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TOPOLOGICAL IMAGE PROCESSING FOR COMPREHENSIVE DEFECT AND DEVIATION ANALYSIS USING ADAPTIVE BINARISATION

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ABSTRACT

PCB topology image processing is an important component of Industry 4.0, as images can be used for automated quality control and visual inspection of manufacturing processes related to PCB production. Image processing can be used to control the quality of printed circuit boards, for example, to detect defects that may be invisible to the human eye.

The main objective of the study is to improve the method of adaptive binarization for images obtained by technical vision systems by developing an automatic algorithm for detecting the required value of the image binarization window. To achievethis goal, it was decided to develop an algorithm for automatically finding the size of the scanning area in adaptive binarization for processing technological images of the SOE topology.
Keywords: Process image processing, Adaptive binarization, Otsu method, GP topology, Finding "Block size".

1. INTRODUCTION

Industry 4.0 is based on advanced research in the fields of artificial intelligence, robotics, cloud computing, additive technologies, etc., the synthesis of which has allowed to improve production processes. The most important area of concept development within Industry 4.0 is the development of new approaches and tools for cyber-physical production systems (CPPS) [1–3]. The peculiarity of the CPPS application is the synthesis of the physical and cybernetic worlds into a single information eco-space, which allows creating very flexible reconfigurable production lines [4]. One of the promising areas of application of CPPS is their implementation in the production of high-tech electronic products and improvement of technical vision systems.

PCB topology image processing is an important component of Industry 4.0, as images can be used for automated quality control and visual inspection of manufacturing processes related to PCB production. The main applications of PCB topology image processing in Industry 4.0 are as follows [5]:

- quality control. Image processing can be used to control the quality of printed circuit boards, for example,

to detect defects that may be invisible to the human eye. Image processing software can automatically recognize defects, such as damaged traces, short circuits, missing parts, and others, and notify operators of their presence.

- visual inspection. Image processing can be used for real-time visual inspection of printed circuit boards. It can help ensure product accuracy and quality during production [6].

- process monitoring. Image processing can be used to monitor PCB manufacturing processes. It can help track equipment movement, monitor temperature and other parameters of the production process.

- automatic topology recognition. Image processing can be used to automatically recognize the topology of printed circuit boards [9]. This can help in the automated process of mounting electronic components on printed circuit boards.

- virtual reality: Image processing can be used to create a virtual model.

Image binarization is the process of converting an image with graded hues into an image where each pixel can only be white or black. Different methods can be used to binarize an image [7 - 8]. One of the simplest methods is global processing, when a threshold value is set, and all pixels with a hue above the threshold are considered white, and those with a hue below the threshold are considered black. This method is applicable to images with high contrast. Optimization methods use statistical approaches to determine the threshold, such as the "Otsu" method, which automatically determines the threshold to maximize the inter-class dispersion between pixels with different hues.

There are also methods that use machine learning algorithms to solve the image binarization problem, such as neural networks. These methods can be useful for binarizing complex images with a high degree of detail.

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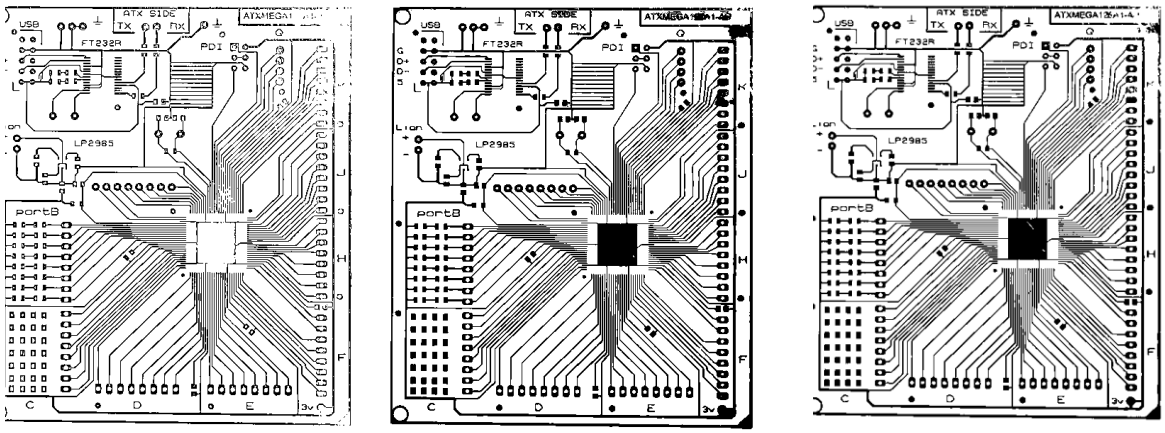
2. DEVELOPMENT OF A METHOD FOR FINDING "BLOCK SIZE" IN ADAPTIVE BINARIZATION

