



中国科学院大学
University of Chinese Academy of Sciences

阴影成像模型与去除算法研究

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研究背景

阴影会极大地损害高层视觉算法的性能，如目标跟踪、识别与检测等。

- **需求**：阴影建模和去除研究致力于**提升复杂光照下视觉系统的鲁棒性**
- **受限场景**：在**复杂光照条件**和**杂乱背景**下，难以彻底去除阴影



Time: 8:26:00 AM
Predict: Speed Limit 30
Confidence: 91.17%



Time: 8:27:00 AM
Predict: Speed Limit 30
Confidence: 90.81%



Time: 8:28:30 AM
Predict: Speed Limit 80
Confidence: 87.87%



Time: 8:29:00 AM
Predict: Speed Limit 80
Confidence: 62.67%



Time: 8:30:52 AM
Predict: Speed Limit 20
Confidence: 47.20%



Time: 8:32:00 AM
Predict: Speed Limit 30
Confidence: 22.69%

现有的阴影去除网络流程长、速度慢

- 大多数阴影去除方法采用**多阶段网络**，依赖于**阴影检测**
- **冗长管道**：阴影图像->阴影检测->阴影去除->图像细化



1. 阴影双线性成像模型

Dichromatic reflection model (Shafer-1985)

$$I^H(x, y) = m_i(x, y) \int E_i(\lambda, x, y) S(\lambda, x, y) Q_H(\lambda) d\lambda + m_b(x, y) \int E_b(\lambda, x, y) S(\lambda, x, y) Q_H(\lambda) d\lambda,$$

Lambertian reflector (i.e., neglect E_i).

$$I^H = \eta \cdot W_H \cdot m_b \cdot \int_{400}^{700} E_b(\lambda) S(\lambda) Q_H(\lambda) d\lambda,$$

$$E_{day}(\lambda) \cdot Q_H(\lambda) \approx K_H \cdot E_{sky}(\lambda) \cdot Q_H(\lambda),$$

Shadow imaging linear model (Tian-CVPR2011)

$$\frac{I_f^H}{I_s^H} = \frac{\eta \cdot W_H \cdot m_b \cdot \int_{400}^{700} E_{day}(\lambda) S(\lambda) Q_H(\lambda) d\lambda}{\eta \cdot W_H \cdot m_b \cdot \int_{400}^{700} E_{sky}(\lambda) S(\lambda) Q_H(\lambda) d\lambda} \approx K_H.$$

$$I_f^H = k_H \cdot I_s^H + b_H$$

Shadow imaging
bilinear model

$$\begin{aligned} I_f^H &= k_H \cdot I_s^H + b_H \\ &= I_s^H + ((k_H - 1) \cdot I_s^H + b_H) \\ &= I_s^H + I_m^H. \end{aligned}$$

$$\begin{aligned} I_f^H &= k_H I_s^H + b_H \\ I_m^H &= (k_H - 1) \cdot I_s^H + b_H \end{aligned}$$

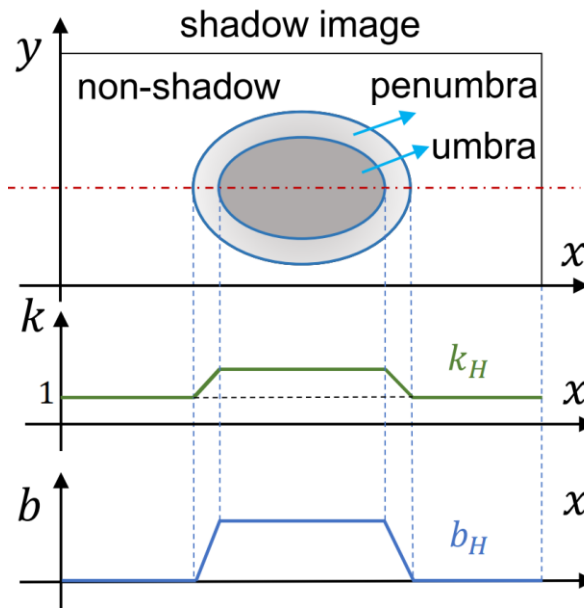
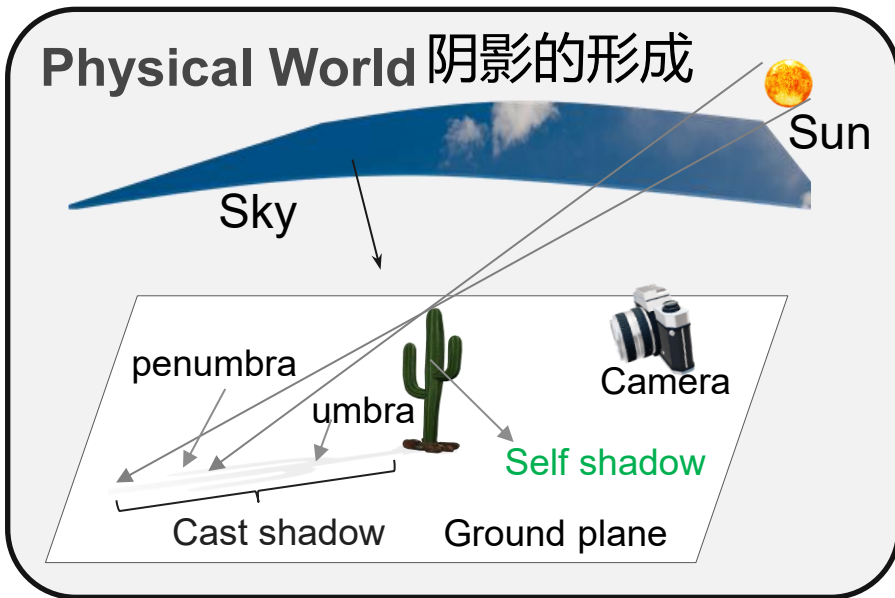
Paper: [A Shadow Imaging Bilinear Model and Three-Branch Residual Network for Shadow Removal \(TNNLS 2023\)](#)

