香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Introduction to Me &
My Undergraduate Research Training

Renyuan Liu (刘稔远)

Machine Life and Intelligence Research Center
School of Mathematics and Information Science
Guangzhou University, Guangzhou, China

1. Personal Introduction

2. Research Training

Experience

香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Renyuan Liu (刘稔远)

Enjoy Basketball, Cooking, Photograph, Hiking ...

Guangzhou University

Sept. 2022 - Jun. 2026(Expected), UG Student

- B.Eng. in computer science (Information Security)
  GPA: **89.81**/100.00; Ranking: **Top 8 %**
- Machine Life and Intelligence Research Center (**~ 3years**)
  5 published papers and 2 under peer review
  Supervisor: Prof. Qinbing Fu

The University of Hong Kong / University of Macau

Nov. 2023, Interdisciplinary Programme, Team Leader

- Commendation Letter for the Winning Team
- GPA: **97.50/100.00**

The University of York, UK

Jun. 2025 - Sept. 2025, Research Associate

- Computational Autonomous Learning Systems Lab, Dept. of CS
  Biologically-plausible mechanisms for life-long learning machine intelligence
  Supervisor: Prof. Pengcheng Liu

Selected Awards

香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Renyuan Liu (刘稔远)

Enjoy Basketball, Cooking, Photograph, Hiking ...

- ✓ **Honorable Mention (International)**
  Mathematical Contest in Modeling (MCM)
  Jan. 2025
- ✓ **First Prize (National; Top 5%)**
  Asia and Pacific Mathematical Contest in Modeling (APMCM)
  Nov. 2024
- ✓ **First Prize (Provincial; Top 3%)**
  Chinese Collegiate Computing Competition (4C)
  May 2025
- ✓ **First Prize & Innovation Silver Award (Provincial; Top 0.2%)**
  "Greater Bay Area Cup" Guangdong-Hong Kong-Macao Financial Mathematics Modeling Competition
  Nov. 2024
- ✓ **Second-Class Scholarship (Top 8%)**
  Guangzhou University, Dec. 2025
- ✓ **Third-Class Scholarship (Top 12%)**
  Guangzhou University, Nov. 2024
- ✓ **First-Class Scholarship (Top 5%)**
  Guangzhou University, Dec. 2023

……

1. Personal Introduction

2. Research Training

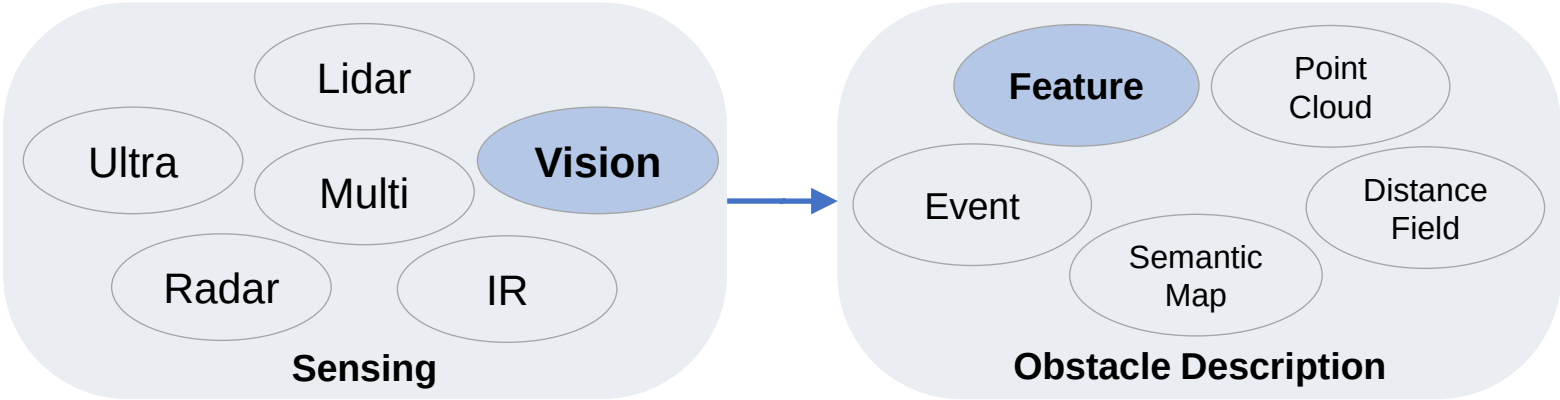
Introduction

Our Vision	A Real-Time, Robust and Low-Cost Collision Perception Solution

Robotic Navigation [13]

Collision Risk [16]

Swarming Locusts: Collision Free

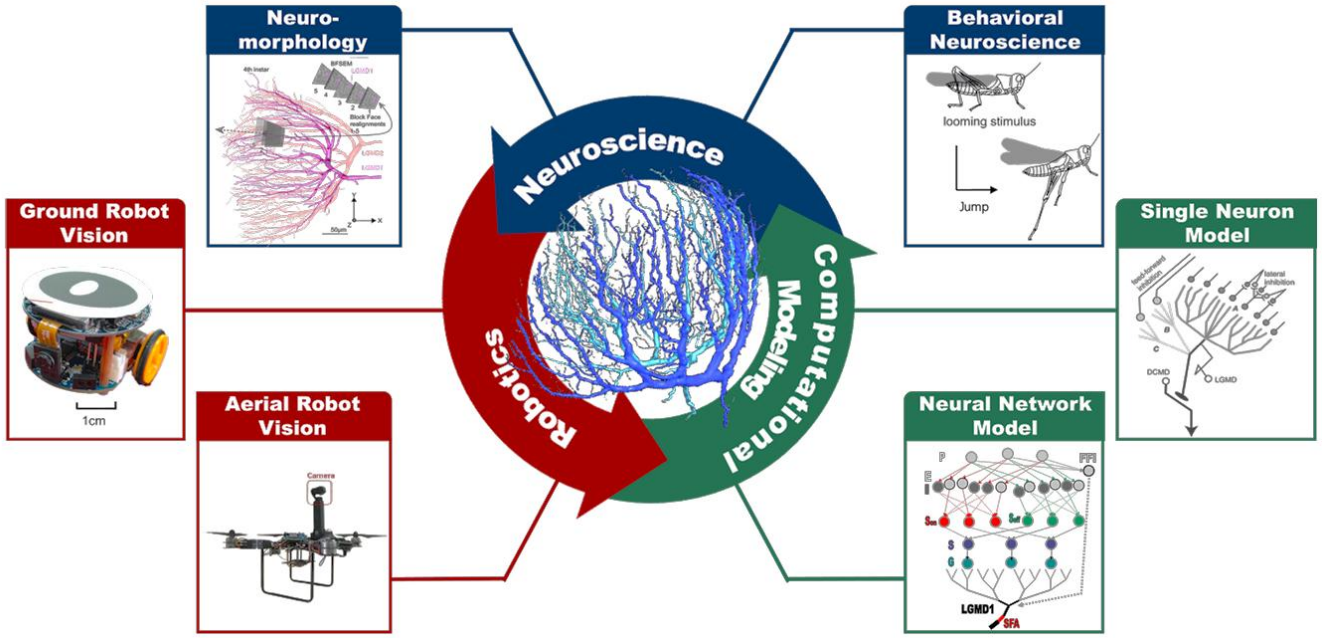


Can robots sense collision like insect do?

