Bio-Inspired Image Sensor: Half-Squaring/Normalization Model of Simple and Complex Cells (SB3-03)

Student: LIU, Kin Yat (01639614)

Supervisor: Dr. Bertram Shi
INTRODUCTION

Have you ever wondered how we see things? Although our eyes are important for vision, it is solely acting as the interface between light reflected from the object to the electrical or chemical signals. This is similar to CCD in digital camera. In fact, what really enable us to see things is the neurons (Figure 1) inside our Primary Visual Cortex V1 (Figure 2). In this project, we mapped a physiological model of the neurons into silicon chip.

WHY BIOLOGY?

Biological vision systems have advantages of:
(i) good power efficiency,
(ii) compact size, and
(iii) noise immunity.

Compared to current state of the art digital image processors, neural vision systems advance several magnitude over the conventional Digital Signal Processing Chip (DSP) and solve many ill-posed problems in machine vision. Thus, by using the working principle of neural vision, we can build a high performance vision system that can 'see'.
The Physiological Model

This model is called Half-Squaring / Normalization. Neurons in the cortex V1 can be classified as:
(i) Simple Cell, and
(ii) Complex Cell.

When signal is fed into simple cell, the response is a half wave rectified and squared (Half-Squaring); The signals are then the input of complex cells which in turn, together with other complex cells suppress the output of simple cells (Normalization).

If such a model is implemented in silicon, contrast normalization can be achieved and the following functions can be realized in electronic system:
(i) Binocular Disparity,
(ii) Motion Orientation, and

Silicon Chip

In this project, we used silicon technology called Complementary Metal Oxide Silicon (CMOS) for the implementation of the physiological model. Using this technology, we can build a system with advantages of:
(i) High Integration Density
(ii) Low Power Dissipation,
(iii) Physical similarity with neurons.
**System**

The system consists of four components:
(i) Spiking Neuron,
(ii) Leaky Integrator,
(iii) Half-Squaring Circuit
(iv) Normalization Circuit

**Schematics**

Figure 5. System Block Diagram of the Half-Squaring / Normalization Circuit.

Figure 6. Schematics of Half-Squaring and Normalization Circuit.

**Reference**