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AMPLIFYING AQUATIC VISUALS

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***Abstract*—Our proposed fusion-based approach aims to combat the degradation of underwater images, addressing issues such as diminished colors and indistinguishable objects. Leveraging contrast stretching and Auto White Balance, the technique significantly improves contrast and color, offering a straightforward yet effective solution to enhance visibility in aquatic images, crucial for applications like video surveillance in outdoor computer vision systems. This straightforward approach plays a pivotal role in enhancing image visibility, contributing significantly to applications like video surveillance and other outdoor computer vision systems. Our dehazing process builds upon two essential statistical observations related to haze-free images and haze. By applying dark channel prior and guided filter to the decomposed image, we effectively estimate atmosphere light, resulting in a dehazed output. This method tackles the intricacies of haze, contributing to the generation of high-quality images with improved details and clarity. Beyond image enhancement, our approach showcases versatility by extending into object classification, demonstrating the broader impact and potential of our method in the realm of outdoor computer vision systems.**

1. INTRODUCTION:

Underwater exploration has gained significant attention from scientists, with applications ranging from oceanic engineering to monitoring marine life and estimating sea populations. Despite the vastness of Earth's water-covered surface, the underwater world remains largely unexplored. The turbidity of water, caused by particles like minerals, sand, and plankton, poses a major challenge in underwater research, introducing haziness in captured images.

Water's density, being approximately 800 times greater than air, results in reflection at the water's surface when light enters from the air. This reflection, combined with scattering effects from particles in the water, reduces the amount of light reaching the object to be captured, leading to dark underwater images. Additionally, water molecules absorb specific colors of light at different depths, causing underwater photographs to exhibit a greenish and bluish tint to address these challenges, researchers have explored both hardware and software-based solutions. High-quality cameras with high-resolution lenses offer a hardware-based approach but are costly. Consequently, attention has shifted towards software- based methods, including polarization effects, noise reduction, and image fusion. Various studies have attempted to handle haziness by reducing noise, enhancing contrast, and improving color using techniques such as contrast stretching, HSI color space adjustment, fusion methods, and polarization effect removal.

Recent attempts include Acute et al.'s fusion technique that reduces temporal coherent noise and uses fusion principles for image recovery. Iqbal et al. utilized contrast stretching and HSI color space adjustments to enhance the color of underwater images. Schechner et al. addressed partial polarization effects and worked on inverting the image formation process. Hitam et al. combined HSV and RGB color models using Euclidean norm and contrast limited adaptive histogram equalization.

Chiang et al. tackled the presence of artificial light sources and light scattering through wavelength compensation and image dehazing. Some researchers have explored single-image-based restoration techniques to simplify setup and implementation complexities associated with fusion methods. While these methods have enhanced degraded underwater images, challenges persist in achieving simultaneous contrast and color balancing.

This paper proposes an effective enhancement approach, focusing on color and contrast improvement using a single- image-based fusion technique. The method processes the original degraded image to derive different images, each emphasizing a significant feature. These processed images are then fused to create a final output image, blending all the features for optimal enhancement. The results demonstrate a substantial reduction in haziness compared to existing methods, such as Acute et al. and Kumar et al.
In conclusion, underwater image enhancement remains a complex challenge due to scattering, absorption, and reflection effects. Both hardware and software-based solutions have been explored, with recent emphasis on single-image-based techniques The proposed method showcased in this paper proves promising in addressing haziness and enhancing

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Fig. 1(a) Hazy underwater Image

Fig. 1 (b) Enhanced Underwater Image Using model

method derives different images each having a significantfeature by processing the original degraded image and then fuses all the images to get final output image which is a blend of all the features of processed images in it. Results of our proposed method prove that haziness of underwater images is removed at a large extent as compared to existing image enhancement methods. VIBGYOR, each of which have a specific wavelength associated with it. When light enter in water, the red color corresponding to highest wavelength gets absorbed first at a depth of 5m-10m only, followed by orange and yellow at 20m and 30m respectively. Green color travels to a maximum of 40m depth and gets vanished. Lowest wavelength corresponds to blue color and thus it travels to maximum depth reaching sea bed. Thus, the photographs captured deep under the water are highly greenish andbluish in color.

