# Progressive Encoding and Compression of Surfaces Generated from Point Cloud Data

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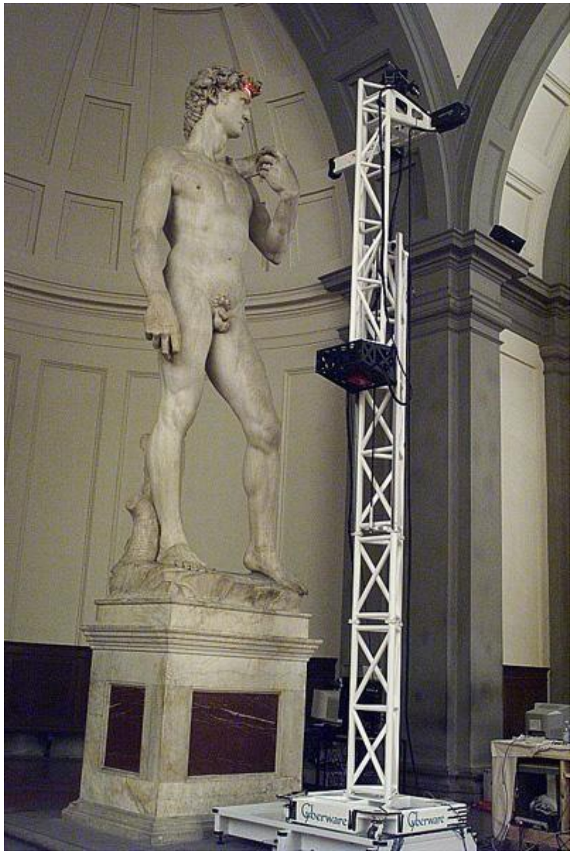
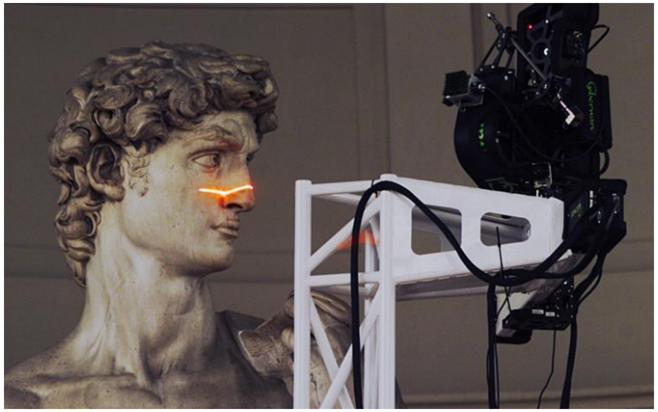
Texas A&M University

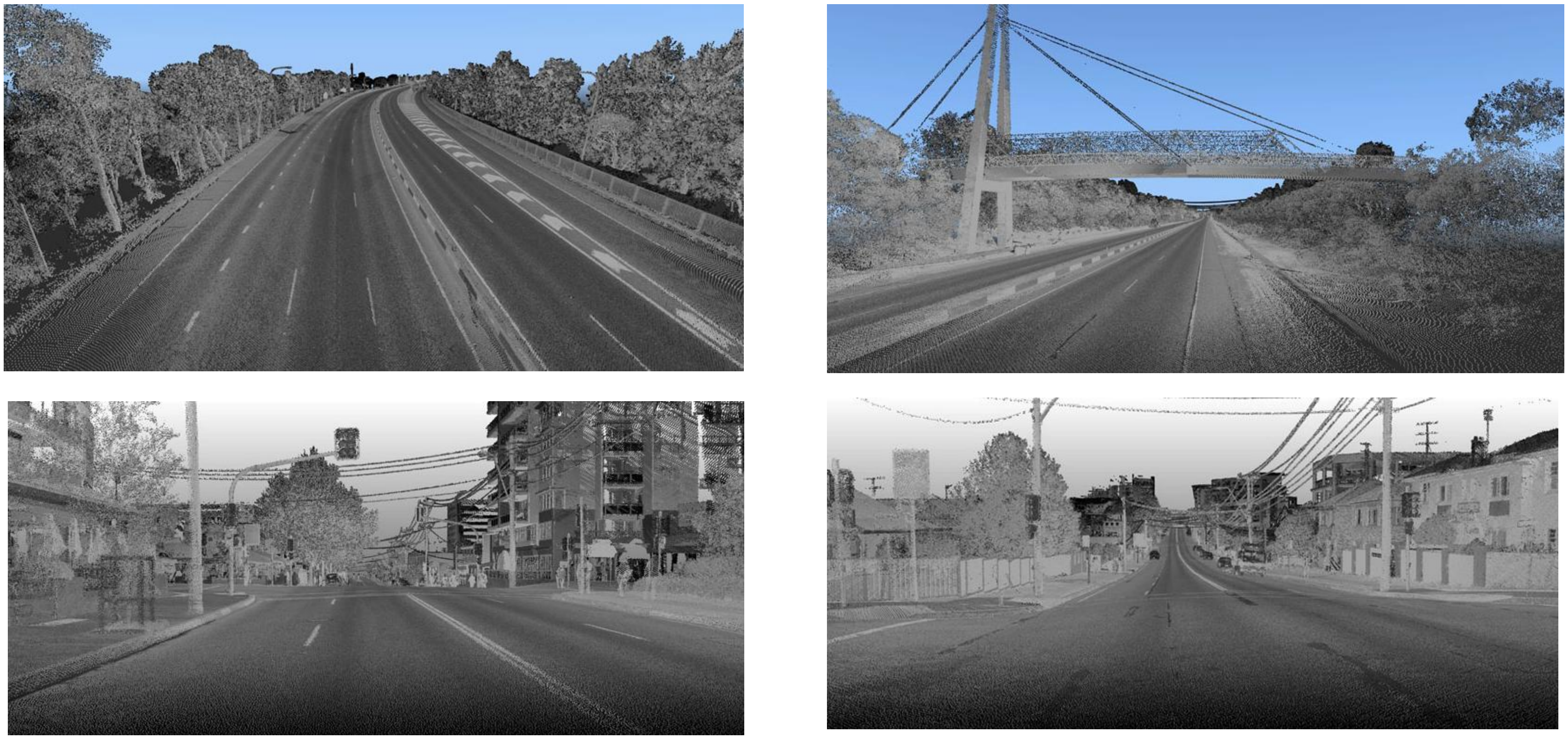
# Motivation





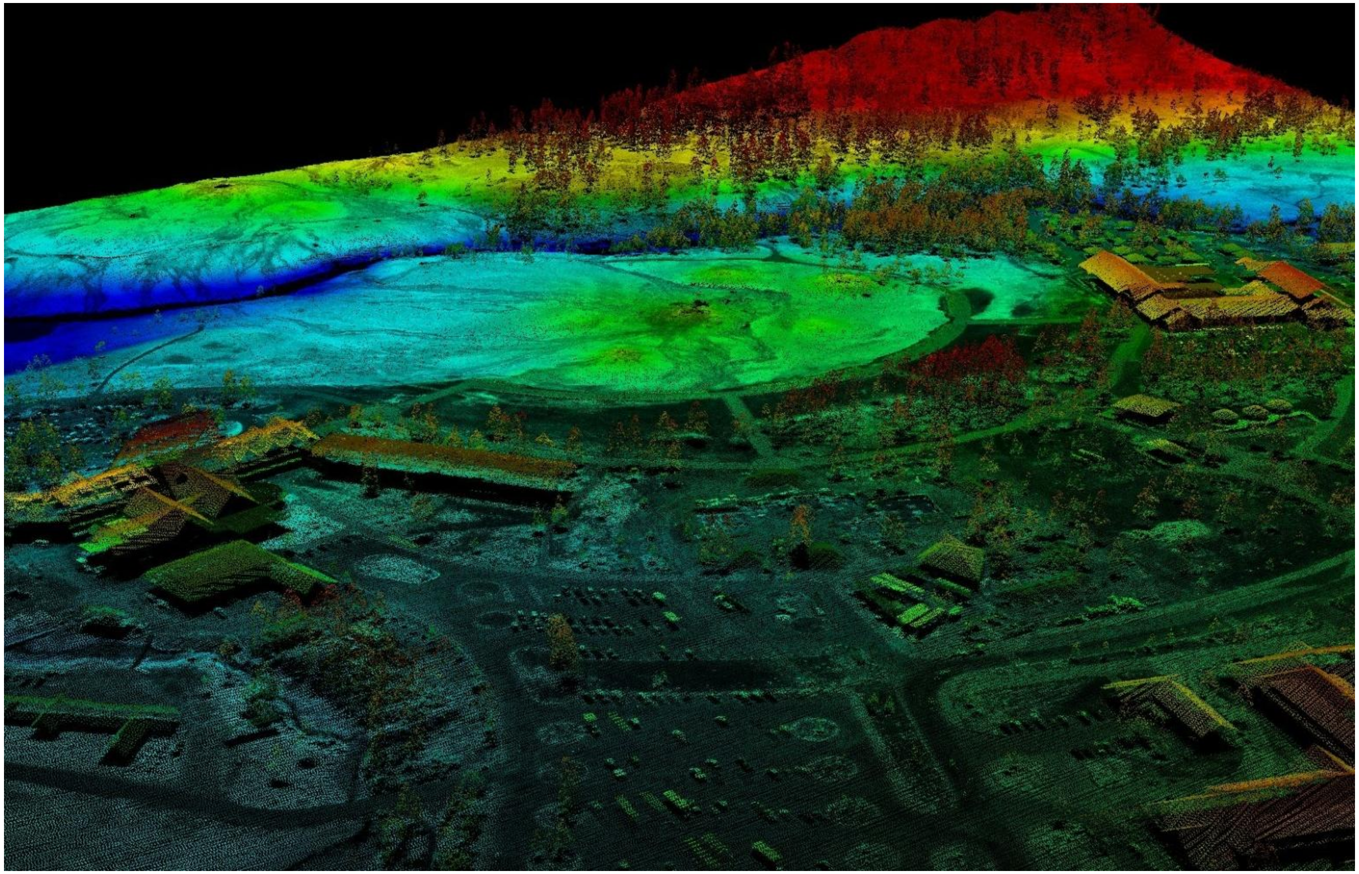
Digital Michelangelo Project

# Motivation



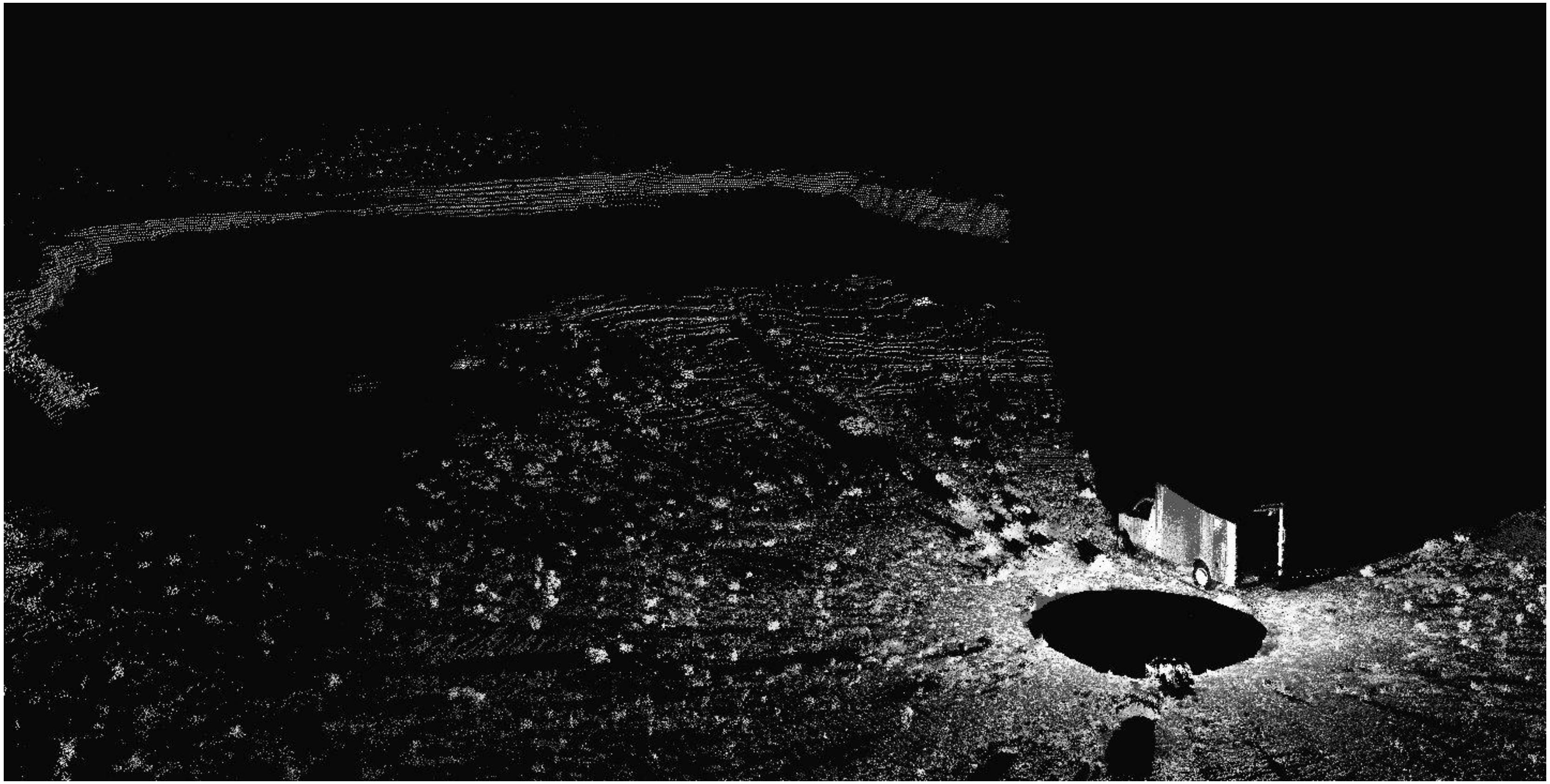
StreetMapper 360

# Motivation



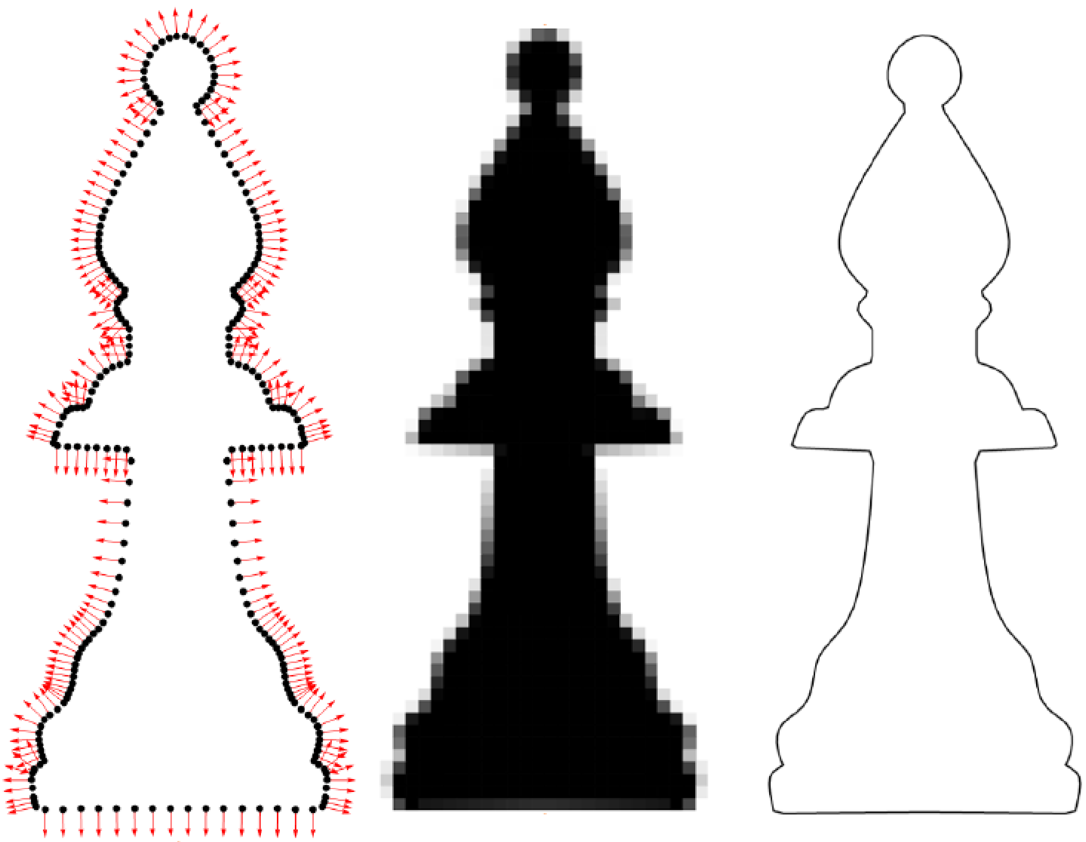
EarthScope LiDAR

# Motivation

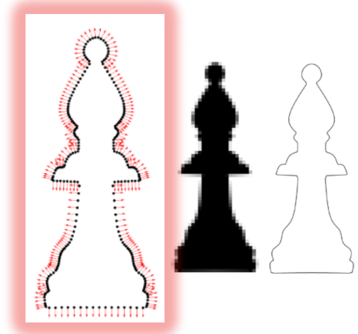


Lunarscience.nasa.gov LiDAR “ILRIS-3D”

# Surface Reconstruction

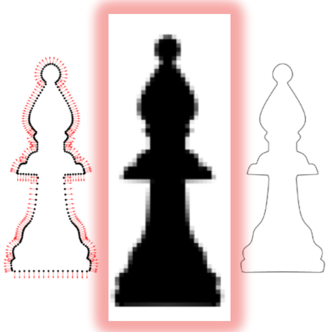


# Related Work



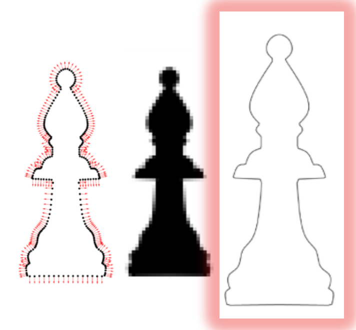
- Octree Quantification
  - [Scnabel and Klein 2006]
  - [Huang et al. 2006]
  - [Huang et al. 2008]
- Oriented Normals
  - [Deering 1995]

# Related Work



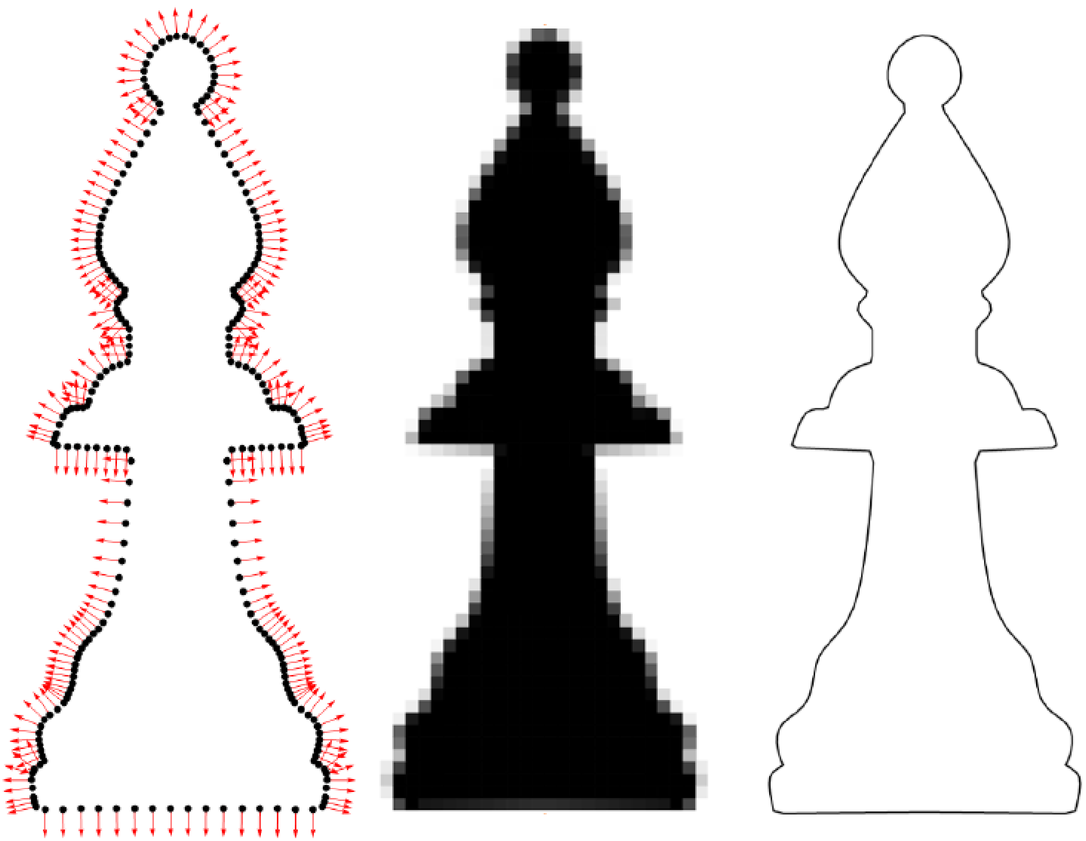
- Compression of wavelet coefficients using a zero tree encoder
  - Laney et al. [2002]
- Compression of a multiscale surflet representation
  - [Chandrasekaran et al. 2009]

# Related Work

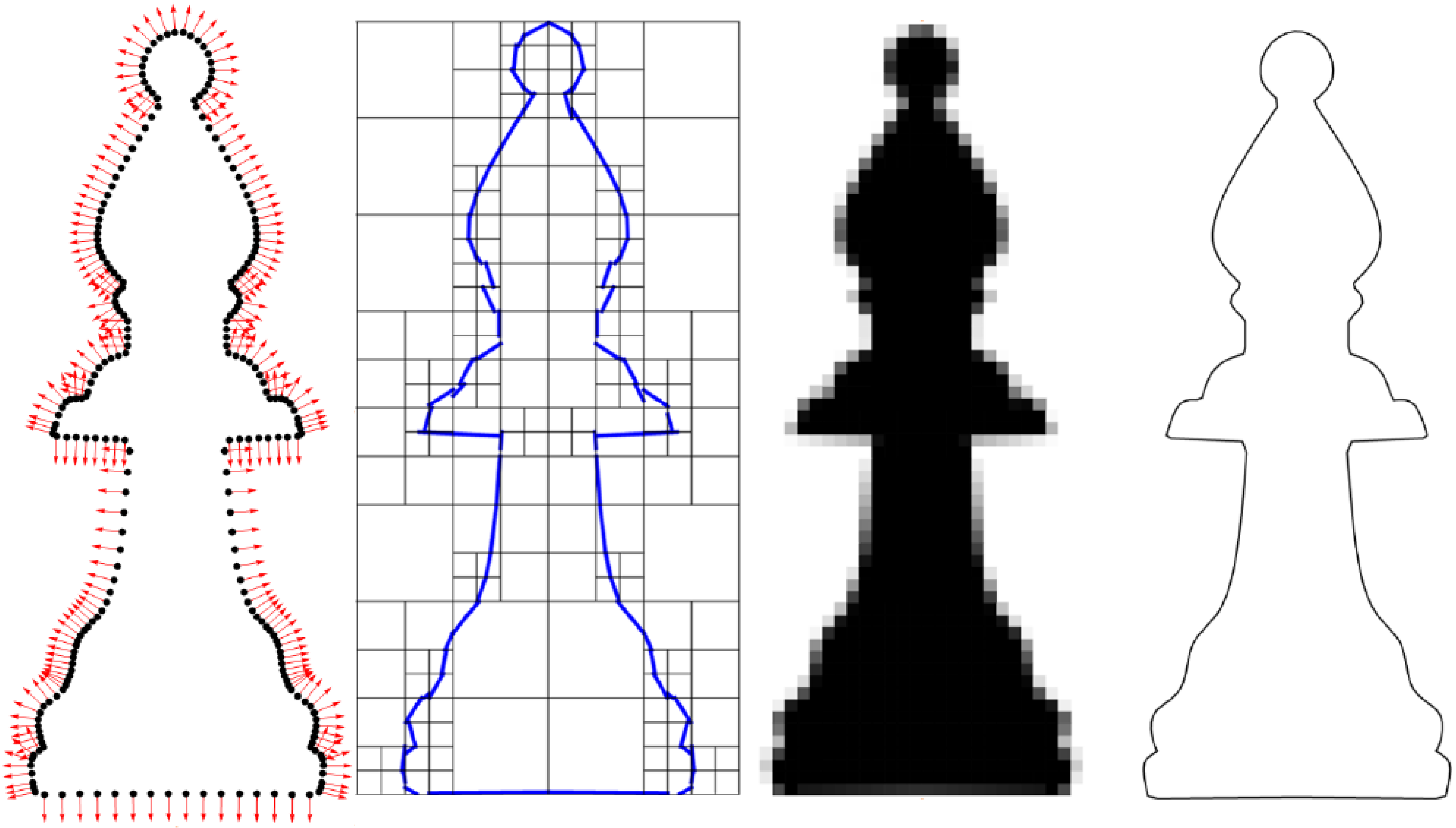


- Unstructured polygon meshes
  - Too many to mention.
- Compression of structured mesh
  - [Saupe and Kuska 2002]
  - [Lee et al. 2003]
  - [Lewiner et al. 2004]

