QUARTER PIXEL BASED RANDOM ACCESS IMAGE SENSOR FOR WIDE VIEW IMAGING

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ABSTRACT

We describe a wide view imaging system using multiple image sensors and mirrors. In this system, each image obtained by real multiple sensors is equivalent to the image obtained by an imaginary sensor. Therefore depth estimation from sensor to each object into the image is not required. In this paper, we describe the wide view imaging system by using random access image sensors we have designed. The circuits of the proposed system consist of the sensors and FPGA. It can capture and display panorama view image or arbitrary view image in real time. The new image sensor has 128 x 128 pixels and the functions of random access and interpolation of pixel values on quarter pitch. We show some result obtained by the chip.

1. INTRODUCTION

We have been investigating random access image sensors which are applicable to smart imaging systems [1][2]. Because the random access image sensor can be output only image data of the pixel selected by the control signals, the sensor is very effective to the imaging system by using multiple sensors.

In this paper, we explain the wide view imaging system for multiple image sensors and mirrors[3]. In this system, each image obtained by real multiple sensors is equivalent to the image obtained by an imaginary sensor. Therefore the further calculation is not required except image projection for combining the multiple images.

We propose the wide view imaging system by using random access image sensors and describe the system architecture using the sensors and FPGA[4]. It can capture and display panorama view image or arbitrary view image and control its view angles in real time. We have fabricated new image sensor which has 128 x 128 pixels. Main functions of the chip are random access of arbitrary pixel position and interpolation of pixel values on quarter pitch.

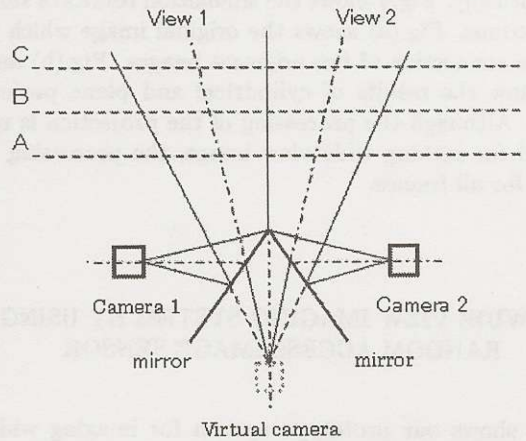


Fig. 1. Wide view imaging with two cameras

2. WIDE VIEW IMAGING SYSTEM BY USING MULTIPLE CAMERAS AND MIRRORS

For wide view imaging, we use not only multiple cameras but also mirrors. Fig.1 shows the cross section of two cameras and mirrors [3]. Although the camera 1 and camera 2 are in opposition to each other, the images obtained by the cameras are equal to the image obtained by the virtual camera by using two mirrors. The virtual camera has twice the view angle compared to the single camera. As shown in Fig.1, the two images correspond to the wide view imaged from one position and have no-overlapped area, therefore the estimation of depth from the camera to the objects and its compensation are not necessary.

Fig.2 shows the wide view imaging system by six cameras and hexagonal mirrors. As Fig.1, the images obtained by the six cameras(a to f) are equivalent to the images obtained by the virtual camera which is positioned on the center of the hexagonal mirrors. Therefore the panorama image can be imaged easily, because of no-processing for depth estimation.

Although the smart system has good features for combining the various images, the processing of projection is required for image reconstruction. Fig. 3 shows the cross section of two camera systems. In this case, the two images on X ' 1 plane or X ' 2 plane are combined and transformed to an image on X plane. If the all images are combined and transformed to an all-direction view image, the all images are transformed cylindrically. Fig.4 shows the simulation results of such projections. Fig.(a) shows the original image which is simple connection of two adjacent images. Fig.(b) and (c) show the results of cylindrical and plane projections. Although the processing of the projection is required for making wide view image, the processing is same for all frames.

