Neural Network Application for External Telephone Network Management

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Abstract

This paper presents neural network application useful for external telephone network management. When a new telephone connection is needed the computer locates the required area from the digital map. A quick program search traces the perimeter of the blocks and finds the potential connections in the area. Here a hybrid program which combines a 3-level back-propagation, an orientation estimator, logical decision rules, and a set of orientated masks which trace the perimeter of the block. A second program search identifies the distribution box with a pair of free cables by using the perimeter tracer and after locating the customer's house, the computer quickly finds the best connection. This work has been tested in a Latin American city without rigid urban planning. The developed method allows one to quickly trace the perimeter to find the best telephone connection, even when there are many perimeter irregularities in the neighborhood.

Keywords: Intelligent Systems, Image Processing, Neural Network, Back-propagation Multi-Layer Perceptron, External Telephone Network Management

1. Introduction

In order to find the best connection in an external telephone network, the method presented in this article uses digitized map processing, recognition of patterns using neural networks[1], an orientation estimator, logical decision rules, and a set of orientated masks.

The method traces the perimeter of the blocks, using a set of reconigtion patterns to detect the perimeter image of the different blocks, using a neural network back-propagation.

The order of this paper is: in section 2, a summary is made about external telephone network management. In section 3, the structure of the neural back-propagation multi-layer perceptron network is described. In section 4, the algorithm for finding the best telephone connection is described. In section 5, contains the conclusions and recommendations of the work.

2. Computer Aided External Telephone Network Management

Nowadays the management aided by computers is indispensable for the efficient control of the telephone networks

For such purpose, the Telephone Administration System (TAS) which permits one to integrally run and control an external telephone network has been developed. In this way, the system will establish itself as a utility tool for the technicians in charge of the external plant. The external maintenance plant which is made up of engineers and technicians, will be able to consult the TAS about the tasks and/or problems which occur in the telephone network, and the answers provided by the system will help in carrying out the tasks and solving the problems with greater efficiency and speed, rendering, in such way, a better service to the users. Once the system is functioning, it should be continually fed with the information about the changes which are being carried out in the external network, in this way, the system is permanently up to date.

To carry out the management of an external network, one should know the location and the size of the network, also all the information should be stored and sorted out in the computer by means of maps. The maps should show us the layout of the telephone network, the number of primary cables and their influence areas, also the detailed secondary network plans in the areas. The secondary network maps per area detail the location of the blocks and the distribution boxes which contain the twin cable telephone connections for their assignment to the subscribers. All the maps are digitized and stored in the computer. The maps with a wider access frequency belong to the districts.

Among the tasks of greater importance in the telephone network management, we can include: installation of new subscribers, changes of subscribers from one district to another, elimination of subscribers, follow-up of network faults, etc.

The tasks related to the assignment of twin cable telephone connections, and subscriber moves make up the application part of the neural network for the external telephone network management.

The objective of this system is to render a high quality service to the users, and the cost reduction in the laying down of the subscriber's lines, considering the best connection according to the minimum distance between the distribution box and the subscriber.

3. Neural Network Perceptron

The perceptron was developed by Rosenblatt [2]. and is the first neural network that has been shown. This perceptron uses the artificial neuron concept McCulloch and Pitts. Each neuron processes the present input by means of a correlation function. The result passes on to be evaluated by a non-linear transference function. The perceptron presents a forward moving process and can extend itself by means of multiple levels.

Every second level neuron combines the input with its respective connection weight and subtracts the given fixed threshold value. This value is made up of a parameter for the transference function, in the case of the perceptron, the transference function is a binary type, see figure 1(a) and 1(b).

The function of the perceptron is very simple. It starts by presenting a pattern at the input level, this can have *n* neurons, therefore there is a *n* longitude vector in the input.

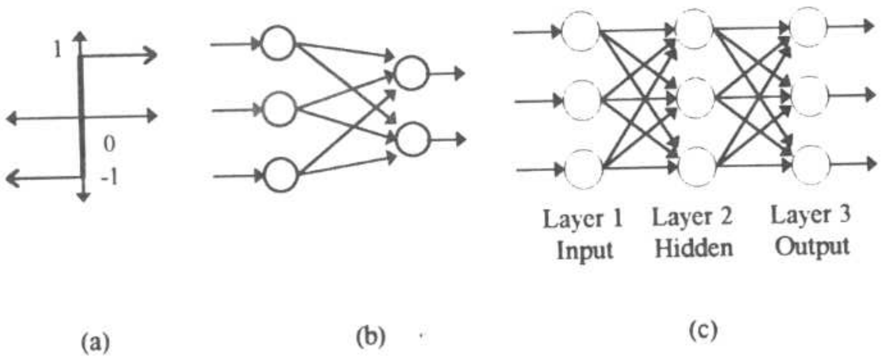


Fig. 1. a) Transference function, b) perceptron structure, c) BMLP.

The neuron activation at the second level can be expressed in the following way.

$$O_{activ} = f\left(\sum_{i=0}^{n} w_{ji}\, x_i - \theta_j \right)$$

Where: O_{activ} is the activation of the jth neuron at the second level.
f is the transference function.
w_{ji} is the weight of the connection between the ith neuron at the input level and the jth neuron at the second level.
x_i is the input of the neuron at the second level.
θ_j is the threshold value of the jth neuron at the second level.