2. DIFFERENT APPROACH

Our Amplifying Aquatic Visuals has always been a critical taskto perform. However, if we go through all the process, we can sum up the Amplifying Aquatic Visuals.

1. Color space dimensionality reduction method.
2. Hybrid framework method.
3. Image Quality evolution metric.

1. Color space dimensionality reduction method: In this approach we use Quad tree sub division iteration algorithm, and a novel transmission estimation method. It is single image dehazing method where each image is divided into sub parts to find the keypart of the image.

2. Hybrid framework method: In this approach we use underwater white balance (UWB) and it is integrated with histogram stretching, we also use gray world algorithm to estimate the amount of {R, G, B} and increase or decrease the values according to the image and we take the output of UWB and guide with variation contrast and saturation enhancement (VSCE) to produce the final output image.

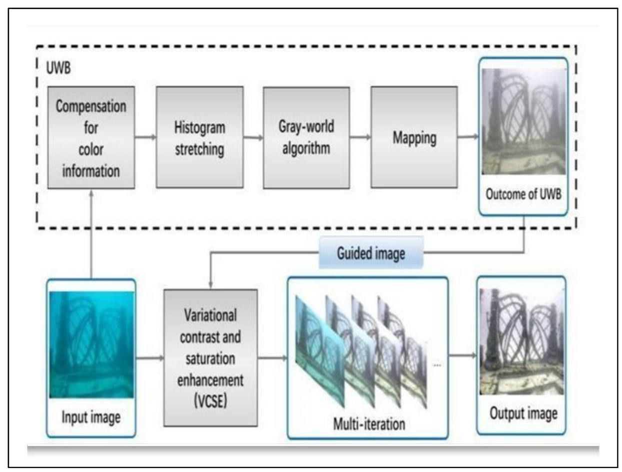

Fig. 2 *Flowchart of the Hybrid framework method.*

3. Image quality evaluation metric: In this approach we use underwater color image quality evaluation metric (UCIQE).These shows the results and capabilities to measure an image. (UCIQUE) is a simple fast solution for real time underwater images. The results show better co relationship between (UCIQUE) and Mean opinion score (MOS).

3. LITERATURE SURVEY

The underwater image dehazing has been a topic of immense interest and research over the years. There has been research works carried out and depending upon the above mentioned approaches many methods being invented for the intended purpose. Here we'll have a look at some of the most important methods in this area.

1. **Image quality enhancement and evaluation**: This method is based on Central neural network (CNN) and deep learning methods for image dehazing. Underwater images have mainly characterized by poor visibility and color degradation, due tothe harsh and complex underwater environment. For example, compared to blue and green light, the wavelengths of red and orange light are absorbed by the water much more quickly. Thus, underwater images often appear in a blue-green tone. These adverse effects limit many practical applications of underwater images and videos in marine biology, archaeology, and ecological explorations. This brings considerable attentionto subjective tests based on the human observer's evaluation, and objective models based on the algorithm's estimation. In digital image processing, there are many image enhancementtechniques are available, for instance, adaptive histogram equalization, contrast limited (CLAHE), and fusion based method. However, these are not applicable to underwater image processing, because these methods are inappropriate for a physical model of underwater. The spatial-domain is mature and simple to implement. These kinds of methods can be directly applied to underwater images, which help to improve Since the color cast has not been fully considered and the noisecannot be suppressed well, by existing achievements artifacts and noise still exist in the enhanced image. Deep learning-based methods have been used for image enhancement based on the idea that hidden features may be learned for quality enhancement by using Convolutional Neural Network (CNN).The approach introduced in propose a CNN-based underwater image enhancement model, which trains an end-to-end transformation model between the hazed images and corresponding clear images. In the authors synthesize ten different marine image databases, then a CNN-based imageenhancement model is employed to train the dataset and generate a clear underwater image. The performance was verified on the synthesis and real underwater image. In proposed a domain-adversarial learning-based underwaterimage enhancement, can handle multiple types of underwater images and generate clear images by learning domain agnostic features. Furthermore, the synthesized dataset cannot be analternative to the real data. The fusion-based underwater image enhancement method in uses the CNN for underwater image enhancement. The approach constructed a large-scale and real- world underwater image enhancement benchmark dataset (UIEBD). In addition, they built a fully connect CNN based on the constructed data. Despite the great effort devoted to the deep learning-based image enhancement, the performance of give a general view of some of the most recent methods applied in underwater image enhancement and quality evaluation. We also wish to provide scholars with some techniques that better suits his problem or application. excising methods relies heavily on both network architecture and training data. Due to the use of synthetic underwater images and the potential drawbacks of deep-learning architectures, these models may only adapt to some limited types of underwater images.

