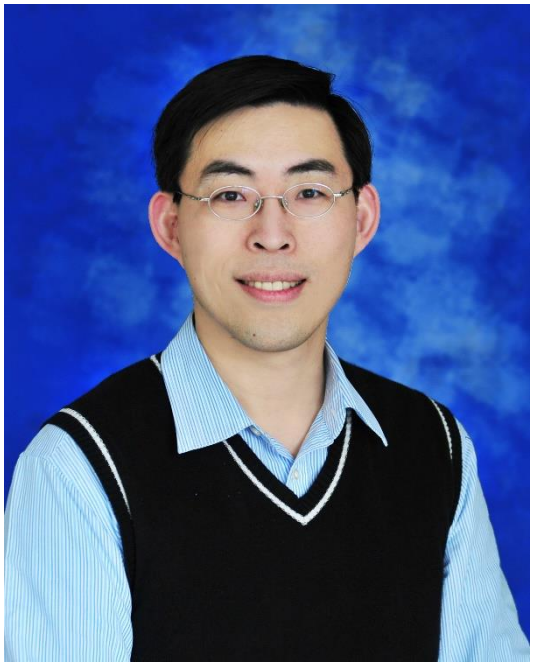
ENIAC
嵌入式仿神經人工智慧晶片團隊
Embededd Neuromorphic & Integrated AI Chips



鄭桂忠

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Research Interests

- **生醫及仿神經電路與系統**

  Biomedical and neuromorphic circuit and system

- **仿生嗅覺系統-電子鼻**

  Bio-inspired olfaction system – Electronic nose

- **醫用植入、腦機介面、神經輔具**

  Medical implant, brain-machine interface, neural prosthesis

- **類比/混合積體電路**

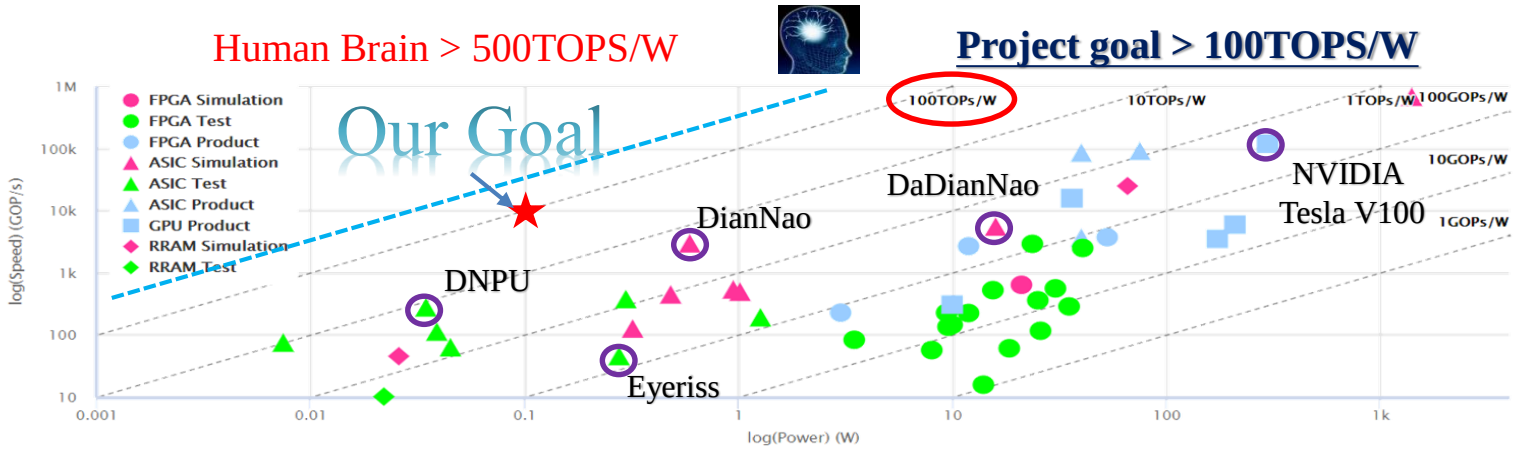
  Analog/Mixed signal VLSI

Enabling Technology of Object Recognition and Tracking for Mobile Devices

Neuromorphic Intelligent Vision System-on-Chip

PI: Kea-Tiong (Samuel) Tang, Dept. of EE, NTHU
Co-PI: Chih-Cheng Hsieh, Chung-Chuan Lo, Ren-Shuo Liu, Hsin Chen

