Ray Tracing for Games

Dr. Jacco Bikker - IGAD/BUAS, Breda, February 3

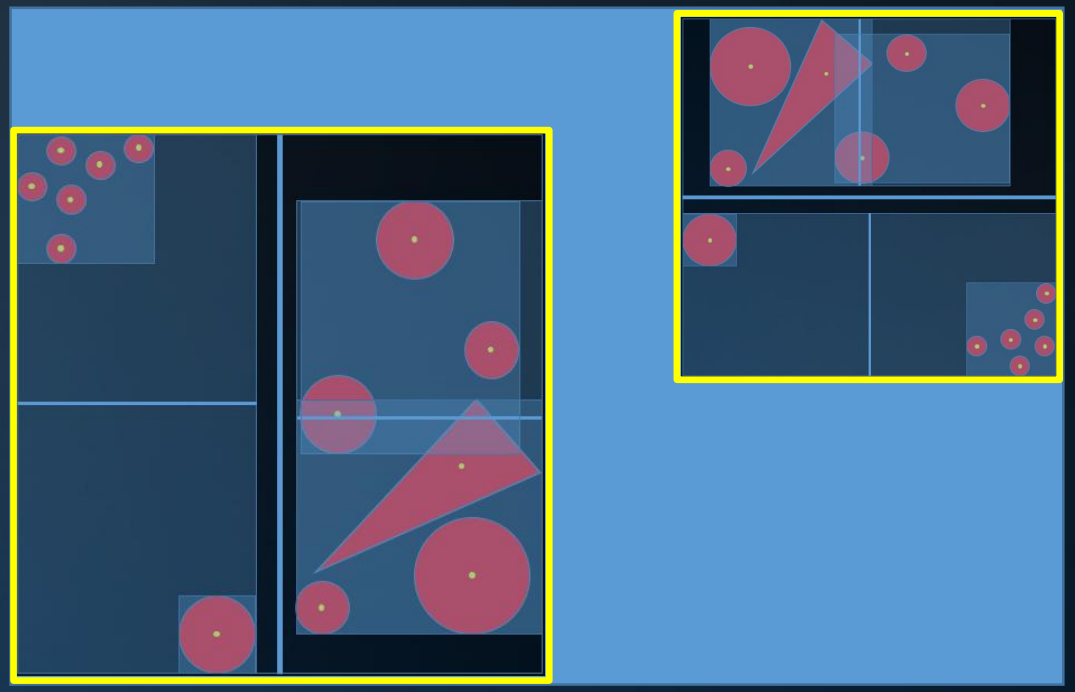
Welcome!

6

Agenda:

- Combining BVHs
- Refitting
- Rigid Motion

Combining BVHs



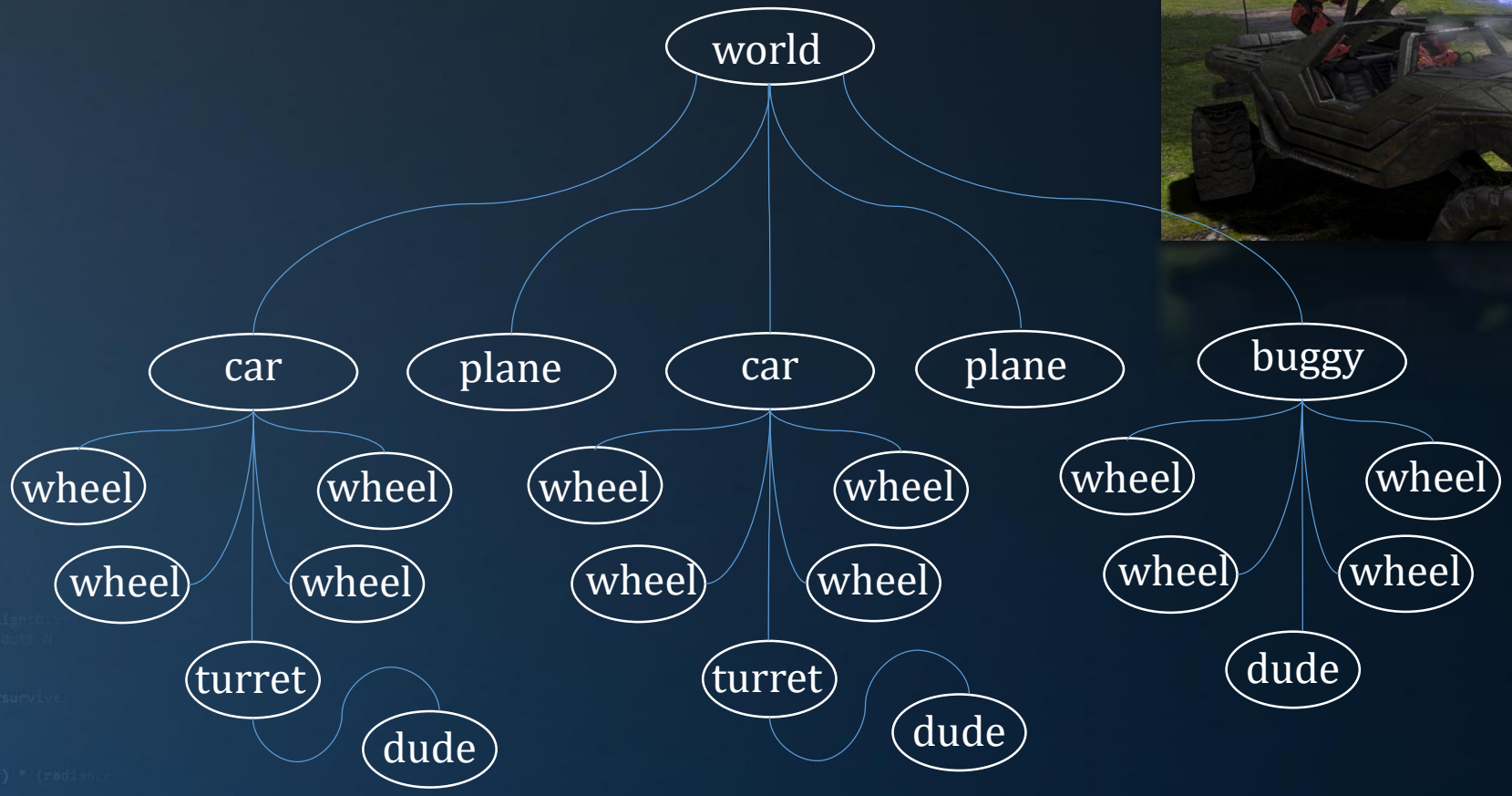
Combining BVHs

BVH #1: Car 1
BVH #2: Car 2
BVH #3: Track

Per frame:

- Rebuild BVH for each car
- Combine car 1 and car 2
- Combine track and cars
- Trace.

Scene Graph


world
car
plane
car
plane
buggy
wheel
wheel
wheel
wheel
wheel
wheel
wheel
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wheel
wheel
wheel
wheel
turret
dude
turret
dude
dude

Scene Graph

If our application uses a scene graph, we can construct a BVH for each scene graph node.

The BVH for each node is built using an appropriate construction algorithm:

- High-quality SBVH for static scenery (offline)
- Fast binned SAH BVHs for dynamic scenery

The extra nodes used to combine these BVHs into a single BVH are known as the *Top-level BVH*.

