REDUCING THE EFFECT OF TURBIDITY IN UNDERWATER IMAGES

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fossasia


“A picture is a poem without words.”
- Horace

NEED FOR UNDERWATER IMAGERY

- Monitoring marine benthic habitats, such as, coral reefs, kelp forests, etc.
- Classify and count various aquatic species in an area
- In Marine Archeology, to analyze the sea-bed and shipwrecks
- Surveillance and monitoring activities with the help of AUVs and ROVs

RAW IMAGE FROM THE DATASET

HOW IS IT DIFFERENT FROM IMAGERY ON LAND?

- Due to the medium (water), scattering causes a blurring effect
- Wavelength absorption causes color reduction
- Artificial lighting causes vignetting in captured images

PROBLEM STATEMENT

- This solution aims to reduce the effect of turbidity from underwater images for Marine Archaeologists
- The research took place at National Institute of Oceanography (NIO), Goa - India
- We worked on datasets provided by underwater explorations in the Arabian Sea, along the west coast of India

OUR APPROACH

Input Image

1. Convert to YCbCr color space
2. Perform CLAHE on converted image
3. Convert back to RGB color space
4. Apply Bilateral Filter on the image
5. Wavelet de-noising

Output Image

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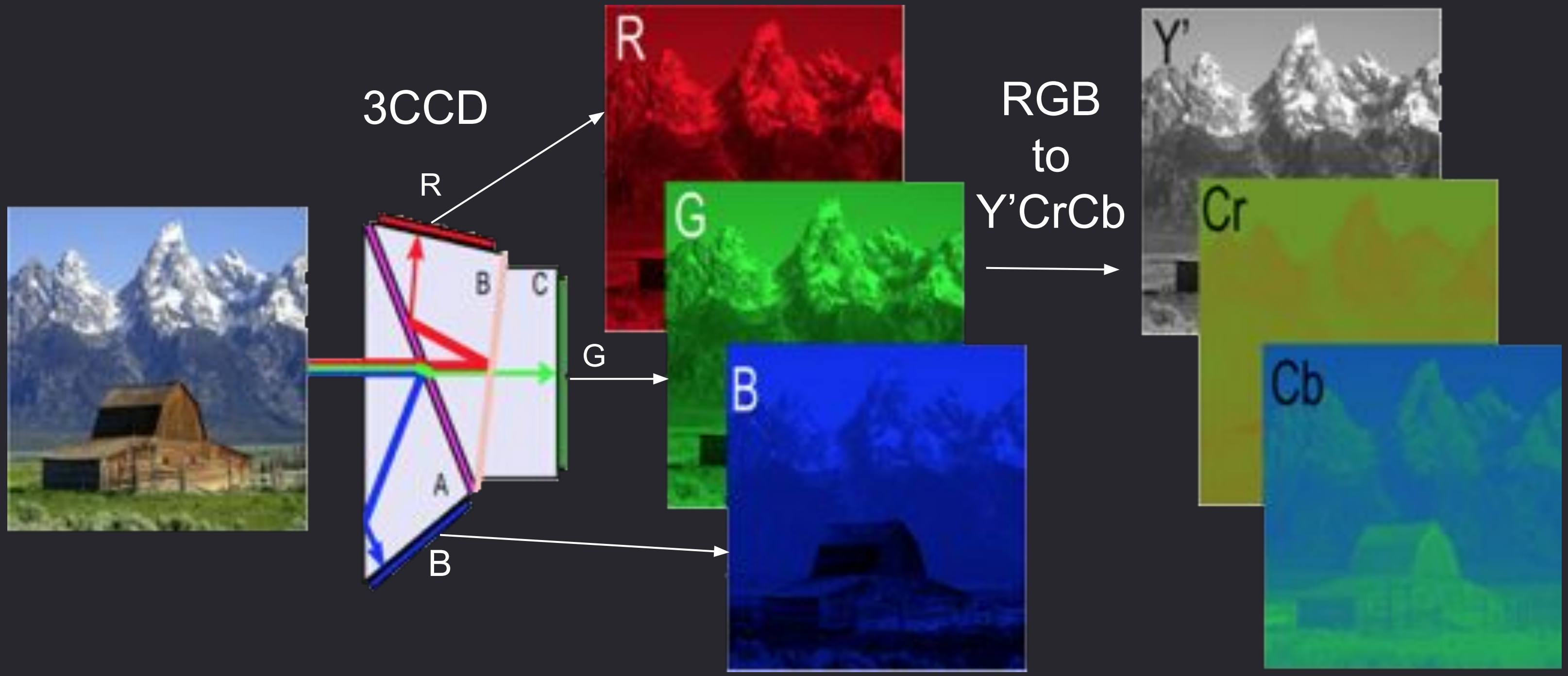
1. CONVERT IMAGE TO YCbCr COLOR SPACE