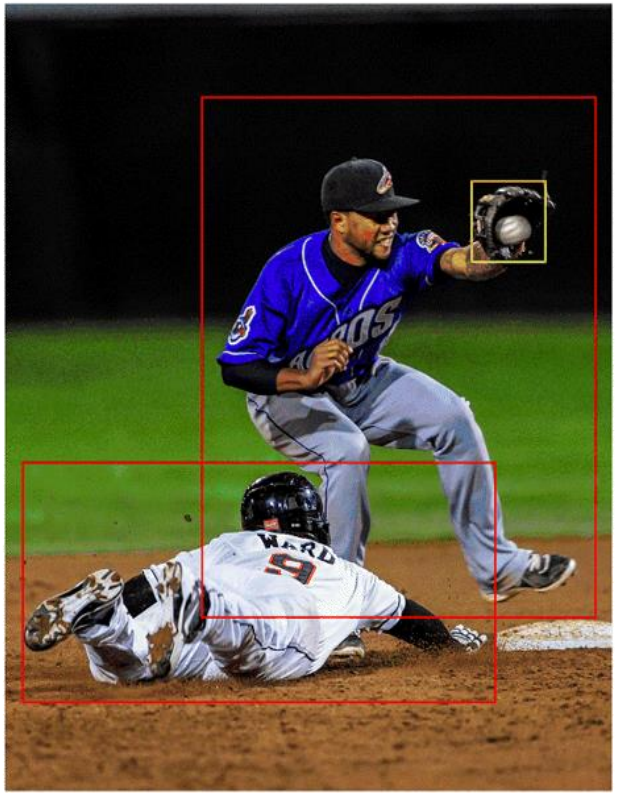
Goal: Approaching the Energy Efficiency of Human Brain



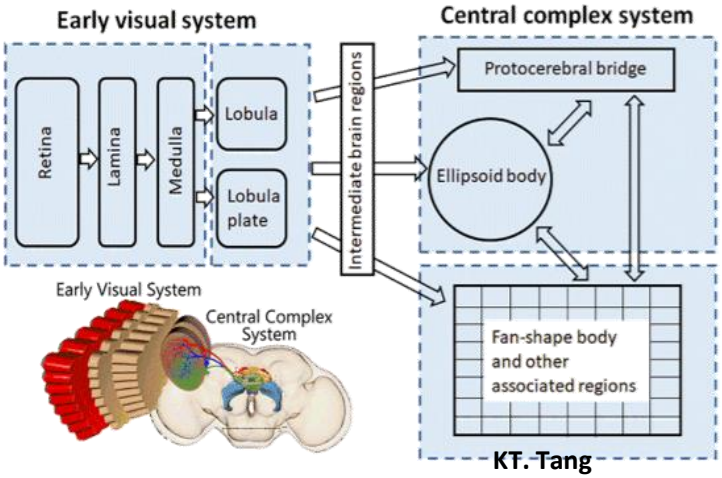
"To overcome the limitations of AI, we must build a bridge between computer science and biology ——Geoffrey Hinton"

- To achieve visual functions of recognition and tracking in mobile devices, the systems need 10 TOPS/s computation at low power.
- To approach the energy efficiency of human brain, we design the neuromorphic fruit fly visual system to develop next generation AI chip.

