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INTELLIGENT PICTURE RECOGNITION SYSTEM AS A BITMAP AND CONVERSION INTO VECTORIAL DRAWINGS

SYSTEM INTELIGENTNEGO ROZPOZNAWANIA OBRAZÓW W POSTACI MAP BITOWYCH I ICH KONWERSJA DO EDYTOWANIA PLIKÓW WEKTOROWYCH

Abstract

The tasks realized thanks to computer systems are very complex and difficult. First steps made in the area of picture analysis and recognition were undertaken in the 1960s. They are directly connected with development of artificial neural networks as well as expansion of computer systems and graphic interfaces. The present report deals with picture analysis and recognition, recognition of technical drawings and their conversion into a vectorial form. An algorithm of intelligent picture recognition has been worked out, which could be used in design offices, at universities, in offices and in industrial institutions successfully, where plans and technical documents are kept in paper form. Work is continued to improve the algorithm.

Keywords: *image analysis*, *neural networks*, *image recognition*, *conversion*, *bitmap*

Streszczenie

Duży wpływ na ciągłą rozbudowę komputerowych systemów rozpoznawania obrazu miała i wciąż ma szybkość obliczeń dzisiejszych komputerów. Niniejszy artykuł podejmuje szczególny przypadek analizy i rozpoznawania obrazu, czyli rozpoznawanie rysunków technicznych oraz ich konwersję do formatu obrazu zapisanego w formie wektorowej. Algorytm inteligentnego rozpoznawania obrazów można z powodzeniem wykorzystywać wszędzie tam, gdzie przechowywane są plany, dokumentacje techniczne oraz projekty w formie papierowej. Algorytm jest wciąż ulepszany i usprawniany, jednak na obecnym etapie pozwala w zadowalający sposób przeprowadzić rozpoznanie prostych rysunków technicznych.

Słowa kluczowe: *analiza obrazu*, *sieci neuronowe*, *rozpoznawanie obrazu*, *konwersja*, *bitmapa*

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1. Introduction

The tasks realized thanks to picture analysis computer systems are very complex and difficult [1]. Picture analysis and Picture recognition are most often used in computer systems like OMR (*Optical Mark Recognition*) [2]. OCR (*Optical Character Recognition*) systems are the most developed trend in picture recognition.

First steps in this field were undertaken in the 1960s. They are directly connected with development of artificial neuronal networks as well as expansion of computer systems and graphic interfaces. Continuous expansion of picture recognition systems has been affected by the speed of calculations of nowadays computers. This report deals with a special case of picture analyses and recognition, recognition of technical drawings and their conversion to a vectorial form.

2. List of picture recognition algorithms

Picture recognition algorithms and technical drawings conversion algorithms are divided into:

1) direct deduction depends on information about pictures without any internal representation of picture,
2) indirect deduction, picture is converted to special intermediate form (e.g. characteristic vector).

Examples of direct deduction:

3) neural networks,
4) some algebraic solutions (e.g. SVD – *Singular Value Decomposition*, that is matrix decomposition to singular values [4]),
5) some SVM applications (*Support Vector Machines*).

The main advantage of direct deduction is simplicity of performance. Disadvantages are restricted usage (small pictures and simple objects).

Examples of indirect deduction:

6) characteristic vector,
7) object and characteristics list,
8) graph of adjacent area.

The primary features of indirect deduction are module recognition mechanism construction, considerably higher labour consumption necessary to execute recognition, and often problems with adequate picture representation selection.

The report presents system, which connects direct and also indirect methods of picture recognition.