- YCbCr is a storage efficient color model
- For histogram equalisation, we need only the luminescence values (i.e., Y channel), and no colors
- To tackle the issue of non-uniform light distribution with increasing depth

1. CONVERT IMAGE TO YCbCr COLOR SPACE



Source: http://www.wikiwand.com/en/YCbCr

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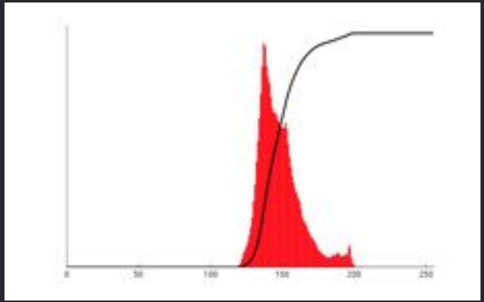
2. **Perform CLAHE on converted Image**

- **C**ontrast **L**imited **A**daptive **H**istogram **E**qualization
- Improves the local contrast and at the same time limits over-amplification of the noise
- The result value of a pixel under CLAHE is proportional to its rank among the pixels in its neighbourhood

2. **Perform CLAHE on converted Image**

Original Image



After performing CLAHE

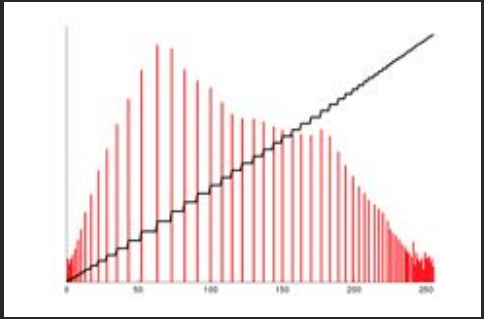


Image Histograms

Source: https://en.wikipedia.org/wiki/Histogram_equalization

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Output Image

3. **Convert Image back to RGB color space**

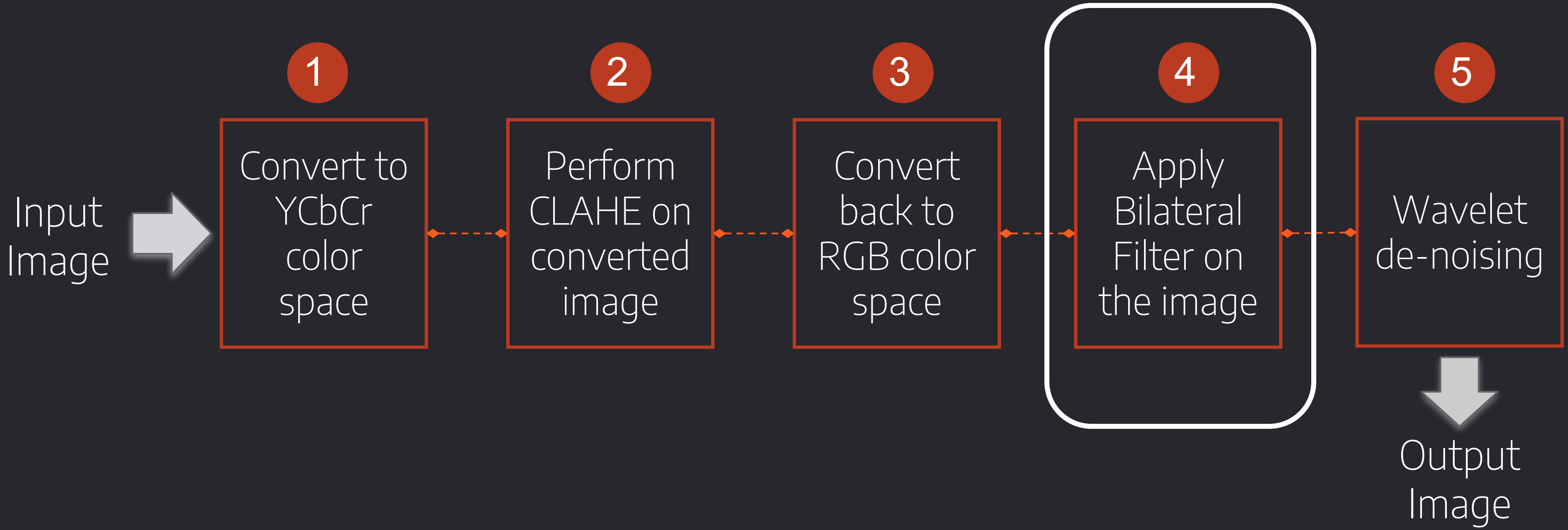
To make the processed image coherent to the original image

