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Multi Agents Classification System with Reliable Measure of Generalization

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Abstract

In this paper an efficient classification system using hierarchal multi_agent's technology based on neural network is introduced, where each agent implements as a neural network (trained using back propagation learning algorithm). The system consist of two layers of agents, the top layer contain one agent works as control agent, its responsibility is to select the right agent from the agents in the lower layer to classify the related pattern depending on data's features. Two techniques were used (regularization and earlier stopping criteria) to select the best one for each data set depending . The system provides a degree of generalization with the ability to improve it if there is a need for more generalization. The developed system was tested using different standard datasets obtained from the (University of California, Irvine) UCI Machine Learning Repository for the empirical analysis of machine learning algorithms. These are (User Knowledge Level, iris, and Banknote Authentication Dataset).

***Keywords*:** Multi-agent System (MAS); Neural Network (NN); Back Propagation (BP); Classification; Generalization.

1. Introduction

When agents interacts with each other within a single system, this is called multi_agent system (MAS), which is a branch of artificial intelligence (AI). Classification is one of the most often encountered decision making tasks of human action. A classification problem occurs when an entity needs to be assign into a predefined collection or class depend on a number of observed features associated to that entity and many problems in industry, science, business, and medicine can be treated as classification problems [1].

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The data classification tasks can be doing by using neural networks. Neural network is a collection of interconnected units that learn from their environment (data), to get essential nonlinear and linear trends in a data, so that it supply dependable predictions for new cases including even partial and noisy information [2]. Generalization is one of the most important concepts at any classification system; it is refer to estimating the value of correct outputs where there is no example [3].

In the developed system, there are multiple agents' implements as neural networks. These agents work together as a hierarchal multi-agent system to perform classification task on multiple datasets in optimal time and with some degree of generalization, it is adopted one of two techniques (regularization or earlier stopping criteria) depending on analysis the results obtained from experiments for each agent separately.

2. Multi agent systems

Agents are seldom stand-alone systems. In many situations they coexist and interact with other agents in several different ways. Multi-Agent Systems are becoming popular in the mainstream of development because an agent tries to process tasks intelligently and autonomously. To take advantage of autonomous control and decrease running costs. Multi-agent systems have become a chosen paradigm to model and solve real-world problems [4].

3. Artificial Neural Network

Artificial neural networks are systems for information processing that have certain computational properties similar to those which have been assuming for biological neural networks [5]. ANNs can learn where, they use knowledge to improve their performance. When exposed to an enough number of training patterns, ANNs can generalize to others they have not yet seen [6].

The architecture of NN can be of single layer or multilayer. In single layer Neural Network, only one input layer and one output layer is there, while in multilayer neural network, there can be one or more hidden layer [7]. The real power of a neural network comes from its pattern recognition capabilities. The neural network should be able to produce the desired output even if the input has been slightly distorted [8].

4. Learning and Generalization

Learning is a hyper surface reconstruction based on existing examples, while generalization means estimating the value on the hyper surface where there is no example. Mathematically, the learning process is a nonlinear curve-fitting process, while generalization is the interpolation and extrapolation of the input data.

The goal of training neural networks is not to learn an exact representation of the training data itself, but rather to build a statistical model of the process which generates the data. The generalization capability of a network is jointly determined by the size of the training pattern set, the complexity of the problem, and the architecture of the network. There are many techniques to improve and measure generalization such as generalization by stopping criterion and generalization by regularization [9].

5. The Developed System

The structure of the developed system is consisting of two hierarchal layers of agents as shown in figure (1). The neural network that represent each agent composed of three layers with z, c, and p nodes acts as input, output and hidden layer nodes where p can be computed using equation (1).

$$p = (z + c) / 2 \quad (1)$$

for the control agent, the number of nodes in input layer equal to the largest number of the dataset's features, while its output layer equal to the number of classification agents.

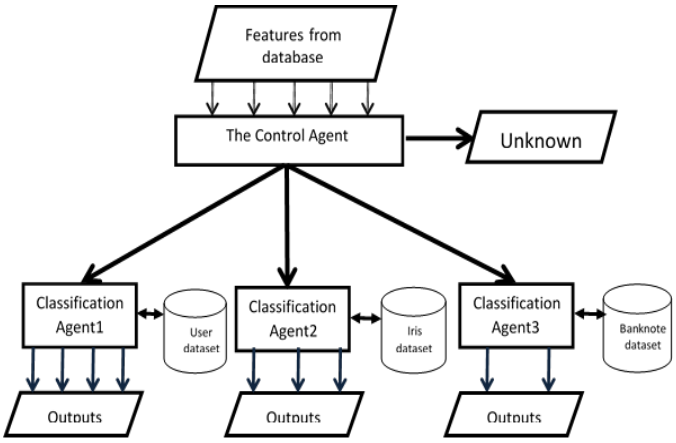

Figure 1: Show the general structure of developed system.

