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Professional Summary

- Excellent Education**  I have obtained my bachelor's, master's, and doctoral degree from top universities/research institutions in China, and the defense results for all of my theses were excellent.
-  I have received numerous awards and honors. Notably, during my doctoral studies, I was honored with the National Scholarship, the highest level of scholarship bestowed by the Chinese government, representing the top 1% of students.
- Solid Foundation**  During my doctoral studies, I have published 10 papers, of which 4 are first-author publications – including top international journals such as IEEE TPAMI (IF=23.6), IJCV (IF=19.5), top international conference like NeurIPS, and a survey in Journal of Images and Graphics (top journal in China).
-  The research platform that I am responsible for building and maintaining has received over 287k visits from 130+ countries and regions worldwide.
- Wide Communication**  I have served as a reviewer for top conferences such as CVPR, AAAI, ACM MM, etc., and will conduct a tutorial at ICIP 2024 conference (tutorial title: *An Evaluation Perspective in Visual Object Tracking: from Task Design to Benchmark Construction and Algorithm Analysis*).
-  Since Sep. 2022, I have initiated and organized interdisciplinary seminars based on computer vision (40+ times, involving 10+ schools and 20+ individuals), covering research areas such as computer vision, cognitive neuroscience, and human-computer interaction.
-  I have assisted and supervised nearly 10 bachelor's, master's, and doctoral students in carrying out research work. The research directions have covered visual object tracking, visual language tracking, visual Turing test, and human-computer interaction technology.

Education Background

- 2019.09 - 2024.01  **Ph.D, Institute of Automation, Chinese Academy of Sciences (CASIA)**
- **Major:** Computer Applied Technology
 - **Supervisor:** Prof. Kaiqi Huang (IAPR Fellow)
 - **Thesis title:** *Research of Intelligence Evaluation Techniques for Single Object Tracking*
 - **Thesis defense grade:** Excellent
- 2017.09 - 2019.06  **M.Sc., Department of Computer Science, University of Hong Kong (HKU)**
- **Major:** Computer Science
 - **Supervisor:** Prof. Choli Wang
 - **Thesis title:** *NightRunner: Deep Learning for Autonomous Driving Cars after Dark*
 - **Thesis defense grade:** A+
- 2013.09 - 2017.06  **B.E., Elite Class in School of Information and Electronics, Beijing Institute of Technology (BIT)**
- **Major:** Information Engineering
 - **Diploma project supervisor:** Prof. Senlin Luo
 - **Thesis title:** *Text Sentiment Analysis Based on Deep Neural Network*
 - **Thesis defense grade:** Excellent

Research Foundation & Interests

- Visual Object Tracking
 - Research on single object tracking algorithms in general scenes and specific scenarios (e.g., unmanned aerial vehicles).
 - Research on the robustness, generalization, and security of single object tracking algorithms.
- Visual Language Tracking
 - Research on multi-modal tracking, video understanding, and visual reasoning tasks based on long video sequences.
 - Exploring human-computer interaction patterns in long video sequences with visual language tracking as a proxy task.
- Benchmark Construction
 - Research on the construction strategy of single-modal and multi-modal datasets incorporating human knowledge structure.
 - Research on designing evaluation mechanism for visual robustness, generalization, and safety.
- Intelligent Evaluation
 - Design of a human-machine universal visual ability evaluation framework.
 - Benchmarking the performance of algorithms based on human abilities in perceptual, cognitive, inferential, etc. Analyzing the bottlenecks of algorithms and human subjects in depth, providing guidance for research on human-like modeling, human-machine collaboration, and human-machine integration.
- AI4Science
 - Cognitive Science: Visual task design, environment construction, and human-machine capability analysis based on human-like modeling principles.
 - Medical Science: Research on medical image processing techniques based on artificial intelligence technologies (e.g., cell segmentation and tracking, denoising of cryo-electron microscopy images).
 - Psychology: Development of gamified assessment systems targeting psychological dimensions such as anxiety, depression, and obsession, along with research on intelligent psychological evaluation technologies.

