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Nephron Algorithm: A New Approach for Rank-Oriented Clustering Case Study: Supplier Selection of Multinational Company

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Abstract- Since, supplier chain management (SCM) can respond to rapid market changes quickly and hence increase competitive advantage and on the other hand, supplier lies in first node of SCM. So, supplier evaluation and selection is important task to the whole SCM's agility and competition. Besides, there exist several proposed approaches to resolve this problem. However, a different methodology is proposed due to its powerful discriminatory performance, in this paper. For this purpose, the algorithm was inspired based of nephron performance because of its intelligent screening. It can be applied as data mining technique in order to cluster as well as prioritize suppliers according their attributes and scores respectively. Therefore, it is employed in order to enhance the power of evaluating the supplier performance based of not only its scores but also its homogeneity with other suppliers. To illustrate the proposed model, the large, multinational, and Telecommunication Company was taken into account. Consequently, applied model is supposed to cluster suppliers precisely and accurately according to intellectual logic of nephron. Thus, data of one multinational and Communication Company were taken to be prioritized by applying the nephron algorithm and suppliers were ranked and categorized based on new approach accurately.

Keywords- *Nephron algorithm; Clustering; Prioritizatio;, and Supplier*

I. INTRODUCTION

The As we know, effective management of collaborative supply chain networks (SCNs) is a lucrative solution to increase the efficiency of production and service performances and competitiveness of companies because of their direct impact on a variety of final product dimensions such as cost, product and design quality. Therefore, Supplier chain management can provide quick response to rapid market changes and hence increase of competitive advantage while maintaining profitability (Celebi et al., 2008). Nowadays not only rising customers' expectations but also increasing the product quality is becoming an important strategic priority in the pretty competitive global business environment. Consequently, Manufacturers must produce the correct products at the accurate time and deliver them promptly to customers to sustain their competitive advantage in the marketplace (Shu et al., 2009).

It was estimated that more than 50% of total cost in organizations pertains to purchased materials, services, and equipments, also, in the automotive industry, the cost of components and parts purchased from outside vendors have increased up to 50% of their revenues (Shu et al., 2009; Jafari et al., 2001). Thus, suppliers with low quality lead to unfair results in companies. As it was indicated, the main object of both suppliers and manufacturers is to satisfy the end-users; hence they must retain their quality based level in long term according to mutual partnering. Therefore, the quality of supplier must be enhanced in order to improve quality of organizations (Jafari et al., 2001). In other literature, it has pointed out that the cost of raw materials and component parts constitutes the main cost of a product and most of the firms have to spend considerable amount of their sales revenues on purchasing so that, in most industries, the cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for up to 70% (Kilincci et al., 2011). Moreover, the high technology firms spend more than 80% of total product costs on purchasing materials and services (Shu et al., 2009; Kilincci et al., 2011). As a result, it was demonstrated that supplier management is one of the key issues of supply chain management. Therefore, it must be stated that the purchasing department can play a key role in an organization's efficiency and effectiveness since the department has a direct effect on cost reduction, profitability. Also, selecting the appropriate suppliers reduces the purchasing costs and improves corporate competitiveness reasonably (Kilincci et al., 2011). Obviously, the quality of parts obtained from suppliers determines the quality of the finished products produced by manufacturers as well as the customers' satisfaction and loyalty (Shu et al., 2009). Besides, supplier lies in first node of SC (supply chain). So, supplier evaluation and selection is important to the whole SC's agility and competition (Wu, 2009). In addition, in a study, the procurement of parts and materials was determined a very important issue in the successful and effective implementation of production specially JIT. Therefore, supplier selection and performance evaluation in long-term relationships have became more critical in production environments (Aksoy et al., 2011). In today's highly competitive and global markets, a firm should establish long term and strategic relationships with its suppliers to accomplish goals of the supply chain effectively. In order to cope with this strategically important issue and manage purchasing function effectively, firms should select best supplier(s) by applying proper model and criteria (Yucel et al., 2011). Therefore, the evaluation of supplier performance and selection of suppliers are becoming major challenges faced by the manufacturing and purchasing managers according to key position of supplier selection in SCM (Shu et al., 2009).

