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CR 3.1B

Image Processing Project: Sequential Gaussian Blur Algorithm

1. Project Description

The project focuses on implementing an image filtering algorithm using a Gaussian Blur filter. The goal is to apply a blur effect to images using a sequential approach in C#. The project will later be extended to include parallel implementations using MS-MPI and CUDA.
Key Specifications:

- Algorithm: Gaussian Blur using convolution with 3×3 kernel ($\sigma = 30$)
- Implementation:
    - Sequential pixel-by-pixel processing
    - Image I/O using SixLabors.ImageSharp
    - Input/Output: JPEG images (128×128 to 32768×32768 px)
- Metrics: Execution time measurement using Stopwatch

2. Platform Information

The sequential implementation was tested on the following machine:

- Operating System: Microsoft Windows 11 Home (Version 10.0.26100 Build 26100)
- Processor: 12th Gen Intel(R) Core(TM) i7-1255U, 1700 Mhz, 10 cores, 12 logical processors
- RAM: 16.5 GB
- GPU:
- Intel(R) Iris(R) Xe Graphics (integrated GPU)
- NVIDIA GeForce MX550 (dedicated GPU)
- Development Environment: .NET 9.0, Visual Studio 2022

3. Experimental Results

The following table shows the execution times for the sequential implementation on images of different sizes:

Image Size	Execution Time (ms)
128x128 px	93
256x256 px	144

512x512 px	255
1024x1024 px	702
2048x2048 px	790
4096x4096 px	2660
8192x8192 px	19915
16384x16384 px	104442
32768x32768 px	505365

Observation: The sequential Gaussian blur demonstrates quadratic time complexity ($O(n^2)$), processing small images (under 2048px) in under 1 second while requiring ~8.5 minutes for 32K images. This performance characteristic clearly shows the algorithm's limitations for large-scale processing, strongly motivating the planned parallel implementations(using MPI and CUDA) to achieve practical processing times across all image sizes. The consistent 3×3 kernel size maintains computational efficiency per pixel, with $\sigma=30$ providing controlled blur intensity regardless of image dimensions.

4. References

- SixLabors.ImageSharp Documentation
- C# Guide
- Gaussian blur