Network Architecture

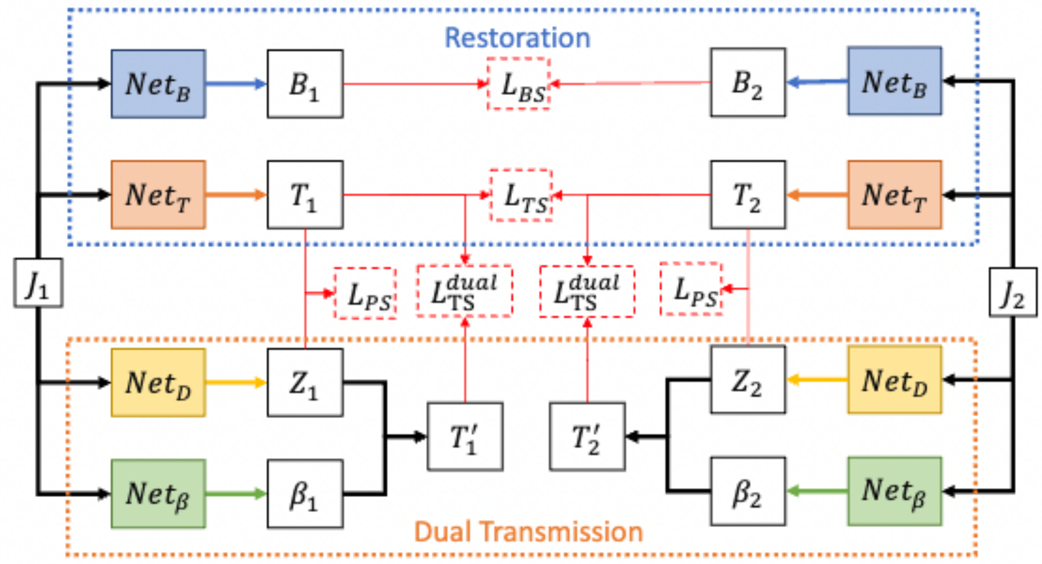

Fig. 1: The overall jointly learning framework of underwater image restoration and depth estimation. J_1 is the input image, J_2 is the perturbed image corresponding to J_1, B is the background light estimated by the back-scattering estimation network Net_B, T is the transmission map estimated by the transmission net Net_T, Z is the estimated depth by depth net Net_D, β is estimated atmospheric attenuation coefficient by β net Net_β and T' is the computed dual transmission map via transmission-depth modeling. The L_{BS}, L_{TS}, L_{PS} and L_{TS}^{dual} are the back-scattering similarity, transmission similarity, Pearson similarity and dual transmission similar loss functions respectively.

