RepMode: Learning to Re-parameterize Diverse Experts for Subcellular Structure Prediction [CVPR'23 Highlight]

VALSE 2023 中国 无锡
视觉与学习青年学者研讨会
VISION AND LEARNING SEMINAR

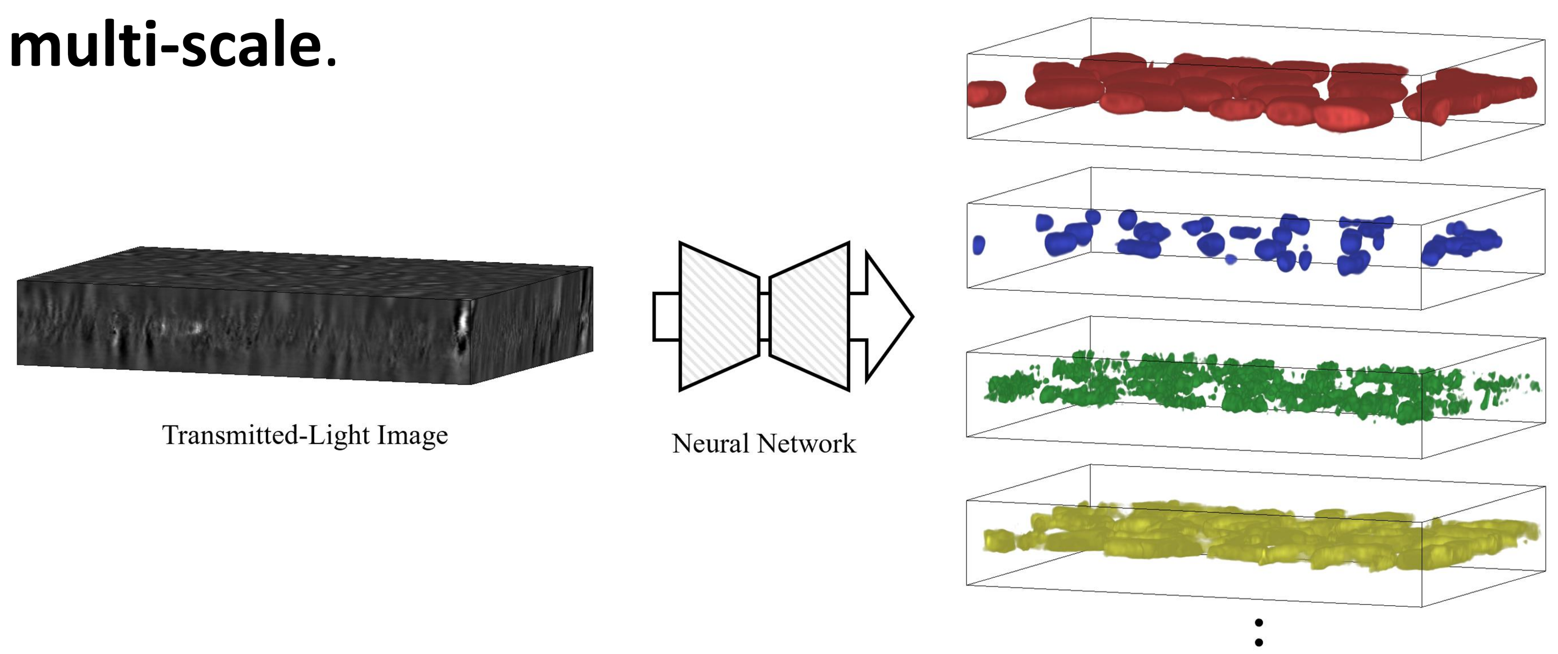
Donghao Zhou[1,2,3], Chunbin Gu[3], Junde Xu[1,2,3], Furui Liu[4], Qiong Wang[1], Guangyong Chen[4*], Pheng-Ann Heng[1,3,4]