Research Experiences

Main Research

☰ Idea & Method Design & Experimental Analysis & Paper Writing & Platform Development

- 2018.03 - 2018.11 ■ **Darknet-Cross: Light-weight Deep Learning Framework for Heterogeneous Computing**
- 🔧 High-performance Computing & Heterogeneous Computing & Deep learning Framework
 - ✍️ Darknet-Cross is a lightweight deep learning framework, mainly based on the open-source deep learning algorithm library Darknet and yolov2_light, and it has been successfully ported to mobile devices through cross-compilation. This framework enables efficient algorithm inference using mobile GPUs.
 - ✍️ Darknet-Cross supports algorithm acceleration processing on various platforms (e.g., Android and Ubuntu) and various GPUs (e.g., Nvidia GTX1070 and Adreno 630).
 - ✓ The work is a part of my master's thesis at the University of Hong Kong (thesis defense grade: A+).

Research Experiences (continued)

- 2019.11 - 2022.02  **VideoCube: A Large-scale Multi-dimensional Global Instance Tracking Intelligent Evaluation Platform**
-  Visual Object Tracking & Large-scale Benchmark Construction & Intelligent Evaluation Technology
 -  This work builds upon the concept of human-like modeling and expands the definition of single object tracking (SOT) task. It presents a new task called global instance tracking (GIT), which broadens the range of applications to adversarial scenarios.
 -  This work proposes a video narrative content decoupling framework based on film theory, and builds a large-scale, multi-dimensional global instance tracking task intelligent evaluation platform called VideoCube, which includes 7.46 million video frames. It is currently the largest SOT benchmark in terms of scale.
 -  Starting from human-computer confrontation, for the first time, human subjects are introduced into the SOT task in order to measure the visual tracking intelligence.
 -  This work has been published by IEEE TPAMI (IF=23.6) in Jan. 2023 [A1]. As of Jan. 2024, the platform has received over 287k visits from more than 130 countries and regions worldwide, with over 1,000 downloads and more than 380 algorithm tests.
- 2023.03 - 2023.09  **MGIT: A Multi-modal Global Instance Tracking Benchmark Based on Hierarchical Semantic Framework**
-  Visual Language Tracking & Long Video Understanding and Reasoning & Hierarchical Semantic Information Annotation
 -  This work extends the GIT task and the VideoCube benchmark by constructing a multi-modal benchmark called MGIT. The MGIT benchmark is designed to capture the complex video narrative relationships and fully encompass the intricate spatio-temporal and causal connections illustrated in long videos.
 -  This work introduces an innovative multi-granularity semantic information annotation strategy by incorporating the hierarchical structure of human cognition. The strategy aims to provide high-quality semantic information and its effectiveness is validated through experiments.
 -  This work introduces an evaluation mechanism specifically designed for the multi-modal SOT task. It conducts a comprehensive experimental analysis on algorithms with various structures, with the goal of thoroughly examining the performance bottlenecks.
 -  This work has been accepted by NeurIPS in Sep. 2023 [A2].
- 2021.07 - 2023.10  **SOTVerse: A User-defined Single Object Tracking Task Space**
-  Visual Object Tracking & Dynamic Open Environment Construction & Visual Evaluation Technique
 -  The proposed task analysis framework, known as the 3E paradigm (where task is defined as the combination of environment, evaluation, and executor), aims to facilitate the efficient utilization of research resources in the evaluation process.
 -  The research integrates representative datasets for SOT to transform the original static and closed data space into a dynamic open data environment named SOTVerse, comprised of 12.56 million frames. Furthermore, a subspace construction algorithm is introduced to aid researchers in promptly identifying highly challenging sequences and constructing specialized experimental environments aligned with their research objectives.
 -  A new evaluation system is proposed to adapt to various evaluation needs and task objectives. It conducts a fine-grained analysis of 23 representative algorithms to effectively identify performance bottlenecks in these algorithms.
 -  This work has been accepted by IJCV (IF=19.5) in Sep. 2023 [A3].

Research Experiences (continued)

2022.05 - 2023.10

📖 **BioDrone: A Bionic Drone-based Single Object Tracking Benchmark for Robust Vision**

🔧 Visual Object Tracking & Drone-based Tracking & Robust Visual Research

✍️ *BioDrone* is the first bionic drone-based SOT benchmark, it features videos captured from a flapping-wing UAV system with a major camera shake due to its aerodynamics. BioDrone highlights the tracking of tiny targets with drastic changes between consecutive frames, providing a new robust vision benchmark for SOT.

