

# Parallel BVH Construction for Real-Time Ray Tracing

Aaron Lemmon

University of Minnesota, Morris

April 30, 2015

## Ray Traced Scene

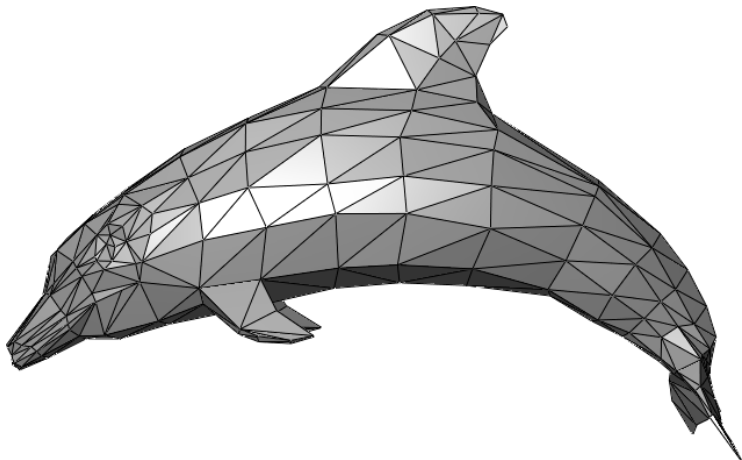


[https://en.wikipedia.org/wiki/Ray\\_tracing\\_\(graphics\)](https://en.wikipedia.org/wiki/Ray_tracing_(graphics))

# Outline

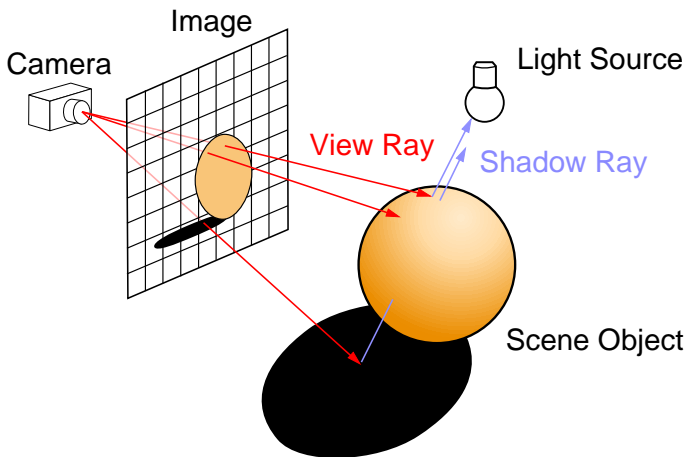
- 1 Ray Tracing Fundamentals
- 2 Grouping Primitives
- 3 Bounding Volume Hierarchy Construction
- 4 Results

# Primitives



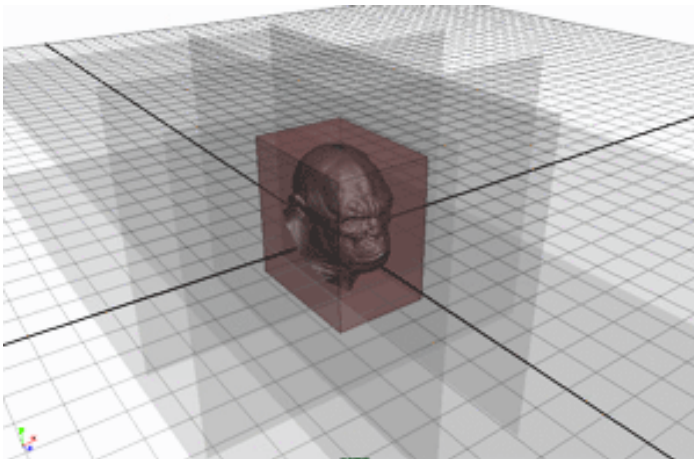
[https://en.wikipedia.org/wiki/Triangle\\_mesh](https://en.wikipedia.org/wiki/Triangle_mesh)

# Ray Tracing



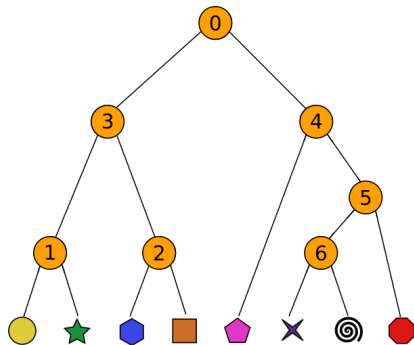
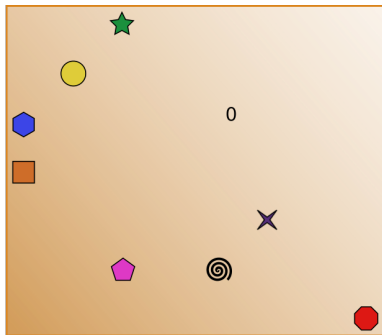
[https://en.wikipedia.org/wiki/Ray\\_tracing\\_\(graphics\)](https://en.wikipedia.org/wiki/Ray_tracing_(graphics))

