Comparative analysis of elbrus 8C processors during processing of images in systems of x-ray inspection of printed circuit boards

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Comparative Analysis of Elbrus 8C Processors During Processing of Images in Systems of X-ray Inspection of Printed Circuit Boards

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Abstract. In this research we studied several processors systems on VLIW (Elbrus 8C) and traditional technology (Intel Core i7) for image processing of X-ray images for printed circuit board X-ray inspection. For such task used test bench including own model of X-ray flat panel detector, microfocus X-ray source and positioning system. Measured time of convolution and Gaussian blur operation via OpenCV libraries in various operating system environment (Astra Linux, Elbrus Linux, Windows 10).

INTRODUCTION

X-Ray inspection (XRI) being one of the main methods of diagnosis of quality of solder joints of electronic parts at assembling sites is widely used for troubleshooting and causes of radio and electronic equipment failure and certification of components.

Work of a production engineer at an X-Ray inspection site involves two basic modes: real-time general search of defects (10-30 frames per second) and static analysis of hi-res pictures. Different algorithms of mathematical processing are used for these two cases. Image processing time is not a key factor for the static mode but it is the principal factor for real-time mode, and it imposes a number of constraints on PC computing capacity. We made a performance comparison of the most commonly used algorithms of image processing on some processor systems including Russian processors of Elbrus 8C series manufactured by MCST company in the study.

MATERIALS AND METHODS

Figure 1 shows examples of X-Ray images of a printed circuit board (PCB). We’ve used a product range of our own detectors with high resolution, 6-26 megapixels, data transfer rate via Ethernet was 1 GBE, to get X-Ray images, data protocol is GigEVision.

Standard tasks of PCB inspection for which methods of image processing are used are: search of contact zones of BGA with surface of a printed circuit board and a chip, segmentation of BGA from microvia projection, segmentation of pads SMD and DIP component, segmentation of chip bonding, void-searching in a bonding pad, searching for obvious defects and damage of a printed circuit board (Short circuit, mechanical failure). Those tasks could be divided into two inspection modes: survey search of defects in real-time, requires from 10 to 30 frames per second, and static analysis of high quality images. For static mode time of image processing is not a key factor, but for real-time survey it is major factor. So inspection process place limitations on computational power of a personal computer. Within this study was made comparison of computational power of several processor systems with or without VLIW technology in X-ray image processing application, e.g. Russian Elbrus 8C processor made by MCST.

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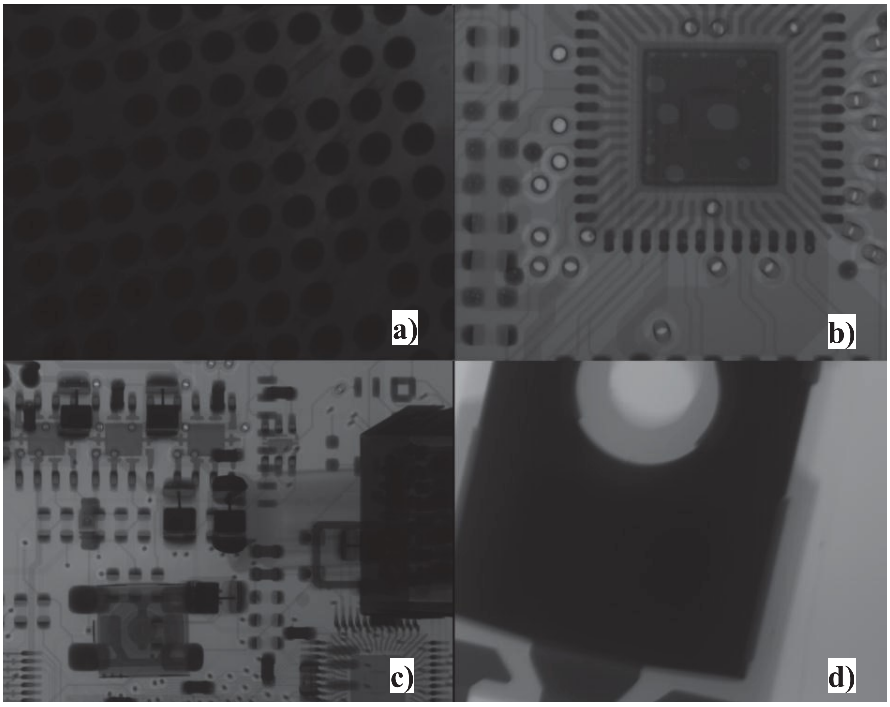

FIGURE 1. Examples of X-Ray images of printed circuit boards: a) angled view of BGA, b) chip with wire bonding, c) a fragment of a PCB, d) a transistor.