Code: <https://github.com/nachifur/TBRNet>

Foundation: 国家自然科学基金(面上项目) -面向海洋中光层的目标检测与跟踪算法研究



1. 阴影双线性成像模型



阴影照明参数

The variation in k_H and b_H on a shadow image.

阴影成像双线性模型

$$\begin{cases} I_f^H = k_H I_s^H + b_H \\ I_m^H = (k_H - 1) \cdot I_s^H + b_H \end{cases}$$



光照补偿模型

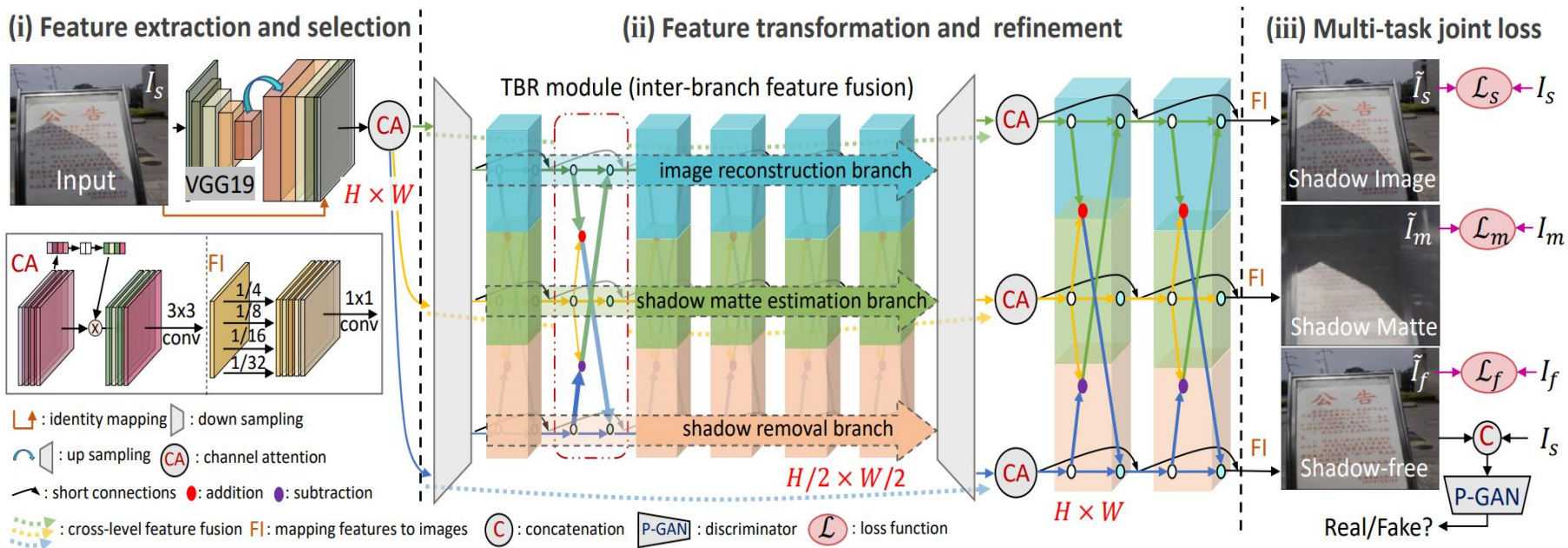
$$I_f = I_s + I_m$$



2.三支残差阴影去除网络

贡献和创新:

