Department of Electrical, Electronic and Computer Engineering	Key words	Sensory information, Vision, Retina, Intelligent vision sensor, Neuromorphic Engineering, Robot vision, Network vision, Smart IT

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Education

Department of Physics, Faculty of Science, Nagoya University. Graduate School of Engineering, Master's program, Nagoya University. Graduate School of Medicine, Ph.D. program, Nagoya University

Professional Background

Research fellow/JSPS research follow, National Research Institute of Physiological Sciences. Assistant professor, Nagoya Institute of Technology. Associate professor, Kyushu Institute of Technology. Professor, Osaka University.

Consultations, Lectures, and Collaborative Research Themes

Image processing, Robot vision, Network vision, Visual control of vehicle, Visual psychophysics

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Main research themes and their characteristics

「Research and development of bioinspired visual system」

The visual system of the brain, that has continued to evolve since the birth of living creatures, is a masterpiece of image processing systems created by nature. The computational capabilities of the biological vision system and its efficiency are far more sophisticated than modern computers. In our laboratory, we have designed a novel image sensor called neuromorphic retina (NM retina) that incorporates the computational principles of visual information processing in the brain in order to utilize it as an eye of robot and artificial intelligence, and also as a substitute for the visual function of blind people.

(1). Development of the neuromorphic retina

The retina converts the continuously changing images of the outside world into electrical information in real time and then extracts the image features critical for higher order computations, e.g., object recognition. Inspired by the function and the structure of the retina, we design a mixed analog/digital integrated image sensor, NM retina. The NM retina executes a spatial as well as temporal band pass filtering on the continuously incoming image, and sends this highly compressed image to the host computer with extremely high efficacy (Fig. 1).

(2). Application of NM retina to robotics and AI

Since the NM retina greatly reduces the computational load of the host computer, it can be applied to visual control of robot and image recognition of artificial intelligence (AI). Fig. 2 shows a real time binocular eye movement control, which is a highly cumbersome computation for solely digital system, using two NM retinas. Using NM retinas, it becomes much easier to conduct the computation of stereovision in real time with extremely low power consumption.

(3). Bionic eye research

The artificial vision is a possible future medical treatment for blindness that partially restores the lost visual function due to serious eye damages. In the development of artificial vision, it is crucial to device an intelligent visual sensor system that efficiently compresses the incoming image and wirelessly communicates with a implanted electrical device in the brain with low power dissipation. The NM retina is considered to meet these requirements and therefore we assess optimal design of the artificial vision system using the NM retina that can be put into clinical practice (Fig. 3)

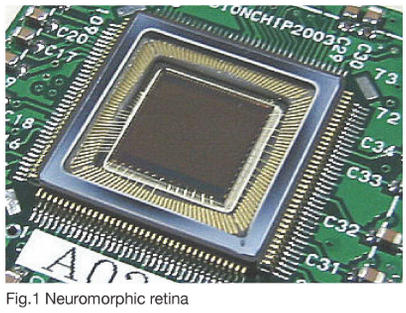

Fig.1 Neuromorphic retina

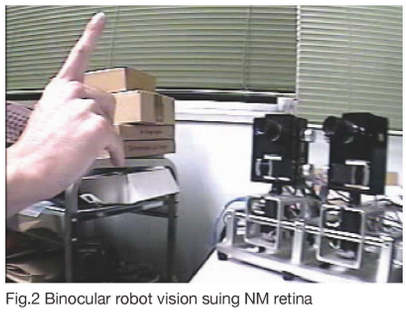

Fig.2 Binocular robot vision suing NM retina

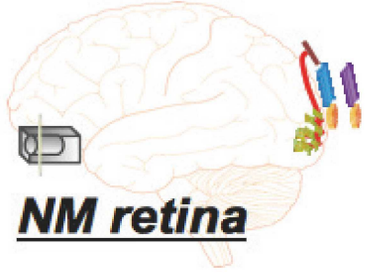

Fig.3 Novel design of the artificial vision

Major academic publications

Y. Tanaka, T. Nomoto, T. Shiki, Y. Sakata, Y. Shimada, Y. Hayashida, T. Yagi, "Focal activation of neuronal circuits induced by microstimulation in the visual cortex", Journal of Neural Engineering, 16(3),036007, (2019)

S. Miyamoto, N. Suematsu, Y. Umehira , Y. Hayashida, T. Yagi, "Age-related changes in the spatiotemporal responses to electrical stimulation in the visual cortex of rats with progressive vision loss", Scientific Reports 7, Article number: 14165 (2017)

Y. Hayashida, Y. Kudo, R. Ishida, H. Okuno, and T. Yagi, "Retinal circuit emulator with spatio-temporal spike outputs at milliseconds resolution in response to visual events", IEEE Transactions on Biomedical Circuits and Systems,vol.11, No.3, pp.597-611, (2017)

S. Yasukawa, H. Okuno, K. Ishii, T. Yagi, "Real-time Object Tracking Based on Scale-invariant Features Employing Bio-inspired Hardware", Neural Networks, vol.81, pp.29-38, September (2016)