II. LITERATURES

A. Supplier

Activities, facilities and processes in every business transaction link the supplier to the customer. Supplier chain management is management process of balancing these deliver best value to the customer at minimum cost and effort for supplier. We can experience supply chains in many situations, such as banks, government, health service, manufacturing business. Complexity and size are two significant characteristics for supply chains but regard to other fundamental principles such as small or large, manufacturing or service, private or public sector, operations can be changed. In addition supply chain management is considered for large name businesses as well as for all businesses (Geunes et al., 2002). Then, it is important to clarify supplier selection problem derived from various literature because there are several paraphrases and definitions on this issue however they imply to same concept so that supplier selection is defined the most important Multi-Criteria Decision Making (MCDM) problem in production and logistics management and also this process includes several tangible and intangible factors (Yucel et al., 2011; Keskin et al., 2010). On other word, supplier selection problems consist of both qualitative and quantitative factors to identify suppliers with the highest potential in order to fulfill a firm's needs consistently along with an acceptable cost (Kilincci et al., 2011). To resolve supplier selection, many researchers have been done and applied numerous quantitative methods. Approximately these quantitative methodologies can be divides into categories: (1) Intelligence approaches (2) multi attribute decision making (MADM) (3) mathematical programming models (4) uncertainly and fuzzy approaches (5) and other methods (Geunes et al., 2002).

B. Cluster Analysis (CA)

Clustering is a popular data mining technique, which involves the partitioning of a set of objects into a useful set of mutually exclusive clusters such that the similarity between the observations within each cluster (i.e., subset) is high, whereas the similarity between the observations from the different clusters is low (Samoilenko et al., 2008;2010). Unlike decision trees which assign a class to an instance (supervised method), clustering procedures are applied when instances are divided into natural groups or clusters (unsupervised method). There are different ways to produce these clusters. The groups may be exclusive i.e. any instance belongs to only one group probabilistic or fuzzy i.e. an instance belongs to each group to a certain probability or degree (membership value) hierarchical i.e. there is a crude division of instances into groups at the top level and each of these groups are refined further up to individual instances (Thomassey et al., 2006). In other literature, overview of two general approaches to clustering was provided: hierarchical clustering, partitional clustering (e.g., k-means, k-median)(Samoilenko et al., 2008). Examples of application of clustering seen in (Ban Field and Rafty, 1992; Ben-Dor and Yakhini, 1999; Dhillon, 2001; Fisher, 1997; Hirschberg&lye,2001; Johnson, 1967; Lai et al., 2009; Okazak, 2006; Wallace et al., 2004).

C. Nephron

A nephron (from Greek νεφρός (nephros) meaning "kidney") is defined as the basic structural and functional unit of the kidney. Its principal function is to regulate water and soluble substances by filtering the blood, reabsorbing what is needed and excreting the rest as urine. Nephrons eliminate wastes from the body, regulate blood volume and pressure, control levels of electrolytes and metabolites, and regulate blood pH. Its functions are vital to life and are regulated by the endocrine system by hormones such as ant diuretic hormone, aldosterone, and parathyroid hormone (Maton et al., 1993). Each nephron is composed of an initial filtering component (the "renal corpuscle") and a tubule specialized for reabsorption and secretion (the "renal tubule"). The renal corpuscle filters out large solutes from the blood, delivering water and small solutes to the renal tubule for modification. About 20% of the blood plasma is forced out of glomerulus (specialized capillaries) and across the membrane Bowman's capsule. It acts to filter some of the substances that are located in blood plasma from others. The renal tubule is the portion of the nephron containing the tubular fluid filtered through the glomerulus (University of Colorado, 2007).

The components of the renal tubule are (Fig1.):

- Proximal convoluted tubule (PCT lies in cortex and lined by simple cuboidal epithelium with brushed borders which help to increase the area of absorption greatly)
- Loop of Henle (hair-pin like i.e. U-shaped and lies in medulla)
    - Descending limb of loop of Henle
    - Ascending limb of loop of Henle
- The ascending limb of loop of Henle is divided into 2 segments: Lower end of ascending limb is very thin and is lined by simple squamous epithelium. The distal portion of ascending limb is thick and is lined by simple cuboidal epithelium.
- Thin ascending limb of loop of Henle
- Thick ascending limb of loop of Henle (enters cortex and becomes DCT-distal convoluted tubule.)