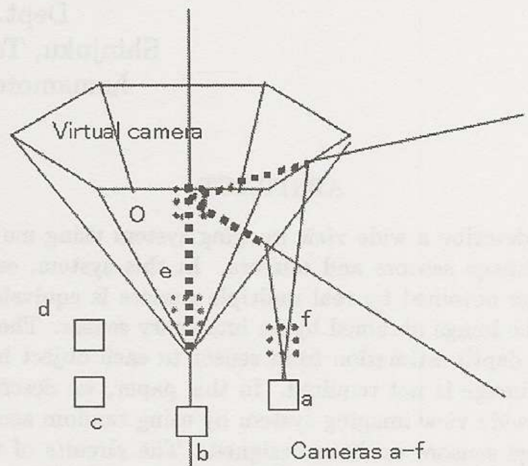


Fig. 2. Wide view imaging with six cameras

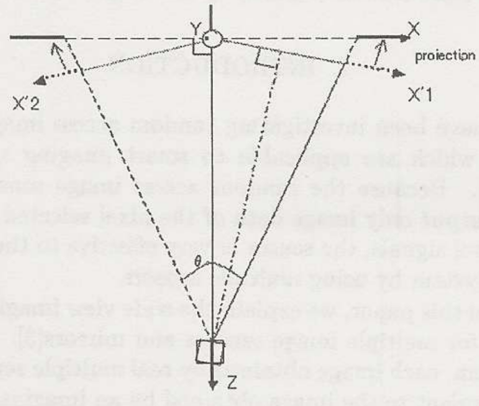


Fig. 3. Projection for combining two images

3. WIDE VIEW IMAGING SYSTEM BY USING RANDOM ACCESS IMAGE SENSOR

Fig.5 shows our prototype system for imaging wide-view. The system consists of eight sensors which are positioned on a plane and the octagonal mirrors. By the system, all-direction view is captured in real time. Fig.6 shows an example panorama image obtained by the normal eight CCD sensors.

Fig.7 shows the system architecture for imaging and displaying of panorama view image or arbitrary view image in real time. In the case of normal CCD sensors, all images obtained by the multiple cameras are memorized and the partial pixels are selected by projection map for the display. Therefore the quite big circuits are necessary if the number of the sensors is large. On the other hand, in the case of random access sensors, selection of the displayed pixels is done on each sensor and only the pixel values shown on the monitor are output. According to projection method for panorama view image or arbitrary view image, FPGA controls the output pixel value by chip selection data and address data and the image data can be directly displayed without further processing. The proposed system using the random access sensors is quite small compared to the system using CCD sensors and the image size or view angle can be also changed at every frames easily.

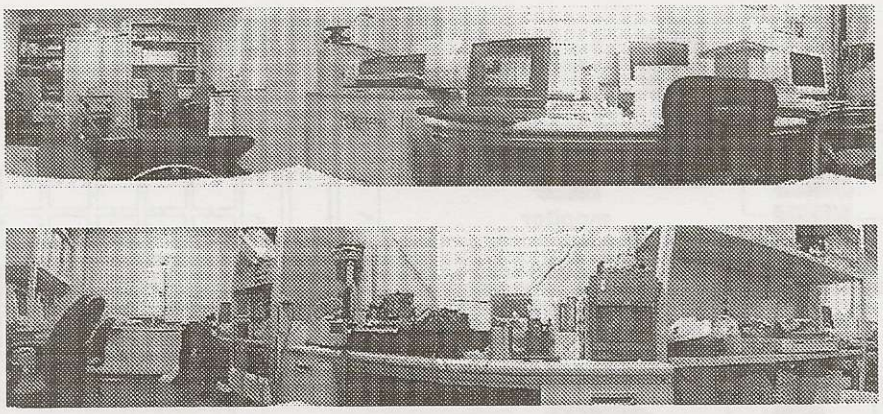
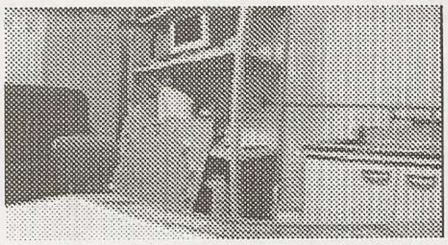
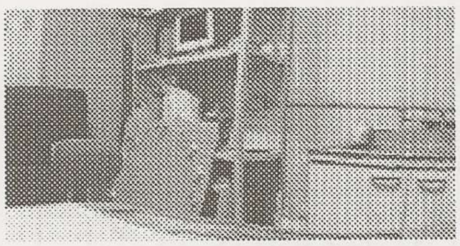


