HUITIEME COLLOQUE SUR LE TRAITEMENT DU
SIGNAL ET SES APPLICATIONS

NICE du 1er au 5 JUIN 1981

Application of a Microprocessor System for Data Acquisition and Processing of Scanning Electron Micrographs

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RESUME

On présente ici une méthode temps-réel de traitement des images obtenues par un microscope électronique en utilisant un microprocesseur.

La technique consiste à utiliser le micro-processeur comme maître et le microscope électronique comme esclave.

On décrit quelques exemples d' application typiques, obtenus dans les laboratoires de l'université de Brême.

SUMMARY

On-line image processing of pictures from an electron microscope can be performed with the aid of a microprocessor.

In this paper we present a method which uses the microprocessor as master and the electron microscope as slave.

Some typical examples are described that have been obtained in the laboratories of Bremen university.

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1. INTRODUCTION

Some image enhancement techniques are shown in the present paper with respect to their application for electron microscopy.

All operations described here have the objective to improve the picture quality or to increase the interpretability in order to recognize details and relevant structures of object information.
To be able to perform on-line processing it is highly desirable to minimize processing time and working storage.

A picture processing method for electron microscopy which uses simple algebraic operations is appropriate for microprocessor implementation.

2. IMAGE PROCESSING

We may be interested in better identification of details and edges of an image produced by an electron microscope.
As small details and sharp edges in space domain correspond to high frequency components in frequency domain, a two-dimensional high-pass filter which attenuates the low and amplifies the high frequency componentes may be required for our purpose.

A simple processing method is required to be able to perform on-line processing. The high-pass filtering can be performed by subtracting a low-pass filtered picture from the original. Low pass filtering may be realized by convolution of the original picture with a simple low-pass impulse response.
A great advantage compared to the Fourier method is that only a small amount of computer memory is needed. The two-dimensional discrete convolution is computed using the equation

$$f_2(x,y) = \sum_{k=-J}^{+J} \sum_{l=-J}^{+J} f_1(x-l,y-k) \cdot g(l,k)$$

$g(l,k)$ = discrete system function
$(2J+1)^2$ = size of coefficient matrix.

Convolution can be easily performed with the aid of simple algebraic operations and is thus appropriate for microprocessor implementation.

The output picture element of a simple high-pass may be described with the aid of an input submatrix and an algebraic operation performed on its elements.

All implementations of digital picture processing methods in this paper are based on local operations.

3. CONFIGURATION OF PROCESSING SYSTEM

A scanning electron microscope has been modified and interfaced to a microprocessor system so that each picture element could be accessed under software control. To achieve a proper synchronization of the deflection systems of both microscope and monitors the internal sweep generators of the STEM-unit have been substituted by 10-bit D/A-converters. These converters were part of an INTEL 8010 microprocessor system running at a clock frequency of 2 MHz. The video signal was quantized and processed using 8 bit resolution.
The configuration of the processing system is shown in fig. 1.
Thus the microprocessor is used as master and the electron microscope as slave.

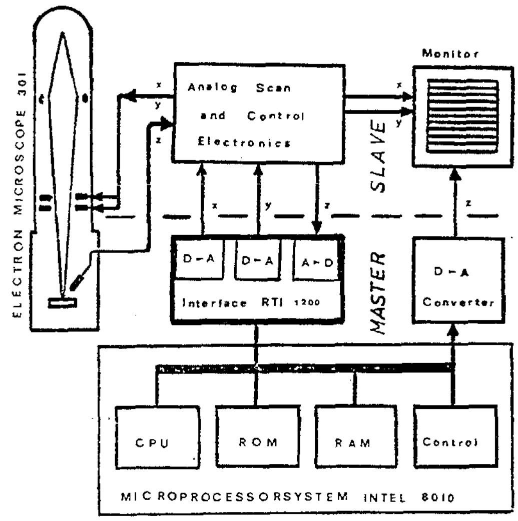

Fig. 1 SYSTEM CONFIGURATION

4. EXAMPLES

Several digital processing methods for image processing have been investigated such as level slicing, histogramm equalization and gradient processing technique.

Level slicing uses the same set of grey values to represent several different ranges of input levels. Ambiguity due to the discontinuities of the transferfuntion can be used for the detection of contours.
Fig. 2 shows the original of an electron microscopic image of zeolith, an artificial crystal.
The magnification is about 5000.
Fig. 3 shows the result of level slicing.

