SIGGRAPH ASIA 2012

Embracing the digital convergence

CONFERENCE 28 Nov - 1 Dec
EXHIBITION 29 Nov - 1 Dec
Singapore EXPO

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www.SIGGRAPH.org/ASIA2012

Foveated 3D Graphics

Brian Guenter Mark Finch Steven Drucker
Desney Tan John Snyder

Microsoft Research

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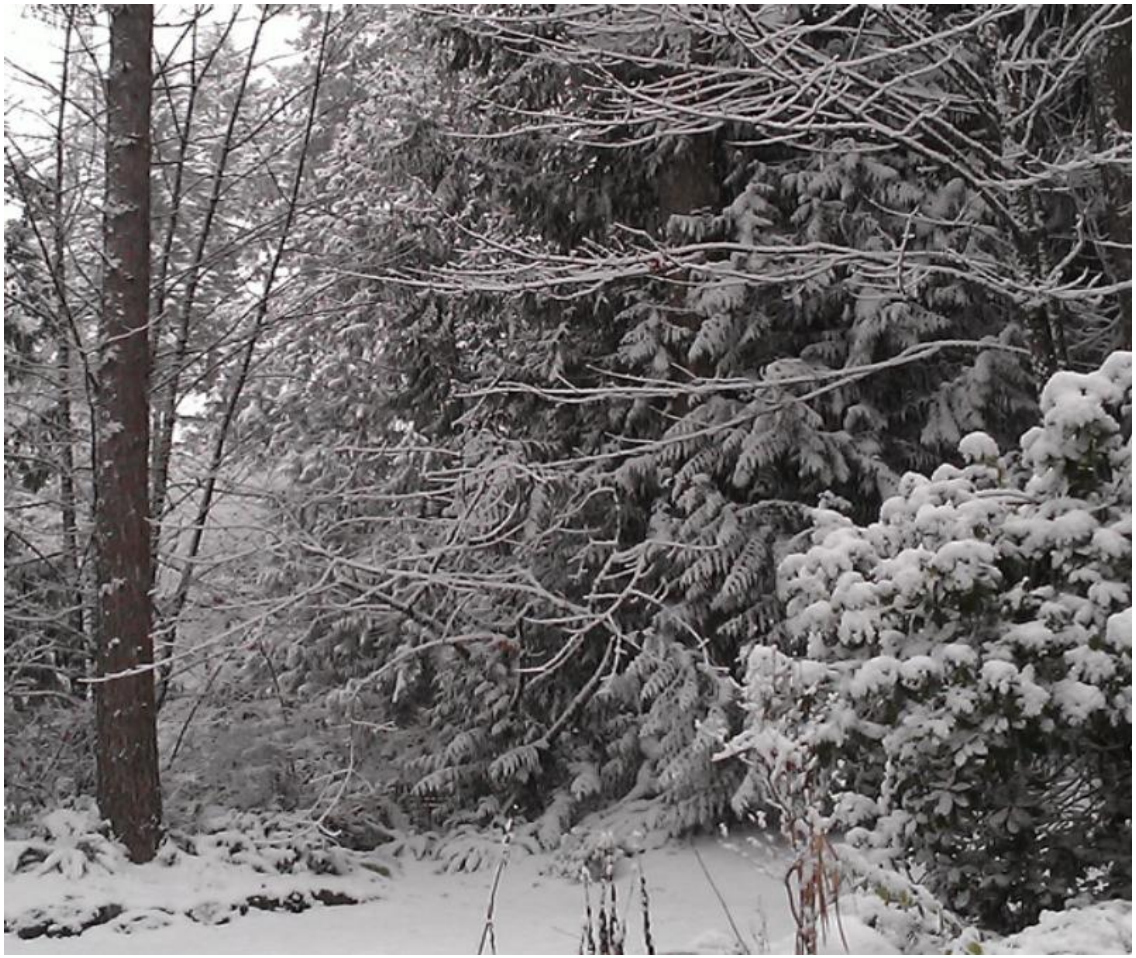
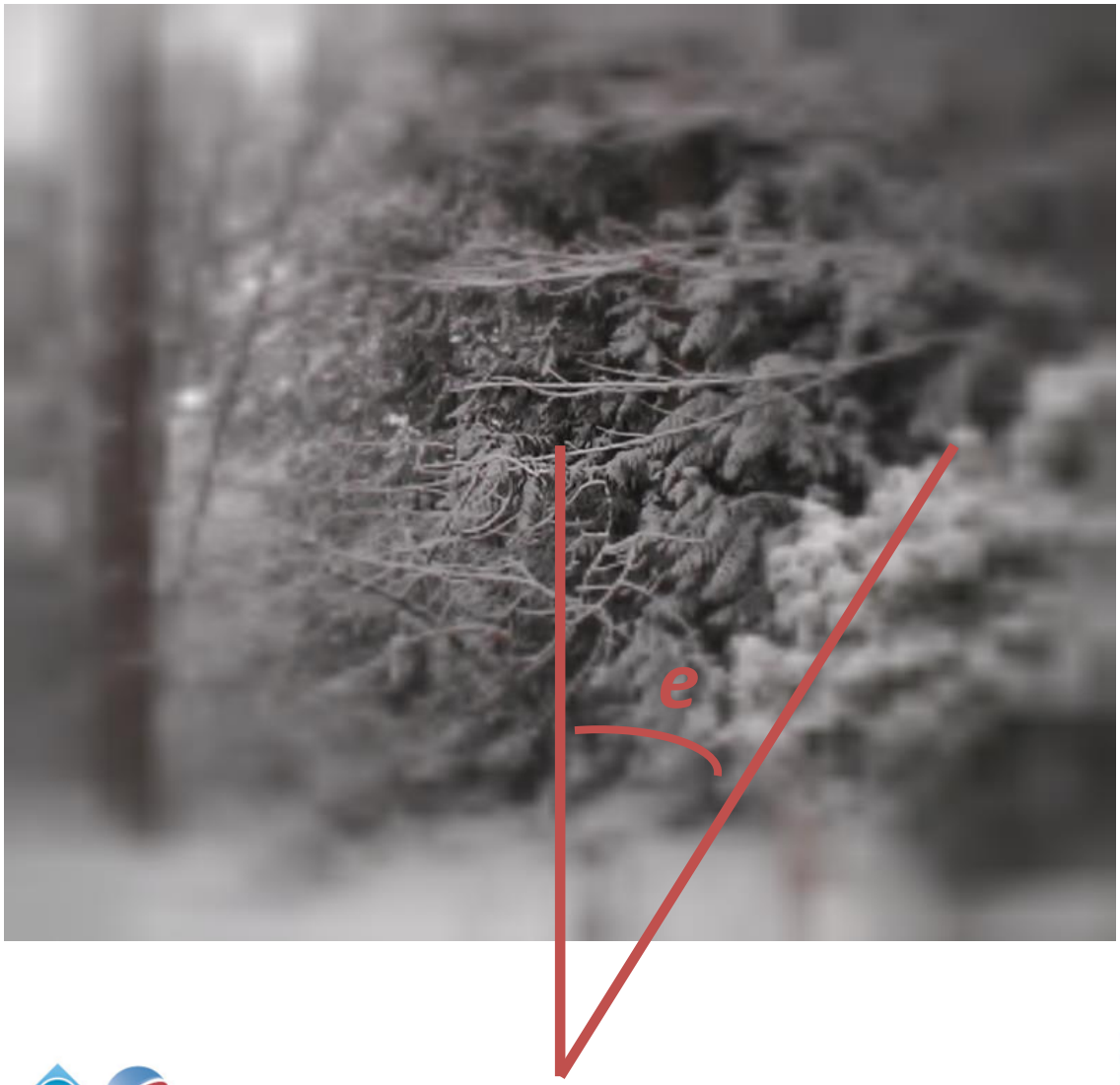
High resolution image