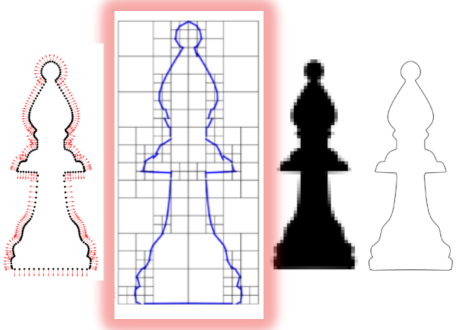
# Surface Compression



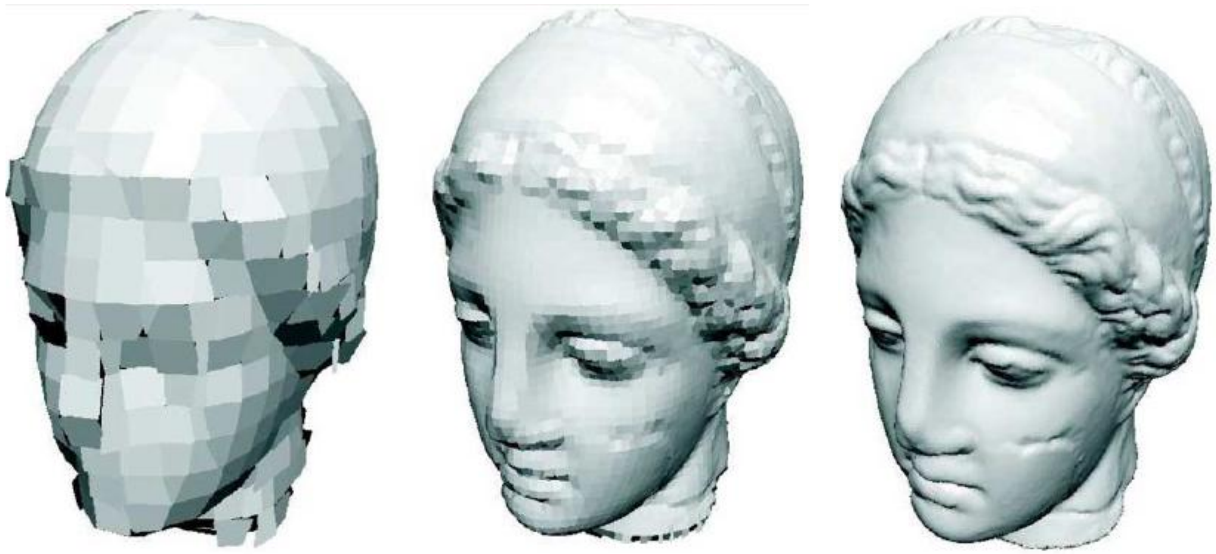
# Surface Compression



# Related Work



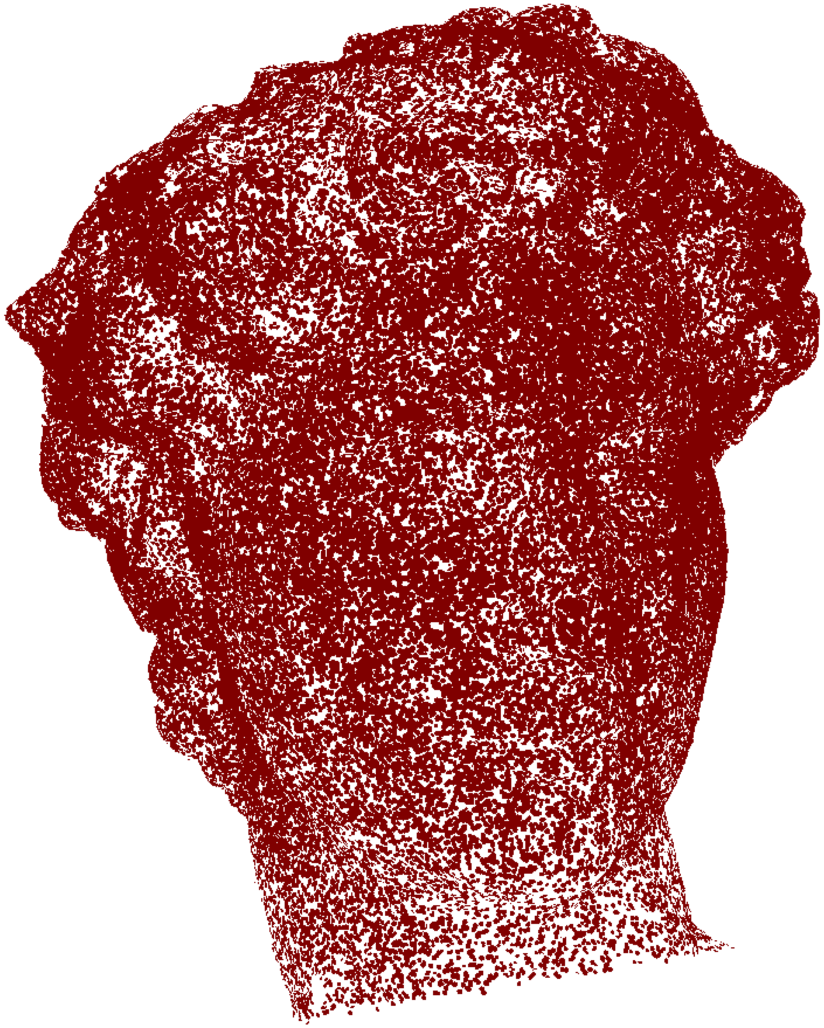
- Construct an octree estimating local regions of surface with planes for each level of the octree.
  - Encode children planes as distances from parent planes [Park and Lee 2009].



# Contributions

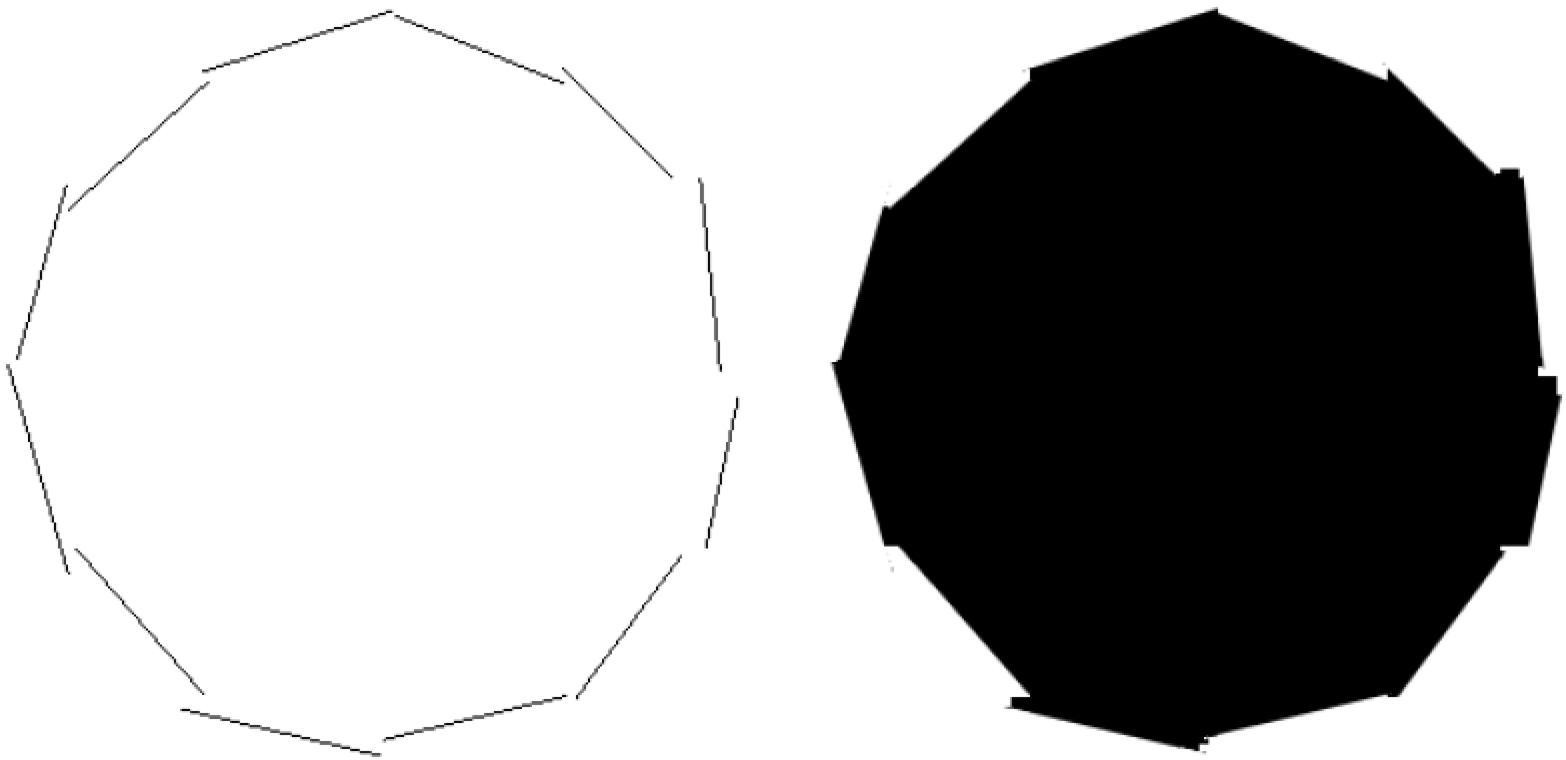
- Compression technique for planes estimating local regions of point clouds
- 2 phase compression
  - Pruning of an adaptive octree for removing redundant geometric data
  - Plane data progressively encoded as displacements

# Point Cloud



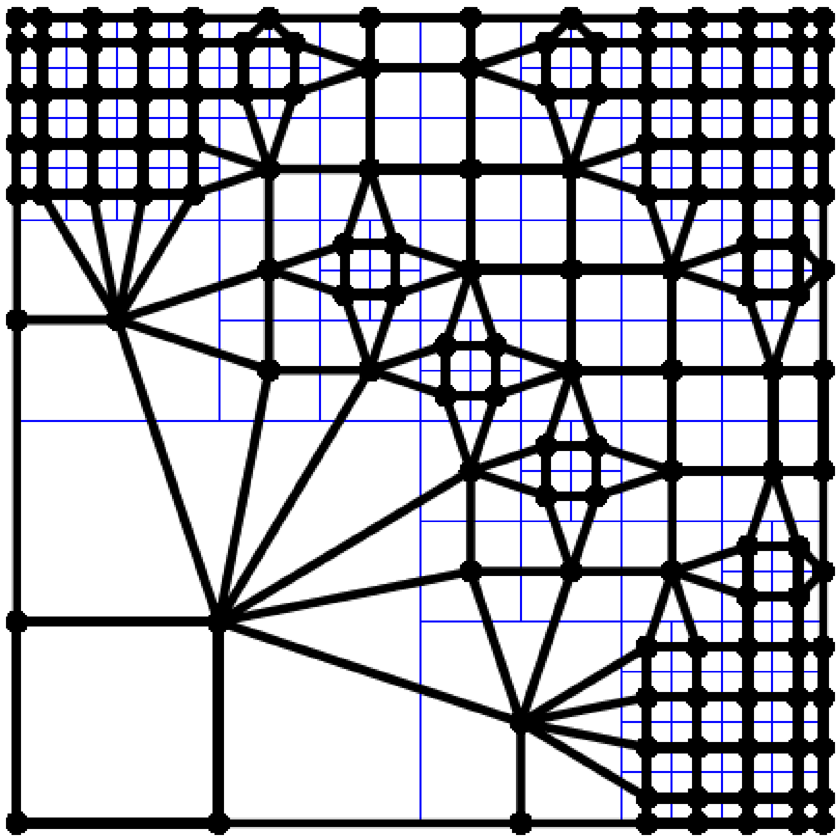
# Intermediate Representation

# Generate Implicit



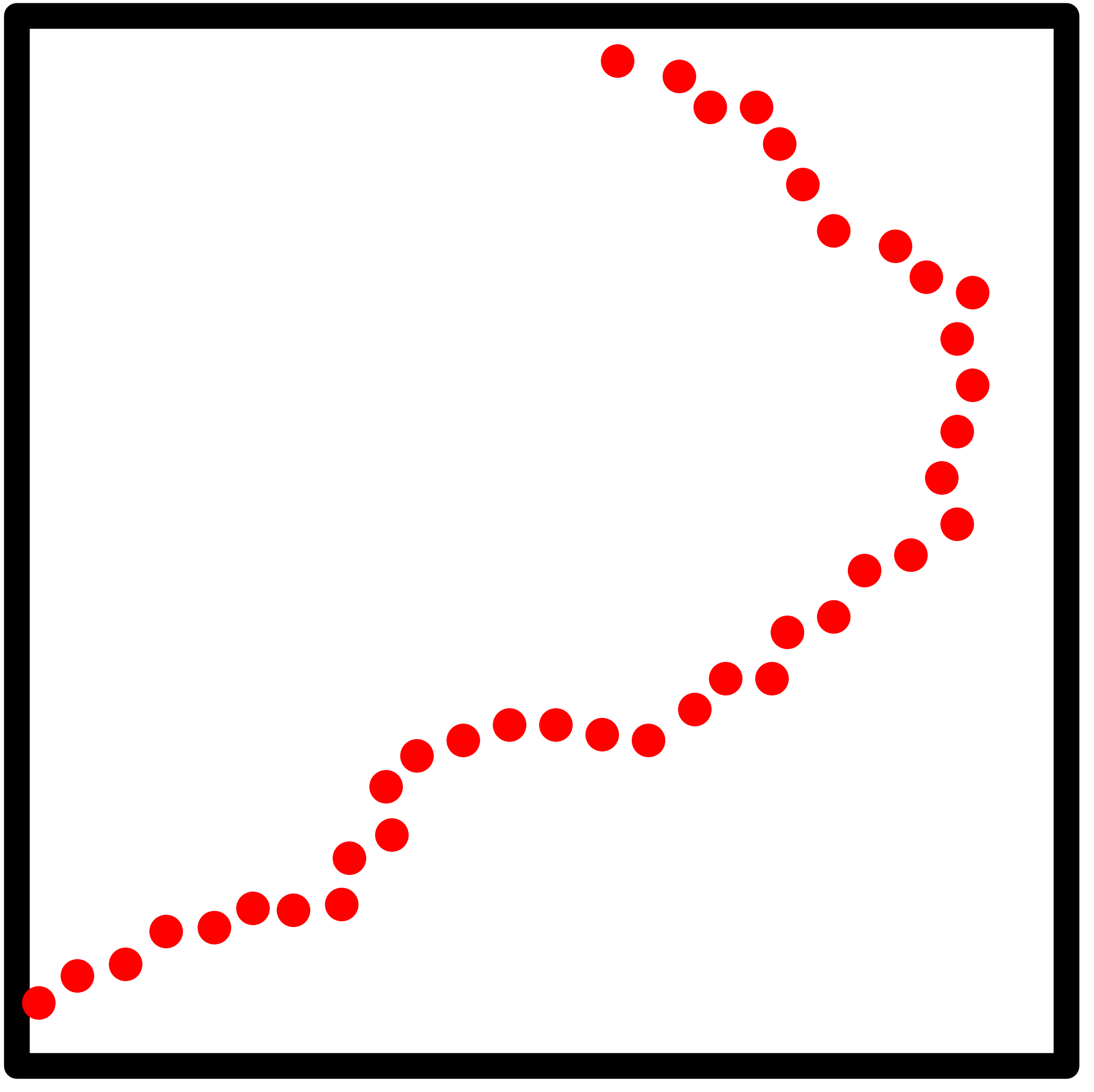
[Manson et al. 2011]

# Generate Surface

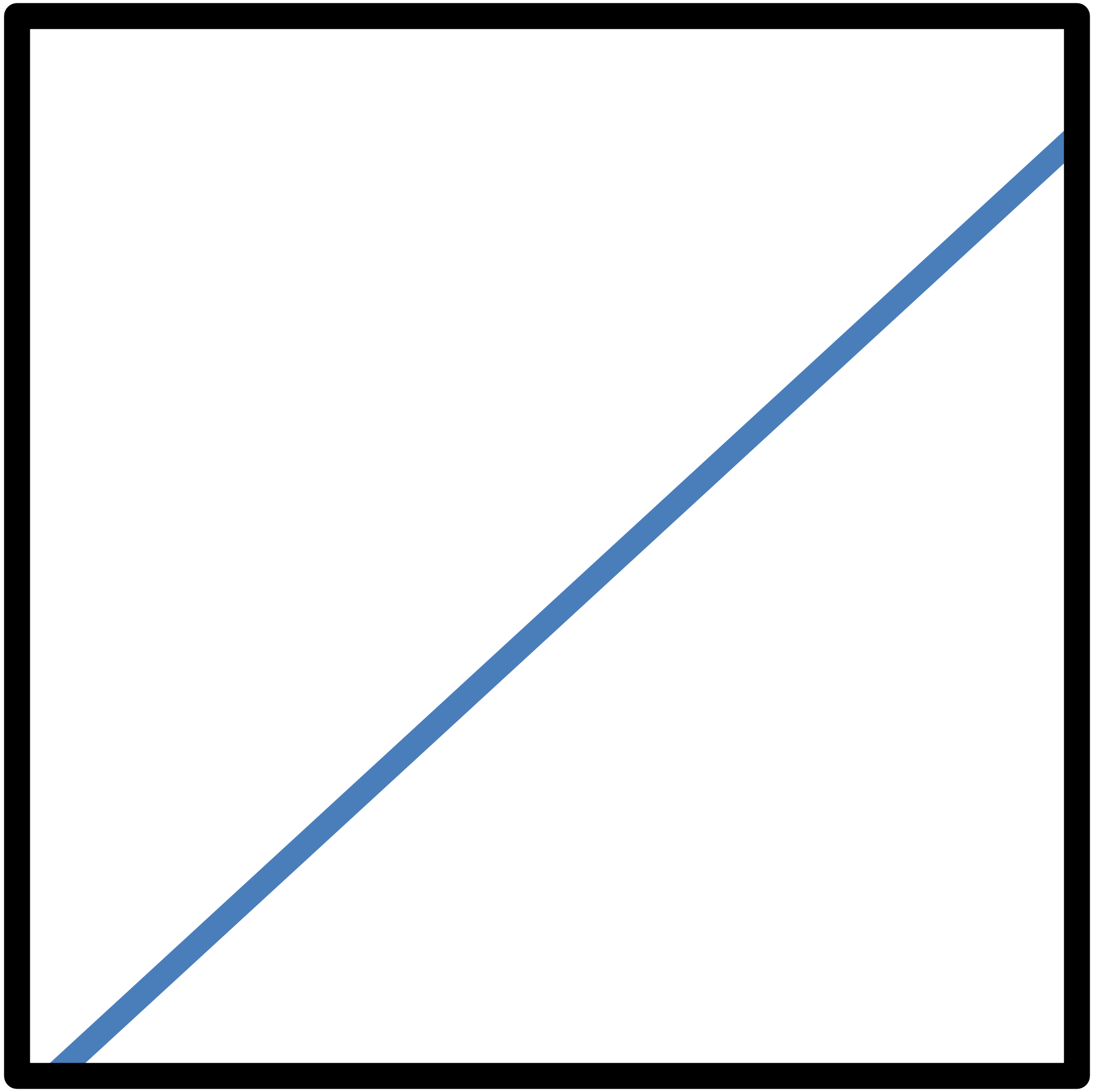


[Schaefer and Warren 2004]

