Condensed Review of SOM and LVQ Research in Japan

Heizo TOKUTAKA

Tottori University
Department of Electrical and Electronic Engineering
4-101 Koyama, Tottori 680, JAPAN
e-mail tokutaka@ele.tottori-u.ac.jp

Abstract

The trend of the publications of SOM and LVQ in Japan were searched using the information retrieval data base JICST. Our works of SOM and LVQ were introduced as two kinds of SOM classification problems, TSP (Traveling Salesman Problem) by SOM, and modified counter propagation used for weather forecast. SOM and LVQ are further used for many classification problems. SOM is becoming popular in Japan Society for Fuzzy Theory and Systems as the Fuzzy SOM and also in Japan Society of Civil Engineering. It is also summarized that SOM will become a powerful tool for chemical analysis problems.

1 Backgrounds

Thank you the Chair person, ladies and gentlemen. I am very honored to give a speech on SOM research in Japan. Professor T. Kohonen came to Japan many times and presented his lectures on SOM and LVQ in the usual conferences and also commercially set lecture courses. The contents of his lecture attracted many people and surely increased funs of SOM and LVQ . I was also attracted to SOM's world and read the Kohonen's 1st SOM book (Self-Organization and Associated Memory)[1]. While I was reading the original English version, soon, the translation by Professor K. Nakatani appeared. Also, while using the 1st SOM book, the 2nd English SOM book which is Self-Organization Maps[2] appeared in March '95. The 2nd book is closer to the engineering applications than the 1st one. I, therefore, decided to translate the book, since our research projects fully depend on SOM. Nowadays, I feel as if the 2nd book is our bible in our SOM research. With our whole group, we completed the translation into Japanese last June. In this January, the publisher told me that they had sold the first 1000 prints in 6 months. It is extraordinary that such a technically oriented book can be sold this much.

2 Information Retrieval for SOM and LVQ in Japan

Using the information retrieval JICST, I searched the articles of SOM and LVQ which had been published in Japanese from 1986. JICST is the abbreviation of JST, Information Center for Science and Technology, JST is the Japan Science and Technology Corporation. The trend of SOM and LVQ publications in each year is shown in Figure 1. Averagely the number gradually increases. Although there is a slight decrease after a major increase of the previous year. It shows probably that the research cycle needs a period longer than a year (eg 1.5 or 2 years). Since data was retrieved from the data base on 17th January '97, the number of publications in '96 is probably higher than the number indicated in Figure 1. Figure 2 shows the contents of the publications, which have been separated into SOM and LVQ. The publications of LVQ are far much larger than those of SOM. It is understood from Figure 2 that LVQ is mainly used in the fields of speech, character and pattern recognition in Japan. SOM is almost equally used in each field.

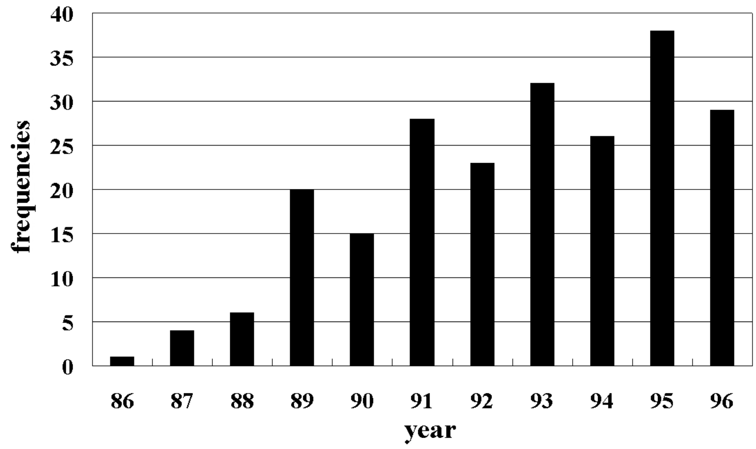

Figure 1: Trend of the number of SOM and LVQ reports in Japan in each year.

