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Spatial vegetation density index from terrestrial laser scanner

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BACKGROUND AND OBJECTIVES

Introduction: Forest monitoring is a key issue in scientific, social and commercial domains. Manual measurements of forests attributes can be tedious and limited. Terrestrial Laser Scanner (TLS) has been introduced in forest monitoring [1]. Vegetation density index is a way to quantify vegetation using voxels from TLS data [2].

Problem statement: The vegetation density index is estimated using ray tracing techniques in a 3D voxel grid. This process can be time consuming and can be improved.

Objectives:

- Decrease the computing time
- Increase the consistency of the calculus

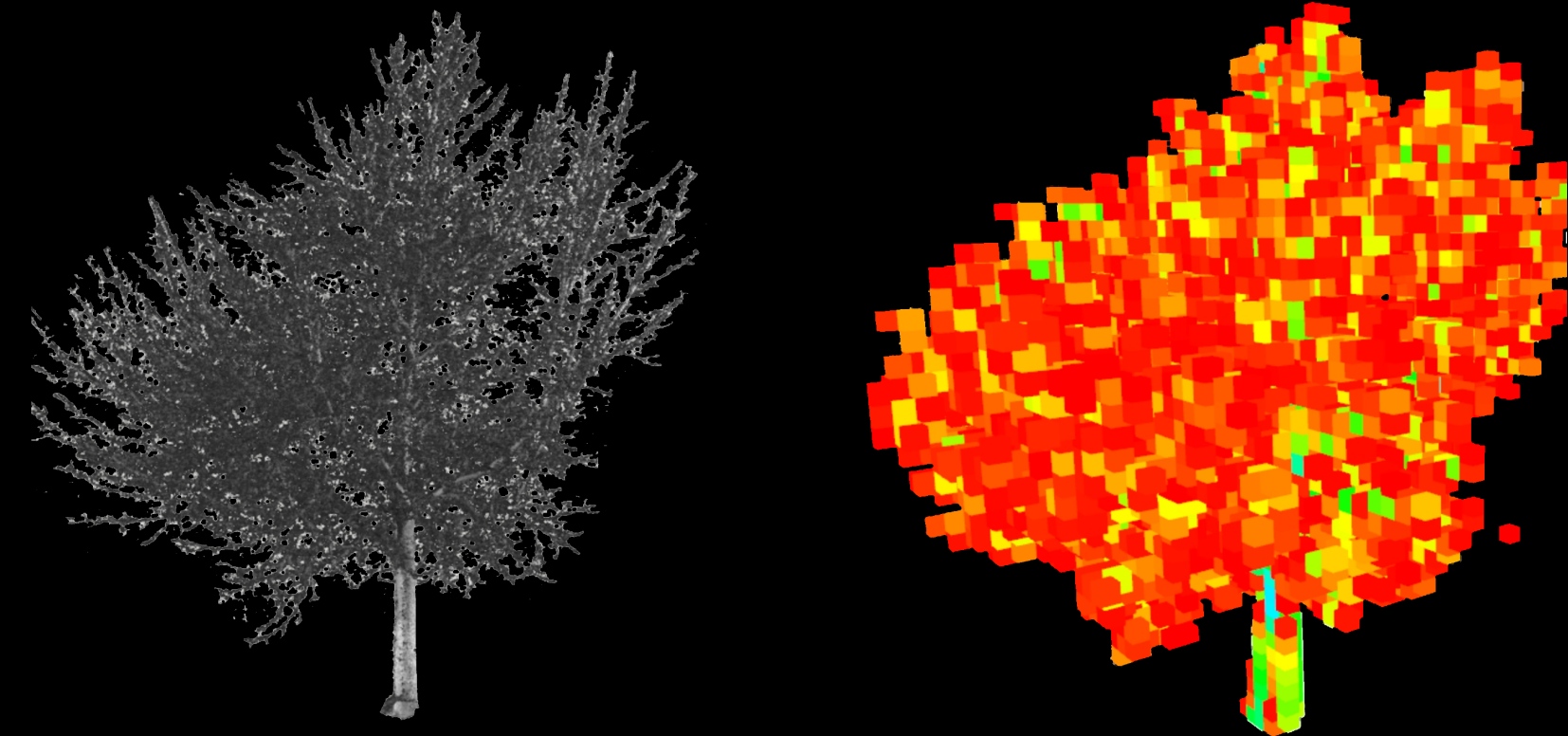


Figure 1: TLS point cloud and voxelisation of a tree

METHODOLOGY

1. Identify the visible faces of all voxels