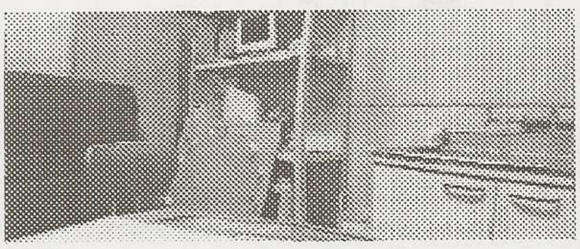
Fig. 6. Example panorama image with eight CCD cameras



(a)original image



(b)cylindrical projection



(c)plane projection

Fig. 4. Simulation results of projection

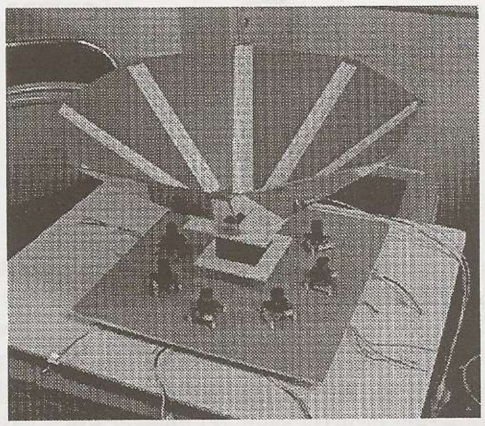


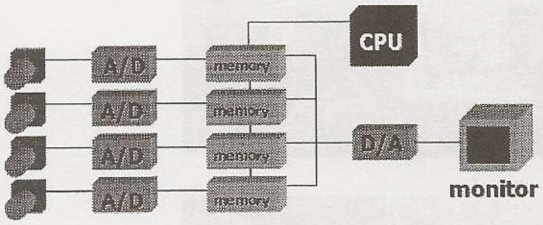
Fig. 5. Prototype system for wide view imaging with eight cameras

4. NEW RANDOM ACCESS IMAGE SENSOR

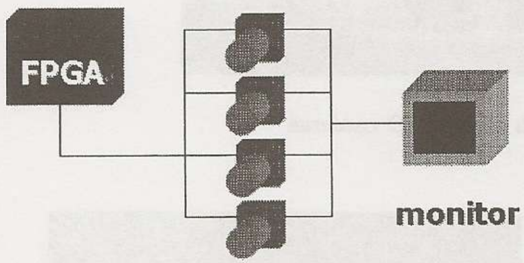
4.1. Design of the proposed sensor

We have fabricated a new random access image sensor for the wide view imaging system. The chip has the following functions.

- Pixel data is output by normal shift register or address decoder.
- Pixel value on every quarter position is estimated by averaging circuit.
- Each chip can be set its fixed number as sensor identification.
- The pixel value is amplified or adjusted for reduction of variation between sensors.



(a)normal CCD sensors



(b)random access sensors

Fig. 7. System architecture

Fig.8 shows the block diagram of the proposed sensor. Each pixel has a sample and hold circuit, and the timing of integration is same for all pixels. In " average circuit", adjacent four pixels are averaged for interpolation by using 16 capacitors. Fig.9 shows the circuit for the estimation of pixel value on quarter pitch between neighbor pixels. Two pixel values A and B are selected by four switches and stored in Cap1 to Cap4. Then the four stored values are averaged when switch CapoutSW is on. Fig.10 shows the example of interpolation. Suppose the pixel value on (01,01) are estimated, the value PD_{ave} is calculated by the following.

$$PD_{ave} = \frac{PD_1 \times 9 + PD_2 \times 3 + PD_3 \times 3 + PD_4 \times 1}{16} \quad (1)$$

We have designed the prototype sensor which consists of 128 x 128 pixels. Table 1 shows the outline of the sensor and Fig.11 shows the prototype chip.

