

Chapter 10

Mathematical Models of Video-Sequences of Digital Half-Tone Images

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ABSTRACT

This chapter is devoted to Mathematical Models (MM) of Digital Half-Tone Images (DHTI) and their video-sequences presented as causal multi-dimensional Markov Processes (MP) on discrete meshes. The difficulties of MM development for DHTI video-sequences of Markov type are shown. These difficulties are related to the enormous volume of computational operations required for their realization. The method of MM-DHTI construction and their statistically correlated video-sequences on the basis of the causal multi-dimensional multi-value MM is described in detail. Realization of such operations is not computationally intensive; Markov models from the second to fourth order demonstrate this. The proposed method is especially effective when DHTI is represented by low-bit (4-8 bits) binary numbers.

INTRODUCTION

As at this writing, the intensification of scientific research and increased complexity of solving scientific and technological problems require the investigation of not only one-dimensional random processes, but also the investigation of the multi-dimensional ones, for example, different types of fields presented in the form of images or video-

sequences. Image processing is of great interest to researchers and engineers in various fields of practice for example: engineers in the area of flaw inspection and the non-destructive testing, developers of industrial robots and systems for the visual inspection of technological processes, experts in automation of scientific research, in TV technologies, in security systems, in remote sensing of natural resources, in space investiga-

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tions, biologists, medical experts, specialists in forensic crime detection, physicists, astronomers, meteorologists, geologists, cartographers, and so forth (Bykov, 1971; Pisarevsky & Chernyavsky, 1988; Vasiliev, 1995; Ablameiko & Lagunovskiy, 2000; Berchtold, 1999; Vasiliev, 2002; Elfeki, 2001; Shalizi, 2003; Bondur, 2003). It is difficult to find a scientific or technological area, in which applied problems of image processing is not present in one form or the other.

The transition to digital image processing using small-bit numbers (4-8 bits) has sharply extended the possibilities of image application as the most capacious carrier of various types of information. In this connection, digital image processing, because of its importance, has been distinguished as an independent scientific and communication area, involving a great number of highly qualified experts. There is every reason to believe that in the nearest future, there will be a great extension of the practical implementation of image processing methods from Medicare to other various types of technological processes.

The development and investigation of image processing algorithms are based on mathematical models (MM), which adequately represent real images. To date, a variety of MM for two-dimensional images are already developed, on the basis of which whole series of effective processing algorithms offered has been reported in the literature by Jine (1981) as well as Derin and Kelly (1989). Most of these algorithms however require enormous computational resources. Approximation of digital half-tone images (DHTI) by random Markov processes (MP) allows for the achievement of significant progress in the area of MM development and algorithms of image processing. Important contributions in the development of Markov type MM have been introduced by Russian researchers like Berchtold (1999), Bondur (2003), Krasheninnikov (2003), Vasiliev (1995), Vasiukov (2002), Furman (2003), Soifer (2003) as well as other experts such as Jine (1981), Abend (1965), Woods (1972), Besag (1974), Kashyap (1981), Vinkler

(2002), Modestino (1993), Politis (1994), Chelapala (1982, 1985). The most interest for practical application is generated by multi-dimensional mathematical models of DHTI video-sequences. The number of publications devoted to such MM are few. Notable among them are Bykov (1971), Vasiliev (1995, 2002), Jine (1981), Derin and Kelly (1989), Spector (1985), Dagion and Mercero (1988), Politis (1994), Petrov (2003), Trubin (2004a, 2004b), Trubin and Butorin (2005).

The MM of DHTI video-sequences based on the multi-dimensional discrete-time and continuous-values Markov process are the most studied by researchers like Vasiliev (1995), Spector (1985), Dagion and Mercero (1988). Two-dimensional MM of DHTI presented by Jine in Jine (1981) and constructed on the basis two-dimensional Gaussian Markov process was developed by Krasheninnikov, Vasiliev, and Spector in Krasheninnikov (2003), Vasiliev (1995), Spector (1985) up to multi-dimensional image MM based on the multi-dimensional Gaussian MP. The structure of the algorithm for generating these processes is rather simple and clear, however, the MM proposed in Jine (1981) based on the causal two-dimensional Gaussian MP has found the widest application (see Box 1).

To realize the MM of equation (1) it is necessary to use four multiplications and three additions, which is fully acceptable for medium sized images.

Krasheninnikov (2003), Vasiliev (1995), Spector (1985), suggested on the analogy of equation (1), MMs of processes of larger dimensions. Thus, for the description of the image frame sequence with two spatial coordinates defining the location of the image element in the frame and the third coordinate: the number of the frame or the discrete time in the frame sequence, the MM will be of the form shown in Box 2.

The computational effectiveness defined by the required computer memory usage and the number of computational operations is one of the most important features of MM. We should con-

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