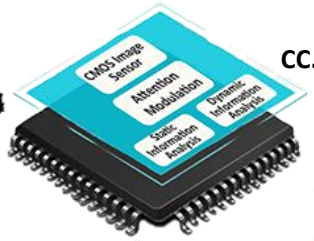
Neuromorphic Realization of the Fruit Fly Visual System

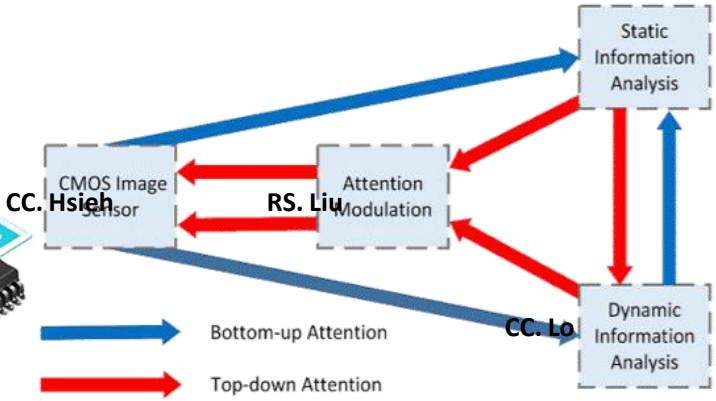


Drosophila
(Fruit Fly)



Neuromorphic
Intelligent
Vision System



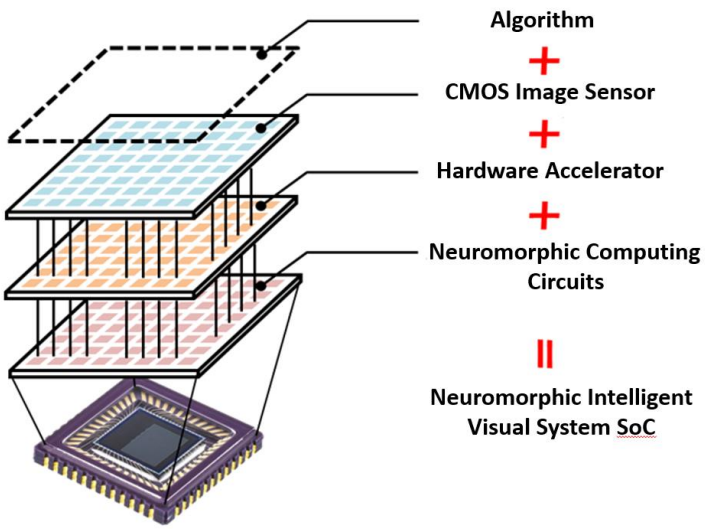


Project Summary

※ **Limitation: The massive computation, power consumption, and heat dissipation limit the feasibility of machine vision AI system at edge and mobile devices.**

※ **Solution: Develop neuromorphic intelligent vision system chip by mimicking biological visual systems.**

※ **Highlight：Low-power, real-time mobile recognition and tracking module**



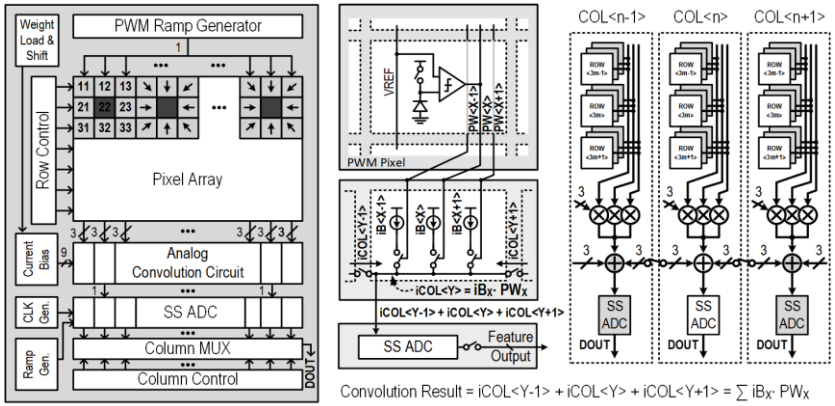
- **Neuromorphic architecture:** Compute the multiply-and-accumulate (MAC) operations using in-memory computing by memory crossbar architecture to avoid energy consumption due to data movement and improve energy efficiency at inference.
- **Neuromorphic system:** Design an event-triggered asynchronous system as spiking neural network to improve energy efficiency.
- **Neuromorphic action detection algorithm:** Build an insect dynamic visual model to detect corresponding actions by temporal response.
- **Neuromorphic circuits:** Build the spiking neural network circuits including neurons, synapse, learning circuits, etc.