4.2. Experiment

Fig.12 and 13 show the example images obtained by the prototype chip. Fig.12 shows the inverse or extended output images only when the address signal for output positions is controlled. The size, direction and extension of output image can be controlled by only the address signal and the estimation of interpolated pixel value can be done on the sensor.

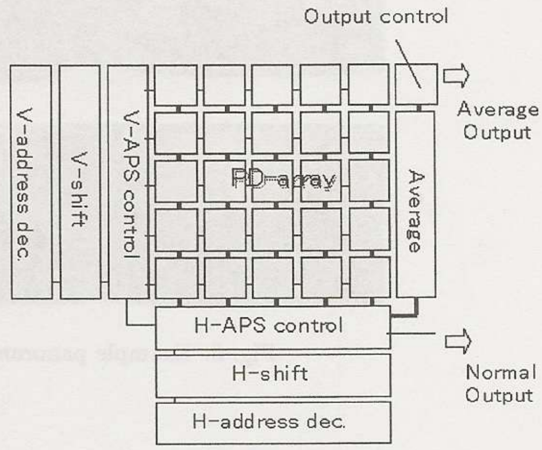
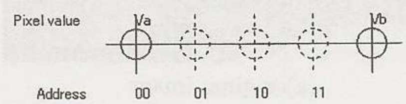
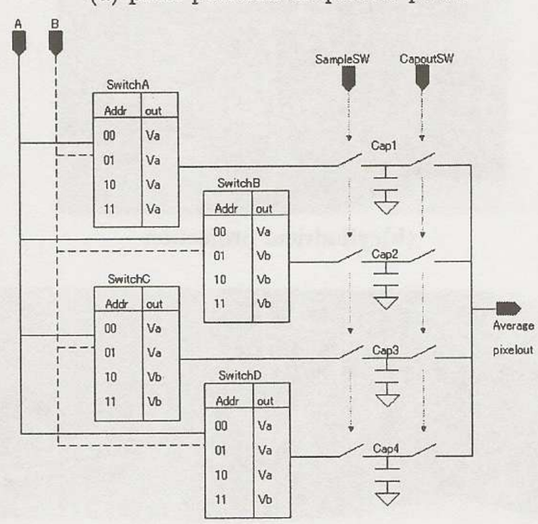


Fig. 8. Block diagram of the random access image sensor



(a) pixel position of quarter pitch



(b) circuit for estimation by averaging two pixel values

Fig. 9. Estimation of pixel value on quarter pitch between two pixels

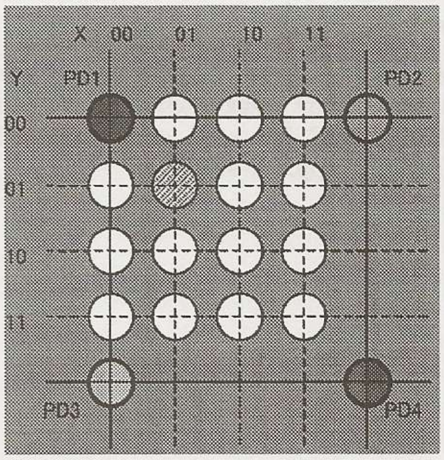


Fig. 10. Estimation of pixel value on quarter pitch between four pixels

Table 1. Outline of the random access image sensor

number of pixels[pixels]	128 ×128
CMOS process[μm]	0.6
die size[mm^2]	4.27×4.26
pixel size [μm^2]	22.0×22.0
number of transistors	
transducer[trs./pixel]	6
average processing[trs./chip]	537
fill factor[%]	22.1
power supply[V]	5