3. Description of the operation of the proposed picture recognition algorithm

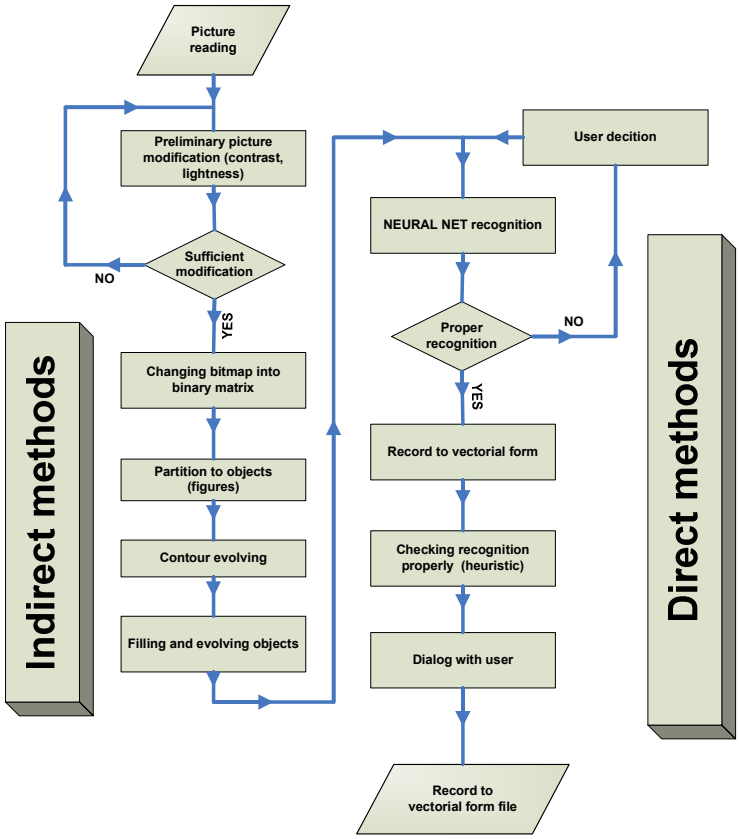

Fig. 1. Block diagram of picture recognition algorithm
Rys. 1. Schemat blokowy algorytmu rozpoznawania obrazów

3.1. Conversion bitmap into binary matrix representation

The proposed picture recognition algorithm uses both direct and indirect recognitions methods.

The file is read as a bitmap, then it is preliminarily modified to eliminate and remove all distorts and noises which arise during picture scanning.

The next step is to change the bitmap into *binary matrix*, every pixel RGB 0,0,0 (black colour) value is represented by *1*, while pixels RGB = (255,255,255) values are represented by 0. This process is shown in Fig. 2.

The next stages are based on binary matrix processing. It is very significant and useful simplification, especially for programmers, who implement the program.

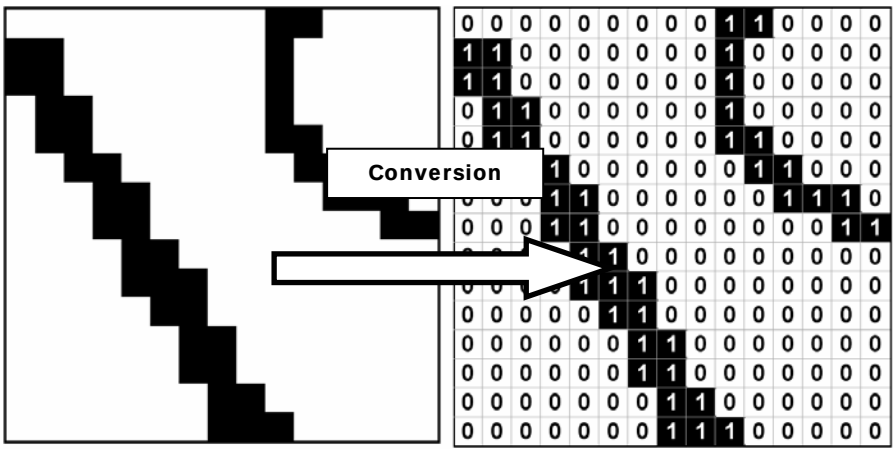

Fig. 2. Conversion of bitmap into binary matrix
Rys. 2. Przekształcenie mapy bitowej w macierz binarną

3.2. Contour recognition and partitioning

The next stage in object recognition in the drawing process is partitioning the contours and evolving objects which have common points. The fundamental point of recognition is evolving objects which are contained in other objects. This stage is shown in Fig. 3.

