

TRC3500 Assignment 2 Report

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1. Two plausible kinds of noise and variability:

a) Salt and pepper noise



Figure 1: Barcode with Pepper Noise [1]

Salt and pepper noise introduces random variations in pixel values, resulting in some pixels becoming either entirely black (salt) or white (pepper). This noise creates random black and white spots within the barcode lines, making decoding challenging. Additionally, it reduces the contrast between black and white lines, making it difficult for scanners to distinguish between them accurately. This might lead to decoding errors due to the disruption of the barcode pattern.

b) Lighting Variability and Shadows

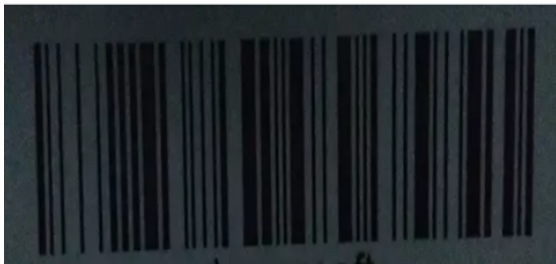


Figure 2: Barcode with Uneven Lighting [1]

Uneven lighting or shadows cast over the barcode can cause variation in image intensity, making it challenging to accurately threshold the image into binary format to isolate it from the background. Poor lighting can lead to reflections, glare, or dark regions within the barcode, complicating the distinction between the black bars and white spaces. This variability affects edge detection accuracy and the subsequent decoding process.

2. Initial Assessment (Based on Observation)

Image	Print Quality	Orientation	Barcode Condition	Interference of graphics and text
IMG_20_240227_0002	Good	No	No blurring or pixelation	No
IMG_20_240227_0003	Good	180 deg	No blurring or pixelation	Yes (Potential)
IMG_20_240227_0004	Good	5 deg	No blurring or pixelation	Yes (Potential)
IMG_20_240227_0005	Decent	No	Pixelated, slightly blurred	Yes (Potential)

IMG_20_240227_0006	Bad	Slight orientation	Not pixelated, slightly blurred	Yes (Potential)
IMG_20_240227_0007	Bad	Slight orientation	Not pixelated, slightly blurred	Yes (Potential)
IMG_20_240227_0008	Slightly bad	Slight orientation	Not pixelated, slightly blurred	Yes (Potential)
IMG_20_240227_0009	Decent	Orientation present	No blurring or pixelation	Yes (Potential)
IMG_20_240227_0010	Good	No orientation	No blurring or pixelation	No

Algorithm Testing

Taking IMG_20240227_0002 as an example, we can see the impact of the variability of noise in the barcode.



From the image above, salt and pepper noises seen on the image will interfere with barcode reading. The most common error will be the inability to locate the midpoint of the barcode. This problem can be tackled by either manually cropping the image in MATLAB, or applying Gaussian filter to remove pepper noise. The value of the sigma for the gaussian filter will be changed accordingly until that a reliable barcode reading can be obtained with the code.

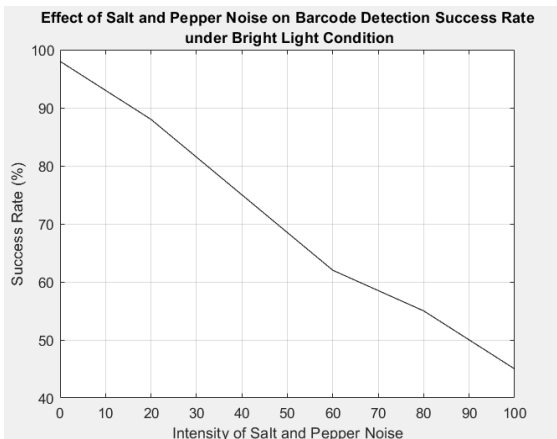
Quantitative Measurement

The graphs display variations in lighting (bright and low light) with different intensity of salt and pepper noise plotted against the success rate of scanning the barcode.