Existing Methods (Pros and Cons)

Overview of Our Research Area

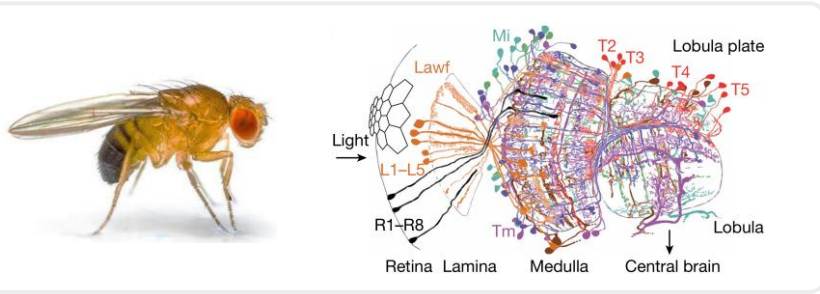
Our Vision	A Real-Time, Robust and Low-Cost Collision Perception Solution



Z. Qin et al., 2025, Journal of Royal Society Interface

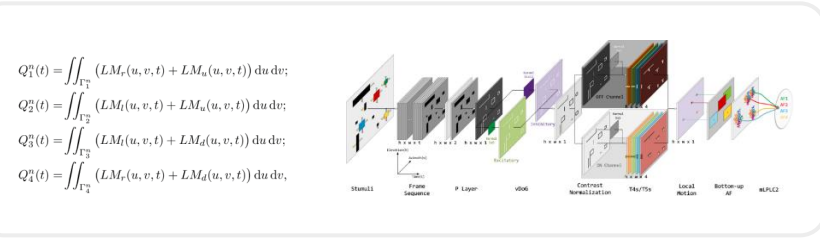
Computer Science & Robotics & Biology [1]

Inspiration



Insect Vision [19]

Application



$$Q_1^n(t) = \iint_{\Gamma_1^n} \left(LM_r(u,v,t) + LM_u(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v;$$
$$Q_2^n(t) = \iint_{\Gamma_2^n} \left(LM_l(u,v,t) + LM_u(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v;$$
$$Q_3^n(t) = \iint_{\Gamma_3^n} \left(LM_l(u,v,t) + LM_d(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v;$$
$$Q_4^n(t) = \iint_{\Gamma_4^n} \left(LM_r(u,v,t) + LM_d(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v,$$

Neural Networks [3]

Machine Vision

Academic Activities:

- 30-min Oral Presentation, *The 14th International Conference on Biomimetic and Biohybrid Systems (Living Machines 2025)*
- Poster Presentation, *The 26th Towards Autonomous Robotic Systems (TAROS 2025)*
- Online Presentation, *The 2025 International Joint Conference on Neural Networks (IJCNN 2025),*
- *The 2024 International Conference on Motion Perception and Sparse Optimization (ICMPSO 2024)*

Academic Publication & Manuscripts under Review:

[1] **R. Liu** and Q. Fu, Attention-Driven LPLC2 Neural Ensemble Model for Multi-Target Looming Detection and Localization. *The 2025 International Joint Conference on Neural Networks (IJCNN) (**CCF-C**, 2025 AR ≈ 38%).*

[2] **R. Liu**, H. Zhou, C. Fang and Q. Fu, How Fly Neural Perception Mechanisms Enhance Visuomotor Control of Micro Robots. ***Under review** in The 2026 International Conference on Robotics and Automation (ICRA) (**CCF-B**).*

[3] M. Wang*, **R. Liu*** and Q. Fu, Enhancing Collision-Selectivity in Autonomous Micro-Robots by Elevated Temporal Derivatives in Neuronal Assembly Framework. ***Under review** in IEEE Transactions on Cognitive and Developmental Systems (**JCR Q1**, IF = 4.9).*

[4] G. Gao*, **R. Liu**, M. Wang and Q. Fu*, A Computationally Efficient Neuronal Model for Collision Detection With Contrast Polarity-Specific Feed-Forward Inhibition. *Biomimetics, vol. 9, no. 11, p. 650, 2024 (**JCR Q1**, IF = 3.9).*

[5] C. Fang*, H. Zhou, **R. Liu**, and Q. Fu*, A neuromorphic binocular framework fusing directional and depth motion cues towards precise collision prediction. *Neurocomputing, 131660, 2025 (**JCR Q1**, **CCF-C**, IF = 6.5).*

[6] H. Zhou, C. Fang, **R. Liu**, and Q. Fu, A Bio-Plausible Neural Network Integrating Motion and Disparity Pathways for Looming Perception. *Acta Electronica Sinica (电子学报), p. 1-16, 2025 (**CCF-A** in Chinese Category).*

[7] J. Huang*, Z. Qin, M. Wang, **R Liu**, and Q. Fu*, A Biomimetic Collision Detection Visual Neural Model Coordinating Self-and-Lateral Inhibitions. *The 14th International Conference on Biomimetic and Biohybrid Systems (**Oral**).*

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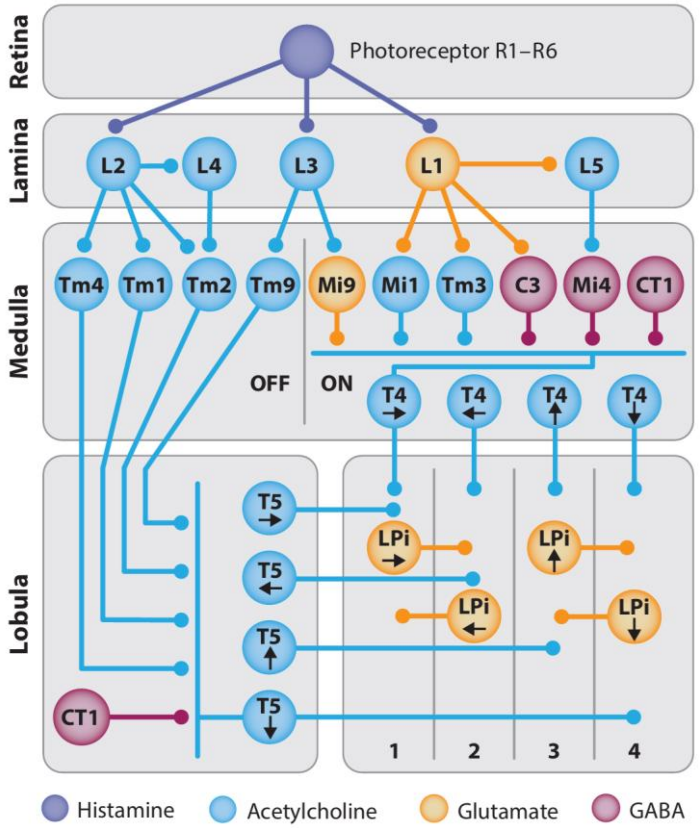
Fly-Inspired Visual Systems



Borst et al., 2024, Annual Review of Neuroscience

Fly's Visual System [19]

Paper 1 :

INTERNATIONAL JOINT CONFERENCE ON NEURAL NETWORKS
IJCNN2025
30 JUNE - 5 JULY 2025 | ROME, ITALY
INTERNATIONAL NEURAL NETWORK SOCIETY

- ✓ **Published at IJCNN 2025**
- ✓ **CCF-C**
- ✓ **Acceptance Rate ≈ 38%**
- ✓ **First Author**

Paper 2 :