5.1 Train and test the system

Back propagation learning algorithm with pattern mode will be used to train each agent in the system; two techniques were used to estimate the generalization of the agents, and then picked the best one of them for each agent. The first one is generalization by earlier stopping criterion and the second one is generalization by regularization. Noises are added to estimate the generalization, the noise will be generated randomly and take range suitable to each dataset depending on nature of the data.

5.1.1 Generalization by Earlier Stopping Criteria

Each classification agent will be trained on 60% of dataset, 20% validation set, and 20% test set; Training should stop at the suitable stopping point according to the validation set error (The generalization error), then noise will added to test set to estimate the generalization.

5.1.2 Generalization by Regularization

Each classification agent will be trained on 80% of dataset and 20% test set. The cross validation selection model will be used to select the best training set and testing set, then the noise will be added to the selected test set to estimate the generalization of the system.

6. Experimental Results

6.1 Classification Agent1

This agent train and test on user knowledge level dataset, overall accuracy of testing classification agent1 by earlier stopping criteria is shown in table 1, the overall accuracy of testing classification agent1 by regularization technique is shown in table 2, the generalization was estimated to both techniques and the results were compared to select the best technique for agent1 as shown in Figure 5 and table 3, where each percent in table3 represents average of five experiments.

Table 1: Overall accuracy agent1 (earlier stopping criteria).

Number of patterns	Overall Accuracy	Error Rate
81	95.06% (77 patterns)	4.93% (4 patterns)

Table 2: Overall accuracy agent1 (regularization technique).

Number of patterns	Overall Accuracy	False rate
81	97.53 % (79 patterns)	2.47% (2 patterns)

Table 3: compare the generalization of earlier stopping criteria and regularization technique (agent1).

Noise range	earlier stopping criteria	regularization technique
0_0.03	92.60%	96.45%
0_0.05	91.36%	94.31%
0_0.07	86.42%	94.81%
0_0.09	83.95%	93.08%
0_0.1	85.20%	90.11%

This comparison demonstrates that the regularization technique is superior to earlier stopping criteria, where the generalization degree in regularization technique is larger than earlier stopping criteria at all amounts of noise. Presently the basic condition which is adopted to pick the best technique to build agent1 is the ability to

generalization and the results of analysis shown that the regularization technique by adding noise to enhance generalization is the best, as indicated by this investigation, regularization technique will be adopted for classifying agent1.

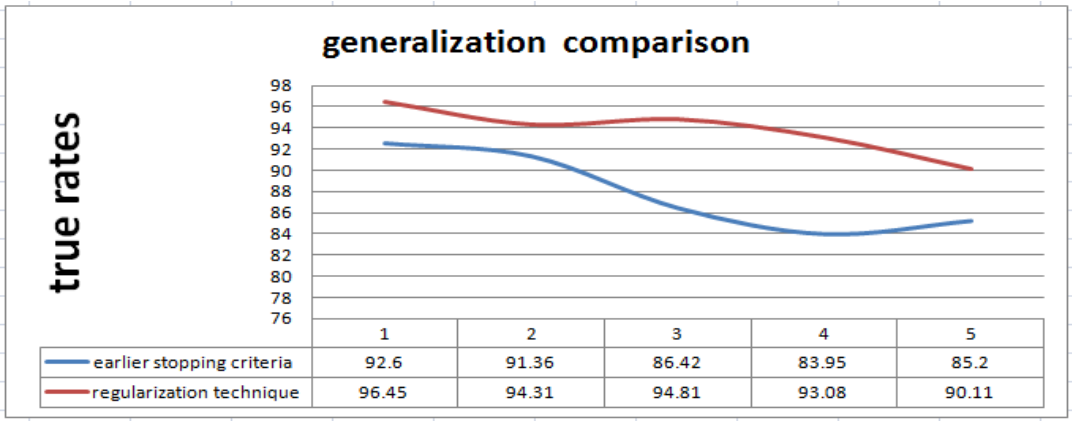

Figure 5: Comparison earlier stopping criteria and regularization technique (agent1).