The perceptron employs a supervised learning. There is a previous neural network training, using definite patterns. This data should be good examples so that the network learns.

The neural network Back-propagation Multi-Layer Perceptron (BMLP) is probably one of the most well-known and widely used networks, this network includes a hidden level, see figure 1(c). Rumelhart, Williams and Parker developed an extension of the delta rule which is called the rule of learning with backward propagation error. In fact, this neural network is a perceptron with a differing transference function. It is very strong and with great learning capacity. The rule propagation error has supervised learning which spreads the output error backwards from the output level up to the input level [3]. Among the applications which are taken into account for the BMLP neural network are: recognition of patterns, signal filtering, noise removal, signal/image segmentation, classification, mapping, adaptive control, data compression, etc.

4. Algorithm for finding the best telephone connection

The use of artificial intelligence techniques, like the neural network, allows us to process the image patterns and to extract the perimeter of the blocks for finding the best connections. Very satisfactory results have been obtained; demonstrating a practical and realistic application of the neural network in the management of telephone systems.

In order to trace the perimeter of the blocks, the program needs to know the location of the subscriber's house in the block. This location establishes the initial reference point to carry out the tracing. The first five points can be found by using the basic masks until the first binary model, which will feed the BMLP neural network for its processing, is obtained. With the active binary model pixels, the orientation estimator computes the contour orientation angle with the slopes which form the adjacent active pixels. With the response of the neural network and the orientation angle, the logical rules will look for the next pixel of the block's perimeter, if the logical rules don't find this pixel, one again resorts to the basic masks. The pixel which is found will form part of the new binary windows, discarding the window's previous first pixel. The program will continue searching until it returns to the initial reference point, indicating that the perimeter has been completely traced.

The BMLP neural network, enables the extraction of perimeter characteristics of the blocks, using a number of patterns and/or models which are appropriate for carrying out this task. Thus, when analyzing images of the block's perimeter regardless of their size and shape, we can find the shortest distance between the customer's house and the distribution box. In order to carry out the extraction of the block's perimeter, we have used the BMLP neural network with the following structure, see figure 2.

The input level has 25 neurons, one neuron for each pixel of the binary window. The hidden level contains 80 neurons, this number guarantees an acceptable learning in the process of the neural network training. The network output level contains 20 neurons, this number is determined by the amount of training models that have been used.

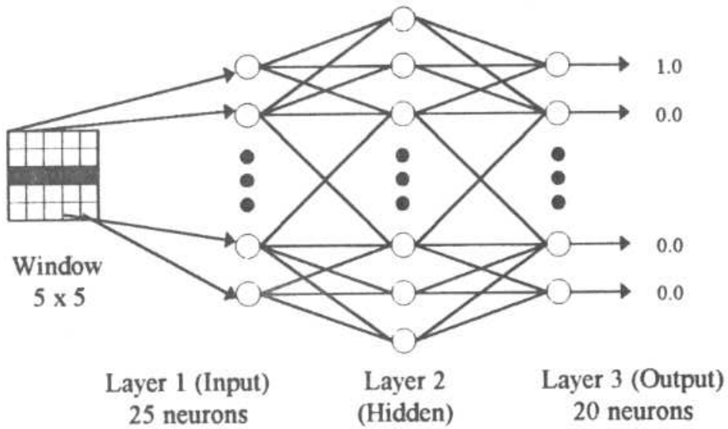


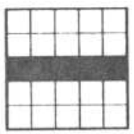
Fig. 2. BMLP neural network structure that was used

The BMLP neural network is used in two modes: training and recall.

In the training mode the neural network learns how to recognize the perimeter images by means of a set of models and/or patterns established by geometrical forms. The number of these patterns is 20, each one of them represented by a binary 5 x 5 window, each element of the window is one pixel wide and each pixel is represented by "1" when it is active and "0" when it is inactive, see figure 3 and 4.

$p_0\,p_1\,p_2\,p_3\,p_4$
$p_5\,p_6\,p_7\,p_8\,p_9$
$p_{10}\,p_{11}\,p_{12}\,p_{13}\,p_{14}$
$p_{15}\,p_{16}\,p_{17}\,p_{18}\,p_{19}$
$p_{20}\,p_{21}\,p_{22}\,p_{23}\,p_{24}$

