MVA2000 IAPR Workshop on Machine Vision Applications, Nov. 28-30, 2000, The University of Tokyo, Japan

8—10

A New Computational Image Sensor With Programmable Spatially Variant Multiresolution Readout Capability

Yasuhiro Ohtsuka, Ikuko Ohta and Kiyoharu Aizawa *

Department of Electronic Information Engineering and Frontier Science
University of Tokyo

Abstract

This paper presents a new image sensor with programmable multiresolution readout capability. The proposed image sensor can output data at varying resolutions. Differing to our previously reported spatially variant sampling sensor which sub-samples without filtering[1], in the multiresolution sensor, blocks of the pixels are averaged and read out then, the new sensor does not suffer from aliasing effects. The resolution can be controlled by varying the block size. We made a prototype of 64 × 64 pixels and examined the programastorageble resolution.

1 Introduction

For a variety of image processing tasks, such as biological vision modeling, stereo range finding, pattern recognition, target tracking, and transmission of compressed images, it is desirable to have image data available at varying resolutions to increase processing speed and efficiency. The user can then obtain a frame of data at the lowest resolution necessary for the task at hand and eliminate unnecessary processing steps.

We present a new image sensor with programmable multiresolution readout capability. The proposed image sensor can output data at varying resolutions. For instance, software intensive image pyramid reconstruction can be eliminated. Differing to our previously reported spatially variant sampling which sub-samples without filtering[1], in the multiresolution sensor, blocks of the pixels are averaged and read out then, the new sensor does not suffer from aliasing effects. The multiresolution image sensor has a 64 × 64 pixel array that is programmable to read out the averaged values around the center pixels. The average value is computed for differing block sizes (3x3, 5x5 or 7x7) around the center pixel. We can select the block size for each pixel. In averaging, a pixel is selected as the center of the block and the averaged value is read out as output. The averaged block can be overlapped each other.

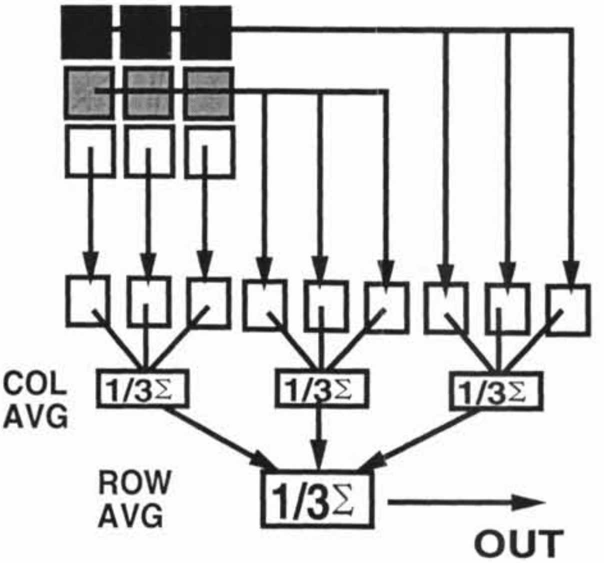


Figure 1: Kemeny's method.

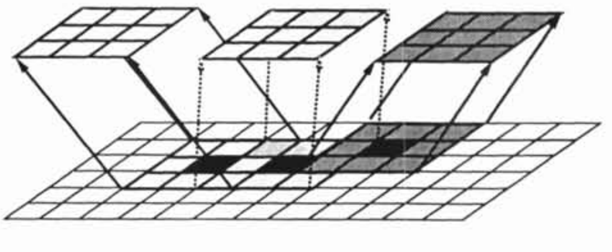


Figure 2: Proposed method

*Address: 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656 Japan. E-mail: ootuka@hal.t.u-tokyo.ac.jp

2 Multiresolution sensor

Multiresolution image sensor can output data at varying resolutions, by placing signal processing circuitry on the imaging focal plane. There has been work related to multiresolution output[2]. Figure 1 shows Kemeny's method in case of 3 × 3 pixels block. In this method, there are a network of capacitors to store pixel values and a set of switches to the adjacent column to perform averaging on any square array of pixels. Pixel values in a specific block are read out to the capacitor and averaged each other. Since we can get only one output value in each block and the block can not overlap to adjacent one, the pixel values in the block is represented by the output value.