Distal convoluted tubule (DCT) (http://en.wikipedia.org/wiki/Nephron)

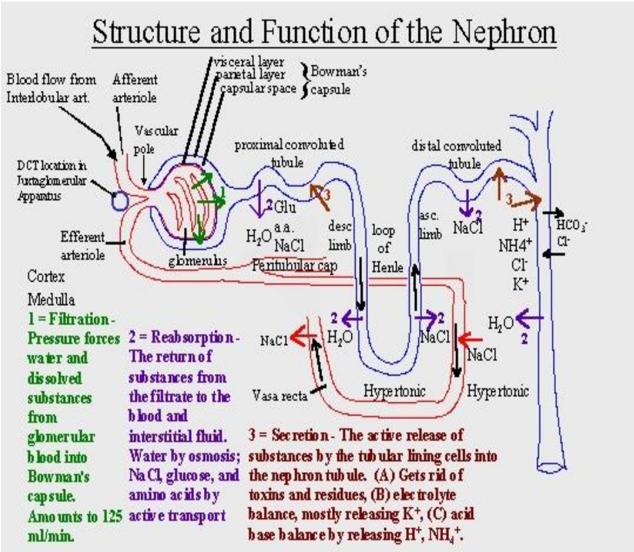

Figure 1. Nephron anatomy

III. METHODOLOGY

Several methods have been proposed and used for supplier evaluation and selection; most of them try to rank the suppliers from the best to the worst and to choose the appropriate supplier(s) (Keskin et al., 2010). As it was indicated, both selection and evaluation of suppliers carried out in major of researches because the selection is based on evaluation results, thus it is necessary to employ the methodologies, which have ability to assess the performance of supplier in the first place, and then best suppliers will be selected according to their prioritization score. This problem requires consideration of a variety of attributes. Various studies have been performed for effective evaluation and selection of suppliers by using several approaches such as linear weighting methods, mathematical programming models, statistical methods (Celebi et al., 2008). In other word, there are several models and methodologies such as MCDM (AHP, FAHP, and TOPSIS), SWOT, ART, and recently data mining techniques especially neuron-fuzzy, ANN, and DT integrated with DEA that was applied to resolve the supplier selection problem. All models consider the most factors of supplier such as cost, goodwill, service, delivery time, and environmental impact quality, price, reference/reputation, flexible contract terms, scope of resources, additional value-added capability, cultural match, existing relationship, location, however quality can be seen as an essential factor for supplier evaluation among various criteria (Shu et al., 2009) to analyze the weights of them in order to prioritize the supplier. Therefore, among these tools, data mining methods are suitable because of their well-known accuracy rate.

In this paper, one algorithm is proposed in order to cluster as well as prioritize suppliers according their attributes and scores respectively. Aforementioned algorithm was inspired based on natural nephron performance so that data are clustered and ranked step by step. Role of nephron in separating and screening of data is important; this algorithm can aid us to separate bad stuffs from good stuffs among whole data, correspondent with principals of nephron performance. The rules of nephron are able to discriminate bad and good stuffs step by step so that finally, the best stuffs will be deposited out of nephron and the rest will exited rank-oriented cluster by cluster in each stage.

In order to conduct the research, four-step methodology is proposed:

1. *Filtration*: according to rule of filtration in nephron, 20 percent of data must be input of it, so for this purpose, 20^{th} quadrant (Q20) was considered as filtrating criteria of this part. Therefore, data which their score is less than Q20 enter to nephron, whereas, the other more than Q20 not be filtrated and will be deposited in vein.
2. *Reabsorption*: this operation is done in PCT part of nephron, some existing data in nephron must be entered to vein based on this rule. So, data will be transferred to vein so as to reduce MSE to lowest value.
3. *Secretion*: this operation is carried out in DCT part of nephron, some existing data in vein must be entered to nephron based on this rule. So, data will be transferred to nephron so as to reduce MSE to lowest value than reabsorption value.
4. *Excreting and repeating*: according to this step, existing data of nephron must be excreted as bad data (lower rank) and the rest data of vein must be passed 3 previous steps till the best data is deposited in vein as first rank data.
5. *Termination condition*: if stopping criteria are met, then stop, else go to filtration step.
    - Assuming that data was reabsorbed more than twice.
    - Provided that the filtration step can not be fulfilled based on mathematical rules (Q20 of the rest data in vein can not be calculated), as a result, there is no data to enter to nephron.

