Laboratorio 3

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Estrategias e Implementaciones

- Paralelizar tinymc no vectorizado
- Paralelizar tinymc vectorizado

Paralelizando el tinymc no vectorizado

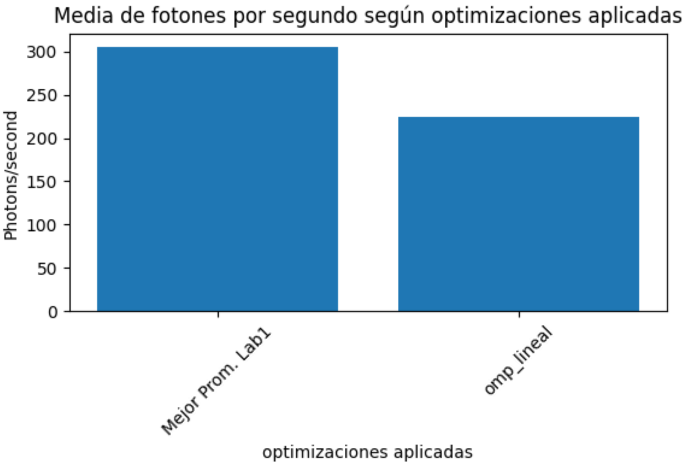
```
#pragma omp parallel for
for (unsigned int i = 0; i < PHOTONS; ++i) {
    photon(r);
}
```

Paralelizando el tinymc no vectorizado

```
#pragma omp parallel for
for (unsigned int i = 0; i < PHOTONS; ++i) {
    photon(r);
}
```

```
#pragma omp critical
heat[shell] += (1.0f - albedo) * weight;
#pragma omp critical
heat2[shell] += (1.0f - albedo) * (1.0f - albedo) * weight * weight;
```

Paralelizando el tinymc no vectorizado



Paralelizando el tinymc no vectorizado

Principales Problemas

- False sharing
- scheduling no dinámico

Paralelizando el tinymc no vectorizado

```
#pragma omp parallel for schedule(dynamic) private(heat_pr, heat2_pr, x, y, z, u, v, w, t, xi1, xi2, shell, weight)
for (unsigned int i = 0; i < PHOTONS; ++i) {
```

Paralelizando el tinymc no vectorizado

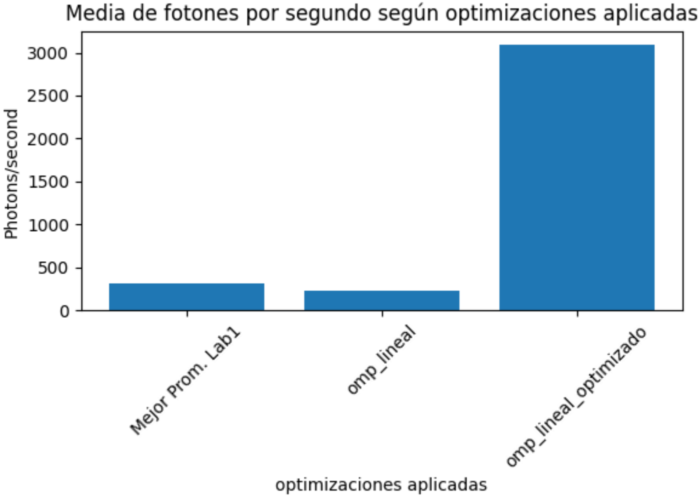
```
heat_pr[shell] += (1.0f - albedo) * weight;
heat2_pr[shell] += (1.0f - albedo) * (1.0f - albedo) * weight * weight;
```

Paralelizando el tinymc no vectorizado

```c
heat_pr[shell] += (1.0f - albedo) * weight;
heat2_pr[shell] += (1.0f - albedo) * (1.0f - albedo) * weight * weight;
```

```c
if ((float)genRand(&r) > 0.1f) {
    // cargando a los shared heats a partir de los privados
    #pragma omp critical
    {
        for (int n = 0; n < SHELLS; ++n) {
            heat[n] += heat_pr[n];
            heat2[n] += heat2_pr[n];
        }
    }
    break;
```

Paralelizando el tinymc no vectorizado



Paralelizando tinymc vectorizado

- Muy difícil paralelizar intrinsics
- Refactorizar el código

Paralelizando tinymc vectorizado

```
#pragma omp simd [clause[[,] clause]...] new-line
    for-loops
```

