Parallel Programming

Joker - Project 🚀

Images transformation

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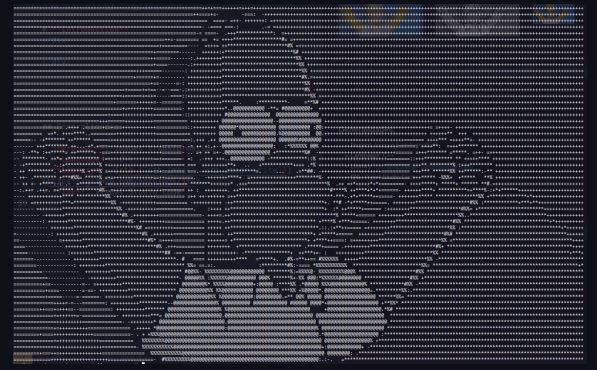
Introducción

Herramienta de transformación de imágenes. Desde `escala a grises`, `redimensionamiento`, hasta filtros de convolución (`desenfoque gaussiano`). Comparando el rendimiento de la versión secuencial y paralela.



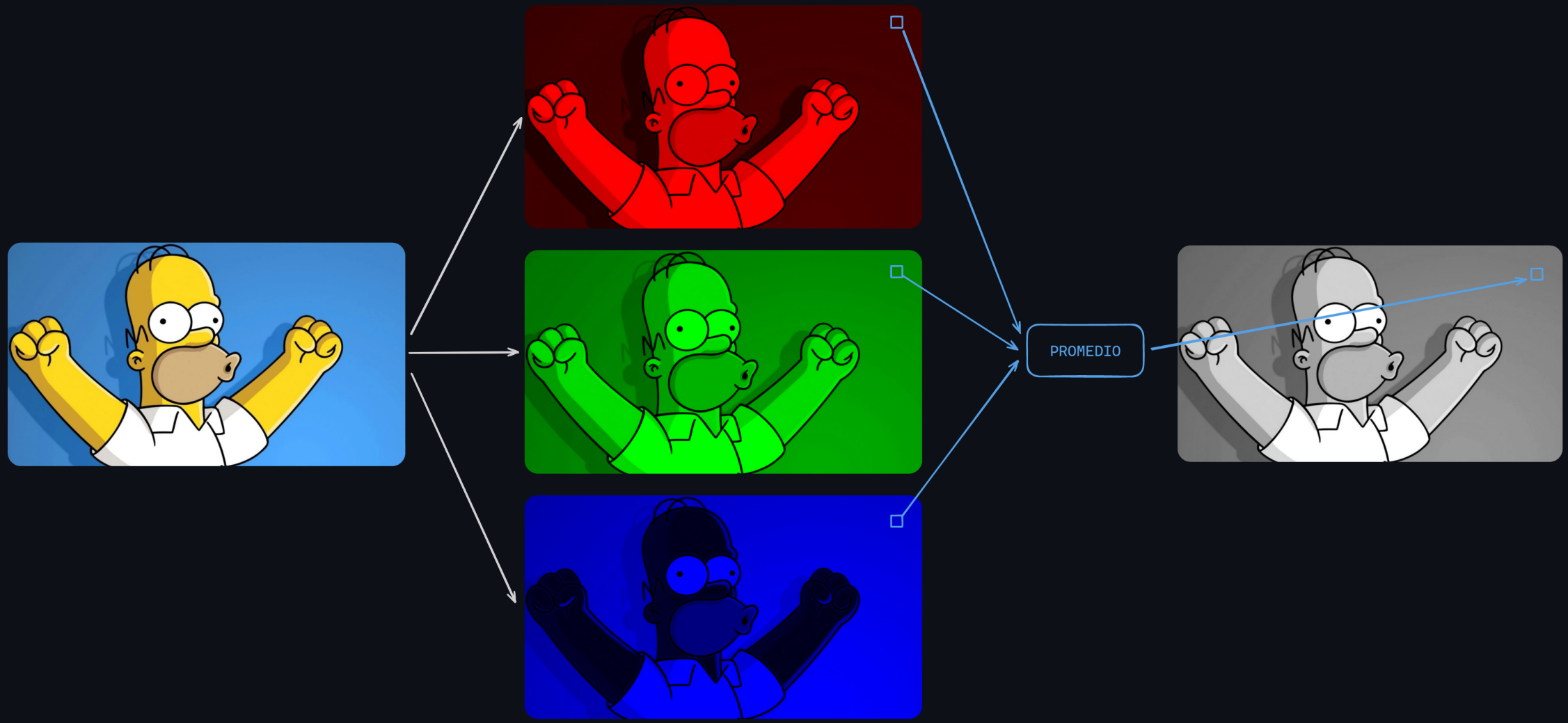



Generalidades:

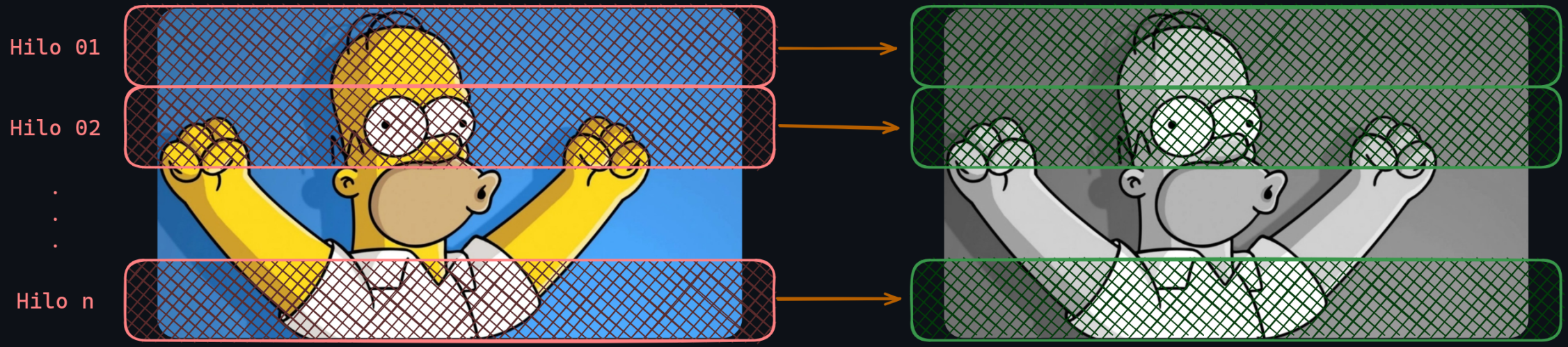
- **Project**: Images transformation
- **Language**: C++
- **Library**: stb (`stb_image` `stb_image_write`)
- **IDE**: Visual Studio Code

1. Escala a grises ✴

1.1. Explicación gráfica:



1.2. Explicación paralela:



Donde:

- `n` = Número total de núcleos de CPU disponibles.

1.3. Implementación:

```
unsigned char *convertToGrayscaleParallel(unsigned char *data, int width, int height, int channels)
{
    unsigned char *grayscaleData = (unsigned char *)malloc(width * height);

    int numThreads = std::thread::hardware_concurrency();
    int rowsPerThread = height / numThreads;
    std::vector<std::future<void>> futures;

    for (int i = 0; i < numThreads; ++i)
    {
        int startRow = i * rowsPerThread;
        int endRow = (i == numThreads - 1) ? height : startRow + rowsPerThread;
        futures.emplace_back(std::async(std::launch::async, convertToGrayscaleThread, data, grayscaleData, width, height, channels, startRow, endRow));
    }

    for (auto &future : futures)
    {
        future.wait();
    }

    return grayscaleData;
}
```

```
void convertToGrayscaleThread(unsigned char *data, unsigned char *grayscaleData, int width, int height, int channels, int startRow, int endRow)
{
    for (int y = startRow; y < endRow; y++)
    {
        for (int x = 0; x < width; x++)
        {
            // Calcular el valor promedio de los canales de color
            int sum = 0;
            for (int c = 0; c < channels; c++)
            {
                sum += data[(y * width + x) * channels + c];
            }
            int average = sum / channels;
            // Asignar el mismo valor a cada canal en la imagen en escala de grises
            grayscaleData[y * width + x] = average;
        }
    }
}
```