# Generate the Octree



# Generate the Octree



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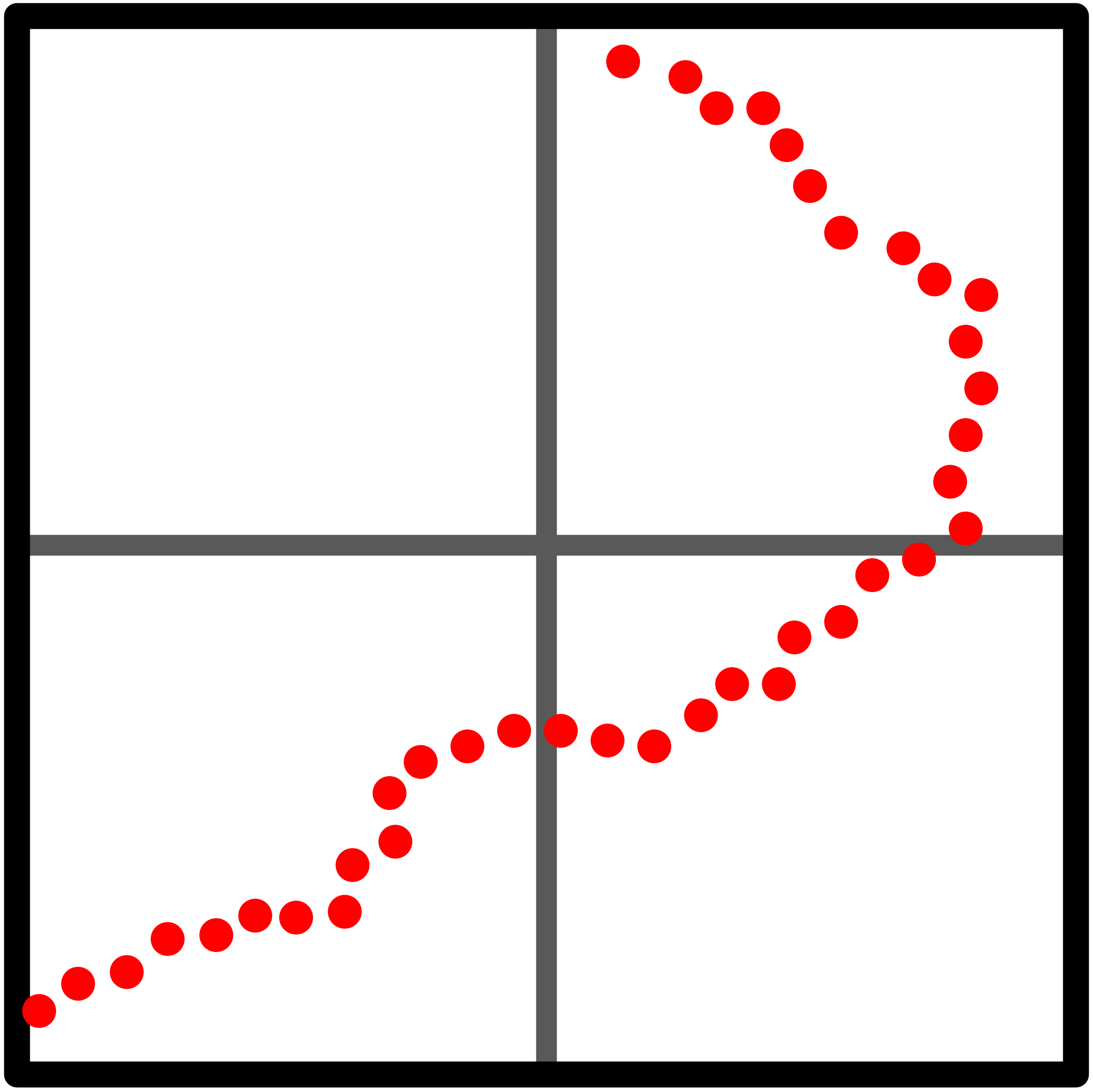
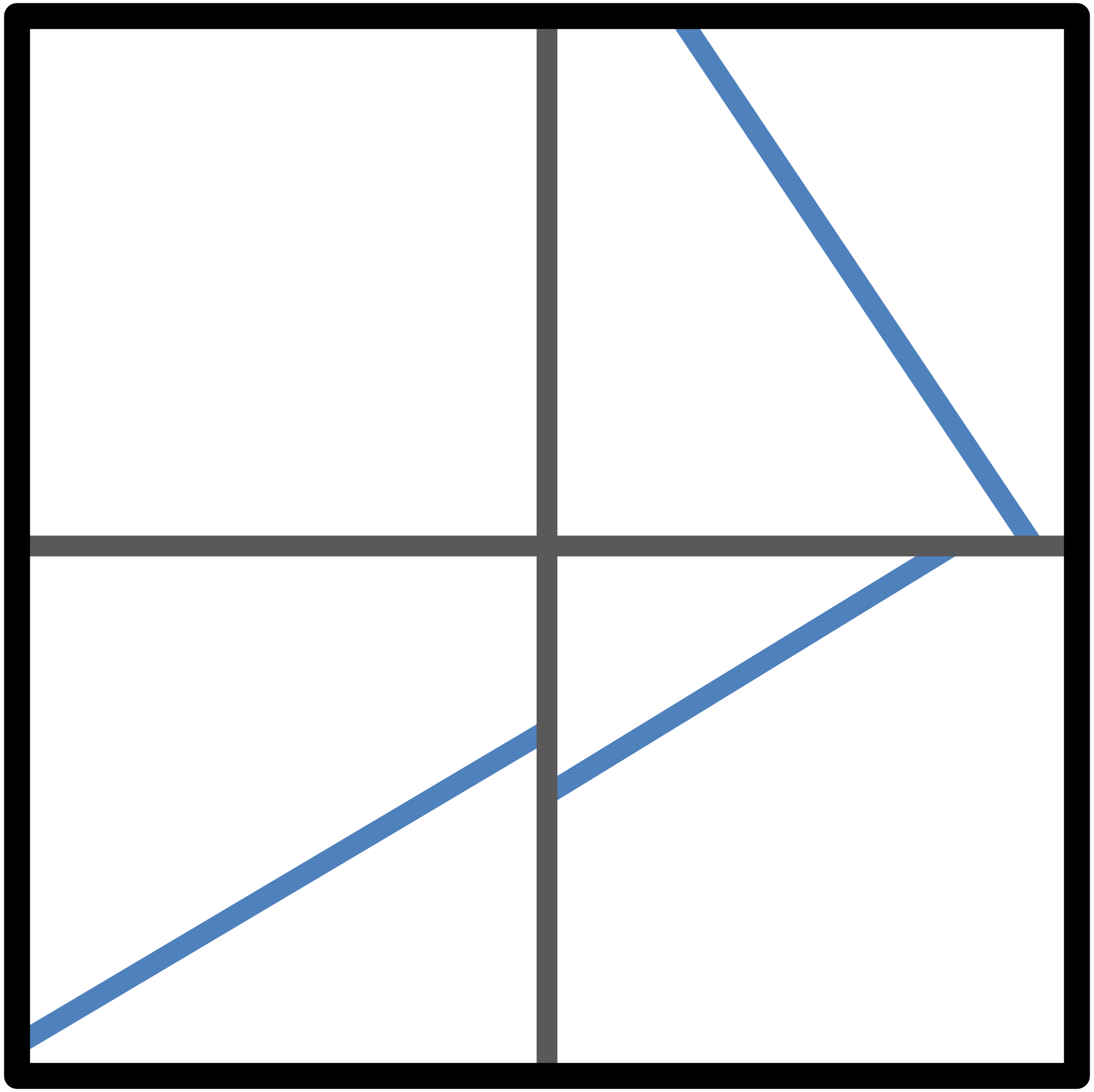
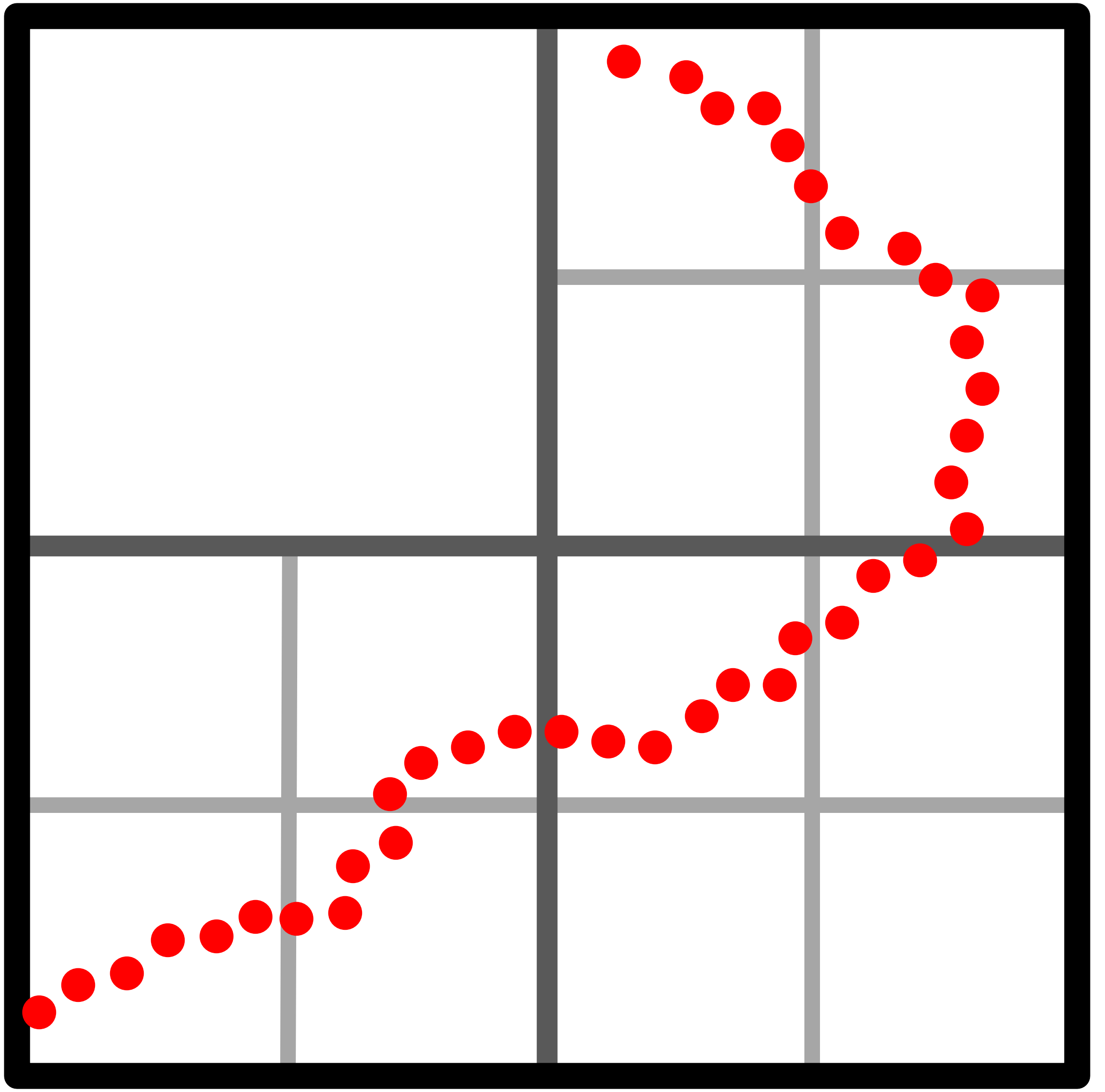


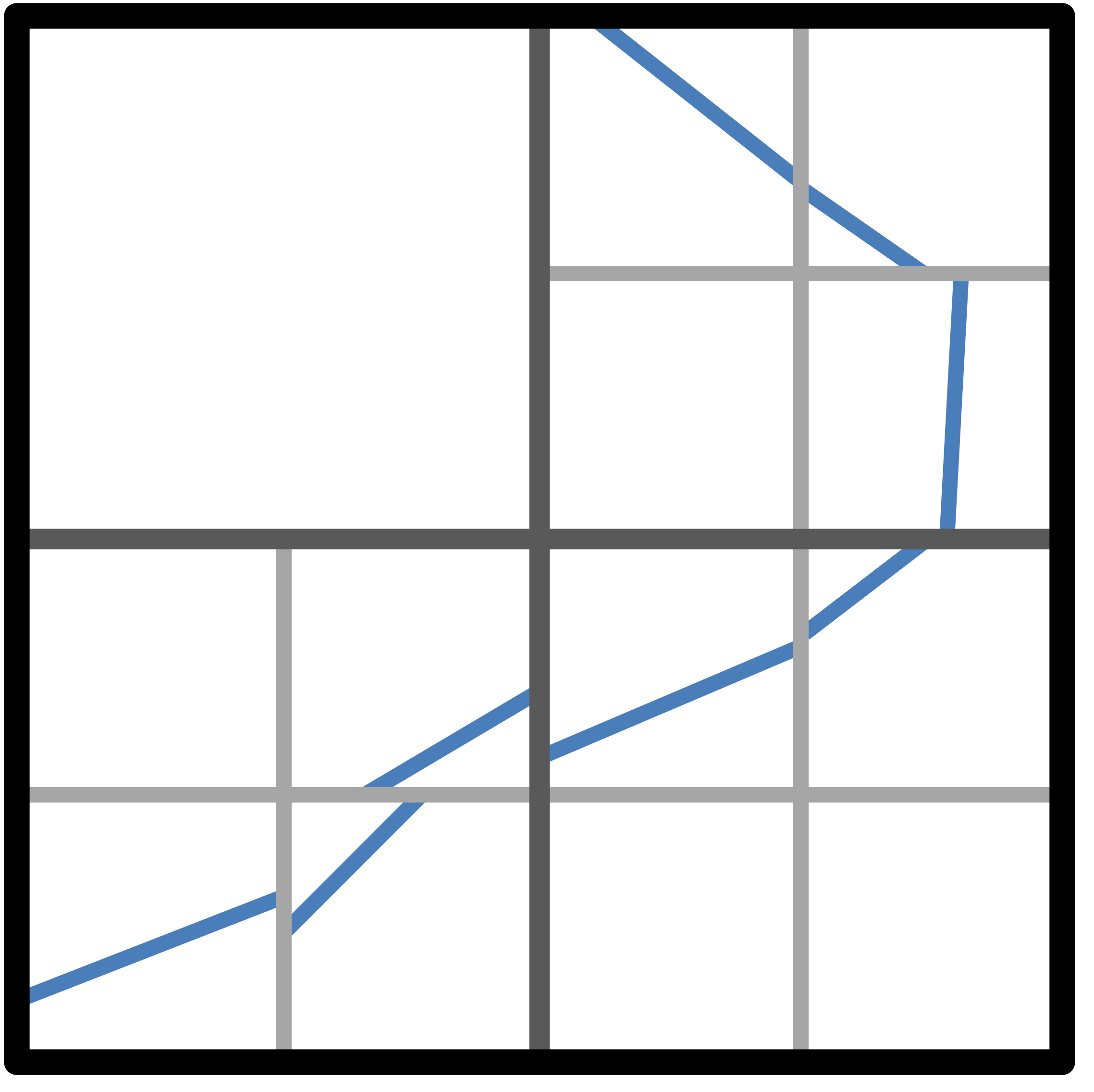
# Generate the Octree



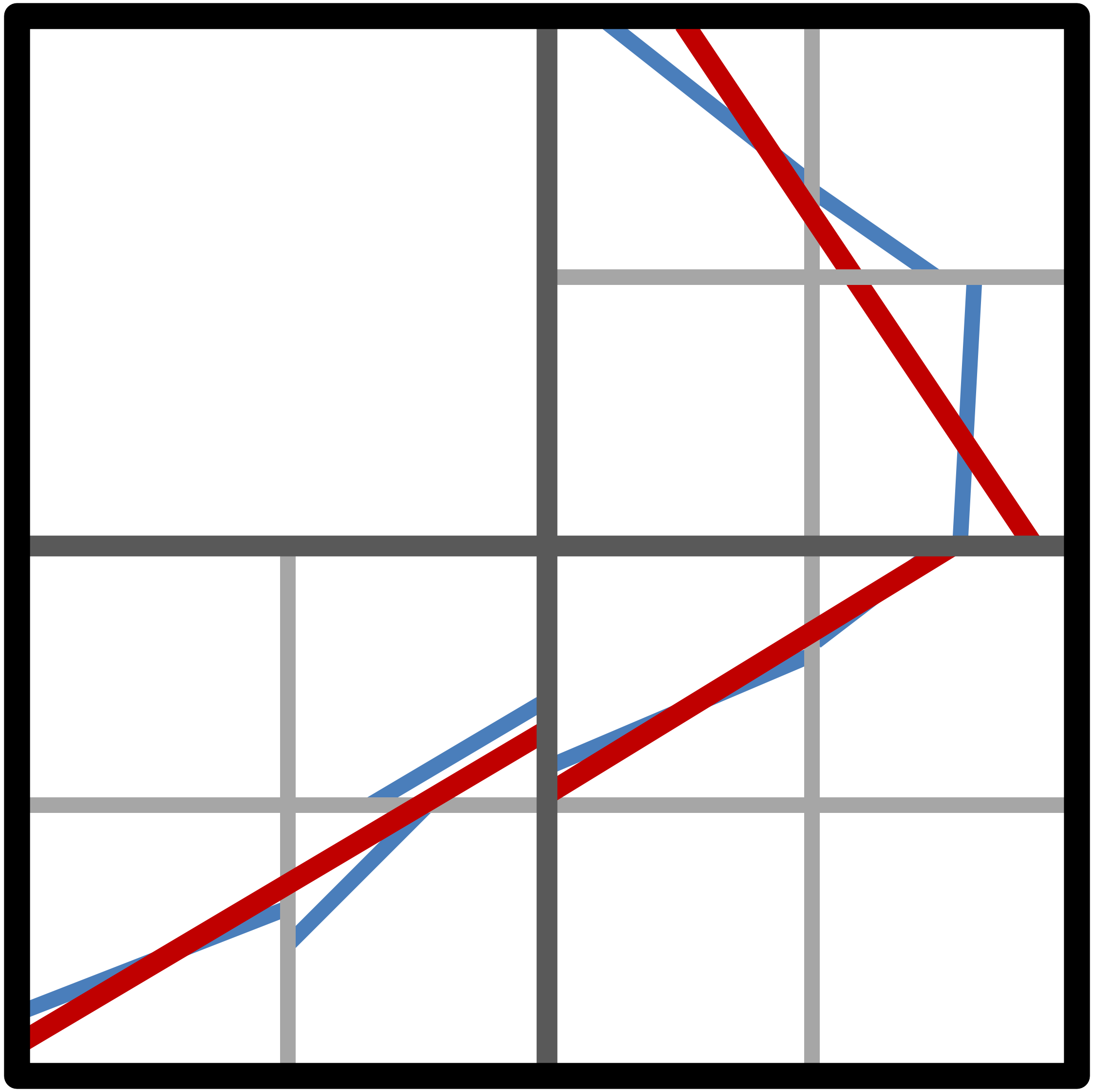
# Generate the Octree



# Generate the Octree



# Prune the Octree



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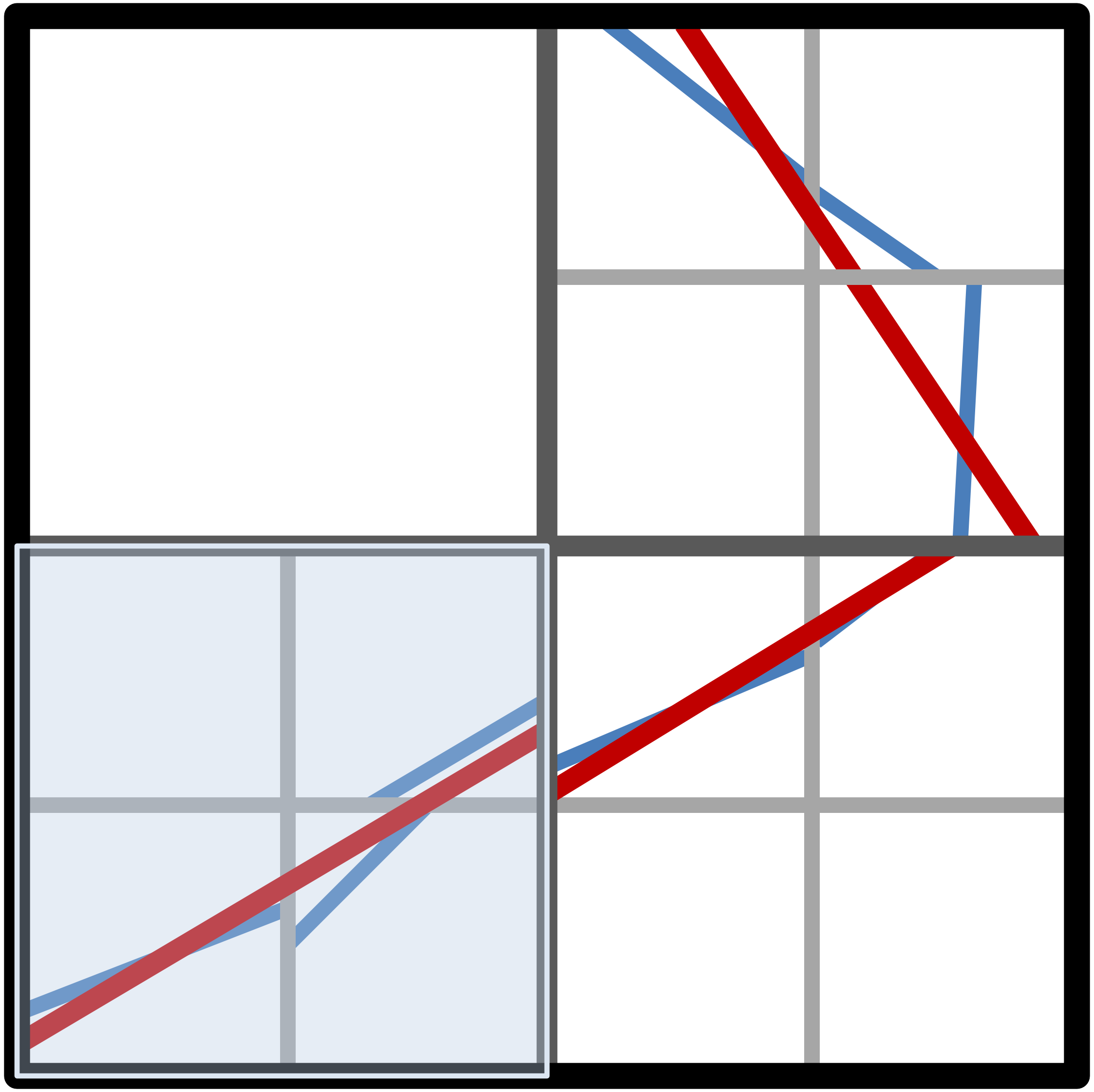

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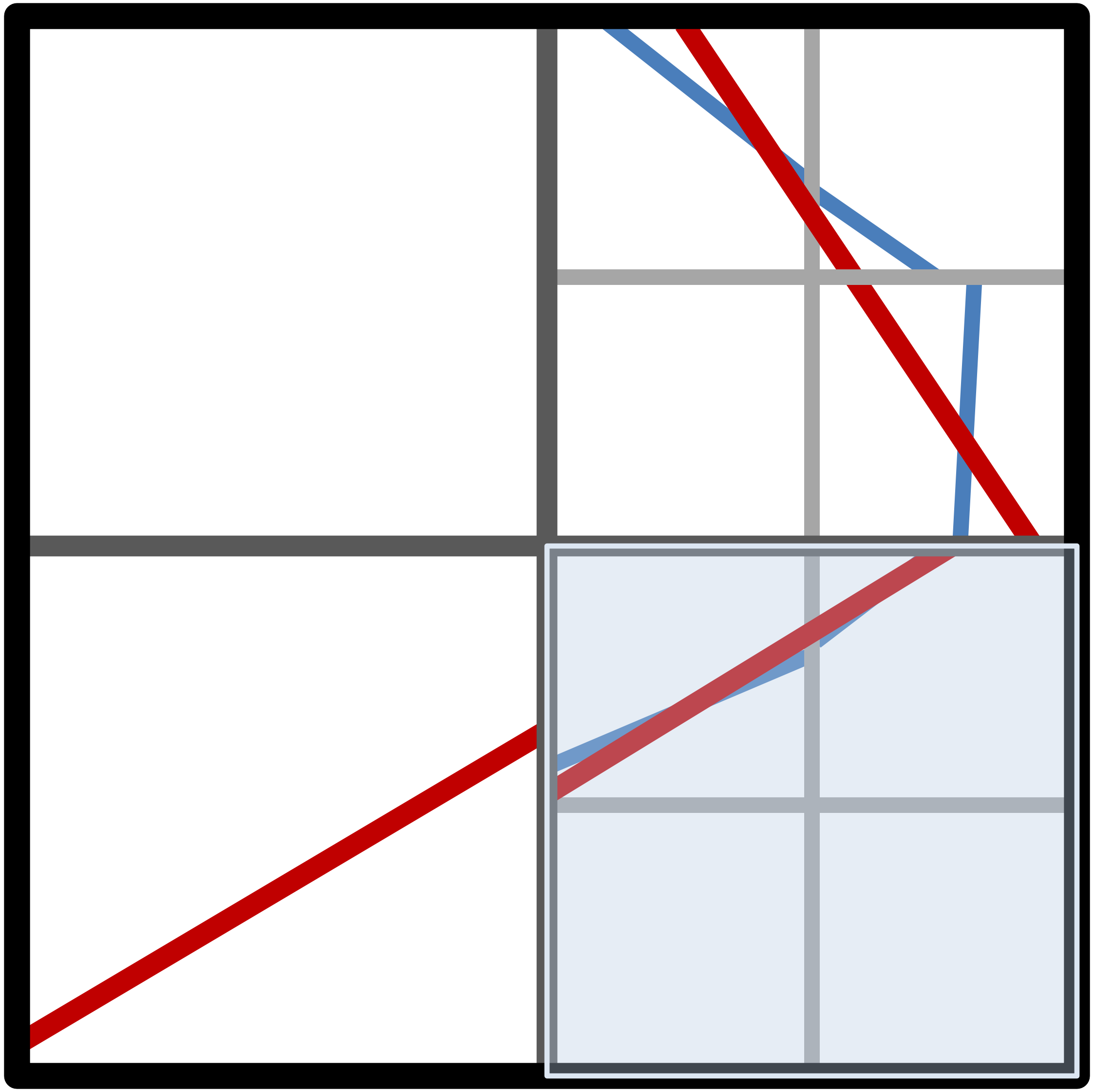