Adaptive binarization is a method of image binarization in which the binarization threshold changes depending on the local average pixel value in the neighbourhood of each pixel. Adaptive binarization is done by calculating the local average pixel value in a certain neighbourhood "Block size". Around each pixel, and then the threshold value is selected depending on (Figure 1) Example of a 3×3 "Block size" area this average value. If the pixel value is greater than.



a) b) c)

a) the threshold value of "Block size" is 23;
b) the threshold value of "Block size" is 423;
c) automatic finding of the value of "Block size"

Figure 1. - An example of finding the "Block size" area using the proposed algorithm

Depending on the complexity of the image, it is necessary to select its own "Block size" values, which takes time during processing. Therefore, the development of an automated method for finding the "Block size" value for different images with different types of elements is an urgent task. The "Block size" should always be an odd number to scan images with an arbitrary size. To automatically select the "Block size" values, the following algorithm was built:

– find the global binarization threshold (t) using the Otsu method;

– binarize the image and find the standard deviation (σ);

– if the obtained value is even, subtract one, if the value is not even, leave it as it is, and substitute this value in the search for "Block size" Figure. 2.

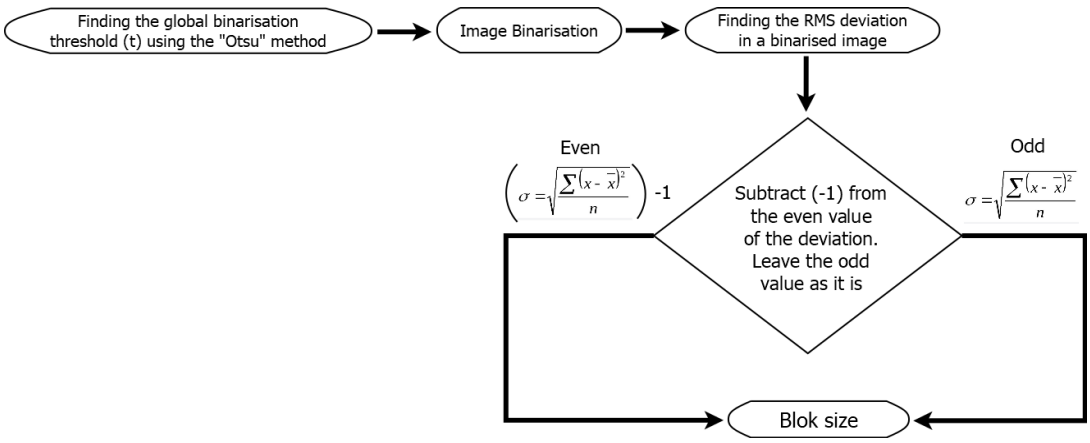


Figure 2.- Algorithm for finding the automatic value of "Block size"

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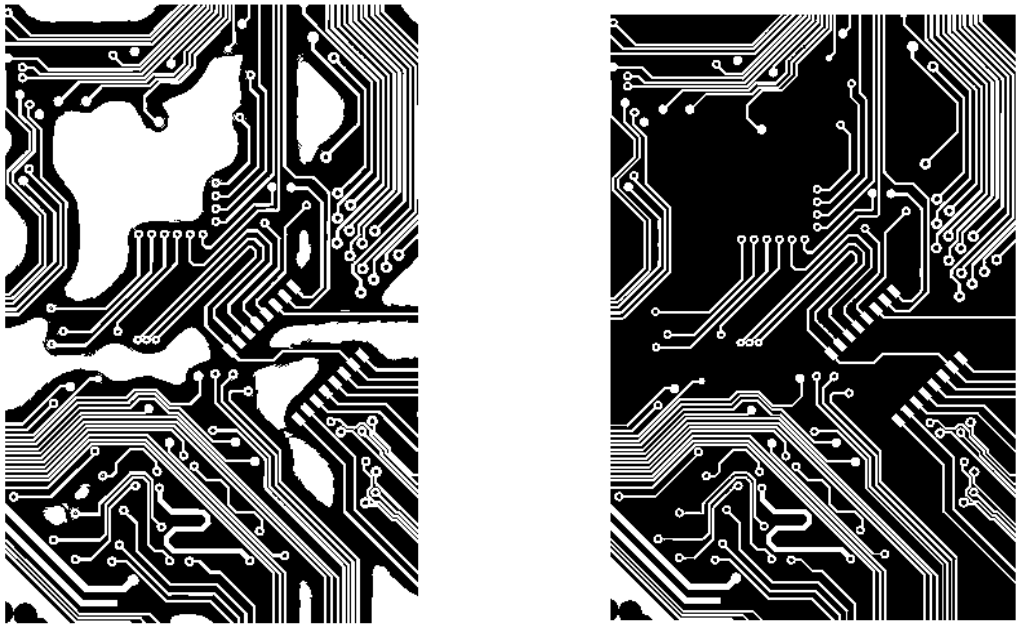
In this approach, we find the mean square deviation already in the binarized image, which provides information about the deviation of the background (e.g. white) and details (e.g. black) values of the image. This information can be used as the size of the scanning area "Block size".