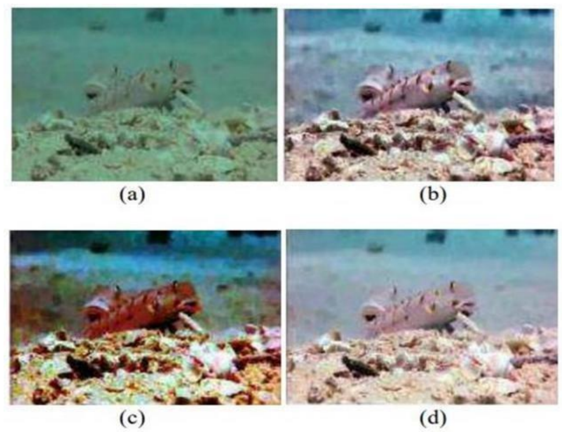

Fig.3 Comparison of the underwater image enhancement methods(a) original image (b) Fusion-based (c) Histogram prior (d)Water-Net

2. **Image Cleaning and Enhancement Technique for Underwater Mining:** The exploration of water bodies from the sea to land filled water spaces has seen a continuous increase with new technologies such as robotics. Underwater images are one of the main sensor resources used but suffer from added problems due to the environment. Multiple methods and techniques have provided a way to correct the color, clear the poor quality and enhance the features. In this paper, we present the work of an Image Cleaning and Enhancement Technique which is based on performing color correction on images incorporated with Dark Channel Prior (DCP) and then taking the converted images and modifying them into the Long, Medium and Short (LMS) color space, as this space is the region in which the human eye perceives color. This work is being developed at INESC TEC robotics and autonomous systems laboratory. Our objective is to improve the quality of images for and taken by robots with the particular emphasis on underwater flooded mines. The paper describes the architecture and the developed solution. A comparative analysis with state- of-the-art methods and of our proposed solution is presented. Results from missions taken by the robot in operational mine scenarios are presented and discussed and allowing for the solution characterization and validation. The visual quality of underwater images plays a crucial and pivotal role in many ocean engineering applications and scientific

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researches, such as marine ecological research, monitoring sea life, taking census of populations, ocean rescue, repair of structural damage and assessing geological or biological environments. Underwater Robotics has seen a wide and growing application in the recent years whether it be for applications like object detection, feature extraction, tracking, docking and mining. The underlining problem is that light travels more slowly through water- as it's a denser medium and thereby causes any camera device to have a tinge of blue and green in the resulting image while recording. Underwater images suffer from degradation due to poor visibility conditions from effects such as light absorption, light reflection, bending of light and scattering of light. External lighting fixtures can be added to capture a better image with more context in the frame but that isn't always the right solution. Image enhancement for underwater applications such as mining would improve navigation, quality and precision. The light from the sun undergoes refraction when it hits the surface of the water. The penetration of the various wavelengths of color. Fundamentally, in common sea water, the objects at a distance of more than 10 meters, on the account of the colors that are fading where the characteristic wavelengths of light are cut according to the water depth, seem indifferent. Once that depth is crossed, the colors are seen to become more in one color than the rest. In usual cases it's either green or blue. There is also the random attenuation of the light which is the main cause of the foggy occurrence. There are also living organisms which might interfere and dirt in that scenario which can be causes of disruption. The proposal of the methodology follows the corresponding steps, the initial being color correction of the image by performing a contrast stretch and equalization to each pixel in the image on the all channels, that is Red, Green and Blue respectively. The image is still foggy and unclear after this, so dehazing the image using DCP is done next Once the image has been dehazed we perform a conversion to the LMS color space. Our main goal is to develop a methodology for cleaningand enhancing images that have been captured in underwater mining scenarios for better vision, the detection of minerals and structures and to be able to integrate this algorithm and providea real time solution or effective enough solution for autonomous underwater robots. Thus, the improvement of image contrast, cleaning and enhancement are investigated. Our proposed framework of the methodology is combining some of the methodologies that is seen above. One of the main aspects is color correcting the image, as the images of are not of their true color. The true color of the object in some cases cannot be identified until it is brought up to the surface. Our attempt is to be able to give that image as much of its color back and clear it enough to be able to be detected and recognized by robots and people manning the station for mining applications