ICRA
IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION

2026 VIENNA

- ✓ **Under Review at ICRA 2026**
- ✓ **CCF-B;**
- ✓ **First Author**

INTERNATIONAL JOINT CONFERENCE ON NEURAL NETWORKS
IJCNN2025
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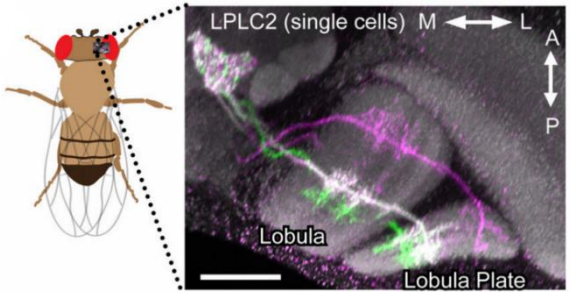
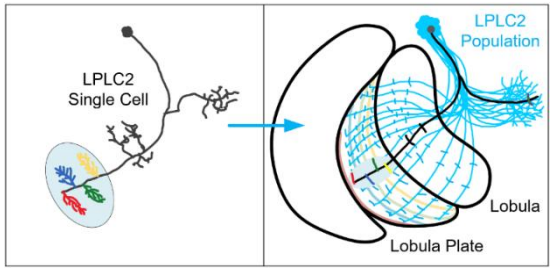
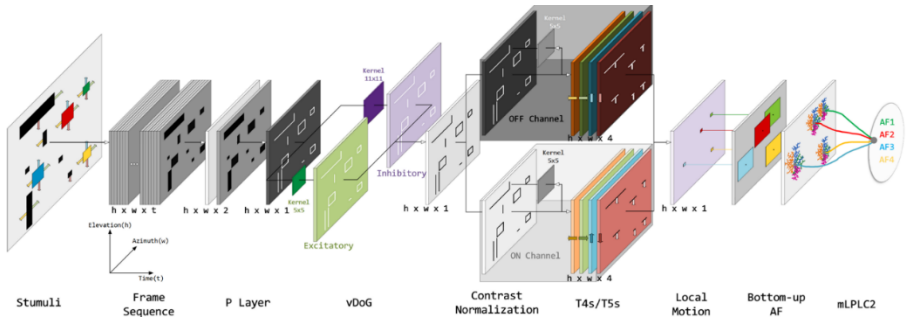
Core Problem	**How to achieve robust and multi-target collision perception**

To address the **insufficient selectivity** of locust-inspired collision detection model, we propose a fly-inspired neural network enabling **ultra-selective** and **multi-target detection**.



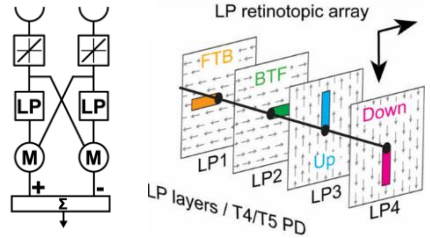


LPLC2 Neuron Population [5]



Directional Motion Cue:

$$M_{r_i}(x,y,t) = N(x,y,t)\cdot D(x,y,t)\cdot D(x+sd,y,t) - \beta\cdot N(x+sd,y,t)\cdot D(x,y,t)\cdot D(x+sd,y,t),$$



Ultra-Selective LPLC2 Cells:

$$Q_1^n(t) = \iint_{\Gamma_1^n} \left(LM_r(u,v,t) + LM_u(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v;$$

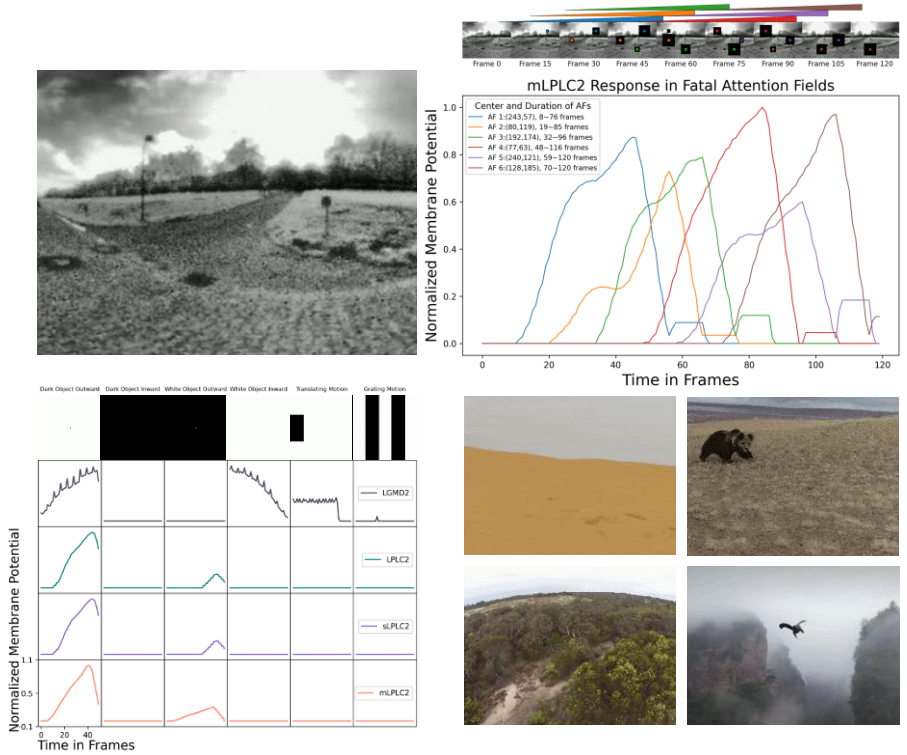
$$Q_2^n(t) = \iint_{\Gamma_2^n} \left(LM_l(u,v,t) + LM_u(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v;$$

$$Q_3^n(t) = \iint_{\Gamma_3^n} \left(LM_l(u,v,t) + LM_d(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v;$$

$$Q_4^n(t) = \iint_{\Gamma_4^n} \left(LM_r(u,v,t) + LM_d(u,v,t)\right) \mathrm{d}u\,\mathrm{d}v,$$

$$LPLC2^n(t) = bool\left(\prod_{i=1}^{4} Q_i^n(t)\right) \times \left(Q_1^n(t) + Q_2^n(t) + Q_3^n(t) + Q_4^n(t)\right)$$

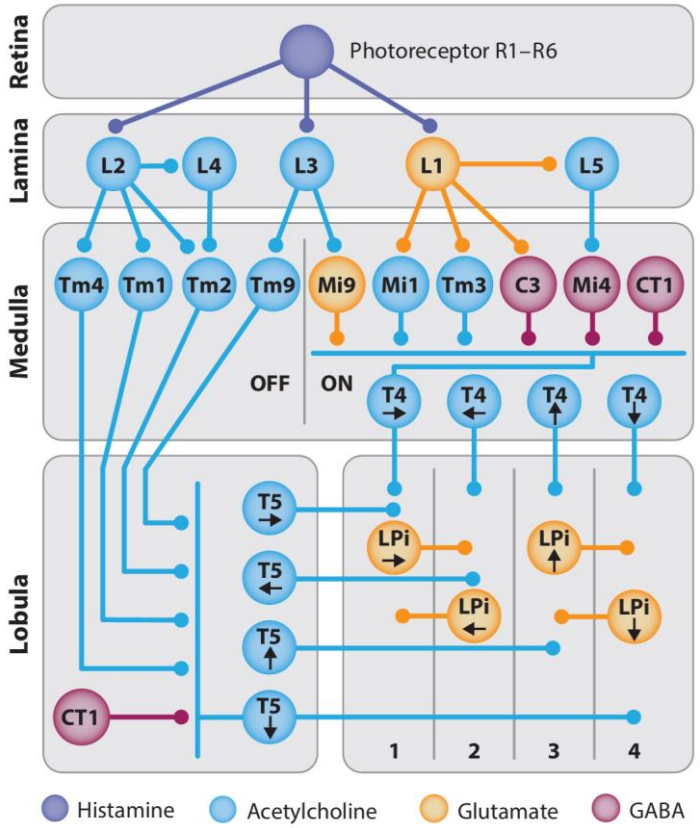
Method



Results: Ultra-selectivity & Multi-Target

The first bio-inspired multi-target collision perception algorithm

Fly-Inspired Visual Systems



Borst et al., 2024, Annual Review of Neuroscience

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ICRA
IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION