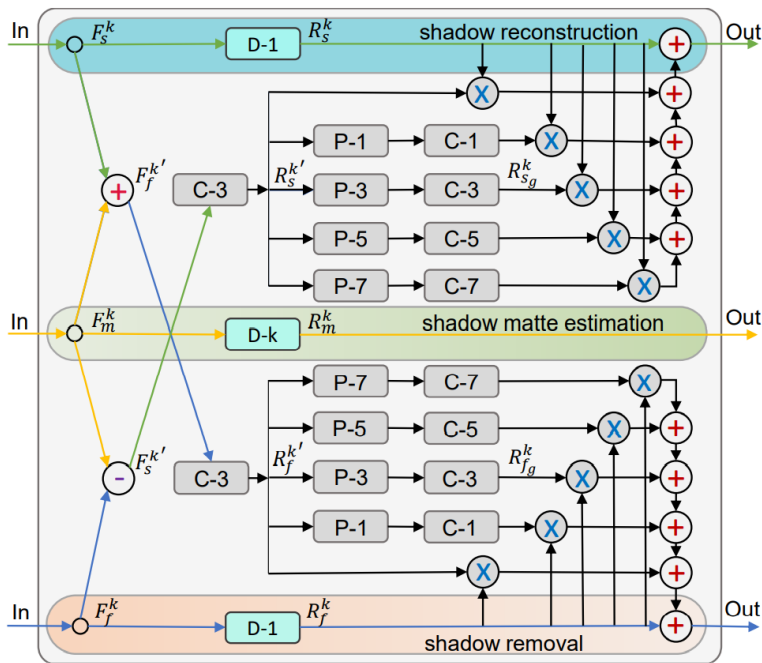
- 通过**建模光照衰减**推导出阴影双线性成像模型，揭示单图像阴影去除过程。
- 设计了基于模型的三支残差阴影去除网络，**不需要额外的阴影检测和图像细化网络**，实现了最优性能。