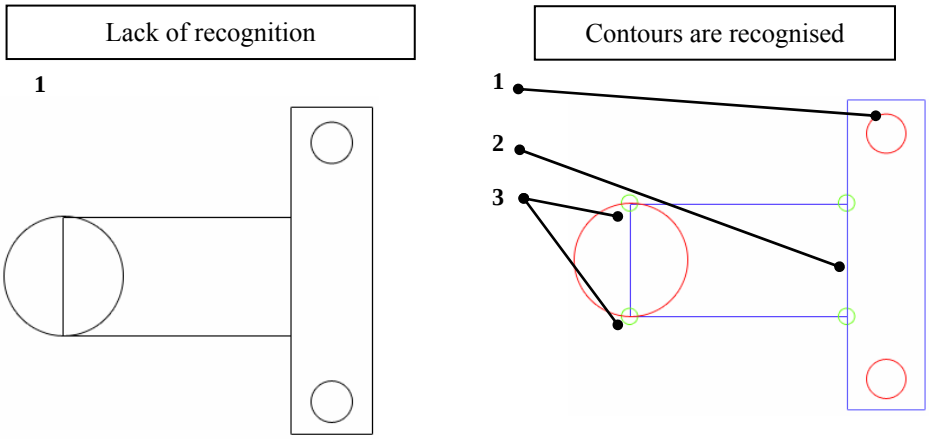

Fig. 3. Recognition of individual contours with common points marked for at least two different figures: 1 – object closed in other object, 2 – common edge for two objects, 3 – common points for two different figures
Rys. 3. Rozpoznanie poszczególnych konturów z zaznaczeniem punktów wspólnych dla co najmniej dwóch różnych figur: 1 – obiekt zamknięty w innym obiekcie, 2 – krawędź wspólna dla dwóch obiektów, 3 – punkty wspólne dla dwóch różnych obiektów

Each of the evolved objects is recognised and classified by an artificial neural network.

3.3. Application of neural network in decision process

The structure and functioning of neural networks enables a wide range of applications. In case of picture analysis and recognition neural nets are the most effective solution for direct deduction [3]. An additional advantage is the correct recognition even at a low resolution rate. Neural networks with special heuristics are found in many experiments [5]. As mentioned before, resolution is not a very big problem for neural nets, which is shown in Fig. 4. However, higher resolution of picture conversion improves the effects and makes the program faster and more precise.

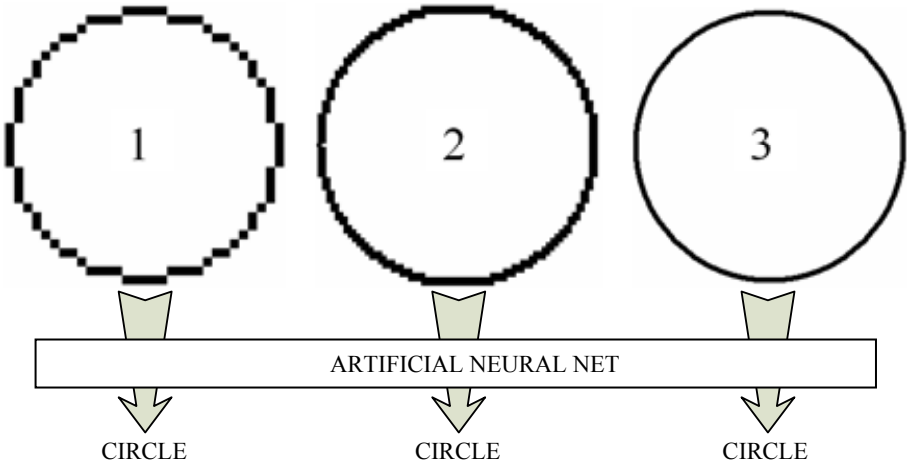

Fig. 4. Circle representations for different solution values: 1 – 10 dpi, 2 – 40 dpi, 3 – 200 dpi, are classified as the same object

Rys. 4. Reprezentacje okręgu dla różnych wartości rozdzielczości skanowanego obrazka: 1 – rodzielczość 10 dpi, 2 – rodzielczość 40 dpi, 3 – rozdzielczość 200 dpi, zostają tak samo sklasyfikowane przez sieć neuronową

Every recognised object can be represented by mathematical equations [6]

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \tag{1}$$

$$ax + b = y \tag{2}$$

$$W(X) = a_n X^n + a_{n-1} X^{n-1} + \ldots + a_1 X^1 + a_0 X^0 \tag{3}$$

(1) ellipse

(2) straight line

(3) polynomial equation (n is a natural number)

The final step is to choose suitable factors for every recognized object.
In case of straight line a formula is written

$$y = ax + b$$

where *a* and *b* are unknown factors. Two different points from the line are sufficient to determine *a* and *b* factors. The system of equations helps to determine those factors and *de facto* ends the recognition process.

3.4. Checking figure recognition correctness

The last fully autonomic process made by the program is checking the correctness of recognition for individual picture elements [7].