Figure 2 shows proposed method. In this method, we can set the block size to each center pixel and an averaging block can overlap to adjacent one. In order to execute this method, we designed a pixel circuit as shown in Figure 3. Pixel values of each pixel is used plural times to enable block overlapping and a storage time of pixel value is unified of all pixel.

3 Design and operation

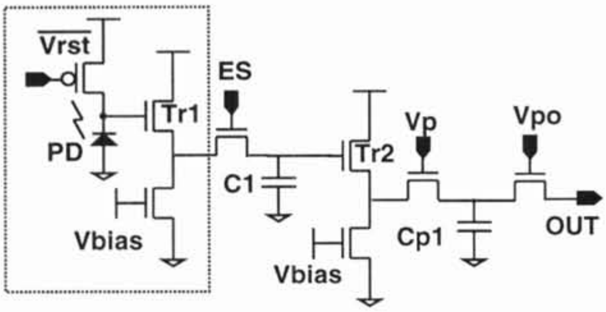


Figure 3: pixel circuit

The pixel circuit shown in Figure 3 has PD, electronic shatter(ES) and two capacitors (C1 and Cp1). C1 is the one for sampling and holding of the pixel value and keeps it during 1 frame. Cp1 is the one used for the averaging of the pixel values. Capacitance of C1 is about 300fF, because pixel values have to be kept during 1 frame. A capacitance of Cp1 doesn't have to be so large, but is also about 300fF by the influence of the wiring capacitance. The circuit uses a passive switched capacitor network to average the pixels in a chosen size of block, which can then be read out by a set of digital shiftregisters. After switching off the ES, since we can control a photo detector circuit (dotted line block in Figure 3) independently, the integration time of pixel value is not influenced by the averaging process.

Figure 4 shows smoothing process in 3x3 block. We use three capacitors (Cp1,Cc1,Cp3) for vertical averaging. Cp2 is not used and the value of PIXEL2 is charged directly into Cc1. In PIXEL1 and PIXEL3, the values are charged into Cp1 and Cp3. We can finish vertical averaging in reading out from the pixel circuit and three sets of averaged three pixel values are kept in Cc1 to Cc3. After switching on Vc1 and Vc2, we can get the averaged value of the block.

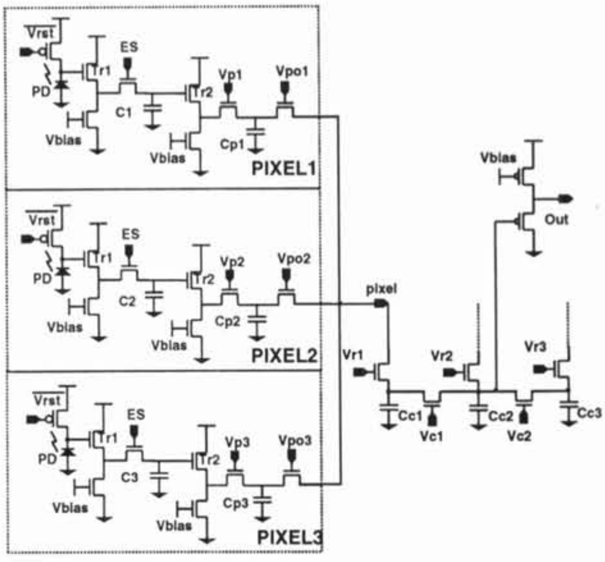


Figure 4: Smoothing process in 3x3 block.