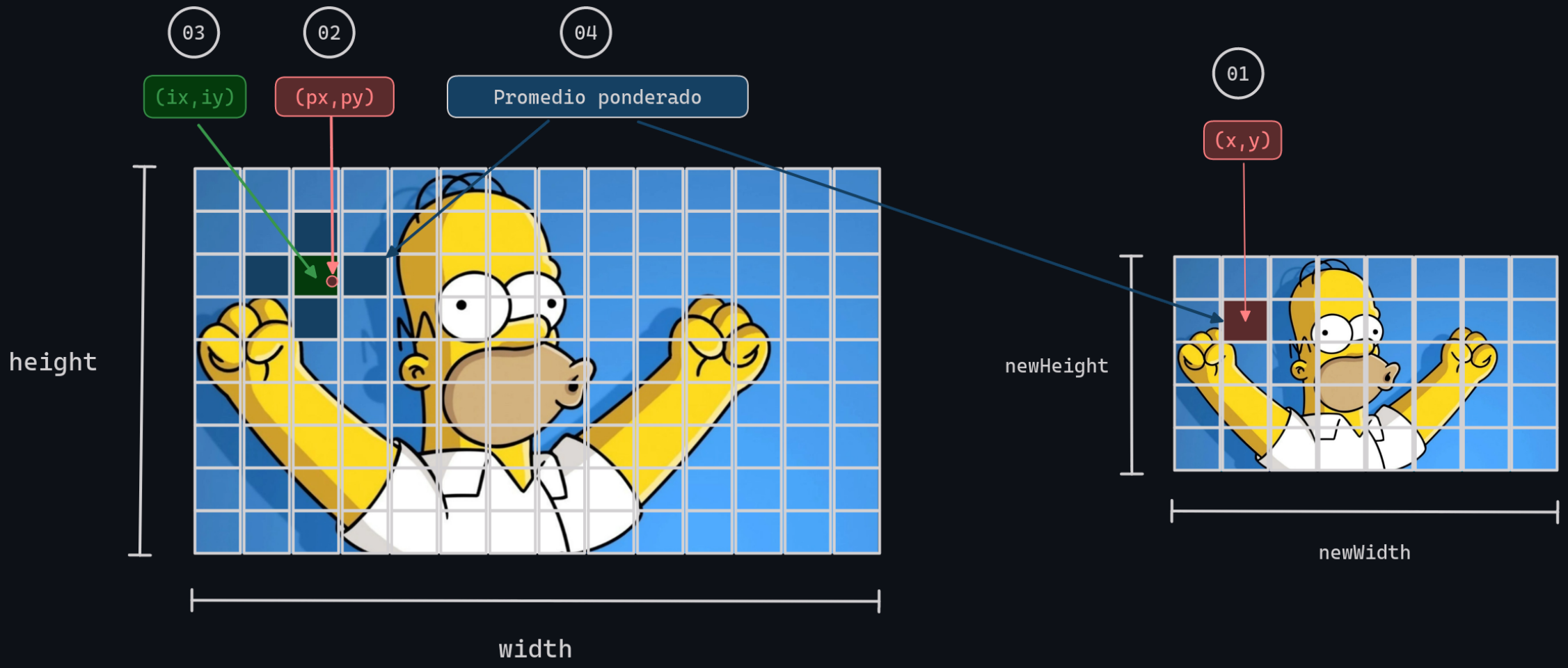
2. Redimensión

`Interpolación bilineal`

2.1. Explicación gráfica:

El proceso de interpolación bilineal implica calcular un `nuevo valor` para un píxel en la imagen redimensionada tomando en cuenta los `cuatro píxeles más cercanos` en la imagen original y `ponderando` sus valores `de acuerdo a su distancia relativa al píxel deseado`.

- (x, y): Posición del píxel en la **imagen redimensionada**.
- (px, py): Posición del píxel en la **imagen original**.
- (ix, iy): Posición del **píxel superior izquierdo más cercano** en la imagen original.
- (fx, fy): Factores de interpolación.
- $(weight_1, weight_2, weight_3, weight_4)$: Pesos de interpolación de los 4 píxeles más cercanos.


03
02
04
01
(ix,iy)
(px,py)
Promedio ponderado
(x,y)
height
width
newHeight
newWidth

3. Desenfoque Gaussiano

`Gaussian Blur`

3.1. Explicación gráfica:

- Obtenemos el `kernel convolution` con la fórmula de distribución gaussiana en el espacio bidimensional es la siguiente:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

(x-1,y-1)	(x,y-1)	(x+1,y-1)
(x-1,y)	(x,y)	(x+1,y)
(x-1,y+1)	(x,y+1)	(x+1,y+1)