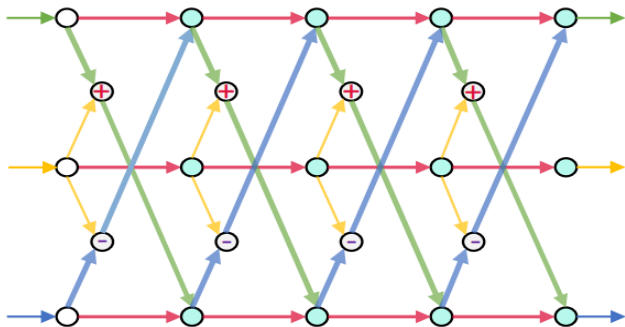


2.三支残差阴影去除网络

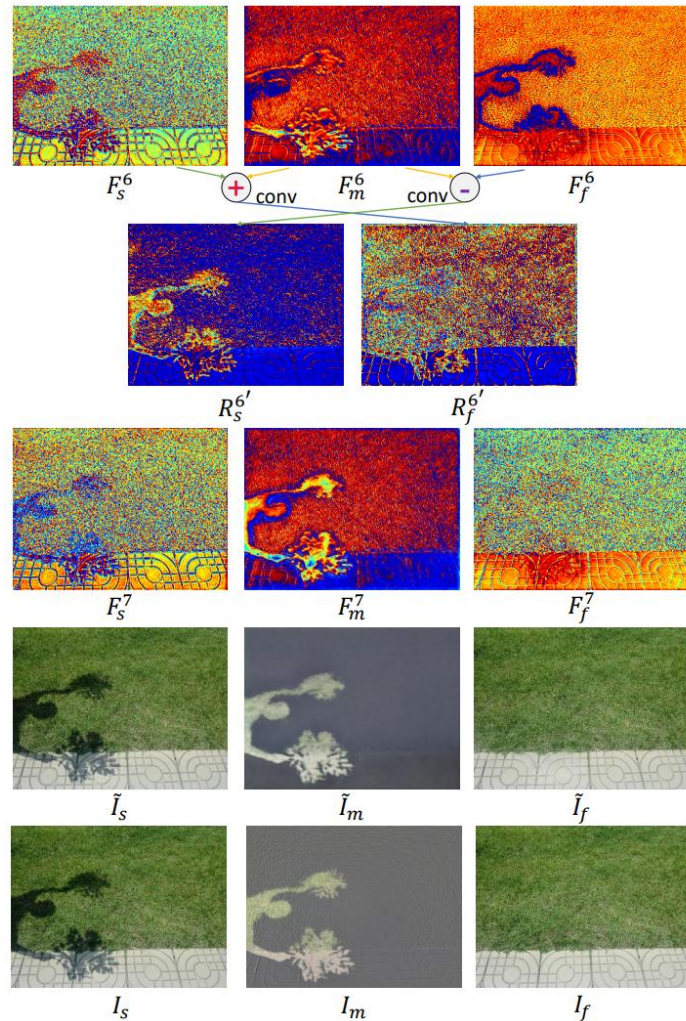
三支残差模块



密集信息流



特征融合可视化



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2.三分支残差阴影去除网络

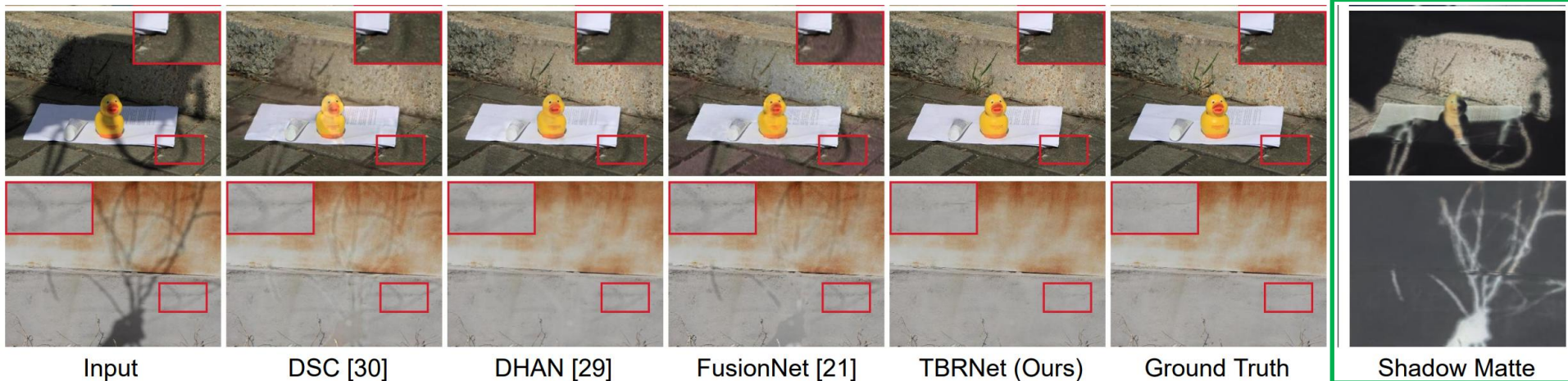
实验结果

Method	Shadow	Non-shadow	ALL
Original	46.87	5.60	14.28
Yang [67] *	23.43	22.26	22.57
Guo [14] *	29.89	6.47	12.60
Gong [68] *	19.58	4.92	8.73
DeShadowNet [33]	11.78	4.84	6.64
DSC [30] ¶	10.89	4.99	6.23
RIS-GAN [35]	8.22	6.05	6.78
DHAN [29]	8.94	4.80	5.67
FusionNet [21]	8.56	5.75	6.51
CANet [32]	7.82	5.88	5.98
Ours (TBRNet)	7.70	4.94	5.62
DHAN [29]+DA	8.39	4.67	5.46
Ours (TBRNet)+DA	7.68	4.89	5.57

SRD



Visual results on the AISD dataset [34].



Input

DSC [30]

DHAN [29]

FusionNet [21]

TBRNet (Ours)

Ground Truth

Shadow Matte



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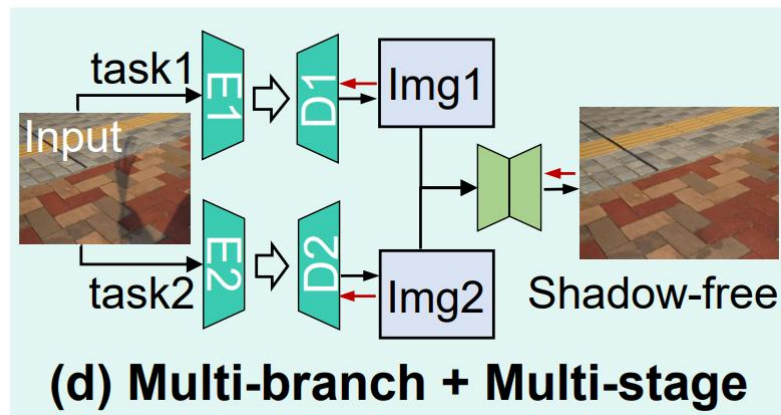
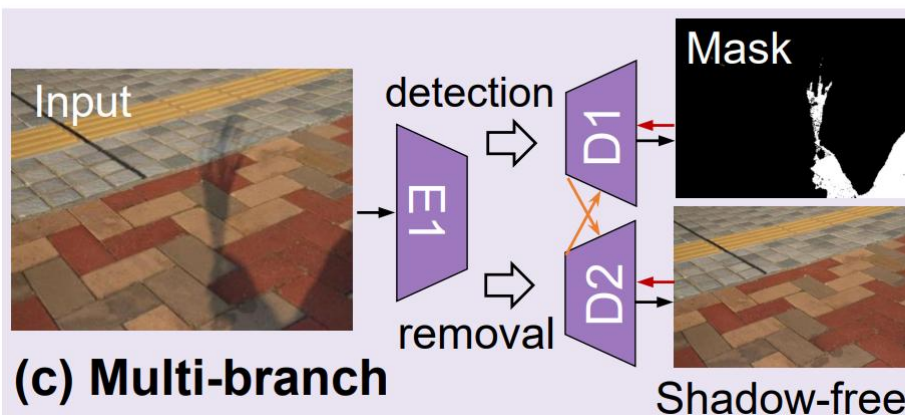
邮箱: liujiawei@sia.cn



