Bio-inspired Self-Organizing Relationship Network as Knowledge Acquisition Tool and Fuzzy Inference Engine

Takeshi Yamakawa\textsuperscript{1,2} and Takanori Koga\textsuperscript{1}

\textsuperscript{1} Department of Brain Science and Engineering, Faculty of Life Science and Systems Engineering, Kyushu Institute of Technology, 2-4 Hibikino, Wakamatsu, Kitakyushu 808-0196, Japan
\textsuperscript{2} Fuzzy Logic Systems Institute (FLSI), 680-41 Kawazu, Iizuka, Fukuoka 820-0067, Japan
\{yamakawa, koga\}@brain.kyutech.ac.jp

Abstract. Since the SOM visualizes the similarity of raw information on the competitive layer, it can be utilized in the field of pattern classification, data analysis, and so on. However, it cannot model the input-output characteristics of the system of interest. In order to squeeze out the input-output relationship from the data set with evaluation obtained by trial and error, the novel modeling tool was developed by the author (1999), which is the extension of SOM and in which the input-output relationship of the system is mapped onto the competitive layer. The system is named as self-organizing relationship network (SOR network). A set of units on the competitive layer of the SOR network after learning exhibits a set of typical input-output characteristics of the system of interest and thus the network achieves the knowledge acquisition (IF-THEN rules) from the raw data with evaluation and the effective fuzzy inference with defuzzification. The plenary talk presents the tutorial aspects of the SOR network and an application to an intelligent control.

Keywords: self-organizing relationship (SOR) network, self-organizing maps (SOM), attractive/repulsive learning, knowledge acquisition, fuzzy IF-THEN rules, fuzzy inference, defuzzification, intelligent control.

1 Introduction

Synaptic junctions are tightly connected by passing through of the signals and the similar external signals activate the synaptic junctions located nearby. Thus the external complicated information can be mapped on the surface of the brain where the signals similar to each other activate the neurons or neuron populations located near by. For instance, somatosensory stimulus is mapped on the central groove of a brain and the map is widely known as “somatotopic map”\cite{1}. This feature of a brain was modeled by Teuvo Kohonen as Self-Organizing Maps in 1982 \cite{2}, \cite{3}, the number of papers related to this topics run to a huge amount and the world congress on SOM is held every other year.

The SOM has the architecture of one or two dimensional alignment of “units” on the competitive layer which are characterized by the so-called “reference vector”
constructed with the same number of elements to those of the input vectors. After the competitive learning with numerous input vectors, the reference vectors of units represent the quantized vectors of the input data. The SOM exhibits the following distinctive features;

(1) Vector quantization  
Reference vector distribution after learning approximates the distribution of input vectors.

(2) Topological mapping  
Reference vectors of neighboring units in the competitive layer are similar to each other.

(3) Visualization of similarities  
Multi-dimensional complicated vectors are mapped onto one-or two-dimensional space.

Since the Self-Organizing Maps (SOM) can statistically squeeze out the feature from an input data set, it can be applied to pattern classification, data analysis, and so on. Therefore it may be extended to summarize a large number of cause and results or input-output data set to obtain the know-how. If the know-how is obtained in the form of IF-THEN rules, inference can be preferably achieved. In order to achieve the knowledge acquisition and inference in the same system, the self-organizing relationship (SOR) network was proposed [4]. The SOR network preserves three features described above and facilitates the fuzzy inference with interpolation between the neighboring IF-THEN rules. The learning of SOR network is achieved with input-output pairs and their evaluations. The evaluation can be given by intuitively [5] or objectively [6].

This tutorial plenary talk presents the learning and execution modes of the SOR network and its application to back-up control of a trailer-truck.

2 Self-Organizing Relationship (SOR) Network

When we create the model of some real system or ideal system, we collect the input-output pairs by the trial-and-error method. Various input signals or actions are applied to the real system at random or by curiosity-driven trial, and the output signals are carefully watched and compared with the real system of interest and evaluated (Fig.1). In the ordinary modeling, the difference between the outputs of the real system and the model is fed back to change the characteristic parameters of the model. However in some cases, we often meet a case when the real system exhibits bad or dangerous reaction for the given input and the preferable model should be created. In order to meet this requirement the evaluation value can be negative as well as positive.

In the supervised learning system, a set of input-output pairs (teaching data) which exactly describes the system under consideration are necessary for the learning. However the teaching data can not be necessarily obtained. Even in this case, the input-output pairs by trial-and-error method and their evaluations are easily obtained, and thus employed as learning data for the SOR network.