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

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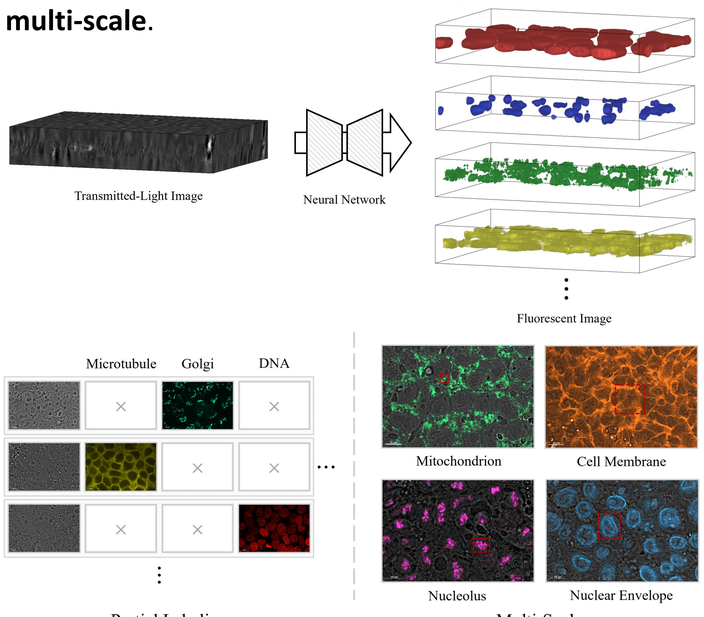
"Can we recreate Warhol's masterpiece for cells?"

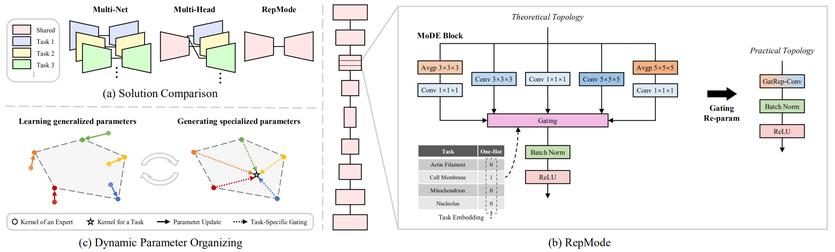
Task and Challenges

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**.

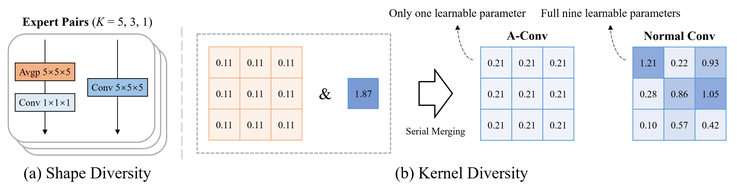


Proposed Method

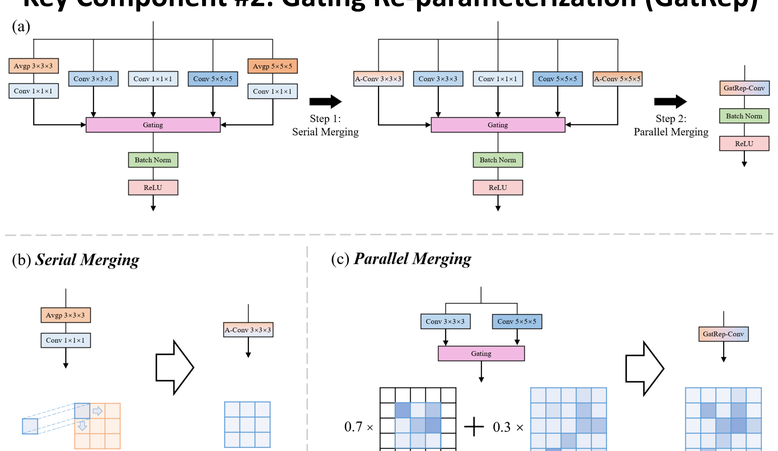
Re-parameterizing Mixture-of-Diverse-Experts (RepMode) is a network that dynamically organizes its parameters with task-aware priors to handle specified prediction tasks of SSP.



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



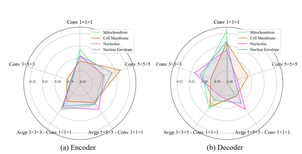
Key Component #2: Gating Re-parameterization (GatRep)



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.



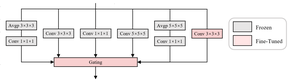
Visualization of channel-wisely averaged gating weights of two MoDE blocks which are from (a) encoder and (b) decoder respectively.

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**	.4137	**.8388**	**.5619**	**.0199**	**.4852**	**.4598**	**.4831**	**.4406**	**.4445**	**.5865**	**.7792**	**.5694**	**.1064**

Methods	Microtubule			Mitochondria			Nuclear Envelope			Nucleolus			Tight Junction			All			Δ_{avg}(%)
	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**

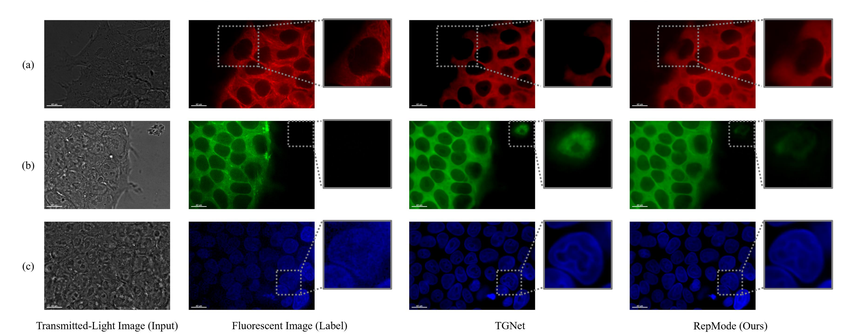
Experimental results of the proposed RepMode and the comparing methods on twelve prediction tasks of SSP.

Methods	Strategies	Nucleolus			Cell Membrane		
		MSE	MAE	R^2	MSE	MAE	R^2
Multi-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



Scanning for the code

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Scanning for the paper