2026 VIENNA

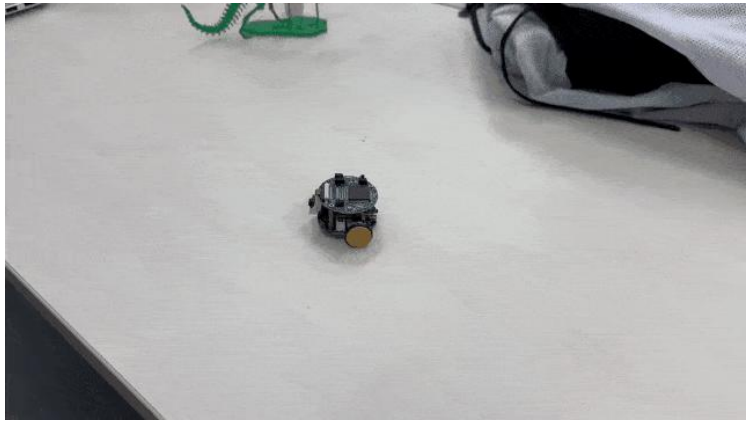
- ✓ Under Review at ICRA 2026
- ✓ CCF-B;
- ✓ First Author

Core Problem

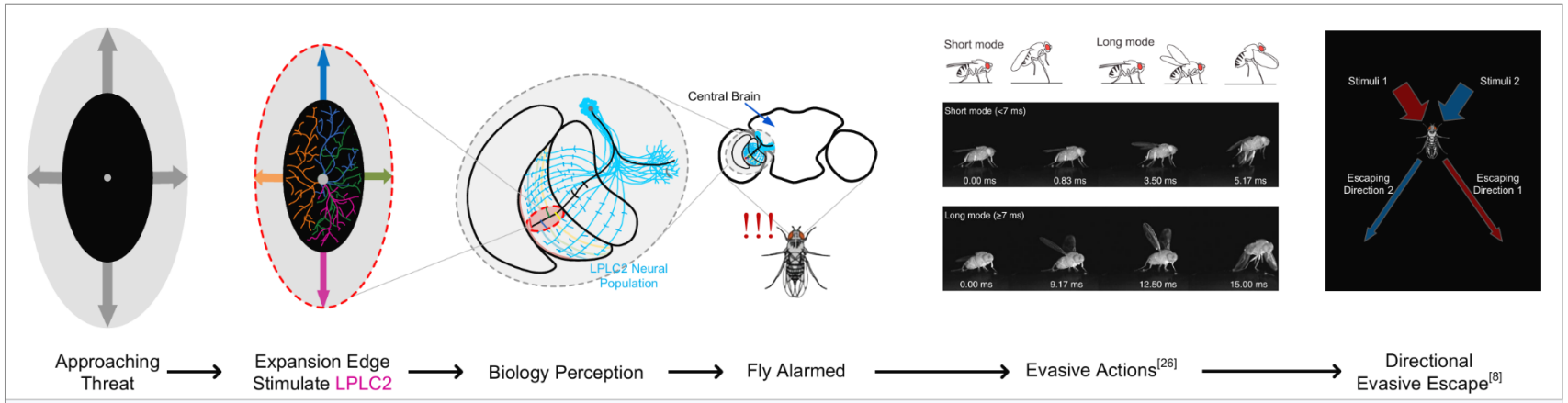
How to mitigate trade-off between resource and performance

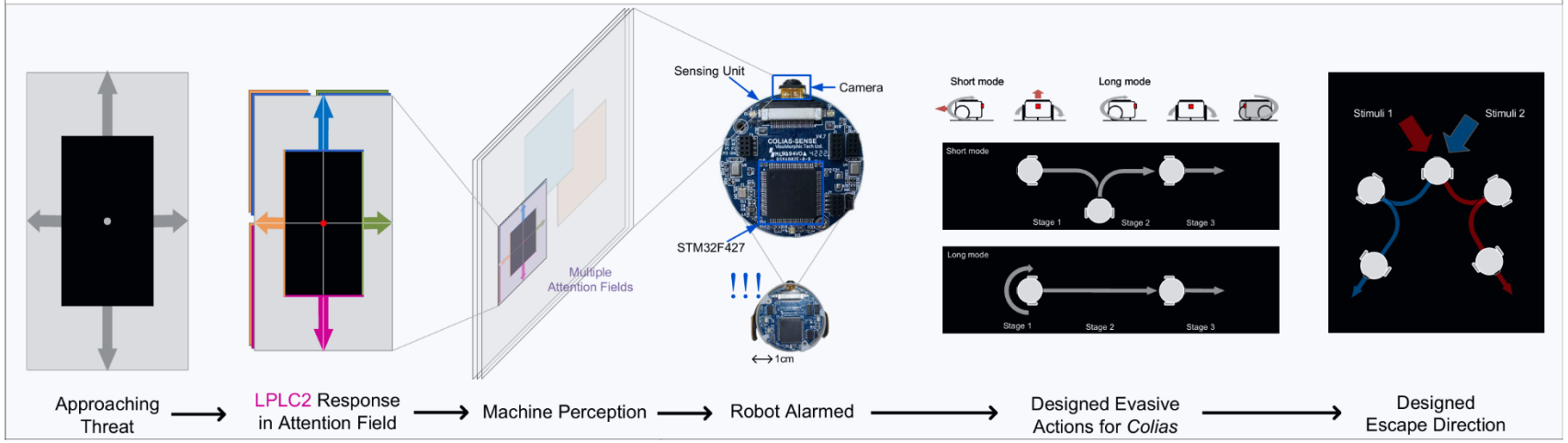
To mitigate the **trade-off** between **performance** and **computational cost**, we propose a **fly-inspired** lightweight **visuomotor** control strategy that enables real-time and robust collision evasion on a **micro-robot**.

Fly alarmed !!!



"Fly" alarmed !!!