Restoration Results

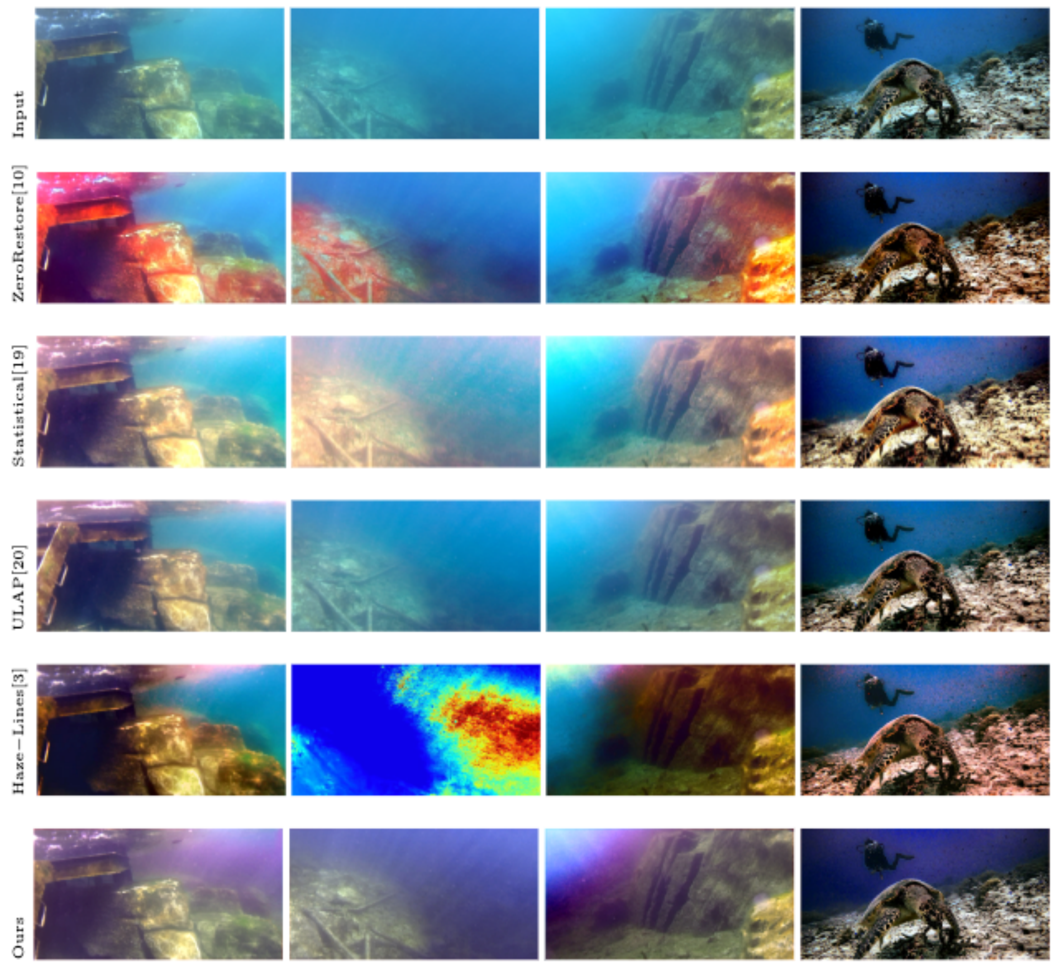

Fig. 2: Underwater image color restoration results tested on Garda #1, Garda #2, Garda #3 and UIEB datasets respectively from left to right.

Table 1: Underwater image restoration quantitative measurements

	Garda #1		Garda #2		Garda #3		UIEB [12]	
	$\psi\downarrow$	UIQM $\uparrow$	$\psi\downarrow$	UIQM $\uparrow$	$\psi\downarrow$	UIQM $\uparrow$	$\psi\downarrow$	UIQM $\uparrow$
Zero-Restore[10]	12.29	2.777	12.23	3.394	12.31	3.346	12.55	3.080
Statistical[19]	9.772	2.714	9.892	3.041	9.885	2.909	9.162	2.852
ULAP[20]	9.772	2.610	9.022	3.946	9.063	3.320	9.004	3.205
HaZe-Lines[3]	9.122	2.993	9.122	2.979	9.112	3.093	9.112	2.705
Ours	12.29	3.419	12.22	3.505	12.31	3.352	12.31	3.349

Depth Results

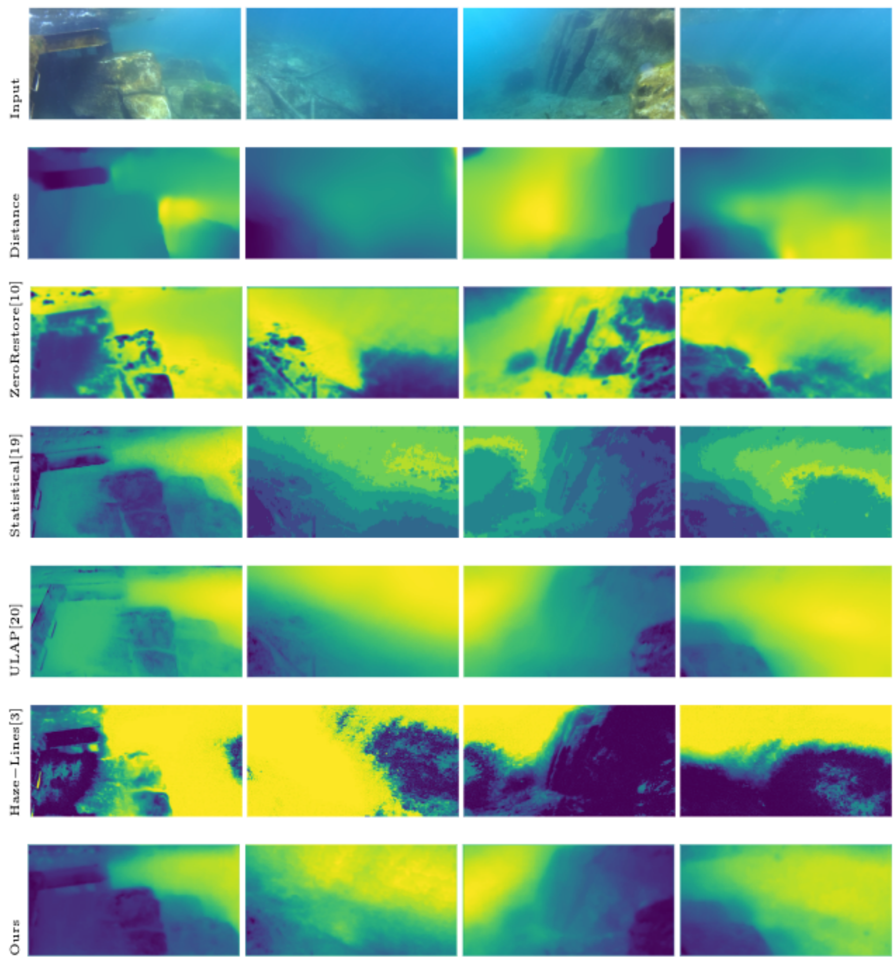

Fig. 3: The underwater image depth estimation results, the first and the last column are samples from Garda #1, the second and the third column is sampled from Garda #2 and Garda #3 respectively.