The algorithm includes of filtration, reabsorption, secretion, and excretion is presented in Fig2. That is inspired by performance of natural nephron.

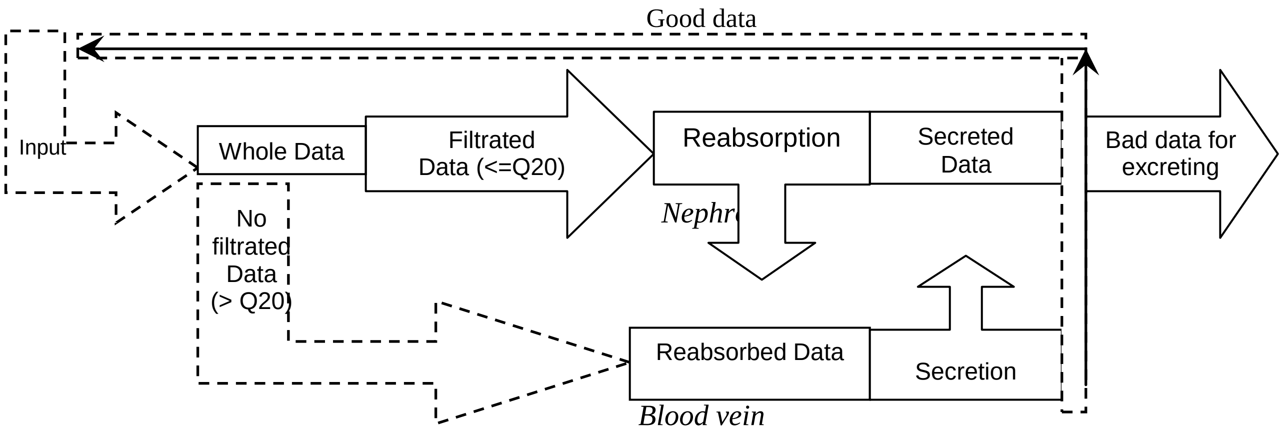

Figure 2. Theoretical (conceptual) framework

IV. NUMERICAL ILLUSTRATION AND RESULTS

A. Data

The numerical example was considered and it is indicated in table1 taken from Talluri and Narasimhan (2005). The data was derived from a large, multinational, and telecommunications company. On the other hand, the data was utilized by Wu (2009) also for supplier selection also. The data presents six input variables, which represent capabilities of each supplier to generate five output factors that represent the performance outcomes of suppliers in the measurement process. In this study, supplier was taken into account as data, with 11 attribute. The inputs and outputs are applied as attributes for clustering only and are determined as follows: Inputs include: Quality management practices and systems (QMP), Documentation and self-audit (SA), Process/manufacturing capability (PMC), Management of the firm (MGT), Design and development capabilities (DD), Cost reduction capability (CR)

Outputs include: Quality, Price, Delivery, Cost Reduction Performance (CRP), other.