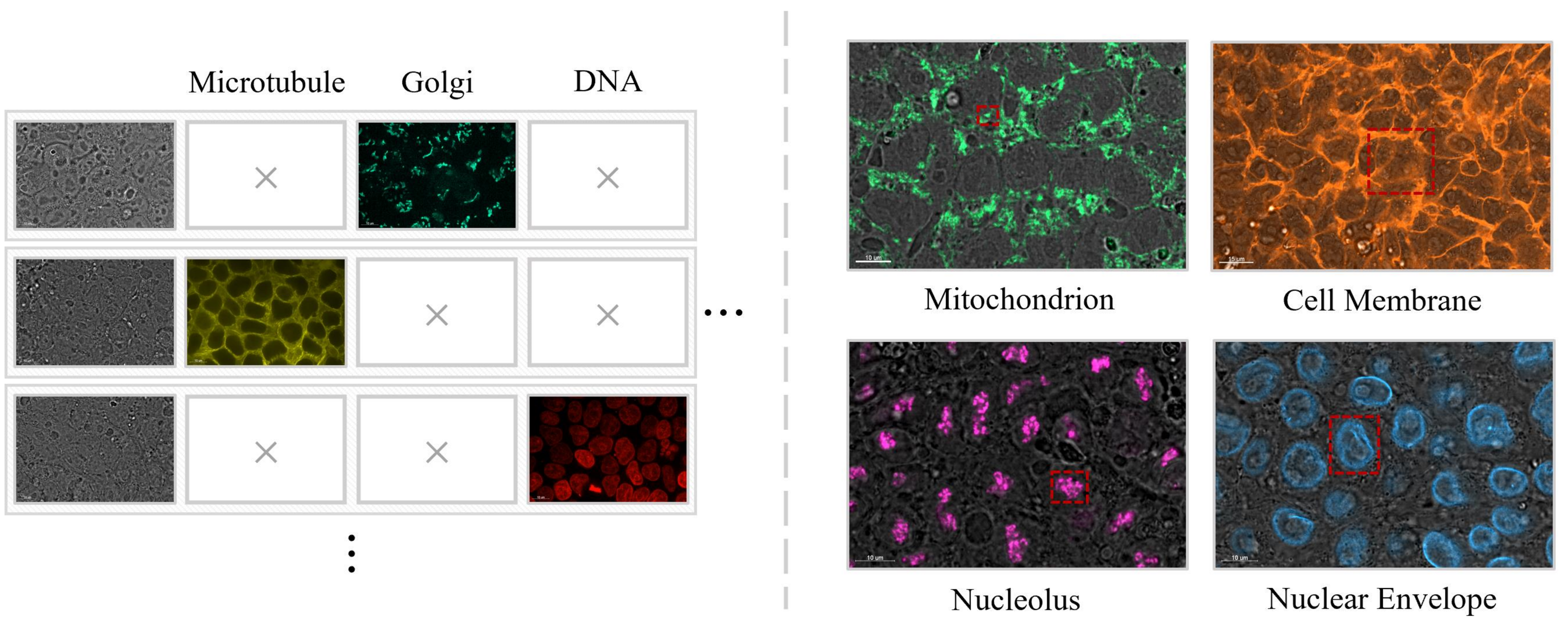
[1] SIAT, CAS [2] UCAS [3] CUHK [4] Zhejiang Lab

"Can we recreate Warhol's masterpiece for cells?"

Task and Challenges

We introduce **Subcellular Structure Prediction (SSP)**, which aims to predict 3D fluorescent images of multiple subcellular structures with a 3D transmitted-light image as input, to the CV community. This task faces two challenges, *i.e.* **partial labeling** and **multi-scale**.



