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VISAPP 2021
16th International Conference on Computer Vision Theory and Applications
Vienna - Austria 8 - 10 February, 2021
VISIGRAPP

Curve based Fast Detail Enhancement for Biomedical Images

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Background

- **Background:** biomedical image processing can help doctors to diagnose and treat patients.
- However, low quality and contrast of biomedical images will reduce the doctor's ability to analyse the images, causing subsequent processing difficulties.
- For example:
  - Frames obtained during minimally invasive surgery may have a large shaded region due to less adequate light introduced into the cavity;
  - Dark-coloured tissue may lack details in high contrast frames.
- It is essential to recognise images that need enhancement then adaptively select the targeted dark regions for further processing and **image contrast enhancement**.

Previous works

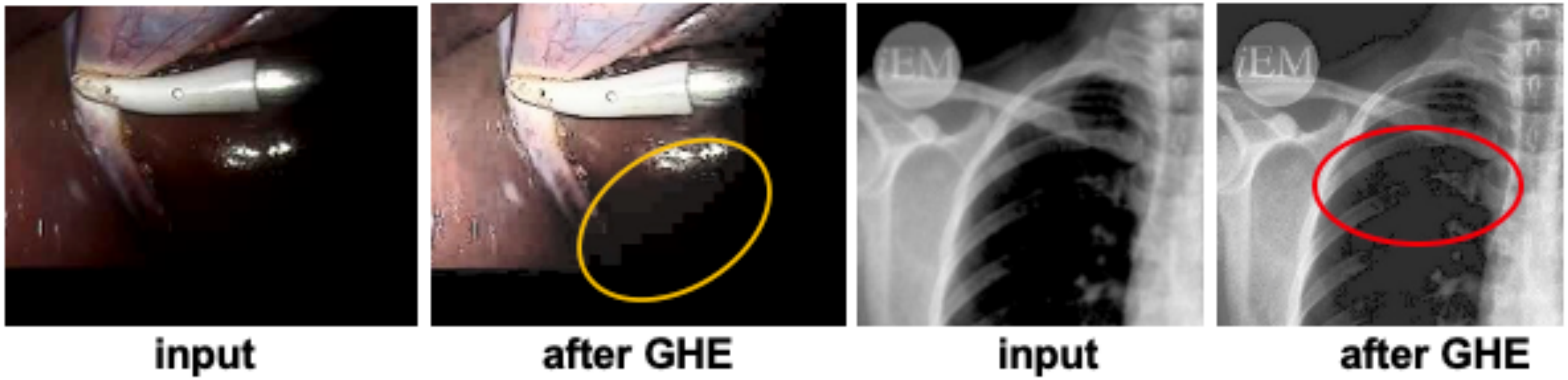
- **Image enhancement techniques:**
  - **Histogram equalization (HE)** image enhancement method (Agaian et al., 2007)
  - Equalized histogram equalization image enhancement method (Kadhum, 2012)
  - Fuzzy set theory image enhancement method (Preethi & Rajeswari, 2013)
  - Nonlinear image enhancement technique (Singh et al., 2015)
  - Wavelet transform technique (Premkumar et al., 2015)
  - Histogram matching image enhancement method (Irmak & Ertas, 2016)

Previous works

- **Histogram equalization (HE) based algorithms:**
  - Local histogram equalization (LHE) (Abdullahal-Wadud et al., 2007)
  - **Global histogram equalization (GHE)** (Mokhtar et al., 2009)
  - Equalized histogram equalization image enhancement method (Kadhum, 2012)
  - Nonlinear image enhancement technique (Singh et al., 2015)
  - Wavelet transform technique (Premkumar et al., 2015)
  - Histogram matching image enhancement method (Irmak & Ertas, 2016)

Previous works

- **Issues of Global histogram equalization (GHE)**
  - Unwanted colour boundaries in dark region
  - Noise around edges are amplified after GHE



Task

- **Task:** This paper proposes a fast method to adaptively enhance the details in the dark regions of biomedical images, including X-rays, video frames of laparoscopy in minimally invasive surgery (MIS).