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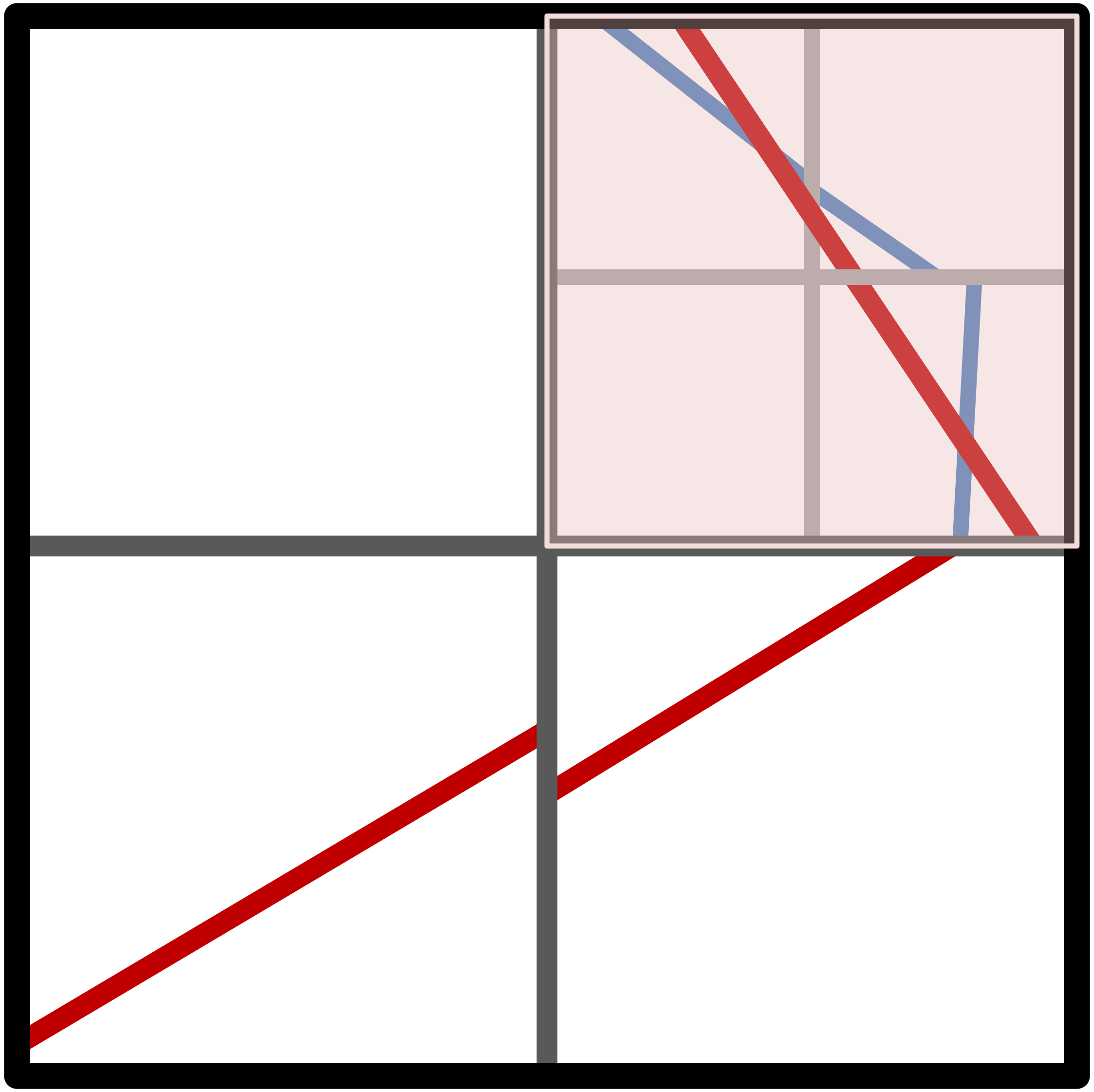
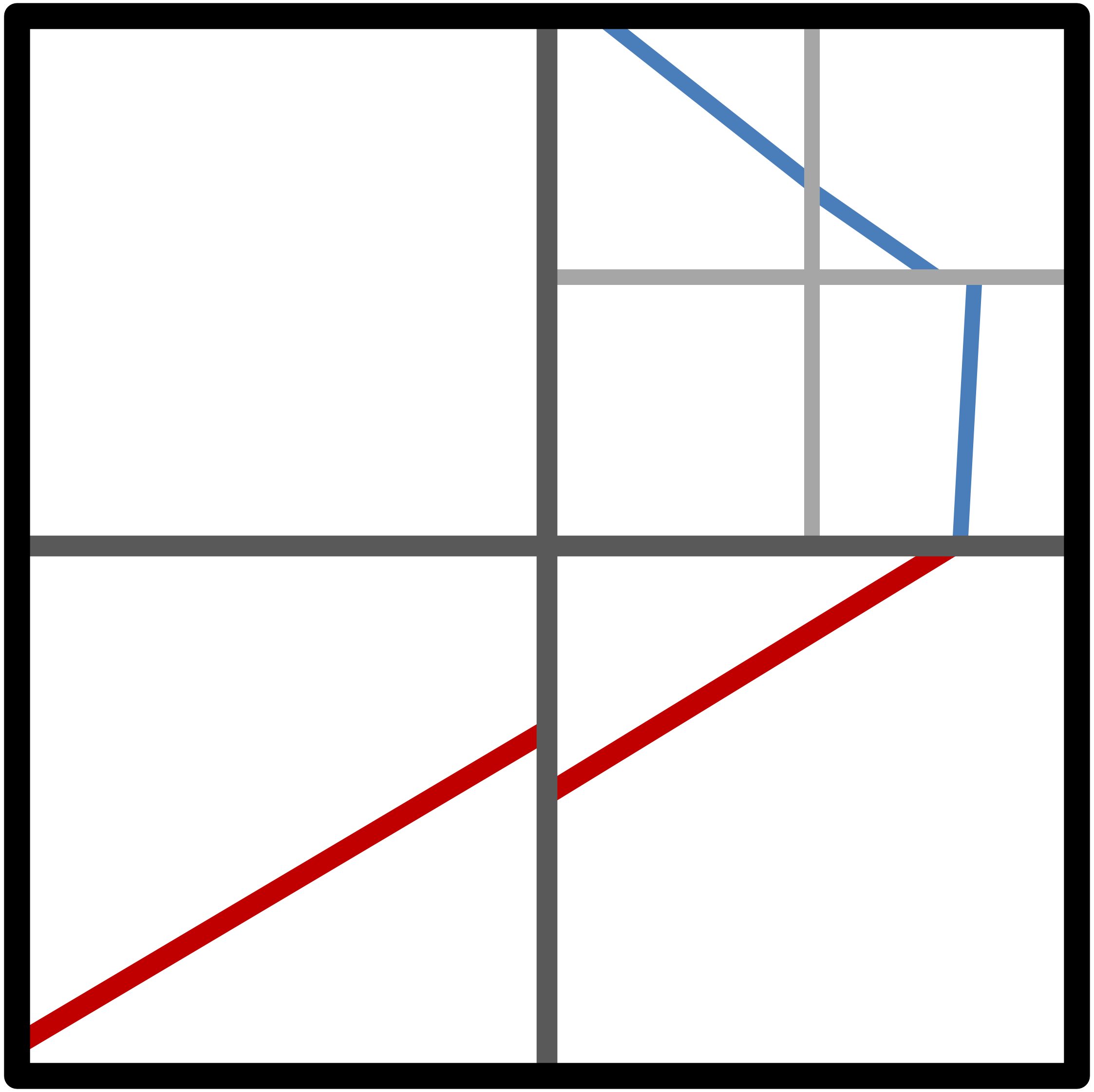
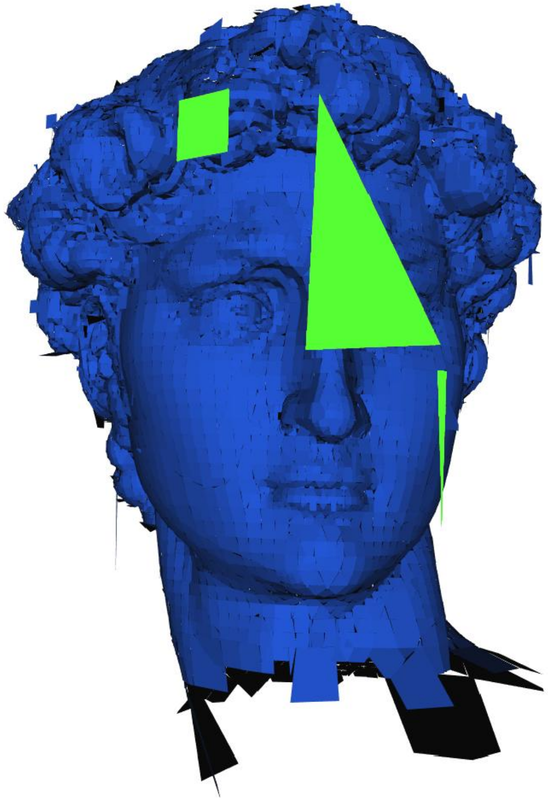
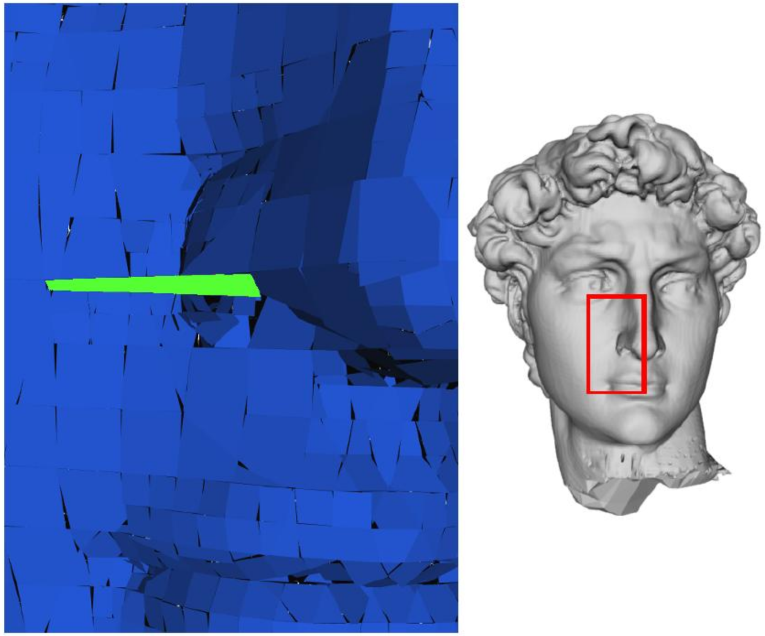


# Prune the Octree

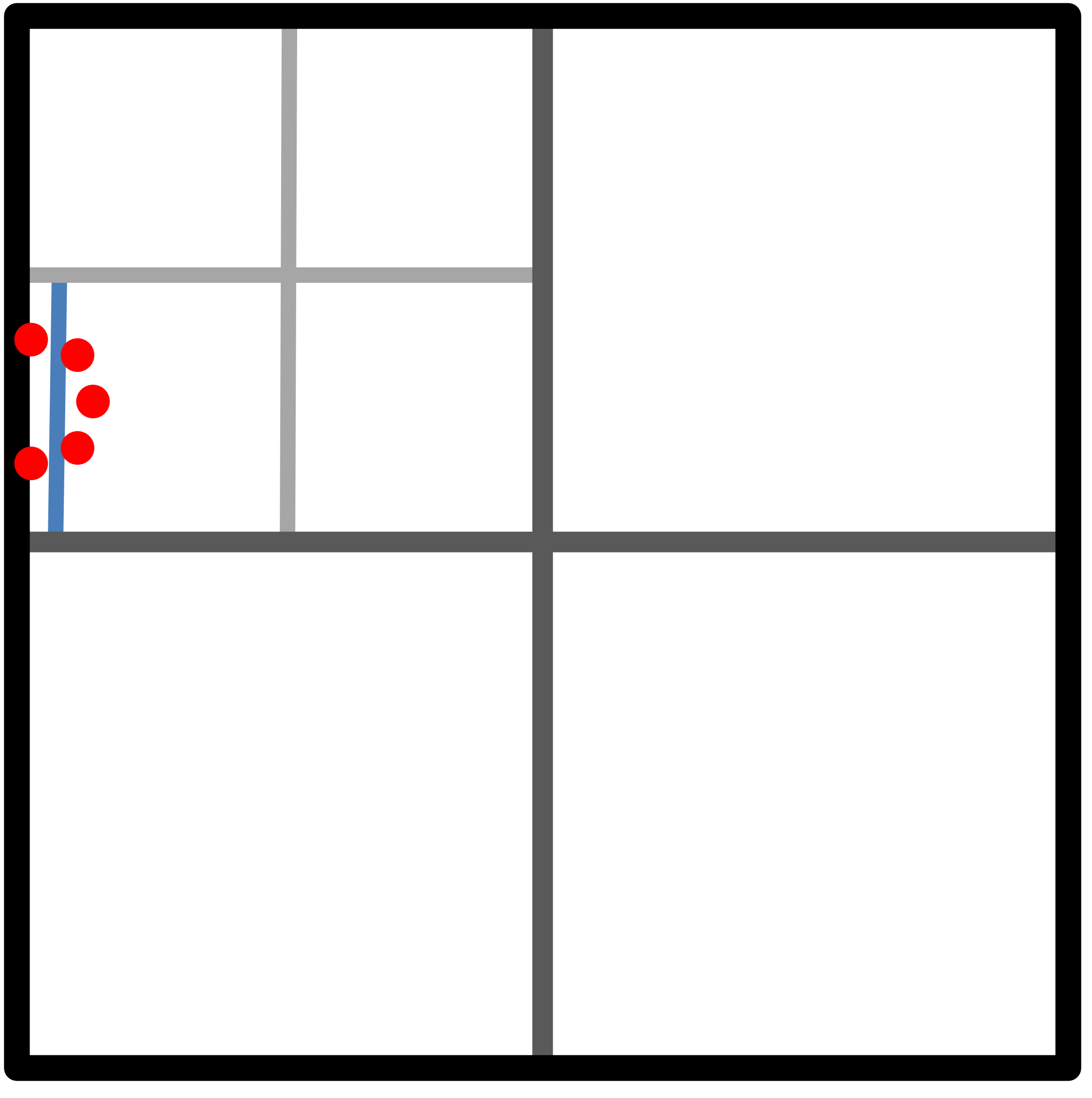


# Problems with Pruning





# Extrapolation



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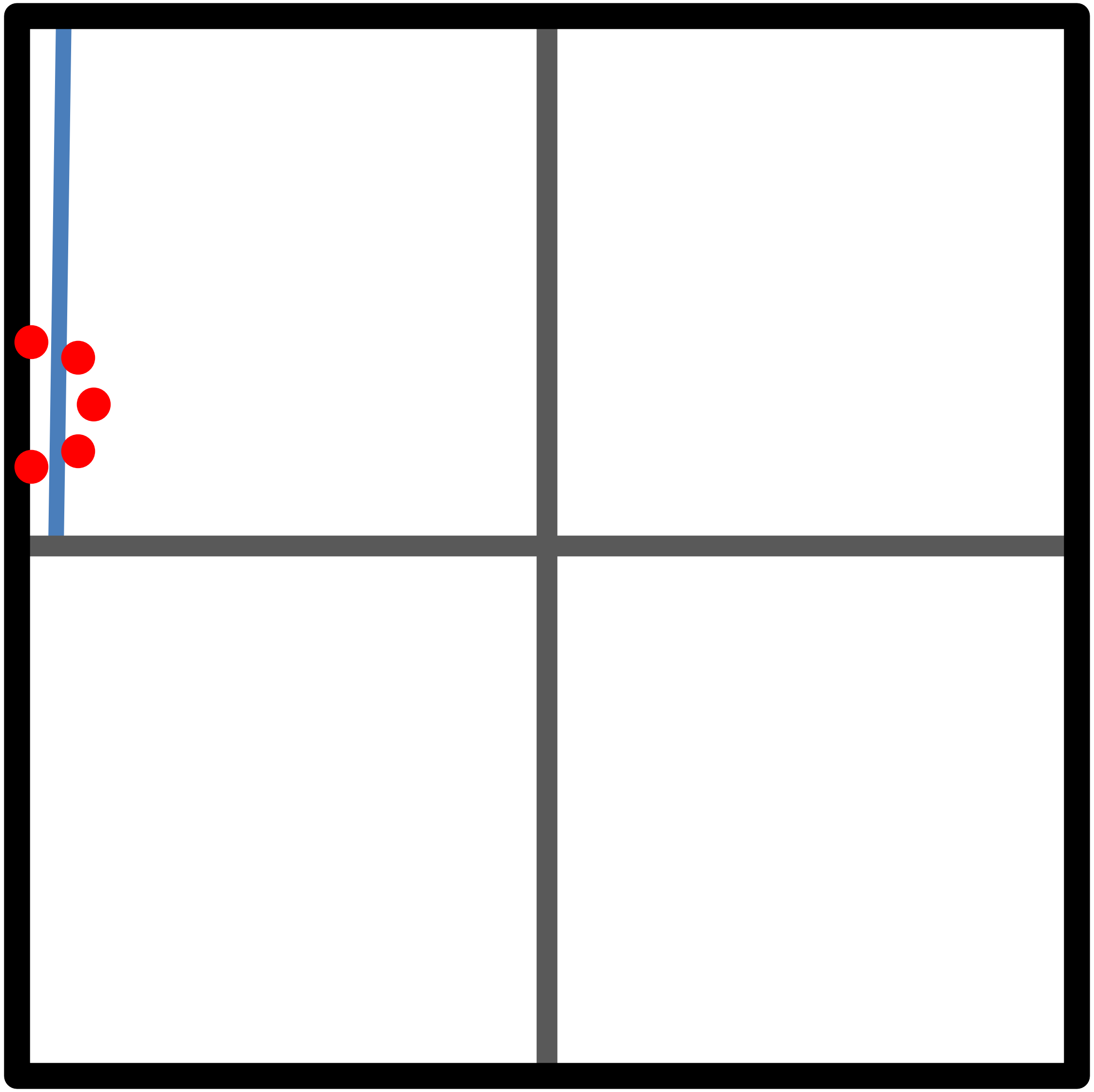

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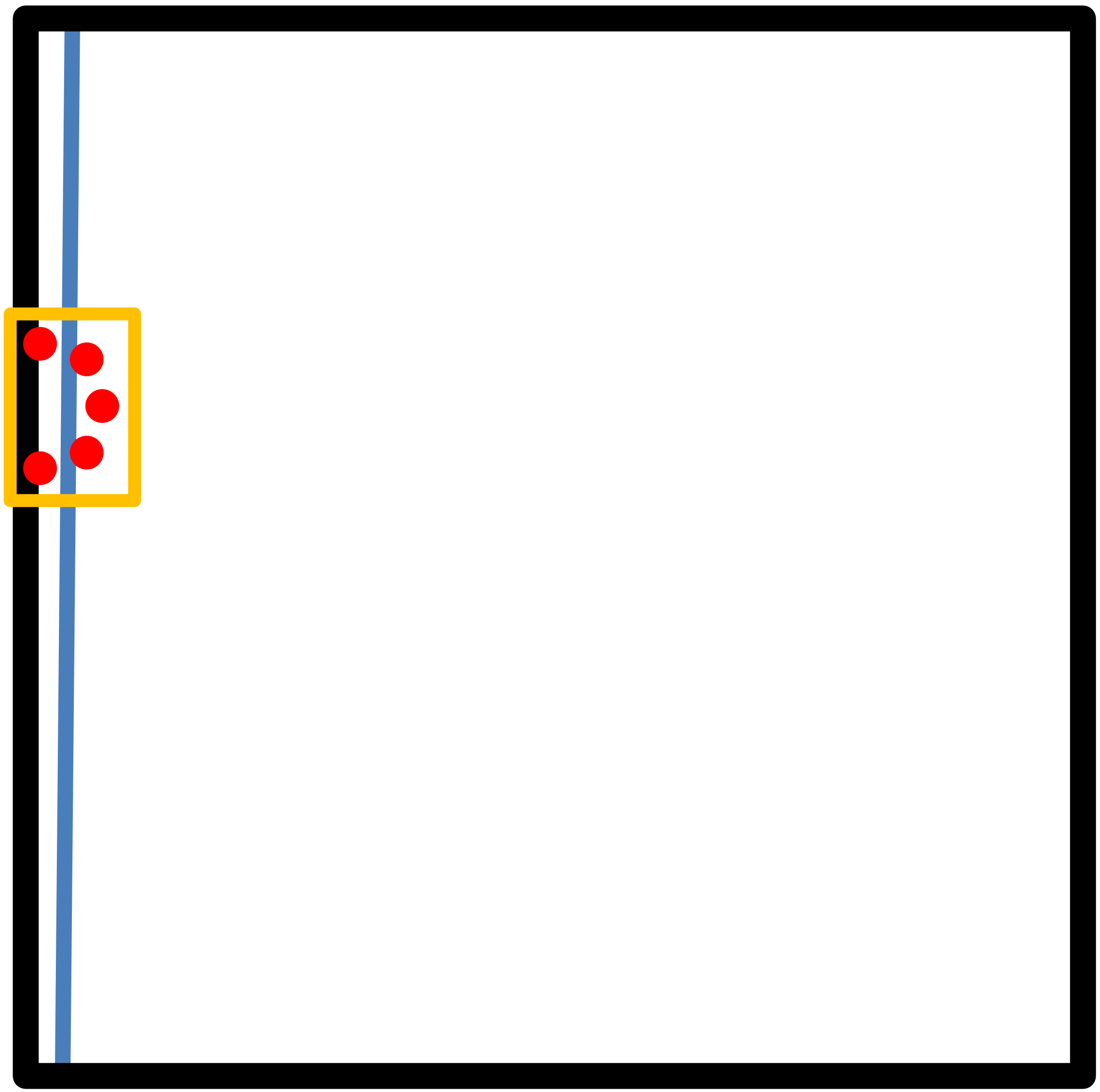

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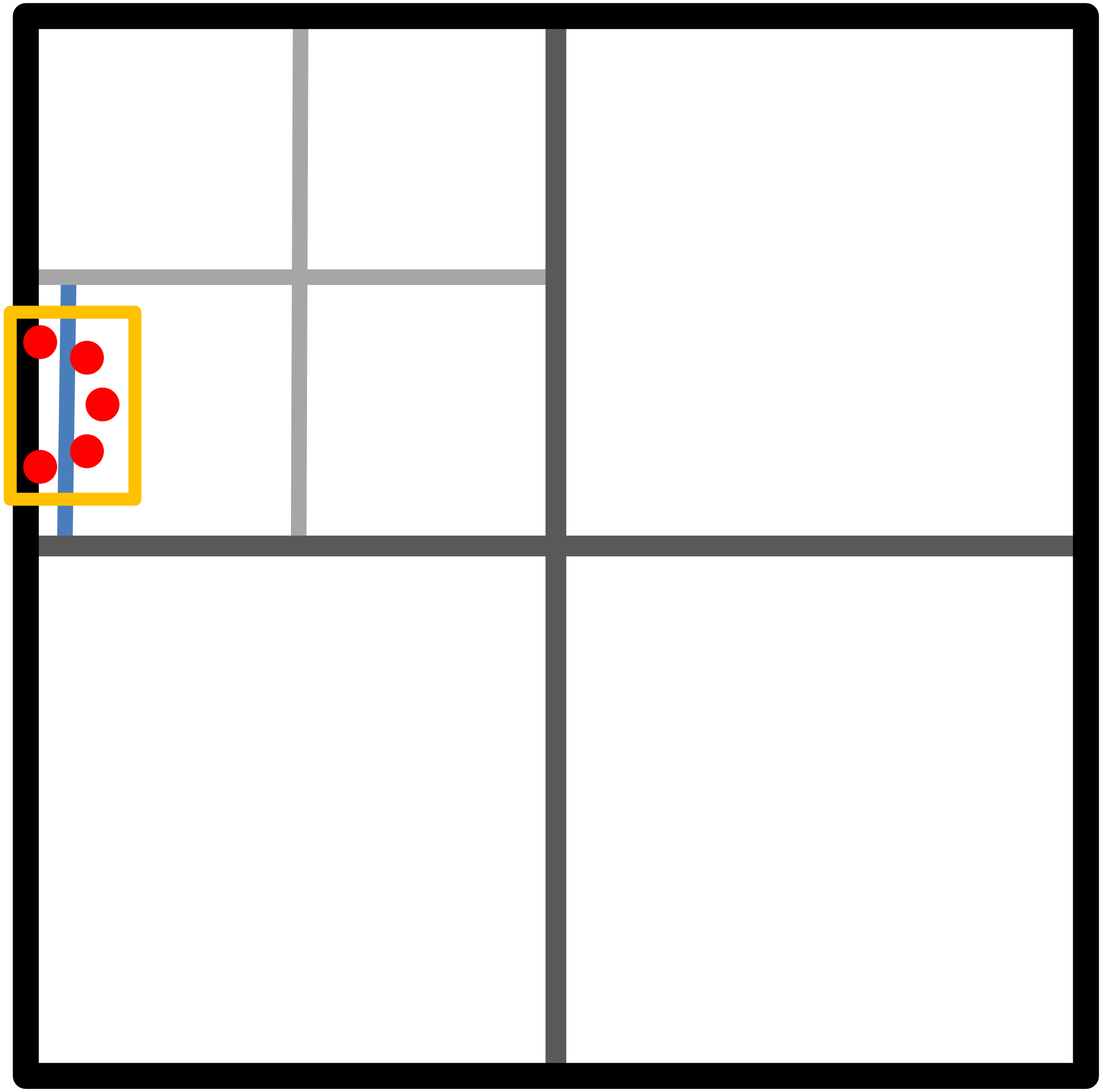

