



# Pihai Sun

M.S. Student, Harbin Institute of Technology | Robust 3D Perception and Embodied AI

Researcher in robust 3D perception and embodied AI, focusing on reliable geometric and semantic understanding from degraded multimodal observations and deployable perception for humanoid robots.

## Selected Projects

### SOLO: Stable Omni-terrain Long-Horizon Perceptive Humanoid Locomotion

Under Review | First Author

**Challenge:** Standard teacher-student perceptive locomotion is fragile in long real-world rollouts: dense CNN-RNN terrain reconstruction smooths foothold-critical details, and pointwise MSE+PPO imitation cannot penalize actions that cause future state drift.

**Contribution:** Built SOLO using one chest-mounted depth camera and proprioception. Proposed QR for per-cell terrain evidence retrieval and TA-MSE for trajectory-level credit assignment. Zero-shot on Omni: 1.5 km outdoor walking, up to 4x lower terrain error, and 3% to 96% sparse-foothold success.

### FUSE: Label-Free Image-Event Joint Monocular Depth Estimation

IROS 2025 | First Author

**Challenge:** Image-event depth estimation lacks large labeled triplets, and images provide low-frequency structures while events emphasize high-frequency dynamics, creating a difficult fusion mismatch.

**Contribution:** Designed PST, a parameter-efficient self-supervised transfer strategy with LoRA, and FreDFuse, a frequency-decoupled fusion module using Gaussian-Laplacian pyramids and dominant-modality guided cross attention.

### TransDepth: Monocular Depth for Specular and Transparent Surfaces

ICCVW 2025 | Rank 2 Lead

**Challenge:** Standard depth models degrade severely on mirror-like and transparent non-Lambertian surfaces.

**Contribution:** Led a robust DepthAnything-V2-based solution with mixed synthetic/real training data, including Hypersim and MIDepth, and added transparent-object segmentation as an auxiliary task to improve transparent-region depth prediction.

### DAS-Depth: Depth-Aware Scale Optimization for Monocular Depth

ECCVW 2024 | Rank 2 Lead

**Challenge:** Training depth values were highly imbalanced, while low-resolution depth maps introduced strong noise.

**Contribution:** Constrained the output space through depth-distribution analysis to stabilize learning, and fine-tuned a pretrained encoder directly from high-resolution RGB images after verifying that noisy low-resolution depth input hurt performance.

## Research Experience and Highlights

- Research intern at Beijing Humanoid Robot Innovation Center (X-Humanoid), working on perception and perceptive locomotion.
- Developed Omni's perceptive-locomotion capability, enabling 15-minute stable walking in randomized urban scenes and one-shot ascent of 17 indoor fire-stair floors.
- Contributed perception algorithms for the inaugural Humanoid Robot Games: 100 m running champion and second place in 4x100 m relay, 1500 m, and 400 m events.
- Developed perception modules for humanoid locomotion and robust depth estimation under degraded observations.

## Selected Publications, Challenges, and Standard

- SOLO: Stable Omni-terrain Long-Horizon Perceptive Humanoid Locomotion**, Under Review, 2026.
- FUSE: Label-Free Image-Event Joint Monocular Depth Estimation via Frequency-Decoupled Alignment and Degradation-Robust Fusion**, IROS 2025, first author.
- TRICKY 2025 Challenge on Monocular Depth from Images of Specular and Transparent Surfaces**, ICCV Workshops 2025; team ranked 2nd.
- Compressed Depth Map Super-Resolution and Restoration: AIM 2024 Challenge Results**, ECCV Workshops 2024; team ranked 2nd.
- DPL: Depth-only Perceptive Humanoid Locomotion**, RAL 2026.
- T/CAMETA 001112-2026** group standard contributor.

## CONTACT

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## EDUCATION

**Harbin Institute of Technology**  
M.S., Electronic Information  
2023 - Jun. 2026

**Qingdao University**  
B.Eng., Computer Science  
2019 - 2023

## KEYWORDS

Robust 3D perception, embodied AI, monocular depth estimation, event camera, multimodal fusion, perceptive humanoid locomotion.

## AWARDS

**Rank 2**, TRICKY Challenge, ICCV 2025 Workshop.

**Rank 2**, AIM Challenge, ECCV 2024 Workshop.

HIT Top Academic Scholarship.

HIT Outstanding Student.

Shandong Province Outstanding Graduate, 2023.

Silver Award, Shandong ACM-ICPC Contest.

First-Class Academic Scholarship, Qingdao University.

## PATENTS

**First inventor**, multi-object rearrangement model training method, rearrangement method, device, and medium.

**First inventor**, diffusion model training method, apparatus, device, and storage medium.