YCbCr Image

RGB Image

Source: https://en.wikipedia.org/wiki/Common_kingfisher

OUR APPROACH



4. **Apply Bilateral Filter on the RGB image**

- Non-linear, edge preserving, and noise reducing filter
- Each pixel is replaced by weighted average of its neighbours
- Preserves the features and strong edges in images which is essential for marine archaeological studies

4. **Apply Bilateral Filter on the RGB image**

a.) Original Image

b.) Smoothened Image

Source: https://en.wikipedia.org/wiki/Bilateral_filter

OUR APPROACH

Input Image

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5. Wavelet de-noising

Output Image

5. **Wavelet De-noising**

- Reconstruct a signal from a noisy one
- Idea is to have the amplitude, rather than the location of the spectrum, to be as out-of-phase from that of the noise
- Allowing shrinking of amplitude of the transform to remove noise

5. **Wavelet De-noising**

a.) Noisy Image

SNR = 10.02 dB

b.) Denoised Image

SNR = 17.57 dB

Source: http://www-cs.ccny.cuny.edu/~wolberg/capstone/opencv/LearningOpenCV.pdf

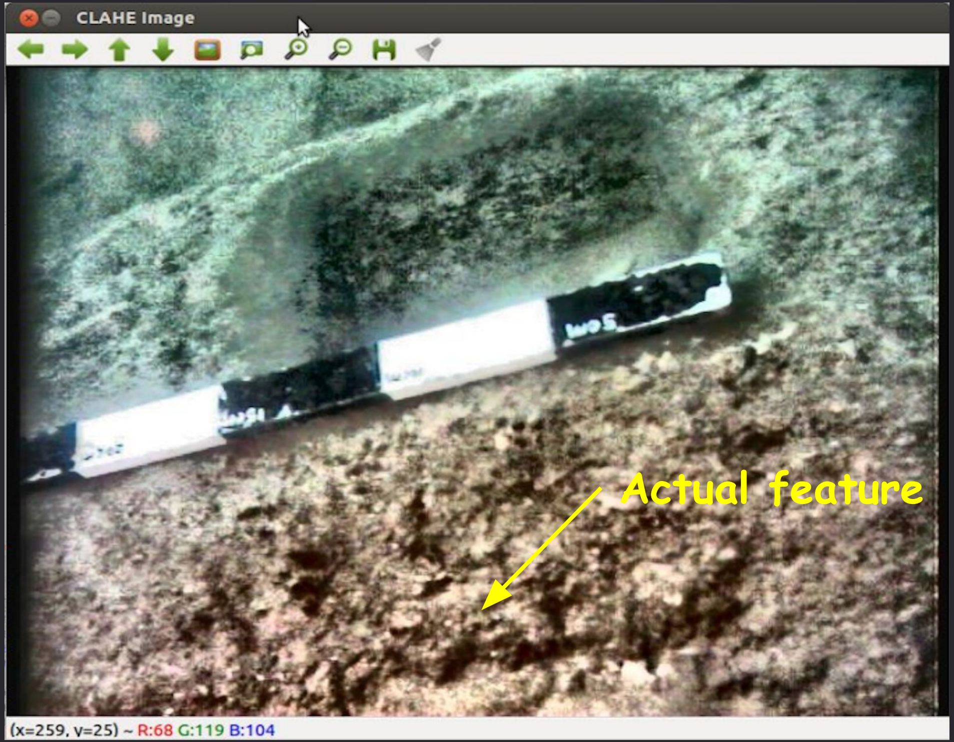
RESULTS

a.) Original Image

RESULTS

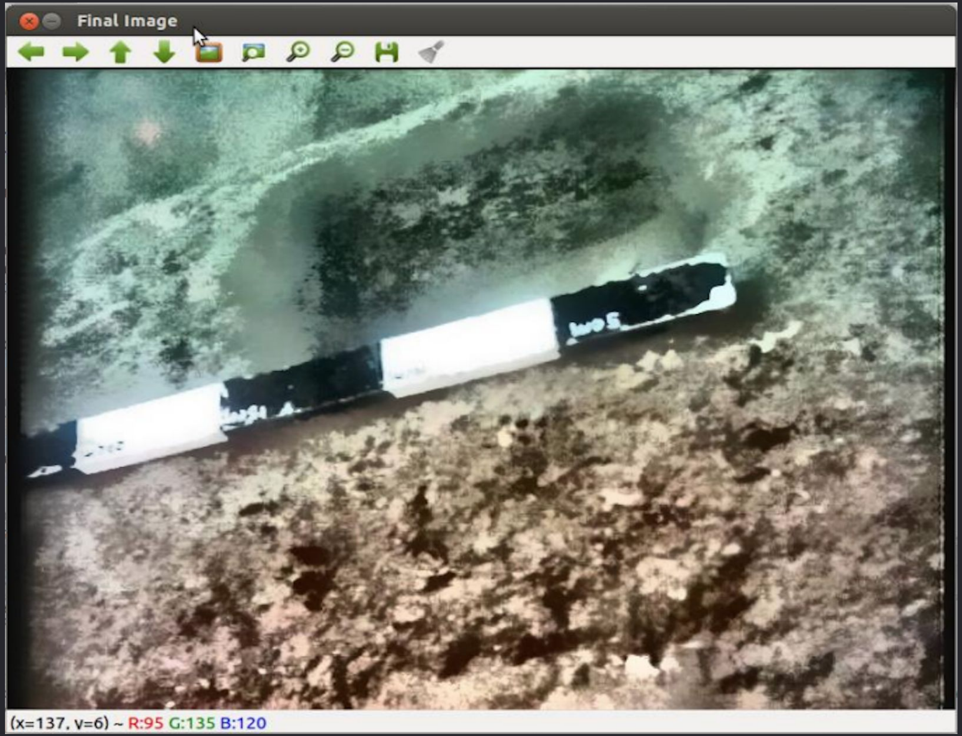
b.) Grayscale Image

RESULTS



c.) Image after CLAHE

RESULTS

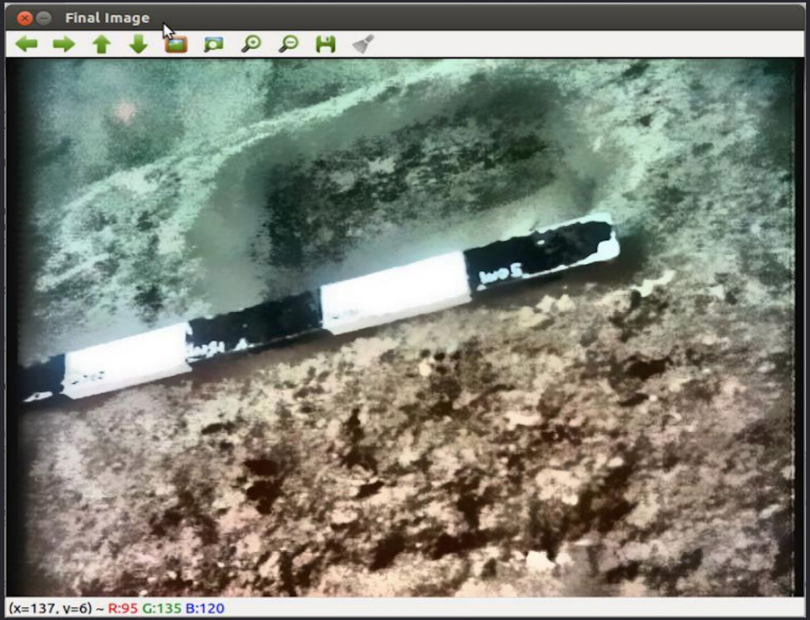


d.) Final Image after Bilateral Smoothing and Wavelet Denoising

RESULTS

Initial Image

Final Image



IMPACT

IMPACT OF OUR WORK

- This solution was integrated in the AUVs and ROVs present at the research facility at NIO, Goa
- It automated the underwater explorations with the help of AUVs & ROVs, and image processing using the NIO servers
- Being further extended to create image mosaics for model reconstruction of shipwrecks

At least **10,000** man-hours saved in a year at NIO, Goa alone.

Whoa! That's a big number, aren't you proud?

REFERENCES

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THANKS!

QUESTIONS?