Research Presentation

Median Filtered Image Quality Enhancement and Anti-Forensics via Variational Deconvolution **and U-Net Architecture**

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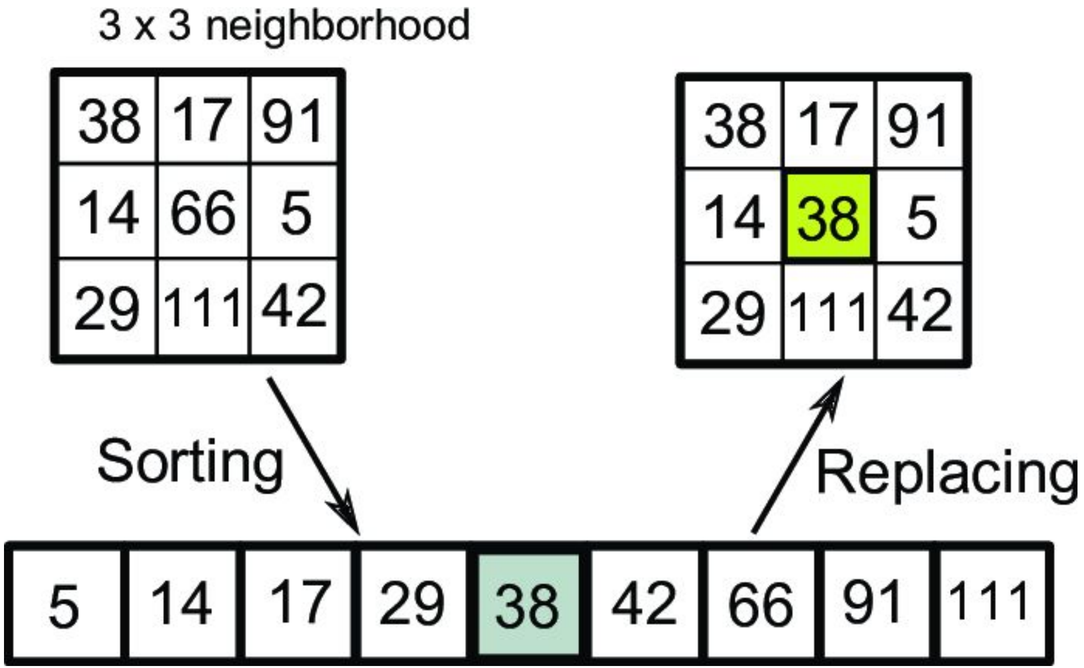
Introduction