## Axis-Aligned Bounding Boxes

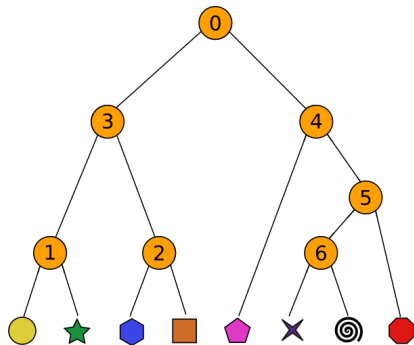
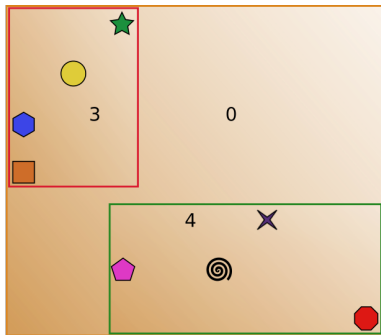


<http://www.scratchapixel.com>

# Bounding Volume Hierarchy

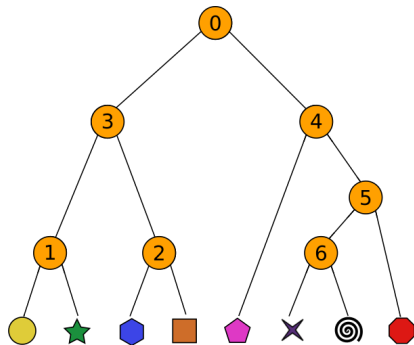
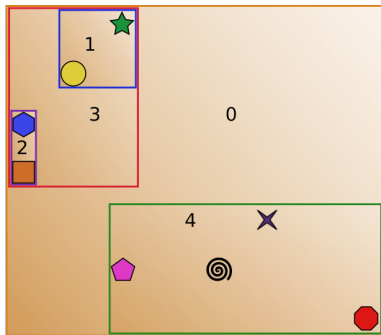


# Bounding Volume Hierarchy



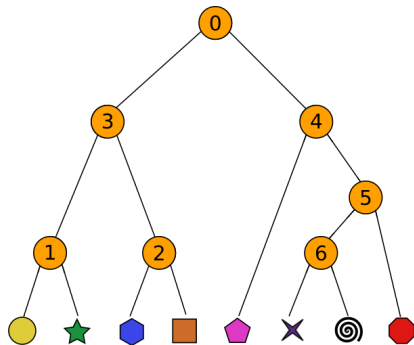
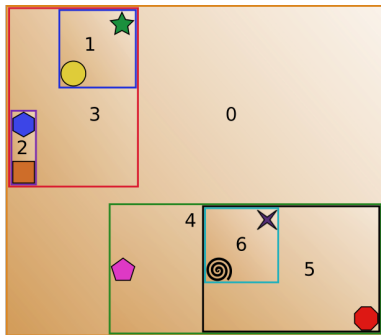


# Bounding Volume Hierarchy

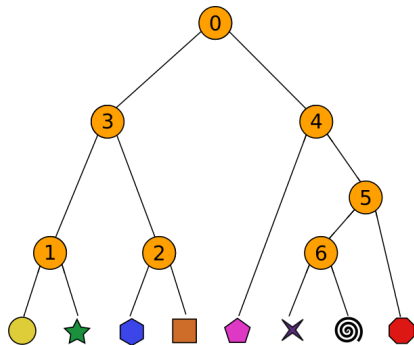
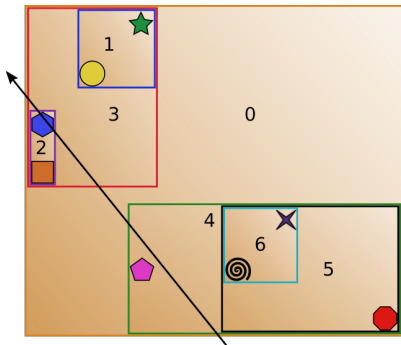




