RESEARCH AND OPTIMIZATION OF METHODS FOR COMPUTING OF CROSS CORRELATION FUNCTIONS FOR SINGLE-DIMENSION AND TWO-DIMENSION SIGNALS

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The paper examines the usage of cross-correlation functions for noise removing in the single dimension signals and pattern recognition in the two-dimensions signals. The practical implementation of the ARMAX – models is observed and the simulation results are presented.

Keywords: single dimension signal, two-dimension signal, cross – correlation, auto – correlation.

1. INTRODUCTION

The basic problems with implementing of computing algorithms for cross-correlation functions for single dimension and two dimension signals is relative to using of very fast signal processors. This led to the necessity of finding adequate algorithms and computer platforms for their implementation. The problem is observed for single-dimension and two-dimension signal processing:

-the method of the cross-correlation functions is used in implementing adaptive digital filtering and noise determination. Currently, these algorithms have the implementation to determine, control, and change the system function (transfer function) of a process are used in motion control, channel equalization for overcoming the deleterious effects of long lines in signals, noise cancellation for removing environmental noise, and even in satellite telemetric signal transmission.

- the two-dimensions cross-correlation computing is limited by the necessity of processing wide-field images. The growth of contemporary CCD-array technologies makes possible the presence of low-cost cameras. The processing of images demands fast algorithms for computing cross-correlation functions. These functions are used for pattern recognition in the industry.

2. PROBLEMS

2.1 Single-dimension cross-correlation implementation

The correlation analysis widely used in problems for system identification . With its help, mathematical discrete models of linear systems can be derived, and also their disturbance can be evaluated. The base discrete model, describing the behavior of a system is the so called „ARMAX” (**A**uto-**R**egression **M**oving **A**verage e**X**ternal signal) – model. There are also other sub models – ARX, AR, ARMA.

The structure of the ARMAX model is as follows:

$$A(z^{-1}).y(t) = B(z^{-1}).u(t).z^{-d} + C(z^{-1}).\varepsilon(t)\,, \qquad (1.1)$$

where **u(t)**, **y(t)** and **ε(t)** are accordingly the input, output and white noise, affecting nto the system, **d** is the transport delay.

A(z), B(z) и C(z) are the polynomials:

$$A(z^{-1}) = 1 + a_1.z^{-1} + a_2.z^{-2} + \ldots + a_n.z^{-n} \qquad (1.2)$$

$$B(z^{-1}) = b_0 + b_1.z^{-1} + \ldots + b_m.z^{-m} \qquad (1.3)$$

$$C(z^{-1}) = c_0 + c_1.z^{-1} + \ldots + c_k.z^{-k} \qquad (1.4)$$

where z^{-1} is the shifting operator.
In real systems(n ≥ m) и (n ≥ k), in order to be physically implementable.
The transfer function, describing the system is:

$$W(z^{-1}) = \frac{B(z^{-1})}{A(z^{-1})}.z^{-d} \qquad (1.5)$$

It can be derived on the base of identification, accomplished in accordance with the correlation analysis. To arrive at (1.5), cross-correlation functions between the input **u(t)** and output **y(t)** of the system were used.

The transfer function, describing the passing of measurable random disturbance through the system is :

$$W_\varepsilon(z^{-1}) = \frac{C(z^{-1})}{A(z^{-1})} \qquad (1.6)$$

The simulation block-chart for simulating the ARMAX models is presented on fig. 1.