Color Correction: We understand from the light properties that the blue and green color travel longer in the water due to them Another approach was experimented on which gave very similar results, which was, taking the image and converting it into its L*A*B planes and applying the CLAHE algorithm to the Luminosity (L) channel of that image. The modifications are performed on the L channel and then merged back into the RGB color space to give us the result

shorter wavelength and this cause underwater images to be dominated by a blue or green color. When a histogram is plotted on any underwater images the distribution ranges of three channels usually does not cover the entire range [0,255]. To solve this problem, a color correction method is implemented which calculates the mean value among the three channels, independently. The values along each channel have a constant value to help equalize the colors. After the minimum and maximum values are found, the values are used for normalization which gives an even and average histogram distribution range to all the channels.

Dark Channel Prior: In computer vision the model to describe a hazed image is

$$I(x) = J(x)t(x) + A(1 - t(x))$$

where I denote the intensity, J is the scene radiance and A is the atmospheric light. The goal is to obtain the values of J, A and t from I. The first term of the equation is direct attenuation and the second term is air light. We obtain the J(dark) values which is the dark channel of J. To perform the removal of the dehaze we follow the same methodology that is stated in

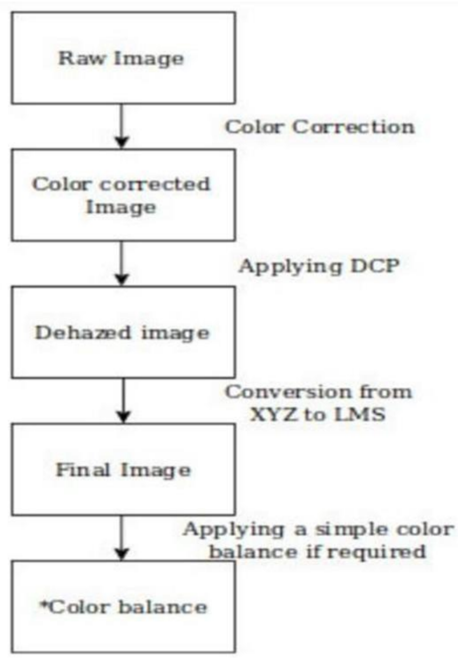

Fig.4 Algorithmic flow

A diagram of the proposed method is shown in fig.4. The process is broken down as follows: First, a color correction is done to solve the color cast, second, we apply DCP to the color corrected image and solve the hazing problem, lastly, we convert the image to XYZ, then convert it from XYZ to LMS. In some cases, a simple color balance can be added to make the image more visually pleasing.

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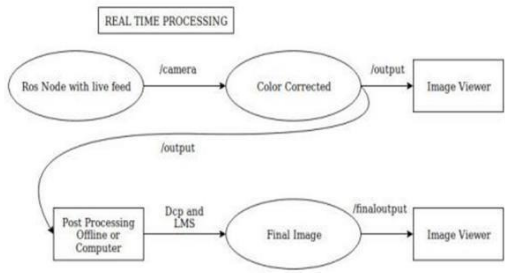

Fig 5 Ros nodes.

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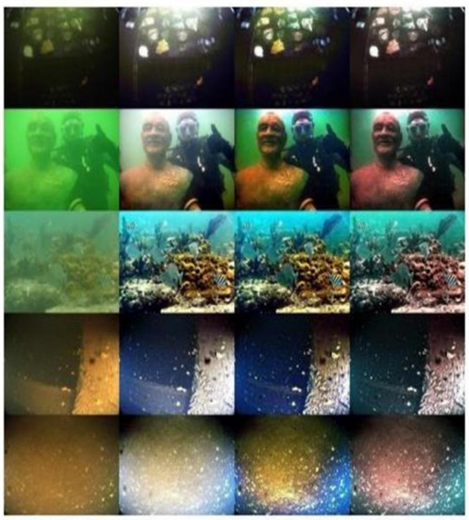