Quite a number of publications in Japanese appear in the Technical Report of IEICE which is the abbreviation of the Institute of Electronics, Information and Communication Engineers. Recently, Fuzzy-SOM also became active in Fuzzy Society in Japan.
Our group in Tottori university uses SOM and LVQ actively to any data which are obtainable. This is our research stance. K. Kurata of Osaka University is working in a similar stance, although his research is mainly focused in image analysis and function approximation, where he is concentrating more in the improvement of SOM and LVQ methods for the projects to be implemented.
CombNET-series (I and II) by Iwata et al [3,4] is one of the most successful and a large scale example of character recognition where SOM and LVQ are used. Several classification methods are also introduced by Kindo et al [5] and Terashima et al [6] of Olympus group, using the data whose distributions are unknown in the beginning.

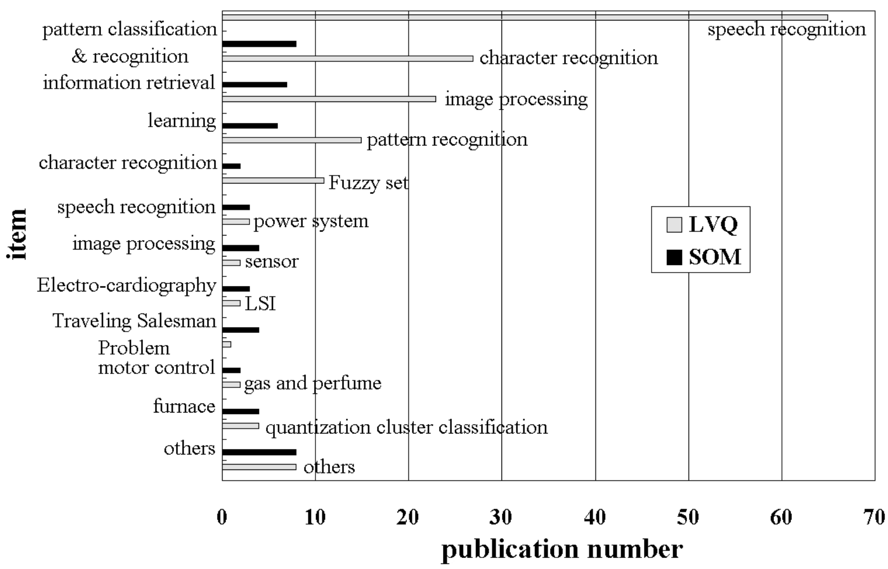

Figure 2: Application fields of SOM and LVQ which appeared in Japanese.

3 Works in Tottori University

3.1 SOM Classifications

3.1.1 Color Matching Problem in the Combination of 15 Buttons and Cloths

The apparel maker in Tottori where I live gave us one project. In the project, 15 buttons are prepared. When a suit cloth comes to the working line, the women workers select only one button among the 15 whose color matches the suit cloth. The manufacturer wants to make the working line run automatically without women workers' help. We applied Kohonen's SOM into this color matching problem[7]. The chromaticity of cloth's color is measured by the method based on CIE-Lab. Each distribution of fifteen buttons is represented and formed by three SOMs on each two dimensional projected plane of CIE-Lab space. From the observation of these SOMs, we confirm that each distribution of fifteen buttons has mutually overlapping regions. In this situation, we proposed a method of classification that has characteristics of ranking by adaptation in each button's SOM, and tested the performance of our method using practical data. From the results, we obtained over 87% correct judgment. Also our method and LVQ showed almost the same recognition rate for the best answer.

3.1.2 Searching the Sites Suitable for Power Generation by Terrestrial Heat

This is the problem which was brought by W. Shiraki of the civil engineering department of Tottori university. Since hot springs are very popular in Japan, it is expected to find the sites suitable for power generation by terrestrial heat. One of the big electric power companies in Japan has started searching for such sites using the data which are obtainable on the ground surface. Since the expenditure to dig only one well for the site costs usually over 100 million yen, the expected site for digging must be selected very carefully.