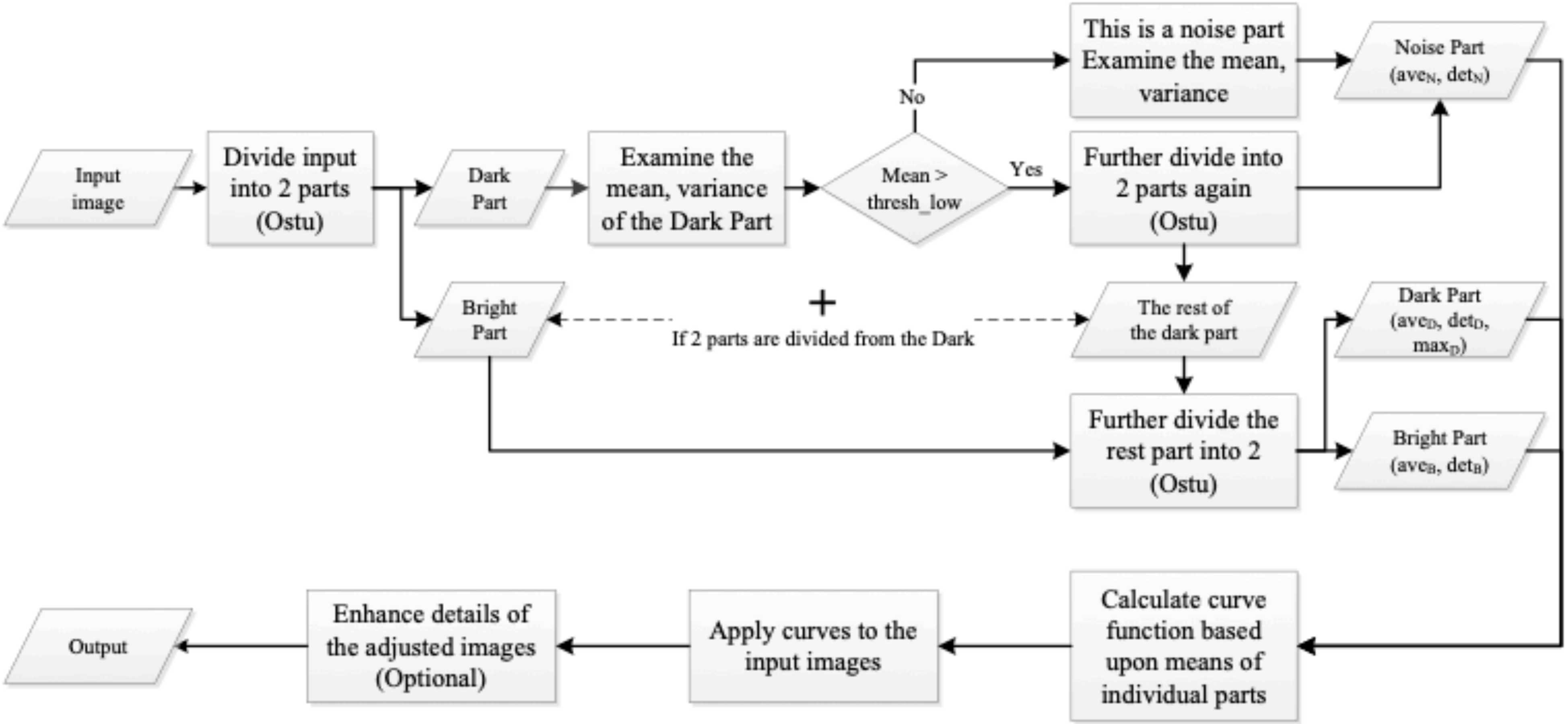
Dataset

- **Experimental dataset:** we used laparoscopic surgical frames and X-ray images from website.
- **Source of images:**

https://www.youtube.com/watch?v=fs_hJO1RZMs Lap chole basic, around 3:12	https://medtube.net/general-surgery/medical-videos/24250-laparoscopic-cholecystectomy-with-mishra-knot
https://www.youtube.com/watch?v=SpSNewRpdW0 Full length HD Laparoscopic Cholecystectomy with Critical View, around 3:44	https://www.youtube.com/watch?v=O4pO_RXELvE Single incision robotic cholecystectomy, around 1:10
http://drkashi.science/?p=3211, Cefuroxime as a prophylactic antibiotic in laparoscopic cholecystectomy	https://smallanimal.vethospital.ufl.edu/clinical-services/internal-medicine/endoscopy/abdominal-endoscopy/, Abdominal Endoscopy
World J Gastrointest Surg. Feb 27, 2019; 11(2): 62-84, Figure 13	
Voermans, Rogier P., et al. "Hybrid NOTES transgastric cholecystectomy with reliable gastric closure: an animal survival study." Surgical endoscopy 25.3 (2011): 728-736. Figure 1	
https://www.flickr.com/photos/iem-student/29110322657	https://www.waybuilder.net/sweethaven/MedTech/Dental/DentalRad/default.asp?iNum=0303

