ECE 313 • Course Project

Impulse Noise Interpolation for Images

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Problem Statement

What is impulse noise?

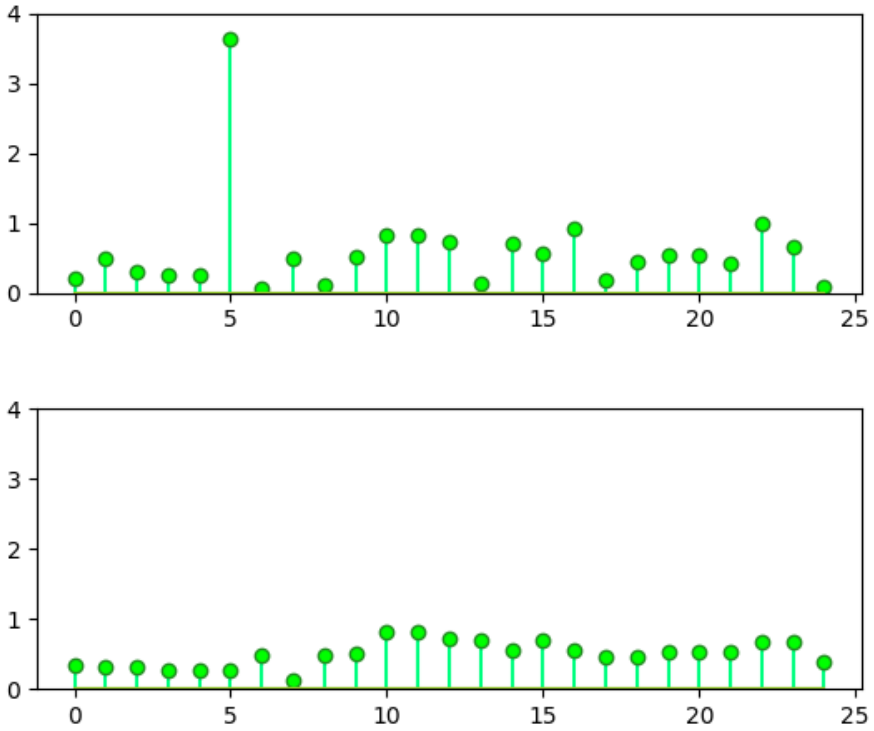
Impulse noise is described as the category of noise that is undesired and of relatively short duration, often caused by switching noise or adverse channel environments in communication.

Other Solutions

Median filter

- Most go-to solution for impulsive noise removal is median filtering
- Involves replacing every pixel with the median of its surrounding pixels
- Downside is the loss of edges and texture of the image
- There is a need for a method that reduces noise while also preserving edges and details

Median filter with n = 3



Solution

In this project we reproduce the methods and results of research paper titled **Impulsive Noise Removal Using Interpolation Technique in Color Images**, authored by professors Yasuhide Wakabayashi and Akira Taguchi.

The solution outlined involves two steps:

1. Impulsive Noise Detection
   Noisy pixels are detected using an appropriate threshold value
2. Noise Interpolation
   Noisy pixels identified are replaced using interpolation of surrounding pixels in all RGB channels of image

Noise Detection: Theory

We start by defining a noisy color channel pixel, $x_k(i,j)$, given by:

$$x_k(i,j) = \begin{cases} s_k(i,j), & 1 - p_1 - p_2 \\ 255, & p_1 \\ 0, & p_2 \end{cases}$$

Detection of this noise can be done by sliding a window of size $N \times N$ across the pixels and computing the following:

$$|x_k(i,j) - {x_k}^{MED}(i,j)| > \varepsilon$$

where ε is a threshold value (the detailed calculation of which can be found on the paper and the report) and ${x_k}^{MED}(i,j)$ is the median pixel value in the $N \times N$ window.