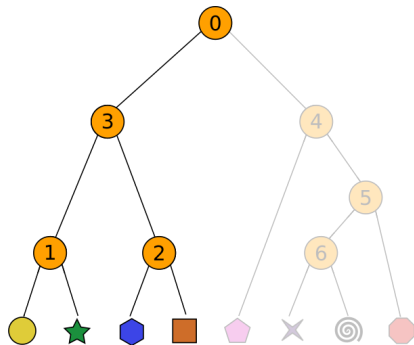
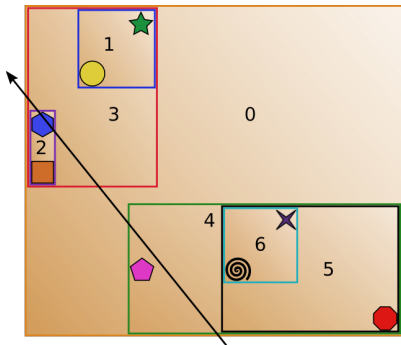
# Bounding Volume Hierarchy



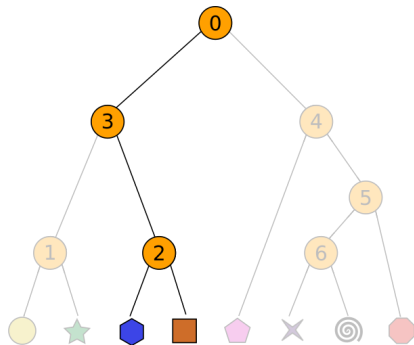
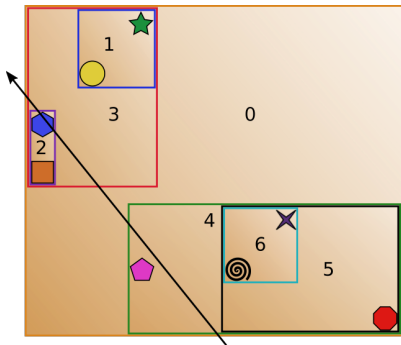
# Bounding Volume Hierarchy



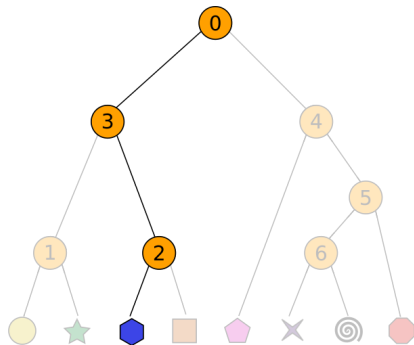
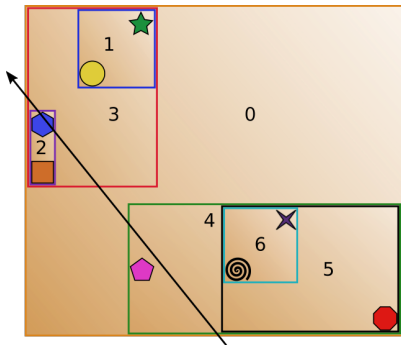
# Bounding Volume Hierarchy



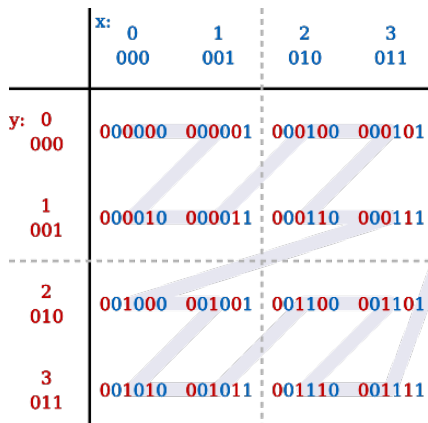
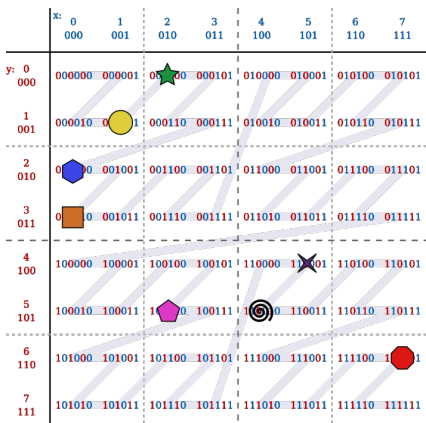
# Bounding Volume Hierarchy