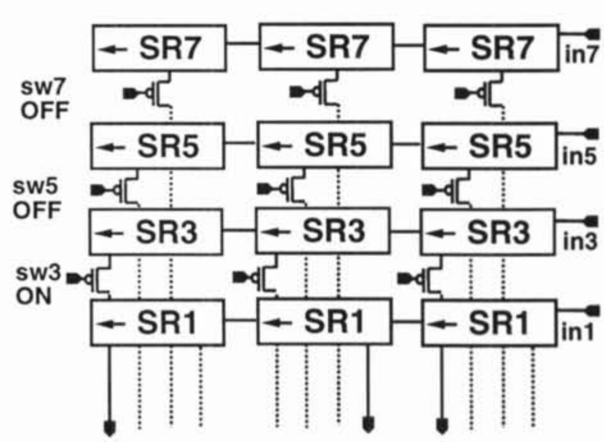


Figure 5: Determination of block size (3x3).

Figure 5 shows determination of block size in case of 3x3 pixels. We use four steps of shiftregister to select the block size. The size of the block is controlled by sw3 to sw7, inputted signals from the outside. If sw3 is ON and sw5 and sw7 are OFF, output signal from the SR3 is only used for selecting the block size. SR1 is used to determine the center pixel address. The output signal from SR3 to SR7 are symmetrical with respect to SR1 as shown in Figure 6.

Figure 7 shows a circuitry of the horizontal shiftregister. The averaged three pixel values are stored in Cc1 to Cc3, and Vc1 and Vc2 are opened for horizontal averaging. Vc1 to Vc3 are controlled by the SC (switching circuit). Since Vc switch is opened only if adjacent SC circuits are activated, Vc3 is not opened as shown in Figure 7. Since the circuit in the dotted line box is on center, the value of Cc2 is outputted.

Figure 8 shows a block diagram of the prototype. There are a sensor array of 64 × 64 pixels and vertical and horizontal shiftregister worked for block size selection and averaging pixel values. Both shiftregisters determine a pixel address as a center of averaging block and set the block size with inputted sw signal. The block size can be selected with respect to each pixels and changed arbitrarily.

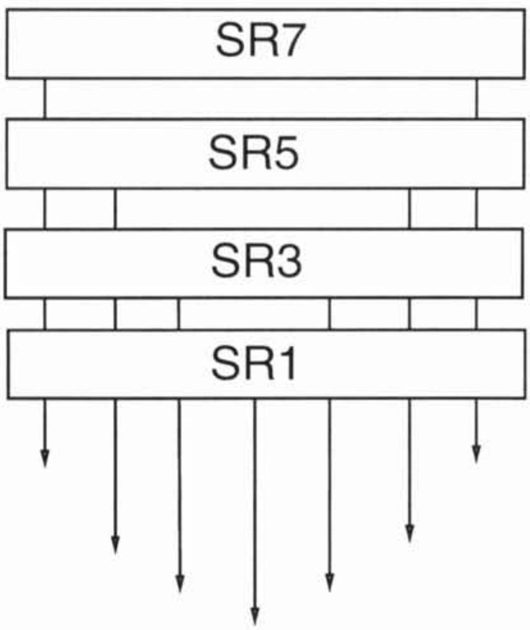


Figure 6: Layout of block selection signals.