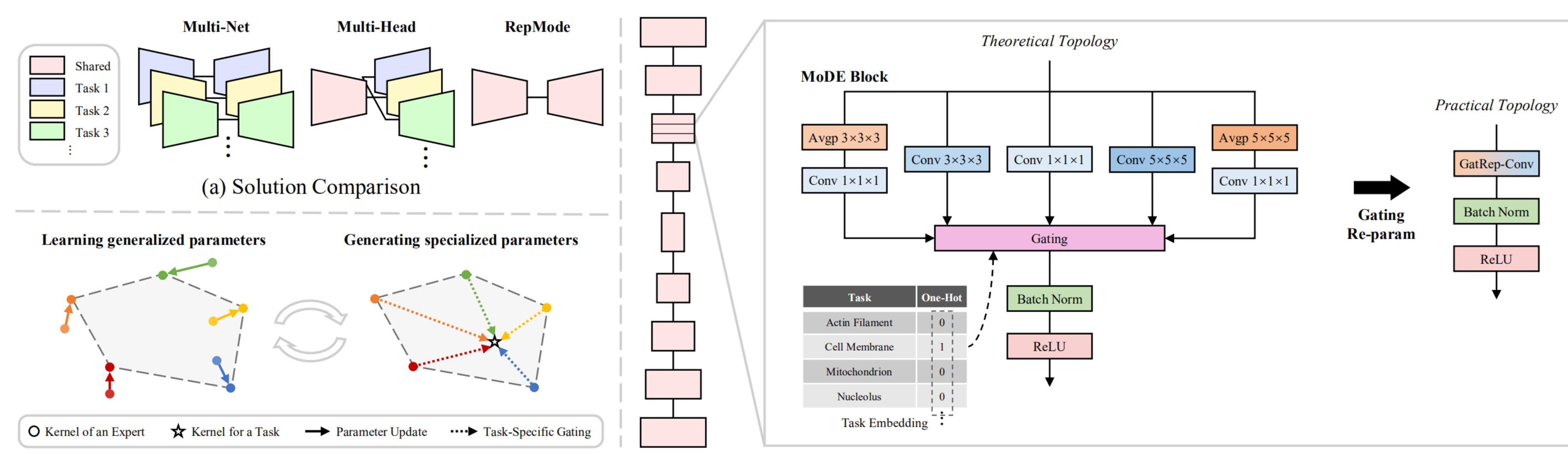


Partial Labeling

Multi-Scale

Proposed Method

Re-parameterizing Mixture-of-Diverse-Experts (RepMode) is a network that dynamically organizes its parameters with task-aware priors to handle specified prediction tasks of SSP.