The Top-level BVH - Construction

Input: *list of axis aligned bounding boxes for transformed scene graph nodes*

Algorithm:

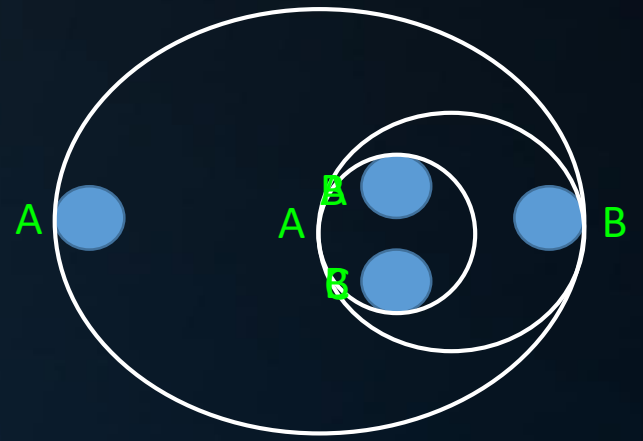
1. Find the two elements in the list for which the AABB has the smallest surface area
2. Create a parent node for these elements
3. Replace the two elements in the list by the parent node
4. Repeat until one element remains in the list.

Note: algorithmic complexity is $O(N^3)$.

The Top-level BVH – Faster Construction*

Algorithm:

```
Node A = list.GetFirst();
Node B = list.FindBestMatch( A );
while (list.size() > 1)
{
   Node C = list.FindBestMatch( B );
   if (A == C)
   {
      list.Remove( A );
      list.Remove( B );
      A = new Node( A, B );
      list.Add( A );
      B = list.FindBestMatch( A );
   }
   else A = B, B = C;
}
```



*: Fast Agglomerative Clustering for Rendering, Walter et al., 2008

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Summary of BVH Characteristics

A BVH provides significant freedom.

- No need for a 1-to-1 relation between bounding boxes and primitives
- Bounding boxes may overlap
- Bounding boxes can be altered, as long as they fit in their parent box
- A BVH can be very bad but still valid

Some consequences / opportunities:

- We can rebuild part of a BVH
- We can combine two BVHs into one
- We can *refit* a BVH

Refitting

Q: What happens to the BVH of a tree model, if we make it bend in the wind?

A: Likely, only bounds will change; the topology of the BVH will be the same (or at least similar) in each frame.

Refitting:

