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Multi-Resolutional Image Format Using Stochastic Numbers and Its Hardware Implementation

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Abstract
Conversion of image formats in hardware is somewhat complicated as compared with other calculations. The recent market of IoT devices made image processing very common. Multiple image formats are used in IoT devices but collective image format is required for communication between IoT devices. The aim of this paper is image reduction by using stochastic numbers generated by stochastic computing. And image format can be treated to be in various resolutions with only single data. From the experiment, we found that the proposed image format allows the reduction of an image by pixel average using stochastic numbers to be implemented into hardware with lower costs as compared with conventional pixel average using binary numbers. These image reductions can also restore the original image.

Keywords: *Stochastic numbers and Stochastic computing, Image format, Image reduction, Image resolution.*

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I. INTRODUCTION

There are several methods of conversion of resolution of the image: Pixel Average, Bi-linear, and Bi-cubic. But when implemented into hardware these methods have problems i.e. circuit size is large and somewhat complicated. The aim of this paper is to reduce its circuit size by pixel average using stochastic computing. In stochastic computing stochastic numbers are used for calculation. In stochastic computing arithmetic operations are implemented by simple logic circuits. Stochastic numbers are the randomly generated bitstreams of variable lengths. These bitstreams mainly consist of input and output is encoded as per probabilities. These probabilities are calculated according to occurrences of 1's. With this concept, arithmetic operations can be done by simple logic circuits.

II. LITERATURE SURVEY

Nowadays, companies develop many IoT devices and their number has been increasing annually. One of the core processes of IoT devices is image processing. Multiple image formats are used in IoT devices. For example, in terms of resolution, QVGA (320 × 240) is used in surveillance cameras and 8K (7680 × 4320) is used in medical cameras. Here, we consider communication between IoT devices. When sending images from IoT devices to general-purpose computers, the image format can be converted using software, and therefore the images can be read. When sending images from general-purpose computers to IoT devices, the image format must match the hardware of the IoT device, and therefore the image format must be fixed before sending. However, when sending images from IoT devices to other IoT devices, the image format must match both of the IoT devices for sending and receiving. Hence, a unified image format is required for communication between IoT devices.

Stochastic Computing (SC) has emerged as an unconventional method of calculating logical circuits. Instead of performing computation on deterministic binary numbers, SC circuits are designed to process random bit-streams. The input and output are represented by bitstreams and their values are encoded as the probabilities of seeing 1's in the bitstreams. The values are confined in the unit interval [0, 1] since probabilities cannot be beyond the unit interval.

Compared to a fixed binary options computer, SC offers many advantages, including hardware cuts and error-tolerant computers. Because of these advantages, SC has been considered as an appropriate alternative to binary computing in different applications such as Image Processing, Neural Network, Digital Filter, and Low-Density Parity-Check Decoding (LDPD)

III. PROPOSED SYSTEM

In the stochastic computing concept by concatenating series of stochastic numbers with the same length the concatenated stochastic numbers have the value of the average of the original ones. Therefore, resolution conversion can be done at a low cost. This paper proposes a multiresolutional image format which is called RESSIF (Recursive Subdivision based Stochastic Image Format) by defining pixels with stochastic numbers. By this concept single image shown by RESSIF can be served in multiple resolutions and image reduction using RESSIF can be implemented with a small circuit. Also, conversion of images will restore the original image.

IV. PIXEL AVERAGE METHOD

The main aim of the pixel average is to calculate the average pixel of a specific area. For the calculation, we have to consider that *l* x b resolutional image, *l* x b image reduced to a 1-pixel image. Let us consider

$$a_{x,y}\ [1 <= x <= l];\ [l <= y <= b]$$

be the pixel of the original image. The pixel of the reduced image(z) becomes;

$$\frac{1}{l\ x\ b}\sum_{x=1}^{l}\sum_{y=1}^{b} a_{x,y} \qquad 1$$

we assume that $h = w = 2$ and pixel average reduces images to one fourth. Eqn. (1) becomes:

$$y = \frac{a1{,}1 + a1{,}2 + a2{,}1 + a2{,}2}{4} = \frac{a+b+c+d}{4} \qquad 2$$

V. STOCHASTIC COMPUTING AND STOCHASTIC NUMBERS

Stochastic numbers are the bitstreams of variable lengths. These bitstreams mainly consist of zeros and ones, bit streams of input, and output are encoded as per probabilities. These probabilities are calculated according to the occurrence of 1's in the given bitstreams. These probabilities are between unit intervals.