The program chooses randomly a few points from the original picture for every figure, and checks if those points are solutions for equations assigned to the figure.

If the verification process shows any errors, the checked object will be returned to the neural net and recognized again. Those steps are made only two times. This condition prevents program's kink.

3.5. Dialog with user

Obviously errors will appear. For now it is impossible to eliminate all mistakes. The dialog-with-user module helps to correct all mistakes and distortions. The user can best decide which objects are in the picture, so the user has always the last word to say. The user is asked about:

1) correctness of object classification (ellipse, straight line, line described by polynomial equation),
2) figure measurement,
3) figure location,

and he answers *YES*, *NO* or *I DON'T KNOW*.

The proper answers make program operation more effective and in future it will help to improve program recognition.

When the whole drawing is recognized and equations are appointed for every object (except the alphanumeric signs and parts of dimensioning) all that left to do is to find a reference point and carry out all dimensions to one unit. The program asks the user about the dimensions of every object, every edge and every angle. It is shown in Fig. 5. When the user feeds proper dimensions, all dimensions are recalculated and updated in actual time.

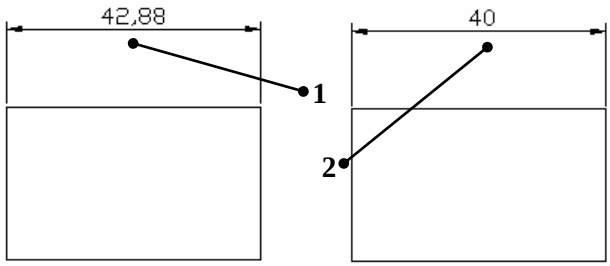

Fig. 5. Correction of dimensions: 1 – dimension recognized by program, 2 – user correction

Rys. 5. Korekcja wymiaru: 1 – wymiar rozpoznany przez program, 2 – korekcja użytkownika

4. Recognised figures are written to metafile

The final stage assembles writing equations describing figures as metadata, easy in interpretation and also easy to convert to popular vectorial files formats e.g. *dwg* (*AutoCAD*). XML is the most universal format to write metadata. XML – *eXtensible Markup Language* designed by *World Wide Web Consortium* is a language to create other languages. It makes extremely easy conversion to almost every known file format possible.

Data obtained in recognition process are written as a raw XML file, which is shown in Fig. 6.

```
<elipsa>
nazwa=elipsa_1;
a=3;
b=5;
center_point=(103,88);
</elipsa>

<prosta>
nazwa=prosta_1;
a=1;
b=0;
start_point=(-8,8);
end_point=(30,30);
</prosta>
```

Fig. 6. XML file shows figure equations
Rys. 6. Fragment pliku XML wraz z zapisanymi równaniami figur

XML's simplicity enables quick picture reconstruction in many programs which maintain vectorial drawings.

5. Program practical applications

The algorithm can be successfully used in design offices, at universities and industrial plants, in many places where technical documentation, old plans and projects are stored as paper documents. To redraw the whole plan the designer has to devote a lot of time and effort. The program makes the same work faster and all corrections can be made during dialog with the user.

6. Conclusion

The article shows a universal algorithm for pictures, plans as well as technical drawings recognition and conversion to XLM files. All the operation steps were shown and described. Work is continued to still improve the program.

References

[1] Tadeusiewicz R., Korohoda P., *Komputerowa analiza i przetwarzanie obrazów*, Wydawnictwo Fundacji Postępu Telekomunikacji, Kraków 1997.
[2] Tadeusiewicz R., Flasiński M., *Rozpoznawanie obrazów*, PWN, Warszawa 1991.
[3] Tadeusiewicz R., *Sieci Neuronowe*, Akademicka Oficyna Wyd. RM, Warszawa 1993.
[4] Cortes C., Vapnik V., *Support-Vector Networks*, Support vector networks, Machine Learning, 20, 1995, 273-297.
[5] Osowski S., *Sieci neuronowe w ujęciu algorytmicznym*, wyd. 2, WNT, Warszawa 1996.
[6] Wojnar L., *Image analysis. Applications In Materials engineering*, CRC Press, 1998.
[7] http://www-idss.cs.put.poznan.pl/~krawiec/ro/.
[8] http://ptsn.pcz.czest.pl/ Polskie Towarzystwo Sieci Neuronowych.
[9] http://abc.img-pan.krakow.pl/pracownicy/obara/index_pl.php.