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NEURALNET 2005: EDUCATION COMPUTER SYSTEM SUPPORTING THE USE OF ARTIFICIAL NEURAL NETWORKS IN AGRICULTURE

Summary

The purpose of this project was to develop an interactive computer application pursuant to software engineering standards that would support education in the field of constructing and operating selected artificial neural network topologies. The project is designed to investigate selected problems having to do with the generation and operation of perceptron and radial network and help to present the networks' operating principles as classification instruments in a case of identifying flower varieties for practical purposes.

NEURALNET 2005: KOMPUTEROWY SYSTEM EDUKACYJNY WSPOMAGAJĄCY PROCES WYKORZYSTANIA SZTUCZNYCH SIECI NEURONOWYCH W ROLNICTWIE

Streszczenie

Celem pracy było wytworzenie, zgodnie ze standardami inżynierii oprogramowania, interaktywnej aplikacji komputerowej, wspomagającej proces edukacyjny w zakresie konstrukcji oraz eksploatacji wybranych topologii sztucznych sieci neuronowych w kontekście wykorzystania ich w rolnictwie. Ma ona przybliżyć wybrane zagadnienia z zakresu generowania i eksploatacji sieci typu perceptron i sieci radialnej oraz praktycznie zaprezentować zasadę działania tych sieci jako narzędzi klasyfikacyjnych na przykładzie zadania identyfikacji odmian kwiatów.
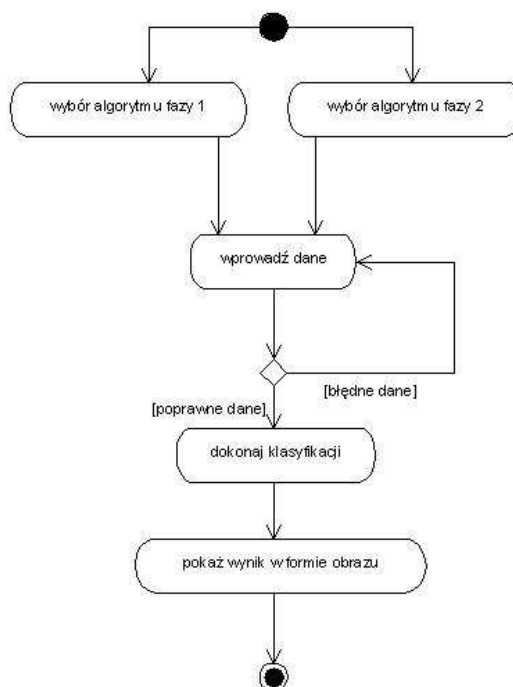
Introduction

Noticeably in recent years, neural networks have found a growing number of applications in the general field of agriculture. Promising results have been generated in attempts to use artificial neural networks for the classification, prediction, identification and recognition of images. These were then applied to design expert systems supporting decision-making processes for many sectors of agriculture. As a consequence, agricultural machines and equipment emerged that do not require human supervision. The purpose of this paper was to develop an interactive computer application in line with software engineering standards that would support education in the areas of the construction and operation of key artificial neural network topologies. The idea was to conduct a closer investigation of selected *perceptron* and radial network challenges and find a practical way to present the principle behind the operation of such networks. The program is expected to help to introduce potential users into the field of artificial neural networks by, among other things, presenting the most popular algorithms used at the stage of network learning.

Technology employed to develop *NeuralNET 2005* applications

The first stage in the development of the IT system was to define application specifications. Clear objectives were identified, the scope of work was defined and a preliminary description of the program was presented. At design stages, diagrams were produced with the use of the *Posejdon* for *UML* program to prepare a more detailed description of the system's implementation. *Borland C++ Builder v.6* was selected from among a multitude of available programming tools. A code simulating the operation of neural networks was generated with the use of *Statistical Neural Networks v.6.0* software. With the help of a code generator, the resulting C language code was fine-tuned to fit the *Borland C++ Builder v.6* programming environment. The next step was to build the *NeuralNET 2005* IT system relying on such a code as a basis for the resulting application. The application was tested for both the generated code and upon the construction of its individual modules.

Fig. 1. Activity diagram for neural networks type *multilayer perceptron (MLP)*

Description of the *NeuralNET 2005* IT system

Codes simulating the operation of artificial neural networks were generated by means of *Statistica Neural Networks v.6.0* modules and by means of a C code generator embedded in the *Statistica* package. All of the networks learned with the use of orris learning set made up of three orris species: *setosa, virginic* and *versicolor* collected and described by *Fisher* (1936), the first researcher to tackle the problem of orris classification. Based on research material made up of 150 flower specimens representing three orris categories, Fisher sought to develop a method of distinguishing each of the three categories from the remaining two. Each of the flowers was described in terms of four attributes:

1. sepal length,
2. sepal width,
3. petal length,
4. and petal width.