2. Compute their solid angles (eq. 1)
3. Compute the adjustment factor (eq. 4)
4. Compute the density index (eq. 5)

CONTACT INFORMATION

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DENSITY INDEX

Assumption: The number of laser beams intercepted within a volume is proportional to the density of vegetation.

Density index: this index is defined as :

$$D = \frac{N_i}{N_t - N_b} 100$$

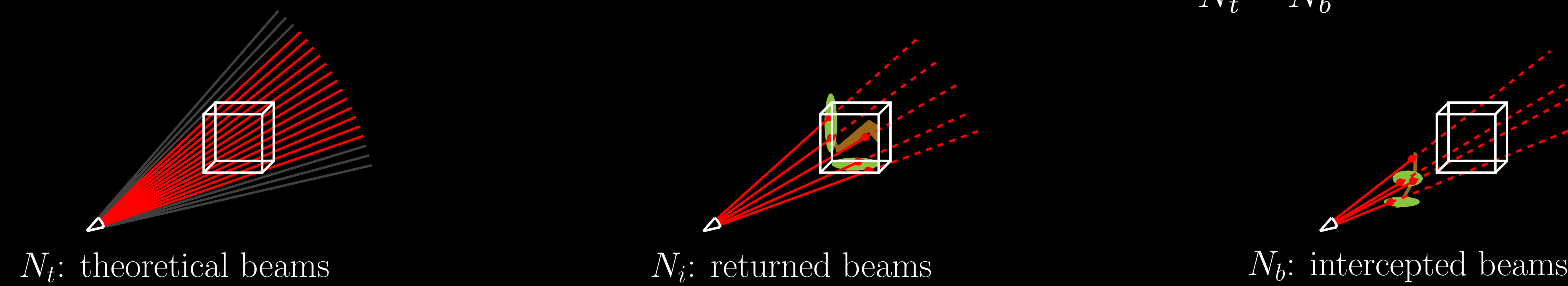


Figure 2: Density index computation using raytracing [3]

ANALYTIC APPROACH

Analytic calculus of theoretical number of beams \$N_t\$ for each voxel :

$$\Omega = \sum \Omega_i \quad (1)$$

$$dS = \rho^2 \cdot \sin \phi \cdot d\phi d\theta \quad (2)$$

$$\Delta S = \int_{\theta}^{\theta+\Delta\theta} \int_{\phi}^{\phi+\Delta\phi} dS \quad (3)$$

$$\overline{\Delta S} = \frac{1}{\phi_2 - \phi_1} \frac{1}{\theta_2 - \theta_1} \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} \Delta S d\phi d\theta \quad (4)$$