6.2 Classification Agent2

This agent train and test on Iris dataset, overall accuracy of testing classification agent2 by earlier stopping criteria is shown in table 4, the overall accuracy of testing classification agent2 by regularization technique is shown in table 5, the generalization was estimated to both techniques and the results were compared to select the best technique for agent2 as shown in figure 6 and table 6, where each percent in table 6 represents average of five experiments.

Table 4: Overall accuracy agent2 (earlier stopping criteria).

Number of patterns	Accuracy	Error Rate
30	100% (30 patterns)	0.0% (0 patterns)

Table 5: Overall accuracy agent2 (regularization technique).

Number of patterns	Overall Accuracy	False rate
30	96.67 % (29 patterns)	3.33% (1patterns)

Table 6: compare the generalization of earlier stopping criteria and regularization technique (agent2).

Noise range	earlier stopping criteria	regularization technique
0.05_0.1	100%	96.66%
0.05_0.2	99.33%	95.33%
0.05_0.3	97.34%	95.99%
0.05_0.4	92.60%	93.33%
0.05_0.5	92.60%	89.32%

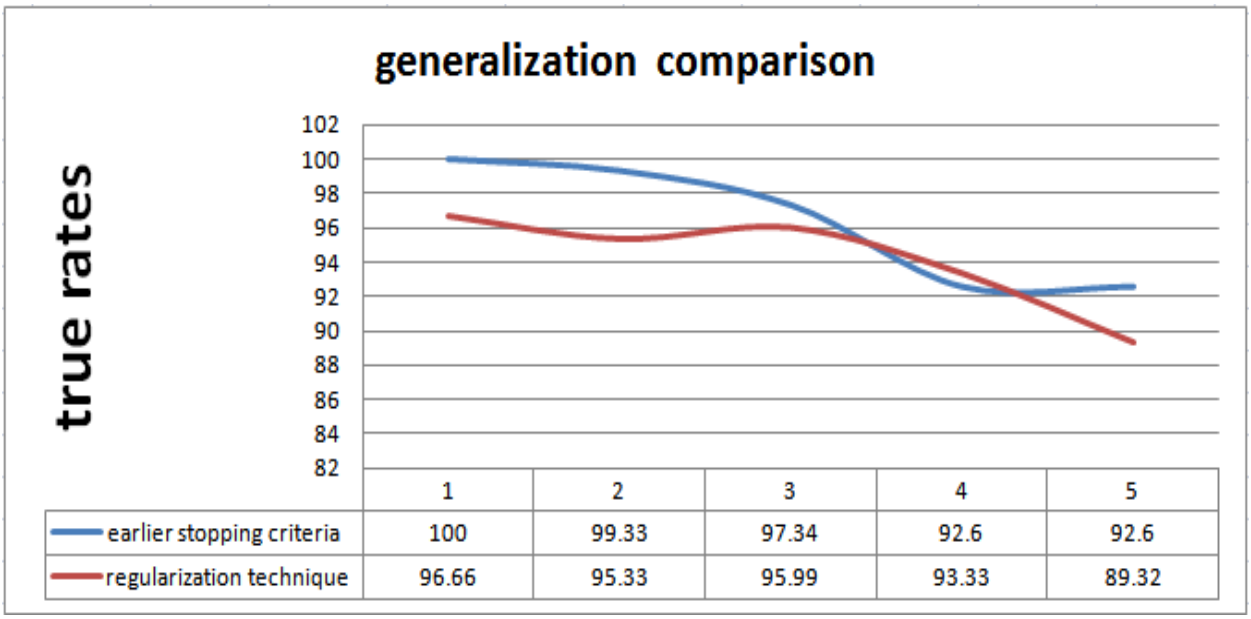

Figure 6: Comparison earlier stopping criteria and regularization technique (agent2).

This comparison demonstrate that the earlier stopping criteria technique is superior to regularization, where the generalization degree in regularization technique is less than earlier stopping criteria at most amounts of noise, this critical condition is adopted to pick the best technique to construct agent2. As indicated by this investigation, earlier stopping criteria technique will be adopted for classifying agent2.

7. Classification Agent3

This agent train and test on banknote authentication dataset, overall accuracy of testing classification agent3 by earlier stopping criteria is shown in table 7, the overall accuracy of testing classification agent3 by regularization technique is shown in table 8, the generalization was estimated to both techniques and the results were compared to select the best technique for agent3 as shown in figure 7 and table 9, where each percent in table 9 represents average of five experiments.