TABLE I. DATA FOR 23 SUPPLIERS

Supplier	QMP	SA	PMC	MGT	DD	CR	Quality	Price	Delivery	CRP	Other
1	0,7826	0,9333	0,923	1	0,909	0,647	0,3733	0,4933	0,0666	0,3333	0,3333
2	0,5714	1	0,6666	0,8125	0	0,7222	0,4166	0,4933	0,2	0	0,1666
3	0,8	1	0,8333	1	0,8333	0,7777	0,6266	0,7333	0,9333	0,6666	0,6666
4	1	1	1	1	1	0,9444	0,3866	0,4933	0,2	0	0,2777
5	0,4728	1	0,5384	0,7058	0,4615	0,3333	0,8666	0,24	0,7333	0	0,6666
6	1	1	1	1	1	1	0,3333	0,6133	0,5333	0,3333	0,6111
7	0,8636	1	1	1	0,923	1	0,4933	0,4933	0,4666	0,3333	0,4444
8	0,913	0,9333	0,923	0,9444	1	0,8888	0,6133	0,48	0,4	0	0,2777
9	0,9565	1	1	1	1	1	0,7333	0,1333	0	0	0,2222
10	0,8695	1	1	1	0,5384	0,9444	0,5066	0,5833	0,7333	0,3333	0,7777
11	1	1	1	0,9375	1	1	0,4666	0,4933	0,5333	0	0,5
12	0,4545	0,8571	0,6923	0,6666	0,6666	0,6111	0,6133	0,24	0,8	0	0,6666
13	0,913	1	0,8461	0,8888	0,7692	0,9411	1	0,6266	0,8	0,3333	0,9444
14	0,913	1	1	1	1	1	0,6	0,7466	0,6	0,3333	0,5
15	0,6521	0,8	0,923	0,8888	1	0,8888	0,7333	0,6666	0,4	0,6666	0,6666
16	0,9565	1	1	0,9444	0,8461	0,83333	0,5066	0,6266	0,3333	0,3333	0,4444
17	0,7	0,7777	0,7272	0,8323	0,7692	0,6666	0,2533	0,4933	0,5333	0	0,4444
18	0,5217	0,8	0,909	0,9444	0,7692	0,8888	0,6133	0,7333	0,4	0,3333	0,3888
19	0,8181	1	0,7692	0,9444	0,583	0,5625	0,7466	0,8666	0,7333	0,6666	0,6666
20	0,7272	0,9333	0,923	0,9444	0,75	0,6666	0,6133	0,4933	0,2	0	0,2222
21	0,8695	1	1	0,8333	0,923	0,7777	0,7	0,4933	0,7333	0,3333	0,5555
22	1	1	0,8461	1	0,8333	1	0,88	0,7333	0,9333	0,6666	0,7777
23	0,8695	1	0,923	0,9411	0,6923	0,8888	0,7466	0,7466	0,6666	0,6666	0,8333

B. Implementation

It must be pointed out that we applied software Excel, and MINITAB in order to analysis of the example. In the first place, mean of attributes of the supplier was considered for decision making in filtration step. In this part, data averages less than or equivalent Q20 are inputs of nephron and the rest (greater Q20) follow in vein. Thereafter, the reabsorption phase must be implemented according to *k*-means method. Among existing data of nephron, some data must be reabsorbed by vein so as to reduce total error in vein data and nephron data as well as to reduce total mean in nephron data. For this purpose, a criterion for reabsorbing data by vein is based on both the greatest mean and greatest error for existing data of nephron. So, multiplying the mean and error (RMSE) is qualified to be initial criteria (the greatest) in order to be reabsorbed (Eq. 1.). As long as, MSE of vein and nephron is decreased, selected data can be absorbed, otherwise, the next step will be implemented.

$$Criteria_{reabsorption} = RMSE_{data} \times Mean_{data} \quad (1)$$

In secretion step, some data of vein must be secreted into nephron for not only reducing MSE but also decreasing mean of nephron, for this aim, a criterion for secretion data by nephron is correspondent with both the lowest mean and greatest error for existing data of vein. Thereby, division of mean per RMSE is selected to be initial criteria (the lowest) in order to be secreted (Eq. 2.). Selected data can be secreted only if MSE of vein and nephron is decreased, otherwise, the last step will be taken.

$$Criteria_{secretion} = Mean_{data} / RMSE_{data} \quad (2)$$

As it is shown, after the 3rd step, worst data based on their ranks and similarities were separated from whole data, and then these are ready to excrete by nephron as a cluster. In addition to excreting in last phase, the rest from vein must be processed again in algorithm and previous steps are repeated for them. By repeating the algorithm, other clusters is figured out and excreted till Q20 of rest data of vein will not be available. So, the last cluster is identified as high ranked data in this methodology. One of the nephron algorithms is indicated in Fig 3.

