INF5470 — Fall 2010

Philipp Häfliger

Lecture 6: Retinomorphic Vision
Content

The Eye and Retina

Photo Active CMOS Elements

CMOS Photo Circuits

Read-Out Strategies

Retinomorphic Circuits

Further (Neural?) Image Processing
  Motion Processing
  Feature Extraction
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Eyeball Cross Section
Retina Cells

Structure of retina: schema

- A: Amacrine cells
- B: Bipolar cells
- C: Cones
- G: Ganglion cells
- H: Horizontal cells
- P: Pigment cells
- R: Rods
Schematized Retinal Cells
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Photo Diode, Impact Ionization
Photo Diode Layout
Photo Transistor Layout
Photo Gate
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Amplification by Early Effect
Logarithmic Amplification
Common Source Amplifier

\[ V_{in} \rightarrow M_{in} \rightarrow V_{out} \]

\[ V_{bias} \rightarrow V_{out} \]

\[ I_{out} = \frac{V_{dd}}{M_{in}} - V_{bias} \]

\[ V_{out} = A(V_{dd} - V_{in} - V_{bias}) \]

\[ A = A(V_{bias}) \]
Common Source, Negative Feedback
Source Follower

3-transistor Active Pixel Sensor (APS)
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Overview

- Addressing/Scanning
- Charge Coupled Devices (CCD)
- Address Event Representation (AER)
Scanning

Clk → scanner (shiftreg) → row sync

out → scanner (shiftreg)

pixel → pixel → pixel

pixel → pixel → pixel

pixel → pixel → pixel
CCD
AER
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Adaptive Pixel
Non-Linear Element (Tobi-Element)
Retina Pixel (Mahowald)
Retina Pixel (Boahen)
Dynamic Vision Sensor (DVS) Pixel (Lichtsteiner)

Key techniques - 
Active logarithmic front end 
Self-clocked switch-cap differentiator
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Token Based Motion Processing: Reichardt Detector
Intensity Based Motion Processing
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A Natural Scene
‘Difference of Gaussians’ Kernel(1/2)
‘Difference of Gaussians’ Kernel (2/2)
Contrast Enhanced Natural Scene
45 Degrees Edge Kernel (1/2)
45 Degrees Edge Kernel (2/2)
45 Degrees Edges Extracted from Natural Scene