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MANNER OF STOCKS SORTING USING CLUSTER ANALYSIS METHODS

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Abstract: The aim of the present article is to show the possibility of using the methods of cluster analysis in classification of stocks of finished products. Cluster analysis creates groups (clusters) of finished products according to similarity in demand i.e. customer requirements for each product. Manner stocks sorting of finished products by clusters is described a practical example. The resultants clusters are incorporated into the draft layout of the distribution warehouse.

1 Cluster analysis

Cluster analysis belongs to multivariate statistical methods [1]. It is defined as general logical technique, procedure which allows clustering various objects into groups – clusters on the basis of similarity or dissimilarity [2].

Having a data matrix *X* type *n x p*, where *n* is the number of objects and *p* number of variables (features, characteristics). Next there is a decomposition *S(k)* of set *n* objects to *k* certain groups (clusters), i.e.

$$S^{(k)} = \{C_1, C_2, C_3, ..., C_k\},$$ [4]:

(1)

$C_i \neq \emptyset, i = 1,...k,$

$\bigcup_{i=1}^{k} C_i$ comprises all the space.

If that set of objects $o = \{A_1, A_2, ..., A_n\}$ and any dissimilarity coefficient of objects *D*, then a cluster is called a subset of *p* sets of objects *o* to which it applies [4]:

$$\max_{i,j} D(A_i; A_j) < \min_{k,l} D(A_k; A_l), \quad (2)$$

where $A_i, A_j, A_l \in o$ a $A_k \notin p$. This means that the maximum distance of objects belonging to the cluster must always be less than the minimum distance any object from the cluster and object outside cluster.

The input for the clustering of the input data matrix and output is a specific identification of clusters. The input matrix *X* of size *n x p* contains the *i*-th row of characters x_{ij} object A_i, where *i = 1, 2, ..., n* and *j = 1, 2, ..., p*. Therefor

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{pmatrix}. \quad (3)$$

Cluster analysis is a summary term for a group of methods that aim to either group the objects into clusters or clusters create a hierarchy of objects. Hierarchical cluster analysis methods analyzed classify objects into a hierarchical system of clusters. After this is important effective programming or utilization available softwares [3]. Between the hierarchical methods of cluster analysis method are simple linkage, complete linkage method, average linkage method, centroid method, median method, Ward `s method. Non-hierarchical methods do not create hierarchical (tree) structure and the objects are categorized into the number of disjunctive clusters specified in advance. Between the non-hierarchical cluster analysis methods of cluster analysis method are k-means, fuzzy clustering. In this paper was used hierarchical cluster analysis method - Ward's method and similarity were expressed by the square Euclidean distance.

Squared Euclidean distance is the basis Ward method of cluster analysis. The distance between the object resp. clusters is expressed as

$$d_{ES}(x_i, x_j) = \sum_{l=1}^{m} (x_{il} - x_{jl})^2 . \quad (4)$$

Ward's method is also marked as a method of minimizing the increases of errors of sum squares. It is based on optimizing the homogeneity of clusters according to certain criteria, which is minimizing the increase of errors of sum squares of deviation points from centroid. This is the reason why this method is different from previous methods of hierarchical clustering, which are based on optimization of the distance between clusters [2], [4].

The loss of information is determined at each level of clustering, which is expressed as the increase of total sum of aberrance square of each cluster point from the average ESS value. Then comes to an connection of clusters where there is a minimal increase in the errors of sum of squares [2], [5].

The accruement of ESS function is calculated according to [2]:

$$\Delta ESS(A_i, A_j) = \frac{1}{2} d_{ES}(A_i, A_j),\ A_i, A_j \in o, \qquad (5)$$

where i,j =1,2,...,n.

1.1 Cluster analysis of stocks

To perform the analysis are needed of data on the expedition of finished products particular company for the year [6]. Figure 1 shows the evolution of customer requirements resp. expedition during the year.

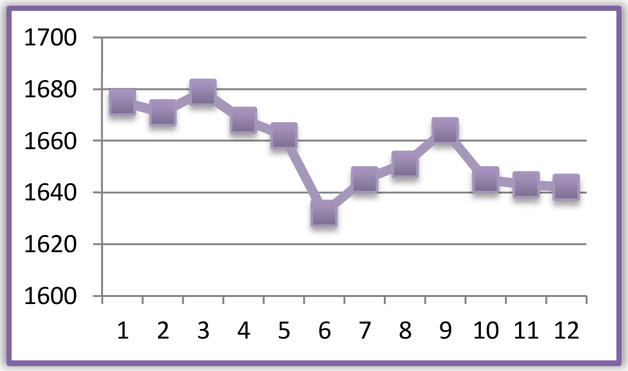

Figure 1 Evolution of customer requirements resp. expedition during the year

It can be seen that the evolution of customer requirements resp. expedition of finished products in the year 2013 has variable course. It can be seen that the evolution of means to customer ie. evolution dispatch of products has variable course, the average expedition represents 1,66 pcs of products per month, the greatest demand resp. export was observed in March of that year and the smallest demand resp. export was observed in June of that year. In some months of 2013 was created a single customer's request for the selected product.