# Bounding Volume Hierarchy



# Morton Codes

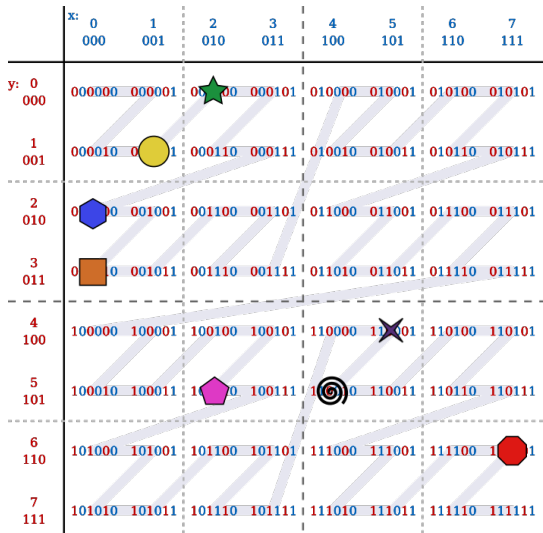




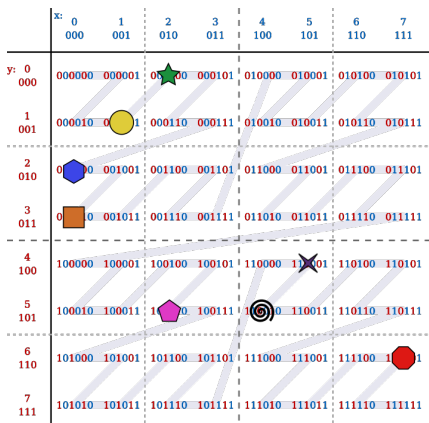
# Morton Codes

	x:	0	1	2	3	4	5	6	7
		000	001	010	011	100	101	110	111
y: 0	000	000000	000001	000100	000101	010000	010001	010100	010101
1	001	000010	000011	000110	000111	010010	010011	010110	010111
2	010	001000	001001	001100	001101	011000	011001	011100	011101
3	011	001010	001011	001110	001111	011010	011011	011110	011111
4	100	100000	100001	100100	100101	110000	110001	110100	110101
5	101	100010	100011	100110	100111	110010	110011	110110	110111
6	110	101000	101001	101100	101101	111000	111001	111100	111101
7	111	101010	101011	101110	101111	111010	111011	111110	111111

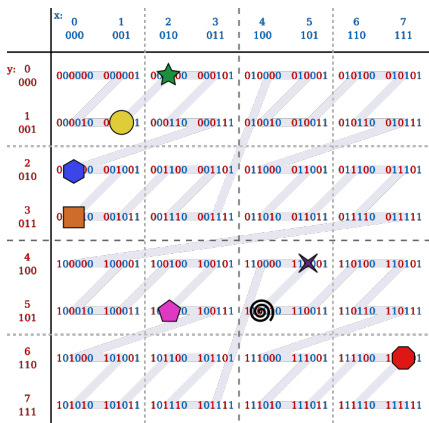
# Morton Codes



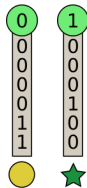
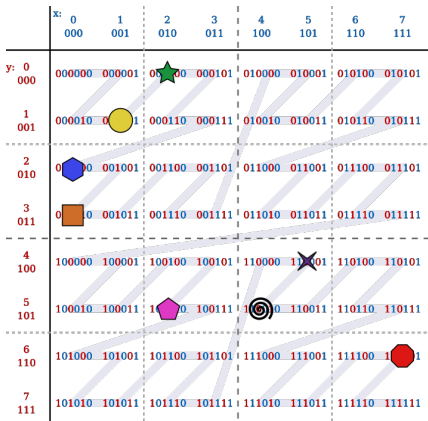
# Morton Codes



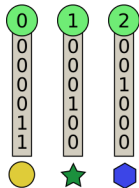
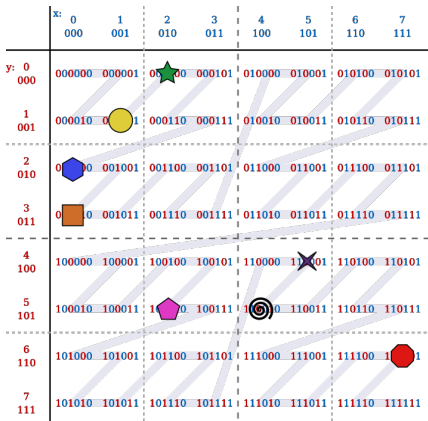
# Morton Codes



# Morton Codes

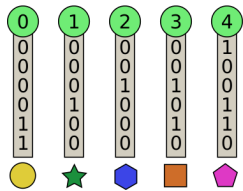
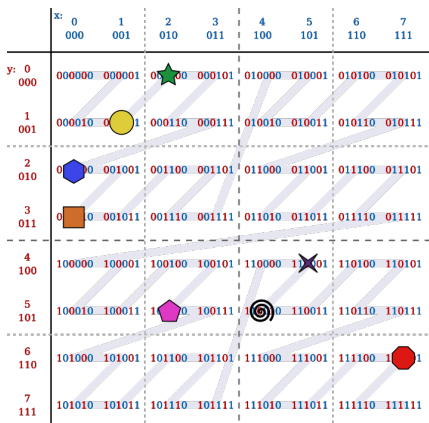