The developed algorithm for finding the size of the scanning area "Block size" in the binarization of technological images of the topology of the SOE gives the following advantages Figure 3.



a) b)

a) global binarization;
b) adaptive binarization with automatic adjustment of the scanning area size
Figure 3.- Results of the algorithm

Thus, we get the average optimal value for binarization:
– the ability to find more details;
– reduction of contrast drop;
– reduction of noise influence.

The use of the proposed algorithm allows to improve the quality of image processing, reduce noise and improve the resolution when detecting small image elements (e.g., thin conductors in the topology of the DP). The developed software will also allow faster processing and comparison of technical images.

With the use of an automatic scanning window, such processing becomes faster and more accurate. The disadvantages of this method include the following:
– slower than conventional global binarization;
– the deviation parameter, and thus the threshold finding, depends on global binarization.

3. CONCLUSION

The block size in binarization can affect the quality of the result. If the blocks are too small, some details may be lost, and if the blocks are too large, the result may be uneven. The optimal block size depends on the size of the image, the nature of the image, and the binarization method used. Typically, larger blocks are used for high-resolution images, such as medical images or high-quality images, while smaller blocks are used for low-resolution images, such as a webcam or mobile phone images. Based on the results of the work, the following tasks were accomplished:
– the subject area was analyzed and the features of image binarization were considered;
– the threshold of binarization by "Otsu" was considered;
– an algorithm for finding the size of the scanning area "Block size" was developed.

The developed algorithm for finding the size of the scanning area "Block size" in the binarization of technological images of the topology of the SOE gives the following advantages:

– automatic finding of the optimal scanning area Block Size;
– resistance to image noise without the use of smoothing filters;
– detection of details in areas of contrast difference.

The sense of using the mean square deviation in the binarized image as the window size in adaptive binarization is as follows:

– this approach allows us to obtain a global binarized image with an automatic "Otsu" threshold;
– use of the mean square deviation in the binarized image as it gives the difference between the size of the background and the image elements.

REFERENCES

[1] Arianna Martinelli, Andrea Mina, Massimo Moggi. (2021). The enabling technologies of industry 4.0: examining the seeds of the fourth industrial revolution. Industrial and Corporate Change, Volume 30, Issue 1, P. 161–188. DOI: https://doi.org/10.1093/icc/dtaa060

[2] Núbia Carvalho, Omar Chaim, Edson Cazarini, Mateus Gerolamo. (2018). Manufacturing in the fourth industrial rev olution: A positive prospect in Sustainable Manufacturing, Procedia Manufacturing, Volume 21, P. 671–678. DOI: https://doi.org/10.1016/j.promfg.2018.02.170

[3] Mohammad Fakhar Manesh; Massimiliano Matteo Pellegrini; Giacomo Marzi; Marina Dabic. (2020). Knowledge Management in the Fourth Industrial Revolution: Mapping the Literature and Scoping Future Avenues, IEEE Transactions on Engineering Management, Volume: 68, Issue: 1, P. 289–300. DOI: 10.1109/TEM.2019.2963489

[4] Andronie, Mihai, George Lăzăroiu, Mariana Iatagan, Iulian Hurloiu, and Irina Dijmărescu. (2021). "Sustainable Cyber-Physical Production Systems in Big Data-Driven Smart Urban Economy: A Systematic Literature Review" Sustainability 13, no. 2: 751 p. DOI: https://doi.org/10.3390/su13020751

[5] Nevliudov, I., & et al. (2021). Development of a cyber design modeling declarative Language for cyber physical production systems, J. Math. Comput. Sci., 11(1), P. 520–542.

[6] Theo Lins, Ricardo Augusto Rabelo Oliveira. (2020). Cyber-physical production systems retrofitting in context of industry 4.0. Computers & Industrial Engineering. Volume 139. DOI: https://doi.org/10.1016/j.cie.2019.106193

[7] Igor Gruzman. (2013). Threshold binarization of images based on the skewness and kurtosis of truncated distributions. Optoelectronics Instrumentation and Data Processing 49(3). P. 215–220. DOI: 10.3103/S8756699013030011

[8] B. Gatos, K. Ntirogiannis, and I. Pratikakis. ICDAR 2009 document image binarization contest (DIBCO 2009). ICDAR, 2009. P. 1375–1382. DOI:10.1109/ICDAR.2009.246

[9] N. Stamatopoulos, B. Gatos, G. Louloudis, U. Pal, and A. Alaei. ICDAR 2013 Handwriting Segmentation Contest. 12th International Conference on Document Analysis and Recognition (ICDAR). 2013. P. 1402-1406. URL: https://www.academia.edu/19693205/ICDAR_2013_Handwriting_Segmentation_Contest