Table 7: Overall accuracy agent3 (earlier stopping criteria).

Number of patterns	Accuracy	Error Rate
274	100% (274 patterns)	0.0% (0 patterns)

Table 8: Overall accuracy agent3 (regularization technique).

Number of patterns	Overall Accuracy	False rate
274	98.91 %(271 patterns)	1.09 % (3 patterns)

Table 9: compare the generalization of earlier stopping criteria and regularization technique(agent3).

Noise range	earlier stopping criteria	Adding noise
0.05_0.1	100%	99.04%
0.05_0.2	99.63%	98.90%
0.05_0.3	98.68%	98.39%
0.05_0.4	97.95%	97.29%
0.05_0.5	95.25%	94.67%

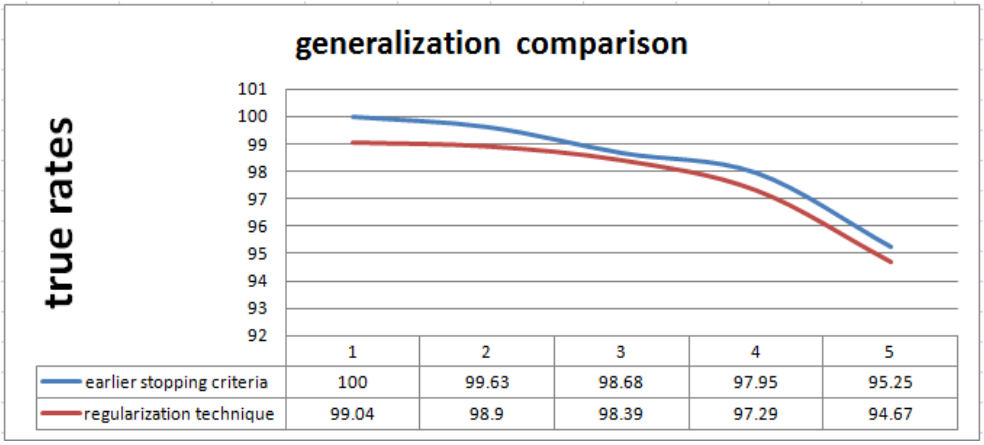

Figure 7: Comparison earlier stopping criteria and regularization technique (agent3).

This comparison shown that the earlier stopping criteria technique is better than regularization, where the

generalization degree in regularization technique is less than earlier stopping criteria at all amounts of noise, Now critical condition which adopt to choose the best technique to build the agent is the capability to generalization and the results of analysis above shown that the earlier stopping criteria technique is better one, according to this analysis will adopted this technique to build classification agent3.

8. The control agent

The results above are shown the best training sets of each agent, these sets will be taken as training set to the control agent as shown in table 10, while test sets of all agents and validation set of (agent2 and agent3) are represent test set of control agent as shown in table 11. The results in table 10 and 11 shown that the control agent give 100% accuracy for each training and testing sets.

Table 10: control agent's training.

Number of patterns	1235
accuracy	100% (1235 patterns)
error rate	0% (0 pattern)
iterations	162
time	3.166805s
Net error	0.00498

Table 11: Overall accuracy of control agent.

Number of patterns	689
True rate	100% (689 patterns)
False rate	0% (0 patterns)

9. Conclusion

This paper attempts to improve the efficiency of a classification system by using a hierarchal multi_agent's technology based on neural network, where each agent implements as a neural network (trained using back propagation learning algorithm). The system consist of two layers of agents, the top layer contain one agent works as control agent, its responsibility is to select the right agent from the agents in the lower layer to classify the related pattern depending on data's features, it classifies a collection of datasets effectively with some degree of generalization, when the pattern is belong to the one of datasets, the system reduces the time to (m + n), where m is the time in control agent, n is the execution time of selected agent. If the pattern is not belonging to the datasets the system will declare it as unknown pattern and it reduces the time to m only. Two techniques

were used (regularization or earlier stopping criteria) to select the best one for each data set depending. The system provides a degree of generalization with the ability to improve it if there is a need for more generalization. The developed system was tested using different standard datasets obtained from the (University of California, Irvine) UCI Machine Learning Repository for the empirical analysis of machine learning algorithms. These are (User Knowledge Level, iris, and Banknote Authentication Dataset).

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