The advantages of stochastic computing are reduced hardware complexity and fault-tolerant computing. Hence the stochastic computing is the alternative way for binary computing. Stochastic computing provides a low hardware complexity that results in a cost-effective computing circuit.

5.1 Generation of Stochastic Numbers

Random Number Generator:

Random numbers are required for the generation of probabilities of the required bitstream i.e. the required stochastic numbers. Random numbers cannot be taken from any of the random functions available in the algorithm as it increases the complexity of the system. So, we have to generate them on the hardware. We can generate them as follows.

For a generation, we require a 4-bit register and an X-OR gate. The connection of the X-OR gate is given in the diagram the L1 and L2 of the 4-bit register are given to the input of the X-OR gate and the output of the X-OR gate is fetched to the L4 bit of the given 4bit register (LFSR).

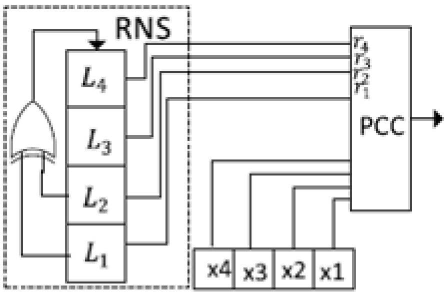


Fig.1: General Structure of SNG

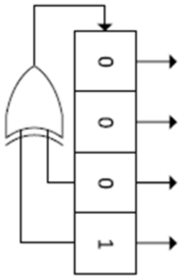


Fig.2: LFSR is used as RNS

CMP Circuit:

CMP circuit is the next block of the stochastic number generation system. The output of the RNG is given parallelly as the input to the CMP circuit. In addition to that 4-bits are parallelly passed on to the CMP circuit. The output of this CMP circuit is the desired encoded stochastic bitstream. The CMP circuit working is as follows that it compares the 4-bits of an input number to the 4-bits of random number generated. If the input 4-bits is greater than or equal to the generated random number then 1 is generated at the output of the CMP circuit. If the input 4-bits number is less than the generated random number then 0 is generated at the output of the CMP circuit.

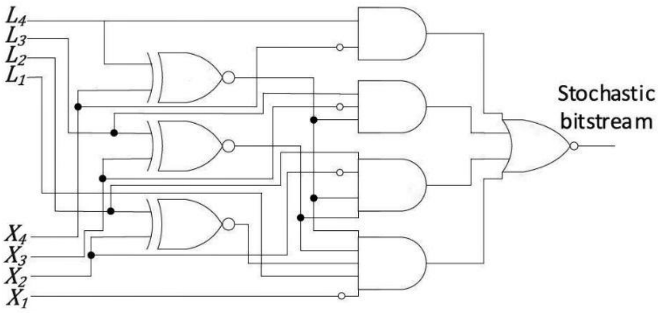


Fig.3: CMP Circuit

Table 1: Output bitstreams for the LFSR when CMP is used as the PCC part

L4	L3	L2	L1	S_{CMP}
0	0	0	1	1
1	0	0	0	1
0	1	0	0	1
0	0	1	0	1
1	0	0	1	1
1	1	0	0	0
0	1	1	0	1
1	0	1	1	1
0	1	0	1	1
1	0	1	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0
0	1	1	1	1
0	0	1	1	1
8/15	**8/15**	**8/15**	**8/15**	**11/15**

Generating Stochastic Number Effectively:

As we know the smallest resolution image used today is a 256 x 256-pixel image which gives us 65536 pixels in total. The simplest image which represents 1bit/pixel will give us 65536 bits, if we take 4bits as input to the CMP circuit one after the other then we will have to generate 4-bits random numbers which vary from 0000 to 1111. These numbers are counted as from 0 to 15 i.e. total of 16 combinations for 4-bits. Thus for 65536 bits, we will have 65536 x 16 combinations i.e. 1048576 combinations. This becomes very difficult and lengthy for the 1CMP circuit to calculate. It takes more than two hours to just process these numbers for the 1CMP circuit.