In the classification using SOM, it is important to build well ordered and classified maps. In those cases, ranks based on certain criterion are usually given to the input data. We must take account of not only classification but also ordering in the classified map domain itself. In classification, we often need to know the detailed ordering in some rank in the map. In this case, it is necessary to control the map domain and try to improve SOM quality, using the method called "Forced Representation in a Wanted Place on the Map".

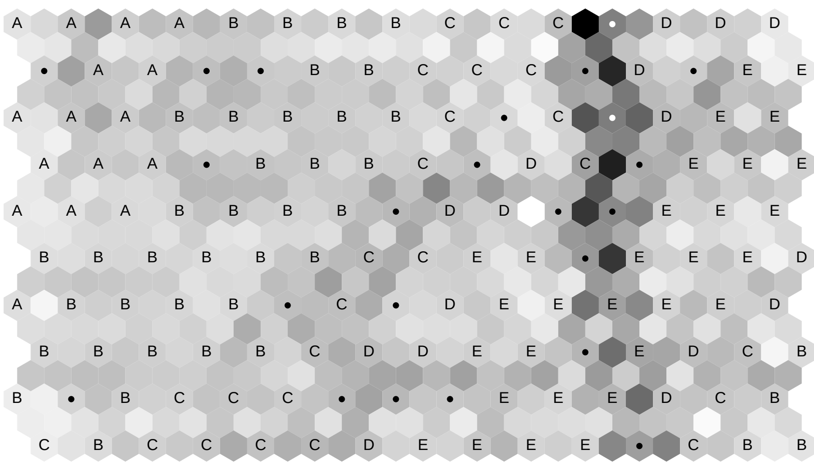

Figure 3: Forced SOM map of ranked expected sites for power generation by terrestrial heat where 5 typical sites from A to E are already located in the map in the beginning.

In this problem, there are 45 items such as geological features, gravity, resistivity, etc. Dimensions of maps are 15×10 and array of the map is hexagonal. Ranks are classified to 5 from A which is not expected, to E which is most expected place. The result is shown in Figure 3[8]. In the map, the distances between units are also calculated and colored as gray level. As shown in the figure, the results are well ordered from A to E. From the figure, it is very easy to find the quality of the ranks. Some of the E ranked positions are closer to D ranked ones. Some D ranks are closer to C ranks and so on.
W. Shiraki is the chairman of the sub-committee of the Japan Society of Civil Engineering which is using neurocomputing, Fuzzy inherence and also Genetic algorithm (GA) for civil engineering problems. In this committee, the methods of Back propagation and GA are very common. However, due to Shiraki's introduction, SOM method has become popular to such a civil engineering problem.

3.2 Traveling Salesman Problem (TSP) Analyzed by SOM

In the beginning, we were solving TSP by Hopfield method[9]. In the method, it often takes over 5 minutes to solve only 10 cities problem. Sometimes back, one of our students built up the algorithm to solve TSP by SOM method of Angeniol et al[10]. By this method, it became very easy to find the route of 10 cities, compared with the Hophield method[9]. GA method is also very powerful. However, the algorithm is not so simple. We are now concentrating in improving the Angeniol's SOM method. In the method, we were the first to introduce the momentum term β in the renewal coefficients[11]. We usually take the negative momentum value β. Then, the renewal coefficients decrease, when the number of nodes (units) increases during the search, and vice versa. Also, the coefficient of the momentum term β is found to be written as $\beta = \gamma/M$[12], where γ is a constant and M is the number of the cities. When the constant γ is fixed and β is defined as γ/M, the effects of the momentum term β to the time and the final distance of TSP in the search can be kept equal, even if the number of cities M is changed. We chose $\gamma = -0.2$. By using the value, we can reduce the time for searching the route by 1/5 compared with the case without the momentum term which is $\beta = 0$. In this case, the searched distance of the route is almost equal to the case of