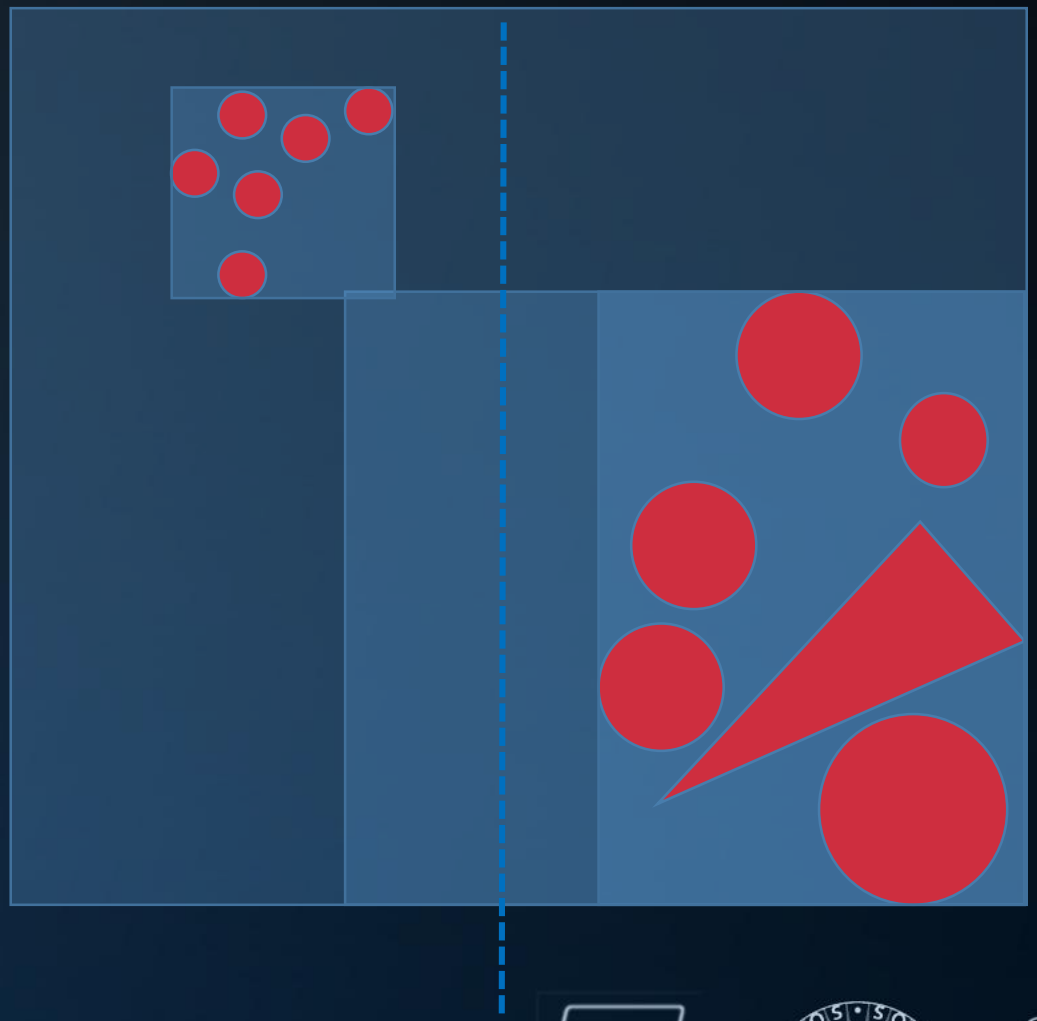
Updating the bounding boxes stored in a BVH to match changed primitive coordinates.

Refitting

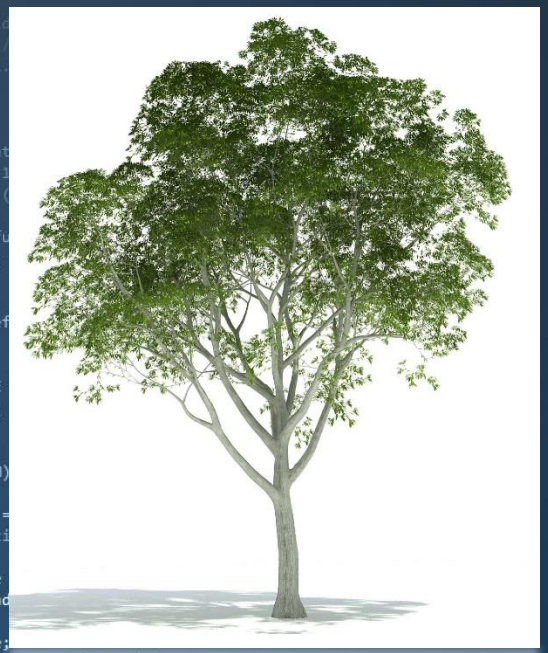
Updating the bounding boxes stored in a BVH to match changed primitive coordinates.