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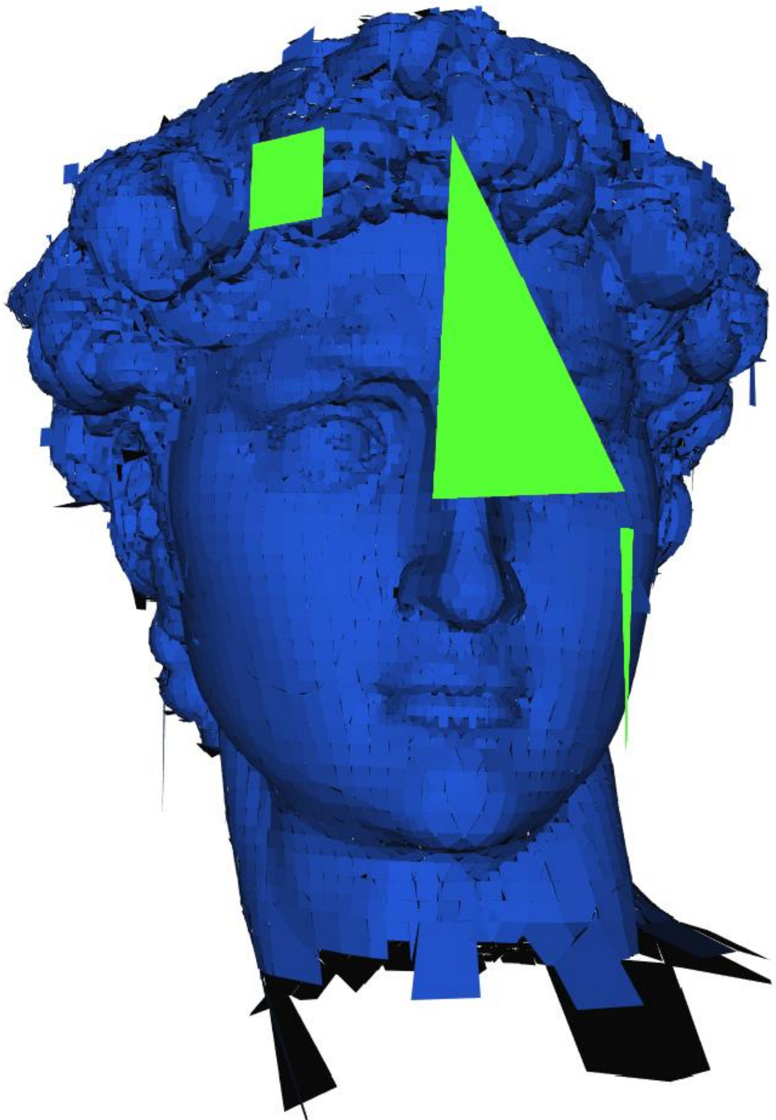
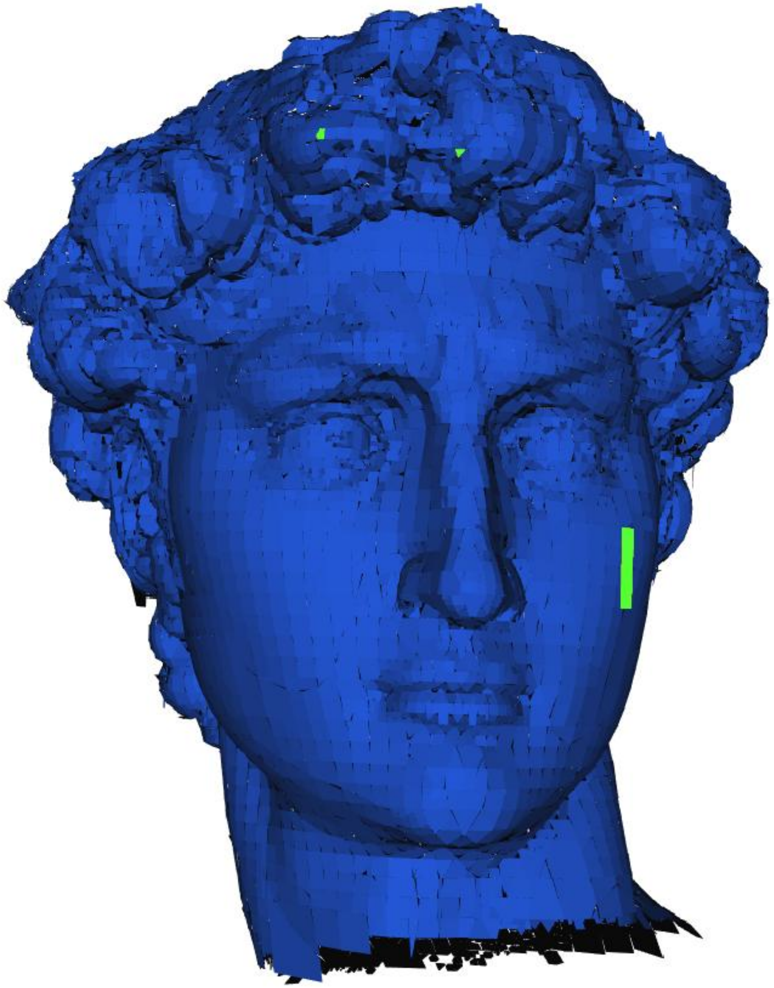
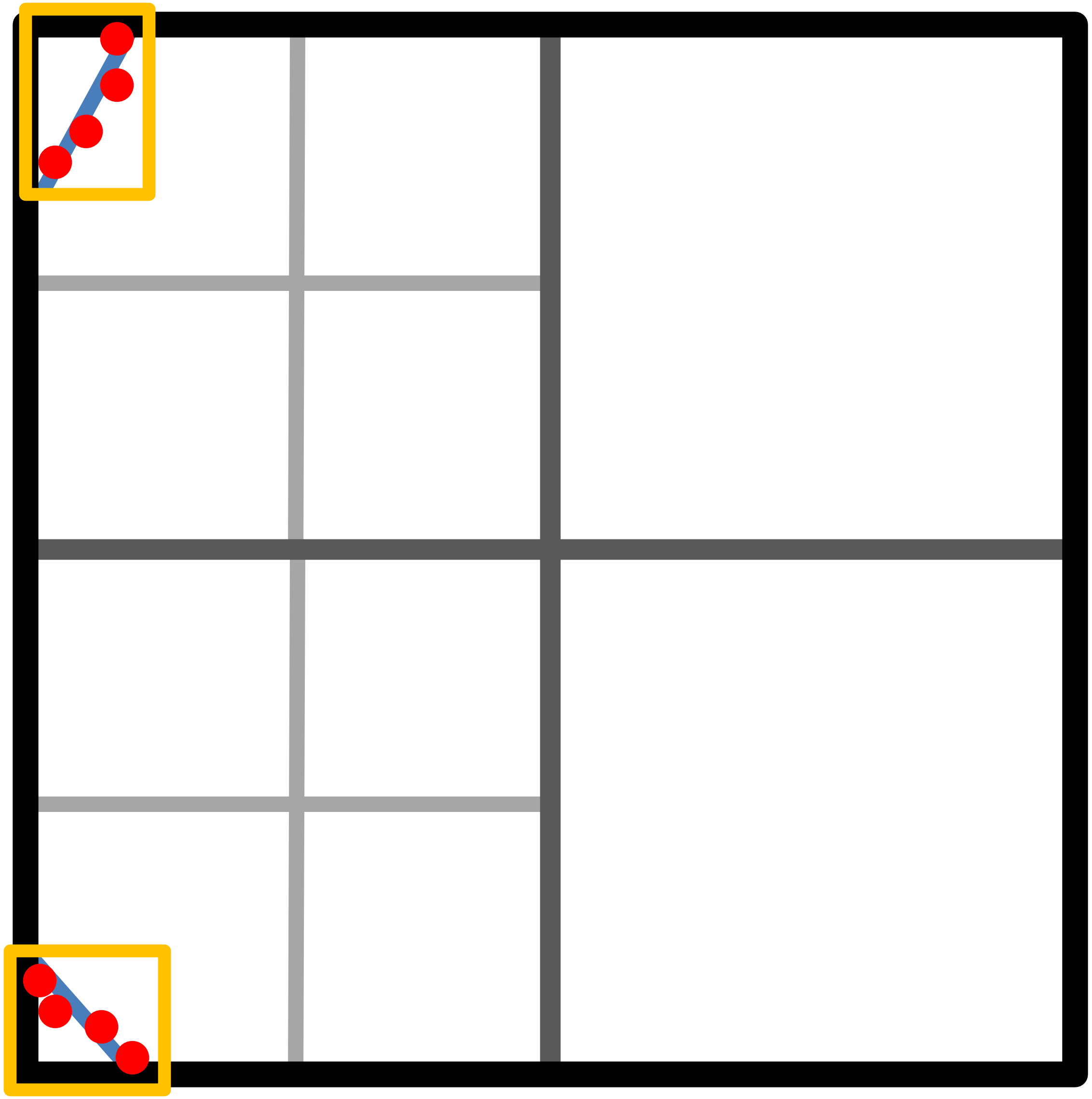


# Prevent Extrapolation



# Merging



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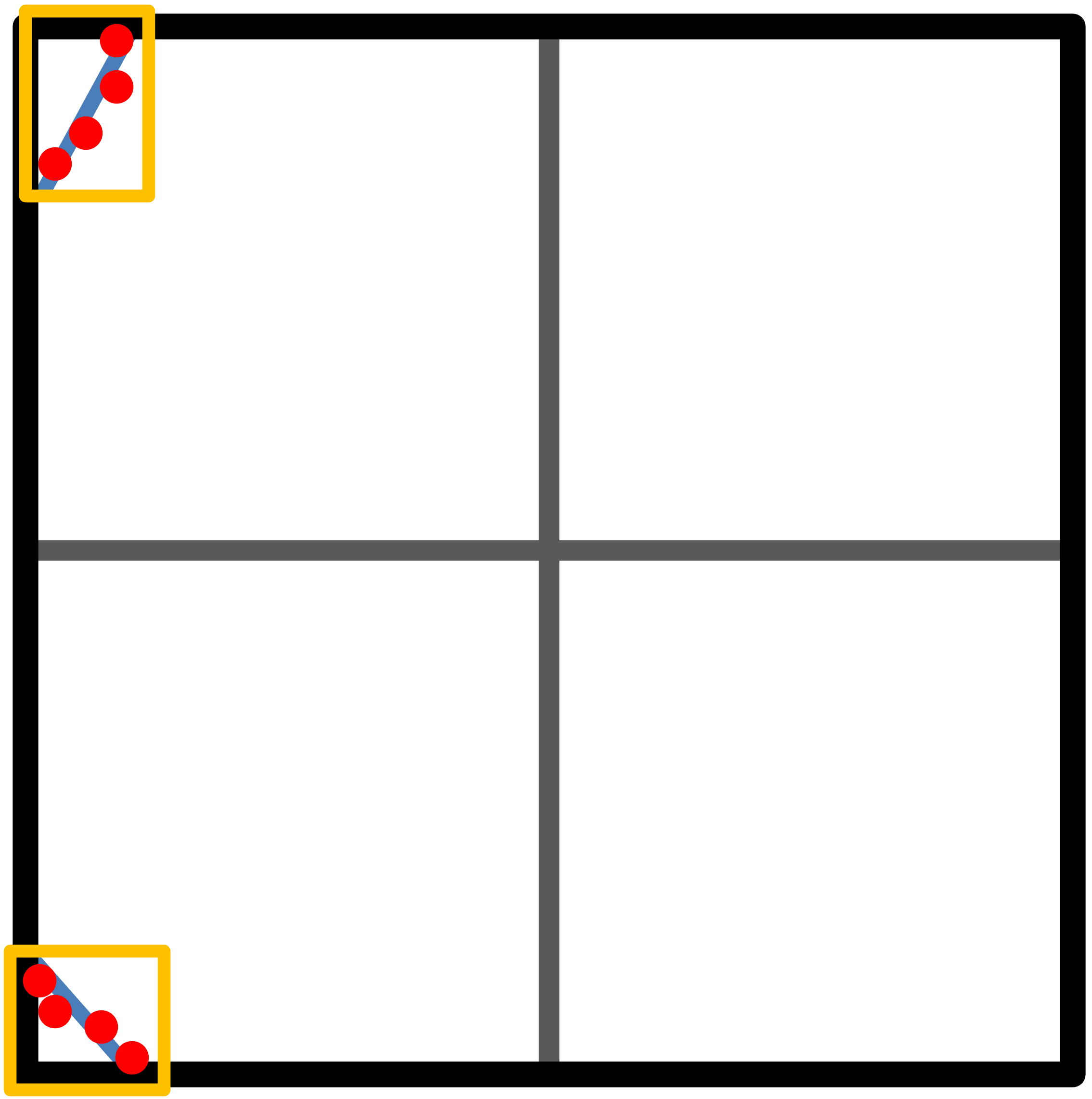

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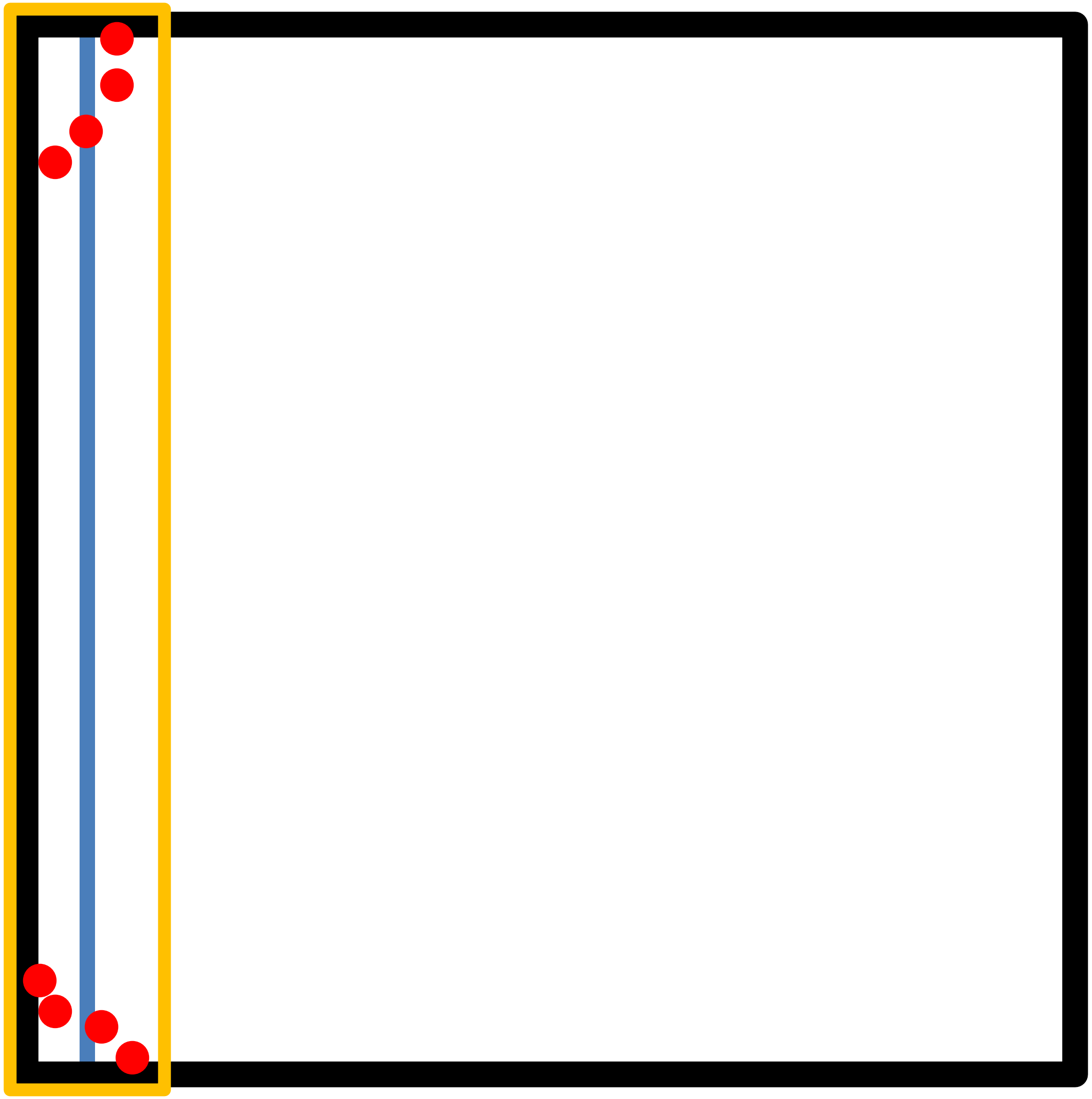

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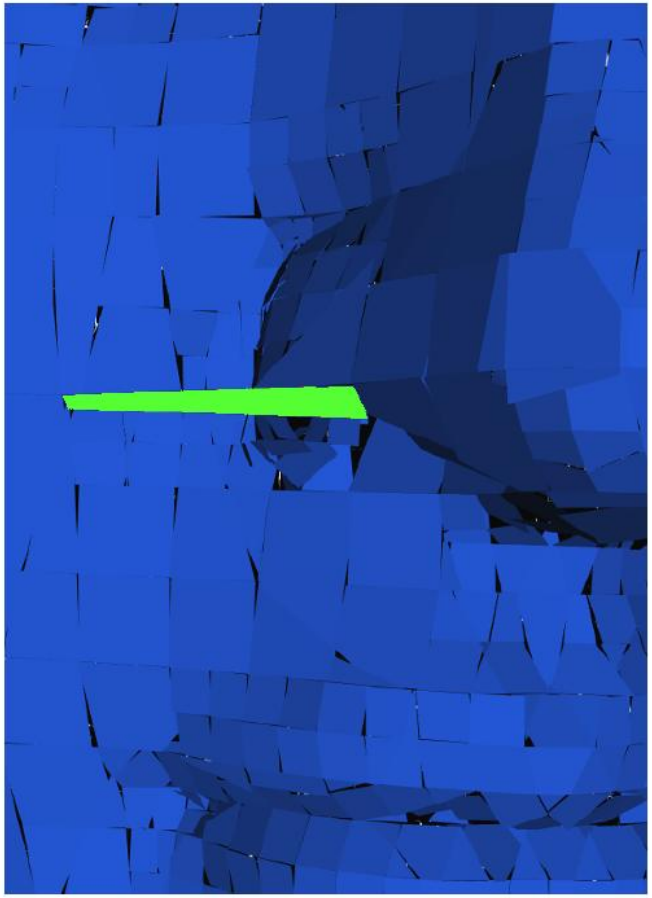

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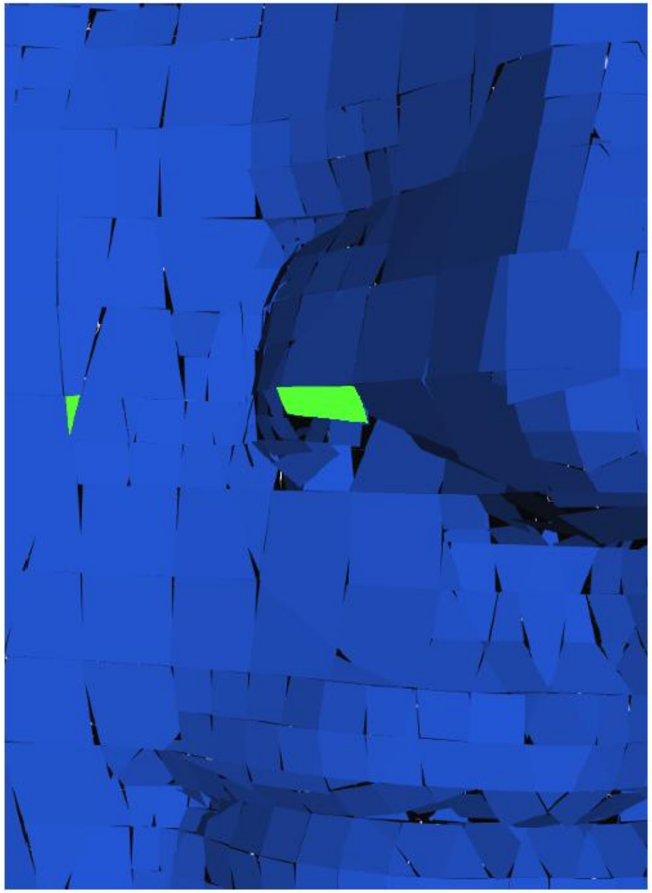


# Results of Pruning

1179.18 KB
100%

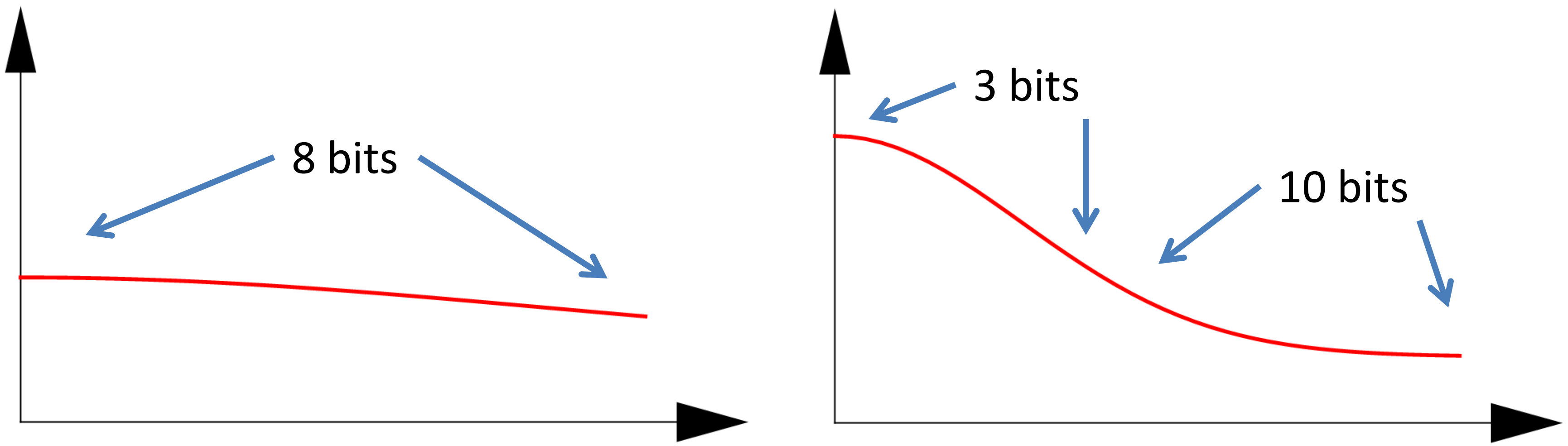
282.47KB
20%

# Encoding Phase

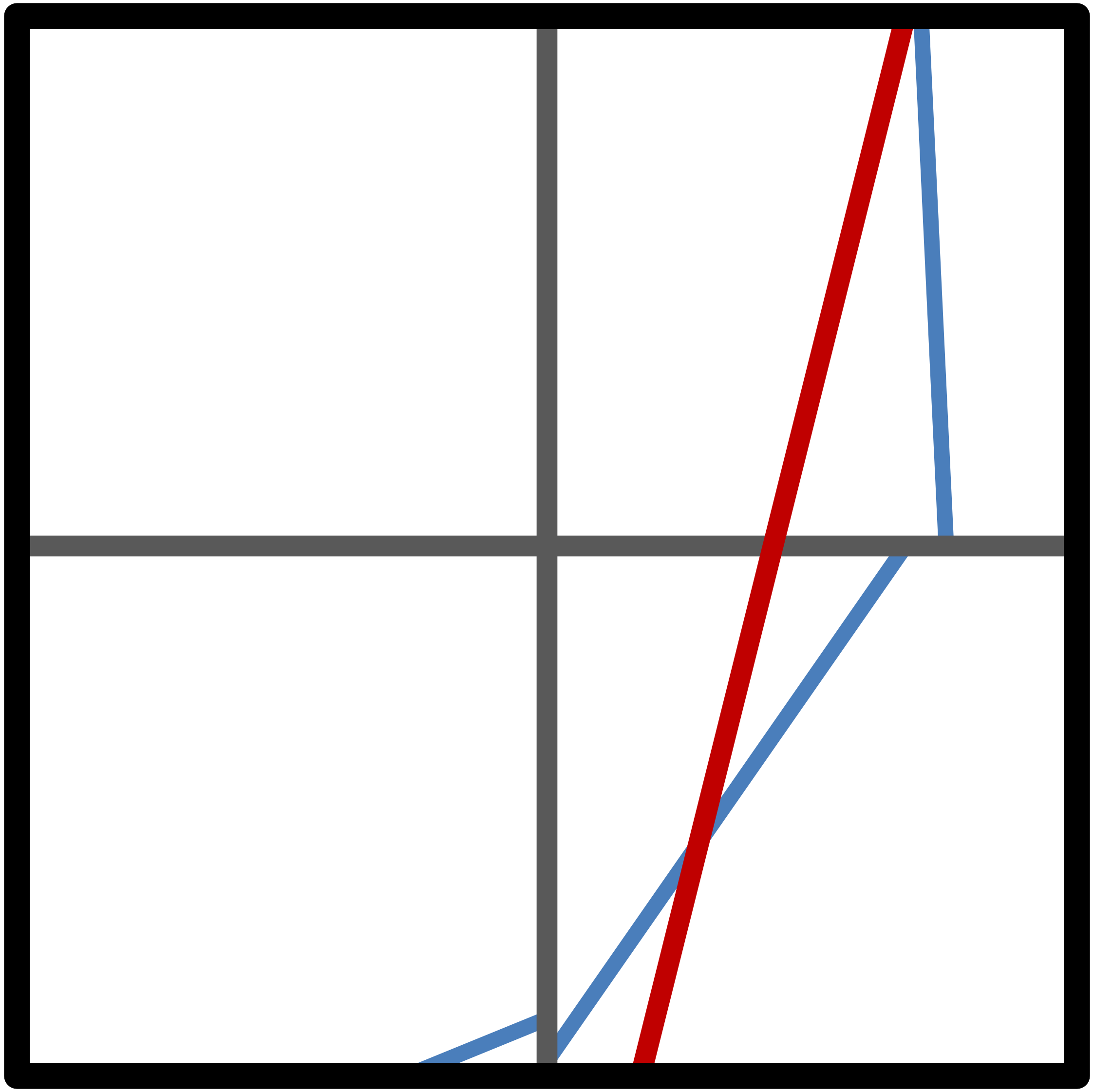
- Progressively encode planes from the root
  - Adaptive octree
    - Leaf bit
    - Children connectivity
  - Data per node
    - Plane displacements
    - Sign bits