Fig .6 Left original image second color corrected imageThird image after dehazing by DCP Right our Purposed Methodology Final result

3. Contrast and Color Improvement based Haze Removal of Underwater Images using Fusion Technique: Scattering and absorption of light in water leads to degradation of images captured under the water. This degradation includes diminished colors, low brightness and undistinguishable objects in the image. To improve the quality of such degraded images, we have proposed fusion based underwater image enhancement technique that focuses on improving of the contrast and color of underwater images using contrast stretching and Auto White Balanced. Proposed method is very simple and straightforward that contributes greatly in uplifting the visibility of underwater images. Entropy specifies the amount of information retained in output image. High value of entropy states that the amount of distortion in the final image is less. PSNR defines the measure of the peak error; therefore, high. value of PSNR means better quality of image and a smaller number of errors in the image. AMBE, on the other hand, specifies average mean brightness error of final image on the scale of 0 to 1. High AMBE value states that the brightness of resultant image is higher than the brightness of original image. Hence, it can be concluded that a visually interpretable and clear image possess high entropy, PSNR and AMBE values. our method derives different images each having a significant feature by processing the original degraded image and then fuses all the images to get final output image which is a blend of all the features of processed images in it. Results of our proposed method prove that haziness of underwater images is removed at a large extent as compared to existing image enhancement methods.

(1) preprocessing the original hazy image to generate white balanced and contrast improved images which are meant to serve as inputs for the next process, (2) imposing luminance, saliency and chromatic weight map on both the input images: color balanced and contrast improved which are obtained from previous step and
(3) finally fusing all images of inputs and weight maps together from (1) & (2) so as to get the enhanced underwater image as output. As a result, significant features of all the fused images are inherited in the resultant output image, as shown in figure 2. The main idea behind our approach is to make use of only the original degraded image instead of merging multiple images taken in different environments.

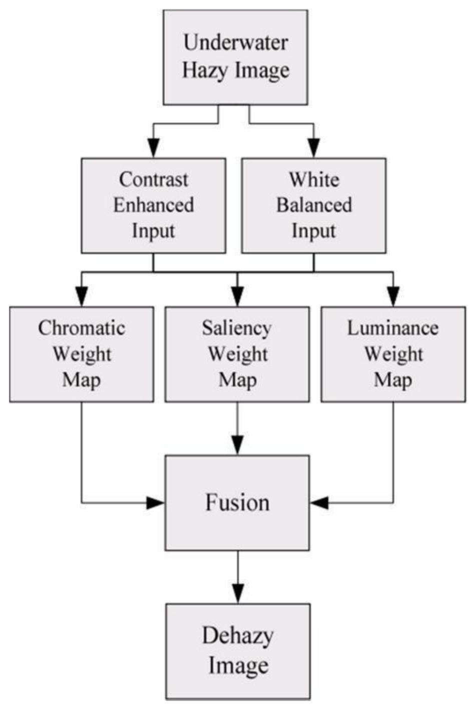

Fig.7 Flowchart of Fusion Based UnderwaterImage Enhancement Technique.

White Balance Image: White balancing constitutes a significant processing step of our method that aims at perceiving the actual colors of the objects present in the image regardless of the light illuminating it. Its major target is to discard unreal color casts and allow white objects to appear white in the image. We have used Auto White Balance Scheme (AWB) in our method which estimates the illuminant and adjust.

Contrast Improved Image: Contrast of an image defines the ability to distinguish the objects present in the image. Scattering phenomenon of light causes light rays to disperse in water which leads to decrease in the amount of light striking on the objects under the sea. This results in attenuation of light which does not allow the viewer to accurately identify and differentiate between the objects under water. Hence, the contrast of the image which marks the existence of various objects in an image is decreased to a great level. Therefore, we have used contrast stretching method to improve the contrast to a better level. In this method, the range of intensity values of the pixels is stretched/expanded to a desired range

Weight Map Images: luminance, saliency and chromatic Luminance Weight Map image. With the aim to make white objects appear white in image, white balance sometimes reduces the colorfulness of the image. Low saturation values in the image correspond to hazy and distorted regions whereas high saturation value depicts clearly visible parts. Therefore, Luminance weight map assigns higher value of saturation to those regions of the image that have better visibility and lower value of saturation to the other regions of image. Thus, higher visibility regions are highlighted more in the output image as compared to the one with lower visibility which has very less contribution in final output. In our work, we have applied luminance weight map for restoring colorfulness in underwater image as described in our previous work 1.