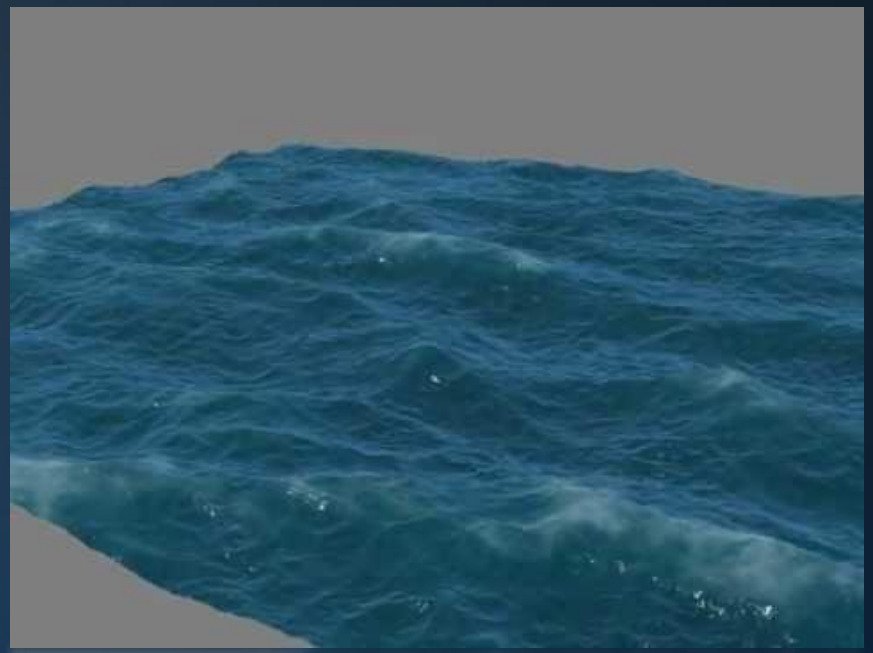
Algorithm:

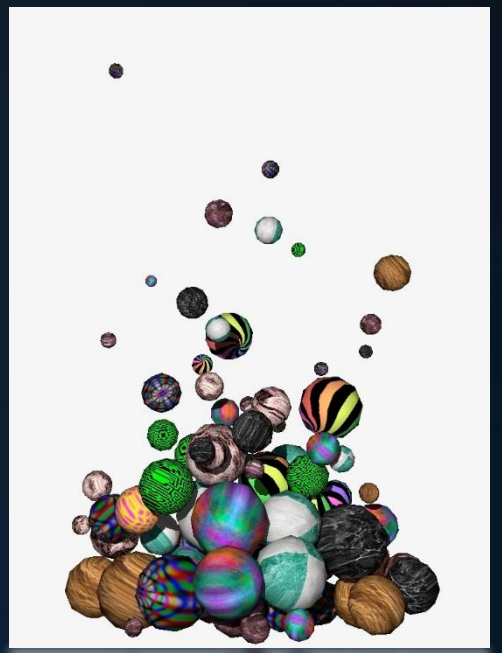
1. For each leaf, calculate the bounds over the primitives it represents
2. Update parent bounds



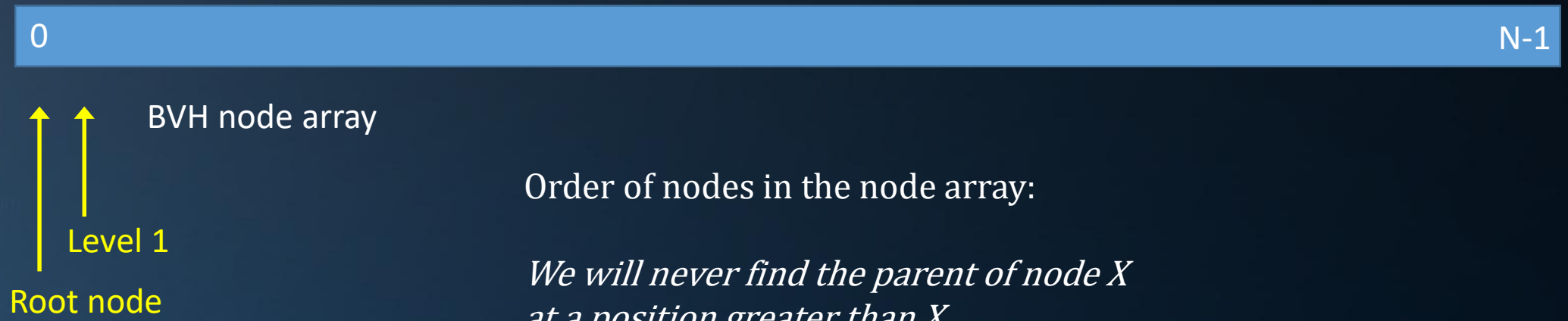
Refitting - Suitability







Refitting – Practical



Order of nodes in the node array:

We will never find the parent of node X at a position greater than X.