# Morton Codes



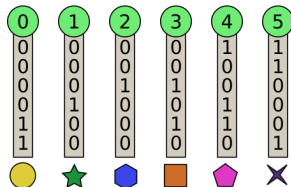
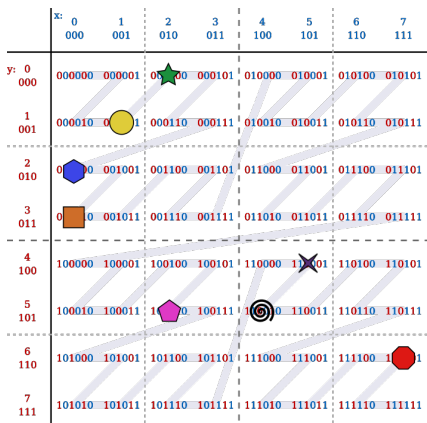


# Morton Codes

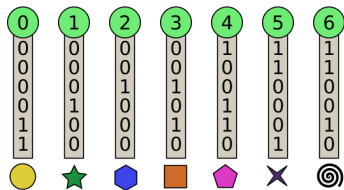
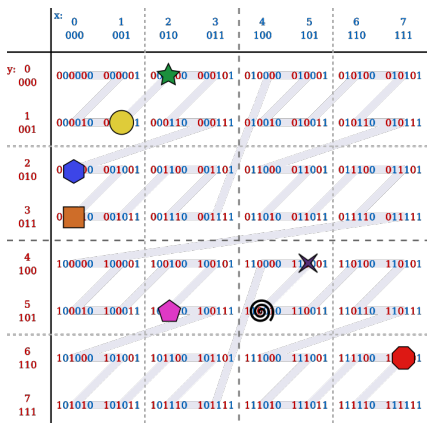




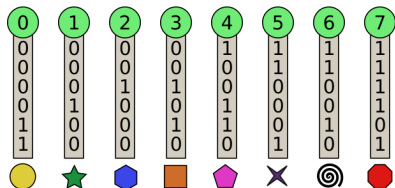
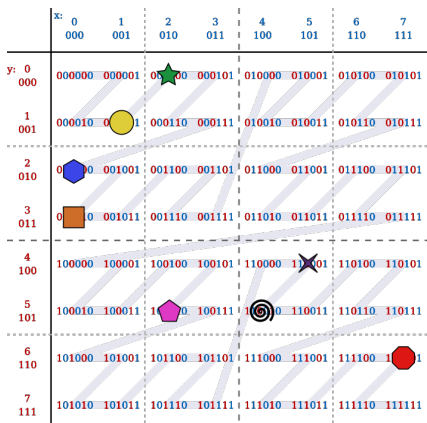
# Morton Codes



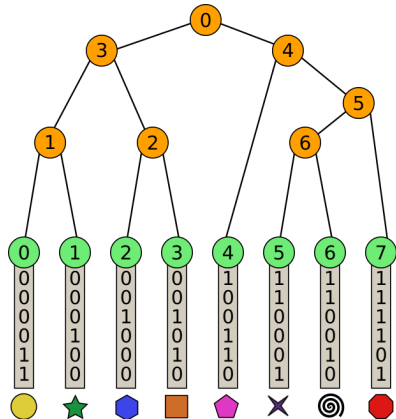
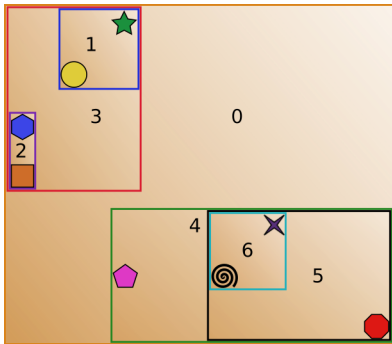
# Morton Codes



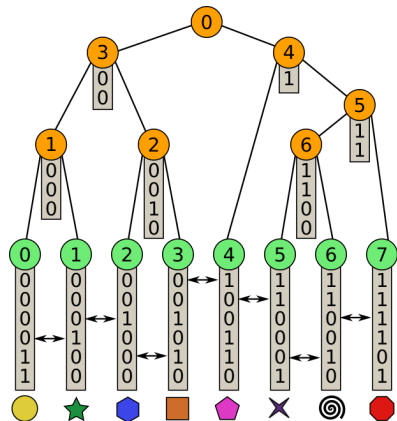
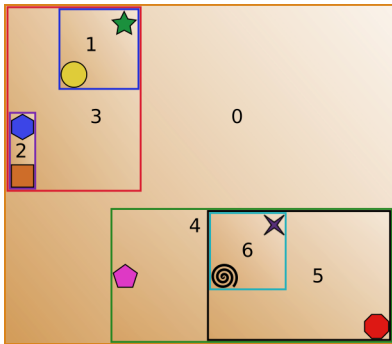
# Morton Codes