✍️ Twenty representative algorithms have been replicated and tested on BioDrone, followed by a detailed analysis of the robustness bottlenecks.

✍️ A baseline algorithm named UAV-KT has been designed. Experimental analysis has been conducted to validate the effectiveness of this method in extracting visual features and maintaining robustness in challenging factors present in UAV scenes.

✓ This work supported the organization of the 3rd High-Speed Low-Power Visual Understanding Challenge as competition data from May to Oct. 2022. The work has been accepted by IJCV (IF=19.5) in Oct. 2023 [A4].

2022.04 - Now

📖 **Intelligent Evaluation Techniques for Visual Object Tracking Based on Visual Turing Test**

🔧 Visual Object Tracking & Intelligent Evaluation Technique & AI4Science

✍️ This work proposes the visual Turing test evaluation paradigm by incorporating the concept of the Turing test, enabling a comprehensive assessment of the visual intelligence of algorithms in comparison to human visual capabilities.

✍️ A controlled experimental environment has been developed to facilitate a fair comparison of dynamic visual abilities between humans and machines. This environment incorporates the perceptual and cognitive capabilities that task objects necessitate during the execution of dynamic visual tasks.

✍️ A suitable task object is selected to conduct tests on human-machine dynamic visual abilities, involving 20 representative algorithms and 15 human subjects.

✍️ A universally applicable multi-scale dynamic visual task evaluation framework has been designed. This framework employs center point distance to assess and analyze tasks at three distinct scales, namely frame-level, sequence-level, and group-level.

✓ Two Chinese review papers were published in 2021 and 2023 [A5], [A6]. The experimental content and main conclusions are being finalized [P1], preparing for submission to the Cell Patterns journal [O1].

Independent Developer

☰ Platform Maintenance & Upgrade

2020.07 - 2024.01

📖 **GOT-10k: A Large High-diversity Benchmark and Evaluation Platform for Single Object Tracking**

🔧 Visual Object Tracking & Evaluation Technology & Platform Maintenance





✍️ GOT-10k is constructed to evaluate the generalization ability of trackers on unseen object classes and motion patterns. The platform provides a high-quality video trajectory dataset containing 10,000 video segments, 563 object classes, 87 motion patterns, and 1.5 million tight annotations, where its coverage of object classes is magnitudes wider than other existing tracking benchmarks.

✓ GOT-10k is the supporting platform for a research accepted by IEEE TPAMI. It receives 2.82M page views, 6k+ downloads, 14k+ trackers from 150+ countries, and gets 18× page views increase after maintenance (statistics by 2024.01).

Research Experiences (continued)