3.多任务解耦的阴影去除网络

存在的问题:

- 多阶段中后续任务依赖于前一任务产生的输出图像，造成系统不鲁棒
- 多分支的特征利用效率低，分支间交互造成参数增加



Paper: [A Decoupled Multi-Task Network for Shadow Removal \(TMM 2023\)](#)

Code: <https://github.com/nachifur/DMTN>

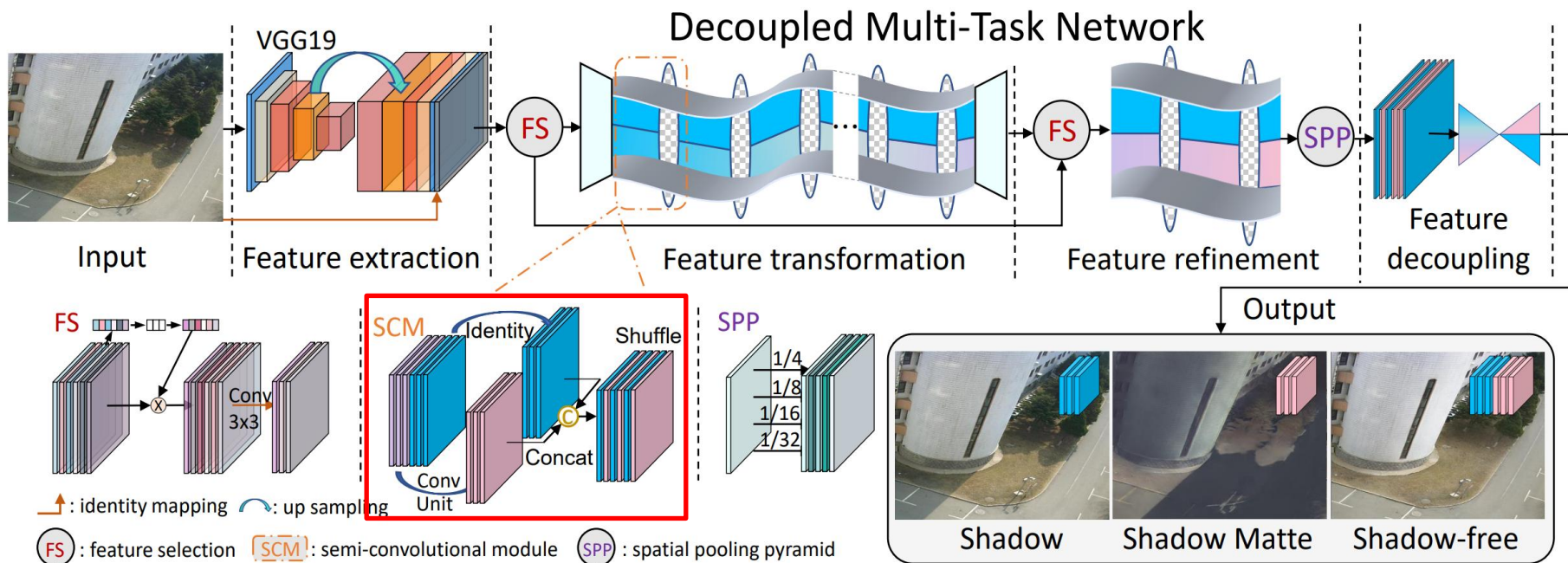
Foundation: 国家自然科学基金重大项目课题 - 复杂海况多艇实时交互认知机制研究



3.多任务解耦的阴影去除网络

贡献和创新:

- 提出的多任务解耦阴影去除网络，**避免了多分支和多阶段网络的缺点。**
- 提出了轻量化的**半卷积模块**，以及受约束的**多任务特征解耦模块**，能够将网络学到的特征聚合为阴影图像，光照补偿图像，无阴影图像。