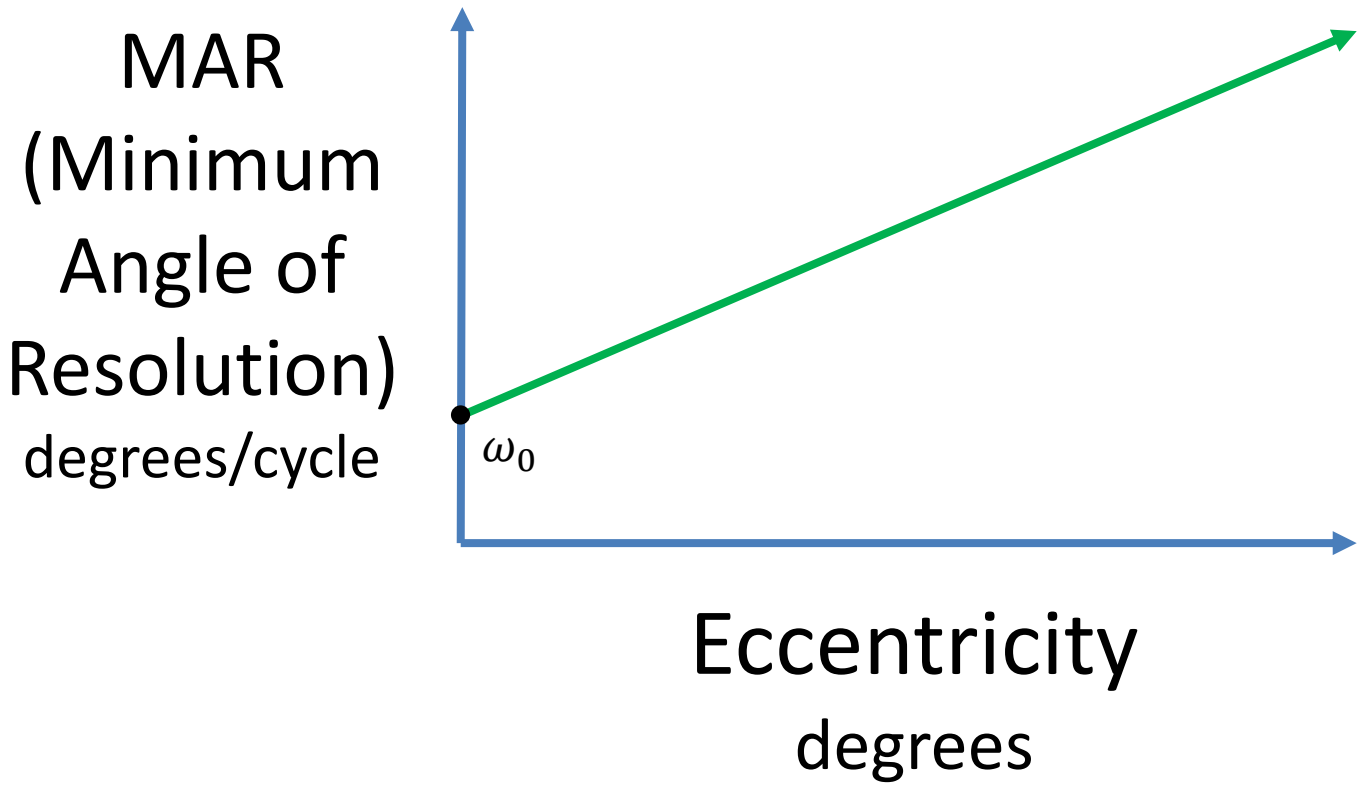
Foveal vision: 2° - 5°

Acuity falloff with eccentricity ***e***



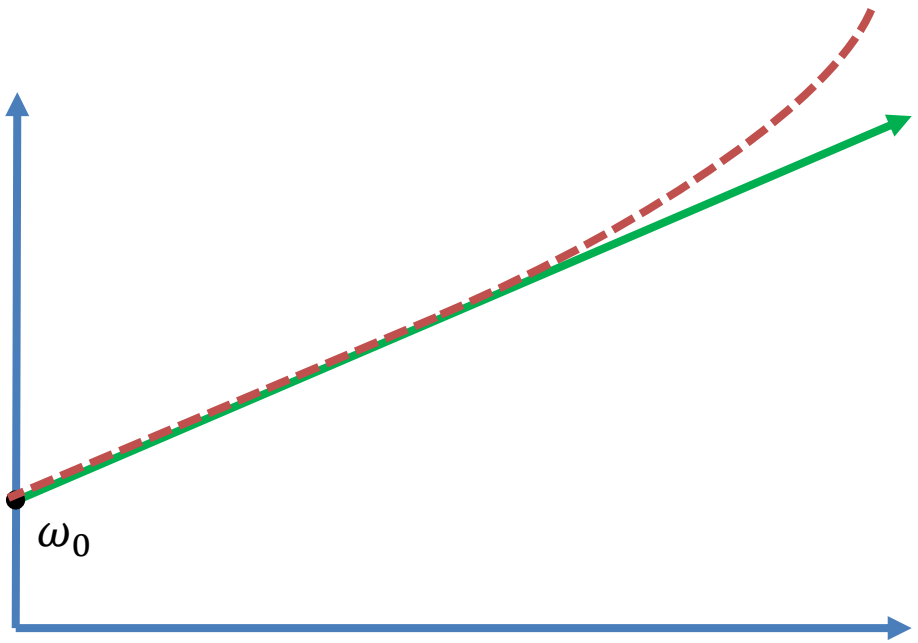
Using Foveation

Human vision model



Human vision model