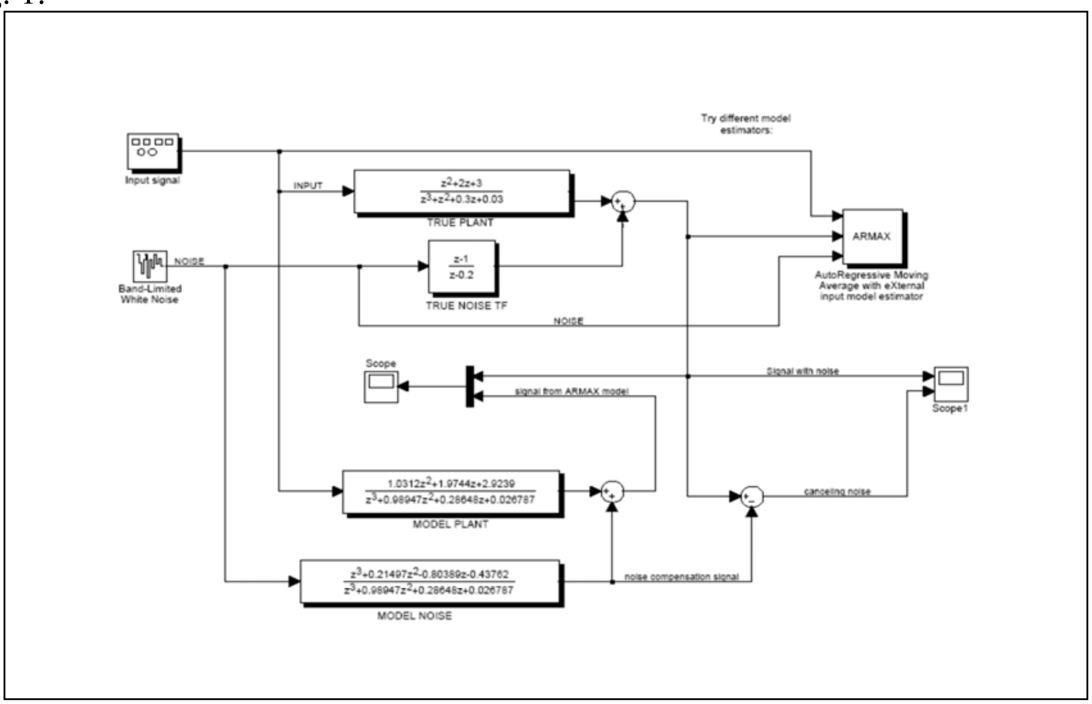

fig. 1

2.2 Two-dimension cross-correlation implementation

With the sage of 2-D cross-correlation functions, it is necessary to consider carefully the properties for fast response of the system. In the last several years – the wide format CCD matrix in the order of 2048 X 2048 and with reading speed of 10 frames per second, became accessible even for the low-cost image processing systems. The increasing popularity of this image processing systems, lead to rising demand of fast algorithms for pattern recognition. One of the most popular is cross-correlation.

The basic formula for cross-correlation of two-dimension signal is:

$$T * I(X,Y) = \sum_{i=0}^{n-1}\sum_{j=0}^{m-1} T(i,j) I(X+i, Y+j) \qquad (2.1)$$

Obviously, when the observed window is 2048x2048 and correlation pattern is 32x32 pixels for each frame, a great computing power will be necessary for the calculations. To speed up that process this can also be done in the frequency domain.

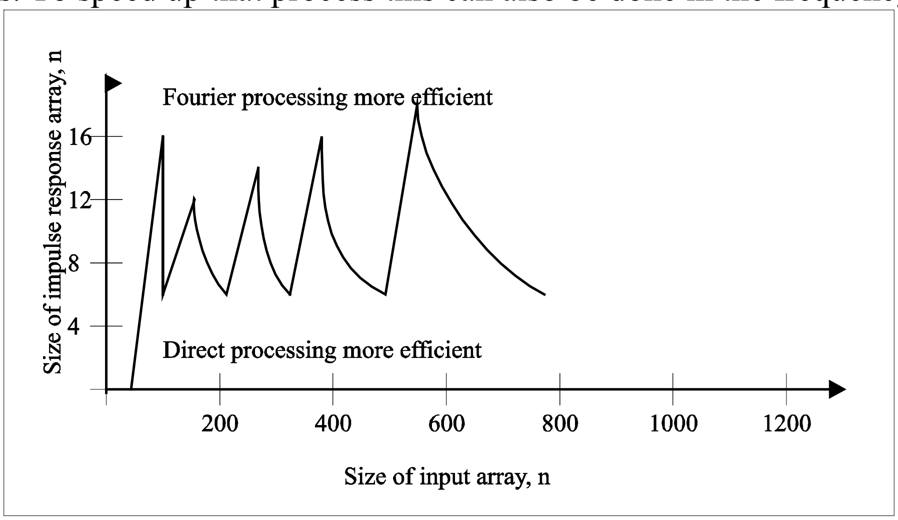

fig. 2

The figure shows the boundary where the calculation frequency and time domain are equal. Over it, it is more efficient to use correlation in the frequency domain.

