Slide 1:

We will be discussing our survey on **Underwater Image Enhancement Using Multi-Fusion Techniques.** This topic is crucial because the underwater environment holds a wealth of biodiversity and untapped energy resources, which are essential for life on Earth. However, capturing high-quality underwater images presents significant challenges due to the unique physical and chemical properties of the medium. Our survey explores various advanced techniques that address these challenges and improve the quality of underwater images, enabling better applications in fields like robotics, search and rescue, and environmental monitoring.

Since the mid-20th century, advancements in technology have exponentially increased our ability to explore marine environments. These advancements have introduced high-tech operations that rely heavily on vision-based technologies to collect and analyze underwater data. Vision-based systems are particularly valued for their ability to handle high-density information and adapt to complex underwater environments. They play a crucial role in diverse applications, including marine robotics, structural inspections, search and rescue operations, and environmental monitoring.

Slide 2:

"Despite these advancements, underwater imaging faces significant challenges. The underwater environment is vastly different from terrestrial settings, primarily due to physical and chemical properties that degrade image quality. One of the primary issues is scattering and absorption of light, which results in images that are hazy, low-contrast, and often distorted by green-blue tints. This is because water attenuates light wavelengths at different rates, with red light disappearing first, followed by green, and then blue. Moreover, particles suspended in water scatter light, which further degrades image clarity and contrast. These conditions make underwater imaging one of the most challenging areas of computer vision."

Slide 3:

"Artificial lighting is often used to improve underwater image quality. While it helps illuminate the scene, it introduces its own set of challenges. For instance, artificial lights often result in non-uniform illumination, where the center of the image is brightly lit, but the edges remain dark. Shadows are also more prominent due to the absorption and scattering of light in water. These factors highlight the need for sophisticated enhancement techniques to address the limitations of both natural and artificial light in underwater imaging."

Slide 4:

Given these challenges, researchers have developed various methods to enhance underwater images and overcome issues such as low contrast, poor color representation, and noise. In this survey, we explore 11 state-of-the-art techniques for underwater image enhancement

Slide 5:

HIFI-Net: Novel Network for Enhancement

This method combines **Reinforcement Fusion Modules** and **Haar Wavelets** to restore image clarity and fine details.

It excels at correcting color casts and removing haze.

The limitation is the technique Limited results reported for some metrics,

Slide 6:

The method SA-GAN (Self-Adversarial GAN) introduces a self-adversarial model that implements two stages of image enhancement

SA-GAN achieves high scores in metrics like UIQM (Underwater Image Quality Metric) and UCIQE (Underwater Image Quality Evaluation).

It's particularly effective for low-light environments, such as deep-sea exploration, where traditional techniques fail."

Slide 7:

Zero-UIE improves underwater image quality without requiring paired training data.

• Uses a novel underwater curve model and non-reference loss functions for color restoration and contrast enhancement.

• Achieves better results than methods like UGAN and WaterNet.

• Provides a cost-effective and generalizable solution for real-time image enhancement.

Slide 8-10: read ppt content

Slide 11:

To evaluate each technique, we use various metrics like

PSNR ,SSIM ,MSE ,VIF, Colorfulness Metric ,Inception Score (IS), Contrast Ratio , Runtime Efficiency.

Slide 12:

By using these metrics, we have compared the performance of the 11 techniques.

Slide 13:

Techniques like Self-Adversarial GAN and Domain Adaptation via Content and Style Separation achieve high visual and structural quality but may have slightly higher computational costs.

Methods emphasizing runtime efficiency, such as Image Dehazing Techniques and Multi-Scale Fusion, are practical for real-time applications.

Future enhancements could integrate the strengths of these methods, such as GAN-based image generation with lightweight architectures for efficiency.

Slide 14:

To conclude, our survey presents a detailed analysis of various advanced techniques for underwater image enhancement. We discussed methods such as reinforcement fusion, GAN-based approaches, zero-reference techniques, two-step fusion, and white balancing, along with newer methods like color correction and content-style separation.

Each technique addresses specific challenges in underwater imaging, such as noise reduction, color restoration, and detail sharpening. These methods leverage innovative algorithms and architectures to provide better accuracy and visual quality compared to conventional methods.

However, challenges remain. Many approaches depend on extensive training datasets, which can be costly to generate and maintain. Furthermore, generalization to diverse underwater environments is still an open problem.

Looking ahead, future research should focus on developing lightweight, cost-effective models that can adapt to various underwater conditions. Integrating hybrid approaches that combine data-driven and physics-based methods may also lead to significant breakthroughs in underwater imaging.

Thank you