# Arithmetic Encoder

- Adaptive Arithmetic Coding [F. Wheeler 1996]
  - Source code at http://www.cipr.rpi.edu/~wheeler/ac



# Connectivity



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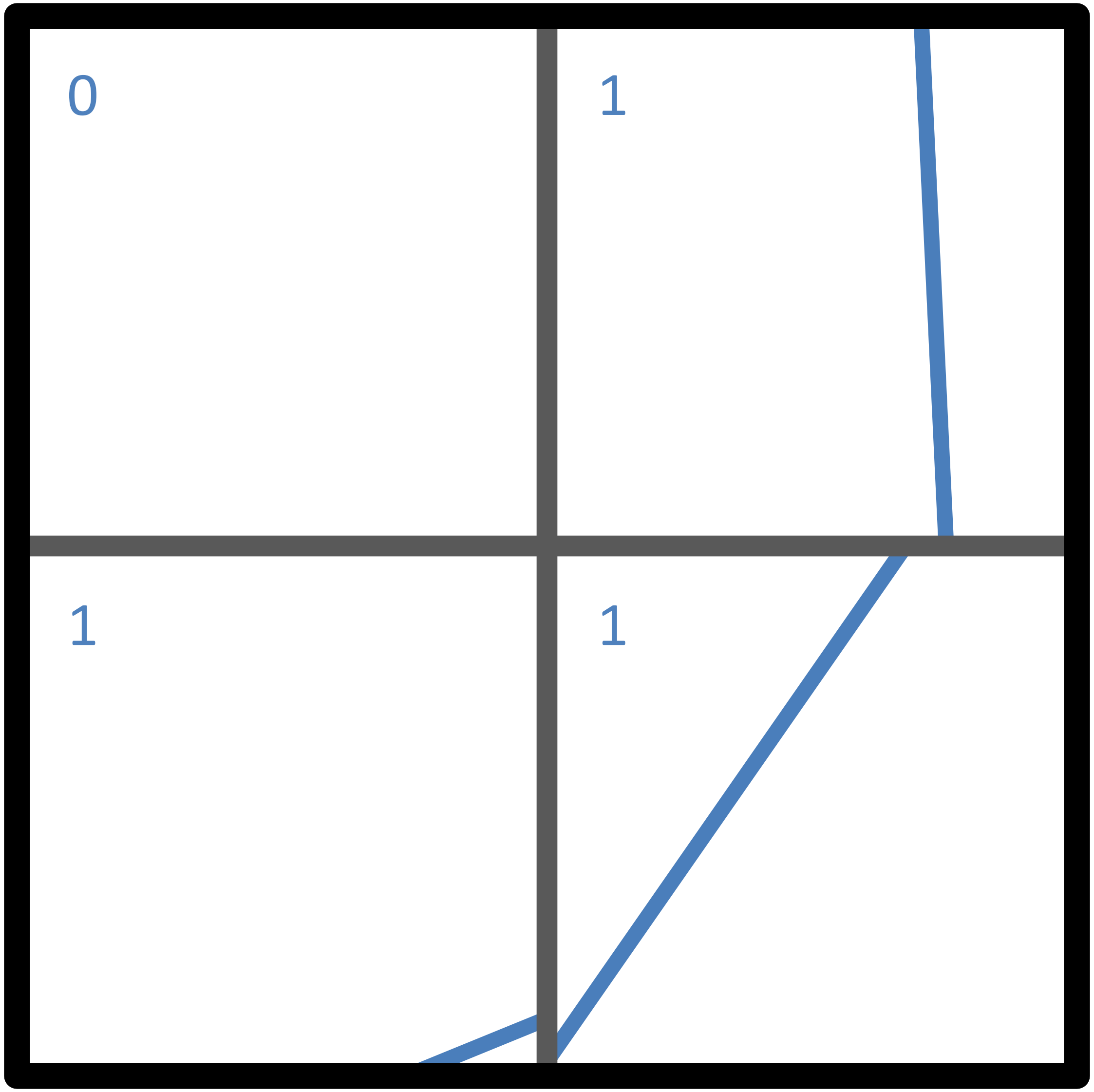

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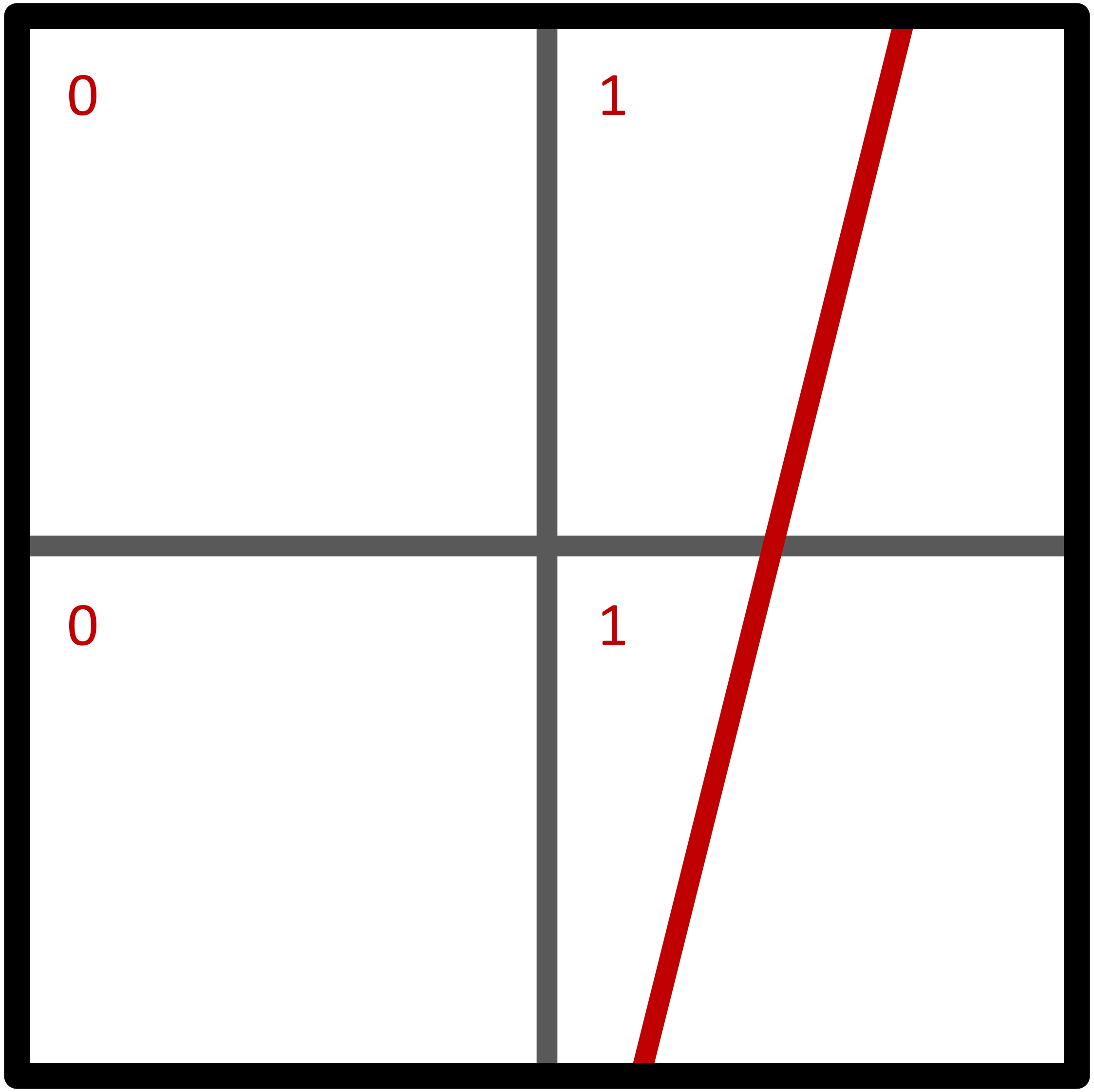

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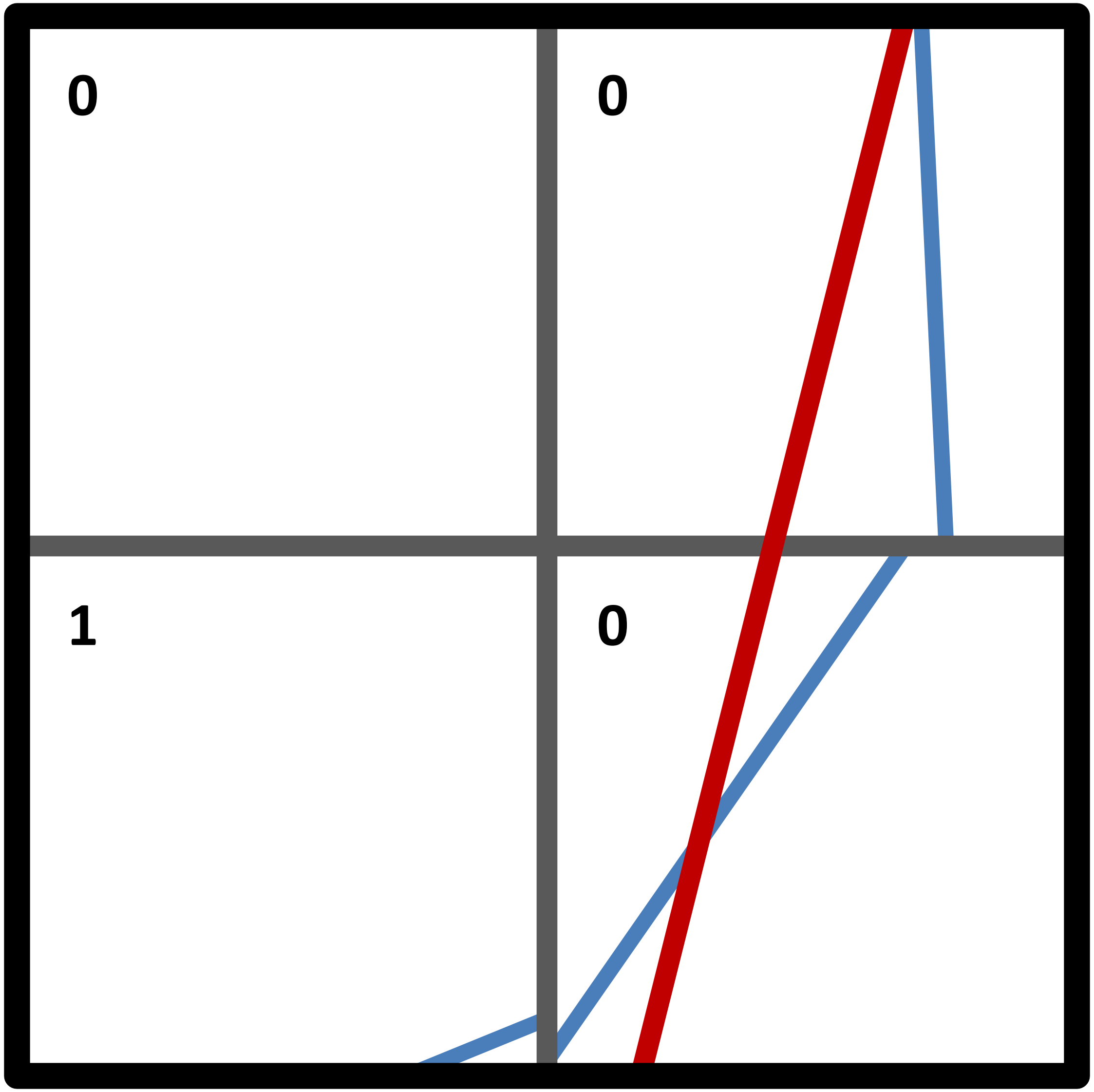
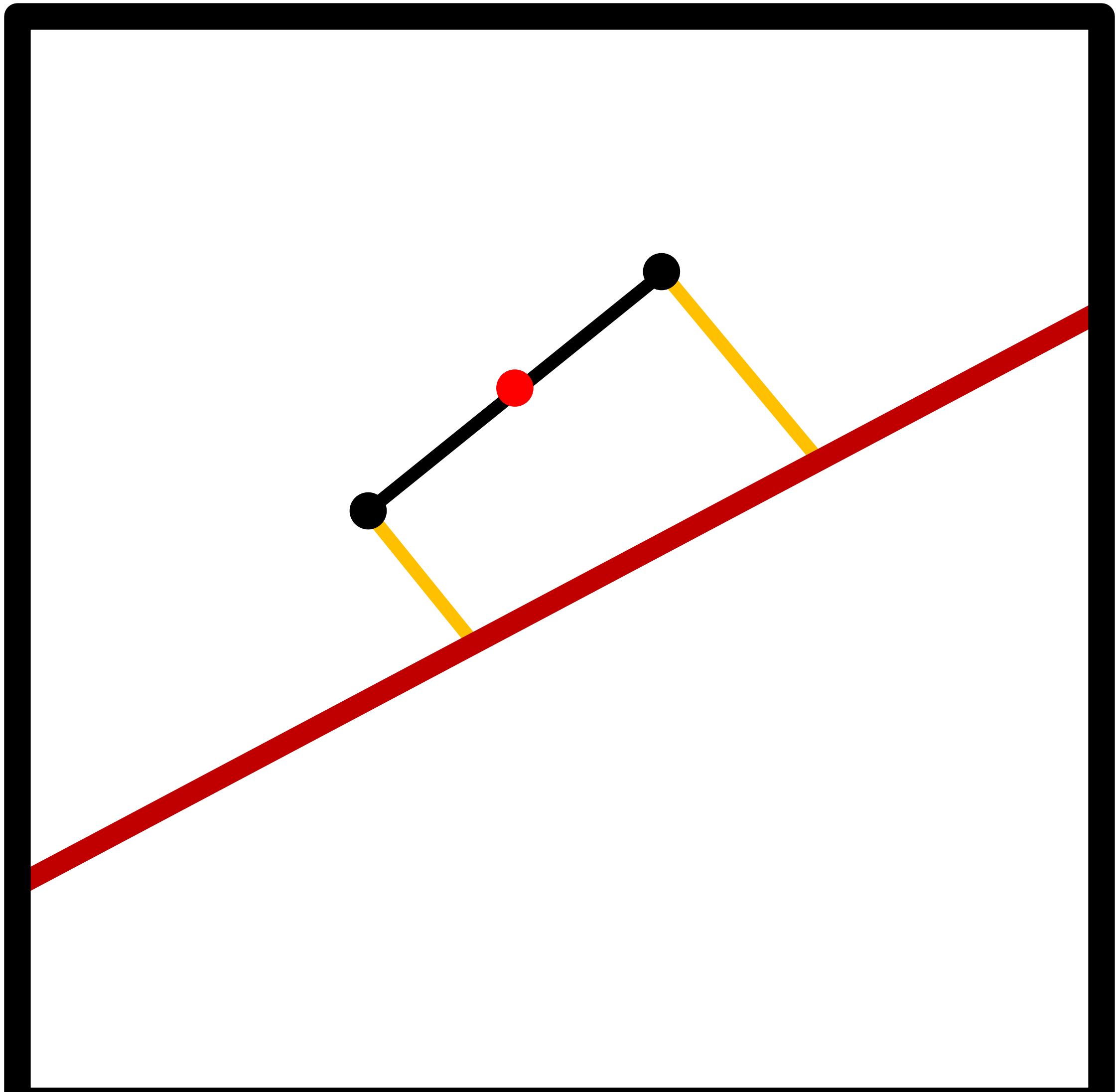


# Encode Displacement



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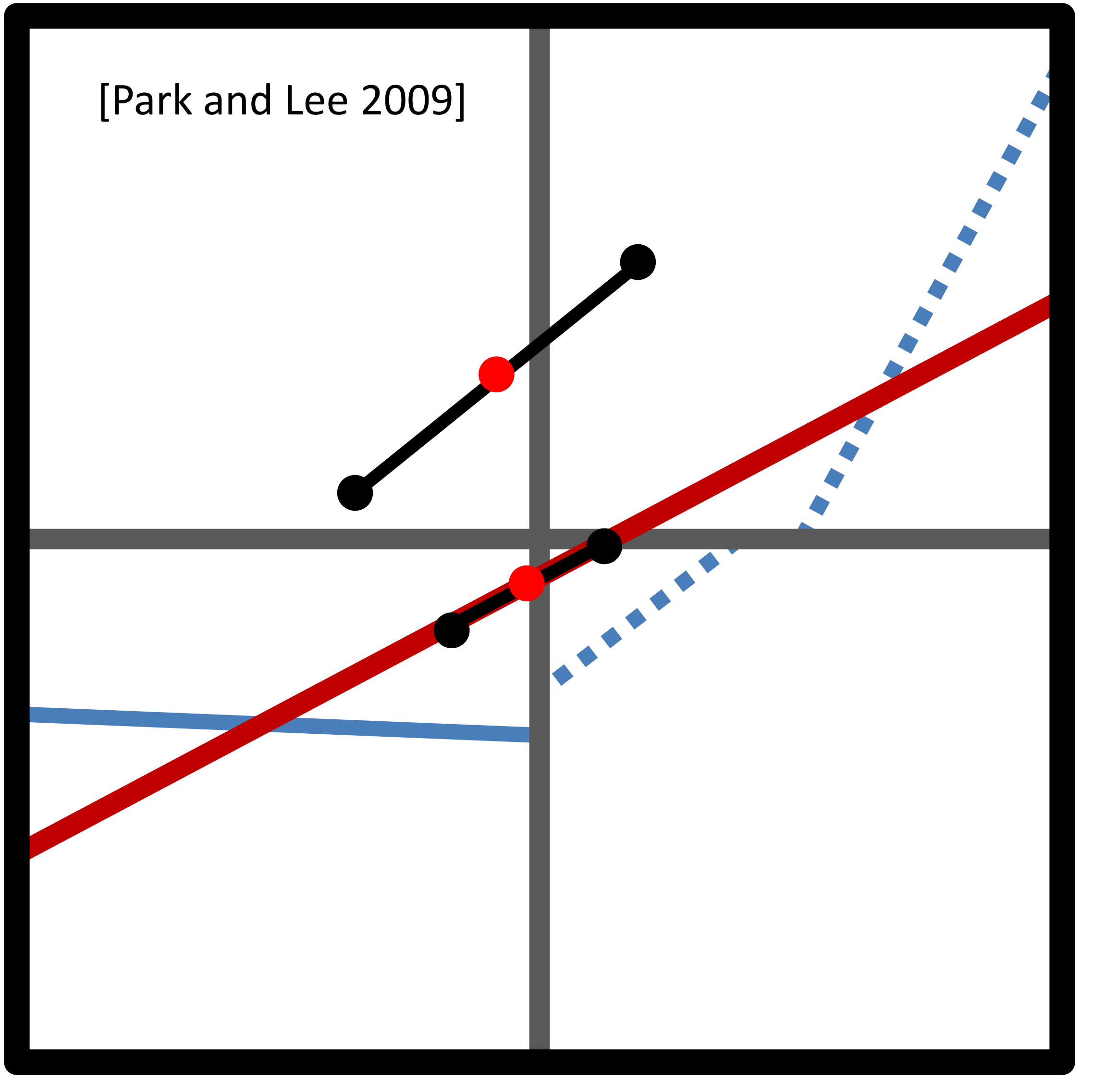

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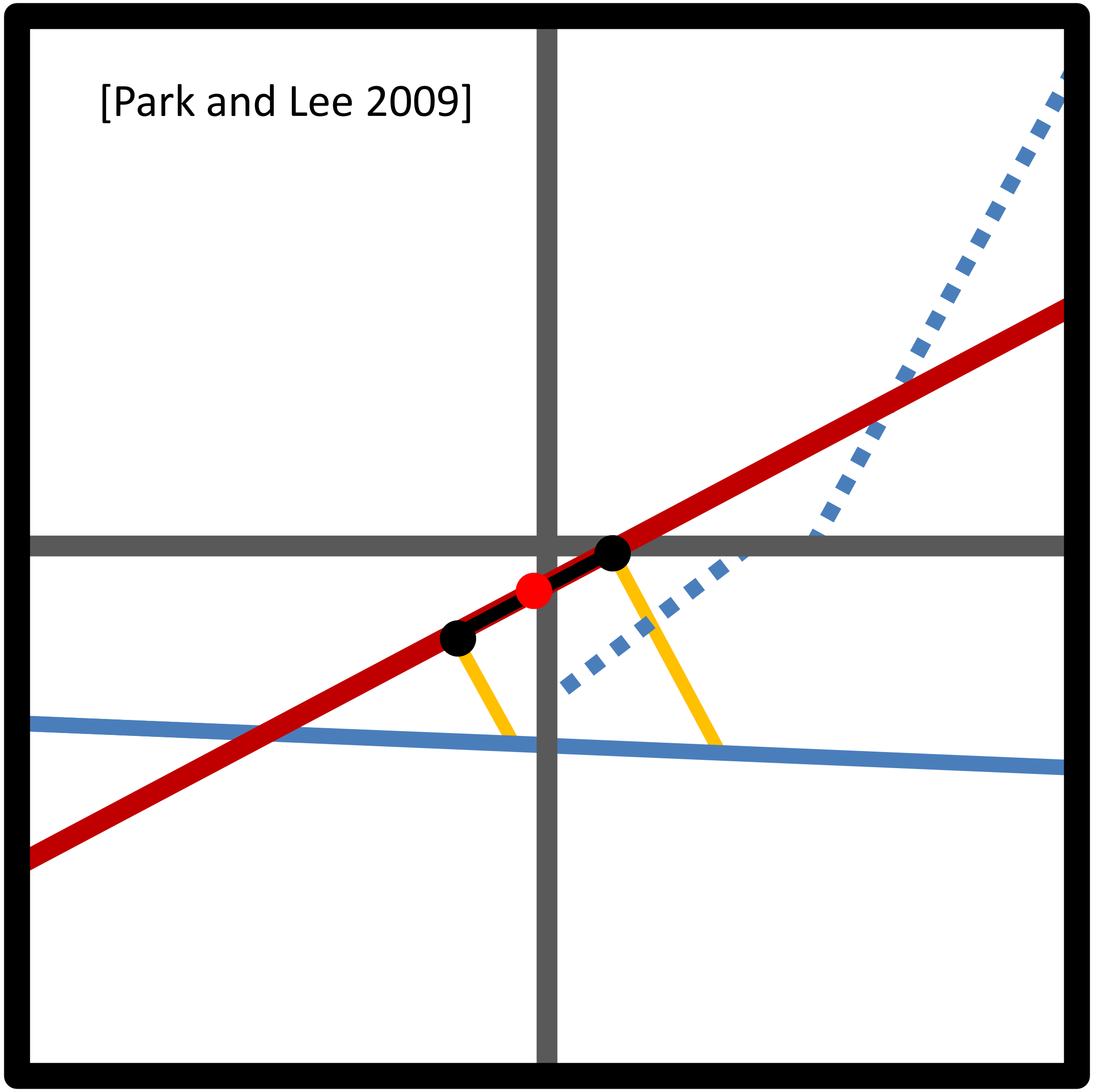