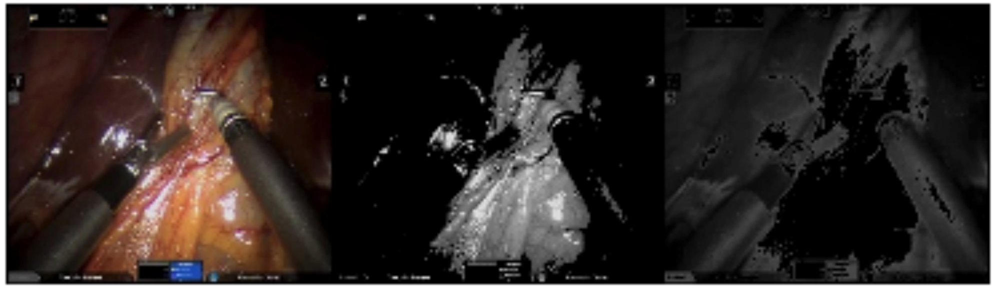
Method

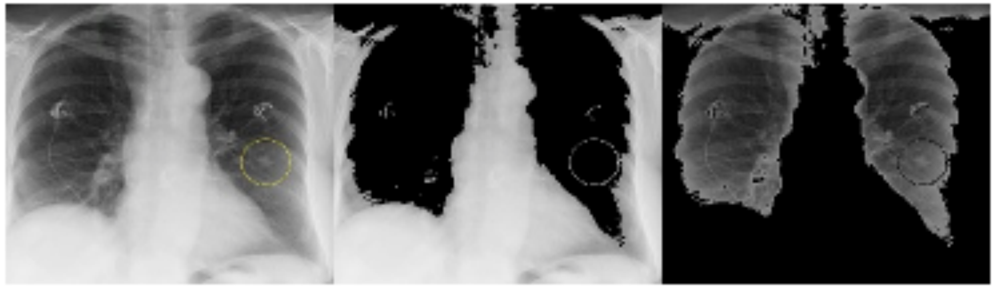
- **Workflow of the proposed algorithm:**



Method

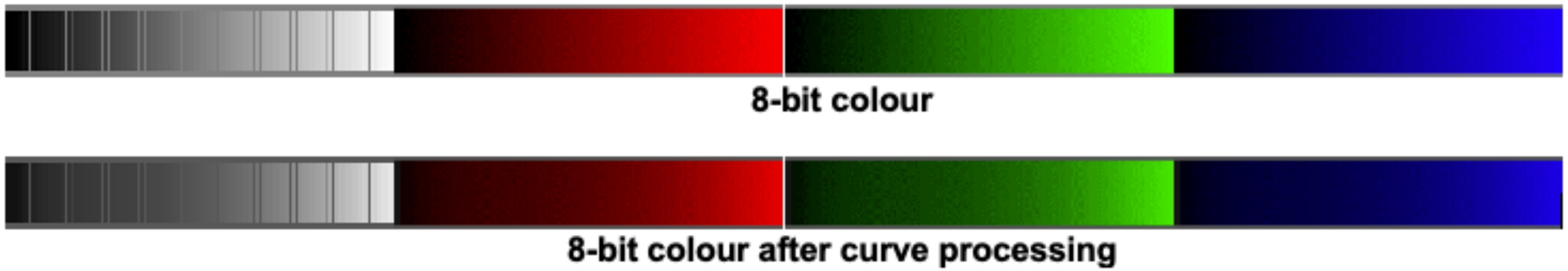
- **The proposed method:**
  - Take advantages of global histogram equalization (GHE).
  - An **adaptive intensity mapping** is applied before GHE to compensate issues of noise and unwanted colour boundaries.
- **Ostu thresholding:**