Based on the input data on a monthly expedition of finished products for the customers in year 2013 was performed cluster analysis. The result of the process clustering is a dendrogram showing the different clusters according to the distance (dissimilarity) show in Figure 2.

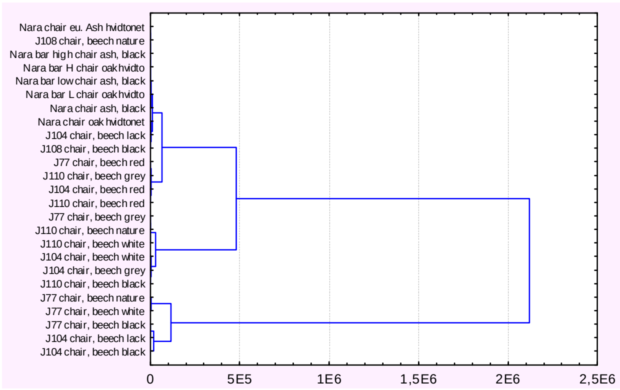

Figure 2 Dendrogram of stocks

Dendrogram is a graphic output of the cluster analysis, which shows clusters according to the distance (dissimilarity). Som other approaches for solving of analysis or sysntesis is described in the book *“Logistics of distribution”* [7]. The choice the clusters is on judgment of the solver [8], [9]. The optimal clusters are clusters of final products described in the Table 1.

Table 1 Clusters of final products

	Final products
1.cluster	Nara chair eu. Ash hvidtonet
	J108 chair, beech nature
	Nara bar high chair ash, black
	Nara bar H chair oak hvidto
	Nara bar low chair ash, black
	Nara bar L chair oak hvidto
	Nara chair ash, black
	Nara chair oak hvidtonet
	J104 chair, beech lack
	J108 chair, beech black
	J77 chair, beech red
	J110 chair, beech grey
	J104 chair, beech red
	J110 chair, beech red
2.cluster	J77 chair, beech grey
	J110 chair, beech nature
	J110 chair, beech white
	J104 chair, beech white
	J104 chair, beech grey
	J110 chair, beech black
3.cluster	J77 chair, beech nature
	J77 chair, beech white
	J77 chair, beech black
	J104 chair, beech lack
	J104 chair, beech black

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It was confirmed that the use of cluster analysis in sorting of stocks of finished products is justified because the clusters are formed on the basis of similarities in our case similarity of expedition to customers, which is the main criterion for the formation of groups of products towards our customers. Products with the greatest expedition should be placed closest to the exit. This criterion will then be taken into account when designing the layout. The percentage share of clusters on total expedition is graphically shown in Figure 3.

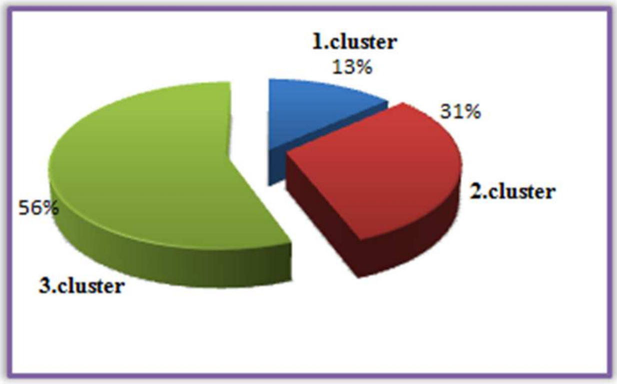

Figure 3 The percentage share of clusters on expedition

From the graphic illustration of Figure 3 follows that largest share of the expedition have products 3.cluster, then 2.cluster and the smallest share has 1.cluster. It is therefore appropriate stored of products 3.zhluku closer towards the exit in the warehouse of finished products. 3.cluster of products includes main groups of J77 and J104.

1.2 Draft of layout according clusters

Draft of layout of distribution warehouse is shown in Figure 4 (2D layout), Figure 5 (3D layout). In the layout is marked clusters by the percentage of share in the expedition.