So, the solution is connecting multiple CMP circuits parallel to each other and take the input simultaneously. The random numbers for all 4-bits CMP circuits are the same thus connect the RNG part as common to all the CMP circuits.

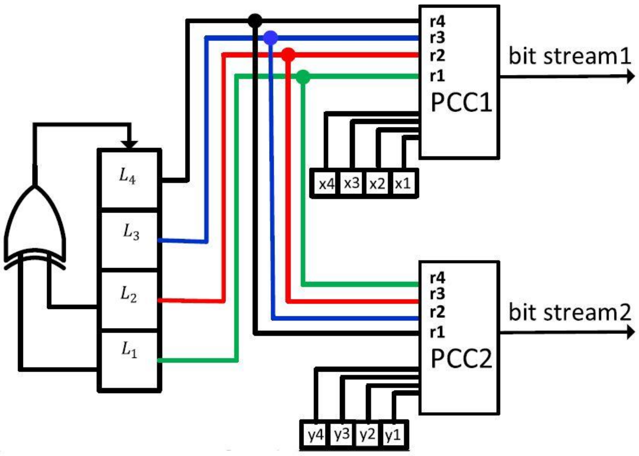


Fig.4: Proposed structure for sharing an LFSR with two SNGs based on output permutation. (a) *n* = 4.

5.2 Recursivity of Stochastic Numbers

When SNs are concatenated or split to form new bitstreams, they are also SNs i.e. SNs are recursive. When concatenating SNs, the following theorem holds.

Theorem: By concatenating multiple SNs with the same length, the value of the concatenated SN is equal to the average of the values of the original SNs.

Proof: Let $x(1)$, $x(2)$, $x(3)$, ..., $x(n)$ be n SNs, and l be their length. Let $Sx(i)$ and $Vx(i)$ be the number of 1's and the value of SN $x(i)$ $(1 \leq i \leq n)$, respectively. Let y and Sy be the concatenated SN and its number of 1's, respectively.

The value Vy of y becomes:

$$Vy = \frac{Sy}{l \text{ x } n} = \frac{\sum_{i=1}^{n} Sx(i)}{l \text{ x } n}$$

$$= \frac{1}{n} \text{ x } \sum_{i=1}^{n} \frac{Sx(i)}{l}$$

$$= \frac{1}{n} \text{ x } \sum_{i=1}^{n} Vx(i) \qquad 3$$

Therefore, the value of the concatenated SN is equal to the average of the values of the original SNs. By substituting $n = 4$, $Vx(1) = a$, $Vx(2) = b$, $Vx(3) = c$, $Vx(4) = d$ and by replacing Vy with y, Eqn. (3) becomes:

$$y = \frac{a+b+c+d}{4}$$

which coincides with equation (2) representing pixel average.

VI. MULTI-RESOLUTIONAL STOCHASTIC IMAGE FORMAT

6.1 RESSIF

REcursive Subdivision Based Stochastic Image Format (RESSIF) is the cheapest way to convert the image resolution. All images are recursive in nature i.e. they can be concatenated or separated to the other image format. From the above Theorem, the average values are calculated based on concatenated stochastic numbers.

Hence the pixel average is implemented using concatenation stochastic numbers. Fig.5 shows the resolution conversion of images expressed by RESSIF and there is a pixel expressed by a 32-bit SN.

In Fig.5(a) by splitting the 32 bits into four 8 bits, the pixel can be divided into four, then it also divides each pixel into four. These operations are implemented by changing wires therefore it is costless.

In Fig.5(b) by combining pixels recursively an image can be expressed by a single SN using RESSIF. Table II shows images expressed by single SN using RESSIF with 2^{14}, 2^{16}, 2^{18}-bit SNs and divided by multiple-precision. When the number of bits representing a pixel becomes smaller, the resolution becomes higher. When the number of bits representing a pixel becomes larger, each pixel can express more colors.