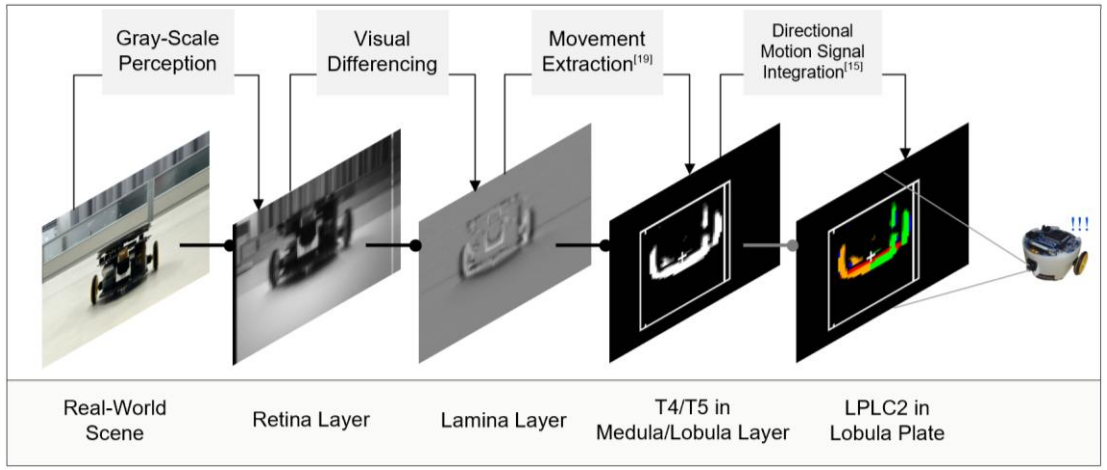


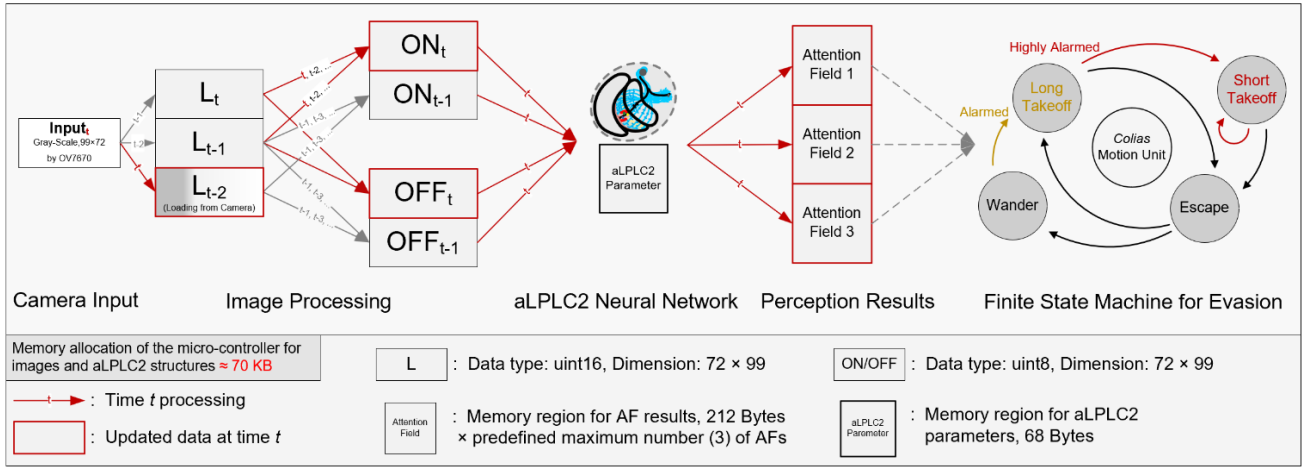
Fly-inspired attention-driven LPLC2 visuomotor system (ALVS)

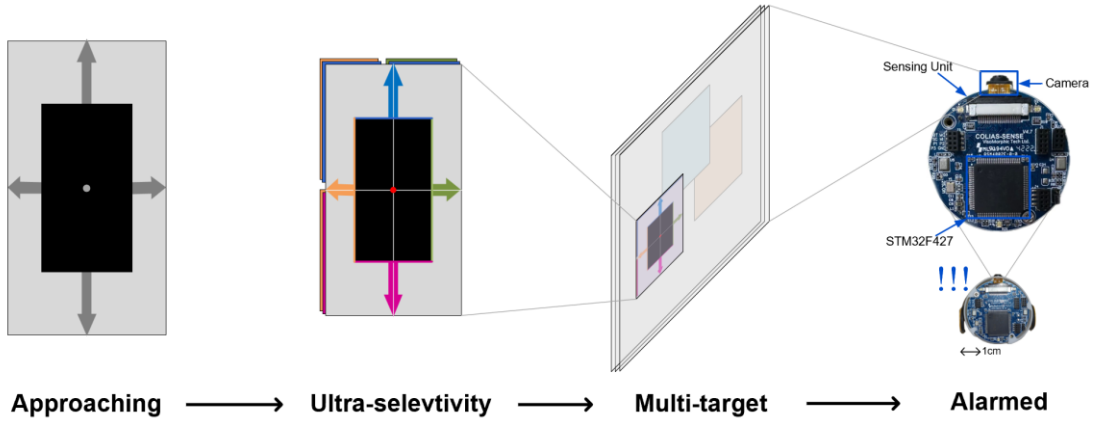
Core Problem

How to mitigate trade-off between resource and performance

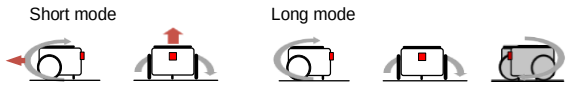
Method:





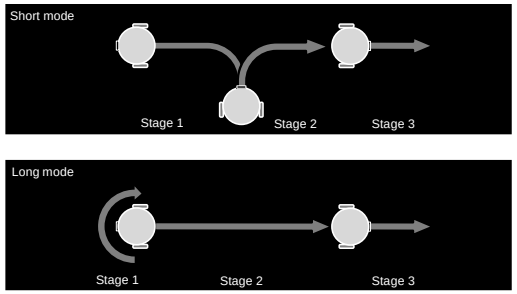


Processing in embedded system



$$S(t) = 1/\left(1 + e^{-\frac{1}{w_s}\sum_{k=1}^{N} LPLC2_k(t)}\right)$$

$$\bar{X}(t) = \frac{\sum_{k=1}^{N} \bar{x_k} \cdot LPLC2_k(t)}{\sum_{k=1}^{N} LPLC2_k(t)}$$

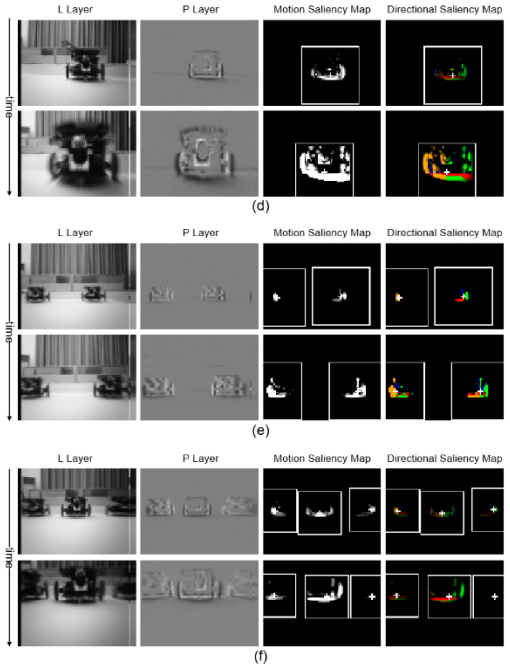


Visuomotor Pathway

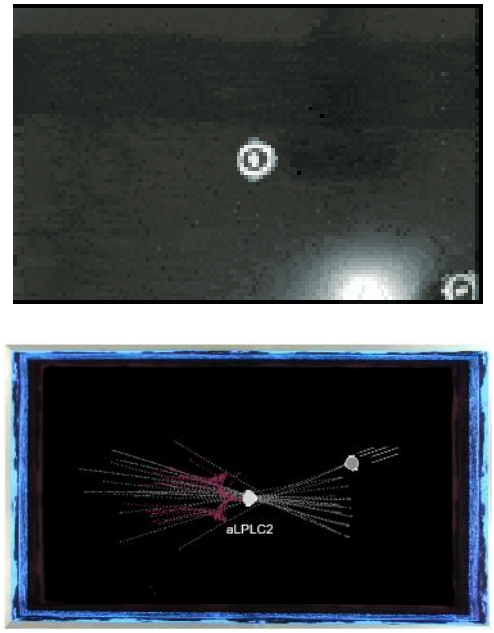
First real-world fly-inspired implementation; 96.1% success; 70KB; 11 ms / frame; STM32 micro-chip