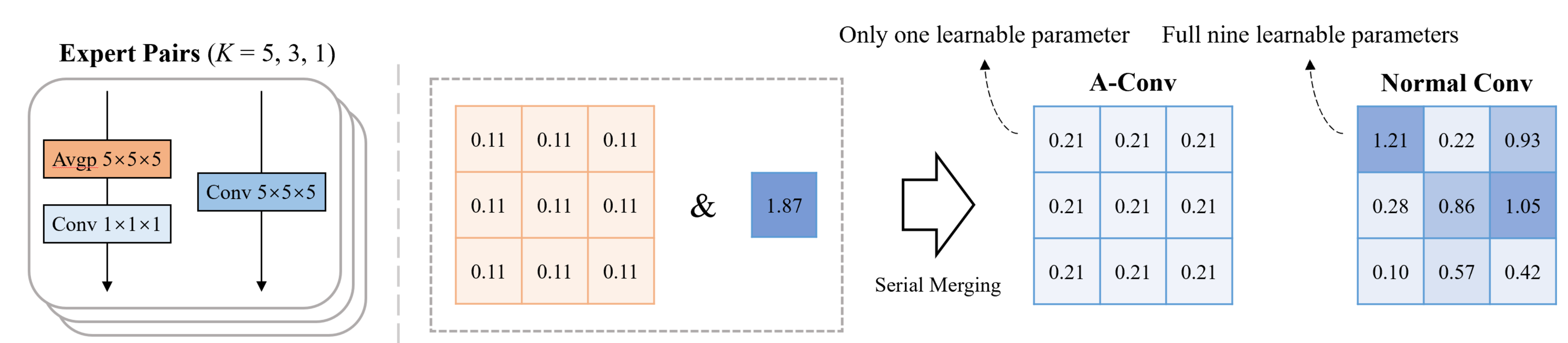


(a) Solution Comparison

(c) Dynamic Parameter Organizing

(b) RepMode

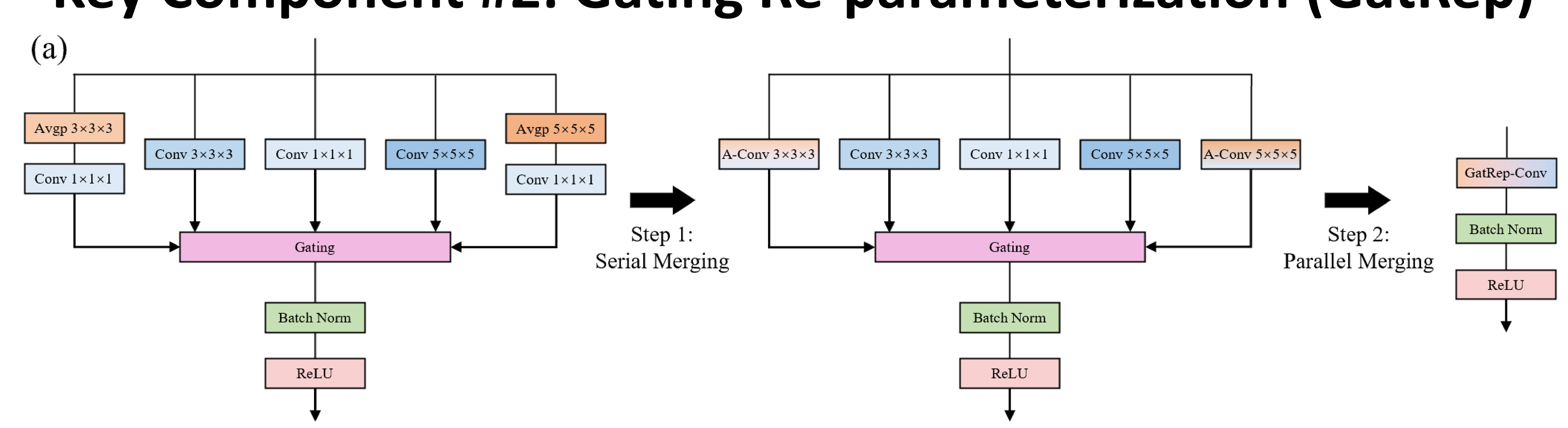
Key Component #1: Mixture of Diverse Expert (MoDE) Block