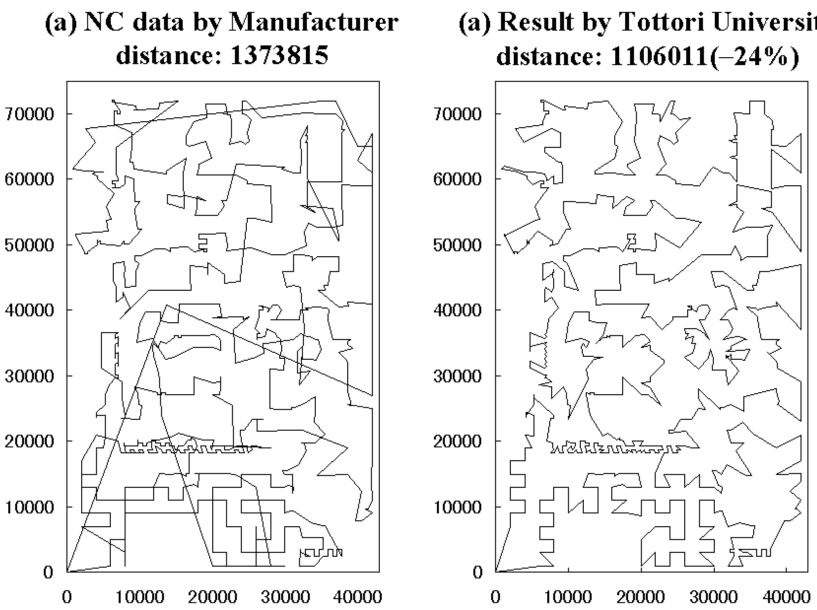

Figure 4: The routes of drill which makes 871 holes on a print board are searched by (a) Manufacturer and (b) Tottori University, using methods of SOM_TSP method.

$\beta = 0$. When the number of cities M is small, this term is not so effective. However, when M is larger like 500, 1,000, 10,000,..., the use of the relation of $\beta = \gamma/M$ is very useful to save the time of obtaining the sub-optimal answer.
We applied this method to the benchmark problem of USA 532 cities[12]. Our result is only 3% worse compared with the most optimized answer[13]. Our method is also applied to open 871 drill holes on the print board. Our result using SOM is shown in Figure 4 with the comparison of the manufacturer's. The manufacturer uses the software which is already contained in the drill NC machine, when it is purchased. The result by the manufacturer is 1.25 times longer than ours. As shown in Figure 4, our result is easily understood to be more compact and the route is shorter than the manufacturer. There, we can drill 500 print boards, while the manufacturer drills only 400 boards using the same time.

3.3 Modified Counter Propagation and its Applications

Fujimura et al of our group has modified Kohonen layer in the counter propagation from 1 dimension to 2 or 3 dimensions[14]. The system is suitable for the multi-classified problem by increasing the space resolution. The network was applied to the weather forecast problem in the winter of the Japan sea side in Japan. During the winter, the pacific ocean side has almost fine weather, whereas in the Japan sea side, it always changes rapidly from fine, cloudy, rain, snow, and/or shower. It depends on days as well as time. Therefore, the precise weather forecast is very difficult, but it is very important for the people who live there. The data of equal pressure heights on Yonago city are taken up to a height of $15km$. The city Yonago is $100km$ west from Tottori where I live. The weather and equal pressure height data contain daily changes of 3 months from January to March '95. As an example, the data of equal pressure height of January is shown in Figure 5. The input labels of weather display are shown by 3 continuous numbers as 233, 300, 324,... The meanings of right and left digit of these 3 continuous numbers are given as: 1-fine, 2-cloudy, 3-rain, and 4-snow. While meanings of middle digit are given as: zero-no change, 1-sometimes, 2-temporarily, and 3-later. As an example, 233 means that it is cloudy later on rain. 300 means that it is all day rain. 324 means that it is rain temporarily snow. And so on.... The weather of Tottori on the day appointed, the next day, 2 or 3 days later are forecasted using the previous one, 2 or 3 days data as indicated in Figure 5. All the forecasts using the previous 3 days data are always over 98% accurate.

