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A Survey on Deep Learning Assisted Video Quality Enhancement in Laparoscopic Videos

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ABSTRACT :

Since it is more convenient and has a reduced risk of infection than open surgery, laparoscopic surgery has become popular in medicine.Successful laparoscopic surgery requires a well-defined operative field of view. Clearness of laparoscopic imaging can be impacted by surgical smoke arises from the usage of tools like lasers, electrosurgical units and ultrasonic devices. Movement and Focus Issues are the main reason for image blur. Temperature Difference and Moisture and Debris causes lens fog- ging..In this work,we provide a systematic review of how different deep learning approaches enhance video quality in laparoscopic vide-os.

INTRODUCTION :

Compared to open surgery, laparoscopic surgery has fewer intraoperative wounds, that will reduce tissue damage and reduced time to recovery. Through a number of tiny incisions, doctors undertake observation and surgical procedures while introducing surgical equipment, cameras, and light sources into the body. Maintaining a clean field of vision during surgical procedures is crucial for surgeons, and this may be greatly enhanced by high-quality laparoscopic video visualisation . Regrettably, surgical smoke, picture blur, and lens fogging often lead to surgical fields of vision that are indistinct or absent, which significantly degrades image quality.

Typically, during laparoscopic surgery, tissue is burned and sliced, producing surgical smoke . In addition to its detrimental effects on patients and surgeons, smoke significantly lowers surgical visualisation . Motion blur can be primarily caused by the movement of the laparoscopic lens, surgical equipment, tissues, and organs . Fog condensation results from an imbalanced temperature differential between the abdominal cavity's (approximately 38 °C) and the laparoscopic lens's (20–26 °C) temperature. This is the primary cause of laparoscopic lens fogging. Surgeons are less able to operate when there is less vision of the surgical area, especially if they are unable to receive touch and sensation directly. The aforementioned problems will all result in longer operating times, higher operating room risks, and grave implications for the patients. Currently, using a suction device to wash the laparoscopic lens and filter surgical smoke is a more dependable method. Although these techniques can remove smoke created by some procedure and fog to preserve the surgical area vision, it cause the process to occasionally stop and interfere with Carbon dioxide insufflation environment, which is necessary for laparoscopic procedures. Surgeons frequently find laparoscopic procedures uncomfortable since there aren't enough real-time solutions available to enhance the intraoperative video quality. Thus, it is necessary to devise a workable strategy to eliminate the variables that interfere with laparoscopic surgery.

To improve visibility in blurry pictures, a significant, numerous computer vision approaches were introduced pre- viously. These comprise of conventional computer vision techniques, CycleGANs used in unpaired image-to-image translation, and GAN used in paired image to image translation. Conventional techniques for picture desmoking em- ploy neural networks or variational interference, whose generators are only updated in accordance with the supplied database. However, the GAN model uses the discriminator's backpropagation to update the generator, leading to more accurate outputs.Image-to-image translation in pairs GANs rely on artificial training data since they need the identical images throughout training, both in the presence and absence of ground-truth fog condition. GANs for unpaired data, on the other hand, offer greater freedom in terms of training data because they can be trained on any examples of crisp and hazy images, avoiding the requirement for generative physical models or ground truths

LITERATURE REVIEW

The DeSmoke-LAP[1] model, for unpaired translation from image to image in two domains, is developed based on CycleGAN. For dark channel prior and inter-channel disparities, two more loss functions are developed. The purpose of these discriminating loss functions is to help optimise the generator for the next iteration by identifying the remaining smoke-covered area on the output image. Combining the traditional processing method DCP with the artificial intelligence technology cGAN. This technique can restore the original image's colour spectrum and lessen the impact of smoke on the final product, demonstrating how a hybrid approach can improve the efficacy of other techniques[2]. MARS-GAN seeks to improve surgical smoke removal in laparoscopic imaging over current techniques. It might be included with laparoscopic equipment to remove smoke in real time, increasing the accuracy and effectiveness of surgery[3].