Ablation Study of Dual-Transmission and Loss

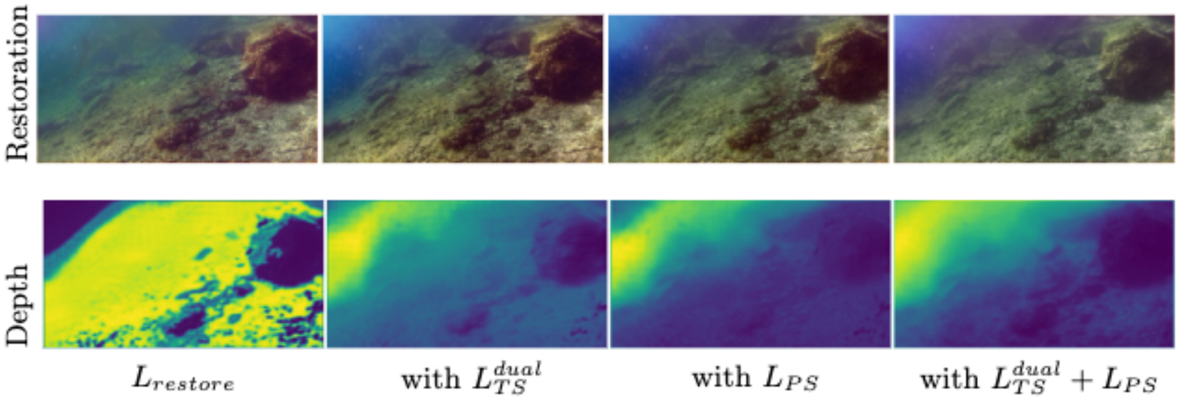

Fig. 4: Ablation studies of proposed loss functions. The first row shows the result of colour correction, and the second row shows the depth estimation results. The first column results are generated with networks trained with $L_{restore}$, the second and third column results are trained to use $L_{restore}$ additional with L_{TS}^{dual} and L_{PS} respectively, the last column results are trained with all of these three loss functions.

Table 3: Ablation studies on proposed loss functions with # Garda #1 dataset.

	$L_{restore}$	with L_{TS}^{dual}	with L_{PS}	with $L_{TS}^{dual} + L_{PS}$
$\psi \downarrow$	12.37	12.34	12.33	12.31
UIQM $\uparrow$	3.170	3.370	3.398	3.419
$\rho \uparrow$	0.075	0.308	0.608	0.677
SI-MSE $\downarrow$	0.083	0.056	0.059	0.056

Ablation Study of Beta-Modeling

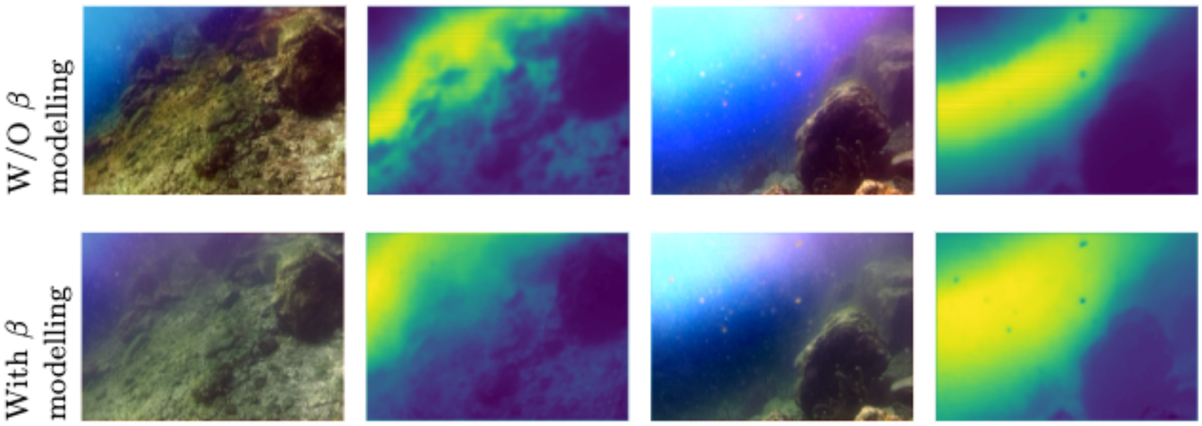

Fig. 5: Examples on attenuation coefficie β modeling ablations. The first row shows that predict β withoutβ-depth model the second-row shows predict β by estimating the β-depth relation first. The first two and last two columns show the different tested samples' colour restoration and depth estimation results.

Table 4: Ablation studies on efficacy of modeling relation between β and depth

	$\psi \downarrow$	UIQM $\uparrow$	$\rho \uparrow$	SI-MSE $\downarrow$
W/O β modelling	12.44	3.025	0.423	0.057
With β modelling	12.31	3.419	0.677	0.056