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ARTIFICIAL LEARNING CLASSIFIERS WITH THE POTENTIAL FUNCTIONS. AN APPROACH OF THE GENERAL CASE

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Abstract: One of the most important applications of the neural networks is in statistical classification theory. In the specialized literature are procedures which use the artificial process of intelligent machines learning [5]. The Potential Functions Method for two classes is one of them. This paper presents an extension of Potential Functions Method. Our procedure is suitable for the general case when the data set has many classes. We start from the classical method for $n = 2$ classes and then we provide a procedure for $n \geq 3$.

Key Words: neural network, classification, potential functions

1. Introduction

The powerful learning and the adaptation capability made the neural networks to be very useful. There are many fields, such as decision-making, image processing, insurance, classification and so, that use the neural networks procedures [2, 3, 4].

The Potential Function (P.F.) Method is one of the methods used for training the artificial learning classifiers. The objective is to find the rules which establish a certain class for a new object. For this aim the procedure works on a learning set $x^1, x^2, \ldots, x^p$, where

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$$x^i = (\ x_1^i, \quad x_2^i, \quad \dots \quad x_d^i\ ), \qquad x^i \in R^d .$$

These data are structured in $A_1, A_2, ..., A_n$ linear separable classes, $A_i \in R^d$.

The learning sequence is $(x^n)_{n>0}$, where each vector is taken infinite times.

The following section is a brief description of Potential Method for two classes. We introduce the basic notation and principles related to this procedure. In Section 3 we offer an extension of the two classes case to the n classes case and finally we make some conclusions and suggest few directions for further research in this domain.

2. Learning Rule with the Potential Method for Two Classes. Notations and Definitions

Definition 1. In physics, a potential function $K : R^d \to R$ which associates each point x with the potential in it where this potential is generated by the unit of charge placed in x^0 is:

$$K(x) = \frac{q}{4\pi\epsilon_0 ||x - x^0||} .$$

Definition 2. Generally, a potential function $K : R^d \times R^d \to R$ is:

$$K(x, x^k) = \frac{c}{||x - x^k||} ,$$

where c is a constant.

Definition 3. The potential function generated by p charges $K : R^d \to R$ is:

$$K(x) = \sum_{k=1}^{p} q_k K(x, x^k) ,$$

where q_k is the charge placed in x^k.

The potential learning method for two classes A_1, A_2 and for learning set $x^1, \quad x^2, \quad \dots \quad x^p$ uses a potential function as decision function:

$$g(x) = K(x) .$$

In each points which are in A_1 is placed a positive unit charge and in each points which are in A_2 is placed a negative one. The electric potential of class A_1 is positive and the potential of class A_2 is negative.

The P.F. procedure starts with a decision function $K(x)$ then the vectors of learning set are treated one by one.

This method is a training method based on error correction. The potential is corrected by modifying the value of q_j in case of incorrect classification for the object x^j. If x^j is in A_1 set and it is incorrect classified in A_2 then the potential is increased by adding one unit of charge to q_j. If x^j is in A_2 and is incorrect classified in A_1 then the potential is decreased by taking a unit of charge from q_j. In case of a correct classification the potential remain unmodified.

Dumutrescu [1] described the previous procedure in the following algorithm:

$$K_{k+1}(x) = \begin{cases} K_k(x) + K(x, x^{k+1},) & \text{if} \quad x^{k+1} \in A_1 \quad \text{and} \quad K_k(x^{k+1}) \leq 0, \\ K_k(x) - K(x, x^{k+1}), & \text{if} \quad x^{k+1} \in A_2 \quad \text{and} \quad K_k(x^{k+1}) \geq 0, \\ K_k(x), & \text{if} \quad x^{k+1} \in A_1 \quad \text{and} \quad K_k(x^{k+1}) > 0, \\ & \text{or} \quad \text{if} \quad x^{k+1} \in A_2 \quad \text{and} \quad K_k(x^{k+1}) < 0\,. \end{cases}$$

3. An Algorithm which Uses the Potential Method for n Classes

Let $A_1, A_2, ..., A_n$ classes, with $n \geq 3$ and $x^1, \quad x^2, \quad \ldots \quad x^p$ the learning set. In this case we have n decision functions which must be founded:

$$g_{ik} : R^d \to R\,, \qquad i = 1, ..., n\,,$$

and k denote the procedure stage.

The decision functions will be the potential functions:

$$g_{ik} = K_k^i.$$

For the general case when the classes number is bigger then two, we give the following rule for change the decision functions. So, we obtain a sequence which converge to the optimal decision functions.

Let $q_1, q_2, ..., q_p$ the charges placed at random in $x^1, x^2, ..., x^p$, then:

$$K_{k+1}^r(x) = \begin{cases} K_k^i(x) + K(x, x^{k+1},) & \text{if} \;\; r = i \text{ and } K_k^i(x^{k+1}) \leq K_k^j(x^{k+1}), \\ K_k^j(x) - K(x, x^{k+1}), & \text{if} \;\; r = j \text{ and } K_k^i(x^{k+1}) \geq K_k^j(x^{k+1}), \\ K_k^t(x), & \text{if } r = t, \; t \neq i, j, \; K_k^i(x^{k+1}) > K_k^t(x^{k+1}), \\ & t = 1, ..., n. \end{cases}$$

where K_{k+1}^i is the i-th class potential at the k-stage and x^k is the learning vector presented at the k-stage.

4. Conclusions and Possible Future Directions

The purpose of this paper is to give a Potential Functions procedure for general case. Thus we will dispose of a new procedure for artificial learning classifiers. In practical classification application this method may be compared with the existent methods or may replaces one of them.

The P.F. method for n classes can be helpfully when the learning set R^2 has a small number of elements or when the space has a small dimension.

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