MAR (Minimum Angle of Resolution)
degrees/cycle



Eccentricity
degrees

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Human vision model

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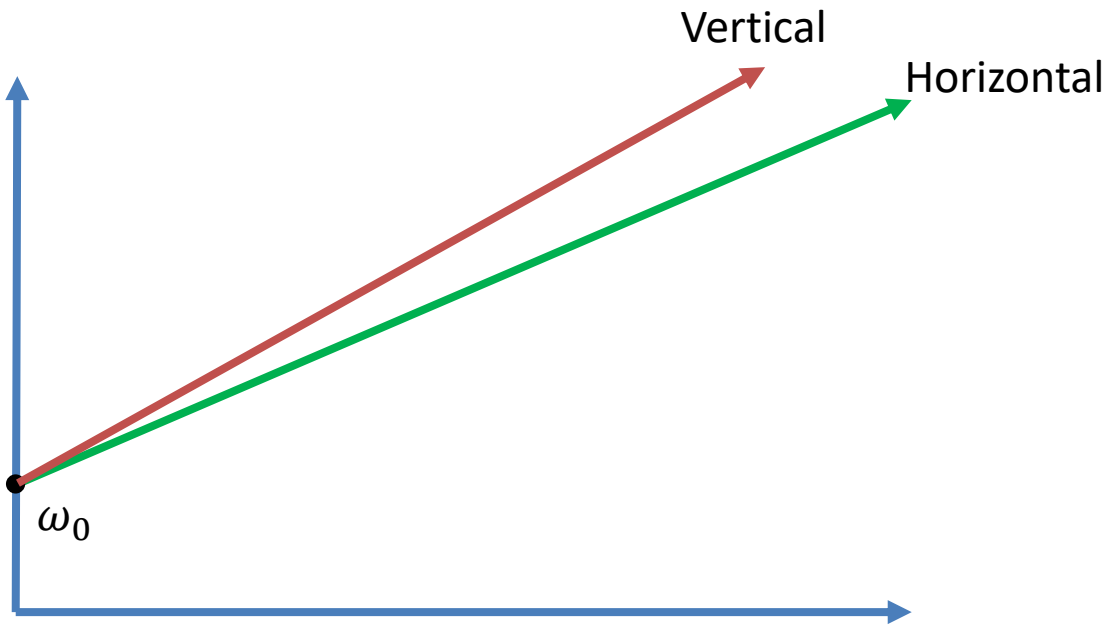