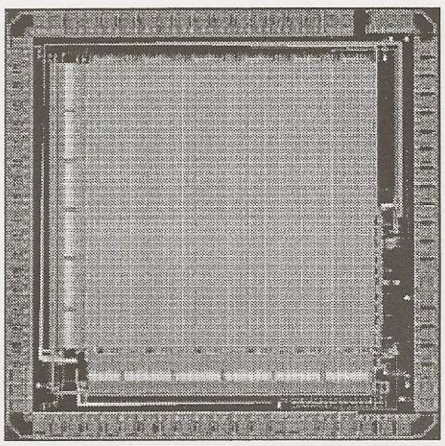
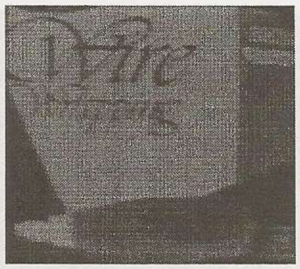
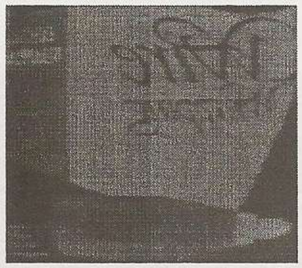


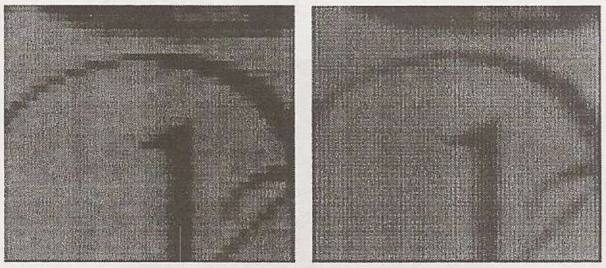
Fig. 11. Prototype chip



(a)normal output



(b)inverse output horizontally



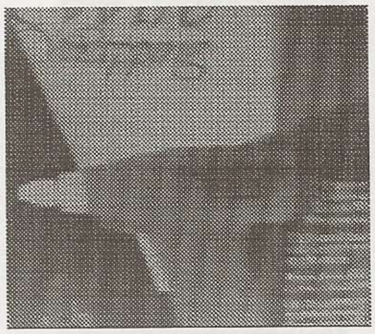
(c)extended image(left: integer pixel pitch, right: quarter pixel pitch)

Fig. 12. Inverse and extended images output by the proposed sensor

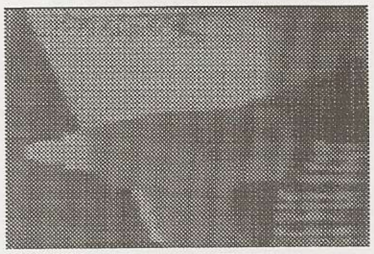
Fig.13(a) shows the output image when all pixel values at integer position are output. Fig.(b) and Fig.(c) show the projected output at integer position and interpolated position, respectively. On the monitor, it appeared that slope line in Fig.(c) is clear compared to Fig.(b).

5. CONCLUSION

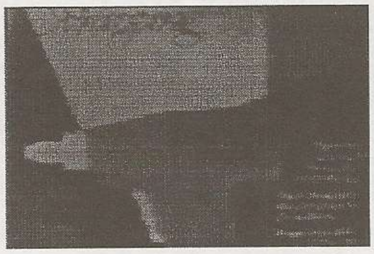
In this paper, we present a random access image sensor, which has 128 × 128 pixels, for wide view imaging system. The sensor is now under further evaluation. The detail of the design and the results of the imaging system will be presented in the conference.



(a)normal output



(b)projected output(integer pixel pitch)



(c)projected output(quarter pixel pitch)

Fig. 13. Projected images output by the proposed sensor

6. REFERENCES

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