Noise Interpolation: Theory

Once we have identified noisy pixels, we perform interpolation, which involves sliding a 3×3 sized window across the pixels and computing the following values:

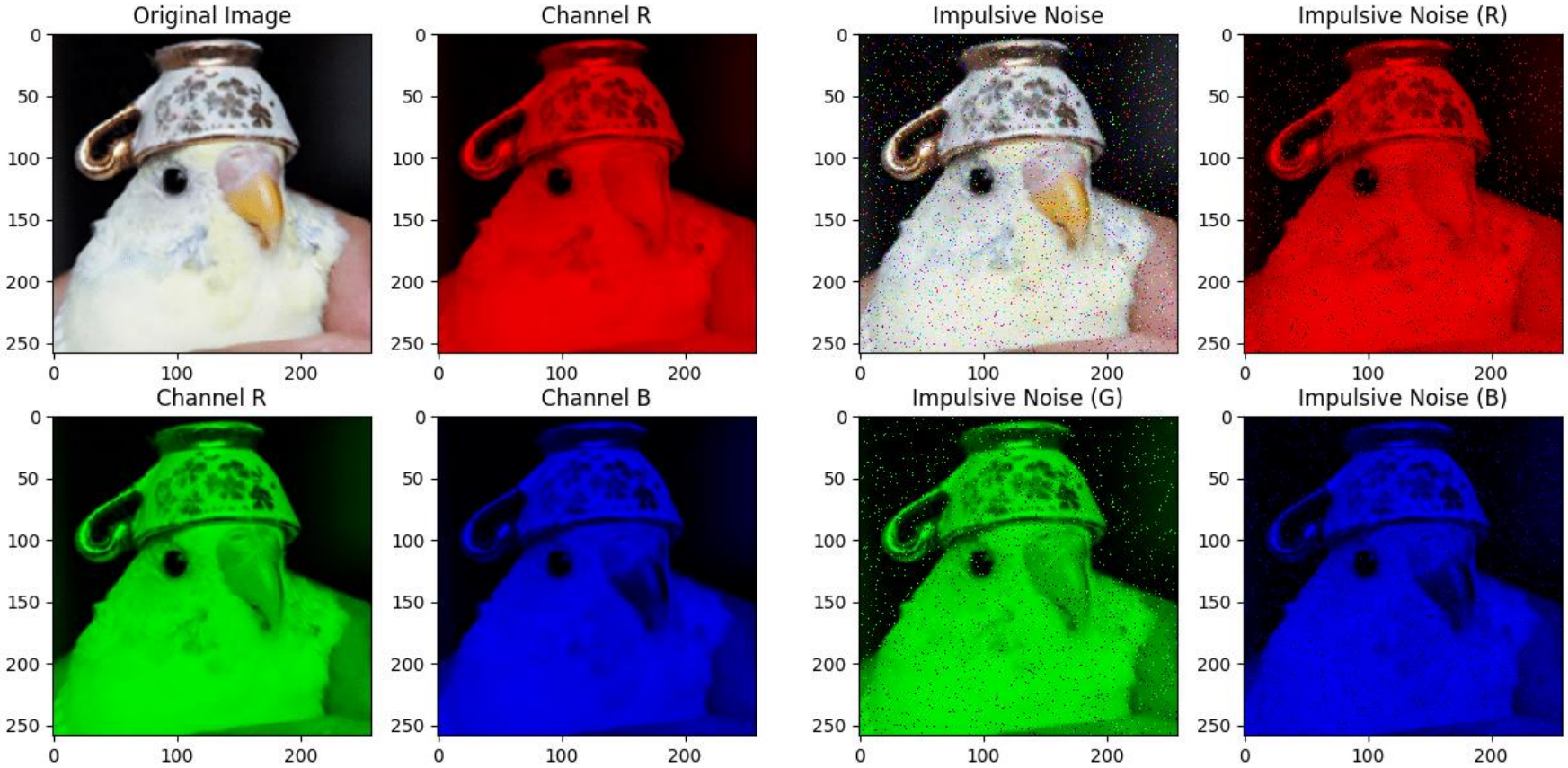
$$\hat{C}[4] = \frac{C[k] + C[l]}{2} + \frac{-A_i[k] + 2A_i[4] - A_i[l]}{2}$$