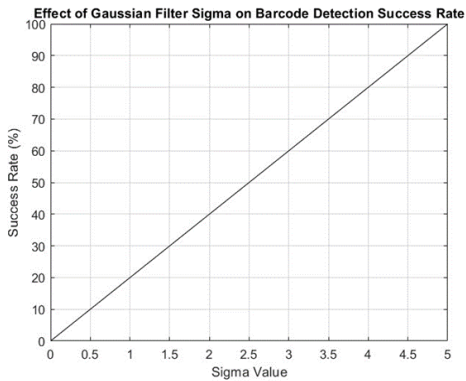
Bright lighting condition

Intensity of Salt and Pepper Noise (%)	Success Rate (%)
0	98
20	85
40	70
60	62
80	55
100	45

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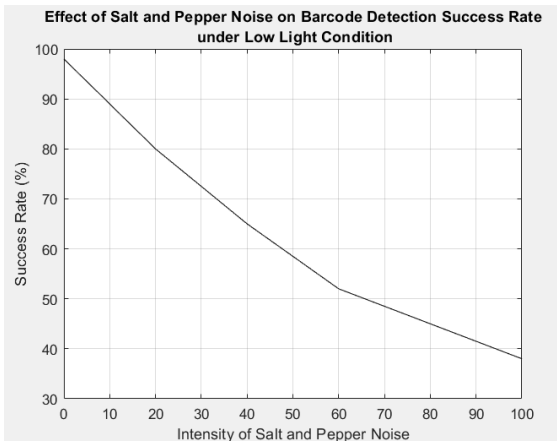


100	45
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Low lighting condition

Intensity of Salt and Pepper Noise (%)	Success Rate (%)
0	98
20	80
40	65
60	52
80	45
100	38



As the value for the sigma value of the gaussian filter increases, so will the success rate of the scanning of the barcode.

Sigma Value of Gaussian Filter	Success Rate (%)
0	98
20	88
40	75
60	62
80	55

3. Ways to improve the system's performance:

a) Adaptive Thresholding and Morphological Operations

Could accommodate better variations in lighting and contrast across barcode images, thereby increasing resilience to physical damage or printing errors. Unlike global thresholding, which applies a single threshold value across the entire image, adaptive thresholding adjusts the threshold value based on the local image characteristics which helps in distinguishing the barcode lines from the background more effectively, especially in areas affected by scratches or smudges. Additionally, morphological operations like 'dilate' and 'erode' could be used to repair the structure of the barcode lines. 'Dilate' helps in closing small gaps in the barcode lines caused by scratches, while 'erode' can remove small blobs of noise. Applying these operations selectively could improve the integrity of the barcode's pattern before decoding.

**2. Addressing Lighting Variability and Shadows
Solution: Localized Image Processing and Dynamic Range Adjustment**

To address uneven lighting and shadows, localized image processing techniques can be employed. Segmenting the image into smaller regions and applying image enhancement techniques like histogram equalization or contrast stretching on a per-region basis compensate for uneven illumination. Uniform enhancement across different lighting is ensured, which improves visibility of barcode lines. Dynamic range adjustment, involving scaling intensity values, improves contrast between the barcode and the background, particularly effective in low light or glare conditions. This enhancement enables subsequent image processing steps, like thresholding and edge detection to be more effective.

General Improvement: Advanced Image Preprocessing Techniques

Integrating advanced image preprocessing techniques like machine learning-driven filters or deep learning models trained to recognize and correct distortions in barcode images could significantly enhance robustness to various noise types. These models can learn from large datasets of barcode images under different conditions, automatically identifying and applying the best corrections for noise, damage, or distortion present in a new barcode image.

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Reference

1. *How to improve the reading of barcodes with noise*
(2022) *Dynamsoft Developers Blog*. Available at:
<https://www.dynamsoft.com/codepool/read-barcodes-with-noise.html> (Accessed: 07 April 2024).