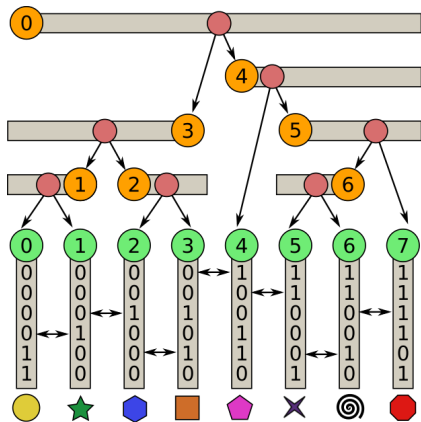
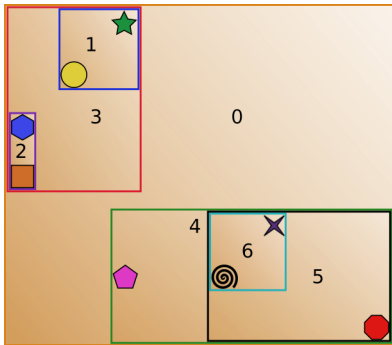
# Goal



# Binary Radix Tree

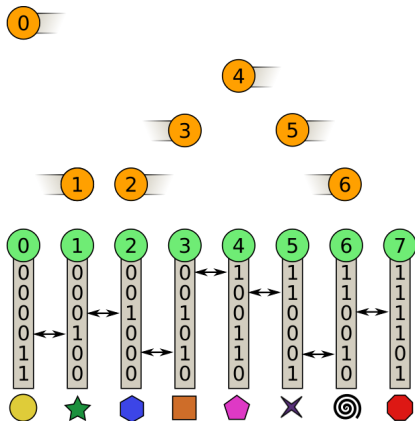
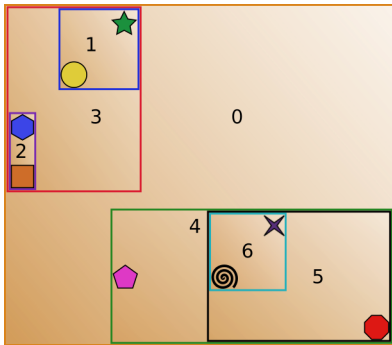


# Internal Node Array





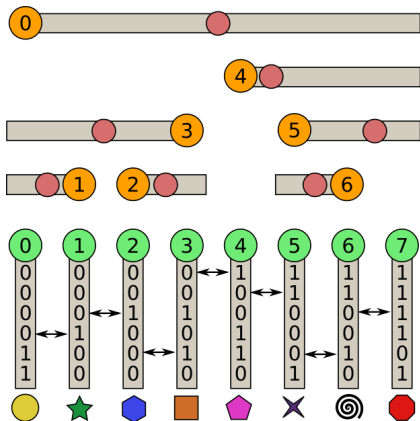
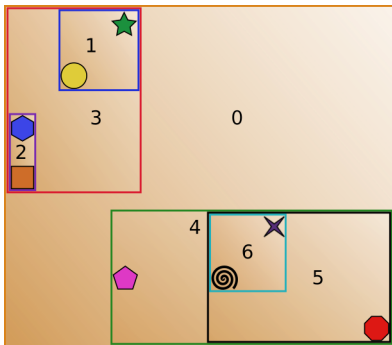
# Determine Range Direction



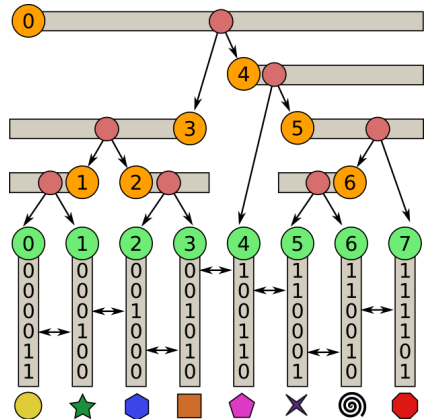
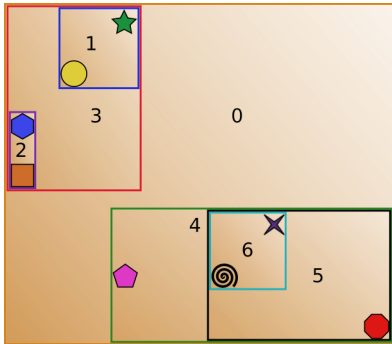