Core Problem	How to mitigate trade-off between resource and performance

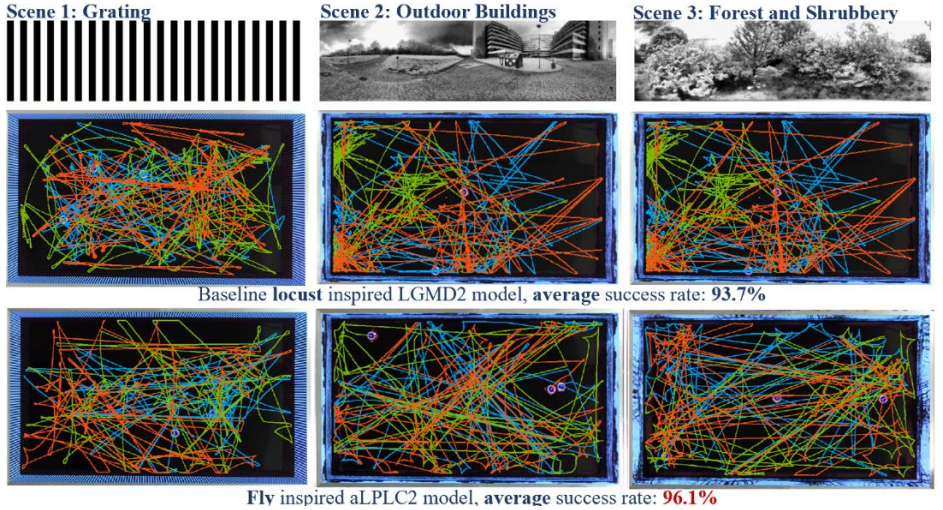
Result:



Multi-target detection



Active evasion



93.5 %, EMD-inspired looming detection (monocular) [12]
98.8 %, EMD-inspired looming detection (binocular) [12]
69 % (min) / 90 % (low-speed), Robot implementation of locust looming detection [10]
93.7 % (average), Advanced robot implementation of locust looming detection [11]
93.5 % (average), Fly-inspired looming detection based on LPLC2-cell simulation [8]
96.1 % (average), **Our Work:** LPLC2 with multi-target attention in micro-robots

Locust-inspired LGMD2 model

Fly-inspired aLPLC2 model

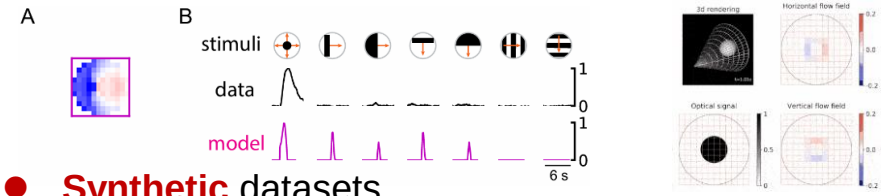
Comparable against **SOTA** solution under **extremely constrained** resource

First real-world fly-inspired implementation; 96.1% success; 70KB; 11 ms / frame; STM32 micro-chip

Against SOTA

SOTA 1:

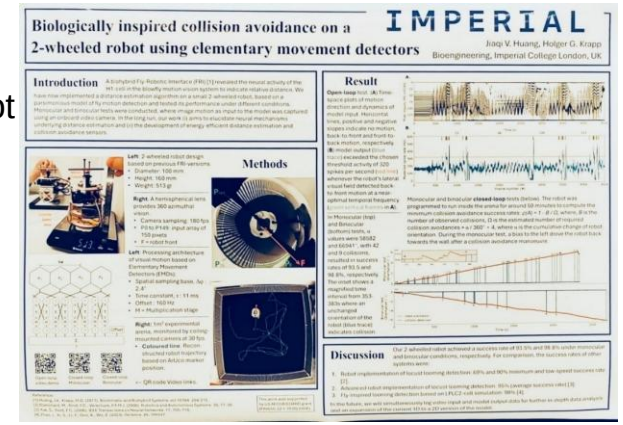
eLife *Zhou, B. et al., 2022, Elife* [9], *Yale University*



- **Synthetic** datasets

Fly EMD Inspired Model *Huang, J. et al., Imperial College London*

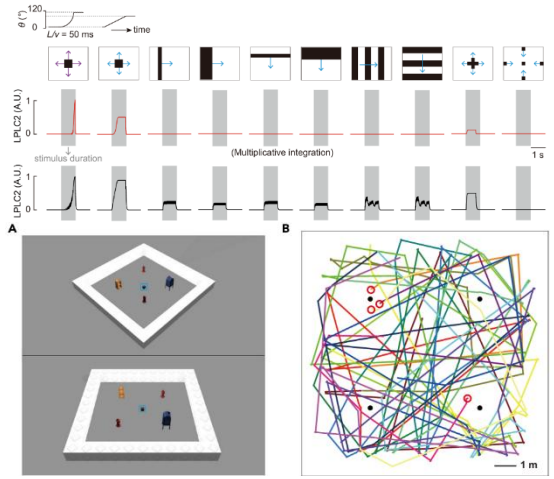
- *Raspberry Pi*-bot
  ¥ ~ 10,000;
  16 x 10^2 cm^3
- **In progress**



SOTA 2:

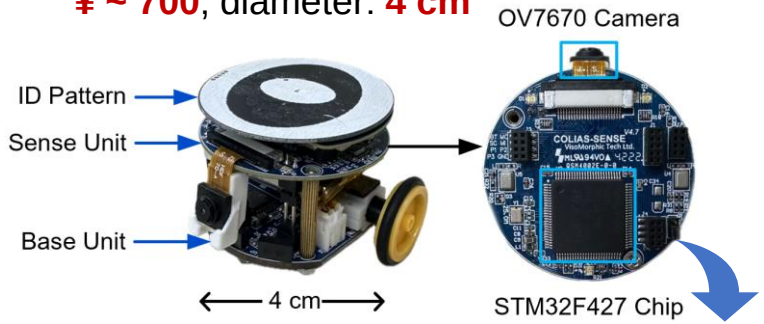
iScience *Zhao, J. et al., 2024, IScience* [8], *Shanghai University*

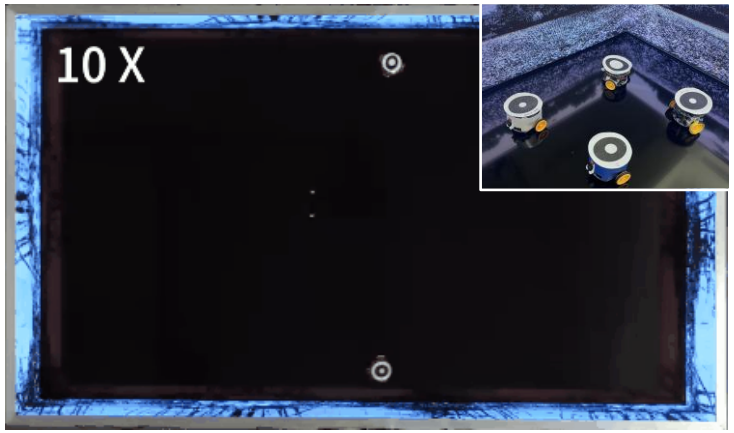
- **Simulated** *Turtlebot3* robot
  ¥ ~ 20,000;diameter:**28.1 cm**
- *Dell w*orkstation **¥ ~ 154,800**



Ours:

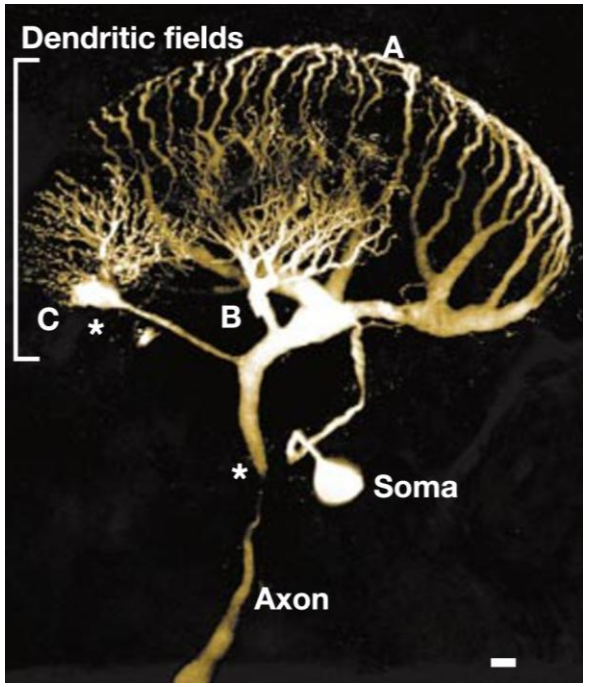
- **Real world** Micro-robot
  ¥ ~ 700; diameter: **4 cm**





First real-world fly-inspired solution; Extremely Limited Computing Resource

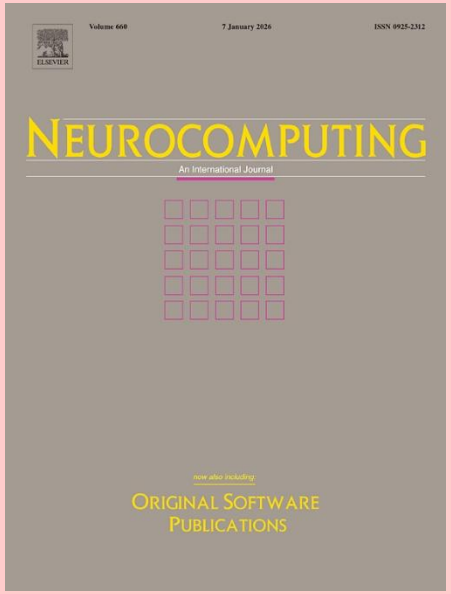
Locust-Inspired Visual Systems



Rind, 2024, Current Opinion in Insect Science

Locust's Visual Neuron [18]

Paper 3:



- ✓ **Published at Neurocomputing**
- ✓ **JCR Q1, IF = 6.5**

Paper 4 :

biomimetics

- ✓ **Second Author**
- ✓ Published at Biomimetics
- ✓ **JCR Q1, IF = 3.9**

Paper 5 :

IEEE TRANSACTIONS ON COGNITIVE AND DEVELOPMENTAL SYSTEMS

- ✓ **Co-First Author**
- ✓ Under review in Trans. on CDS
- ✓ JCR Q1

Paper 6 :

电子学报

- ✓ Published at Acta Electronica Sinica (电子学报)
- ✓ **CCF-A in Chinese**

Paper 7 :

LIVING MACHINES
The 14th International Conference on Biomimetics and Biohybrid Systems

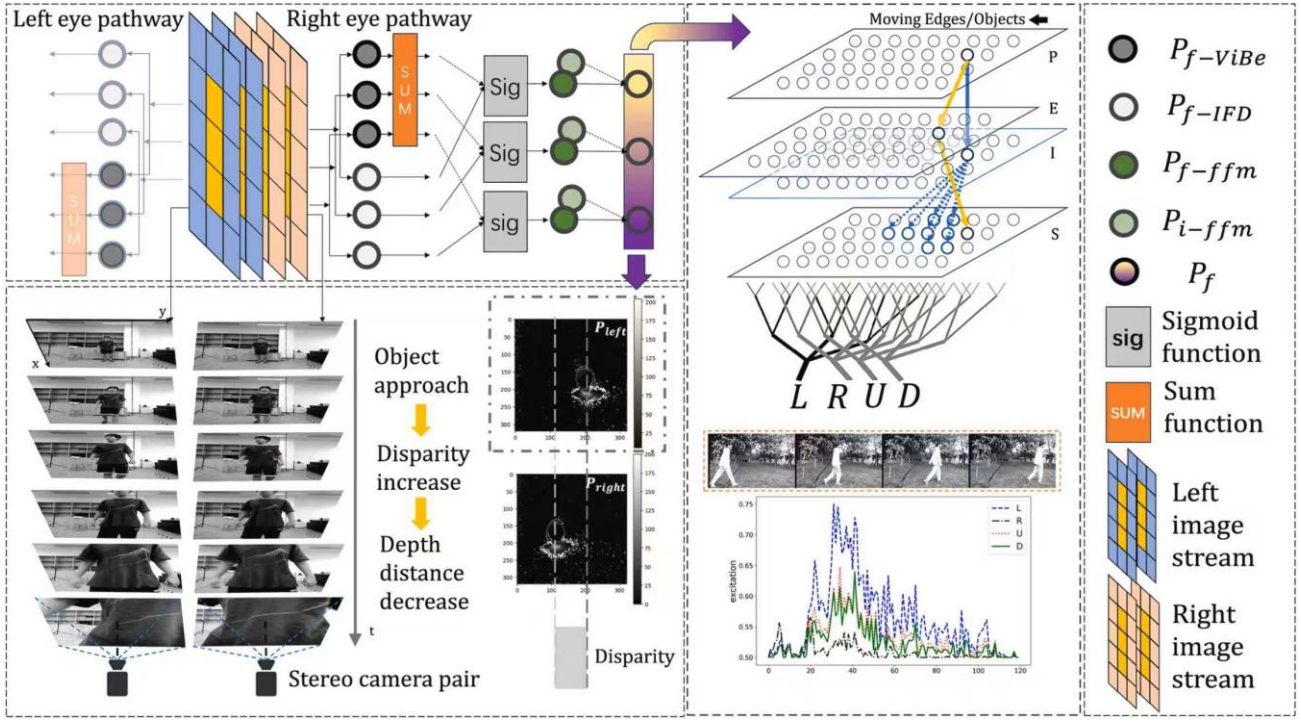
- ✓ Published at Living Machines Proc.
- ✓ **Oral**

NEUROCOMPUTING
An International Journal

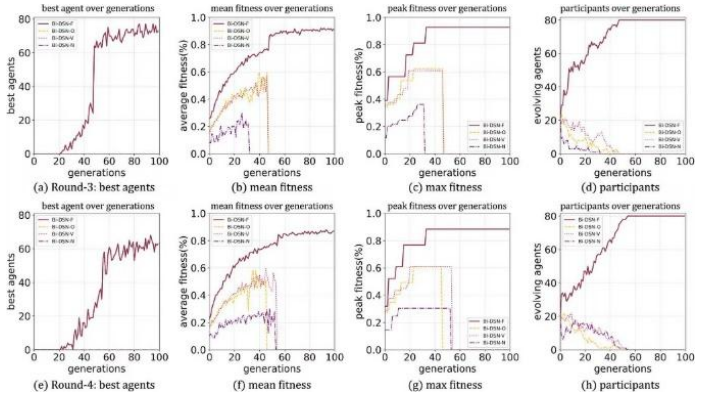
Core Problem

How to boost the robustness against complex background

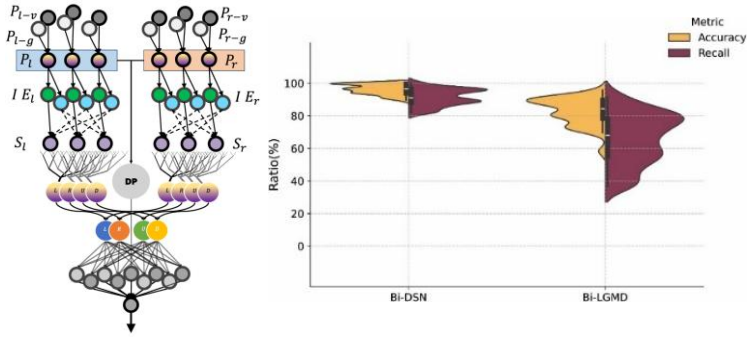
To address the poor robustness under **complex** backgrounds, we for the first time integrate **binocular depth** and **directional motion** information, significantly enhancing performance **across diverse cluttered scenarios**.