0.1	0.1	0.1
0.1	0.2	0.1
0.1	0.1	0.1

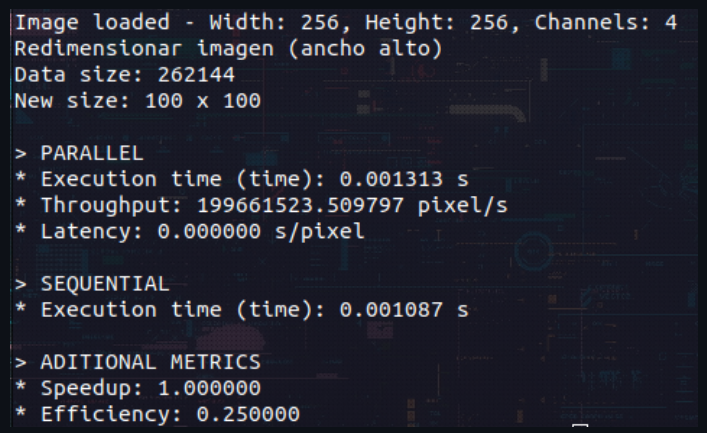
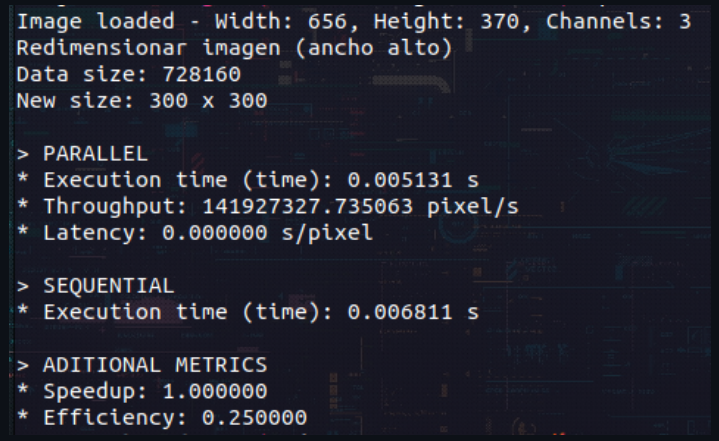
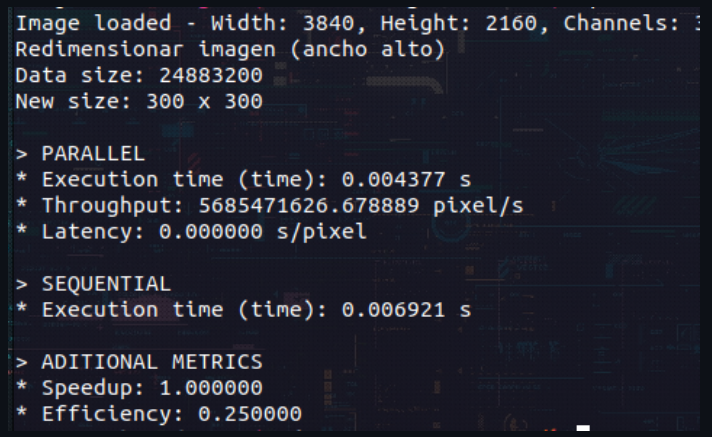
- Alinear el centro del kernel de convolución con el elemento correspondiente de la matriz a procesar. Los elementos correspondientes se multiplican y suman para obtener el resultado.

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

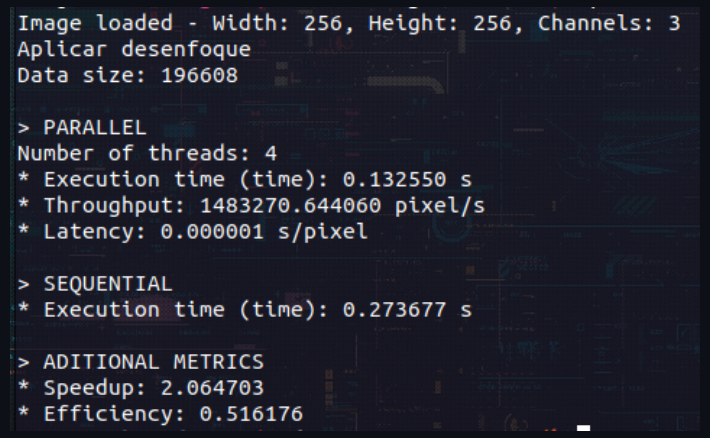
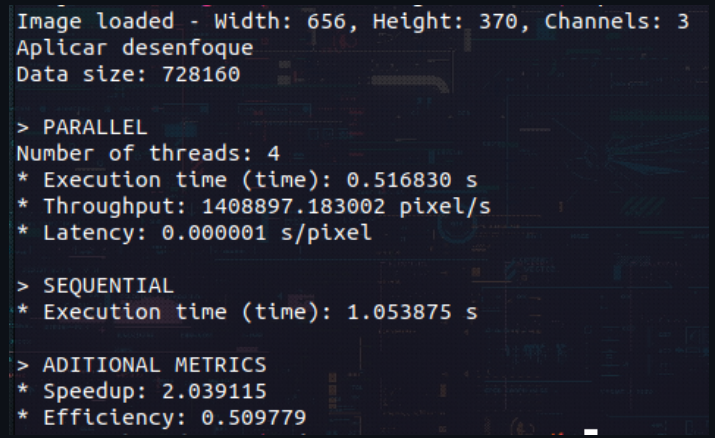
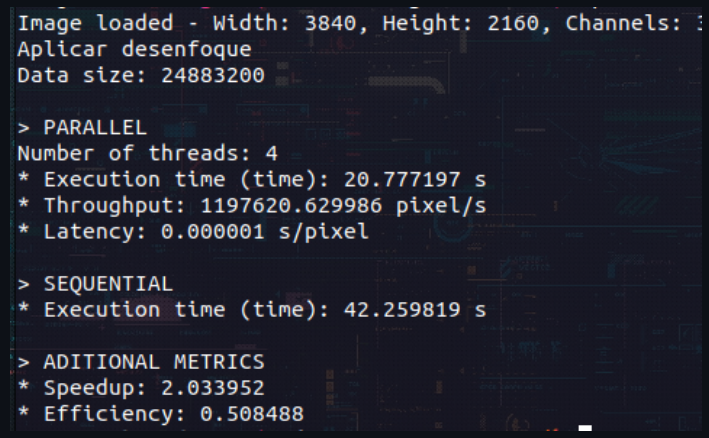
1.5	2.6	3.3	2.6
3.8	6	7	5.3
6.7	10	11	8.1
5.9	8.6	9.3	7