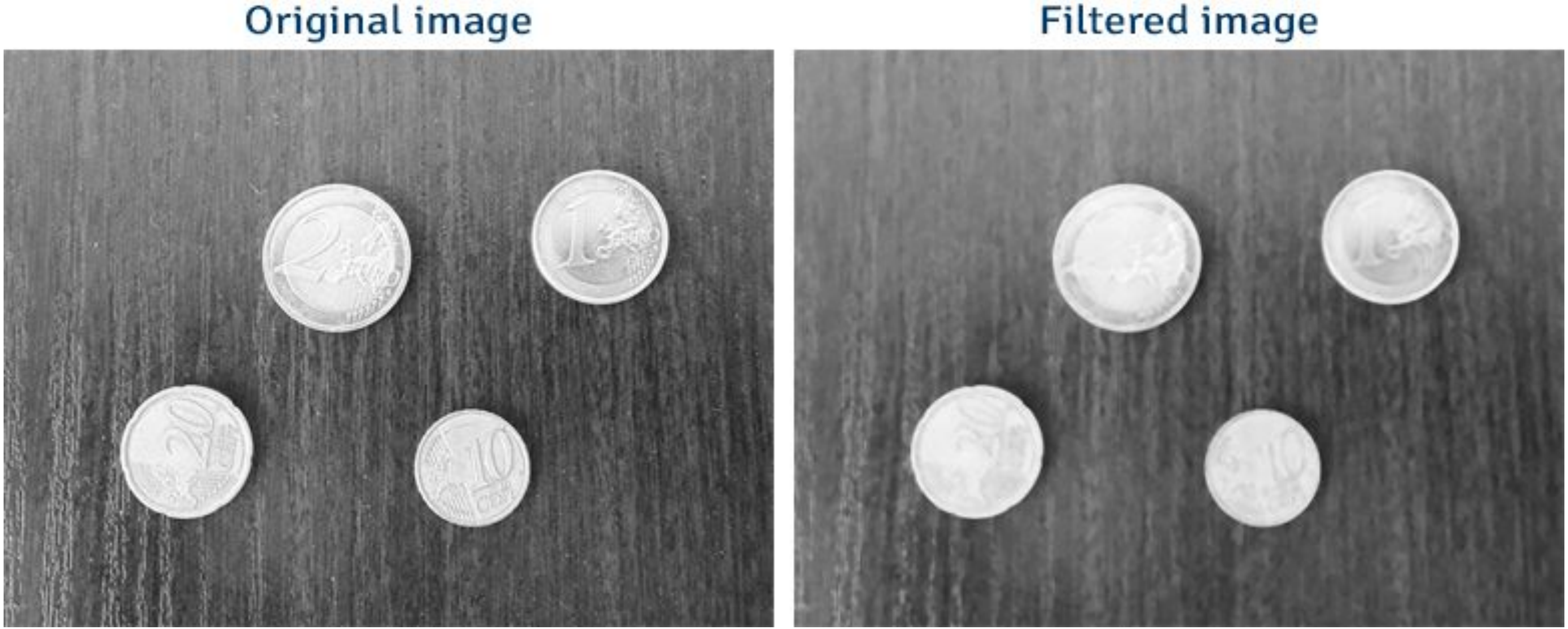
Median Filtering

- Low Pass Filtering
- Non - Linear
- Smoothing Tool
- De-Noising Tool
- Salt & Pepper Noise



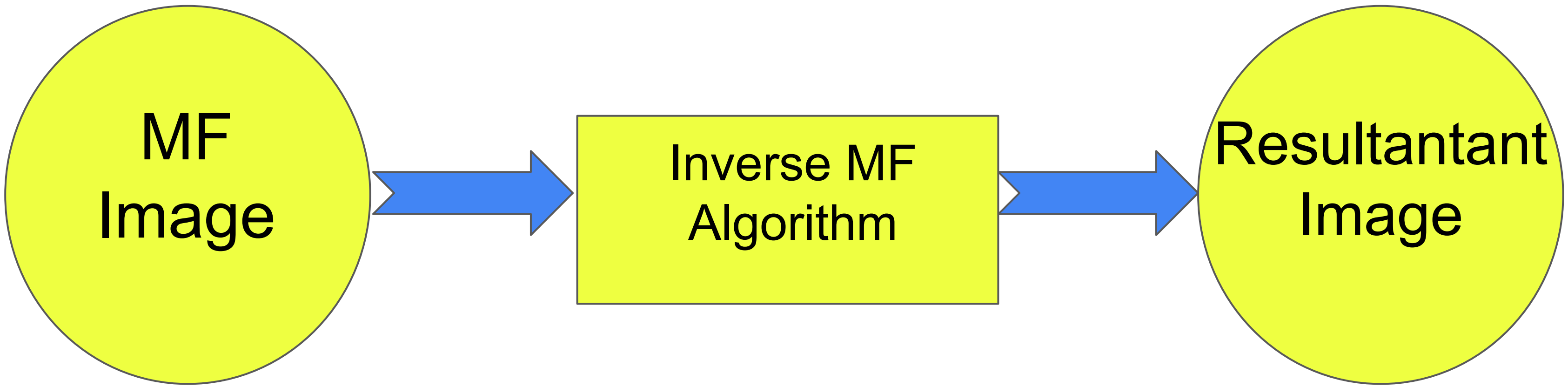
Why Author targeted the Median Filtering