Eccentricity
degrees

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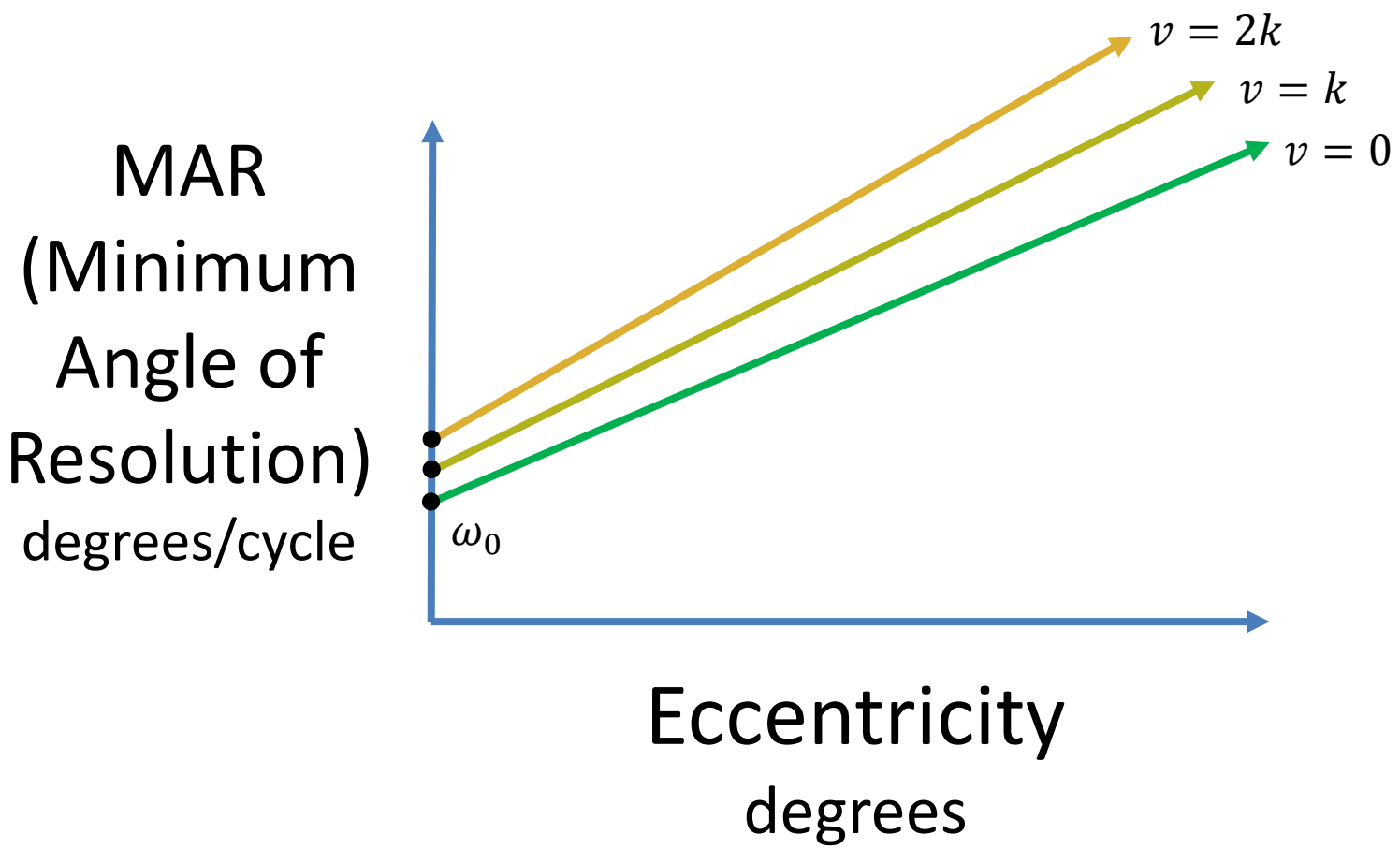
Human vision model



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Related Work

- 2D Systems
  - Watson et al. 1997
  - Watson et al. 2004
  - Lochsky & McConkie 2000
  - Duchowsky 2007

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Related Work

- 3D Rendering – Model based
  - Ohshima et al. 1996
  - Lubke et al. 2000
  - Reddy 2001

- 3D Rendering – Image based/hybrid
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  - Murphy & Duchowski 2007