Performance 📈

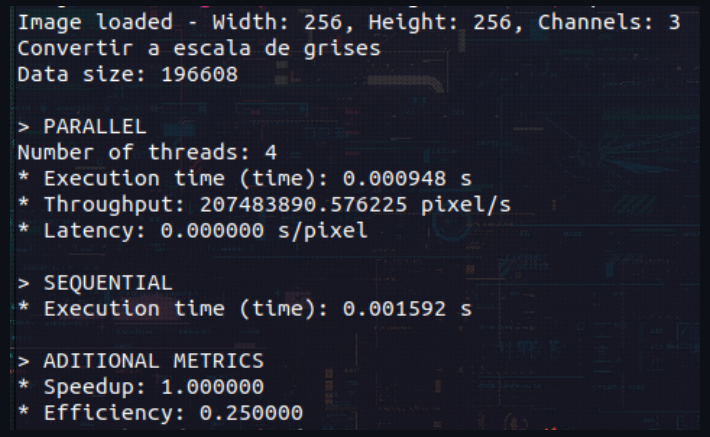
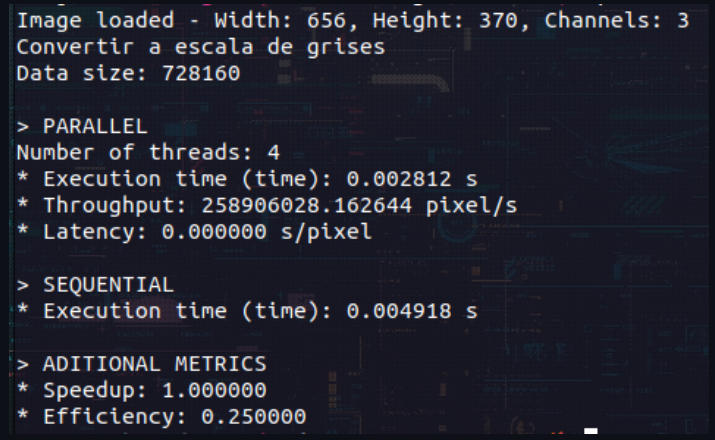
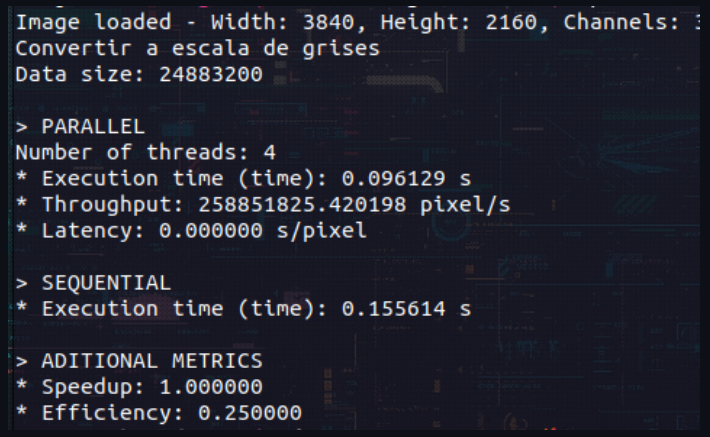
Redimensión:

small	medium	large
		

Gaussian Blur:

small	medium	large
		

Grayscale:

small	medium	large
		

¡¡Gracias!! 🚀