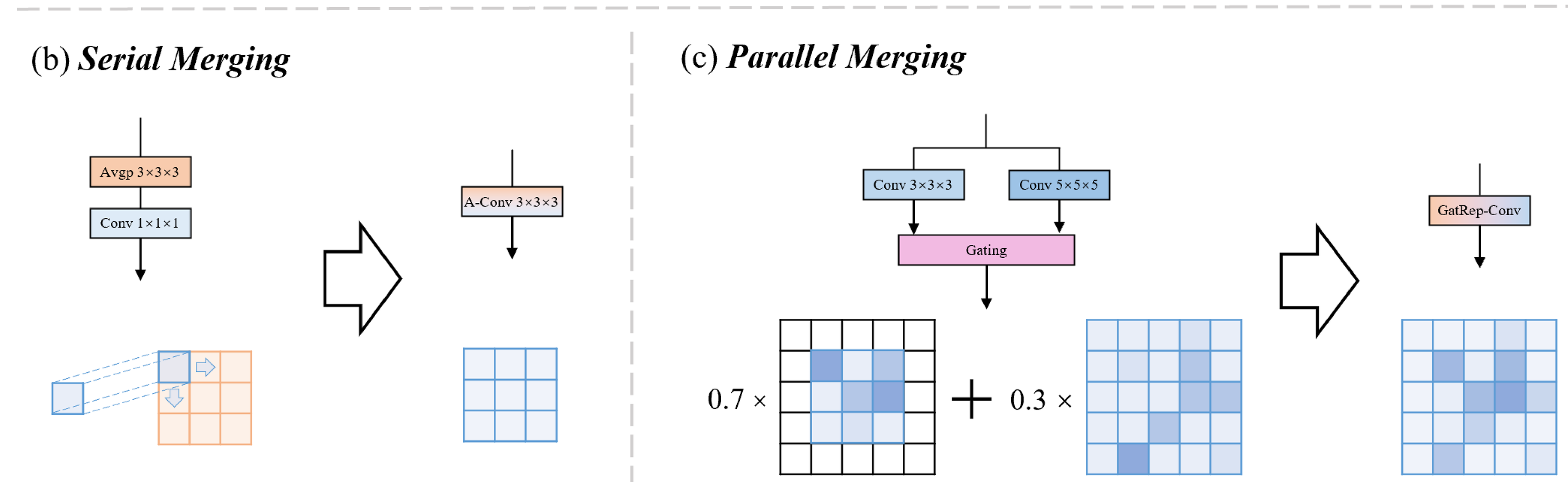


(a) Shape Diversity

(b) Kernel Diversity

Key Component #2: Gating Re-parameterization (GatRep)





(b) *Serial Merging*

(c) *Parallel Merging*

Experiments and Analysis

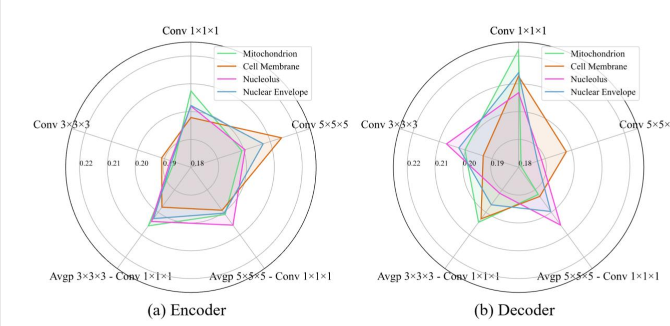
Ablation	Methods	MSE	MAE	R^2
Scope	only in Dec.	.5097	.4139	.4590
	only in Enc.	.5079	.4184	.4607
Expert	w/o $1\times1\times1$ expert pair	.5027	.4106	.4662
	w/o $3\times3\times3$ expert pair	.5080	.4141	.4605
	w/o $5\times5\times5$ expert pair	.5017	.4108	.4672
	w/o Conv expert	.5631	.4346	.4042
	w/o Avgp - Conv expert	.5037	.4101	.4651
Average Pooling	w/o Avgp	.4999	.4112	.4691
	all use $3\times3\times3$ Avgp	.4974	.4072	.4716
	all use $5\times5\times5$ Avgp	.4964	.4091	.4725
Gating	use Gauss. task embedding	.5071	.4155	.4616
	use two-layer FCN	.4980	.4060	.4710
	use Sigmoid activation	.4992	.4094	.4698
Original	RepMode	**.4956**	**.4078**	**.4735**

Experimental results of ablation studies from four aspects.