Method

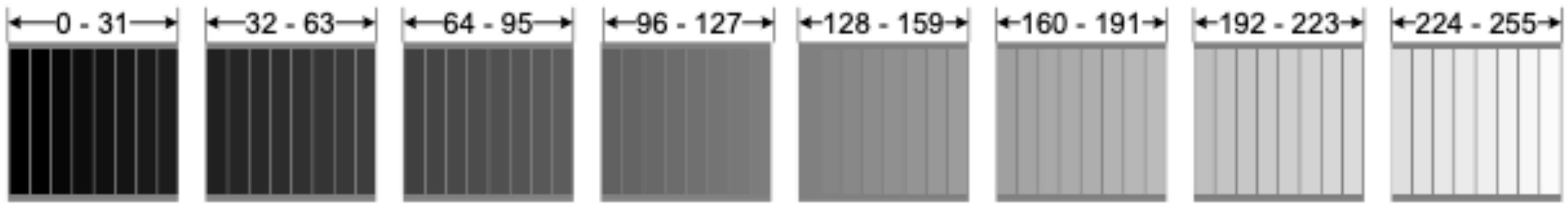
- **Curve function :**
  - After applying the curves, pixels in the dark parts should have smaller values than pixels in the bright parts;
  - Logarithm curves is applied to pixels to improve the perceptive linearity of the relevant dark region
  - Near saturation region is supressed using sinuous function to reduce the area of near saturated region



Method

- **Intensity mapping function :**

  - The design of the intensity mapping function and the threshold selection is based on the non-linear perception of eyes in brightness and colour to the input pixel values.
  - As the 8-bit gray scale colour bar, the perception of intensity change vary in each group.
  - Eyes are more sensitive to the colour difference in the mid-dark range (32 – 224) but not in the near black (0 – 32) and near saturated (224 – 255) range.

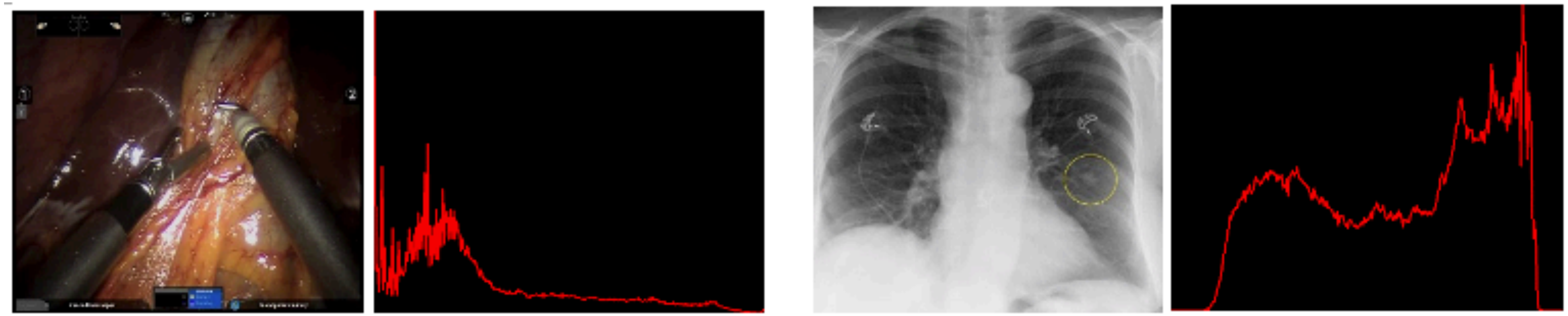


Results

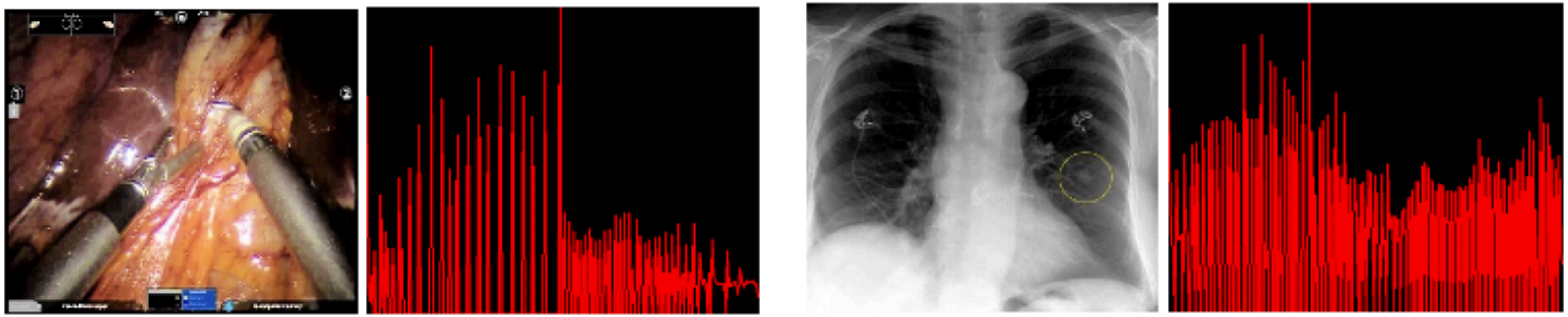
- **Evaluation Criteria:**
  - Amount of details revealed before / after the application
  - The colour consistency and truthfulness before and after the application
  - Amount of noise, alien boundaries introduced through the application of the algorithm
  - Perceived change in brightness