2.

Saliency Weight Map image: The salient or critical region is that part of the image which has some information associated 3. with it. Saliency weight map is used to make the existence of these regions more prominent with respect to their 4. neighborhood. The resultant image computed using Saliency Weight Map exhibits very high-resolution feature along with the advantage of lifting dominant regions. To implement this map 5. in our method, first both white balanced and contrast improved images are unblurred by applying Gaussian 3×3 filter. for each color channel respectively.

Chromatic Weight Map image: The absorption of colors having large wavelength leads to loss of colors in the image. Therefore, restoration of colors is ensured by using chromatic weight map. Since color is a property of saturation, we have used chromatic weight map which works on increasing the saturation of the color balanced and contrast improved images. Fusion After generating all weight map images from the previous process, i.e. luminance, saliency and chromatic weight map, now we need to fuse each input with derived weights.

Fusion: After generating all weight map images from the previous process, i.e. luminance, saliency and chromatic weight map, now we need to fuse each input with derived weights. The blend of different inputs and weight maps together termed as fusion, holds crucial importance in enhancement procedure of underwater image, considering that the final image preserves the information present in the original image and also does not include any additional artefacts in. Incorporates DCP into underwater image enhancement. Sathya's methodology extracts the colour features and source of illumination, performs a dark channel estimation and then removes the haze from the image. Ancuti uses a locally adaptive colour correction with a model DCP with colour shifts in their fusion technique which is mentioned above and rectifies colour changes in the intensity. Various Illumination properties have been added. Reference images help color correction better. Color channels are a part of the illumination process. SIFT is used for matchmaking to give a better understanding of the result. Deep underwater image enhancement using a Convolutional Neural Network has a trained database which generates enhanced images. These images are then post processed in the HSI space to improve the saturation, contrast and brightness of the image. One of the main aspects is color correcting the image, as the images of are not of their true color. The true color of the object in some cases cannot be identified until it is brought up to the surface. Our attempt is to be able to give that image as much of its color back and clear it enough to be able to be detected and recognized by robots and people manning the station for mining applications. This produces the final image, in some cases there needs to be a simple color balance added to retain the color of the image or bring back some color. It also gives a saturation to the image within the parameter that is specified.

Algorithm: Input: Underwater hazy image. Output: Enhancedimage.

Take an underwater image which is hazy in appearance.

Obtain the white balanced image and contrast enhanced image from single hazy image

Apply luminance, saliency and chromatic weight maps on previous step obtained input images.

Now apply multi-scale fusion technique on two input images: contrast improved and white balanced image and their corresponding weight map images: luminance, saliency and chromatic image.

Obtain a color and contrast enhanced underwater

4. CONCLUSION

Fusion techniques for underwater enhancement have emerged as a revolutionary approach, solving underwater imaging challenges and paving the way for significant advances in various fields such as marine biology, marine research, and hydrology below the view. The main strength of the fusion method is its ability to overcome the limitations of individual imaging techniques. Underwater conditions, characterized by poor visibility, illumination variables a n d I m pa c t variables, of ten hamper the effectiveness of traditional imaging technologies If data from sensors such as optical, acoustic and infrared in combination, this technique compensates for any weaknesses, resulting in better image quality and more accurate representation of underwater images. Furthermore, the fusion method offers greater motivation in detecting and classifying submerged objects. Whether it's marine life, underwater structures, or potential threats to safety management, the enhanced visualization facilitates more accurate assessments. This has important implications for scientific research, environmental monitoring and safety management, where the ability to distinguish details in underwater imagery is critical. In addition to the impact on visual clarity, fusion techniques play an important role in improving underwater detection and monitoring by integrating information from different sensors and providing a detailed view of underwater features on the snow. This proves invaluable in situations such as oil and gas pipelines

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