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# **A Decision Support System for Market Segmentation**

## **- A Neural Networks Approach**

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### **Abstract**

Market segmentation refers to "the subdividing of a market into distinct subsets of customers where any subset may conceivably be selected as a market target to be reached with a distinct marketing mix" [Kotler 1980]. The reason for segmenting a market is that consumers are often numerous, geographically dispersed, and heterogeneous, and therefore seek varying benefits from the products they buy. Consumers within a segment are expected to have homogeneous buying preferences whereas those in different segments tend to behave differently. By properly identifying the benefit segment of a firm's product, the marketing manager can target the sales effort at specific groups of consumers rather than at the total population.

The identification of consumer segments is of critical importance for key strategic issues in marketing involving the assessment of a firm's opportunities and threats. The marketing manager must evaluate the potential of the firm's products in the target segment and ultimately select the most promising strategy for the segment. In this research, we introduce a new approach, a neural networks based method, to discover market segments and configure them into meaningful structures. The particular type of neural networks, the Self-Organizing Map networks, can be used as a decision support tool for supporting strategic decisions involving identifying and targeting market segments. The Self-Organizing Map (SOM) network, a variation of neural computing networks, is a categorization network developed by Kohonen. The theory of the SOM network is motivated by the observation of the operation of the brain. This paper presents

the technique of SOM and shows how it may be applied as a clustering tool to market segmentation. A computer program for implementing the SOM neural networks is developed and the results will be compared with other clustering approaches. The study demonstrates the potential of using the Self-Organizing Map as the clustering tool for market segmentation.

## **1. Problem Statement**

Different groups of consumers place different amounts of importance on the various attributes of the product they buy. The recognition of this fact has led to research on the subject of market segmentation. As consumers are more educated and discernible of the variety and availability of product on the market, the competition among products of similar nature accelerates. Therefore, it becomes more and more important for a firm to accurately characterize its product niche and the benefit segment in order to maintain its competitive advantage. The value of performing market segmentation analysis includes: to acquire a better understanding of the market in order to properly position its products on the marketplace, to identify the correct benefit segment when introducing new products, to find new opportunities for existing products, and to increase competitive advantage through product differentiation.

Market segmentation has been an important marketing concept in both academic literature and marketing practice. Researchers have used various clustering methods to identify market segments. It is generally recognized that there is no one best way to segment markets, as each approach has strengths and weaknesses depending on the product-market being considered and the managerial objectives for segmentation. Traditionally, numerical taxonomy techniques have been used to identify market segments as discrete or overlapping groups. In discrete segment structures, it is assumed that each consumer belongs to a single segment. In overlapping segment structures, a subject may belong to multiple segments which is more consistent with the notion that consumers may exhibit preferences spanning across segments. Researchers have also attempted to come up with other complex structures which may better represent the latent consumer preferences. These include fuzzy groups, hierarchical structures, and the coarse and fine structures. Fuzzy groups are similar to overlapping structures, except that their membership is indicated by the nearness of the subject to the group. Hierarchical structures assume that a hierarchical relationship exists among some or all of the groups and that subgroups are proper subsets of other larger groups. Dowling and Midgley [1988] introduced coarse and fine structures which represent a two-tier segmentation structure. There is no a priori relationship between the two levels, which is a coarse group may be comprised of items from a combination of finer segments, and the items in a finer segment may belong to different coarse groups. Each method imposes a special segmentation structure to the data under analysis and will work well only when the structure is appropriate for that particular market data.

## **2. Research Methodology**

In this research, a neural networks based method, the self-organizing map (SOM) network [Kohonen 1989], will be used to represent the relationship among various consumer preferences and market segments. Unlike other neural network approaches, the SOM network performs unsupervised training. The more common approach to neural networks requires supervised training of the network, i.e., the network is fed with a set of training cases and the generated output is compared with the known correct output. The SOM network, on the other hand, does not require the knowledge of the corresponding outputs. The nodes in the network converge to form clusters to represent groups of entities with similar properties. The number and composition of clusters can be visually determined based on the output distribution generated by the training process.