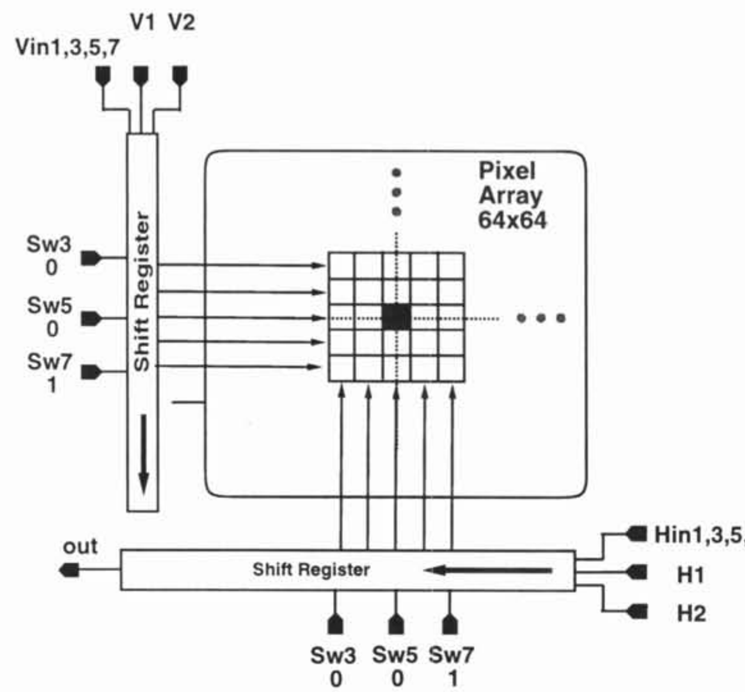


Figure 8: Block diagram of the prototype.

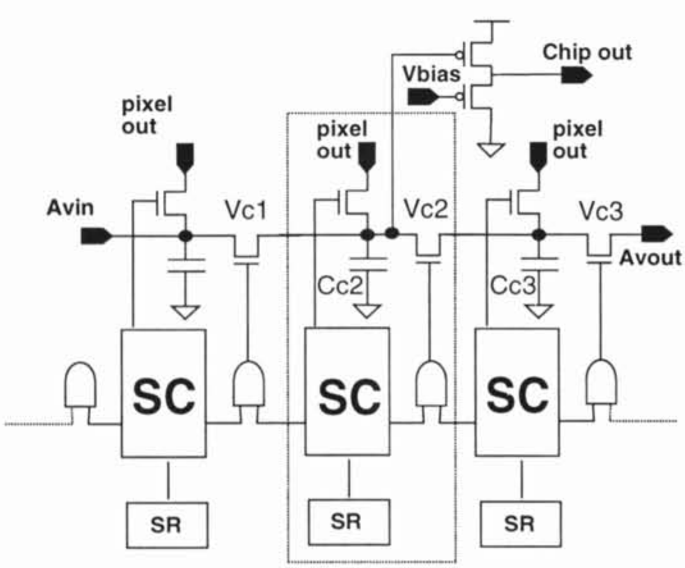


Figure 7: Horizontal shiftregister.

4 Prototype chip

Figure 9 shows a prototype chip of the proposed sensor. The chip is designed under 2-poly 2-metal CMOS $0.8\mu m$ process rules. Number of pixels is 64 × 64 and an arrangement of each elements follows the block diagram shown in Figure 8. Table 1 shows the outline of the prototype.

Figure 10 shows images obtained by the prototype. (a) in the figure is a normal image of 64 × 64 pixels. (b),(c) and (d) in the figure are averaged image, the block sizes are 3 × 3, 5 × 5 and 7 × 7 each. Figure 11 shows images in which averaging block sizes are arbitrarily controlled locally. (a) in the figure shows the normal outputted image obtained by the prototype. (b) in the figure show the retina-like outputted image. In (b), central area of the image is constructed by normal outputted pixel values. The block size of the peripheral area change from 3 × 3 into 7 × 7.