3.多任务解耦的阴影去除网络

光照补偿模型



I_s : shadow image I_m : shadow matte I_f : shadow-free

光照、图像、参数分解

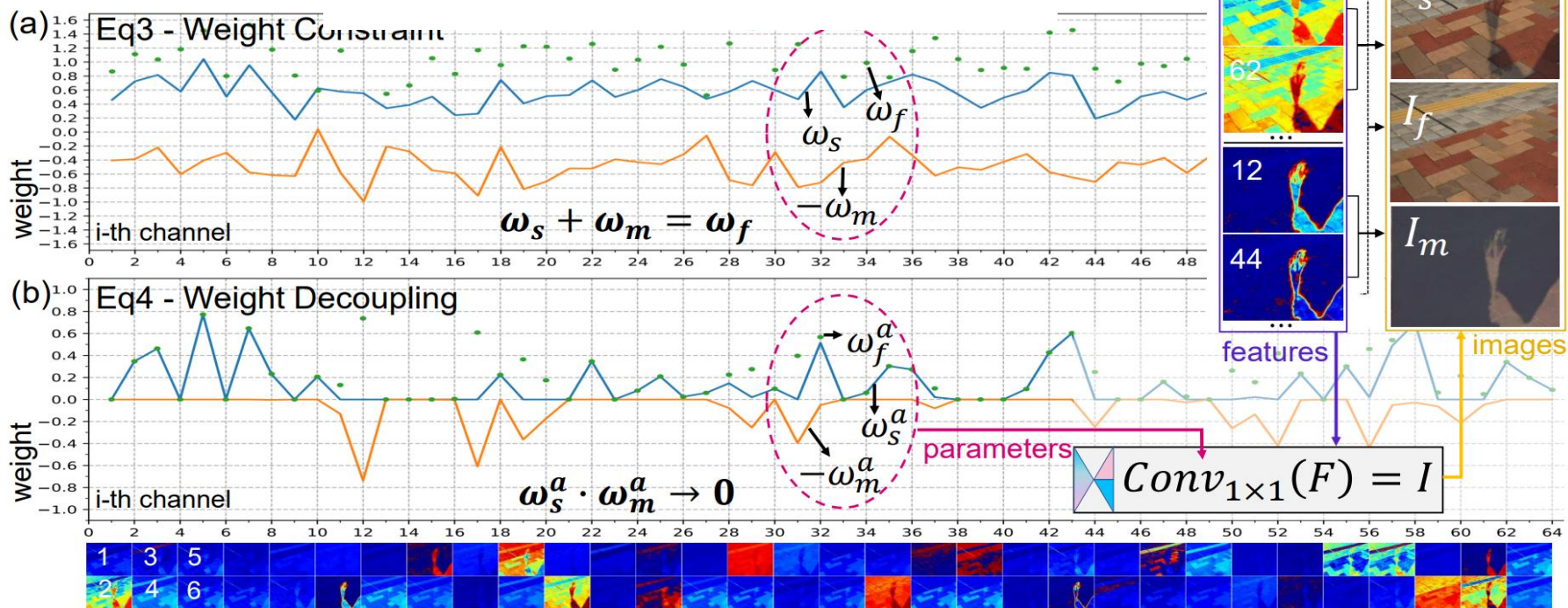
Decomposition

Illumination: $L = L_a + L_d$

Image: $I_f = I_s + I_m$

Parameter: $\omega_f = \omega_s + \omega_m$

受约束特征解耦模块

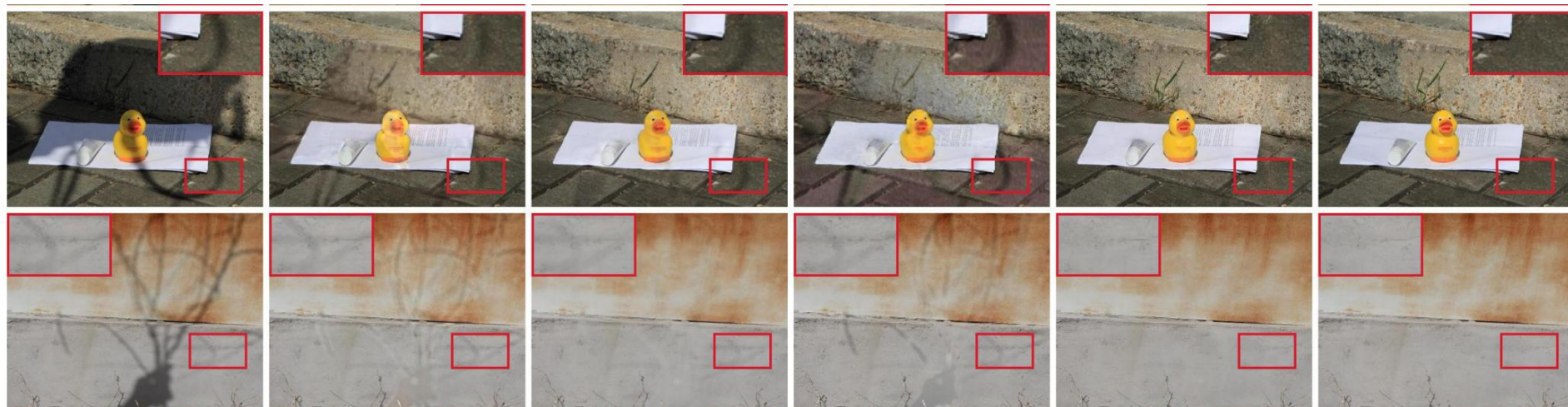




4. 开源软件- MulimgViewer

项目网站: <https://github.com/nachifur/MulimgViewer>

- 并行放大比较、提供中英文文档网站、支持跨平台
- **880+Star**|**5.2k+**下载|**180+**人社区|**5**人参与贡献
- 已被国内外很多**顶级大学、公司、研究机构的研究人员使用**，如：中科大、清北、南理、UC Berkeley、纽约大学石溪分校、南洋理工、帝国理工、字节、腾讯、旷世、沈自所、光电所等
- 积极参与并推动中国科学院开源软件协会**OpenCAS**的发展



