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The Vision Chip with Electrical Fovea Motion

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1. Introduction

The human retina has smaller photoreceptors in the central region, namely fovea, to detect the accurate shape of targets with high resolution and larger photoreceptors in the peripheral region to detect the rough shape with reducing useless data[1,2]. Foveated vision is known to reduce the amount of information passed to subsequent processing layers significantly and therefore lends itself to image processing and pattern recognition tasks which are currently performed using uniformly spaced imagers. The foveated vision, however, has evolved concurrently with the eye motor system, where fovea focuses on areas of interest, because foveated vision chips were composed of photoreceptors with different size. It is great disadvantage to the foveated vision chip.

In this paper, we propose the vision chip which can electrically focus the fovea on the target using two resistive networks.

2.Algorithm for electrically moving fovea

Address-event representation is utilized as output format[3]. The value of the light intensity is represented by number of spike per unit time and spike sequencing.

In order to realize foveated structure electrically on the pixels with same size, we introduce two concepts; refractory period(RP) and receptive field, into the algorithm. The RP and the receptive field size depend on the distance from the fovea. Namely, the receptive field size at fovea is smaller than in peripheral region, and the RP at fovea is shorter than in peripheral region. Firstly, the pixel with largest signal in the active state is selected and address data is sent to the external device. Then the selected pixel moves to the pause state, in other words refractory period, to suppress successive data output from same pixel. The other pixels in receptive field also move to the pause state. After the refractory period, pixels move to active state and wait their turn to read out. As a result, data from peripheral region are suppressed and foveated structure is realized.

In order to realize this algorithm, we utilize two resistive networks in our vision as shown in Fig.1. One defines the center position of the fovea, the area of the receptive field and the refractory period. The other propagates the inhibitory signal from the selected pixel to other pixels in the receptive field.

The fovea position signal is applied and propagates through the resistive network I and modifies the diffusion length of the resistive network II. The receptive field size at each pixel depends on the diffusion length. Furthermore the refractory period at each pixel depends on the voltage on the resistive network I. When the pixel is selected and address data is sent out, the inhibitory signal propagates through the resistive network II and inhibits readout from adjacent pixels in receptive field.

Figure 2 shows the results of simulation to evaluate basic function of our algorithm. As is obvious in Fig.2 (b), a contrast emphasized image of the input image is obtained as an output image. In addition, as is clear in Figs.2(c) and 2(d), it is possible to reduce the total output data size maintaining the high resolution in the fovea.

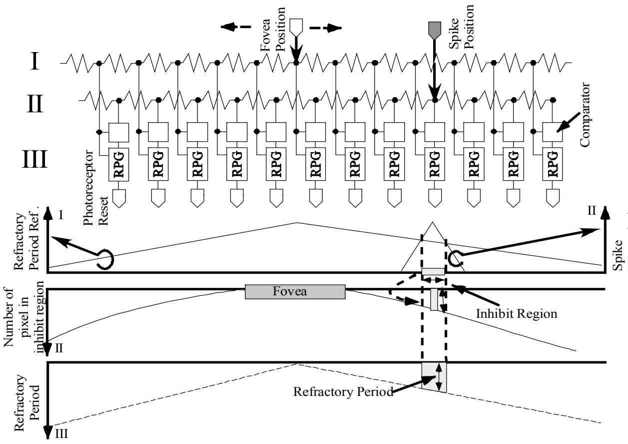


Fig. 1 Relationship between fovea position and inhibit region and refractory period.

(a)Input image. (128x96 256)

(b) Output image.

(c) Output image.
Center Region:15%
Center Position (X=64,Y=48)

(d) Output image.
Center Region:15%
Center Position (X=85 Y=60)

Fig. 2 Simulation Results.

3. Design of analog circuits for the vision chip

Our vision chip is divided into five circuit blocks: photocircuit, Winner Take All (WTA) unit, Refractory Period Generator (RPG) and two resistance networks as shown in Fig.3. WTA unit select the pixel with largest signal and read out address data. The output signal of WTA unit is sent to the RPG and the resistive network II. The RPG generates the refractory period. The schematic diagram of the RPG is shown in Fig.4. This circuit generates the control signal for turning off the photocircuit. The time of turning off a photociruit depends on the reference voltage. The reference voltage in proportion to the distance from the fovea, which is expressed as 'RP_CTL' in Fig.3, controls RP. 'RP_CTL' is generated by the resistive network I. The voltage distribution on the resistive network II defines the receptive field size. As a result, we can easily and rapidly change the fovea position.