3. RESULTS

3.1 Single-dimension cross-correlation simulation

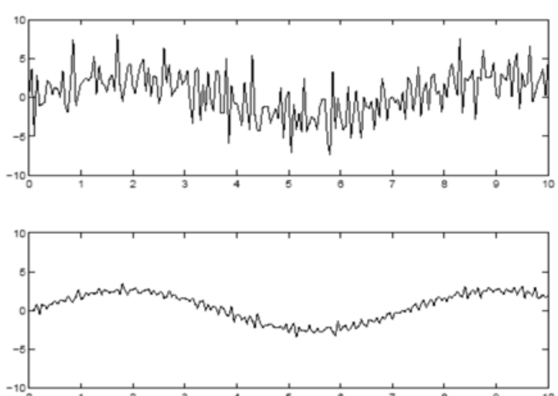

fig. 3

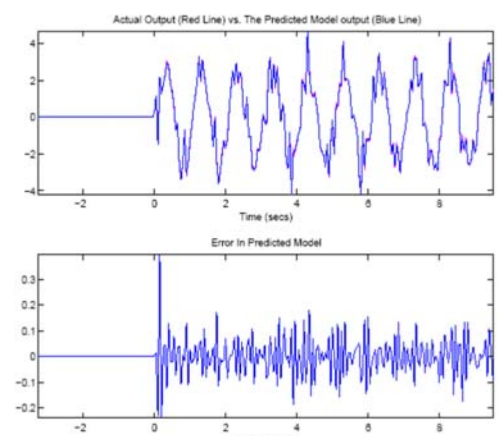

fig. 4

The experiment expresses in the filtering the signal which is noisy. The both signals are shown on fig. 3. The first is this with the noise and below it is the processed signal, gained on the output of the system.

The predicted output from the model versus the real signal is shown on fig. 4 On this basis the absolute error of the processing is shown on the fig. 4. As it can be observed from the figure the absolute error is below 0.2, Only in the first moment – the start of the system it is over 0.3.

3.2 Two-dimension cross-correlation simulation

The experiment for the two-dimension cross-correlation is made with a image of printed circuit board fig.5 (*1378x1068 pixels*) and a pattern (32 pixels), which is part of the picture it self.

The 3-D result of the cross-correlation is presented on fig. 7.

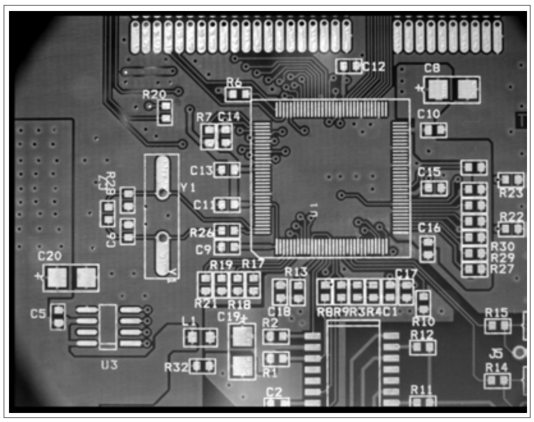

fig. 5

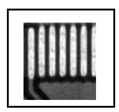

fig. 6

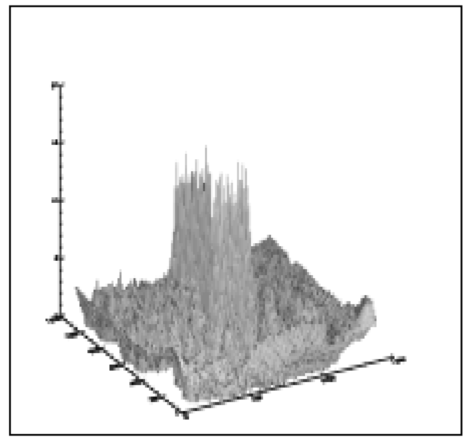

fig. 7

4. CONCLUSION

The modern signal processing hardware allows the execution of high-complexity algorithms at speeds, undreamed of only a decade ago. This solves one of the major drawbacks of algorithms based on correlation and cross-correlation analysis – the vast number of additions and multiplications. Using special techniques in hardware and software development it is now possible to achieve online processing of huge signals. The correlation analysis allows for its multiple applications – from signal filtering to image recognition. The use of digital models, and filters allows the use of a single DSP processor in system implementations.

5. REFERENCES:

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