The perceptron networks were comprised of four input-input layers, a hidden 10-unit layer and an output 3-neuron layer producing one response. Phase one incorporated 100 areas, phase two: 500. Entropy was used to classify the error function. In the algorithms of back and fast propagation of errors, the learning speed coefficient was set at 0.1.
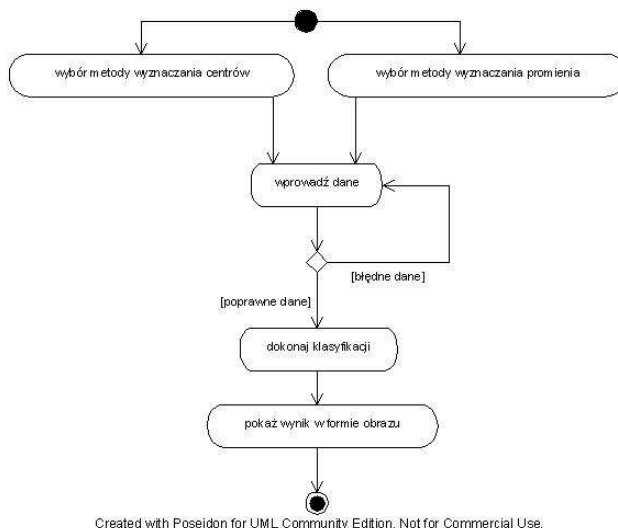

Fig. 2. Activity diagram for neural networks type *Radial Basic Function (RBF)*

In their hidden layer, radial type networks held 8 neurons. The classification of error function was also carried out with the use of entropy.

The resulting networks had the following characteristics showed in table 1.

Table 1. Features of generated neural networks learning by a combination of methods and algorithms

Network type	Algorithms used in learning	Quality of learning	Quality of validation	Learning error	Validation error
MLP	*BP-BP*	0.973684	0.918919	0.194796	0.356116
MLP	*BP-FP*	1.000000	0.945946	0.041189	0.276641
MLP	*BP-GS*	0.960526	1.000000	0.231350	0.036083
MLP	*FP-BP*	0.986842	1.000000	0.143987	0.081848
MLP	*FP-FP*	0.973684	0.918919	0.259964	0.332766
MLP	*FP-GS*	0.973684	0.945946	0.224705	0.251427
MLP	*GS-BP*	1.000000	0.918919	0.160771	0.298451
MLP	*GS-FP*	0.763158	0.621622	0.545352	0.632984
MLP	*GS-GS*	0.960526	0.945946	0.347597	0.348281
RBF	*LOS-RD*	1.000000	0.891892	0.086952	0.674311
RBF	*LOS-IZ*	0.973684	0.945946	0.199117	0.243707
RBF	*LOS-KN*	0.921053	0.972973	0.322624	0.280369
RBF	*KS-RD*	0.973684	0.837838	0.237046	0.219635
RBF	*KS-IZ*	0.960526	0.891892	0.277391	0.482038
RBF	*KS-KN*	0.947368	0.945946	0.374097	0.364427

where:

MLP denotes *perceptron*-type network,
RBF denotes radial-type network,
BP denotes back propagation algorithm,
FP denotes fast propagation algorithm,
GS denotes conjugate gradients,
LOS denotes random selection of centers,
KS denotes k-averages,
KN denotes k of the nearest neighbors,
RD denotes manual selection by users, radius equal 1,
IZ denotes isotropic scaling equal 1.

As can be seen, the best general results are offered by *perceptron* type networks which learned based on the fast error propagation algorithm in phase one and algorithm back error propagation algorithm in phase two.

The initial phase of using *NeuralNET 2005* applications is that of installation. The program's default installation directory is C:\Program Files*NeuralNET 2005* (the target directory can be changed during installation). Once the application is launched, the main form opens with information about the program. The form offers the following options:

- *MLP,*
- *RBF,*
- POMOC (HELP),
- AUTOR (AUTHOR),
- WYJŚCIE Z PROGRAMU (EXIT - power sign icon).

One can also return to the window during program operation by clicking on the AUTOR button on the main form.

A click on the *MLP* button activates a *perceptron* neural network form. The form contains four data entry windows (secured against letter entry as only numerical characters are accepted) to be used to classify orris flowers. These are:

- sepal length,
- sepal width,
- petal length,
- and petal width.