OpenMP incluye directivas para vectorizar for loops

Detalle de vectorización con OpenMP

```c
float heat_pr[SHELLS];
float heat2_pr[SHELLS];
float x[8] = { 0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f };
float y[8] = { 0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f };
float z[8] = { 0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f };
float u[8] = { 0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f };
float v[8] = { 0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f,0.0f };
float w[8] = {
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
};
float weight[8] = {
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
    1.0f,
};
```

Detalle de vectorización con OpenMP

```
#pragma omp simd aligned(albedo, shells_per_mfp:32)
for (unsigned int i = 0; i < 8; ++i) {
    albedo[i] = MU_S * (1.0f / (MU_S + MU_A));
    shells_per_mfp[i] = 1e4 * (1.0f / MICRONS_PER_SHELL) * (1.0f / (MU_A + MU_S));
}
```

Detalle de vectorización con OpenMP

```
while (photon_count < PHOTONS) {

launch */
    #pragma omp simd aligned(t, x, y, z, shell, weight:32)
    for (unsigned int i = 0; i < 8; ++i) {
        t[i] = -logf((float)genRand(&r)); /*move*/
        x[i] += t[i] * u[i];
        y[i] += t[i] * v[i];
        z[i] += t[i] * w[i];
        shell[i] = (unsigned int)sqrtf(x[i] * x[i] + y[i] * y[i] + z[i] * z[i]) * shells_per_mfp[i];

        if (shell[i] > SHELLS - 1) {
            shell[i] = SHELLS - 1;
        }

        heat_pr[shell[i]] += (1.0f - albedo[i]) * weight[i];
        heat2_pr[shell[i]] += (1.0f - albedo[i]) * (1.0f - albedo[i]) * weight[i] * weight[i]; /* ad
        weight[i] *= albedo[i];
    }
```

Detalle de vectorización con OpenMP

```
do {
    #pragma omp simd aligned(xi1, xi2:32)
    for (unsigned int i = 0; i < 8; ++i) {
        xi1[i] = 2.0f * genRand(&r) - 1.0f;
        xi2[i] = 2.0f * genRand(&r) - 1.0f;

        if (t_mask[i] == 0) {
            t[i] = xi1[i] * xi1[i] + xi2[i] * xi2[i];
        }
    }
    #pragma omp simd aligned(t:32)
    for (unsigned int i = 0; i < 8; ++i) {
        if (t[i] <= 1.0f) {
            t_mask[i] = 1;
        }
    }


} while (check_t_greater_1(t));
```

Detalle de vectorización con OpenMP

```c
#pragma omp simd aligned(u, v, w, t, xi1, xi2, weight, x, y, z:32)
for (unsigned int i = 0; i < 8; ++i) {

    u[i] = 2.0f * t[i] - 1.0f;
    v[i] = xi1[i] * sqrtf((1.0f - u[i] * u[i]) * (1.0f / t[i]));
    w[i] = xi2[i] * sqrtf((1.0f - u[i] * u[i]) * (1.0f / t[i]));


    if (weight[i] < 0.001f) { /* roulette */
        weight[i] *= 10.0f;

        if ((float)genRand(&r) > 0.1f) {
            // reset lane
            x[i] = 0.0f;
            y[i] = 0.0f;
            z[i] = 0.0f;
            u[i] = 0.0f;
            v[i] = 0.0f;
            w[i] = 1.0f;
            weight[i] = 1.0f;
            #pragma omp atomic
            photon_count++;
            #pragma omp flush
        }
    }
}
```

Detalle de vectorización con OpenMP

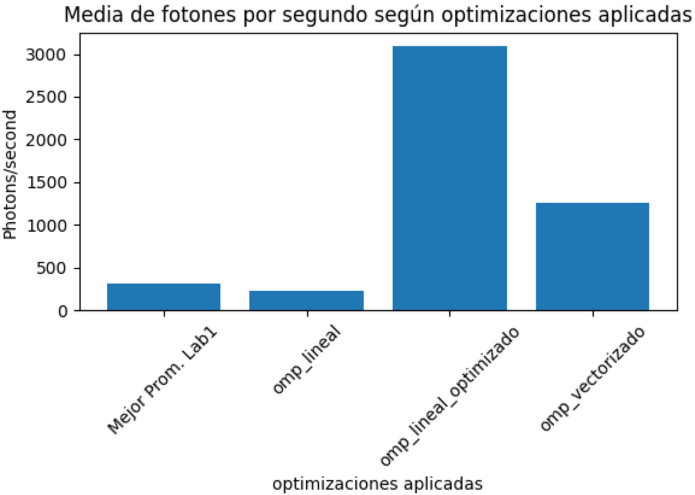
```
#pragma omp simd
for (unsigned int i = 0; i < SHELLS; ++i) {
    #pragma omp atomic
        heat[i] += heat_pr[i];
    #pragma omp atomic
        heat2[i] += heat2_pr[i];


}
```