Methods	Actin Filament			Actom. Bundle			Cell Membrane			Desmosome			DNA			Endop. Reticulum			Golgi Apparatus		
	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2
Multi-Net [47]	.4241	.4716	.5695	.7247	.4443	.2606	.5940	.4351	.3930	.8393	.5640	.0162	.5806	.5033	.3822	.4635	.4914	.5262	.8023	.5732	.0801
Multi-Head (Dec.)	.4278	.4803	.5657	.7052	.4363	.2804	.5785	.4625	.4089	.8431	.5677	.0118	.5312	.4764	.4346	.4454	.4832	.5448	.7925	.5768	.0910
Multi-Head (Las.)	.4648	.4978	.5281	.6697	.4222	.3168	.5568	.4441	.4310	.8402	.5637	.0148	.5088	.4824	.4581	.4372	.4697	.5531	.7918	.5807	.0921
CondNet [15]	.4246	.4719	.5688	.6873	.4286	.2988	.5635	.4157	.4242	.8422	.5655	.0126	.4967	.4707	.4712	.4290	.4697	.5615	.7996	.5823	.0831
TSNs [56]	.4279	.4779	.5656	.6691	.4111	.3174	**.5309**	.4346	**.4575**	.8392	.5630	.0160	.4974	.4682	.4702	.4362	.4785	.5543	.7892	.5777	.0949
PIPO-FAN [16]	.4063	.4603	.5873	.6815	.4306	.3046	.5440	.4389	.4441	.8417	.5674	.0131	.4868	.4626	.4813	.4433	.4832	.5470	.7968	.5861	.0861
DoDNet [71]	.4215	.4706	.5721	.6989	.4204	.2870	.5459	.4390	.4422	.8415	.5633	.0133	.5280	.4810	.4382	.4414	.4844	.5490	.7927	.5774	.0909
TGNet [63]	**.3917**	**.4535**	**.6023**	.6843	.4213	.3018	.5856	.4227	.4015	.8392	.5654	.0160	.5011	.4746	.4666	.4441	.4806	.5460	.7870	.5774	.0973
RepMode	.3936	.4558	.6004	**.6572**	**.4103**	**.3295**	.5443	**.4136**	.4437	**.8358**	**.5619**	**.0199**	**.4852**	**.4598**	**.4831**	**.4046**	**.4445**	**.5865**	**.7792**	**.5694**	**.1064**

Methods	Microtubule			Mitochondria			Nuclear Envelope			Nucleolus			Tight Junction			All			Δ_{Imp}(%)		
	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2	MSE	MAE	R^2
Multi-Net [47]	.3682	.4348	.6296	.4684	.3921	.5172	.3014	.3006	.6954	.2164	.1789	.7826	.6474	.3369	.3370	.5341	.4269	.4337	0.000	0.000	0.000
Multi-Head (Dec.)	.3932	.4594	.6044	.4545	.3888	.5315	.2687	.2895	.7284	.2114	.1762	.7877	.6396	.3252	.3451	.5226	.4258	.4456	2.149	0.272	2.752
Multi-Head (Las.)	.3781	.4465	.6196	.4649	.3991	.5208	.2909	.3057	.7059	.2213	.1870	.7778	.6547	.3367	.3298	.5223	.4275	.4461	2.218	-0.12	2.868
CondNet [15]	.3868	.4523	.6108	.4673	.4067	.5184	.2876	.3014	.7094	.2203	.1865	.7787	.6569	.3241	.3274	.5206	.4232	.4478	2.534	0.884	3.249
TSNs [56]	.3407	.4235	.6572	.4625	.3956	.5233	.2904	.2991	.7064	.2116	.1751	.7874	.6479	.3320	.3367	.5113	.4192	.4572	4.263	1.804	5.437
PIPO-FAN [16]	.3604	.4365	.6373	.4750	.4171	.5105	.2904	.3003	.7065	.2097	.1782	.7894	.6437	.3282	.3410	.5141	.4237	.4543	3.747	0.766	4.764
DoDNet [71]	.3972	.4606	.6004	.4772	.4119	.5081	.2976	.3164	.6992	.2250	.1934	.7740	.6703	.3336	.3137	.5276	.4291	.4406	1.227	-0.49	1.607
TGNet [63]	.3569	.4310	.6410	.4585	.3971	.5274	.2748	.2940	.7222	.2093	.1799	.7897	.6232	**.3238**	.3619	.5108	.4183	.4578	4.363	2.022	5.566
RepMode	**.3389**	**.4171**	**.6590**	**.4459**	**.3885**	**.5404**	**.2631**	**.2820**	**.7340**	**.1995**	**.1682**	**.7997**	**.6168**	.3245	**.3685**	**.4956**	**.4078**	**.4735**	**7.209**	**4.482**	**9.176**

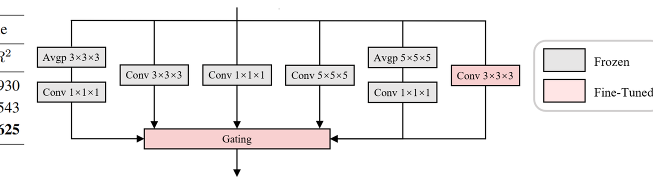
Experimental results of the proposed RepMode and the comparing methods on twelve prediction tasks of SSP.