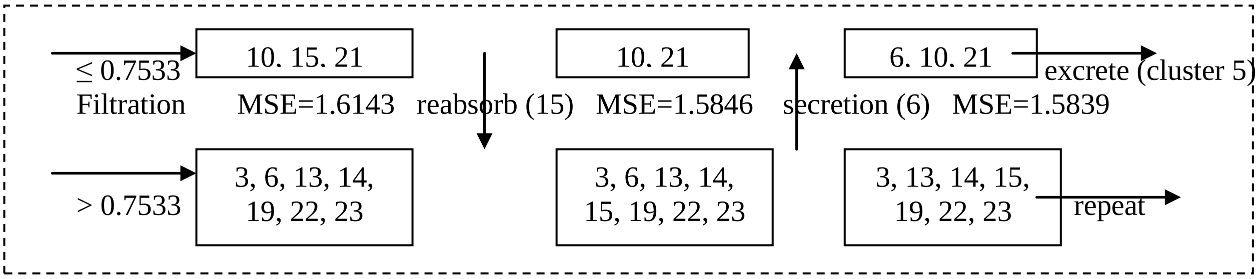

Figure 3. Figuring the 5th cluster

C. Analysis of numerical results

In this part, output results of nephron were analyzed according to indicated information in table2. In addition to mean of data (supplier score), the MSE of nephron (MSE of each cluster) are presented. Advantage of this methodology in comparison with other clustering techniques is to prioritize the data as well as to categorize homogenous data step by step. This algorithm aids us to discriminate data from each other along with ranking the data accurately. Innovation in this paper is not only to cluster but also to rank by nephron learning as a data mining approach as well as a screening algorithm.

TABLE II. PRIORITIZATION RESULTS

Cluster No. (rank)	Suppliers No.	Mean of Data	MSE of nephron
1	13, 22, 23	0.8396	0.199942
2	3	0.8064	0
3	14, 15	0.7717	0.170871
4	19	0.7597	0
5	6, 10, 21	0.7554	0.494070
6	7, 16, 18	0.7013	0.213859
7	1, 4, 8, 9, 11	0.6626	0.675422
8	2, 5, 12, 17, 20	0.5464	1.571906

It must be pointed out that to evaluate the results of the nephron model; the validation of it must be verified. So, R-Squared index (RS) of clusters is calculated according to Eq.3-6 (Momeni, 2011). Cj, d, n, indicate jth cluster, number of attributes, and number of data (suppliers), respectively. SSt

,SSw ,SSb show Square standard deviation of total data, within each cluster, and between each cluster, respectively. Also, x_{ij}, $\bar{x}_j$, $\bar{x}_{ij}$ show quantity of jth attribute of ith data, mean of jth attribute of data, and mean of jth attribute in ith cluster (Momeni, 2010).

$$SS_t = SS_b + SS_w \qquad (3)$$

$$RS = SS_b / SS_t = (SS_t - SS_w)/SS_t \qquad (4)$$

$$SS_w = \sum_{i=1}^{k} \sum_{x \in C_j} \sum_{j=1}^{d} (x_{ij} - \bar{x}_{ij})^2 \qquad (5)$$

$$SS_t = \sum_{i=1}^{n} \sum_{j=1}^{d} (x_{ij} - \bar{x}_j)^2 \qquad (6)$$

It was demonstrated that a RS near to 1 is regarded as acceptable validation for a clustering whereas, far from 1 is regarded as reject (Momeni, 2011). According to aforementioned equations, RS of rank-oriented clustering was estimated 0.78 approximately and hence it has to state that this model can be regarded as valid.

V. CONCLUSION

In this paper, we studied on supplier selection and evaluation as an important node of supply chain management (SCM) because of its effects on SCM. Several researches were conducted on this issue in order to measure the suppliers and hence rank them. In this study, the methodology was employed in order to evaluate supplier as well as to cluster them according to mean score of supplier and their attributes respectively. The proposed algorithm was presented based upon natural nephron performance in kidney as a meta-heuristic in order to improve the clustering and ranking data step by step because of its discriminatory power and its excreting power for bad stuffs. Results show both prioritization and categorization were carried out precisely and accurately. The nephron algorithm was employed in order to separate the best suppliers from the worst suppliers according to their homogeneity as well as their rank for the first time. Ranking and clustering are two issues, which are taken into account in researches simultaneously, thus nephron is able to play key role in screening, discriminating, and ranking data in order to make rank-oriented categorizing. Consequently, the nephron clustered data to eight unsupervised and prioritized groups, which data within each cluster are more homogenous than to each other while clusters have least similarity to each other. Because, the RS is 0.79 and it demonstrate high validation of rank-oriented clustering. It is pointed out the nephron algorithm is applied in order to resolve supplier selection as innovative application, and thereby, this proposed model with capabilities such as reabsorption and secretion functions can be improved in next researches in order to enhance accuracy in clustering.

Aim of this paper is to introduce nephron meta-heuristic technique for optimization and to improve the clustering and ranking data. Furthermore, it can be applied as optimization technique to resolve non-parametric (NP) problems such as decision tree (DT) and also to resolve parametric problems such as linear programming (LP). Therefore, it is suggest applying this algorithm in resolving LP problems for future researches.

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