

## Question 3

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### Research Paper Summary on Underwater Image Restoration

**Title:** “Underwater Image Restoration Based on Deep Convolutional Generative Adversarial Network”

**Venue and Publication Year:** IEEE Access, 2019

**Problem Statement:** Underwater images often suffer from issues such as color distortion, low contrast, and blurriness due to light absorption and scattering in water. This paper addresses the problem of restoring underwater images to enhance their visual quality and recover true colors.

**Cost Function:** The restoration process utilizes a Deep Convolutional Generative Adversarial Network (DCGAN) framework, which involves two primary components:

1. **Generator Loss ( $L_G$ ):** The generator aims to produce images that are indistinguishable from real, high-quality underwater images. Its loss function combines two terms:
  - **Adversarial Loss ( $L_{adv}$ ):** Measures how well the generator can fool the discriminator.
  - **Content Loss ( $L_{content}$ ):** Ensures that the generated image retains the content of the input degraded image.

The generator loss is defined as:

$$L_G = \lambda_{adv} \cdot L_{adv} + \lambda_{content} \cdot L_{content}$$

Where:

$$L_{adv} = -\log(D(G(I_{degraded})))$$

- $D$ : Discriminator network
- $G$ : Generator network
- $I_{degraded}$ : Input degraded underwater image

$$L_{content} = \|G(I_{degraded}) - I_{reference}\|_2^2$$

- $I_{reference}$ : Reference high-quality underwater image

$\lambda_{adv}$  and  $\lambda_{content}$ : Weights balancing the adversarial and content losses.

2. **Discriminator Loss ( $L_D$ ):** The discriminator’s objective is to distinguish between real high-quality underwater images and those generated by the generator. Its loss function is:

$$L_D = -[\log(D(I_{reference})) + \log(1 - D(G(I_{degraded})))]$$

Where:

- $D(I_{\text{reference}})$ : Discriminator's output for a real high-quality image
- $D(G(I_{\text{degraded}}))$ : Discriminator's output for a generated image

By optimizing these loss functions, the network learns to restore degraded underwater images, improving their visual quality and color accuracy.