Detalle de vectorización con OpenMP

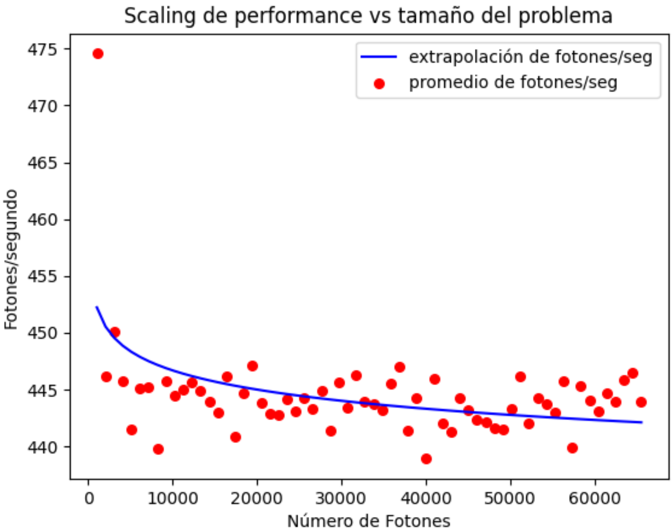
```
#pragma omp parallel shared(photon_count, heat, heat2)
    {
        photon(r);
    }
```

Comparación de velocidades



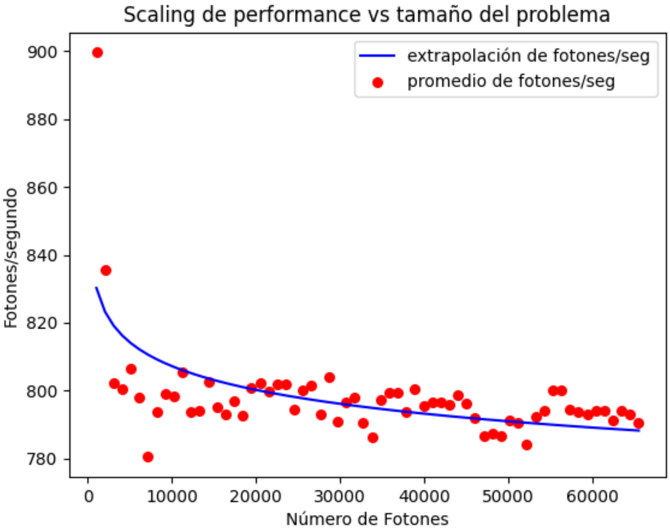
Scaling según número de threads

2 Threads



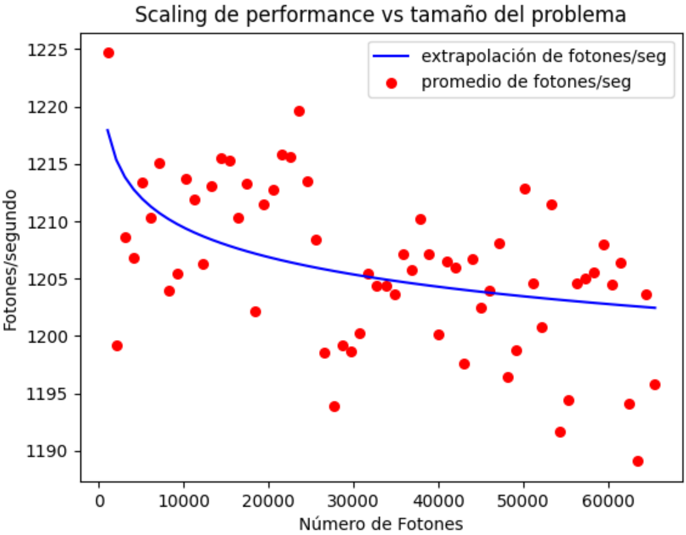
Scaling según número de threads

4 Threads



Scaling según número de threads

8 Threads



Conclusiones

- Código mucho más legible
- Mejoras notables en velocidad respecto a versiones anteriores

Potenciales Mejoras

- Seguimos sin vectorizar el generador de números