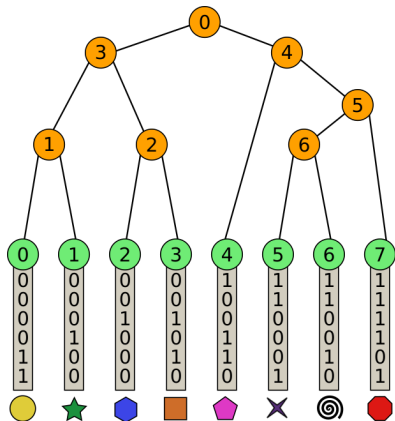
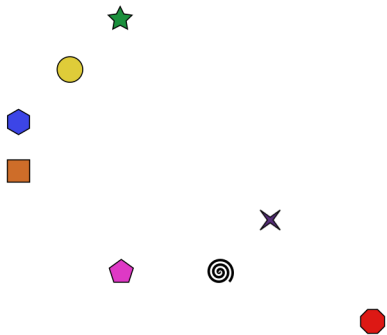
# Determine Split Location



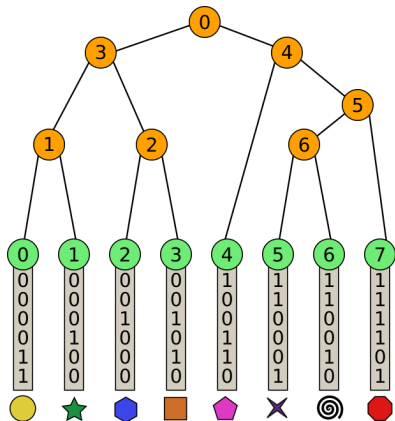
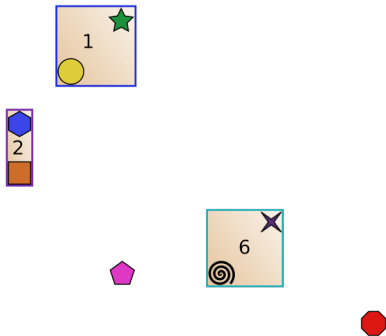
# Determine Children



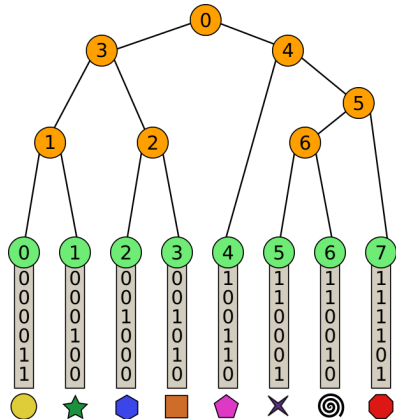
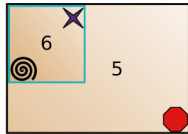
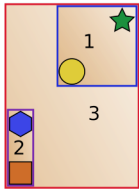
# Fitting Boxes



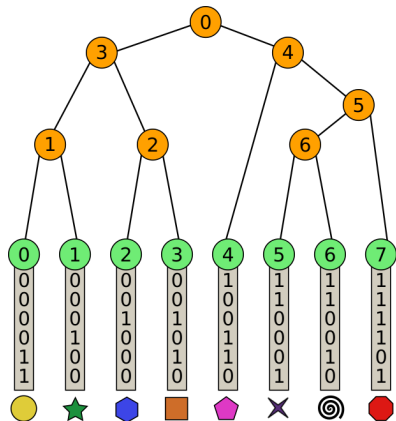
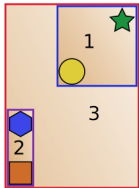
# Fitting Boxes



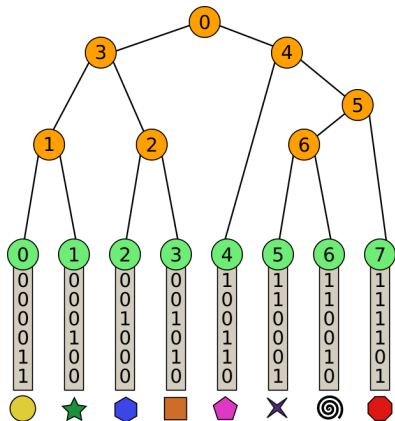
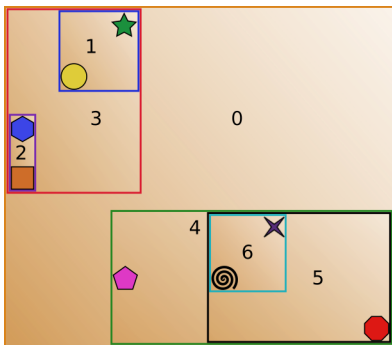
# Fitting Boxes