$$N_t = \frac{\Omega}{\overline{\Delta S}} \quad (5)$$

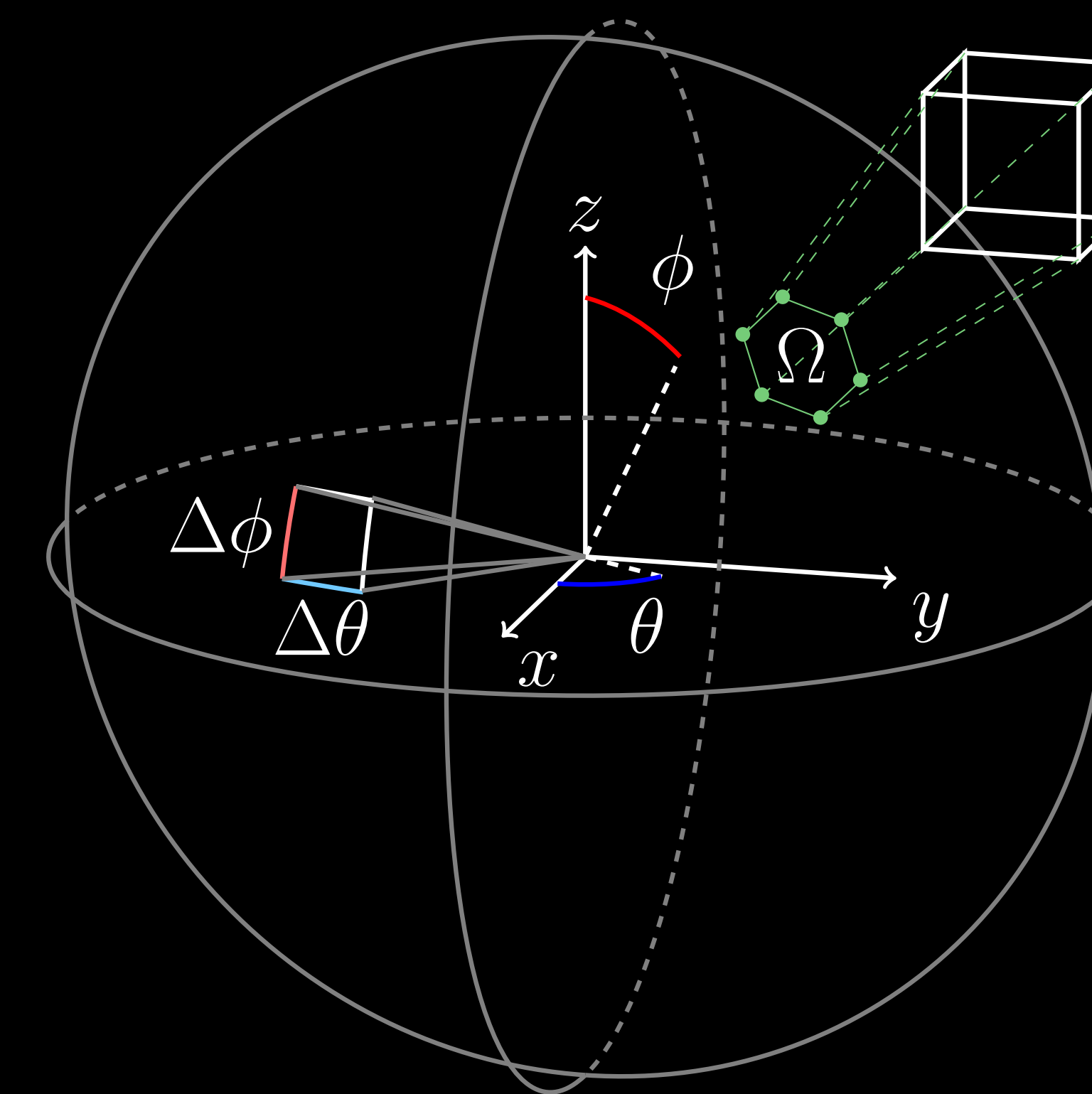


Figure 5: Spherical geometry for the analytic calculus