- Convicts uses Median Filtering to Hide Traces after tampering image



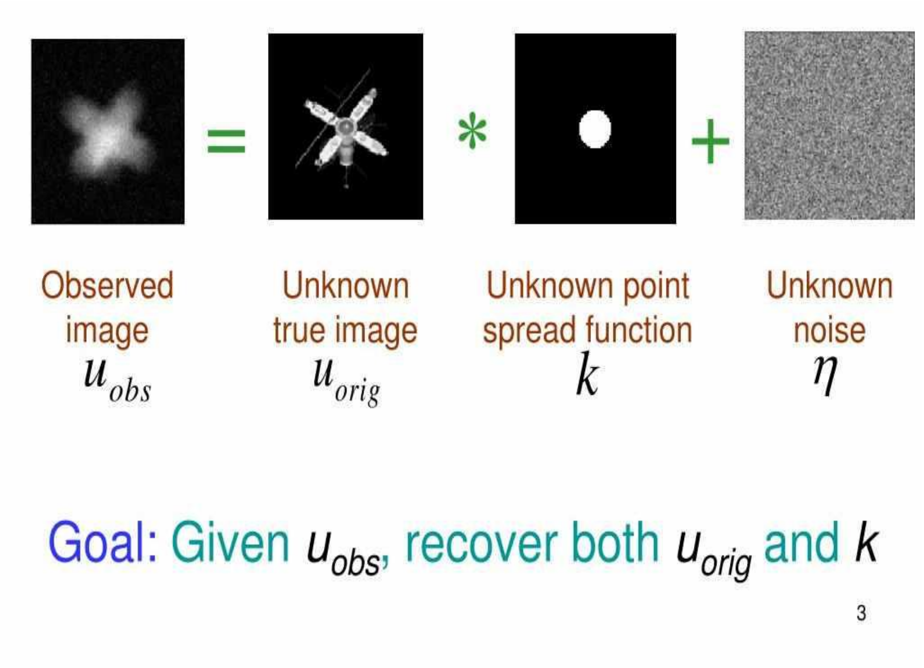
Goal

- To deduce an Anti-Median Filtering Technique

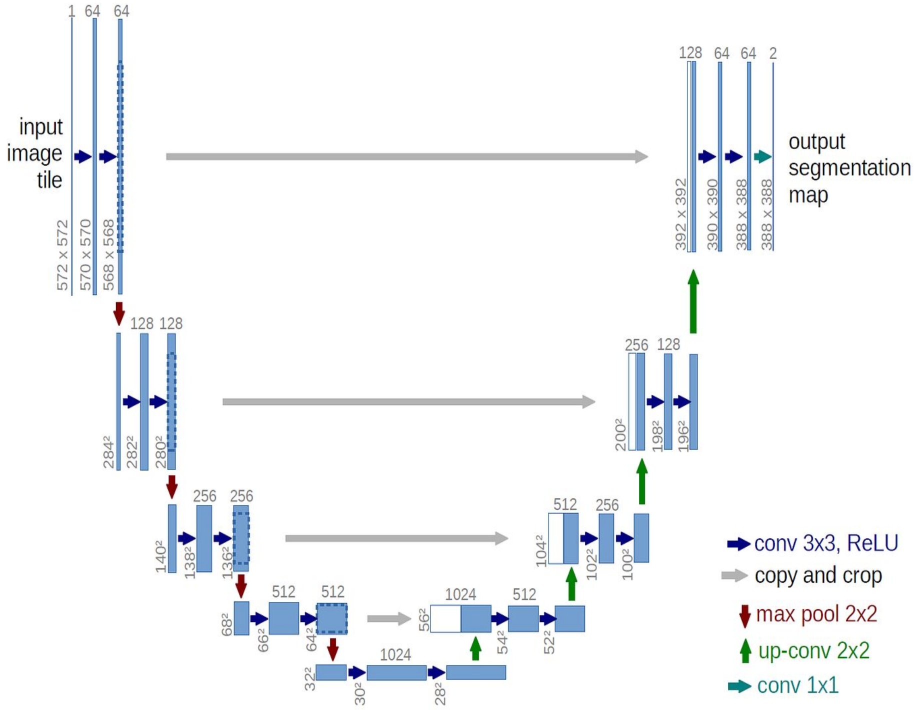


Proposed Solutions:

Blind Deconvolution



U-Net Architecture



Blind Deconvolution

"blind" = incomplete knowledge of kernel.

$$\kappa = \frac{\Gamma(5/\beta)\Gamma(1/\beta)}{\Gamma(3/\beta)^2}$$

Proposed method for deconvolution:

$$\tilde{\mathbf{x}} = \arg\min_{\mathbf{u}} \left(\frac{\lambda}{2} \left(\|\mathbf{K}\mathbf{u} - \mathbf{y}\|_2^2 + \omega \|\mathbf{u} - \mathbf{y}\|_2^2 \right) + \sum_{j=1}^{J} \left\| \frac{\mathbf{F}^j \mathbf{u}}{\alpha_j} \right\|_{\beta_j}^{\beta_j} \right).$$

u = MF img. (Matrix)
K = filter (approximated)
λ, β, α, ω = approximation parameters obtained from other statistical equations.

Blind Deconvolution

Blur Model: The observed (blurred) image g is typically modeled as:

$$\mathbf{g = h \ast f + n}$$

- h: Unknown blur kernel (PSF)
- f: Original sharp image
- n: Noise
- $\ast$: Convolution operation

Objective: Estimate both f and h from the observed image g.

Steps in Blind Deconvolution:

1. **Initial Estimation:** Start with an initial guess for the sharp image and blur kernel.
2. **Iterative Refinement:** Use iterative algorithms to refine the estimates of f and h.
3. **Regularization:** Apply constraints or regularization terms to ensure stable and realistic solutions, reducing the impact of noise.

U-Net Architecture

Brief Description:

- U-Net is a **Convolutional Neural Network (CNN)** designed for **image segmentation** and **restoration**.
- Features a **U-shaped structure** with an **encoder-decoder** design and **skip connections**.

Key Benefits:

- **Retains Fine Details:** Skip connections prevent information loss.
- **Handles Complex Degradations:** Learns directly from data without estimating blur kernels.
- **Versatile:** Effective for tasks like **denoising**, **deblurring**, and **super-resolution**.

