

# Parallel metric trees for multi-billion body simulations

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This work combines metric and parallel computing on both multi-GPU and distributed memory architectures when applied to multi-million or even billion bodies simulations.

Metric trees are data structures for indexing multidimensional sets of points in arbitrary metric spaces. First proposed by Jeffrey

K. Uhlmann [1], as a structure to efficiently solve neighbourhood queries, they have been considered, for example, by Sergey Brin

for indexing very large databases.

We propose a parallel algorithm for the construction of metric trees that preserves the theoretical work bound of order  $n \log(n)$ , for indexing a set of  $n$  points.

We discuss possible applications of the parallel algorithms obtained in the context of probabilistic Hough Transform applications

for line detection and multi billion body simulations.

N-body simulations are of particular interest for beam dynamics simulations in the context of particle accelerator design.

We use a parallel metric tree and a variation of a parallel Fast Multipole Method and evaluate its efficiency in a multi-billion points simulation on three different architectures: a multi-GPU cluster; a 256 core Infiniband, distributed memory cluster; and a multi-core architecture. Of particular interest is the evaluation of effects of locality on

communication and performance overall.

[1] Uhlmann, Jeffrey (1991). "Satisfying General Proximity/Similarity Queries with Metric Trees". *Information Processing Letters* **40** pp175-179 doi:10.1016/0020-0190(91)90074-r.

[2] Brin, Sergey (1995). "Near Neighbor Search in Large Metric Spaces".

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## Tertiary Keyword (Optional)

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**Author:** CARDOSO LOPES, Raul (Brunel University (GB))

**Co-author:** HOBSON, Peter (Brunel University (GB))

**Presenter:** HOBSON, Peter (Brunel University (GB))

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