Input

DSC [30]

DHAN [29]

FusionNet [21]

TBRNet (Ours)

Ground Truth

一键生成实验对比图|图文并行显示|多图像显示前端



4. 开源软件- MulimgViewer



视频链接: <https://youtu.be/-3oI1gSRG3c>

为欧洲海洋地质项目 [Geomorphology-Geoswim Project](#) 提供多维数据的可视化解决方案（水上图像、水下图像、经纬度、温度、压强等）。

Immagini in time-lapse per modellizzare la zona intertidale
Implementazione di un multi-image viewer

Image ID	Latitude N	Longitude E	GPS Altitude (m)	GPS Date	Image Path	GPS Time	Pressure[cmH2O]	Temperature[C]	Conductivity[μmhos/cm]
00018528	35.514435	12.626426	12.626426	2020/9/17	a:\G0018528	09:15:02	1265.03	17.5	63.36
G001852	35.514435	12.626426	12.626426	2020/9/17	b:\G0020296	09:15:02	1265.03	17.5	63.36
G001853	35.514435	12.626426	12.626426	2020/9/17	b:\G0020296	09:15:02	1265.03	17.5	63.36
G002029	35.514435	12.626426	12.626426	2020/9/17	b:\G0020296	09:15:02	1265.03	17.5	63.36
G002030	35.514435	12.626426	12.626426	2020/9/17	b:\G0020296	09:15:02	1265.03	17.5	63.36

Lavoro di: studenti PhD Valeria Vaccher (Università di Trieste) e Jiawei Liu (State key Laboratory Robotics, Shenyank Institute of Automation)

Il programma GEOSWIM - Rilievi a nuoto delle coste rocciose del Mediterraneo



83次观看 3个月前
A cura del Prof. Stefano Furlani
Università degli Studi di Trieste
Caffè di Geologicamente - 15 febbraio 2023, ore 17:00 展开

CONSIGLIO NAZIONALE DELLE RICERCHE
ISTITUTO DI SCIENZE MARINE

CICLO DI SEMINARI

15th December 2022
Swim surveys of the Mediterranean rocky coasts:
The Geoswim programme
Stefano Furlani
Department of Mathematics and Geosciences, University of Trieste

The Geoswim programme is an expedition-type project which is aiming to monitor, measure and survey rocky coasts of the Mediterranean Sea. The project officially started in 2012 with the first one-month survey of about 200 km by snorkelling along the NE Adriatic coast, and is ongoing. Now far 159.5 km of rocky coasts have been surveyed, over 98 days of survey, and several thousand thousand data (depth, temperature, salinity, and surface images) have been collected, along with the acquisition around 27 sites in the Mediterranean. Bathymetric data and physical-chemical parameters, such as temperature and electrical conductivity, have also been collected during the snorkel surveys. Measurements are based on an Instrumented Support Boat (ISB). The Geoswim database represents a significant archive that provides 1) images and videos as a baseline for future comparisons, 2) large amount of images to build 3D models of the studied coasts, 3) data for statistics, and 4) a valuable approach of possible discoveries of unknown coastal objects, such as sea caves, etc. (unpublished data, unclassified observations, etc.).