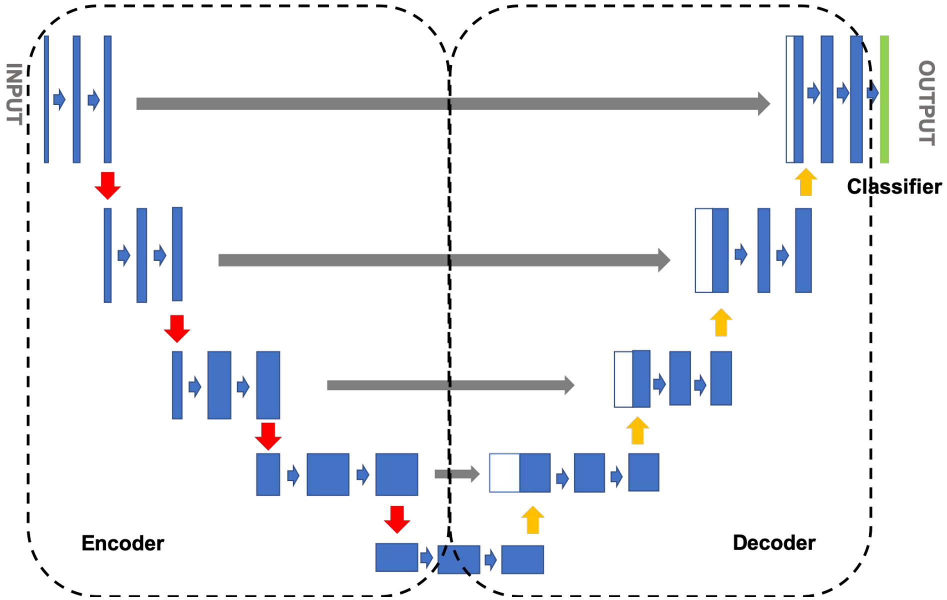
U-Net Workflow

Step-by-Step Workflow:

- **Input:** Blurred image.
- **Encoder:** Convolution + ReLU → Max Pooling (downsampling).
- **Bottleneck:** Convolutional layer (deep features).
- **Decoder:** Upsampling → Convolution → Skip Connection.
- **Output:** Restored (deblurred) image.

Key Components:

- **Encoder:** Captures high-level features using convolution and downsampling (max pooling).
- **Bottleneck:** Connects the encoder and decoder, capturing deeper image representations.
- **Decoder:** Reconstructs the image using upsampling and feature concatenation from skip connections.
- **Skip Connections:** Bridge corresponding encoder-decoder layers to retain spatial details.

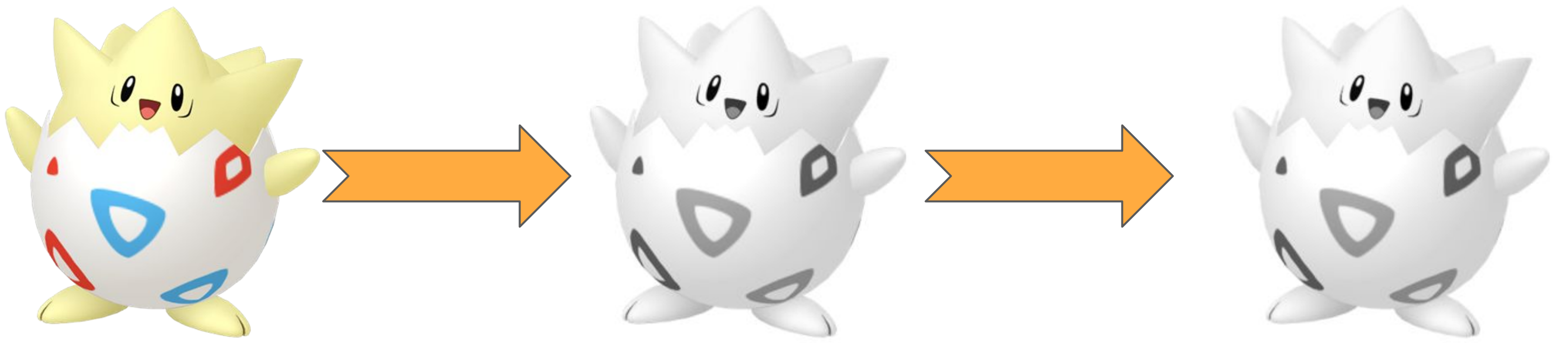


Dataset & Processing Pipeline

Original dataset: **Pokemon-ds** link

Images: 1538 (8-bit 512x512)

RGBA- ds Grayscale-ds Median Filtered ds



Deconvolution Results (proposed by Wei Fan et. al.)