The SOM network typically has two layers of nodes, the input layer and the Kohonen layer. The input layer is fully connected to a two-dimensional Kohonen layer. The Kohonen layer functions similar to biological systems in that it can compress the representation of sparse data and spread out dense data using a two-dimensional map. This is done by assigning different sub-areas of the Kohonen layer to the different categories of information, therefore the location of the processing element in a network becomes specific to a certain characteristic feature in the set of input data. The resulting network resembles the tree structures that can be derived by conventional clustering methods.

SOM can learn from complex, multi-dimensional data and transform them into a map of fewer dimensions, such as a 2-dimensional plot. The 2-dimensional plot provides an easy-to-use graphical user interface to help the decision-maker visualize the similarities between consumer preference patterns. For example, suppose there are ten measures of customer attributes that are to be used to segment a market. It would be difficult to visually classify individuals based on all these attributes because the grouping must be done in a 10-dimensional space. By using the information contained in the 10-variable set but mapping the information into a 2-dimensional space, one can visually combine customers with similar attributes. These relationships can then be translated into an appropriate type of structure that genuinely represents the underlying relationships between market segments. The traditional approaches assume an underlying structural relationship between segments and then apply the appropriate clustering technique. The technique proposed in this paper does not make any assumption about the existence of a pre-determined structure. The number of segments and the structural relationship can be decided by the manager from the results based on the 2-dimensional plot according to the nature of the problem.

Neural networks are especially suited for applications requiring recognition of hidden patterns and for performing classification activities [Tam and Kiang 1992]. The task of recognizing consumer preference patterns and the clustering of consumers into segments has the characteristics of a neural networks application. Since neural networks have not been used in this problem domain, this paper investigate the technique and compares the results with previous approaches.

### **3. The Implementation**

During the training process, input data are fed to the network through the processing elements (nodes) in the input layer. An M-valued input pattern can be denoted by a vector of order M as:

$$\mathbf{x} = (x_1, x_2, \dots, x_M)$$

Each node in the Kohonen layer has a weight vector with M weight values associated with it. The weight vector of a node i can be denoted by:

$$\mathbf{w}_i = (w_{i1}, w_{i2}, \dots, w_{iM})$$

where  $w_{ij}$  is the weight associated with node i corresponding to the input node j. As the training process proceeds, the nodes adjust their weight values according to the topological relations in the input data. The node with the minimum distance is the winner and adjusts its weights to be closer to the value of the input pattern. The most common way of measuring the distance between a node in the Kohonen layer and an input pattern is the Euclidean distance measure ( $D_i$ ) given by:

$$D_i = \sqrt{(x_1 - w_{i1})^2 + (x_2 - w_{i2})^2 + \dots + (x_M - w_{iM})^2}$$

During training, the weights of the winning node are adjusted based on the following formula:

$$w_{ij, t+1} = w_{ij, t} + \alpha(x_j - w_{ij, t})$$

At the end of the training process, the resulting Kohonen layer will contain the topological relations of the input data while performing a dimensionality reduction of the representation space.

The SOM network program has been developed in C++ language, an object oriented programming language. The network training for the experiments will be performed on a cluster of IBM RS/6000 mini-computers. Experiments will be conducted to test and compare the performance of the SOM networks with that of other clustering approaches, such as k-means analysis and kNN method. Performance will be assessed based on both the isolation of clusters and their internal homogeneity. The multivariate F statistic test for centroid equality will be used to determine the significance of the difference between cluster centroids. The overall quality of the internal homogeneity is measured by the weighted average of the within cluster centroid distance (C) and the dispersion (V). The variance, V, is the weighted average of the variances of all clusters within the design. The variance is the most commonly used measure of dispersion. Based on the same number of clusters, the lower values of C and V are preferred over higher values.

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