Figure 5 shows the characteristic of RPG. It is clearly shown that the RP is commensurate to the reference voltage. It is obvious in Fig.6 that the RP and the number of pixel in receptive field depend on the distance from the fovea.

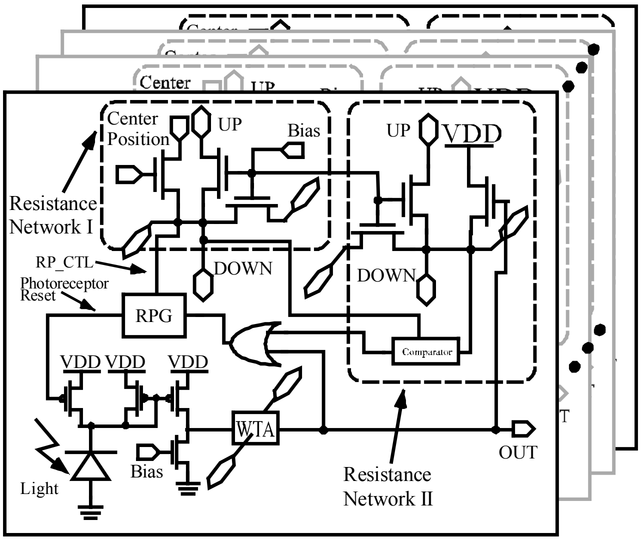


Fig.3 Schematic diagram of the vision chip with electrically moving fovea.

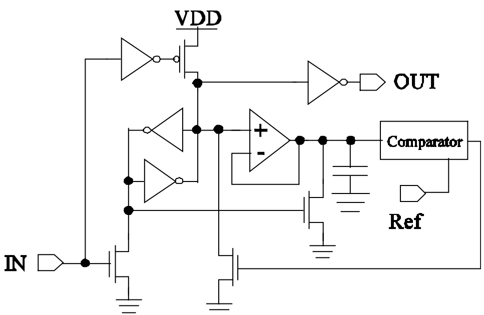


Fig.4 Schematic diagram of refractory period generator.

4. Conclusions

We propose the vision chip with electrical fovea motion using two resistive network. We employs the address-event representation as output format, the receptive field and the refractory period for our chip. The receptive field and refractory period are realized by two resistive networks. Furthermore the circuit blocks for our vision chip are designed and their basic functions were confirmed by simulation.

Acknowledgements

The VLSI chip in this study has been fabricated in the chip fabrication program of VLSI Design and Education Center(VDEC), the University of Tokyo in collaboration with Rohm Corporation and Toppan Printing Corporation.

References

[1] J.E.Dowiling, "*The Retina*", *Belknap Harvard*, *1987.*

[2] J.G.Nichollis, et al*, "From Neuron to Brain", Sinauer Associate, 1992.*

[3] E.Culurciello, et al., *ISSCC Dig. Of Tech. Paper, 2001,*p. 92.

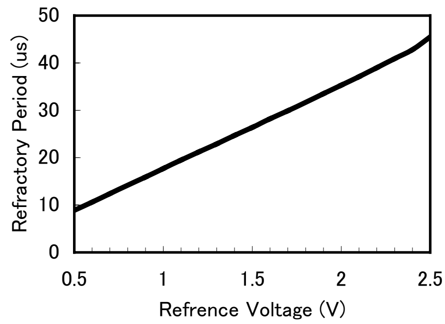
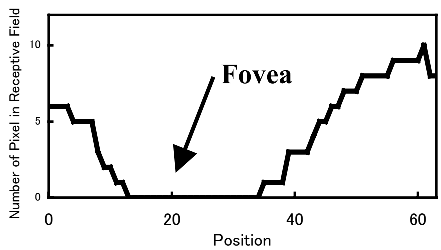
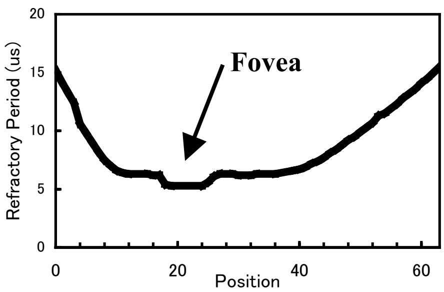


Fig.5 Characteristic of Refractory Period Generator.



(a) Receptive field size vs. distance from fovea.



(b) RP vs. distance from fovea.

Fig.6 Simulation results. Fovea Position: X=20