Imaging Science Report

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Please take single grayscale photograph of a textured surface (such as paper, fabric, or a wall)
that appears non-uniformly lit due to uneven illumination — some areas
are brighter and some are shadowed.
The challenge is to reconstruct the true texture pattern of the surface as if it were uniformly illuminated, without any prior knowledge of the lighting source or Direction.

1.Model Formulation
Assume the observed image I(x, y) is
formed as:
I(x,y)= R(x,y)×L(x,y)
where
1.R(x, y) = reflectance (the actual texture pattern you want), 2
.L(x, y) = illumination (a smooth, slowly varying function).

Explain why simple histogram equalization cannot recover R(x, y) and propose a mathematical or
algorithmic strategy to estimate both R and L from a single
image (without knowing either).

- The goal of this task is to remove uneven lighting from the grayscale image of a textured fabric,cloth, paper or wall and to regenerate the original reflectance pattern of the grayscale image.
- The task is to recover both reflectance R(x,y) and illumination from one image, without any knowledge of light source.

The observed image is modeled as : I(x,y) = R(x,y)× L(x,y)
Taking the logarithm, we get: log I(x,y) = log R(x,y) + log L(x,y)
This turns the multiplicative relation into an additive one,making it easier to seperate high and low frequency components.

The code is uploaded in folder :-
The algorithm was implemented in Python using NumPy and OpenCV, without built-in high-level filters.
Gaussian smoothing was implemented manually using separable convolution.
The program automatically saves all intermediate results and histograms.

Why histogram equalization fails ?

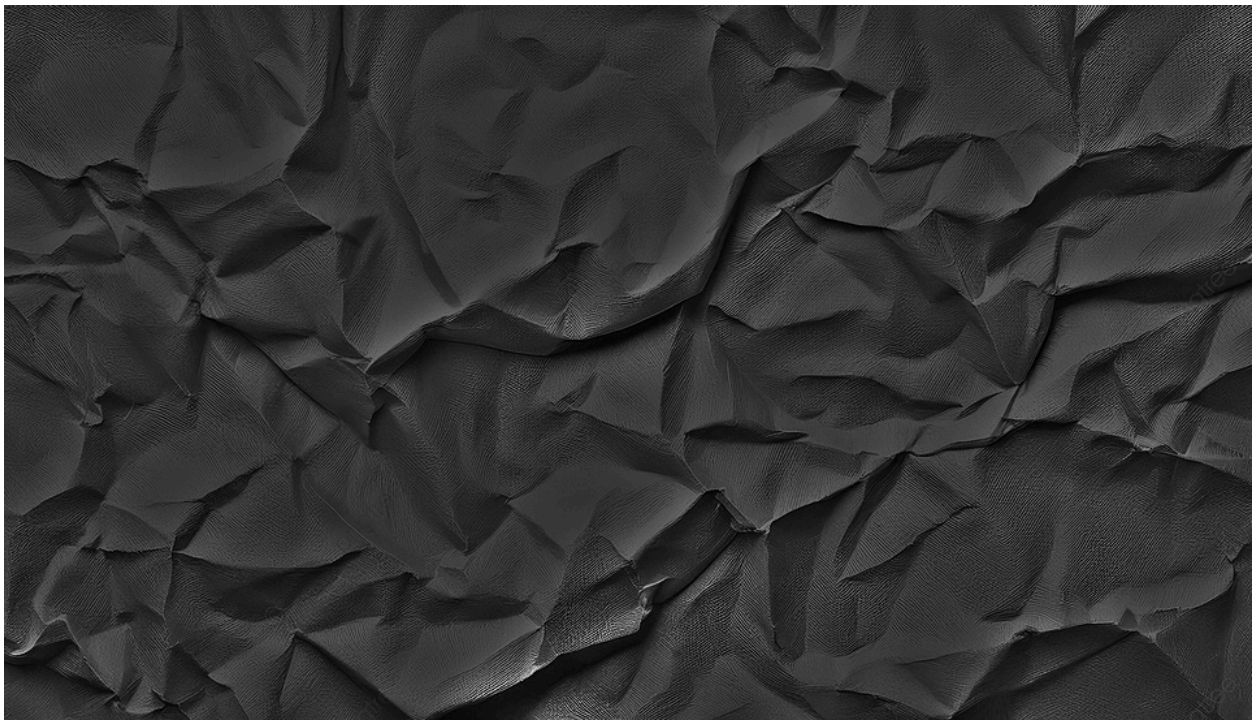
- Simple histogram equalization treats intensity variation as a global contrast problem.
- It does not separate illumination (low-frequency lighting variation) from reflectance (high-frequency texture).
- Therefore, it may over-enhance bright areas and wash out details in darker regions.
- To correctly recover reflectance, illumination must be estimated and divided out , not just equalized globally.

Results

Original image (Unevenly lit)

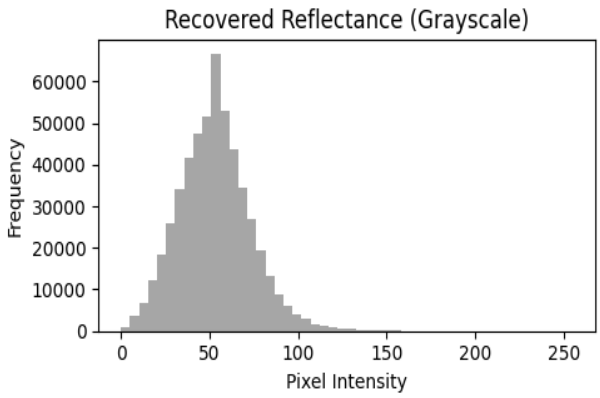
Estimated illumination (log L)

Estimated Reflectance

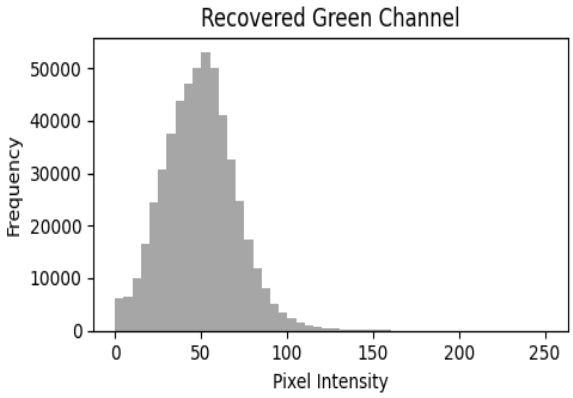


Histograms

Before



After



- The recovered reflectance image shows uniform texture across regions that were previously under uneven lighting.

- Shadows and highlights were suppressed while preserving surface detail.
- The recovered histogram is more balanced compared to the original one.

Conclusion:

- The proposed algorithm successfully separates illumination and reflectance using log-domain filtering.
- It reconstructs the intrinsic texture of the surface without prior lighting information.
- The approach demonstrates how frequency separation can approximate intrinsic image decomposition from a single input.