CELLULAR AUTOMATA AND WATERMARING FOR IMAGE COPYRIGHT PROTECTION

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Abstract— In image processing there is some copyright protection and techniques are available. Digital Watermarking is the technique for copyright protection of data (image).Cellular automata is successfully applied in image processing. Cellular automaton growth is controlled by predefined rule or programs .The rule describes how the cell will interact with its neighborhood. Once the automaton is started it will work on its own according to the rule specified.

This paper will describe the image watermarking and cellular automata (CA).There are other techniques available for image watermarking, here watermarking based on cellular automata is describe with the types of cellular automata which be employed for image authentication through this key. the regular, modular, and cascadable structure of CA with local interconnections makes the scheme ideally suitable for VLSI implementation.

Keywords- Cellular automaton (CA), Watermark, Image embedding, VLSI

Introduction

In our daily life, from the newspaper we pick up in the morning to a recipe for a new dish, nearly everything was created by someone. The fact that people can own the expression of their ideas means they can potentially earn a living by developing them. For example if an individual comes up with a brilliant new work(image) and someone else simply make copies it and starts mass-producing prints, then the original owner is much less able to make a living from his work.

Thus to prevent this happening we need a copyright protection. In case of digital images we need the powerful copyright technique which is watermarking. The laws of copyright are designed to prevent this happening.

The piracy of software, images, video, audio, and text has long been a concern for owners of these digital assets. Protection schemes are usually based upon the insertion of digital watermarks into the data. The watermarking introduces small errors into the object being watermarked which are not easily recognized by the human eye. These intentional errors are called marks, and all the marks together constitute the watermark. The name comes from the faintly visible watermarks imprinted on stationary that identify the manufacturer of the stationery.

Watermarking can also done by cellular automata (CA) which is based on permutation of the pixels of the image and replacement of the pixel values. The permutation is done by scan patterns that generated by the SCAN methodology. The pixel values are replaced using a progressive CA substitution with a sequence of CA data that is generated from the CA evolution rules.

There are many CA evolution rule available, thus we can produce many sequence of CA data for image embedding and retrieval. A Progressive CA substitution is integer arithmetic and/or logic operation, which is an easy and simple computation.

Introduction to watermarking

Techniques of embedding a secret imperceptible signal, directly into the original data in such a way that always remains present, called watermark.

Digital watermarking is an adaptation of the commonly used and well-known paper watermarks to the digital world. Digital watermarking describes methods and technologies that allow hiding of information, for example a number or text, in digital media, such as images, video and audio. The embedding takes place by manipulating the content of the digital data that means the information is not embedded in the frame around the data. The hiding process has to be such that the modifications of the media are imperceptible. For images this means that the modifications of the pixel values have to be invisible. Furthermore, the watermark has to be robust or fragile, depending on the application. With robustness we refer to the capability of the watermark to resist to manipulations of the media, such as lossy compression, scaling, and cropping, just to enumerate some. Fragility means that the watermark should not resist tampering, or only up to a certain extent.

A watermark is a special digital message hidden in an image, which is imperceptible to the human eye but readable by a computer. Generally watermark is embedded by making subtle changes to the luminosity of the pixels in an image. Techniques available for digital image processing are LSB, EOF and DCT. The new one is based on cellular automata.

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Introduction to cellular automata

Cellular automata were introduced by Ulam and von Neumann ([3]). The idea that pushed von Neumann to propose the cellular automata model, was constructing a self replicating machine, which components would obey physical laws defined by differential equations. A cellular automaton is basically a computer algorithm that is discrete in space and time and operates on a lattice of sites (in our case, pixels). It consists of a regular grid of cells, each in one of a finite number of states, such as "On" and "Off" (in contrast to a coupled map lattice). The grid can be in any finite number of dimensions. For each cell, a set of cells called its neighborhood. The communication between constituent cells is limited to local interaction.

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Image Embedding Method

CA Embedding Scheme of Image

Given a N* N -cell dual-state von Neumann 2-D CA runs over T time steps, it has $2^{2^5} = 2^{32}$ rules, $2^{N\times N}$ initial configurations, 2^{4N} boundary conditions, and results in 2^{32+N^2+4N} CA evolution ways for generating $T\times N$. N-bit generalized CA data. For easy implementation, we used 6-bit rule Control data to indicate some specific CA rule numbers in our system. The simplified rule can be expressed as

$$\begin{aligned} a(i,j,t+1) = C_0 \oplus (C_1 \cdot a(i+1,j,t) \oplus C_2 \cdot a(i,j-1,t) \\ \oplus C_3 \cdot a(i,j,t) \oplus C_4 \cdot a(i,j+1,t) \oplus C_5 \cdot a(i-1,j,t)) \end{aligned} \qquad (1)$$

Where C1, C2, C3, C4 and C5 are control bits which are used for switching control, C0 decides whether the output of exclusive OR is inverting or not. We thus need CA keys with 6+N*N+4N bits assign a specific CA evolution way where the firstly 6 – bits are rule control data for specifying CA rule number, next N*N bits are initial data for assigning initial configurations, the residuary 4N bits are for setting boundary conditions.

The proposed progressive CA embedding substitution satisfies both confusion and diffusion properties. The confusion and diffusion properties are achieved by transforming the sequence of bits embedding.