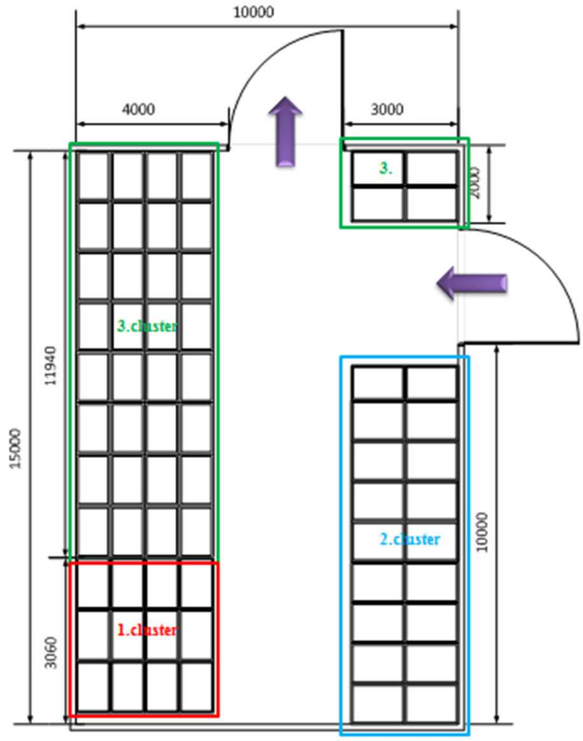

Figure 4 2D layout of distribution warehouse

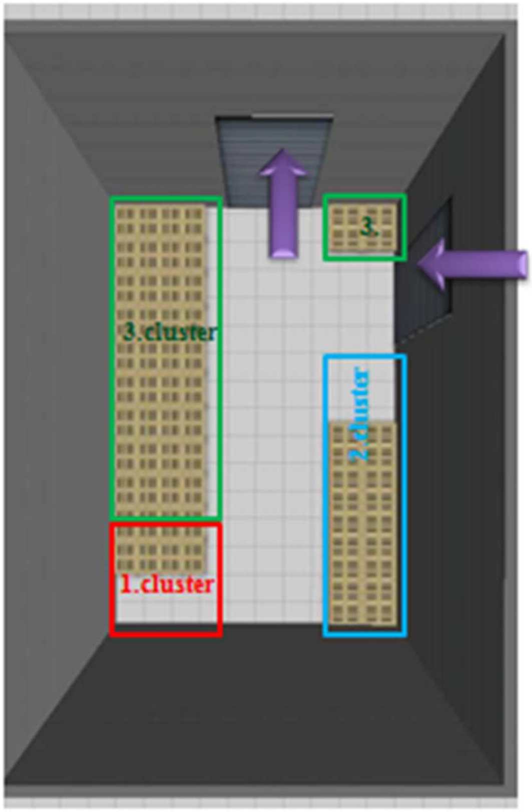

Figure 5 3D layout of distribution warehouse

Conclusion

Described procedure of the application of cluster analysis in sorting of stocks is a systematic and logical. In the paper was applied for stocks of finished products. This procedure is applicable in all types of warehouses, in the input warehouse, in warehouse of auxiliary materials and in warehouse of finished products. When creating groups (clusters) of stock items using cluster analysis are necessary information about the process, which immediately followed, ie. for the analysis of stock items in output warehouse are input data of information on the expedition of products from previous years. When using cluster analysis in the development clusters of stocks depend on the type of stocks. The principle is also applicable in the field of ***supply of medical products***, where the criterion for the formation of clusters of stocks may be e.g. criterion storage conditions.

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References

[1] BACHER, J., POGE, A., WENZIG, K.: Cluster analysis - Application-oriented introduction to classification methods, Munchen, Oldenbourg, p. 432, 2010. (Original in German)
[2] BOŽEK, P., KŇAŽÍK, M., ŠTOLLMANN, V.: Conceptual planning and scheduling of operating funds for the real production of the company, Jaroměř, In: Technological forum, 5th International Technical Conference, Kouty, p. 192-198, 2014.
[3] TRNKA, K., PINTÉR, T., KŇAŽÍK, M., BOŽEK, P.: Effective programming of energy consumig industrial robot systems, Bratislava: STU in Bratislava, In: Power Engineering. Energy – Ecology – Economy, [Electronic], Conference EEE p. 4, 2012.
[4] EVERITT, B.S., LANDAU, S., LEESE, M., STAHL, D.: Cluster Analysis, London, Wiley, p. 348, 2011.
[5] HAN, J., KAMBER, M.: Data Mining – Concepts and Techniques, San Francisco, MK Publisher, p. 772, 2006.
[6] KAUFMANN, L.: Finding groups in data: an introduction in cluster analysis, Hoboken, Wiley, p. 342, 2005.
[7] STRAKA, M.: Logistics of distribution, How effectively to put product into the market, 1st edition, Bratislava, EPOS, p. 400, 2013. (Original in Slovak)
[8] TREBUŇA, P., HALČINOVÁ, J.: Experimental modelling of the cluster analysis processes, In: Procedia Engineering, Vol. 48, p. 673–678, 2012.
[9] ZGODAVOVÁ, K., ŽIVČÁK, J., HUDÁK, R., ČURILLA, E.: Quality in healthcare, Košice, Faculty of Mechanical Engineering TU in Košice, p. 141, 2013. (Original in Slovak)

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