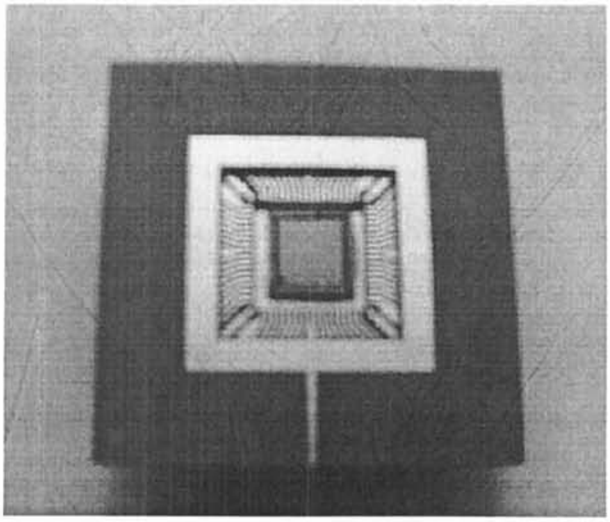
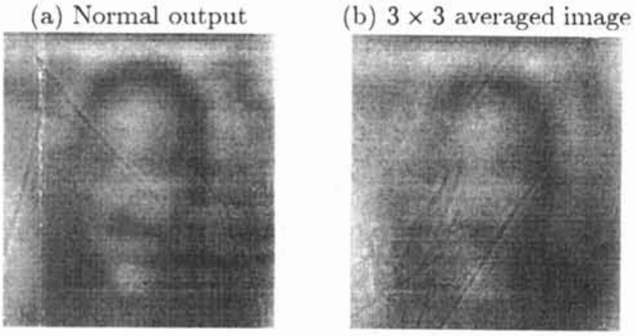


Figure 9: prototype chip

Table 1: Performance of the prototype.

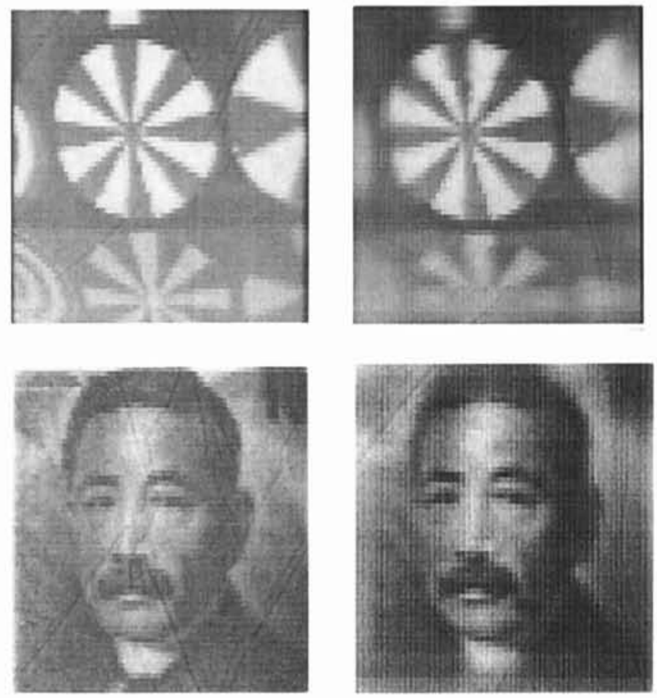
Number of pixels	64 × 64
Chip size [mm^2]	5.5 × 5.5
Pixel size [μm^2]	60 × 60
Number of Tr.	9 trs. / pixel
Fill factor [%]	14.5 %
Power dissipation[W]	0.25
Power supply[V]	5

(a) Normal output (b) 3 × 3 averaged image



(c) 5 × 5 averaged image (d) 7 × 7 averaged image

Figure 10: Image obtained by the prototype.



(a) Normal output (b) Retina-like output

Figure 11: Retina-like image obtained by the prototype.

5 Conclusion

We propose a new computational image sensor with programmable spatially variant multiresolution readout capability. We present principles of processing and designs of their circuits.

It should be possible to get the following effects from the sensor.

- We can easily select the one of four block sizes for averaging by inputting sw signal from outside of the sensor.
- The averaging block can overlap with adjacent one.
- By setting the block size locally, we can get retina-like image.

References

[1] **Y.Ohtsuka**,etc. "A New Image Sensor With Space Varient Sampling Control On A Focal Plane" *MVA98*,11-1,Makuhari,Japan (1998-11)

[2] S. E. Kemeny, etc:"Multiresolution Image Sensor", *IEEE Trans. on Cir.Sys.for VT*, Vol.7, No.4, pp.575–583,(1997)