Results

- **Experimental results:**



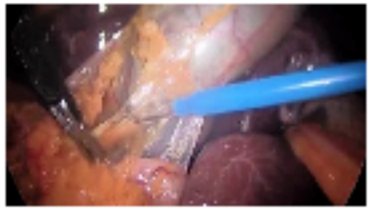
(a) Laparoscopic frame (b) histogram (c) X-ray (d) histogram



(e) processed (a) (f) histogram (g) processed (c) (h) histogram

Results

- **Experimental results:**

Original images	Global Histogram Equalization	Processed results
		
		
		

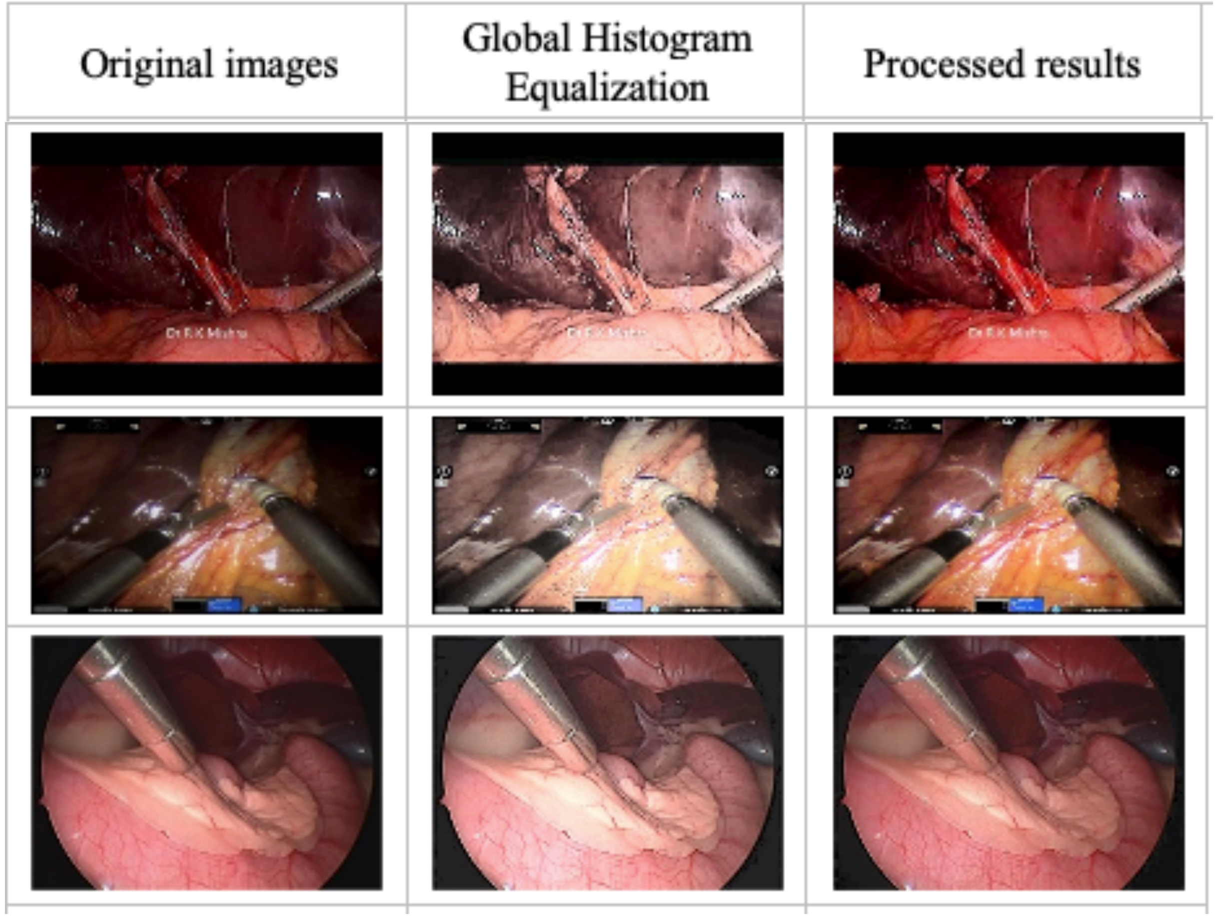
Results

- **Experimental results:**

Original images	Global Histogram Equalization	Processed results
		
		
		