$C[0]$	$C[1]$	$C[2]$
$C[3]$	$C[4]$	$C[5]$
$C[6]$	$C[7]$	$C[8]$

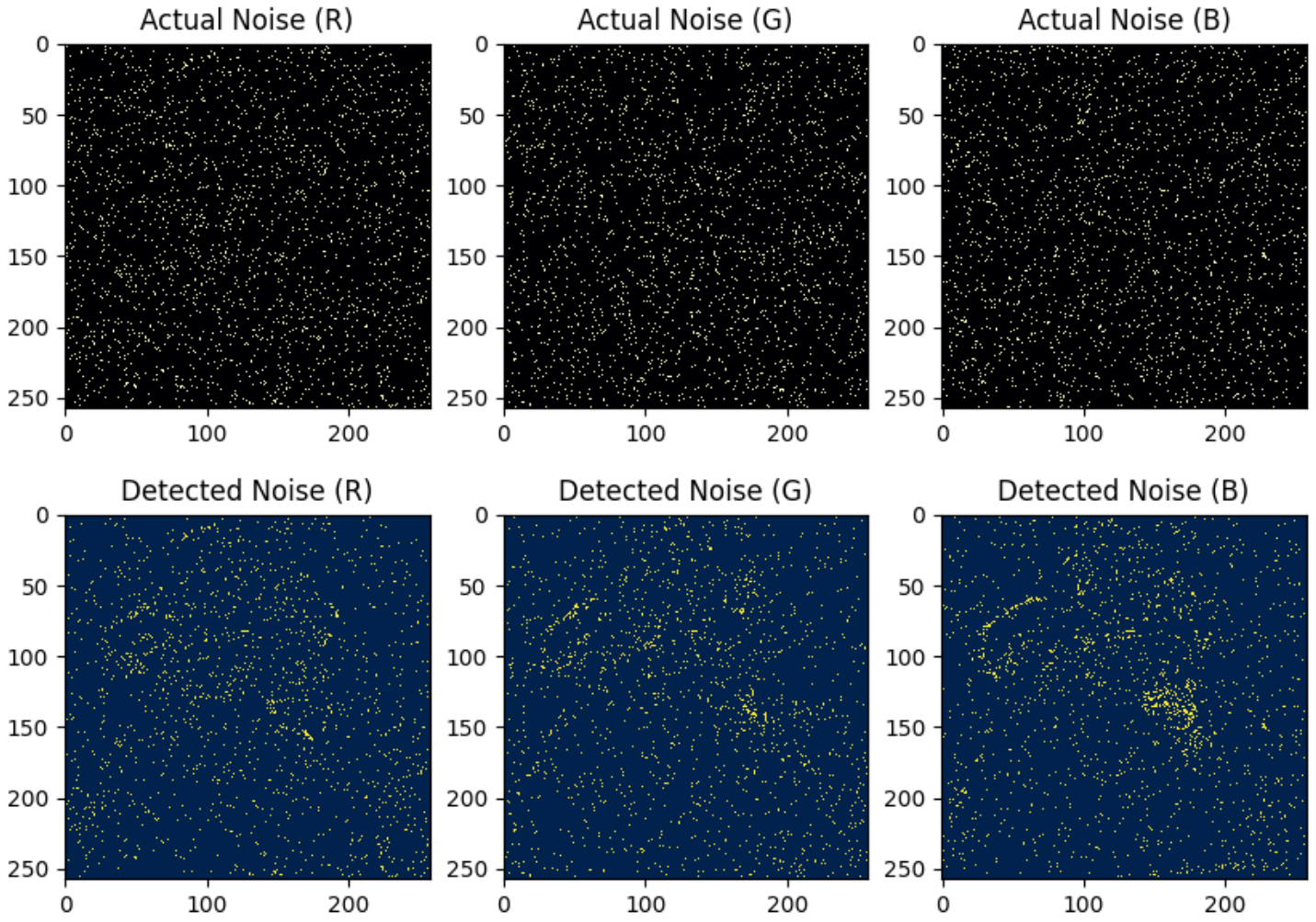
$A_i[0]$	$A_i[1]$	$A_i[2]$
$A_i[3]$	$A_i[4]$	$A_i[5]$
$A_i[6]$	$A_i[7]$	$A_i[8]$