In order to classify the flowers, classification methods need to be selected before or after data entry. The following algorithms are available in both phases:

- back propagation of errors,
- fast propagation of errors,
- conjugate gradients.

The classification is possible upon the selection of algorithms and entry of all correct data. The result is an image of an orris flower.

The *RBF* form is designed identically as the *perceptron* network form. The only difference lies in the choice of other algorithms for the classification method.

Available at the center identification phase are:

- The k-avera*ge*s method,
- Radial sampling.

While at the radius (deviation) identification phase:

- The k closest neighbors method,
- Manual assigning of radius value equal 1,
- Isotropic determination of the radius, scaling equal 1.

At each stage of using the *NeuralNET 2005* application, it is possible to access the help file by pressing the POMOC (HELP) button in the main form. Once the option is selected, the help window opens which contains:

- program user's manual,
- information on radial and perceptron networks,
- a description of algorithms used in the *NeuralNET 2005* software.

The system main window is represented in figure 3.

Non-functional requirements

The system offers a simple and intuitive interface allowing the user a way to master its functionalities fast. It allows one to conduct classifications with the use of networks learning by means of various algorithms or methods. The system requirements needed for smooth operation are:

- PC running a Windows® operating system,
- at least 64MB RAM,
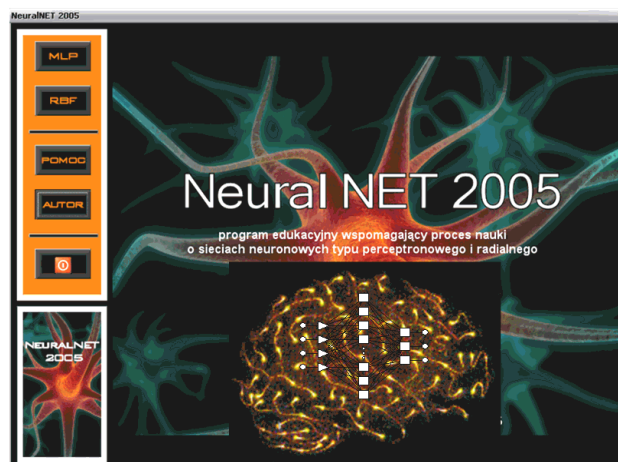- monitor resolution of at least 800x600 pixels.

Fig. 3. Application main window

Help on the operation of each form can be accessed at any time by clicking on the question mark in the upper left corner of the form.
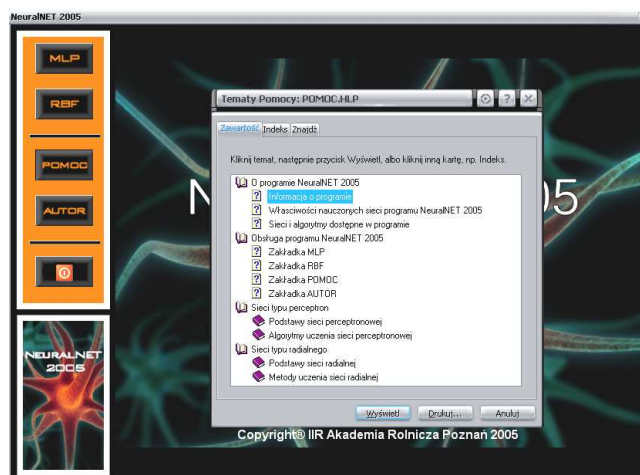

Fig. 4. Help window

Conclusions

The above discussion on the use of *MLP* and *RBF* neural networks as a classification instrument suggests that:
1. Artificial neural networks find a growing number of applications in agriculture. Ever more software applications are developed that rely on artificial neural network (classification systems, prediction systems, decision support systems, etc.). Many of them (such as *NutMan* and *EXSEL*) have been applied successfully for years with excellent results.
2. The *NeuralNET 2005* application meets the requirements put to educational tools. Its simple intuitive user interface and help facility effectively support users seeking to learn about the practical operation of artificial neural network such as multilayer *perceptrons* (*MLP*) and radial (*RBF*) types.

3. Most projects relying on artificial neural networks attempt to automate agricultural processes and reduce the need for human involvement in strenuous and painstaking agro-technical jobs (such as crop monitoring).Neural decision-support systems serving the general needs of agriculture are ever more extensive and, in effect, more effective. Such systems are not limited to a single area of agricultural pursuits. They are becoming an increasingly more important part of operation in the farms where production is highly automated.

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