<https://github.com/nachifur/MulimgViewer/issues/57>



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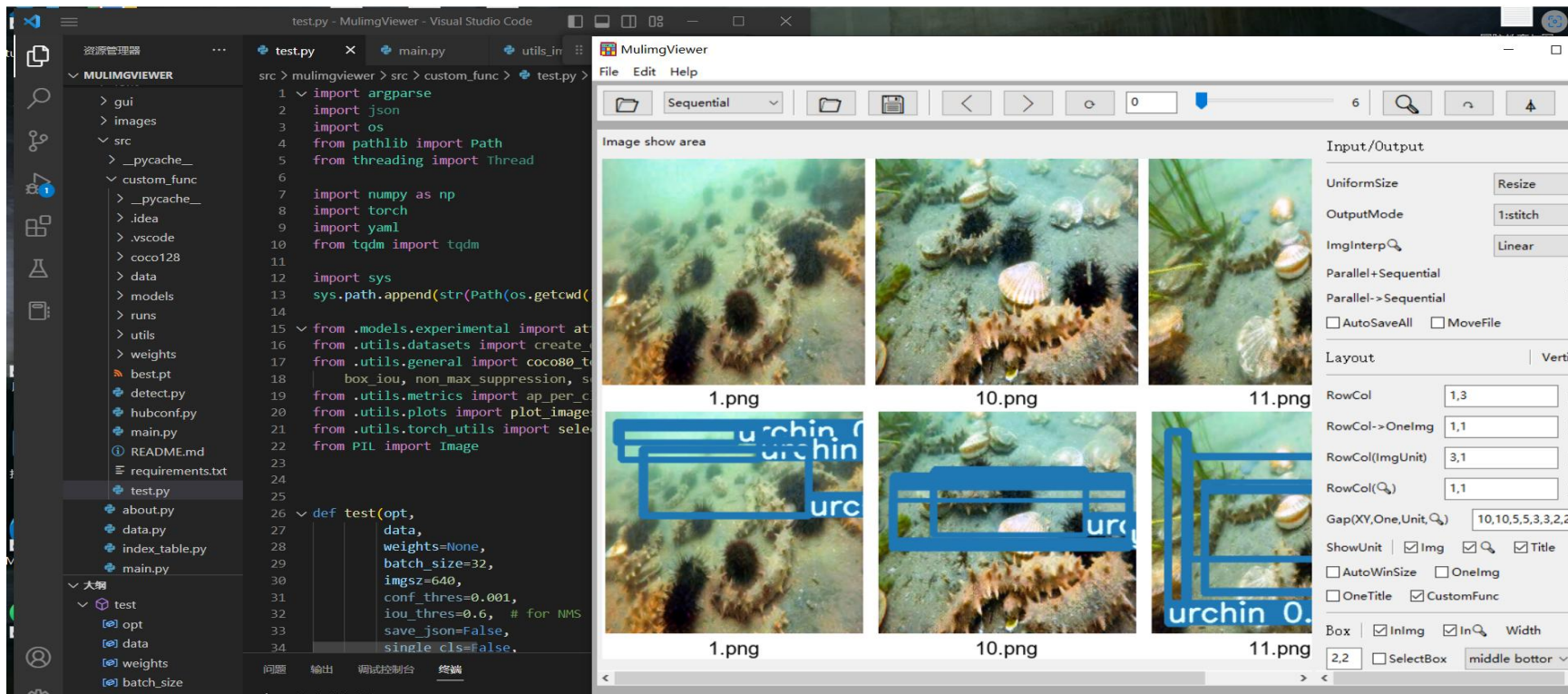
姓名: 刘佳伟
邮箱: liujiawei@sia.cn



4. 开源软件- MulimgViewer

➤ 支持用户自定义图像处理函数

作为图像显示前端，支持任何定制的python图像处理算法，如：使用CPU的传统图像处理算法，或者使用GPU的深度学习算法（检测、识别、分割等）



<https://github.com/nachifur/MulimgViewer/issues/74>



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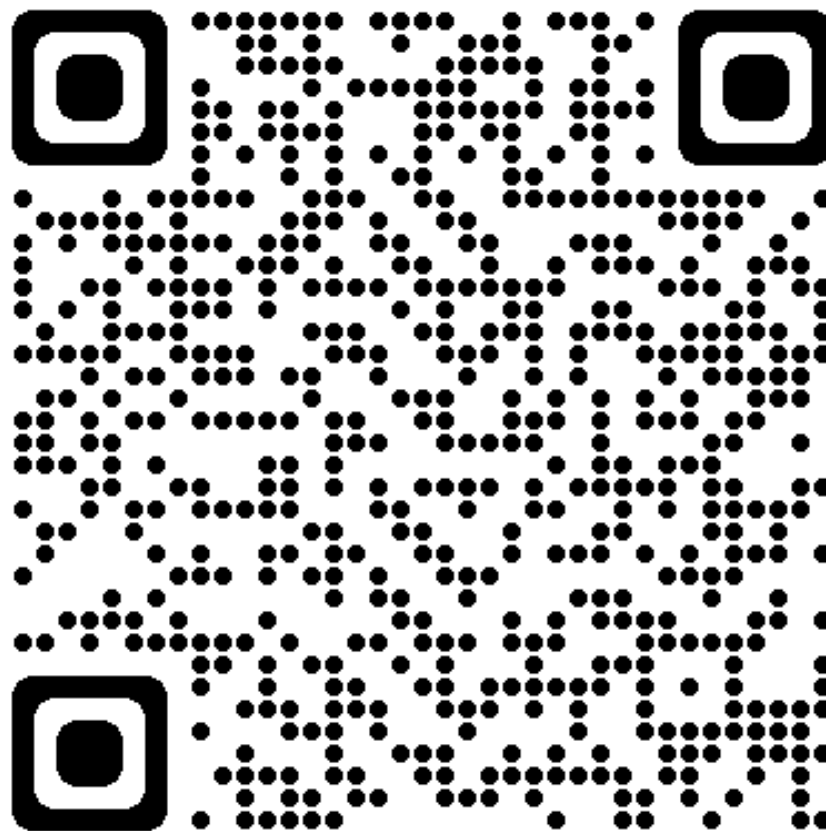
姓名：刘佳伟

邮箱：liujiawei@sia.cn

WeChat: nachifur



[Code: github.com/nachifur](https://github.com/nachifur)



谢谢各位老师同学， 敬请指正！



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