Collaborative Research

☰ Idea Discussions & Experimental Analysis & Paper Revision

- 2019.05 - 2019.10  **A Skin Color Detection System without Color Atlas**
- ✚ Color Constancy & Skin Color Detection & Illumination Estimation
 - ✍ Under 18 different environmental lighting conditions and with 4 combinations of smartphone parameters, skin color data was collected from 110 participants. The skin color dataset consists of 7,920 images, with the testing results from CK Company's MPA9 skin color detector serving as the ground truth for user skin colors.
 - ✍ Using an elliptical skin model, the essential skin regions are extracted from the images. The open-source color constancy model, FC⁴, is employed to recover the environmental lighting conditions. Subsequently, the skin color detection results for users are calculated using SVR regression.
 - ✓ The related work has been successfully deployed in Huawei's official mobile application 'Mirror' for its AI skin testing function.
- 2020.11 - 2021.03  **A Project for Cell Tracking Based on Deep Learning Method**
- ✚ Medical Image Processing & AI4Science & Cell Segmentation and Tracking
 - ✍ This method follows the tracking by detection paradigm and combines per-frame CNN prediction for cell segmentation with a Siamese network for cell tracking.
 - ✓ This project was submitted to the cell tracking challenge in Mar. 2021, and maintains the second place in the Fluo-C2FL-MSD+ dataset and the third place in the Fluo-C2FL-Huh7 dataset (statistics by Oct. 2023).
- 2023.08 - 2023.10  **Robust Single-particle Cryo-EM Image Denoising and Restoration Research**
- ✚ Medical Image Processing & AI4Science & Diffusion Model
 - ✍ The cryo-electron microscopy at low temperatures can reveal molecular information at almost atomic scale through the reconstruction of 2D micrographs. However, the reconstruction process requires overcoming low signal-to-noise ratio and complex noise structures. This work proposes a diffusion model with a post-processing module to effectively denoise and restore single-particle cryo-EM images.
 - ✍ The effectiveness of the method is validated through experimental results on simulated and real datasets.
 - ✓ The work has been accepted by IEEE ICASSP in Dec. 2023 [A7].
- 2023.01 - 2024.01  **Research on Single Object Tracking Task with Similar Object Interference Challenges**
- ✚ Visual Object Tracking & Similar Object Interference & Data Mining
 - ✍ Based on the operational principles and case analyses of mainstream tracking algorithms, this work redefines the challenge of similar object interference from the perspective of algorithms. It focuses on analyzing the cognitive biases of humans and machines when facing similar object interference.
 - ✍ This study presents a data mining algorithm that enables the automatic extraction of sequences from representative single-object tracking SOT datasets. The extracted sequences consist of instances where similar object interference occurs, and are used to create the TrackingSOI dataset. The extraction process is performed without any manual intervention.
 - ✍ An algorithm called TransKT is proposed to effectively handle similar object interference. It is capable of distinguishing candidates that have similar appearance information to the target object, thereby achieving robust visual object tracking ability.
 - ✓ A simplified version of this work has been accepted as an oral paper by the CSAI conference in Nov. 2023 [A8]. The full version has been submitted to IEEE TCSVT (IF=8.4) in Jan. 2024 and is currently under review [R1].

Research Experiences (continued)

2022.10 - Now

AWCV-100k: A Unconstrained Air-writing Benchmark for Real-World Applications

✚ Air-writing Technique & Benchmark Construction & Human-machine Interaction

✎ This study has developed a large-scale and high-quality video dataset named AWCV-100k, which consists of air-writing of Chinese characters. The objective is to establish a more natural and comprehensive experimental environment for human-computer interaction research.

✎ The AWCV-100k dataset comprises 8.8 million video frames, encompassing diverse environmental settings and lighting conditions. It provides comprehensive coverage of 3,755 Chinese characters from the GB2312-80 character set, establishing it as the most extensive and comprehensive air-writing video dataset currently accessible.

✎ An air-writing character recognition algorithm called VCRec is proposed. This baseline algorithm is capable of extracting fingertip features from sparse visual cues and analyzing them using a spatio-temporal sequence module.

✎ Representative algorithms and VCRec have been reproduced and tested on the AWCV-100k. Experimental results confirm the robustness and effectiveness of VCRec.

✓ This work has been submitted to IEEE TCSVT (IF=8.4) in Dec. 2023 and is currently under review [R2]. Subsequent work will be conducted based on this benchmark for human-computer interaction technology research.

2023.02 - Now

Intelligent Psychological Assessment System based on Electronic Sandplay

✚ Psychological Assessment System & Gamified Assessment & AI4Science

✎ An intelligent psychological assessment system based on electronic sandbox has been developed to address the limitations of traditional assessments, including participants' lack of inherent motivation and limited insight. It facilitates the evaluation and analysis of various dimensions, such as anxiety, depression, and obsession.

✎ This system integrates artificial intelligence technology, offering multiple advantages in comparison to traditional questionnaire assessments and gamified assessments. By extracting linked psychological measurement evidence from dynamic process data within games, it significantly improves the authenticity and interpretability of measurements.

✎ Recruiting participants from educational and public safety settings and conducting validity and reliability tests as well as case analysis, the experimental results confirmed the effectiveness of the electronic sandbox.

✓ The sandbox theme recognition model employed in this work has been accepted by the PRCV conference in Sep. 2023 [A9]. As an interdisciplinary and systematic work spanning psychology, game design, and artificial intelligence, the development trajectory of its technical route and framework will be submitted in the form of a review article and technical papers to top psychology journals in China [R3], [R4].

2023.07 - Now

Robust Visual Language Tracker Based on Human Memory Modeling

✚ Visual Language Tracking & Human-like Memory Modeling & Adaptive Prompts

✎ In response to the inadequate robustness of visual language tracking algorithms in long videos, a robust multi-modal tracker called MemTrack is designed from the perspective of human-like memory modeling.