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3D Rendering

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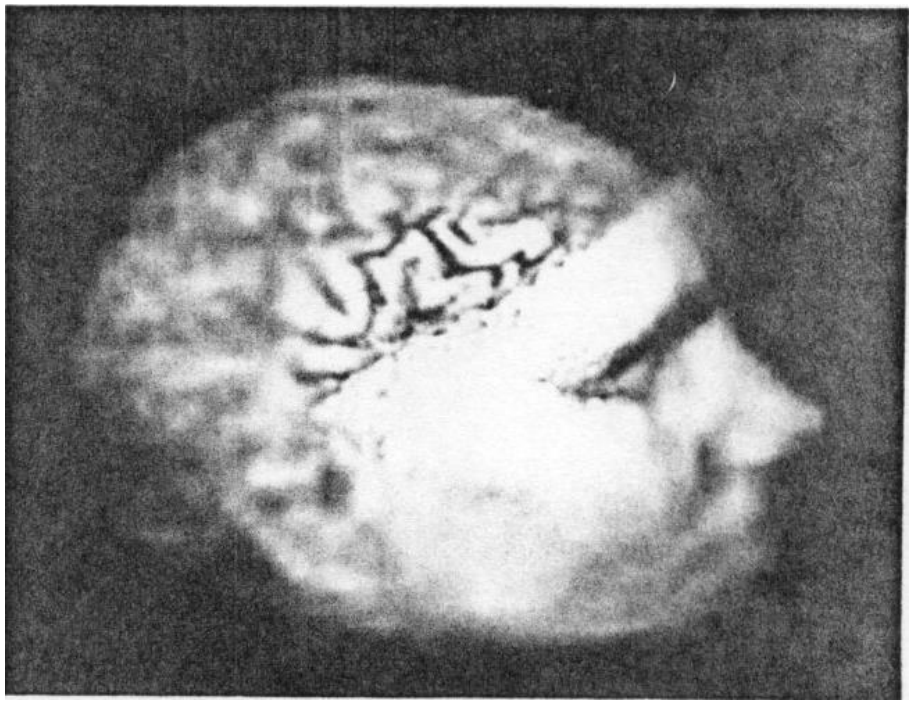

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3D Rendering

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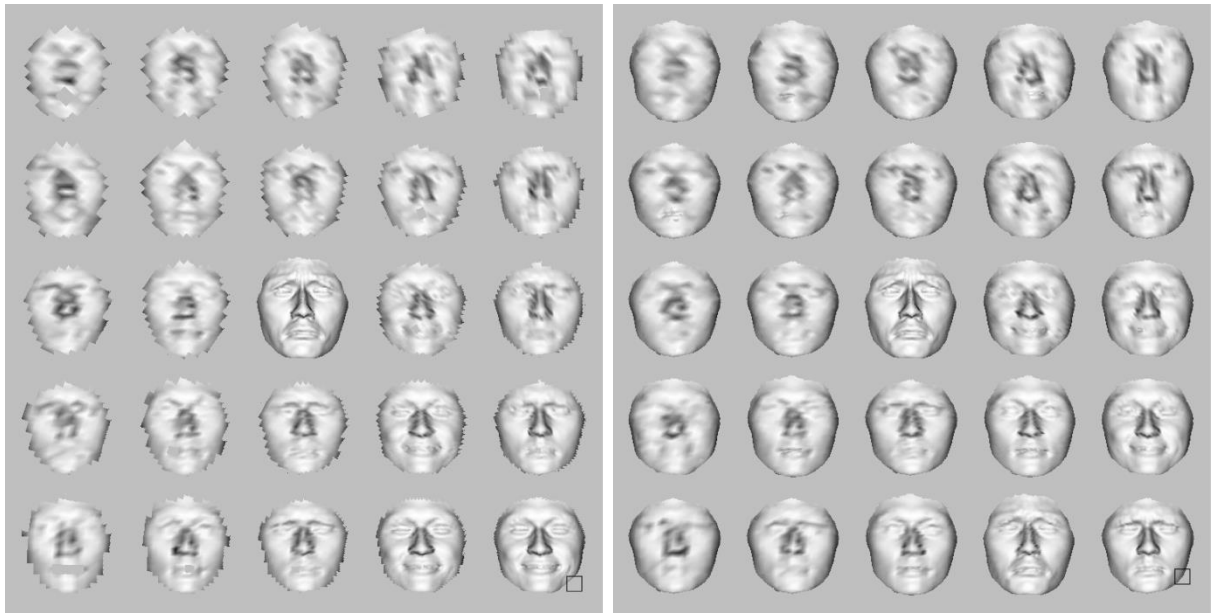
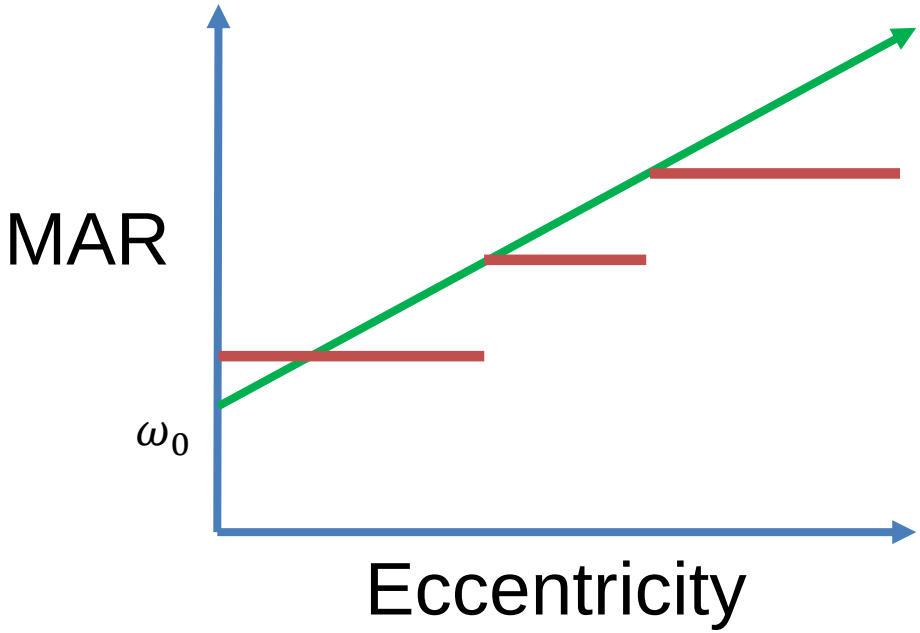
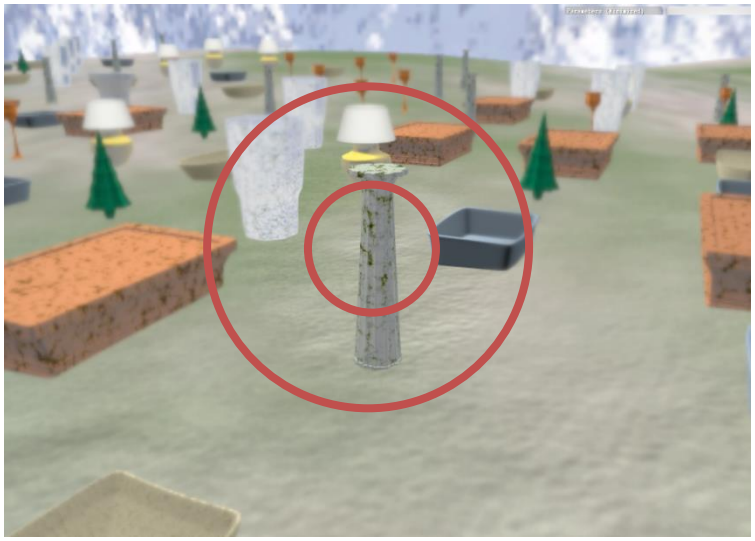