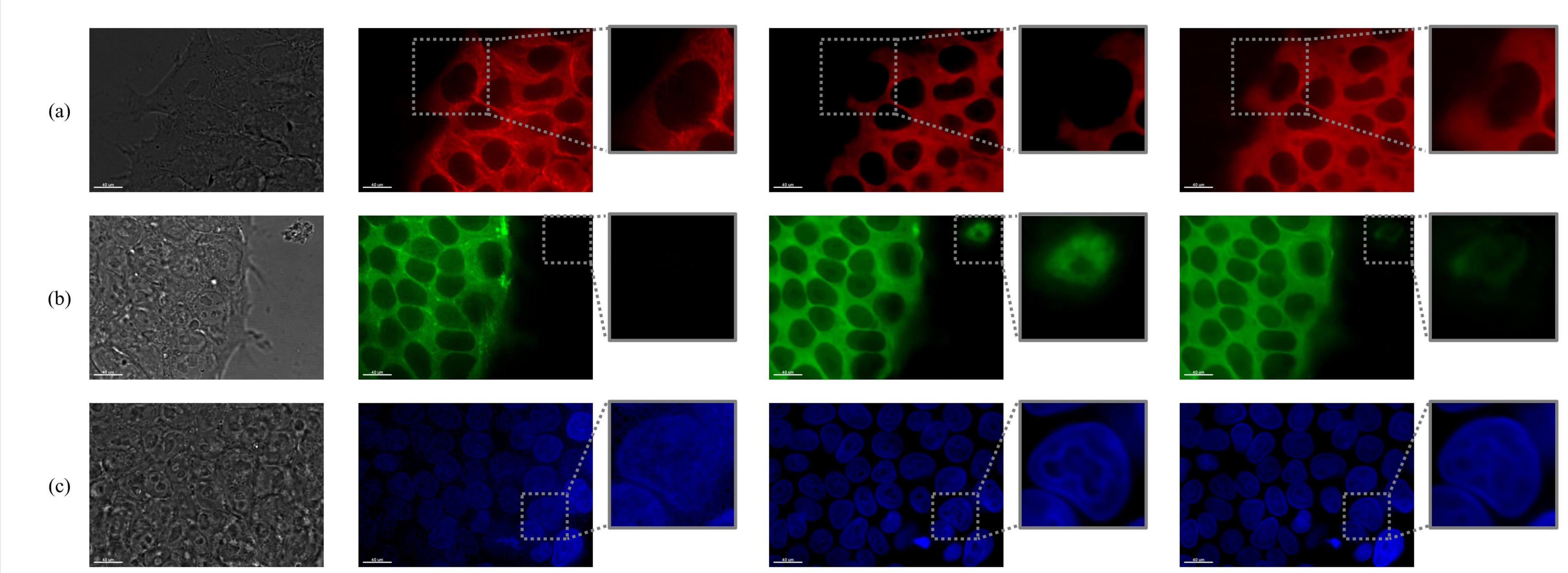
Visualization of channel-wisely averaged gating weights of two MoDE blocks which are from (a) encoder and (b) decoder respectively.

Methods	Strategies	Nucleolus			Cell Membrane		
		MSE	MAE	R^2	MSE	MAE	R^2
Mutli-Net [47]	Individual Training	.2164	.1789	.7826	.5940	.4351	.3930
Multi-Head (Dec.)	Fine-Tuning	.2121	.1811	.7870	.5339	.4097	.4543
RepMode	Experts Frozen	**.2052**	**.1774**	**.7939**	**.5260**	**.4077**	**.4625**

Experimental results of task-incremental learning.



Visualization Results



Transmitted-Light Image (Input) | Fluorescent Image (Label) | TGNet | RepMode (Ours)

Scanning for the code

E-mail: *dh.zhou@siat.ac.cn*

Scanning for the paper