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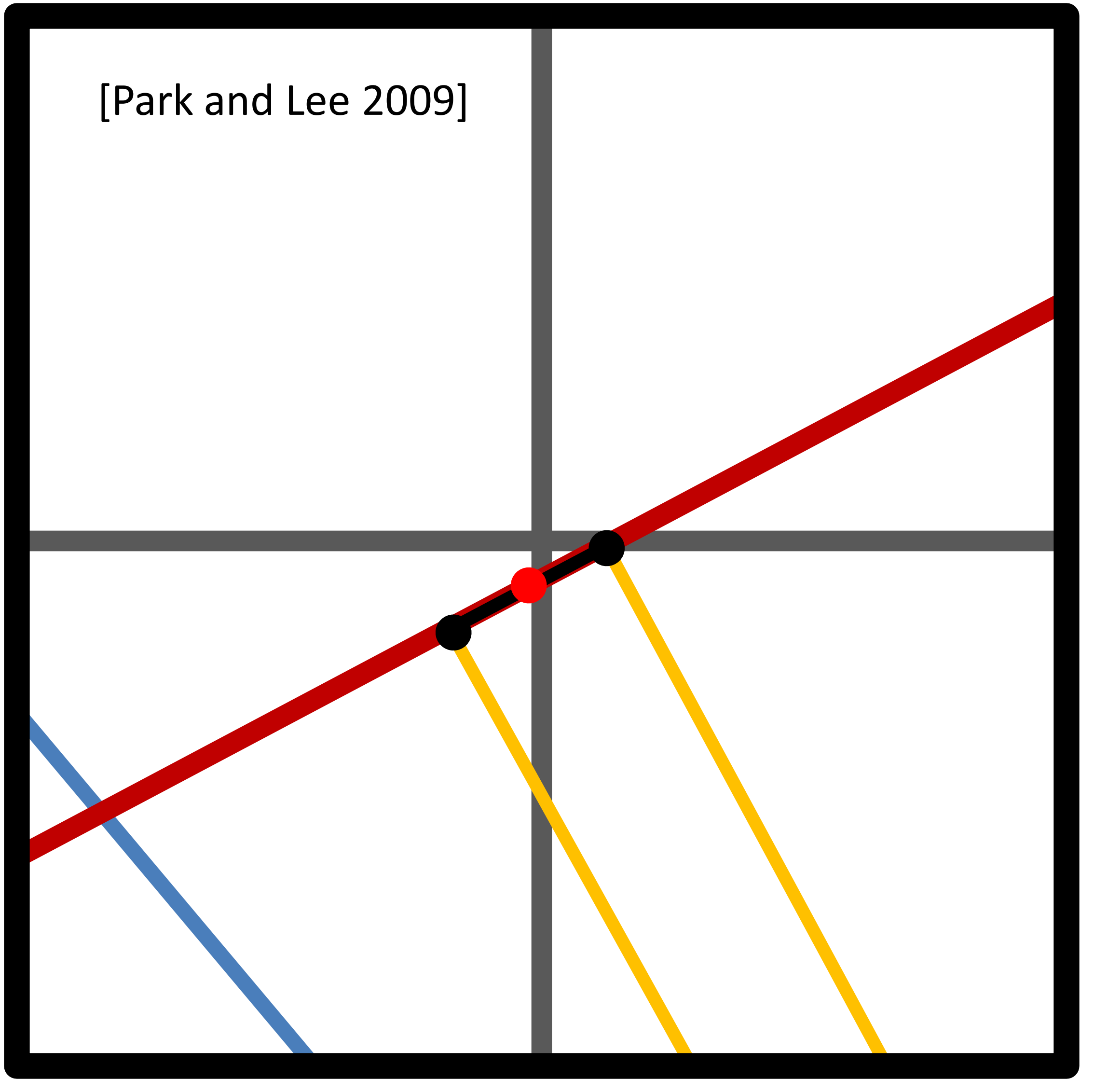

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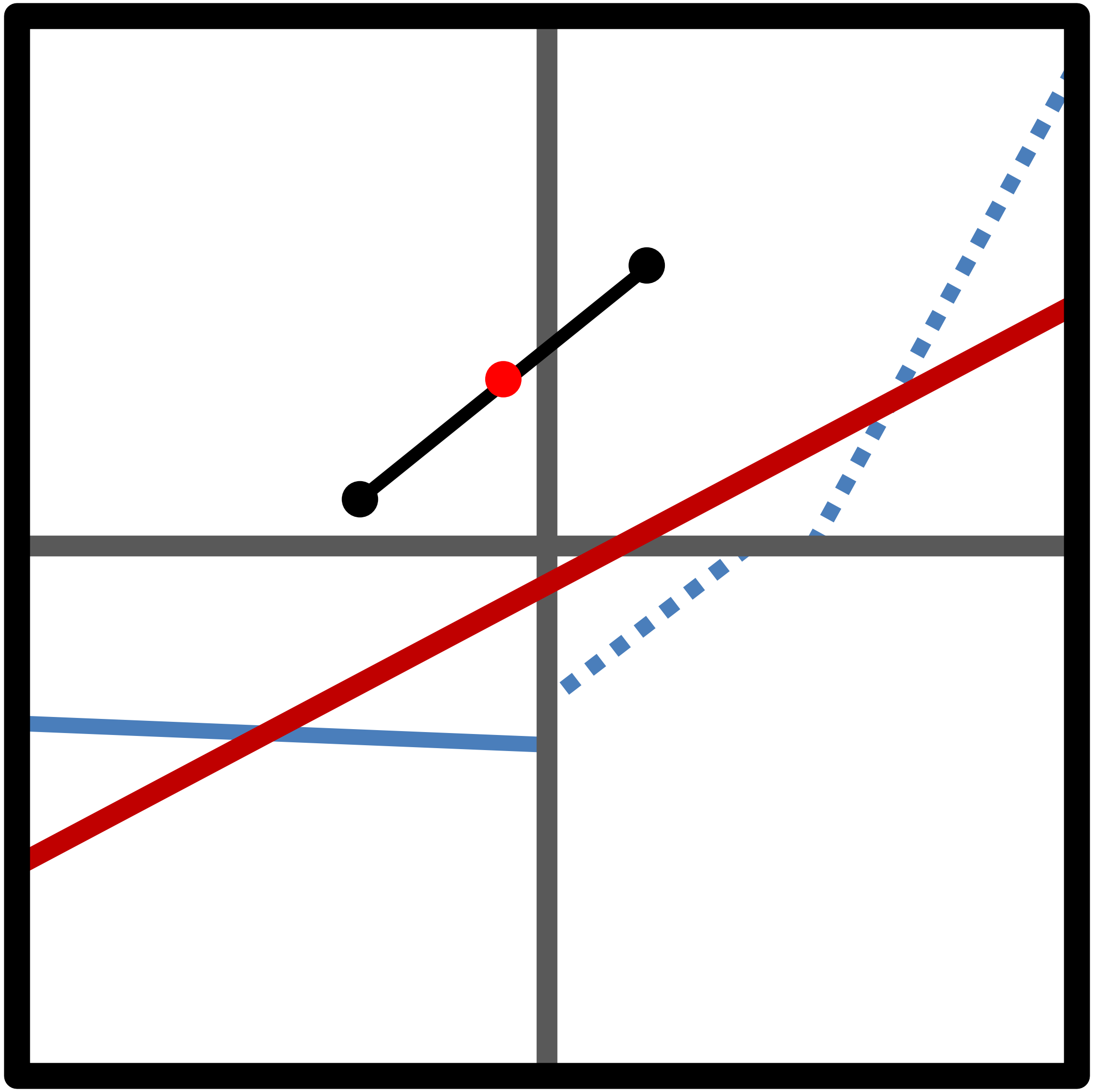

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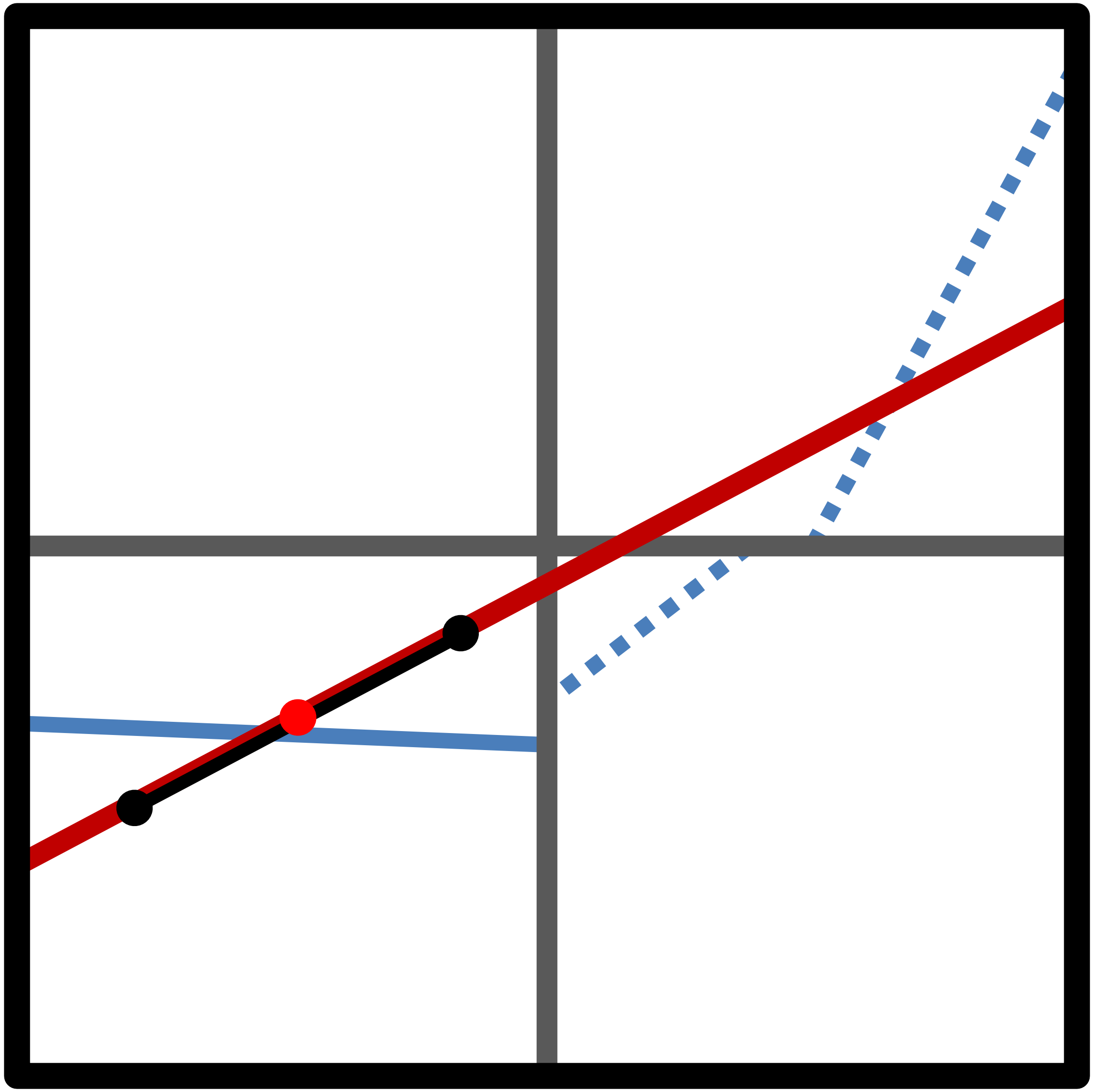

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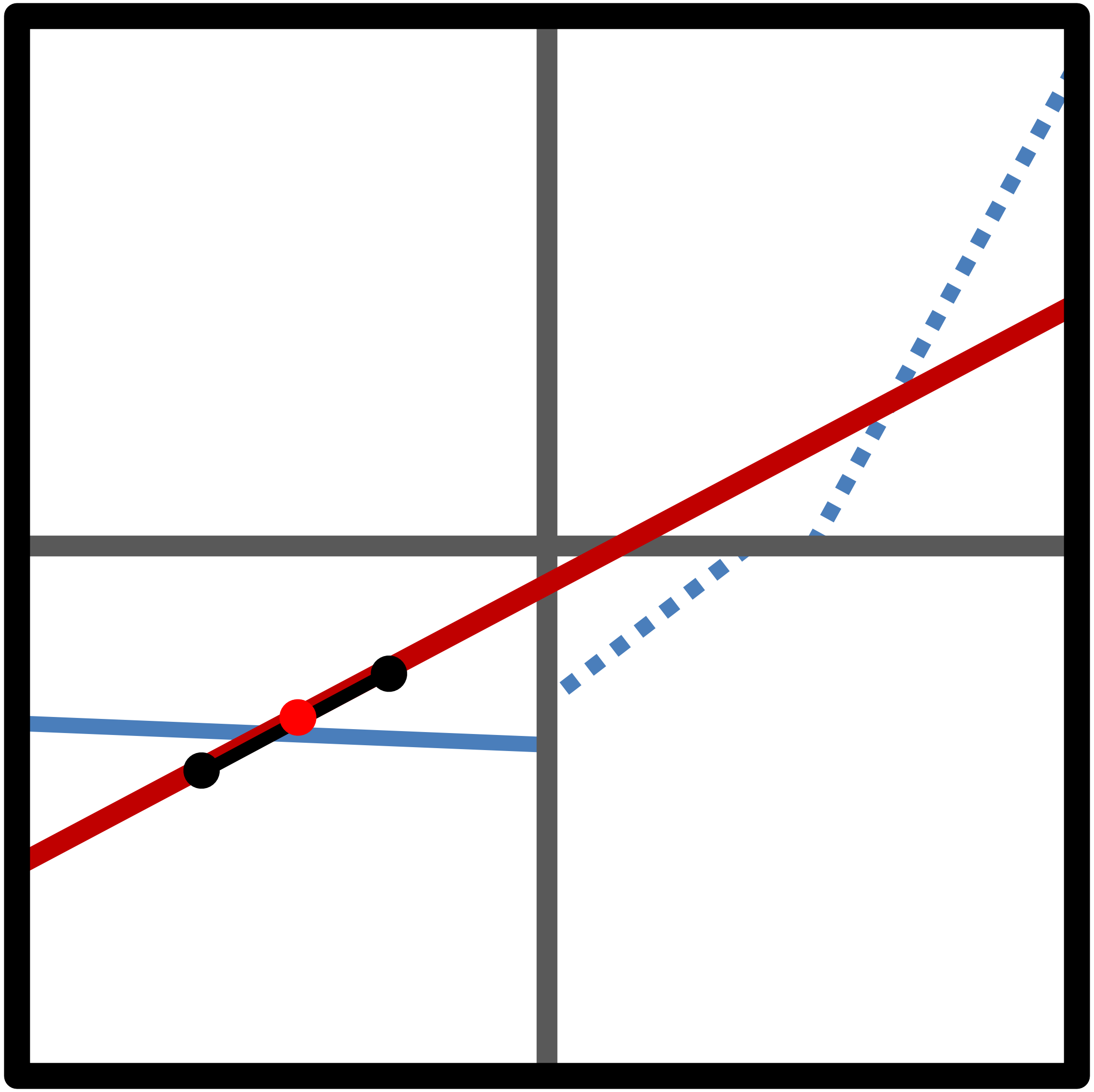

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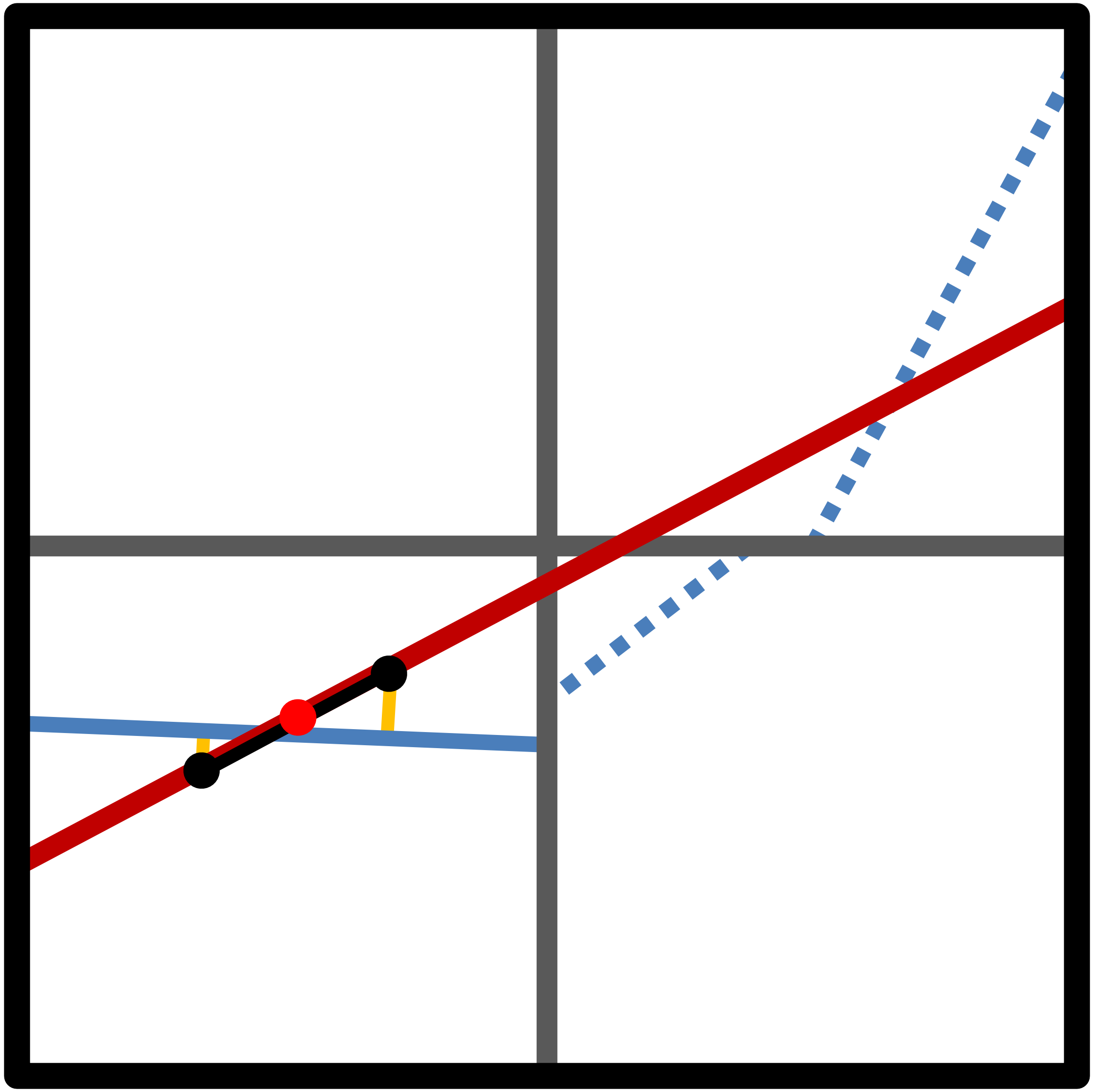

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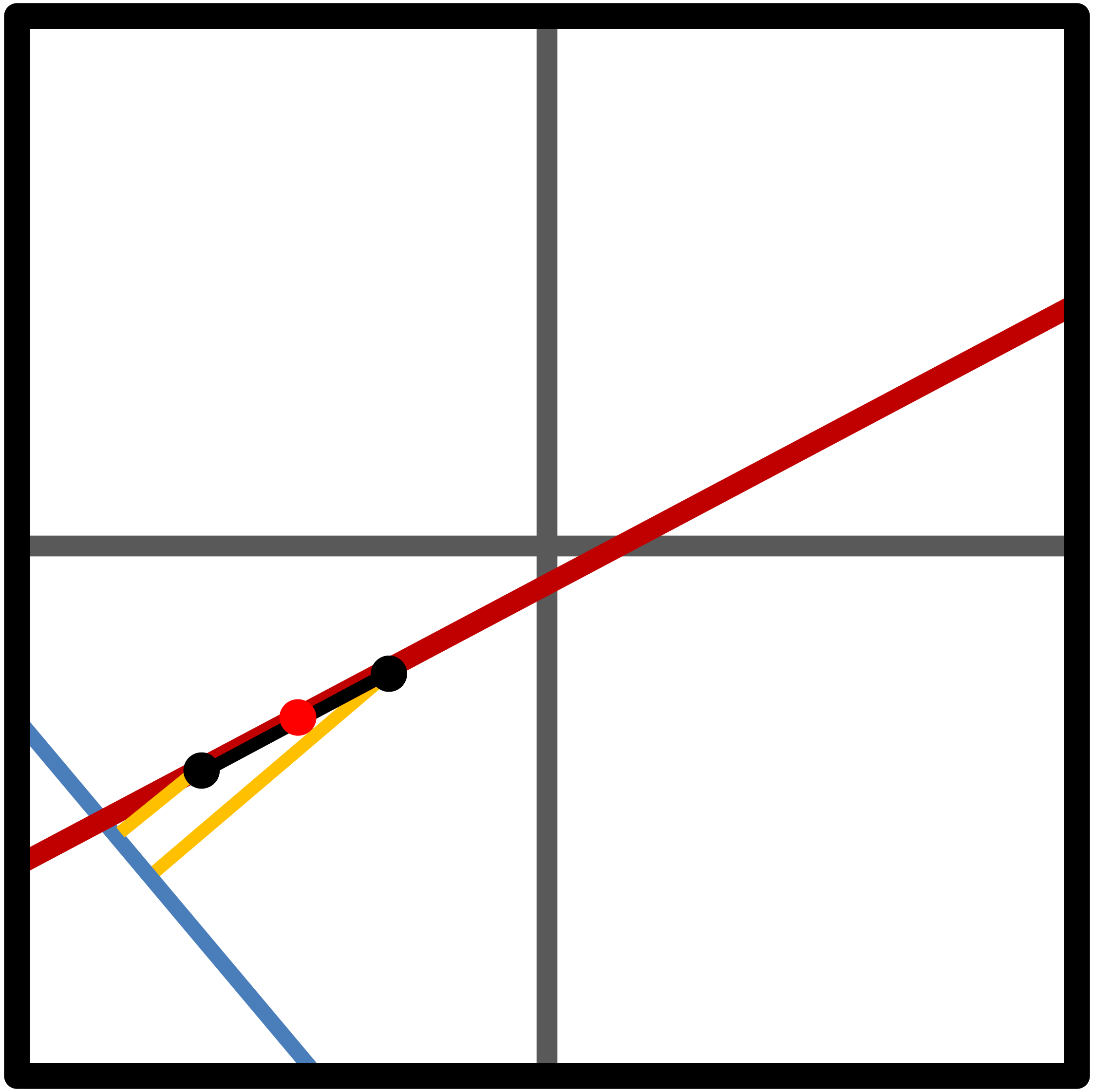
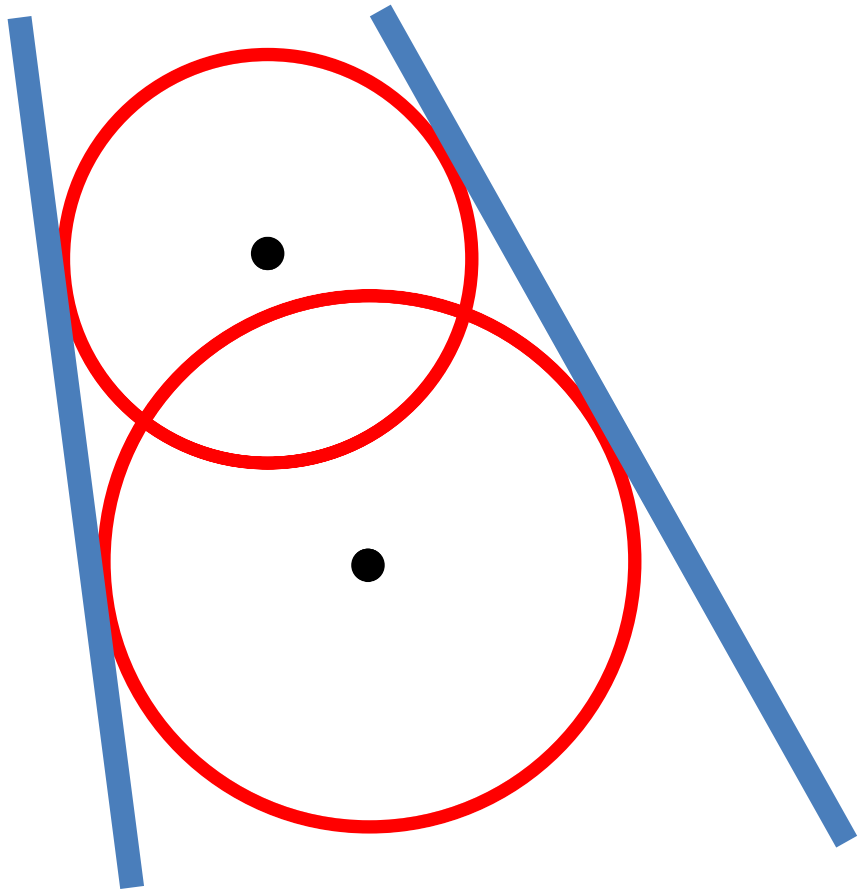
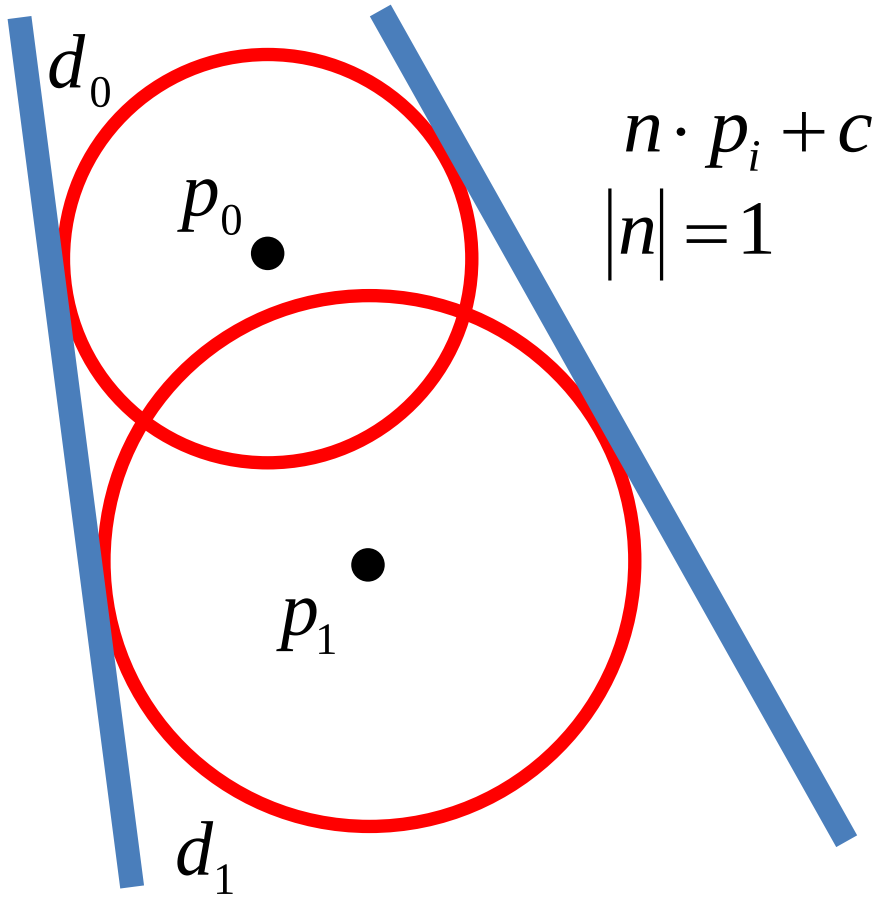