Technology Highlight No. 1

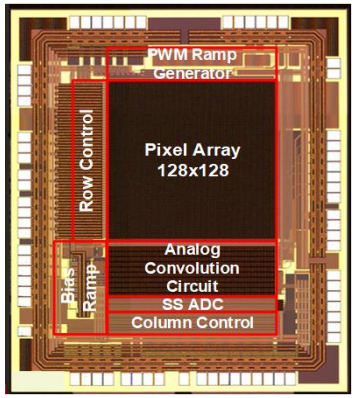
0.5V Programmable 4-bit Weight Convolutional CMOS Image Sensor

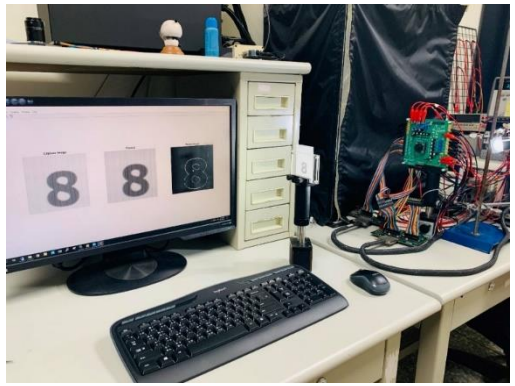
Key Technology

1. 0.5V CIS in TSMC 0.18um Technology
2. 128x128 Linear-response PWM pixel array
3. Programmable 3x3 kernel with 4-bit weights
4. Tunable-resolution column-parallel ADC
5. Real-time analog-domain convolution-on-readout technique