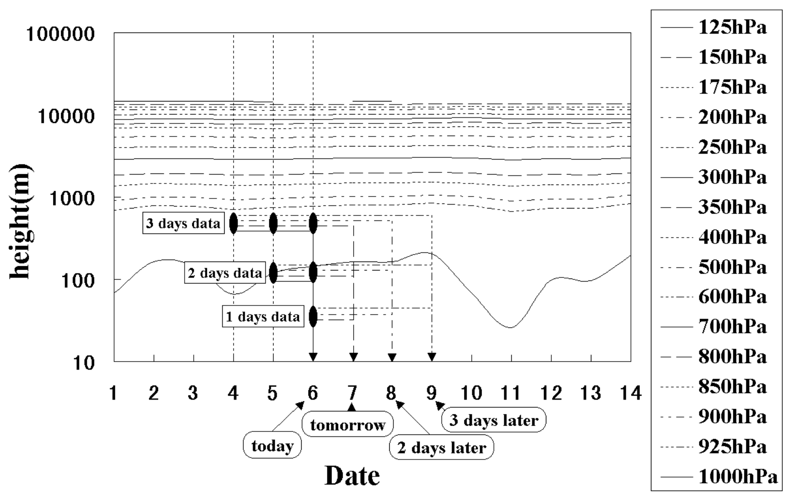

Figure 5: The daily trend of the equal pressure heights of January '95 on Yonago point, $100km$ west from Tottori, Japan where I live.

4 Classification Methods by SOM and LVQ

4.1 Complicated Hand Written Character Recognition by SOM and LVQ

Iwata et al [3] successfully introduced LVQ to their CombNET-I system in order to recognize Japanese Kanji characters. In the first stage of the system, LVQ is used in order to classify the input data broadly. In the LVQ, SOM is used for learning. Layered neural networks are used in the 2nd stage of the system. In the CombNET-II [4] which is the modification of CombNET-I, the neuron numbers become equally balanced after the broad classification of the first stage. Using the system, hand written alpha-neumeric and 1000 Japanese Kanji characters and over 6000 printed Japanese Kanji were successfully recognized.

4.2 Competitive Models for Unsupervised Clustering

Kindo et al [5] carried out unsupervised clustering by sequential learning using the data whose probabilistic distributions are unknown. They proposed competitive learning methods which decided the representative point of each cluster. There are three methods: (1) LVQ+MM, which combines LVQ and MAX_MIN distance method, (2) LBVQ (Learning Biased VQ) where learning results are shown clearly as representative point and (3) LBQ (Learning Bayesian Quantization) which uses a discrimination function for Baesian determination as a distance scale. After the numerical examinations of the above three models, LBQ was found to be best and the clustering boundary obtained became the Bayesian determination boundary.

4.3 Unsupervised Clustering Method using Data Density Histogram on SOM

Terashima et al [6] proposed a clustering method, which can be applied to data set whose cluster distribution is unknown. Using the neurons whose number is larger than the expected clustering number, SOM method is first carried out on the input data. Then, the histogram of data density on SOM is built in order to find the accumulation of the clustering. After that, the number of the clusters can be estimated using the boundary between the histograms where the mountain-like peaks and valley-like bottoms exist.

5 Fuzzy SOM (FSOM)

Miyoshi et al[15] are engaged in Fuzzy-SOM (FSOM) in Japan. By their recent article, they concluded that FSOM is more effective than other methods with feedforward neural networks like RBF and GA for adaptive rule extraction. Moreover, the shapes of the membership functions using FSOM were more adapted for data than those of other methods. Therefore, they conclude that extracted rules by FSOM can be easily understood and effective from the viewpoint of decision making.

6 Summary

SOM and LVQ in speech and image recognition are not only popular in Japan, but also in the whole world. SOM and LVQ are also now becoming popular in civil engineering and Fuzzy Society in Japan as shown in this article.
The other day, I demonstrated to the society of chemical analysis, some possibility of SOM in chemical analysis using the Table and the Figure whose ideas come from Table 3.4 and Fig. 3.22, respectively in SOM book by T. Kohonen[2]. People in the audience became very interested in

SOM and LVQ. After the meeting, K. Yoshihara of National Research Institute for Metals gave us XPS (X-ray Photoelectron Spectroscopy) data of Figure 6 of 15 materials and asked us to make SOM maps of these 15 materials with gray-level presentation. In Figure 6, all the data are taken from 20 to 1,000eV by 1eV step. These data are then averaged for each 10eV step. The number of each curve is reduced to 98 points which become to 98 dimensions. The groups of the materials are nicely separated as shown in the tentative result of Figure 7 using Forced SOM method which is described in 3.1.2. We think it is the start of the introduction of SOM and LVQ to the "Chemical Analysis" projects.
As you know, SOM and LVQ are the typical information processing technique which can be seen and observed by the eyes and applicable to any possible fields. We now anticipate to expand SOM and LVQ world in Japan more in future and endeavor to do it.