Therefore:

```
for( int i = N-1; i >= 0; i-- )
   nodeArray[i].AdjustBounds();
```

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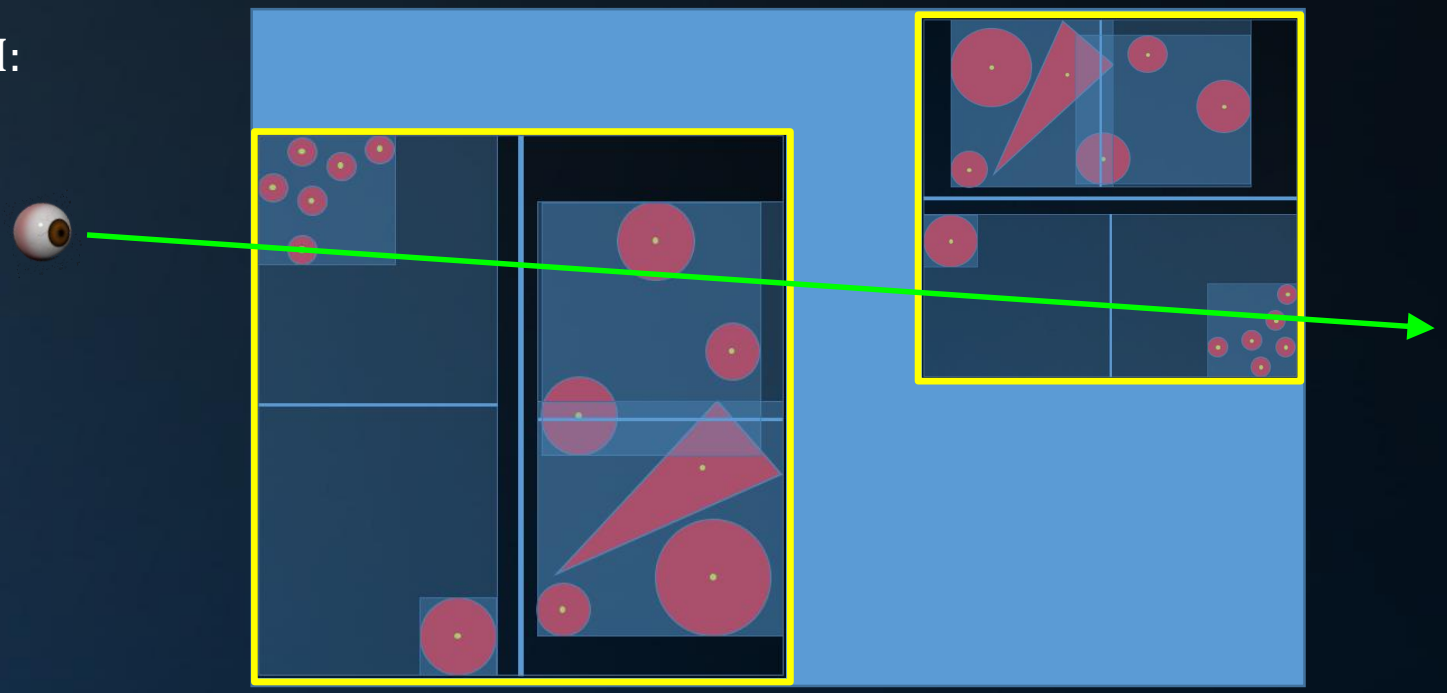
Rigid Motion

Applying rigid motion to a BVH:

