Cellular Automata Algorithms for Digital Image Processing

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ABSTRACT

In this paper are presented solutions to develop algorithms for digital image processing focusing particularly on edge detection. Edge detection is one of the most important phases used in computer vision and image processing applications and also in human image understanding. In this chapter, implementation of classical edge detection algorithms it is presented and also implementation of algorithms based on the theory of Cellular Automata (CA). This work is totally related to the idea of understanding the impact of the inherently local information processing of CA on their ability to perform a managed computation at the global level. If a suitable encoding of a digital image is used, in some cases, it is possible to achieve better results in comparison with the solutions obtained by means of conventional approaches. The software application which is able to process images in order to detect edges using both conventional algorithms and CA based ones is written in C# programming language and experimental results are presented for images with different sizes and backgrounds.

INTRODUCTION

Digital images are intensively used in automated applications for object detection or various decisional systems based on information from the visible or invisible spectrum. Image processing is important in data transmission and data storage and has many applications in surveillance, medicine, biometrics, automatic identification data capture and many more. In this context, analysis and image processing techniques have become more and more popular, and among the methods used for image processing are thinning, edge detection, segmentation and texture processing. Based on these operations, can be made different measurements, object recognition and other parameters can be interpreted such as distances, areas, and perimeters and so on.

The goal of edge detection is to process a two-dimensional image and computationally determine where there are edges or boundaries in the image. The edges are a part of an image that contain important visual

information since they correspond to geometrical variations of the objects. The human vision system easily picks out edges in an image, but finding an edge computationally is a challenging problem. The front end of many computer vision systems consists of an edge detection module and the high interest in edge detection uses the conjecture that boundaries manifest as intensity changes. Although there exists a lot of edge detection algorithms, a problem is that quantitative evaluation is realized on synthetic images and this is an accepted practice in order to compare different edge detectors by presenting visual results. On the other side, one of the biggest challenges for the nowadays informational and technological society is near a paradox: the desire of construct machines that can decide like a human being. These machines need to be efficient enough so they can be trustworthy. In these conditions and having in mind the above mentioned problems, the research presented in this chapter is based on the using of digital image edge detection techniques that works accordingly with bio-inspired systems (cellular automata) theory. The essence of the theoretical and practical research which are done in the image processing domain is justified by the opinion that cellular automata based edge detection techniques are capable to have similar performances regarding the classical edge detection methods based on gradient and Laplacian.

This chapter is organized in six sections as follows. The *background section* provides all the needed mathematical information on the basic concepts of both digital images & edge detection and cellular automata, including surveys on earlier work about digital image edge detection techniques. This section is organized into four subsections which deal with the following issues: digital images, literature review of classical edge detection techniques, basics of cellular automata and literature review of cellular automata based edge detection techniques. In section three, software implementation of CA edge detection techniques, the CA based model for edge detection are described in detail, including the most important source code for the CA evolution rules. In section four, testing and results, using different original images, the results derived from the classical edge detection techniques and CA based edge detection method is presented. Finally, section five sets some goals for future research directions and section six draws a conclusion of this study.

BACKGROUND

Digital Images

The computer representation, transmission and storage of an image is generally discrete, as opposed to images in the real world which are typically continuous. A digital image consists of discrete values arranged in a two-dimensional matrix.

For a color image, each pixel is typically represented by three values: a red value, a green value and a blue value. Each value is typically represented as an integer with values between 0 and 255 or, for example in OpenGL, as a floating-point values between 0.0 and 1.0. The representation of some sample colors are: red (255, 0, 0), green (0, 255, 0), blue (0, 0, 255), white (255, 255, 255), yellow (255, 255, 0), black (0, 0, 0). Because each value is an integer between 0 and 255, eight bits are necessary to store a value. Thus, 24 bits are required to store the color for each pixel of the digital image and a total of 2^{24} (more than 16 million) different colors can be represented on the computer display. In some cases, in function of the image format, an additionally 8 bits are used in order to store the transparency value (usually known as alpha value) of each pixel of the image. Here, as an example, if alpha value is 0 that means completely transparent and a value of 255 is completely opaque.