On the Additional Learning by a Multi-Layer Hybrid Neural Network Model

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In this paper, a novel multi-layer hybrid neural network model is proposed. The author have named it the *Adaptive Category Unifying Network* (ACTUN). The model is able to learn patterns in additional manner and to unify the recognized categories to a class of categories.

Patterns that the Adaptive Resonance Theory(ART) can not classify are examined. Such a problem is called "subset problem" in this paper.

First, we deifne the meaning of the word to express a classisfied group. In many articles, the word "category", "cluster" and "class" are used as the words to express a classified group, and these words are not distinguished. In this paper, these three words are distiguished as follows,

1. category: a basic or a least classification units,
2. cluster: a set of several similar categories,
3. class: a set of several arbitrary categories.

The proposed architecture self-organizes and self-stabilizes a category corresponding to arbitrarily binary input patterns, and then unified to categories to a class given by teacher signals.

In general, a neural network that has already trained is difficult to learn additional new patterns. Because such learning causes a state change of the network which remembers the patterns learning before. Therefore, if the network is to be trained by new patterns, it must be trained by using all patterns, including trained at past, from the very beginning of training.

Neural networks can be classified roughly into two types: a supervised learning model and an unsupervised one.

Simple Perceptron, which is supervised learning neural network model, known well, can not classify the linearly unseparable patterns. On the other hand, competitive learning neural network model, which is unsupervised learning model, can classify arbitrary input patterns, but can not unify classified categories to a class of categories. A learning model, of which a classification measure is similarity such as Hamming distance, can not classify the linearly unseparable input patterns properly. That is, each category to which it is linerly unseparable patterns are classified means that it is not similar.

A combination of the features of these two learning model can derive new abilities which can categorize arbitrarily binary input patterns and can unify categories to a class. In other words, it classifies by the competitive learning model and unifies classified categories by the supervised learninig model.

The proposed architecture consists of two strata. The first stratum is the ART which performs classification of input patterns and the second one is a simple perceptron with plain Hebb's rule which unifies categories to a class. These are called A-stratum and P-stratum respectively. In particular, output layer of the ART is called "category representation layer" and output layer of the P-stratum is called " class representation layer". A category representation layer's output means a category, in which input patterns belong to, and an output of class representation means a class in which the categories belong to.

The behavior of this architecture can be divided into two phases: a categorizing phase and a category unifying phase. In the categorizing phase with the ART discriminates categories as fine as possible. The resolution of categorizing is adjusted by the vigilance parameter ρ. Usually a value of ρ is set to more than 0.8 at least. Then given categories are unified by P-stratum(category unifying phase).

The relation of the category and the class are following four cases according to a combination of new patterns and trained ones.

1. the same category and the same class.

2. the same category and the different class.

3. the different category and the same class.

4. the different category and the different class.

The first case, the third and the fourth one assure that link weights are not changed by learning the perceptron that eats output of the competitive learning. In other words, the modified link on the pathway by learning is independent each other.

However in the second case, it is including a problem that points are not in "general position" of the perceptron and subset problem of the ART. When such input patterns are presented to the architecture, in the P-stratum, a learning is not converged. However this problem about general position is not a defect of ACTUN, it is caused by categorizing failure in the A-stratum.

This occures when ρ is more smaller. Accordingly a value of ρ must be set on the high side in the architecture. For subset problem can be resolved or repaired to represent patterns which is caused a problem again.

The architecture is assured that a learning is converged if a value of the ρ is enough high.