1. Refit the top-level BVH
2. Refit the affected BVH



Rigid Motion

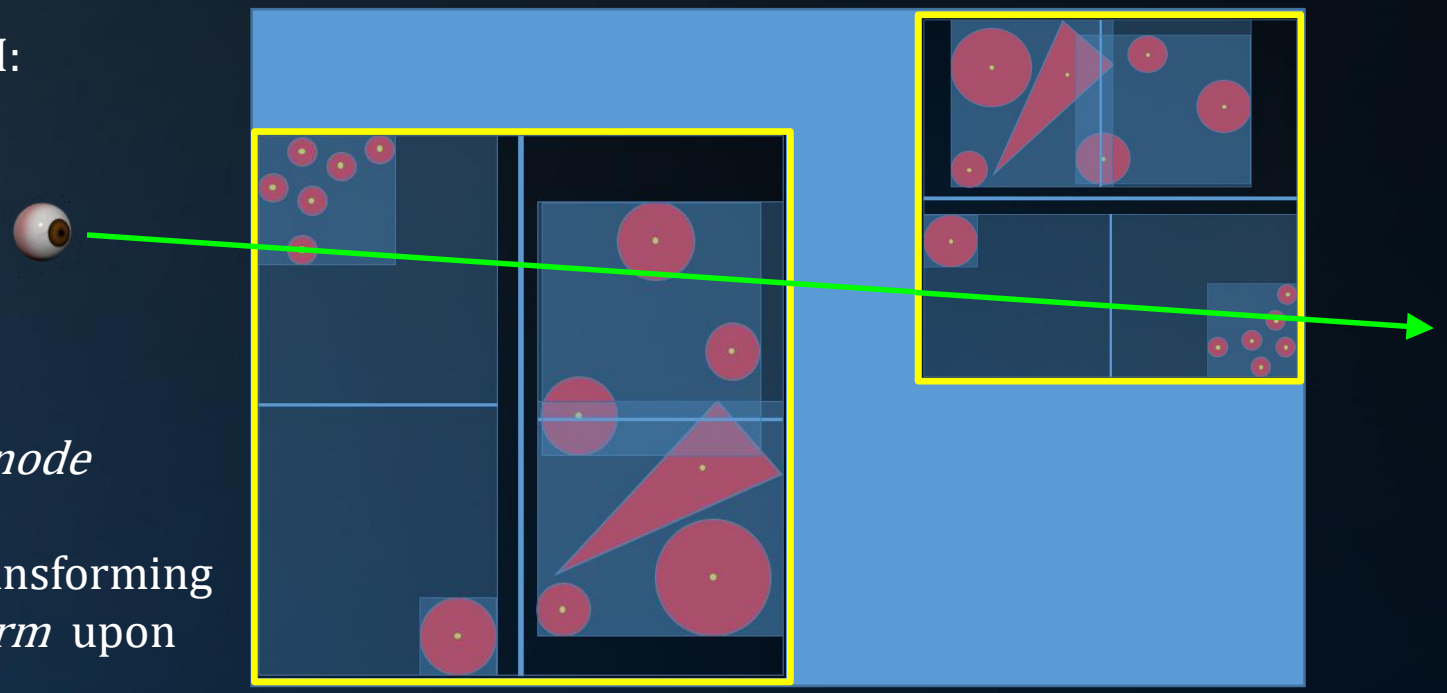
Applying rigid motion to a BVH:

1. Refit the top-level BVH
2. Refit the affected BVH

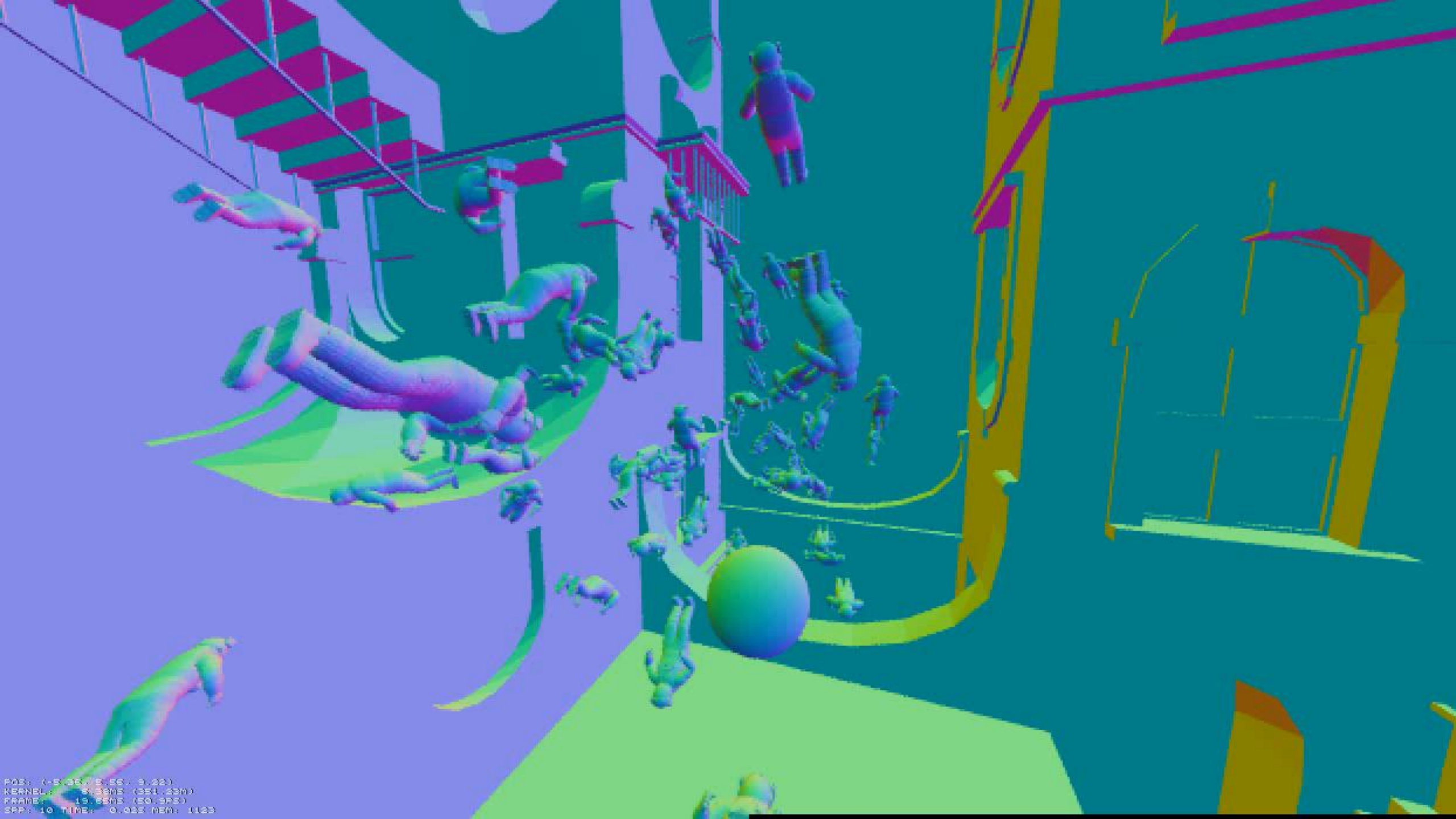
or:

2. *Transform the ray, not the node*

Rigid motion is achieved by transforming the rays by the *inverse transform* upon entering the sub-BVH.



(this obviously does not only apply to translation)


POS: (-5.36, 5.56, 9.22)
KERNEL: 8.38MS (351.23M)
FRAME: 19.68MS (50.9FS)
SPP: 10 TIME: 0.02S MEM: 1123

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End of PART 6.