Convolution Result = $iCOL<Y-1> + iCOL<Y> + iCOL<Y+1> = \sum iB_X \cdot PW_X$





Image：Raw Data

Convolution A-B：Edge

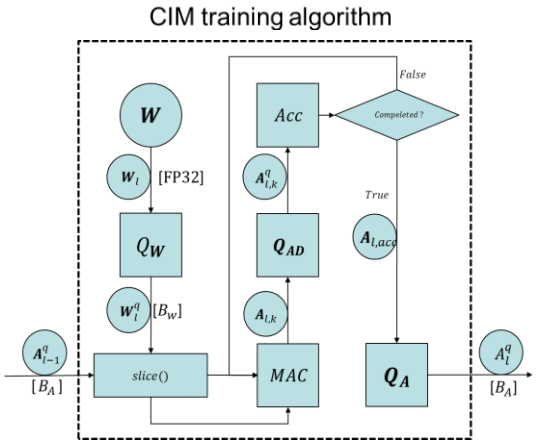
Convolution：Positive Kernel

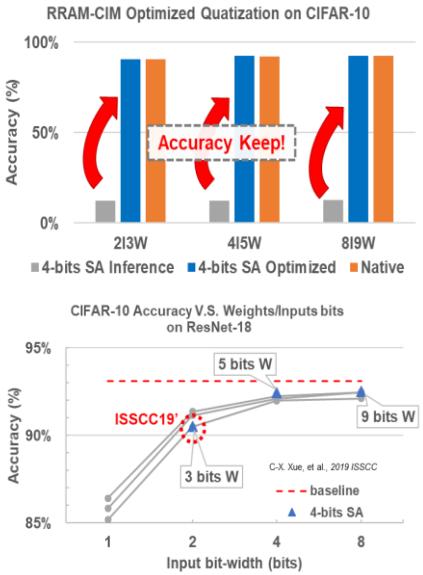
Convolution：Negative Kernel

Technology Highlight No. 2

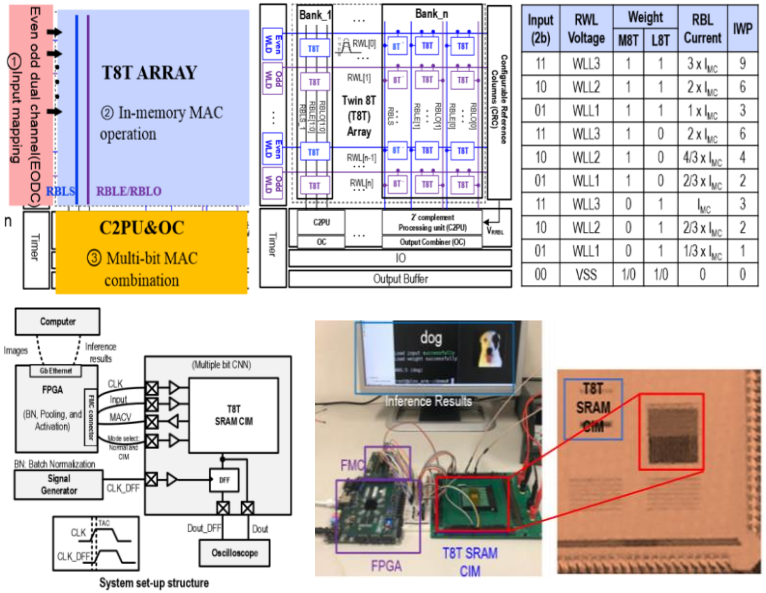
In-memory Computing Marco and Algorithm for Deep Neural Network

- **Model compression based on In-memory computing**
  - ResNet-18 model for CIFAR-10 dataset.
  - Optimization for ADC output resolution limitation.





- **Twin-8T SRAM In-Memory Computing Macro**

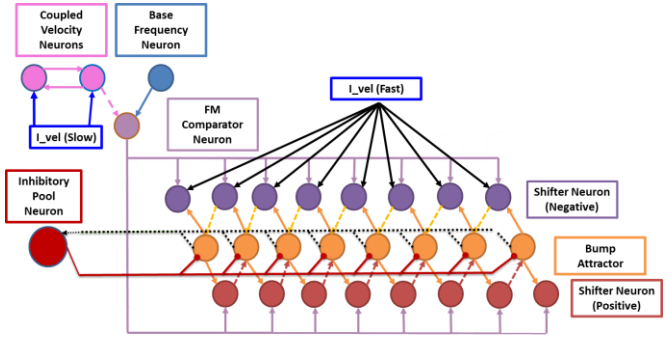


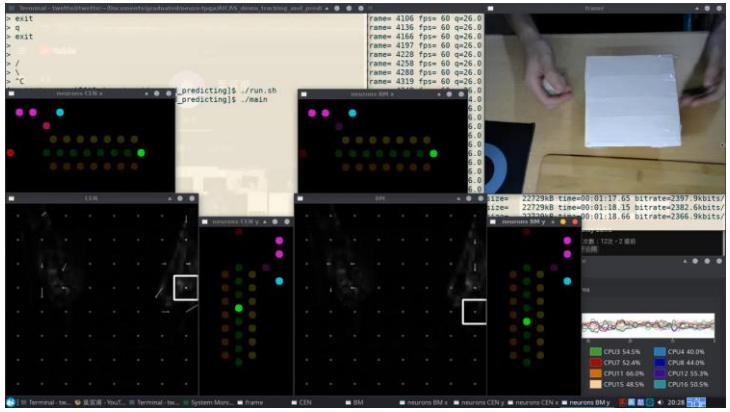
Input (2b)	RWL Voltage	Weight M8T	Weight L8T	RBL Current	IWP
11	WLL3	1	1	$3 \times I_{MC}$	9
10	WLL2	1	1	$2 \times I_{MC}$	6
01	WLL1	1	1	$1 \times I_{MC}$	3
11	WLL3	1	0	$2 \times I_{MC}$	6
10	WLL2	1	0	$4/3 \times I_{MC}$	4
01	WLL1	1	0	$2/3 \times I_{MC}$	2
11	WLL3	0	1	I_{MC}	3
10	WLL2	0	1	$2/3 \times I_{MC}$	2
01	WLL1	0	1	$1/3 \times I_{MC}$	1
00	VSS	1/0	1/0	0	0

Technology Highlight No. 3

Neuromorphic Object Tracking Algorithm Based on Insect Neural Model

- **Sub-network model for object tracking**





- **Neuromorphic autonomous car**
  - The central complex network in fruit flies