p_i = pixels



Model based on geometrical

0	0	0	0	0
0	0	0	0	0
1	1	1	1	1
0	0	0	0	0
0	0	0	0	0

Binary representation

Fig. 3. Window of 5 x 5 pixels, binary model

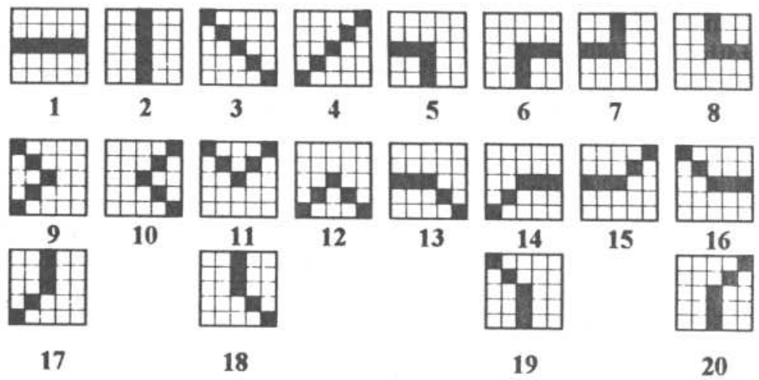
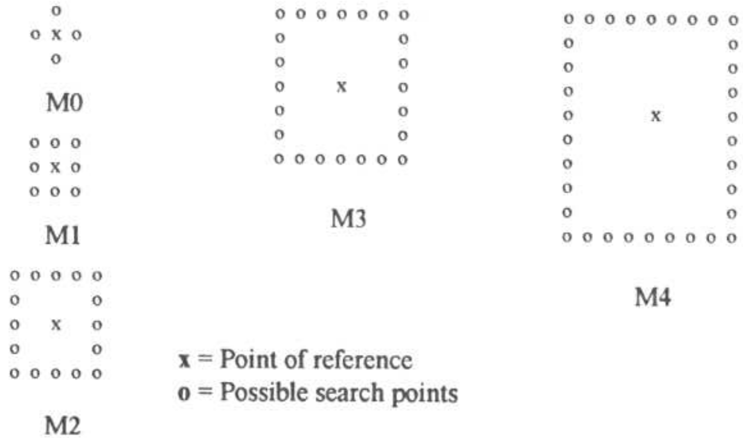
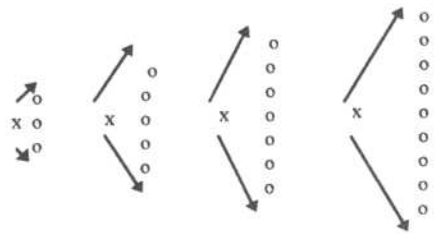


Fig. 4. The set of training models for the BMLP neural network



x = Point of reference
o = Possible search points

Fig. 5. Basic Bidimensional Masks for pixel searching



Pixel search on the "east" side of the reference point. There are 15 more masks in other search directions
x = Point of reference
o = Possible search points

Fig. 6. Oriented Bidimensional Mask for pixel search

The angle of image orientation is obtained through a simple orientation estimator.

$$\alpha_o = \frac{\sum_{i=(n+1)/2}^{n} \alpha_i}{(n-1)/2}$$

where:

- n represents the size of the window, $n=5$
- α_i angle between adjacent points
- α_o orientation angle of the image in the 5 x 5 window

In the recall mode, the neural network processes the image patterns which show up at the input level, for the classification of the pattern, the highest value of the output neurons is selected.

In a hybrid program which combines the 3-level BMLP neural network, an orientation estimator, logical decision rules and a set of oriented masks enables one to continue the tracing of any block's perimeter. The distribution boxes that are on the houses are located by this program, and the customer's house is identified in the block, then the computer will quickly find the best connection. The details of the algorithm are given belongs:

Stage 1.- The program is started with the initial point of reference. From this point on, the perimeter of the block will be followed. In order to find the following point of the block's perimeter the basic masks are used M0, M1, M2, M3, M4, see figure 5, the search starts in the 4 adjacent pixels using mask M0, if this pixel can't be found, one reverts to mask M1, and in this way, successively until M4; if there is a greater distance than 4 pixels between adjacent points of the block's perimeter, then it is considered to be a mistake in the tracing of the block. The search continues until the completion of the first 5 points which enables one to form the binary model in the 5 x 5 window, only when you have the first binary model, may you feed the BMLP neural network, with this image.

Stage 2.- The given image in a 5 x 5 pixel window will be presented in the input of the BMLP neural network, the network processes the present information in the neurons at the input level and, as a result of this process, a response is obtained in the neurons at the output level. This is interpreted as a response of the network to the maximum value in one of the neurons of the output level.

Stage 3.- The orientation estimator computes the contour orientation angle using the slopes of the pixels within the 5 x 5 window.

Stage 4.- With the information given by the neural network and the orientation estimator, we proceed to use a set of logical rules which will enable us to find the next pixel that belongs to the perimeter of the block, this point is found by making use of orientated masks, see figure 6; take note that a minimum number of bits are used here for the search. In the case that the next pixel is not found, which may

happen because of the sudden change in the shape of the block, one resorts to using the basic masks until the next pixel is found.

Stage 5.- Once the pixel is found, it becomes part of a new 5 x 5 pixel window, discarding the first pixel, which means the next window was moved one pixel, with this new image you return to stage 1 and repeat the process.

5. Conclusion

This application of the neural network enables the best connection between a distribution box, which contains free twin telephone cables, and the customer's house which are in the same block in the area, to be accomplished.

The work is carried out by means of tracing the perimeter of the block, regardless of its shape and size.

This application was tested by tracing the more complex irregular perimeters which occur in real situations, obtaining the same results.

6. Acknowledgments

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