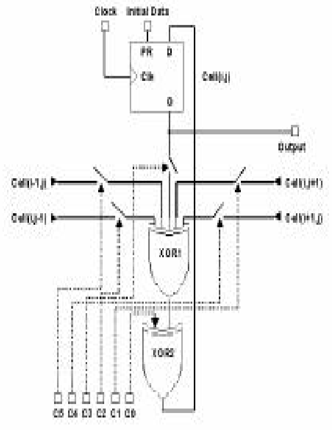

Fig. 1 The proposal 1-bit 2-D von Neumann PCA For image embedding

Types of Cellular Automata

One-dimensional CA

A one-dimensional cellular automaton consists of two things: a row of "cells" and a set of "rules". Because of its inherent simplicity, the one-dimensional CA with two states per cell became the most studied variant of CA. There are also two-dimensional cellular automata, which use rectangular grids of cells. Each of the cells can be in one of several "states". The number of possible states depends on the automaton. Think of the states as colors. In a two-state automaton, each of the cells can be either black or white. the cells can change from state to state. The cellular automaton's rules determine how the states change. It works like this: When the time comes for the cells to change state, each cell looks around and gathers information on its neighbors' states. (Exactly which cells are considered "neighbors" is also something that depends on the particular CA.) Based on its own state, its neighbors' states, and the rules of the CA, the cell decides what its new state should be. All the cells change state at the same time. The neighborhood generally varies from three to five or sevencells. In another type of CA, the states are assumed to be a string of elements in a Galois field GF (q), while q is the number of states of a CA cell. Additive and linear CA gained popularity in the V LSI era, due to local interaction of simple cells, each having two states `0' or `1' - the elements of the field GF(2). The next state logic of linear and additive CA is expressed in terms of xor and xnor logic gates.

Cellular automata on multi-dimensional grids have also been proposed. The grids have either null or periodic boundary. In null boundary configurations the boundary cells are assumed to have `null' (logic `0') dependency. A variation of the null boundary configurations is the fixed boundary configurations in which the boundary cells instead of being considered `0' are replaced by a fixed value.

Advantages

Robust

Since watermarking is primarily used for copyright protection and proving ownership, the embedded watermark has to survive and be extractable after the marked image has been submitted to a variety of things, for example:

- scaling of the image
- converting a color image to grayscale
- Blurring, sharpening and other image-effect algorithms
- Lossy compression, for example JPEG, used widely on the internet

Transparent

There are some obvious reasons for wanting to embed the watermark, without being able to see any difference on the marked image contra the original. Not being able to see the watermark, may keep some people from trying to remove it. If the image is used unrightfully, and your watermark can afterwards be extracted, you have a pretty good case against the copyright violator. It is also desirable to preserve the quality of an image, even though a watermark is embedded in it. Imagine for example that beautiful pictures promoting a tourist website are severely distorted by the watermarking. Then the algorithm would be practically unusable.

Robust and fragile watermarks

It seems that for most applications, it would be ideal to have a watermark that is able to survive transmission, usage and attacks. Such a watermark is named robust. On the other hand, watermarks are also used to detect if the image they are in, has been altered. That is watermarks that cannot resist any alteration. Such watermarks are called fragile. Finally watermarks have been proposed, trying to combine robustness and fragility. That is a watermark that can survive some alterations, but would break if the image was cropped for example, or parts of another image were inserted into it.

Tamper resistant

Tightly linked to robustness, since any effort made to remove or deteriorate the watermark should result in the watermarked image being severely degraded in quality. There are different approaches for achieving a good level of robustness, which will be discussed later.

Cheap and easy implementation

For a watermarking algorithm to have success, it has to be relatively easy to implement, while not costing a fortune. An algorithm is of no use if it takes a day to mark a picture, and a day to extract the mark again. It has to be usable in real life which of course is application dependant.

Reversible

A cellular automaton is said to be reversible if for every current configuration of the cellular automaton there is exactly one past configuration (preimage). If one thinks of a cellular automaton as a function mapping configurations to configurations, reversibility implies that this function is bijective. If a cellular automaton is reversible, its time-reversed behavior can also be described as a cellular automaton.[Richardson, D. (1972), "Tessellations with local transformations", J. Computer System Sci.] .For cellular automata in which not every state has a preimage.

For one dimensional cellular automaton there are known algorithms for deciding whether a rule is reversible or irreversible. However, for cellular automata of two or more dimensions reversibility is undecidable; that is, there is no algorithm that takes as input an automaton rule and is guaranteed to determine correctly whether the automaton is reversible.

Image retrieval

Reversing the operations of progressive CA embedding performs the progressive CA image retrieval. The method for retrieval is 8-bit, and 2-D 8*8 -cell von Neumann CA is selected. The CA key is 011111, 16 uniform initial states, zero boundaries with cyclic boundary at right down corner, and linear permutation with 16(00). It is clear that the rule control data is 011111, which means that the 2-D 8*8 -cell dual-state von Neumann CA evolution is controlled by the function

$$\begin{aligned} a(i, j, t+1) = a(i+1, j, t) * a(i, j\ 1, t) * a(i, j, t) * \\ a(i, j+1, t) * a(i\ 1, j, t). \end{aligned} \qquad (2)$$

Once the initial data, boundary condition data, and rule control data were decided, the 2-D von Neumann CA run over approximately 8192 time steps to generate the generalized CA data of size at max 65536. Then 8-bit permutation control data 16(00), guides the system to do linear permutation from the first N-bit data of the CA initial state (1st time step) to generate the pseudo random sequence of CA data.

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