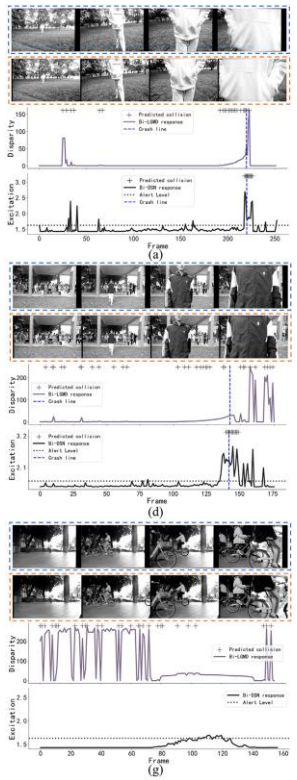
Proposed Bi-DSN neural network



Genetic evolution algorithm



Accuracy: 95.26%; Recall: 92.43%



Against SOTA

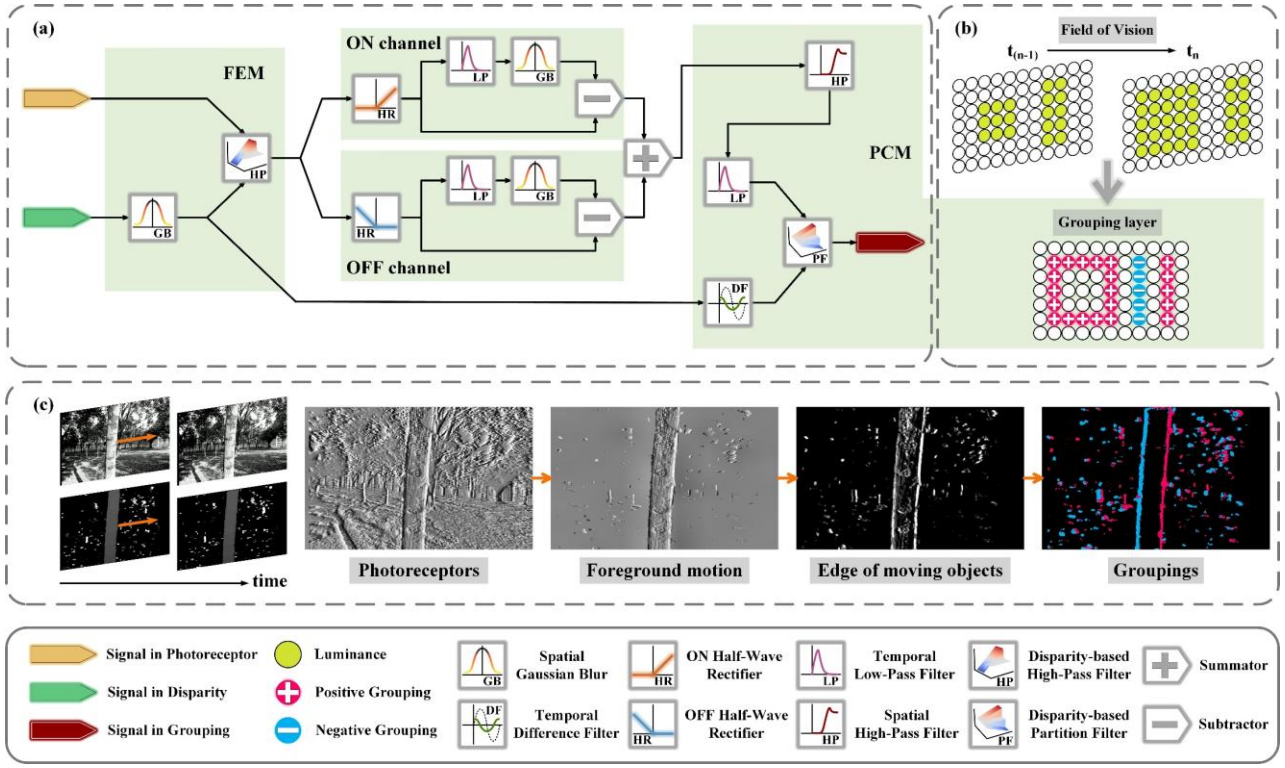
Pioneered bio-inspired architecture integrating binocular depth and directional cues

DIANZI XUEBAO
ACTA ELECTRONICA SINICA

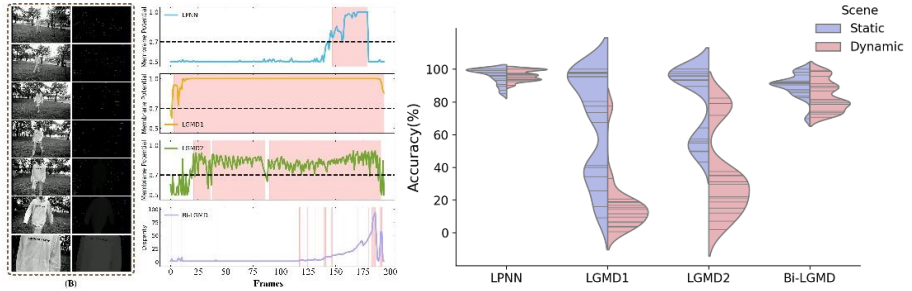
Core Problem

How to boost the robustness against complex background

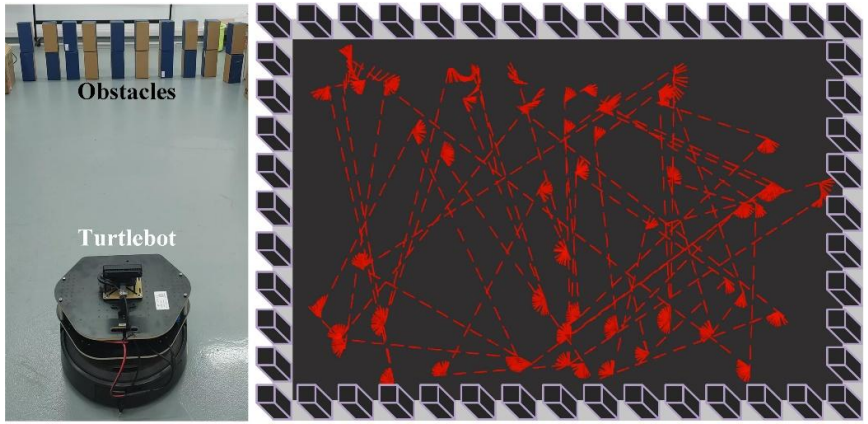
Addressing the trade-off between robustness and computational efficiency in **depth point-cloud-based** collision detection, this study proposes a **locust-inspired** model to achieve **low** computational cost while overcoming **non-looming interference**.



3D collision perception neural network



Offline experiment



Online robotic experiment

Achieved 110.9% higher accuracy in dynamic scenarios with an order-of-magnitude lower complexity

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Thanks for Your Attention ! ! !