TABLE 1. Literature review Comparison

Sl.No	METHODOLOGY	RESEARCH CONTRIBUTION	RESEARCH GAP
[1]	image-to-image CycleGANs dark channel prior loss functions and inter-channel discrepancies	Using the image-to-image Cycle-GANs, inter-channel discrepancies.	Research focuses on laparoscopic hysterectomy videos, not gen- eralizes to other laparoscopic procedures.
[2]	DCP method and a pixel-to-pixel neural network architecture GAN.	Dark channel prior (DCP) method.	Research utilizes a relatively small dataset of laparoscopic videos. PSNR = 25.00, SSIM = 0.88
[3]	smoke removal GAN model, ResNet-50 classification models and MPRNet motion blur removal model.	created 19,245 clear images synthetic data, 19,245 synthetic data of motion blur images and smoke/fog images of synthetic data 19,245 numbers.	Research primarily relies on synthetic data alongside a limited set of real laparoscopic videos. PSNR = 29.67, SSIM = 0.9551
[4]	MARS-GAN used to remove Surgical Smoke	MARS-GAN model	Research utilizes synthetically generated data. No real surgical videos and it is not generalized.
[5]	Cyclic-DesmokeGAN an unsupervised approch for desmoke the la- paroscopic surgery images.	Cyclic-DesmokeGAN	Research used a small dataset (Cholec80) and it is not generalized

MARS-GAN [4] tackle the issues of surgical smoke obscuring visibility during laparoscopic procedure. An un- supervised learning technique to eliminate smoke from laparoscopic pictures. The multiscale residual blocks in the suggested generator architecture helps to recover and improve more complex edges and structure while assisting in the reduction of the smoke element at various sizes[5].

METHODOLOGY :

The DeSmoke-LAP[1] method tackles the challenge of improving visibility in laparoscopic surgery by virtually removing smoke from surgical videos. Unlike existing methods, it doesn't require paired data (clear images corre- sponding to smoky ones) or rely on complex atmospheric scattering models. A deep learning technique CycleGAN, allows the model to learn the transformation between hazy (smoky) laparoscopic images and clear ones, even without paired examples.

The combined power of deep learning (GAN) with a well-established image processing technique (DCP) to address the challenge of smoke in laparoscopic surgery. By effectively removing smoke, this approach has the potential to improve surgeons visibility and potentially lead to safer and more efficient procedures[2].

GAN is used to create a model capable of removing fog and smoke from laparoscopic videos[3]. Pre-trained deep learning models (ResNet-50) are used for image classification tasks within LVQIS. These models might be used to identify specific features like surgical instruments or blurry regions. MPRNet addresses the issue of motion blur, which can arise from camera movements or instrument manipulation during surgery.

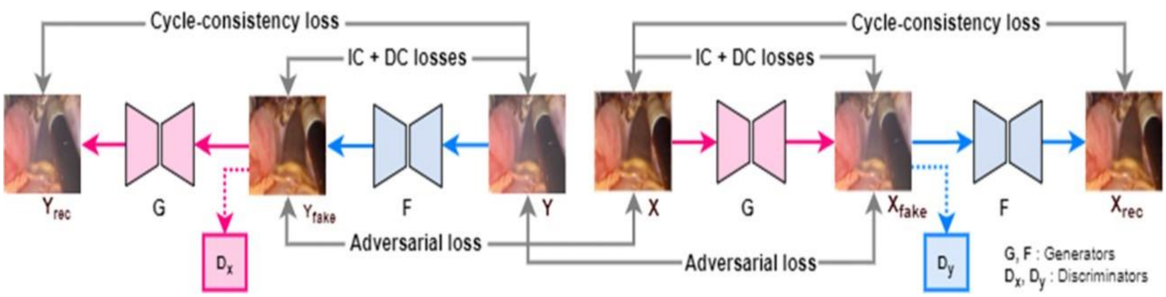

FIGURE 1. A synopsis of the suggested DeSmoke-LAP technique. The introduction of the dark channel (DC) before and inter- channel (IC) discrepancies helps to ensure and adversarial losses and cycle consistency in removal of smoke by classifying residual smoke.

A novel deep learning technique called MLFA-AGAN for removing smoke from laparoscopic videos is incorporation of an attention mechanism with GAN. This mechanism helps the model focus on the most critical image features relevant to smoke removal, such as the areas obscured by smoke[4].

Using an unsupervised approach, Cyclic-DesmokeGAN eliminates smoke from laparoscopic surgery images with- out the need for pre-labeled training data[5]. Unlike prior methods that rely on paired datasets,Cyclic-DesmokeGAN leverages unsupervised learning.

CONCLUSION:

However, smoke pro duced during laparoscopic surgery as a result of electrocauterization has the potential to endanger both patients and surgeons. To deal with this matter. In this study, we conducted a survey on deep learning-assisted laparoscopic video quality enhancement. In particular, we have undertaken a significant effort to evaluate the quality of laparoscopic videos by contrasting several models that are applied to enhance the quality of laparoscopic videos.

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