✎ Inspired by the theory of Complementary Learning System in the cognitive field, MemTrack consists of three modules: memory storage, interaction, and guidance. It aims to simulate the complex modulation process of human memory between the hippocampus and the neocortex.

✎ The effectiveness of MemTrack is validated through experiments on multiple representative benchmarks for visual language tracking.

✓ This work has been submitted to IJCAI in Jan. 2024 and is currently under review [R5].

Research Publications

Acceptance

- 1 **S. Hu**, X. Zhao, L. Huang, and K. Huang, "Global instance tracking: Locating target more like humans," *IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI, CCF-A Journal, IF=23.6)*, vol. 45, no. 1, pp. 576–592, 2023.  DOI: 10.1109/TPAMI.2022.3153312.
- 2 **S. Hu**, D. Zhang, M. Wu, X. Feng, X. Li, X. Zhao, and K. Huang, "A multi-modal global instance tracking benchmark (mgit): Better locating target in complex spatio-temporal and causal relationship," in *the 37th Conference on Neural Information Processing Systems (NeurIPS, CCF-A Conference, Poster)*, 2023.
- 3 **S. Hu**, X. Zhao, and K. Huang, "Sotverse: A user-defined task space of single object tracking," *International Journal of Computer Vision (IJCV, CCF-A Journal, IF=19.5)*, pp. 1–59, 2023.  DOI: 10.1007/s11263-023-01908-5.
- 4 X. Zhao, **S. Hu** , Y. Wang, J. Zhang, Y. Hu, R. Liu, H. Ling, Y. Li, R. Li, K. Liu, and J. Li, "Biodrone: A bionic drone-based single object tracking benchmark for robust vision," *International Journal of Computer Vision (IJCV, CCF-A Journal, IF=19.5)*, 2023.  DOI: 10.1007/s11263-023-01937-0.
- 5 **S. Hu**, X. Zhao, and K. Huang, "Visual intelligence evaluation techniques for single object tracking: A survey (单目标跟踪中的视觉智能评估技术综述)," *Journal of Images and Graphics (《中国图象图形学报》, CCF-B Chinese Journal)*, 2023.
- 6 K. Huang, X. Zhao, Q. Li, and **S. Hu**, "Visual turing: The next development of computer vision in the view of human-computer gaming (视觉图灵：从人机对抗看计算机视觉下一步发展)," *Journal of Graphics (《图学学报》, CCF-C Chinese Journal)*, vol. 42, no. 3, p. 339, 2021.  DOI: 10.11996/JG.j.2095-302X.2021030339.
- 7 J. Zhang, T. Zhao, **S. Hu**, and X. Zhao, "Robust single-particle cryo-em image denoising and restoration," in *the 49th IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP, CCF-B Conference, Poster)*, 2024.
- 8 Y. Wang, **S. Hu**, and X. Zhao, "Rethinking similar object interference in single object tracking," in *the 7th International Conference on Computer Science and Artificial Intelligence (CSAI, EI Conference, Oral)*, 2023.
- 9 X. Feng, **S. Hu**, X. Chen, and K. Huang, "A hierarchical theme recognition model for sandplay therapy," in *the 6th Chinese Conference on Pattern Recognition and Computer Vision (PRCV, CCF-C Conference, Poster)*, 2023, pp. 241–252.  DOI: 10.1007/978-981-99-8462-6_20.
- 10 Y. Zhang, C. Liu, W. Chen, X. Xu, F. Wang, H. Li, **S. Hu**, and X. Zhao, "Revisiting instance search: A new benchmark using cycle self-training," *Neurocomputing (Neu, CCF-C Journal, IF=6)*, vol. 501, pp. 270–284, 2022.  DOI: 10.1016/j.neucom.2022.06.027.

Preprint

- 1 **S. Hu**, X. Zhao, Y. Wang, Y. Shan, and K. Huang, *Nearing or surpassing: Overall evaluation of human-machine dynamic vision ability*, 2023.  URL: https://openreview.net/forum?id=LGbzYw_pnsc.

