Unsigned distance function

# Git repos

<https://github.com/paragpathak2006/unsigned_distance_function>

<https://github.com/paragpathak2006/CudaRuntime1>

# Mesh

Define a Mesh that has vertex Points and Triangular faces as

# Bounding box

If point is outside a bounding at distance, them point is automatically a Beta distance.

# Convex hull method

If point is outside a bounding at distance, them point is automatically outside a Beta distance.

# Pointwise distance

Q is query point. is maximum truncated distance.

# Facewise distance

Q is query point. is maximum truncated distance.

Ref: [Distance Between Point and Triangle in 3D (geometrictools.com)](https://www.geometrictools.com/Documentation/DistancePoint3Triangle3.pdf)

(<https://www.geometrictools.com/Documentation/DistancePoint3Triangle3.pdf>)

Let Face Triangle be defined as

Face Triangle to Point distance can be found using the formula

# Brute force approach

Go over all the points and faces to find the minimum possible distance between target point and mesh points.

# Spatial indexing approach

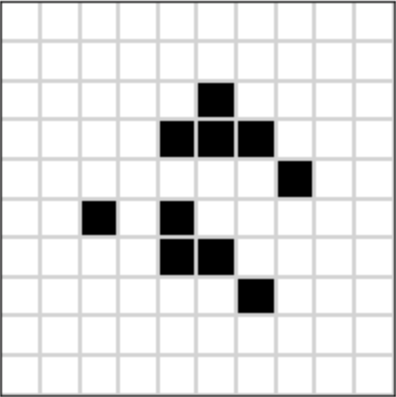


Figure 1 Space map showing spatial indexing of points

Recommended approach of indexing is using octree, but in our case were going to implement a simple space map to spatially Index the mesh points. After indexing, find all the points and faces in a sphere to minimize list of candidate Points to search.

Spatial indexing using CUDA, requires us to implement unordered map using CUDA. A vectorized unordered map is implemented using an additional vector container for storing indexes. The program is supposed to handle each spatial index on an individual CUDA thread. However, the process of indexing is still serial, as we have assumed this will not be repeated and is not time-constrained.

CUDA streams can be used to further enhance the concurrency of the data transfer process.

# Parallel Hashmap

A parallelized version of Hashing was also implemented.

# Thrust library function

typedef thrust::host\_vector<double> Hvec;

typedef thrust::host\_vector<Point> HPoint;

typedef thrust::device\_vector<double> Dvec;

typedef thrust::device\_vector<Point> DPoint;

double min\_dist\_calculation2(

const HPoint& Hpoints,

const Point& target,

const double& beta2

){

DPoint points = Hpoints;

Dvec distances(Hpoints.size());

// apply the transformation

thrust::transform(\_ITER\_(points), distances.begin(), dist2\_point(target));

return thrust::reduce(\_ITER\_(distances), beta2, min\_dist());

}

Where,

# OUTPUT

- find materials in: /content/3DObjects/./cube.obj.mtl

Num of points : 3456

Num of faces : 1152

Bounding Box : Min(-1.000000,-1.000000,-1.000000) , Max(1.000000,1.000000,1.000001)

dist test :

0.72

0.04

Point\_index(-50,-50,-50)

Point\_index(50,50,50)

Target point : Point(0,1,1.2)

Target point index : Point\_index(0,50,60)

Beta : 0.3

Map size : 0.02

---------------------Pointwise(brute force)-----------------

Unsigned distance for Points (brute force) =>

Unsigned distance : 0.2

Target point : Point(0,1,1.2)

Nearest point : Point(-5e-07,1,1)

-----------------------Facewise(brute force)---------------------------

Unsigned distance for Faces (brute force) =>

Unsigned distance : 0.2

Target point : Point(0,1,1.2)

Nearest Face : Face(870,871,872)

---------------------Pointwise(local)---------------------------

Unsigned distance for Points (space map) =>

Unsigned distance : 0.2

Target point : Point(0,1,1.2)

Nearest point : Point(-5e-07,1,1)

---------------------Pointwise(Serial)-----------------

Unsigned distance for Points (Serial) =>

DIMs :

max\_size\_index : 16 , Threads\_dim : 4 , blocks\_dim : 8 , Dim : 32

(i0, j0, k0) : ( -16 , 34 , 44 )

(i1, j1, k1) : ( 16 , 66 , 76 )

Unsigned distance : 0.2

Target point : Point(0,1,1.2)

-----------------------Facewise(Serial)---------------------------

Unsigned distance for Faces (Serial) =>

DIMs :

max\_size\_index : 16 , Threads\_dim : 4 , blocks\_dim : 8 , Dim : 32

(i0, j0, k0) : ( -16 , 34 , 44 )

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Unsigned distance : 0.2

Target point : Point(0,1,1.2)

Nearest Face : Face(870,871,872)

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*CUDA\_TEST\_BEGINS\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

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{1,2,3,4,5} + {10,20,30,40,50} = {11,22,33,44,55}

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*CUDA\_TEST\_SUCCESS\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

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---------------------Pointwise(cuda)---------------------------

Unsigned\_distance\_cuda\_hash\_table with Points =>

DIMs :

max\_size\_index : 16 , Threads\_dim : 4 , blocks\_dim : 8 , Dim : 32

(i0, j0, k0) : ( -16 , 34 , 44 )

(i1, j1, k1) : ( 16 , 66 , 76 )

Kernel execution time: 0 ms

Unsigned distance : 0.2

Target point : Point(0,1,1.2)

-----------------------Facewise(cuda)---------------------------

Unsigned\_distance\_cuda\_hash\_table with Faces =>

DIMs :

max\_size\_index : 16 , Threads\_dim : 4 , blocks\_dim : 8 , Dim : 32

(i0, j0, k0) : ( -16 , 34 , 44 )

(i1, j1, k1) : ( 16 , 66 , 76 )

Kernel execution time: 0 ms

Unsigned distance : 0.2

Target point : Point(0,1,1.2)