each obtained rule and omitted the rules with a lift value less than one, finally, 9 rules were obtained as a reliable rule in this step. The result of the 9 rules is shown in table 5.

Table 5: association rule of citizen profile

Rule ID	*Association rule*		*support*	*confidence*	*lift*
	premises	*conclusion*			
1	*Subject=359, region=14*	*Cluster2*	*2.341%*	*98.3%*	*1.331*
2	*Subject=138, section=02*	*Cluster2*	*2.432%*	*99.1%*	*1.341*
3	*Subject=359, month=03*	*Cluster2*	*2.37%*	*99.2%*	*1.343*
4	*Region=12*	*Cluster2*	*2.41%*	*99.3%*	*1.345*
5	*Subject=359, month=04*	*Cluster2*	*2.20%*	*99.5%*	*1.346*
6	*Subject=138, region=12*	*Cluster2*	*2.30%*	*99.6%*	*1.351*
7	*Month=3*	*Cluster2*	*2.29%*	*99.8%*	*1.354*
8	*Section=04*	*Cluster2*	*2.35%*	*99.4%*	*1.347*
9	*Region=12, section=04*	*Cluster2*	*2.52%*	*98.2%*	*1.349*

Rule extraction

Table 5: demonstrate the *citizen call profile of urban needs* in the form of association rules, where each rule shows a citizen profile that was significant relationship up with citizens matching that cluster. For example, the first law shows that in region14 in subject=359 problems accrued in cluster2 with 98.3%confidence. According to the above rules, it can be concluded that in 4sections of the region 12 problems accrued in cluster 2 with more than 74/54 confidence. Therefore, in general, it can be concluded wherein all sections of the region in all the months, the problem of cluster 2 is more reliable than other clusters. And given the high level of confidence, the problem of cluster 2 are problems which are more important to citizens in all sections of the region. as mentioned in the previous section the urban needs, classified into 3 sections. From this, Municipality can build a more accurate profile in each target group of citizens for identifying temporal-spatial patterns of problems by briefly reviewing the 4 clusters. And it should be considered the risk of the arising problem by different citizen call.

Analyzing the rules of performance of the municipality

In this step, the association rules between ‘unit’, ‘final status of the subject’ and ‘subject’ variable were extracted by using the Apriori algorithm has three variables were considered respectively, as input and output of this algorithm. The minimum value of support and confidence values were adjusted 1% and 70%, respectively. We also calculated the lift value for each obtained rule and omitted the rules with a lift value less than one, finally, 9 rules were obtained as a reliable rule in this step. The result of the 7 rules is shown in table 6.

Table 6: association rule of performance of the municipality

Rule ID	Association rule		Support%	Confidence%	lift
	premises	conclusion			
1	Unit=12	Final status of subject=accomplished and confirmed	2.10%	93.4%	4.193
2	Unit=30 & subject=138	Final status of subject=disaffiliation	2.37%	93.5%	3.773
3	Unit =27	Final status of subject=satisfaction	2.13%	94.1%	2.156
4	Unit=30 & Subject=359	Final status of subject=disaffiliation	2.47%	92.9%	3.726
5	Subject=138	Final status of subject=disaffiliation	2.01	93.6%	3.124
6	Unit=34 & subject=359	Final status of subject=repeated and informed	2.09%	95.1%	2.164
7	Unit=34 & subject=362	Final status of subject=repeated and informed	2.11%	95.2%	2.168
8	Unit=34	Final status of subject=repeated and informed	2.14%	95.9%	2.098
9	Subject=138 & unit=12	Final status of subject=accomplishment and informed	1.76%	93.8%	1.98

Rule extraction

The performance of the municipality is not suitable in controlling the complaint which refers to 'Sound pollution has caused inconvenience by construction', 'illegal construction it takes place on the spot ', and 'The location from parking or residential to commercial, office or warehouse is changing'. The probability of the final status of the subject being accomplished and confirmed is 93.4% in the unit=12. The performance of the municipality in handling the "Sound pollution has caused inconvenience by construction" in unit 30 is not perfect and citizens fell disaffiliation with a probability of 93.5%. citizens feel satisfaction with unit=27 with a probability of 94.1%. this unit has a good performance just in controlling the complaint and statutes of the subject. The performance of municipality in controlling the complaints of "illegal construction it takes place on the spot' in-unit =34, the final status of subject= "repeated and informed" with 95.1%.

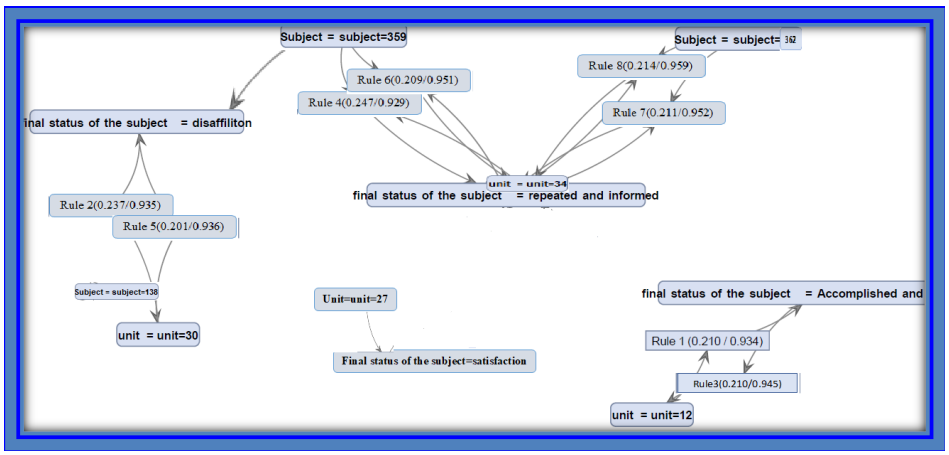

Fig 4. the graph of association rule

VI. Conclusion

The main goal of this study discovering hidden cluster structures in citizen-call compliant of the municipality by using data mining techniques. According to the results of the combined method of data mining include a self-organizing map (SOM) based on RFM analysis and association rule with Apriori algorithm leads to identify hidden knowledge of daily call compliant of urban problems. First, the pattern extracted from the Self-organizing map (SOM) clustering represents three grade levels of urban problems based on Frequency, Recency, Number of days attributes. Then the result of clustering is chosen as a new feature for the output of association rules analysis with the Apriori algorithm to create citizen call profile regarding temporal-spatial patterns of problems. The research results indicate that priority needs are in cluster 2 and cluster 4 that allocated a high database of problems and more temporal-spatial patterns occurred in this cluster at all of the sections of region 4. This study provides a good method of analyzing databases of the call center of the municipality. Further research may propose using a new feature in RFM analysis with a new hybrid method for human resource performance (HR) from better service to citizen problems. Future research works on ideas about prediction citizen /customer relationship management in every E-government around the world.

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Conflict of interest

All the authors are hereby declared that they have no conflict of interest.

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