Under Review






- 1 Y. Wang, **S. Hu**, D. Zhang, M. Wu, T. Yao, Y. Wang, L. Chen, and X. Zhao, "Target or distractor? rethinking similar object interference in single object tracking," *IEEE Transactions on Circuits and Systems for Video Technology (TCSVT, CCF-B Journal, IF=8.4, Under Review)*, 2024.
- 2 M. Wu, K. Huang, Y. Cai, **S. Hu**, Y. Zhao, and W. Wang, "Finger in camera speaks everything: Unconstrained air-writing for real-world," *IEEE Transactions on Circuits and Systems for Video Technology (TCSVT, CCF-B Journal, IF=8.4, Under Review)*, 2024.

- 3 K. Huang, Y. Kang, C. Yan, **S. Hu**, L. Wang, T. Tao, and W. Gao, "Intelligent game-based psychological assessment(基于游戏的智能化心理测评系统)," *Chinese Mental Health Journal* (《中国心理卫生杂志》, *CSSCI Journal*, *In Preparation*), 2024.
- 4 Y. Ren, X. Feng, **S. Hu**, Y. Kang, C. Yan, Y. Zeng, L. Wang, and K. Huang, "Intelligent psychological assessment with sandplay based on evidence-centered design theory (基于证据中心设计理论的智能心理沙盘测评系统)," *Acta Psychologica Sinica* (《心理学报》, *CSSCI Journal*, *Top-1 Psychological Journal in China*, *Under Review*), 2024.
- 5 X. Feng, X. Li, **S. Hu**, D. Zhang, M. Wu, X. Chen, and K. Huang, "Remembering target more like humans: A robust visual-language tracker with adaptive prompts," *the 33rd International Joint Conference on Artificial Intelligence (IJCAI, CCF-A Conference, Under Review)*, 2024.

Ongoing Research

- 1 **S. Hu**, J. Zhu, Y. Wang, X. Zhao, and K. Huang, "Vt³: A visual tracking turing test of human-machine dynamic vision ability," *Cell Patterns* (*In Preparation*), 2024.




Skills

- Languages  Mandarin Chinese (native speaker) and English.
- Coding  Python, Java, Matlab, C, \LaTeX .
- Development  Android, Flask, SQLite.
- Linux  Shell, OS virtualization.
- Misc.  Academic research, leadership, presentation.

Awards and Honors

- 2023  **China National Scholarship**, Ministry of Education of the People's Republic of China (Top 1%).
-  **First Prize of Climbing Scholarship**, Institute of Automation, Chinese Academy of Sciences.
- 2022  **Merit Student**, University of Chinese Academy of Sciences.
- 2017  **IE Admission Scholarship**, Chinese University of Hong Kong.
-  **Academic Scholarship**, Beijing Institute of Technology.
-  **Excellent Innovative Student**, Beijing Institute of Technology.
- 2016  **College Scholarship**, Chinese Academy of Sciences.
-  **Academic Scholarship**, Beijing Institute of Technology.
-  **Excellent League Member on Youth Day Competition**, Beijing Institute of Technology.
- 2015  **National First Prize**, Contemporary Undergraduate Mathematical Contest in Modeling (Top 1%).
-  **Academic Scholarship**, Beijing Institute of Technology.
-  **First Prize of Mathematics Modeling Competition**, Beijing Institute of Technology.
-  **Outstanding Individual on Summer Social Practice**, Beijing Institute of Technology.
-  **Second Prize on Summer Social Practice**, Beijing Institute of Technology (Team Leader).
-  **Outstanding Student Cadre**, Beijing Institute of Technology.
-  **Outstanding League Cadre on Youth Day Competition**, Beijing Institute of Technology.
-  **Outstanding Youth League Branch**, Beijing Institute of Technology (Team Leader).
-  **Top 10 Activities on Youth Day Competition**, Beijing Institute of Technology (Team Leader).
- 2014  **Academic Scholarship**, Beijing Institute of Technology.
-  **Outstanding Student**, Beijing Institute of Technology.

Awards and Honors (continued)


- 2013  **Academic Scholarship**, Beijing Institute of Technology.
- 2012  **Second Prize of the 27th China Adolescents Science and Technology Innovation Contest**, China Association for Science and Technology.
- 2010  **Merit Student**, Zhengzhou, Henan Province.

References

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