# Fitting Boxes

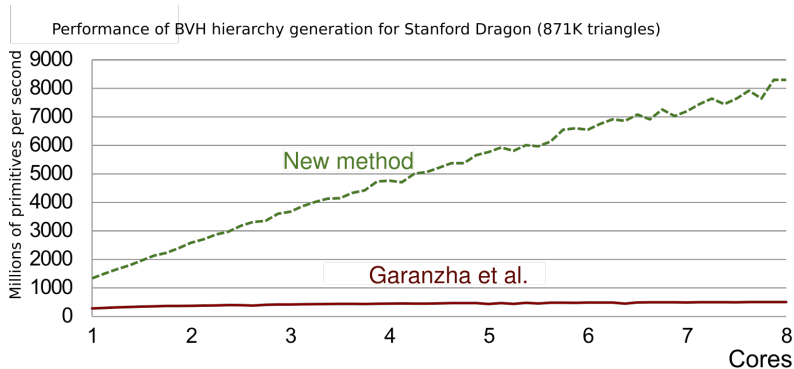


# Fitting Boxes



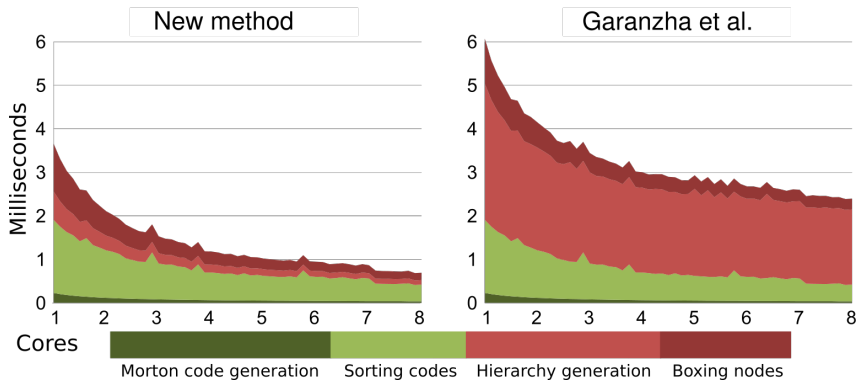


# Results



Tero Karras 2012 [3].

## Results



Tero Karras 2012 [3].

## Questions?



## Bibliography

- 1 Kirill Garanzha, Jacopo Pantaleoni, and David McAllister. 2011. Simpler and faster HLBVH with work queues. In Proceedings of the ACM SIGGRAPH Symposium on High Performance Graphics (HPG '11), Stephen N. Spencer (Ed.). ACM, New York, NY, USA, 59-64. DOI=<http://dx.doi.org.ezproxy.morris.umn.edu/10.1145/2018323.2018333>
- 2 Christiaan Gribble, Jeremy Fisher, Daniel Eby, Ed Quigley, and Gideon Ludwig. 2012. Ray tracing visualization toolkit. In Proceedings of the ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games (I3D '12), Stephen N. Spencer (Ed.). ACM, New York, NY, USA, 71-78. DOI=<http://dx.doi.org.ezproxy.morris.umn.edu/10.1145/2159616.2159628>
- 3 Tero Karras. 2012. Maximizing parallelism in the construction of BVHs, octrees, and k-d trees. In Proceedings of the Fourth ACM SIGGRAPH / Eurographics conference on High-Performance Graphics (EGGH-HPG'12), Carsten Dachsbacher, Jacob Munkberg, and Jacopo Pantaleoni (Eds.). Eurographics Association, Aire-la-Ville, Switzerland, Switzerland, 33-37. DOI=<http://dx.doi.org.ezproxy.morris.umn.edu/10.2312/EGGH/HPG12/033-037>
- 4 Timo Viitanen, Matias Koskela, Pekka Jskelinen, Heikki Kultala, and Jarmo Takala. 2015. MergeTree: a HLBVH constructor for mobile systems. In SIGGRAPH Asia 2015 Technical Briefs (SA '15). ACM, New York, NY, USA, , Article 12 , 4 pages. DOI=<http://dx.doi.org.ezproxy.morris.umn.edu/10.1145/2820903.2820916>
- 5 Ingo Wald. 2007. On fast Construction of SAH-based Bounding Volume Hierarchies. In Proceedings of the 2007 IEEE Symposium on Interactive Ray Tracing (RT '07). IEEE Computer Society, Washington, DC, USA, 33-40. DOI=<http://dx.doi.org/10.1109/RT.2007.4342588>
- 6 Turner Whitted. 1980. An improved illumination model for shaded display. Commun. ACM 23, 6 (June 1980), 343-349. DOI=<http://dx.doi.org/10.1145/358876.358882>