Histogramm modification is an adaptive kind of function processing.
The empirical probability density function of the picture element brightness values is first analysed, then a special transfer function is computed an a redistribution is achieved by function processing.
Fig. 4 shows the original of an electron microscope image of the nucleus of a kidney of mussel.
The magnification is about 3000.
Fig. 5 shows the result of histogramm linearisation.

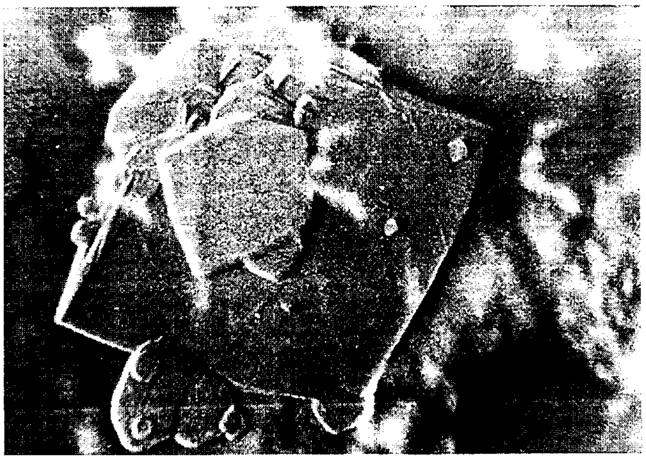

Fig. 2 ORIGINAL

Fig. 4 ORIGINAL

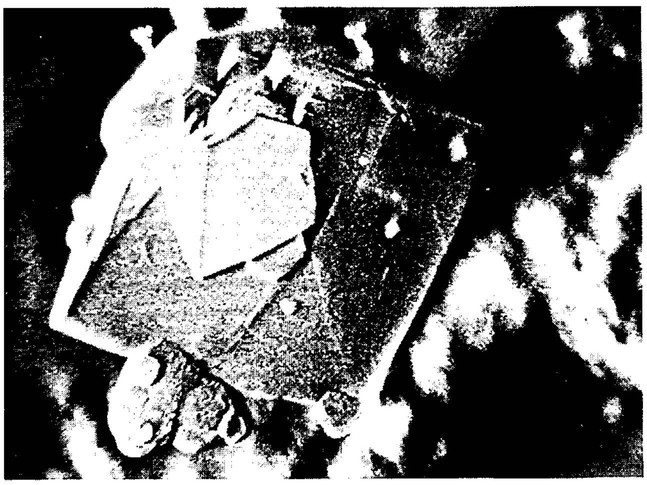

Fig. 3 LEVEL SLICING

Fig. 5 HISTOGRAM LINEARISATION

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In technical and biological pattern recognition systems the detection of grey-level changes is often important.
A gradient operator can be used for such purposes. The gradient of a twodimensional function f(x,y) is given by

$$\text{grad } f(x,y) = \frac{\partial f}{\partial x}(x,y)\cdot e_x + \frac{\partial f}{\partial y}(x,y)\cdot e_y$$

Fig. 6 shows the original of an electron microscope image of steel alloy. The magnification is about 2000.
Fig. 7 shows the result of the application of the gradient operator.

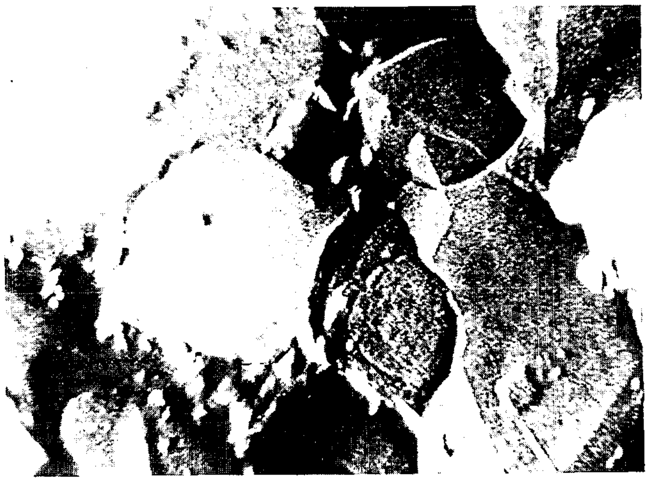

Fig. 6 ORIGINAL

Fig. 7 GRADIENT OPERATOR

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