Foveated 3D Display





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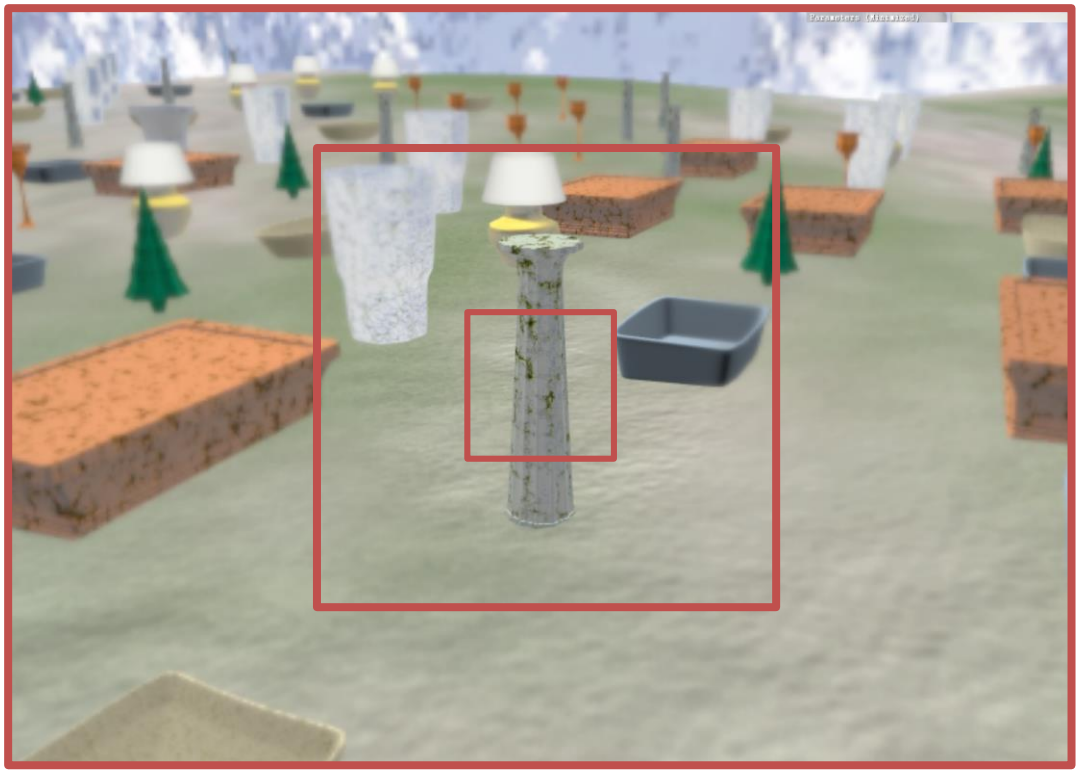
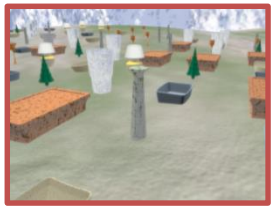
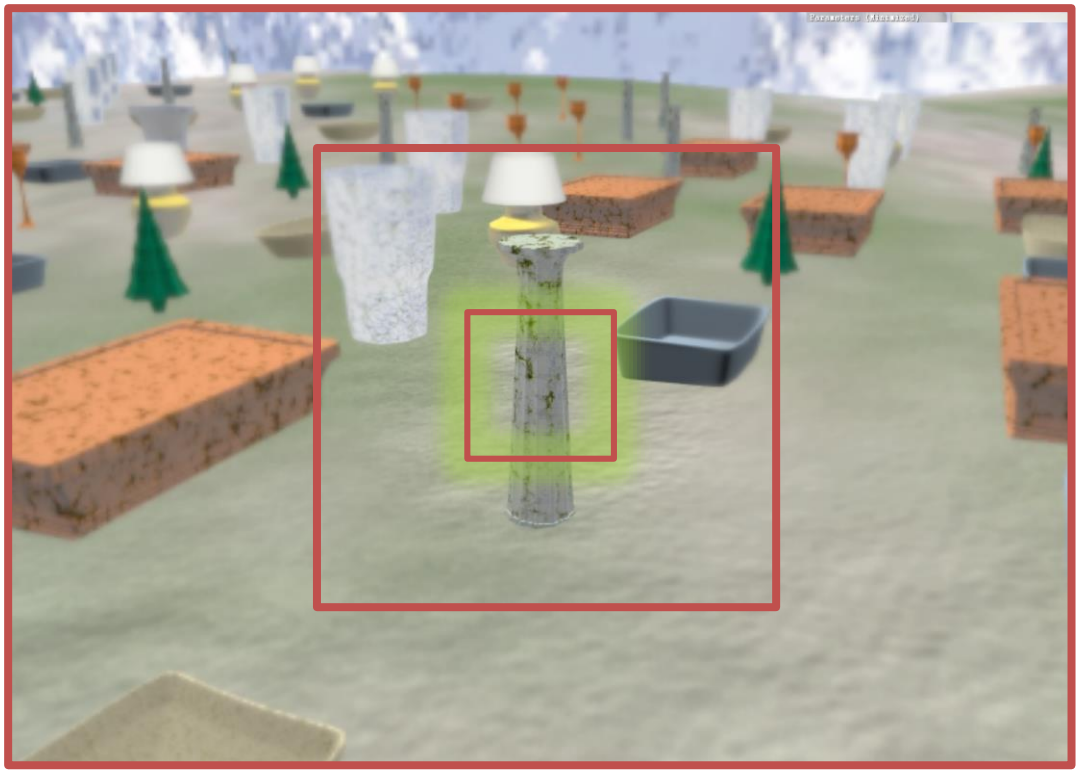