# Plane Solution



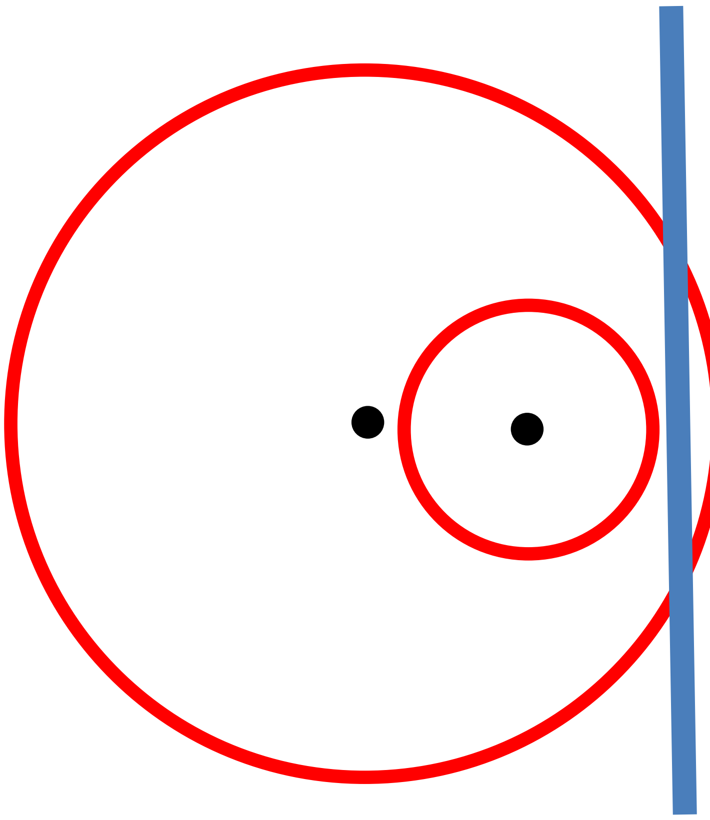
# Plane Solution



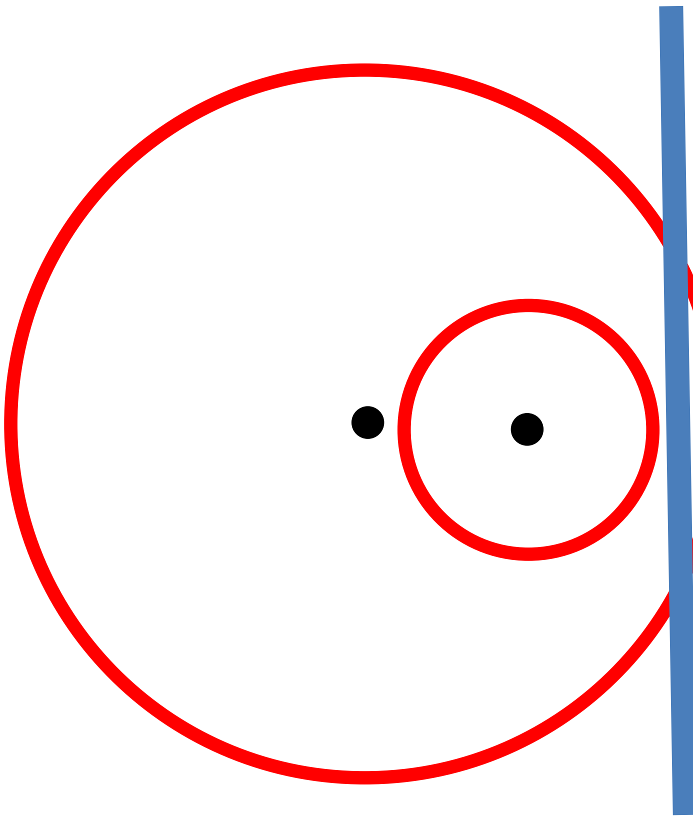

$$n \cdot p_i + c = d_i$$

$$|n| = 1$$

# Problem of Quantization



# Problem of Quantization

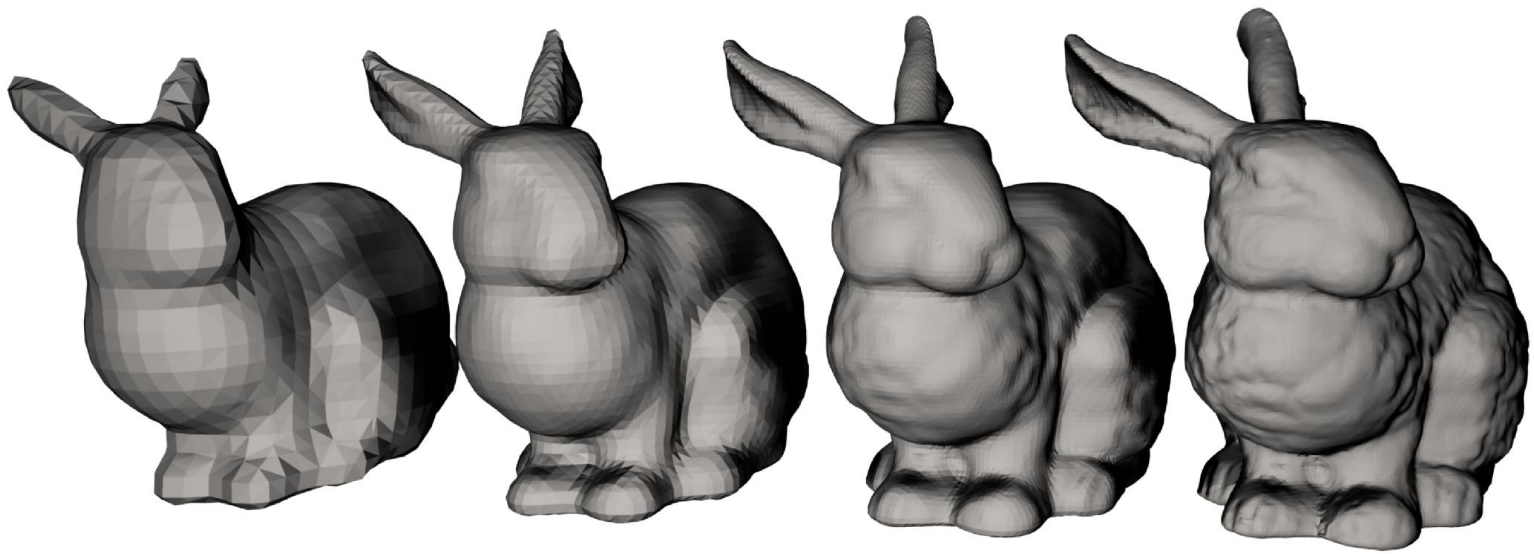


$$\min_{n} \; (|n|^2 - 1)^2$$

subject to

$$n \cdot p_i + c = d_i$$

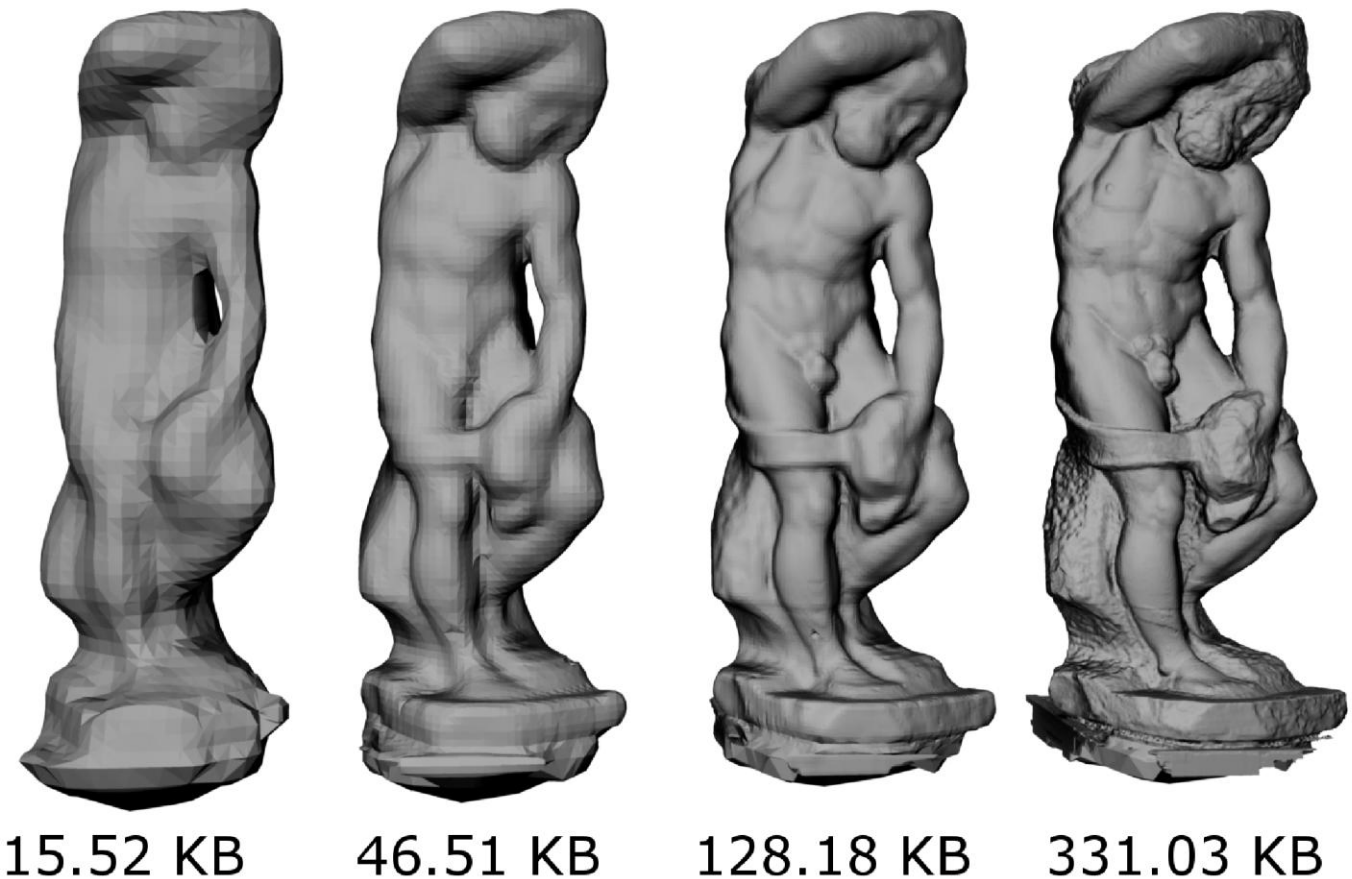
# Results



7.63 KB　22.46 KB　45.36 KB　53.14 KB

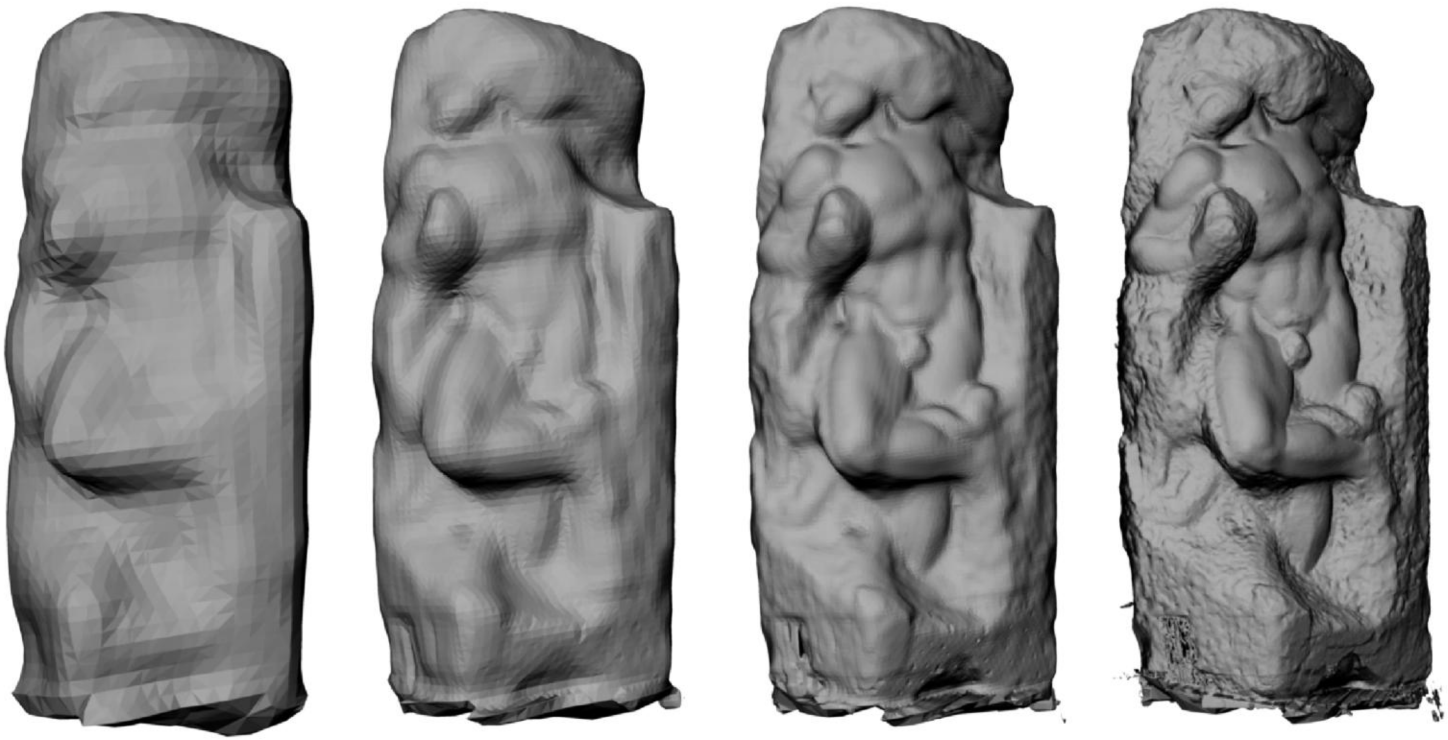
247,064 Polygons

# Results




1,990,811 Polygons

# Results



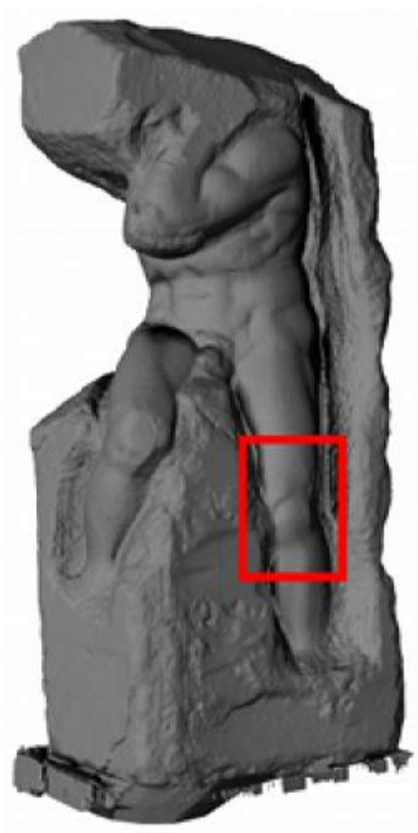
16.86 KB 51.41 KB 143.38 KB 235.86 KB

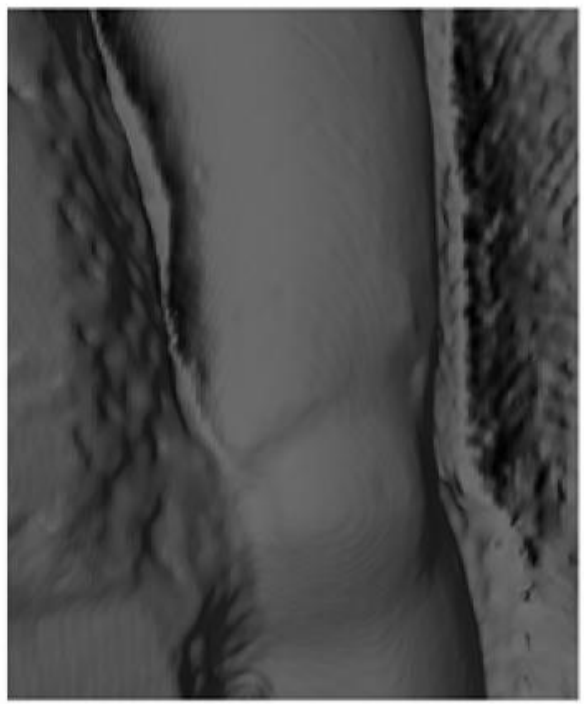
2,283,540 Polygons

# Comparison

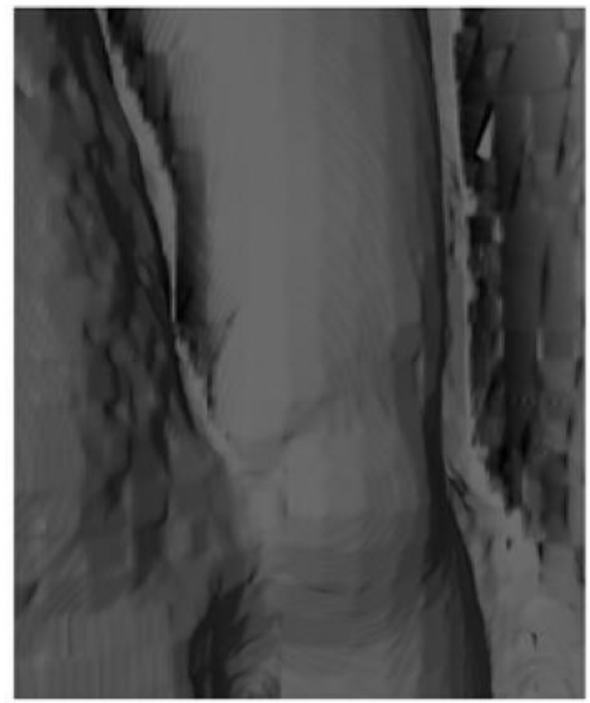
| Data Set | Num Points | Park and Lee | Ours |
|---|---|---|---|
| African Statue | 220,318 | 47.93 | 38.61 |
| Bunny | 362,272 | 154.37 | 53.14 |
| David Head | 4,520,803 | 405.33 | 282.47 |
| Atlas | 8,195,996 | 1269.63 | 309.99 |
| Awakening | 7,621,482 | 722.65 | 235.86 |
| Barbuto | 6,577,132 | 1030.25 | 331.03 |

# Comparison





Ours



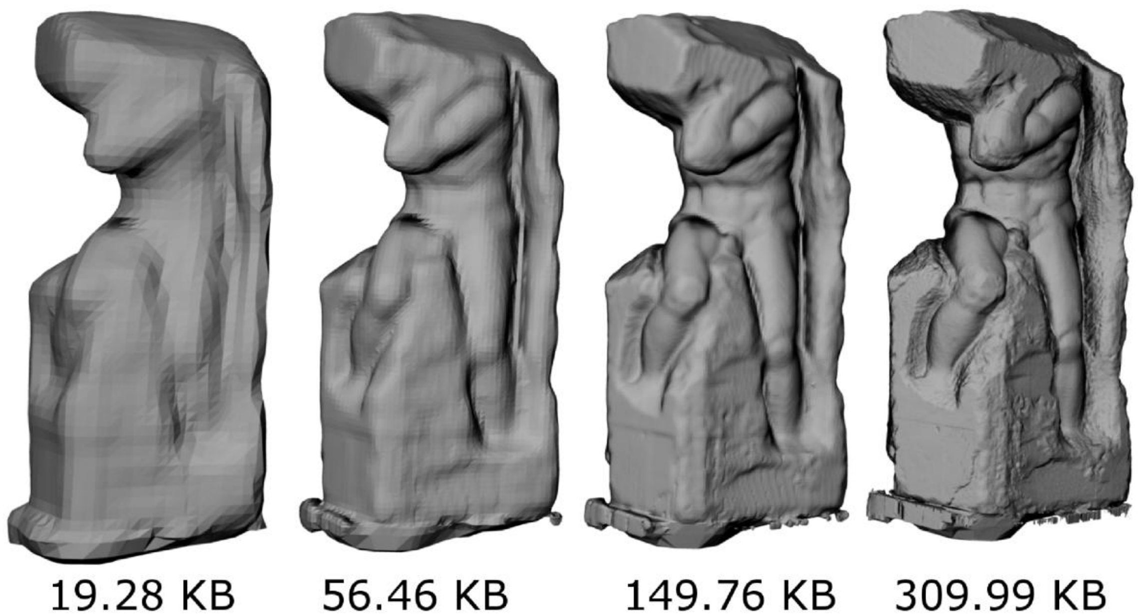
[Park and Lee 2009]

# Limitations

- No guarantee of topology or geometry of original model.
- Progressive nature does not allow for random access to arbitrary data in the model

# Conclusion

- Our algorithm is fast
- Outperforms other state of the art methods




2,685,874 Polygons