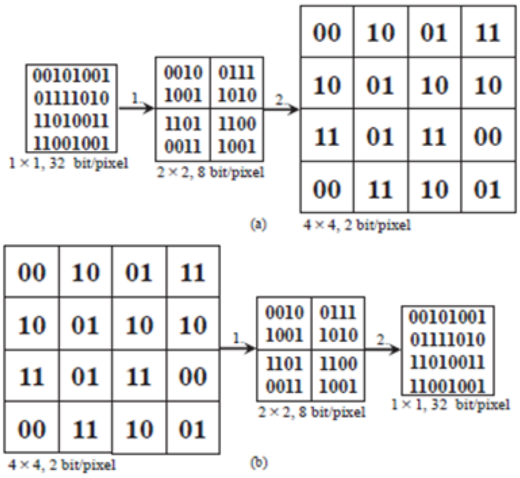
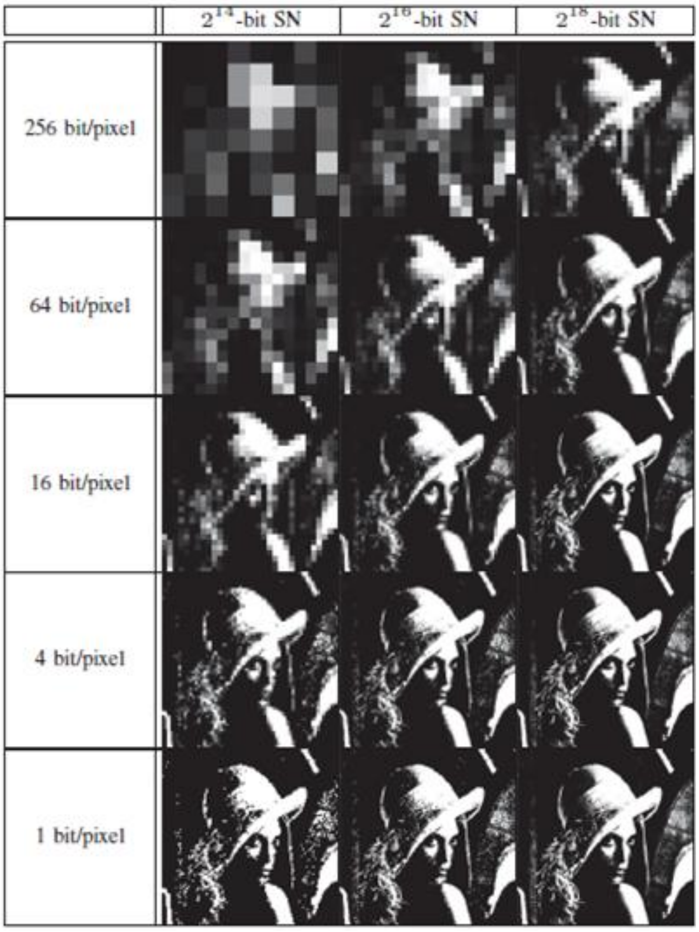


Fig.5: Resolution Conversion of Images Expressed by RESSIF
(a) Magnification of an Image Expressed by RESSIF
(b) Reduction of an Image Expressed by RESSIF

Table II: Images Expressed by *RESSIF* with 2^{14}, 2^{16}, 2^{18}-bit SNs and Divided by Multiple Precision.



VII. CONCLUSION

In this paper, we have investigated the construction of lower costs as well as slightly related SNG circuits using LFSR sharing. Reduction the convergence between small streams created, we have agreed to pre-shared LFSR releases before use as input SNGs are different. We have also developed an acquisition algorithm a set of permits that can be shared between m SNGs by the lower junction of the cross. We have implemented the proposed SNGs in SC-based use of multiple applications and the results show that, with low hardware complexity, we get better comparative accuracy compared to previous methods.

This paper has suggested a picture with multiple resolutions format RESSIF. RESSIF can make a pixel measurement at a lower cost per expression images use SNs and can retrieve original images completely. In the future, we will use working image process circuits using RESSIF benefits.

REFERENCES

[1]. Ishikawa, R., Tawada, M., Yanagisawa, M., and Togawa, N. (2020). *"Multiresolutional Image Format Using Stochastic Number and Its Hardware Implementation"*. San Jose: Institute of Electrical and Electronics Engineers Inc.

[2]. Salehi, S. A. (2020). *"Low-Cost Stochastic Number Generators for Stochastic Computing"*. University of Kentucky, Lexington, USA: IEEE.