Introduction to GPU programming: GPU accelerated Convex Hull computation

Computational geometry

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Why

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MergeHu

BottomUp MergeHul

Parallel MergeHu

Results

Reference

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December 2021

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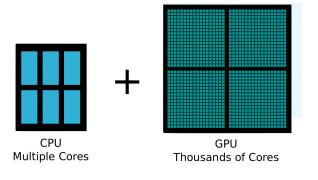
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Why



• Laverage the parallel power

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Why

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How

OpenCL MergeHull:

 https://github.com/pfagurel/OpenCL-ConvexHull/ blob/main/GPUHull.pdf

CUDA QuickHull:

 https://timiskhakov.github.io/posts/ computing-the-convex-hull-on-gpu

OpenCL QuickHull code:

 https://github.com/pfagurel/OpenCL-ConvexHull/ tree/VsProject

Interface code:

 https://github.com/pfagurel/OpenCL-ConvexHull/ tree/Interface VVh

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What

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Convex Hull

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MergeHull Algorithm

Algorithm CH

```
Input. A set S = \{a_1, \ldots, a_n\}, where a_i \in E^d and x_1(a_i) < x_1(a_i) \Leftrightarrow i < j \text{ for } i, j = 1, \ldots, n.
Output. The convex hull CH(S) of S.

Step 1. Subdivide S into S_1 = \{a_1, \ldots, a_{\lfloor \frac{1}{2}n \rfloor}\} and S_2 = \{a_{\lfloor \frac{1}{2}n \rfloor}, \ldots, a_n\}.

Step 2. Apply recursively Algorithm CH to S_1 and S_2 to obtain CH(S_1) and CH(S_2).

Step 3. Apply a merge algorithm to CH(S_1) and CH(S_2) to obtain CH(S) and halt.
```

- First presented in Preparata's and Hong's paper Convex Hull of a Finite Set of Points in Two and Three Dimensions
- Divide and Conquer technique

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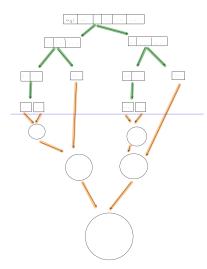
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General View



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```
bool done = 0;
while (!done)
{
    done = 1;
    if(m>1)
    while (side(W[ix2], V[ix1], V[(ix1 + 1) % m])>= 0)
        ix1 = (ix1 + 1) % m;
    if(n>1)
    while (side(V[ix1], W[ix2], W[(n + ix2 - 1) % n])<= 0)
    {
        ix2 = (n + ix2 - 1) % n;
        done = 0;
    }
}</pre>
```

- Finding of upper tangent points
- Similar for lower

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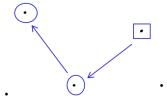
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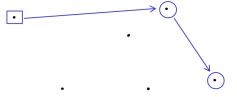
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Parallel MergeHull Problems

We want to decrease the number of merge operations. **Original MergeHull problems**:

- riginai iviergenuii problems
- The smallest subset size is not fixed.
 It can only be bound.
- Two arbitrary sets can not be merged.
 They have to be convex hulls.

Why

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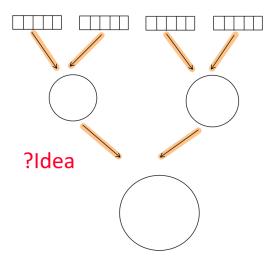
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Algorithm

```
for (int sz = d_size; sz < size; sz = sz + sz)
        for (int lo = 0; lo < size - sz; lo += sz + sz)
```

No merge yet.

Convex Hull

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Algorithm

OK.

First compute convex hulls. (e.g Jarvi's March)

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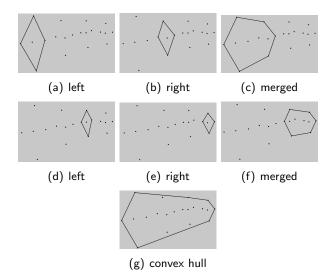
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Example



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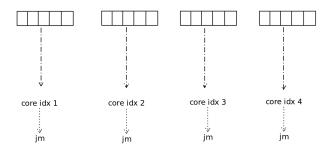
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Parallel MergeHull **GPUA**

```
jm_gpua();
for (int sz = d_size; sz < size; sz = sz + sz)
        for (int lo = 0; lo < size - sz; lo += sz + sz)
                         merge ( . . . );
```

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Results Preliminary

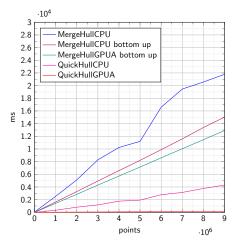


Figure: Execution on I7 4790k GTX980

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Parameter change

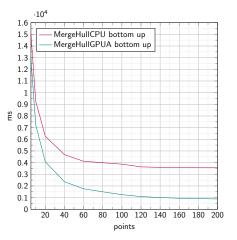


Figure: dsize change over 9 million points

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MergeHull vs QuickHull

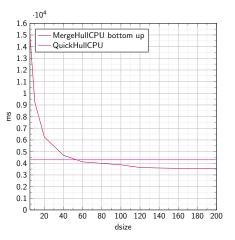


Figure: dsize threshold

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MergeHull vs QuickHull

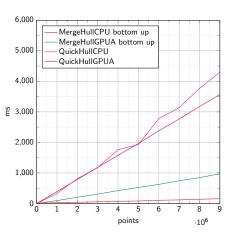


Figure: Execution on I7 4790k GTX980 with dsize=160

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References

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