RESULTS

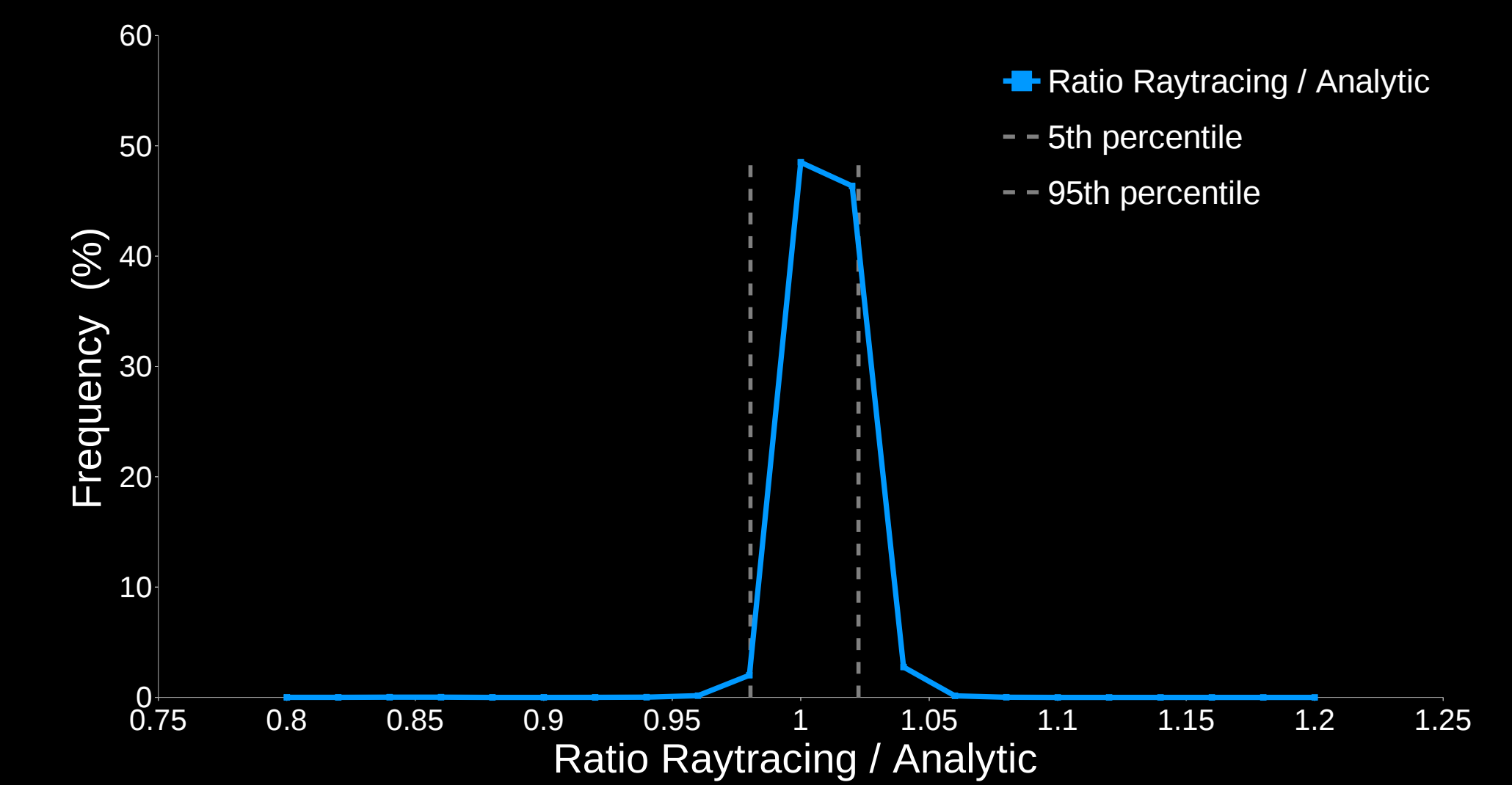


Figure 3: Comparison of density index between raytracing technique and analytical solution