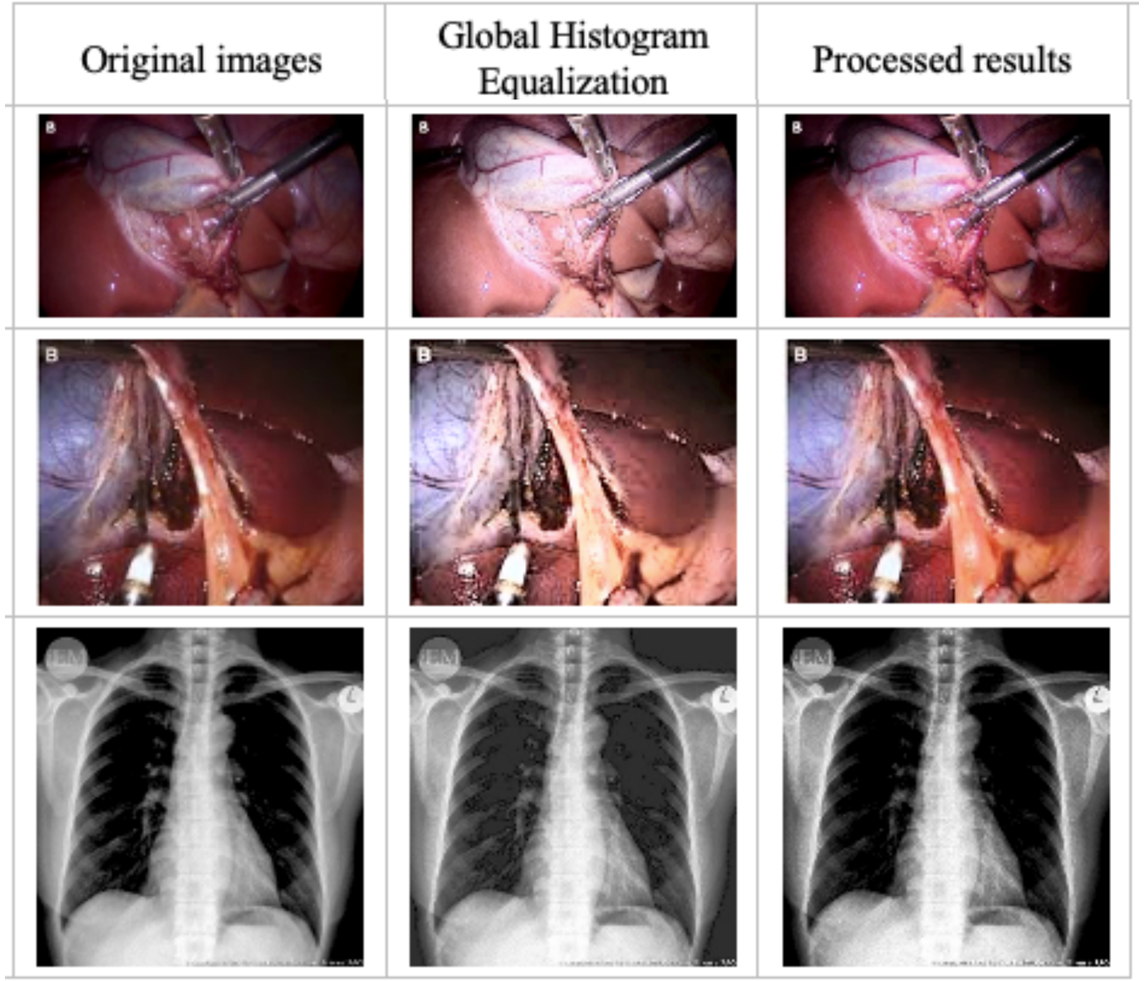
Results

- **Experimental results:**



Results

- **Experimental results:**



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Kadhum, Z. A. (2012). Equalize the histogram equalization for Image enhancement. *Journal of Kufa for Mathematics and Computer*, *1*(5), 14-21.

Thanks for listening !