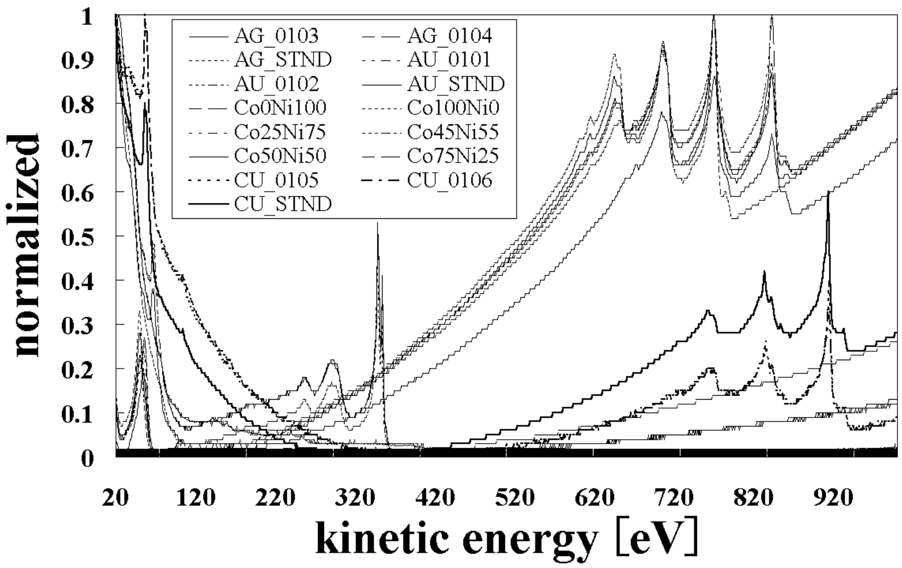

Figure 6: All XPS data of 15 materials from 20 to 1,000 eV, where STND is the abbreviation of standard.

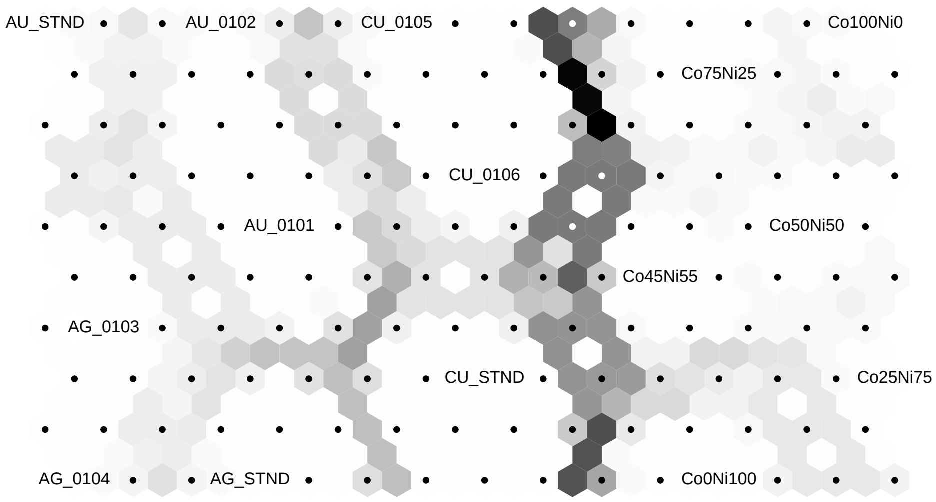

Figure 7: 2 dimensional Forced SOM map of 15 materials from XPS data of Figure 6.

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