Depending on the problem to be solved such methods of X-Ray digital processing as linear contrasting, histogram equalization, gradation conversions, Euclidean transformations, contrast enhancement, noise reduction filtration, boundary detection are applied [2].

Linear contrasting, work with a histogram and gradation conversions allow to improve visual perception of an image without changing the basic data. As a rule, Euclidean transformations (rotation, reflection) have low level optimization on the basis of stack of image processing and don't require additional processor power for computation.

Methods of contrast enhancement, noise reduction and boundary detection change the original image and usually are resourse-intensive operations performed on a video card or a processor of image processing system. Most of such methods are based on matrix convolution, i.e. on equations of such a kind:

$$s(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) \cdot f(x+s, y+f) \tag{1}$$

A filter in the form of a matrix with size MxN, a=(M-1)/2, b=(N-1)/2, w(s,t) – weight coefficients of the matrix also called a mask or a kernel. Mask of the matrix – a matrix of some size (usually 3-5-7) used as an argument for local transformation of image brightness.

The following methods of digital processing turned out to be the most promising; Laplace filter, local contrast CLAHE [3] – for contrast enhancement, Kirsch filter – for boundary detection and segmentation due to its orientation independence. Gaussian blur being a very common method of noise reduction in X-Ray images and is a separate function. From a mathematical standpoint it is also an operation of convolution with weight coefficients obtained according to Gaussian distribution. But due to frequency of use this method is more optimized than the usual operation of convolution.

RESULTS AND DISCUSSION

Application of processor architecture with a Very Long Instruction Word (VLIW) must increase performance in matrix operations that can be used for implementation of different systems of X-Ray image processing, X-Raying, automatic X-Ray non-destructive testing on assembly lines etc. The task of this study is quantitative evaluation of change in productivity of X-Ray image processing systems based on modern Russian processors Elbrus 8C (1300

MHz) [4]. As at 2020 Elbrus 8C is the most productive Russian processor supporting VLIW technology and available in the commercial market.

Performance analysis was carried out in operating system (OS) environment: OS Astra Linux version Leningrad 8.1 (processor Elbrus 8C), OS Elbrus version 5.0 rc2 (processor Elbrus 8C), OS Astra Linux version Smolensk 1.6 (processor Intel Core i7) and OS Windows 10 (processor Intel Core i7). It should be pointed out that the version of OS Astra Linux Leningrad 8.1 doesn't include optimized libraries EML (Elbrus Mathematical and Multimedia Library) allowing to significantly accelerate image processing by means of low level optimization with the use of VLIW architecture of Elbrus processor. For this reason, we also provide the data on performance analysis on OS Elbrus 5.0 supporting the optimization. We should also note the difference in image processing speed depending on the type of data: unsigned int (16U), signed int (16S) or float (32F). Table 1 presents results of measuring time of performing of different operations on image processing using different processor systems. We used versions 3.2 and 4.4 of OpenCV [5] libraries, convolution kernel 5x5, image size 3000x3000 pixels for processing.

TABLE 1. Time of operations of image processing using different processor systems in ms.

OS version	Elbrus 5.0rc2	Astra Leningrad 8.1	Astra Smolensk 1.6	Windows 10	Windows 10
Processor model	Elbrus-8C	Elbrus-8C	Intel Core i7 7700	Intel Core i7 9750H	Intel Core i7 9750H
OpenCV version	3.2	3.2	3.2	3.2	4.4
Convolution, 16S	35	334	99,7	94	105,9
Convolution, 16U	244	280	-	98	106,5
Convolution, 32F	32	271	23,9	24	11,4
Gaussian blur, 16S	15,3	257	36,3	35	5,7
Gasussian blur, 16U	184	251	-	12,5	40
Gaussian blur, 32F	14,5	222	8,1	7,7	6,2

CONCLUSION

Improving quality of X-Ray inspection of printed circuit boards and electronic assemblies requires both hardware and software enhancement. The existing algorithms of X-Ray image processing allow to perform standard tasks of control but automatization of these tasks requires fast performance in image processing. Concurrently information security and import substitution of critical components in computing systems are vital tasks too so application of Russian processors is getting highly demanded in a great number of branches of manufacture.

In some operations VLIW architecture of the processor Elbrus 8C can either double productivity in image processing or decrease this index in according to modern Intel Core i7 processor. Non-optimized versions of OpenCV software package and some OS show loss in productivity up to 20 times. Not all the commercial operating systems make such optimization available, and it prevents one from using all the advantages of VLIW. Currently only original OS Elbrus made by MCST are available to show advantage in task of X-ray image processing.

Machine learning and neural network optimization for X-ray image processing using Russian processors on VLIW technology should be studied additionally.

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