where (k, l) take values of $\{(0, 8), (1, 7), (2, 6), (3, 5)\}$ and i takes values of $1, 2$. This gives us 8 possible interpolated pixels, the process of choosing which is described in greater detail in the paper and the report.

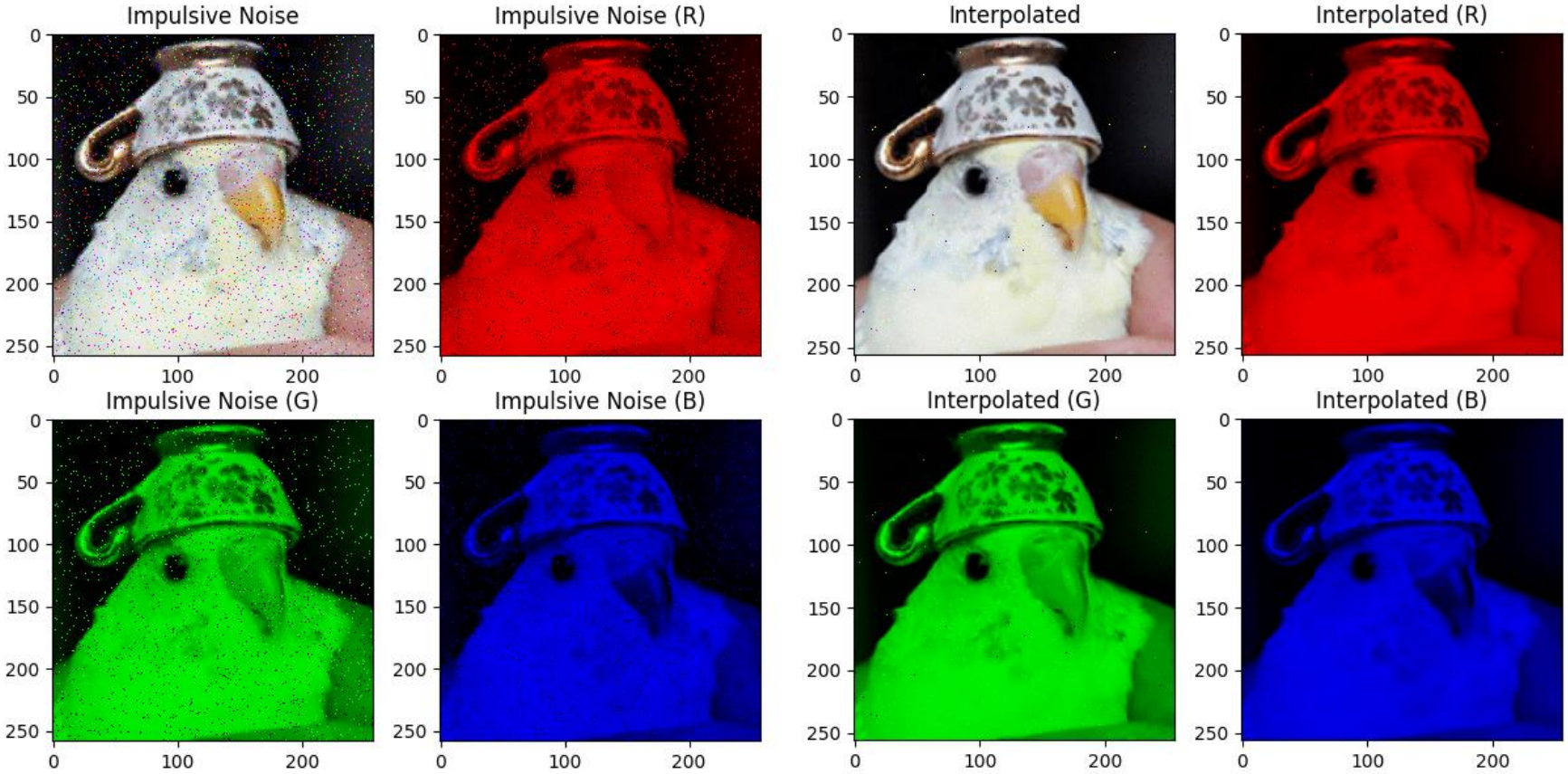
Noise Generation: Implementation



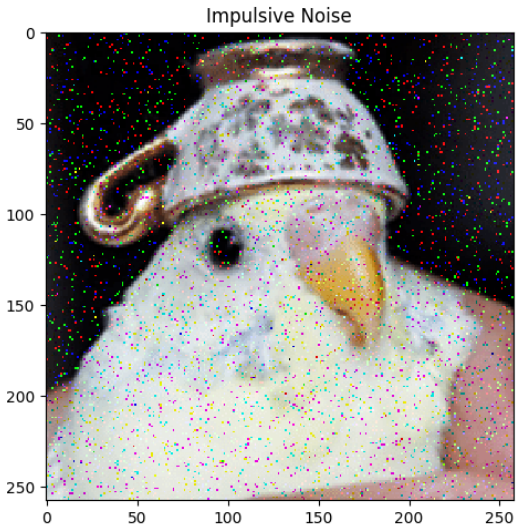
Noise Detection: Implementation

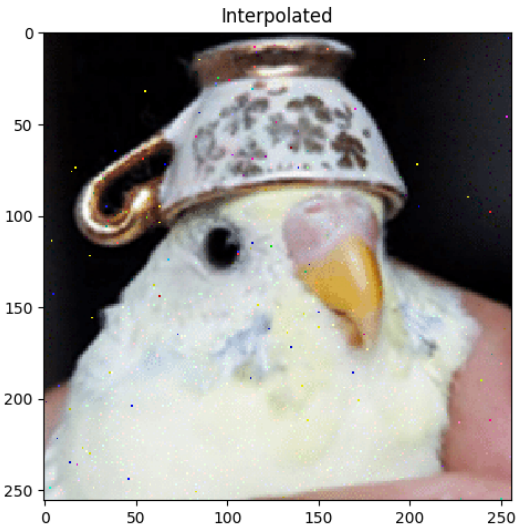


Noise Interpolation: Implementation



Performance





Normalized Mean-Squared Error Between Image Pixels

	Red Channel	Green Channel	Blue Channel
Noisy & Original	0.193763	0.199618	0.198139
Interpolated & Original	0.040137	0.038811	0.043348

Limitations

It is, however, important to remember the context of these results, and identify limitations to this method:

- The noise used in this project was salt-and-pepper noise, which involves noise that is sharp, and either very high or very low in value. If an image is affected by noise that can vary between a large range of values, this method may not be appropriate.
- This method assumes correlation between the RGB channels of an image. If no such correlation exists for an image, this method will likely not perform well.

Resources

Github Repository:
https://github.com/alvii147/ImageNoiseInterpolation

Source Code Documentation:
https://alvii147.github.io/ImageNoiseInterpolation/build/html/utils.html

Project Report:
https://alvii147.github.io/ImageNoiseInterpolation/report/ECE_313_Course_Project

References

Y. Wakabayashi, A. Taguchi. (2005, December). *Impulsive Noise Removal Using Interpolation Technique in Color Images*. Available https://ieeexplore.ieee.org/document/1595367

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D. Chappelle, N. Brennan. (2004, March). Chappelle's Show (Season 2, Episode 8).

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