Median-Filtered Image

Deconvoluted Image

Results Comparison

Variational Deconvolution

Mse_DC: 29.94275665283203

Min_Mse_DC: 1.389920711517334

Max_Mse_DC: 633.2599487304688

U-Net with BCE Loss

Train Loss: 0.1541

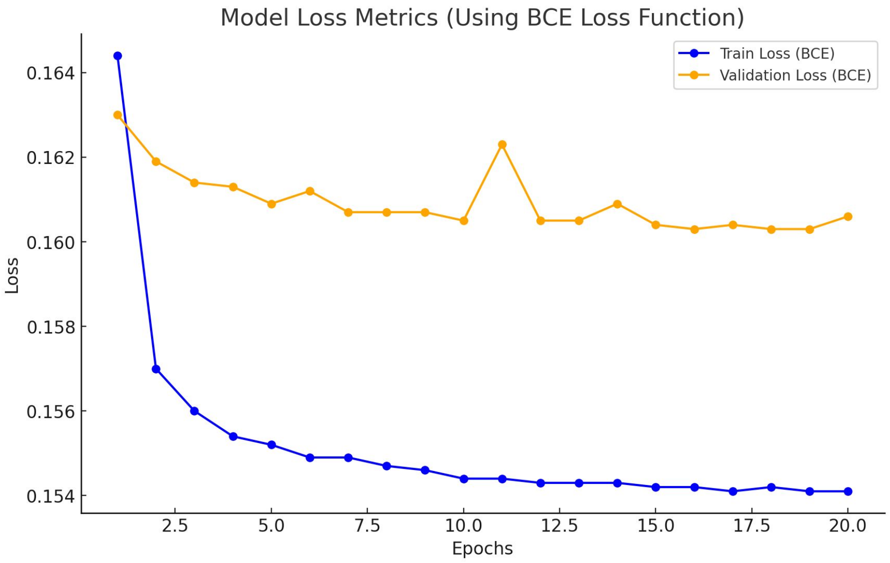
Validation Loss: 0.1606

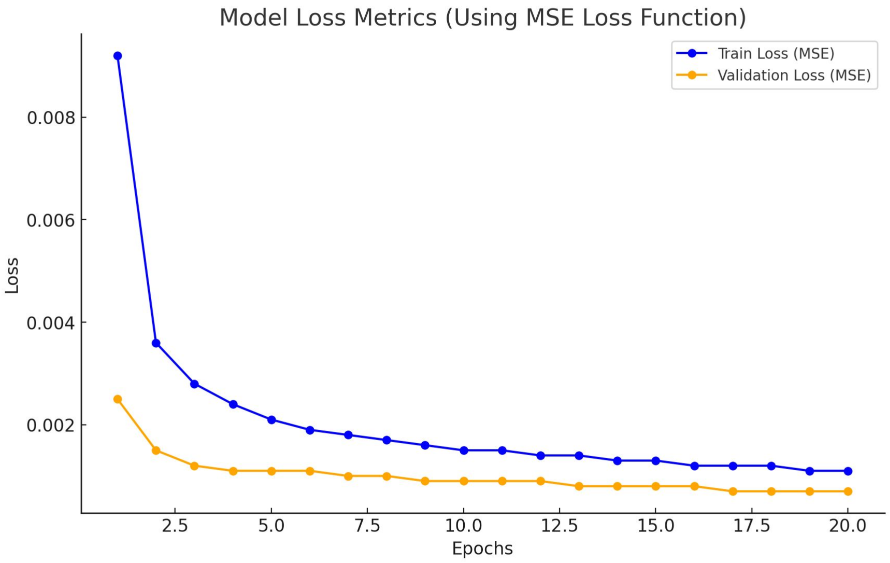
U-Net with MSE Loss

Train Loss: 0.0011

Validation Loss: 0.0007

U-Net Loss Function Comparison





Results: U-Net performs better with MSE loss Function

U-Net Results (Self - Proposed)

Median-Filtered Image

U-Net Generated Image

References:

- https://ieeexplore.ieee.org/document/7027174 (original Paper Link)
- https://github.com/Akshat6133/De-Median_Filtering_using_DeConvolution_and_U-Net
- https://lindevs.com/uploads/posts/content/2021/06/image_filtering_using_median_filter_and_opencv.png?v=1680423474
- https://miro.medium.com/max/1400/1*IvXoKMHoPJMKpKK7keZMEA.png

Let’s Move to Coding(600 lines) part

Thank you