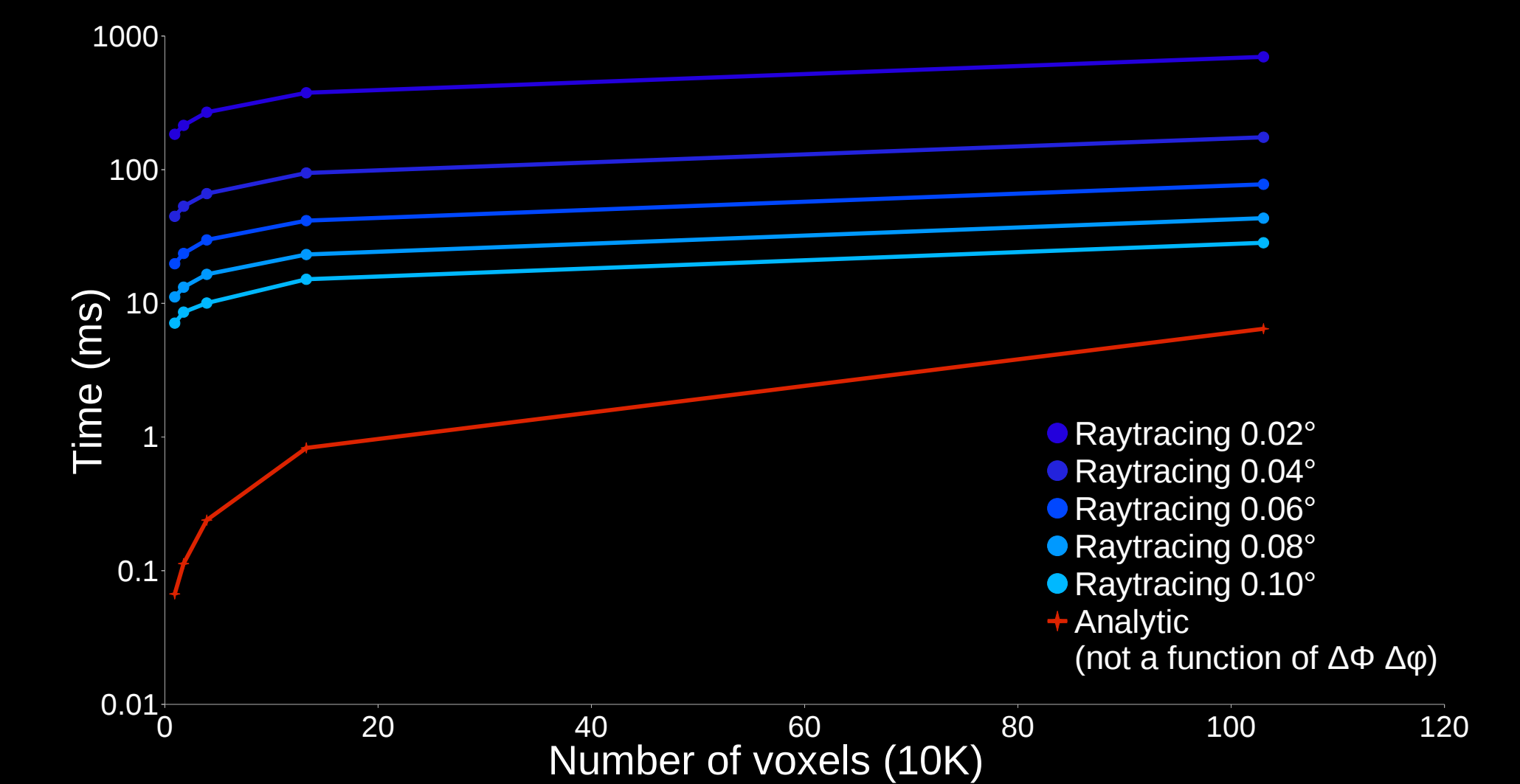


Figure 4: Computational time for both approaches

CONCLUSION

- Raytracing and analytic process give **similar results**
- The analytical calculus represents an **important gain of time**
- **Parallel processing** is easy to set up

FUTURE RESEARCH

Characterizing the limits and conditions that need to be fulfilled while using our methodology.

Provide an analytical calculus for the average distance covered by a beam inside a voxel.

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- [3] Amanatides and Woo. A fast voxel traversal algorithm for ray tracing. In *Proceedings of EUROGRAPHICS*, volume I, pages 3–10, 1987.