Foveated 3D Display



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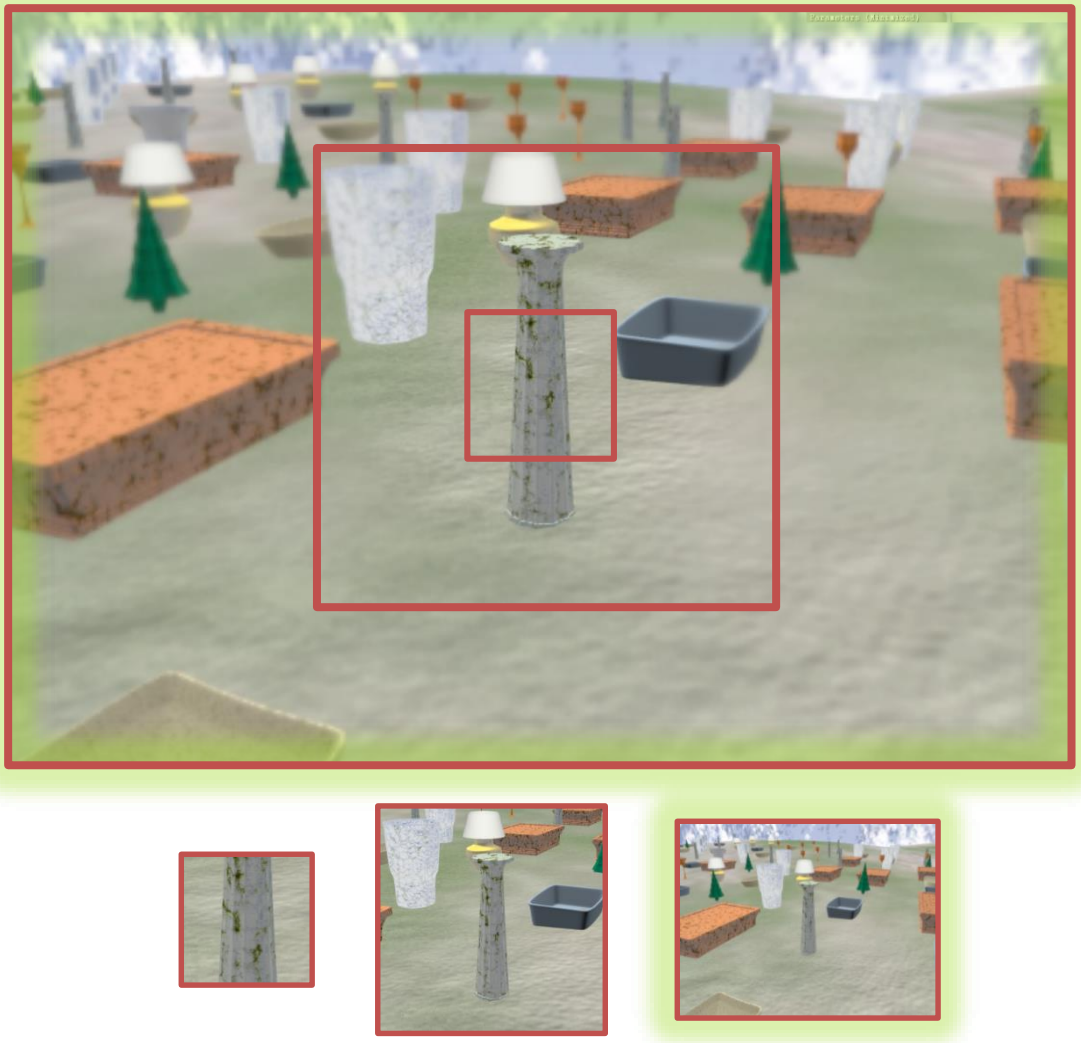

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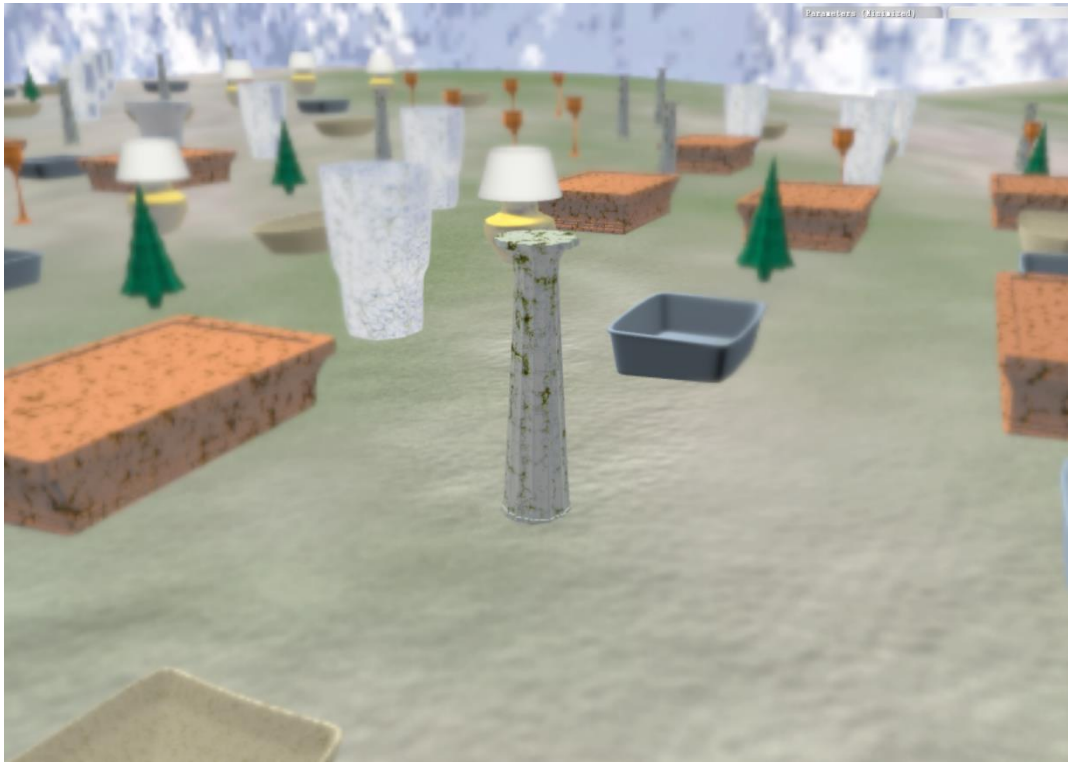

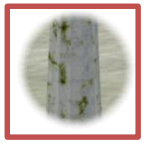

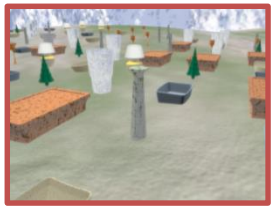

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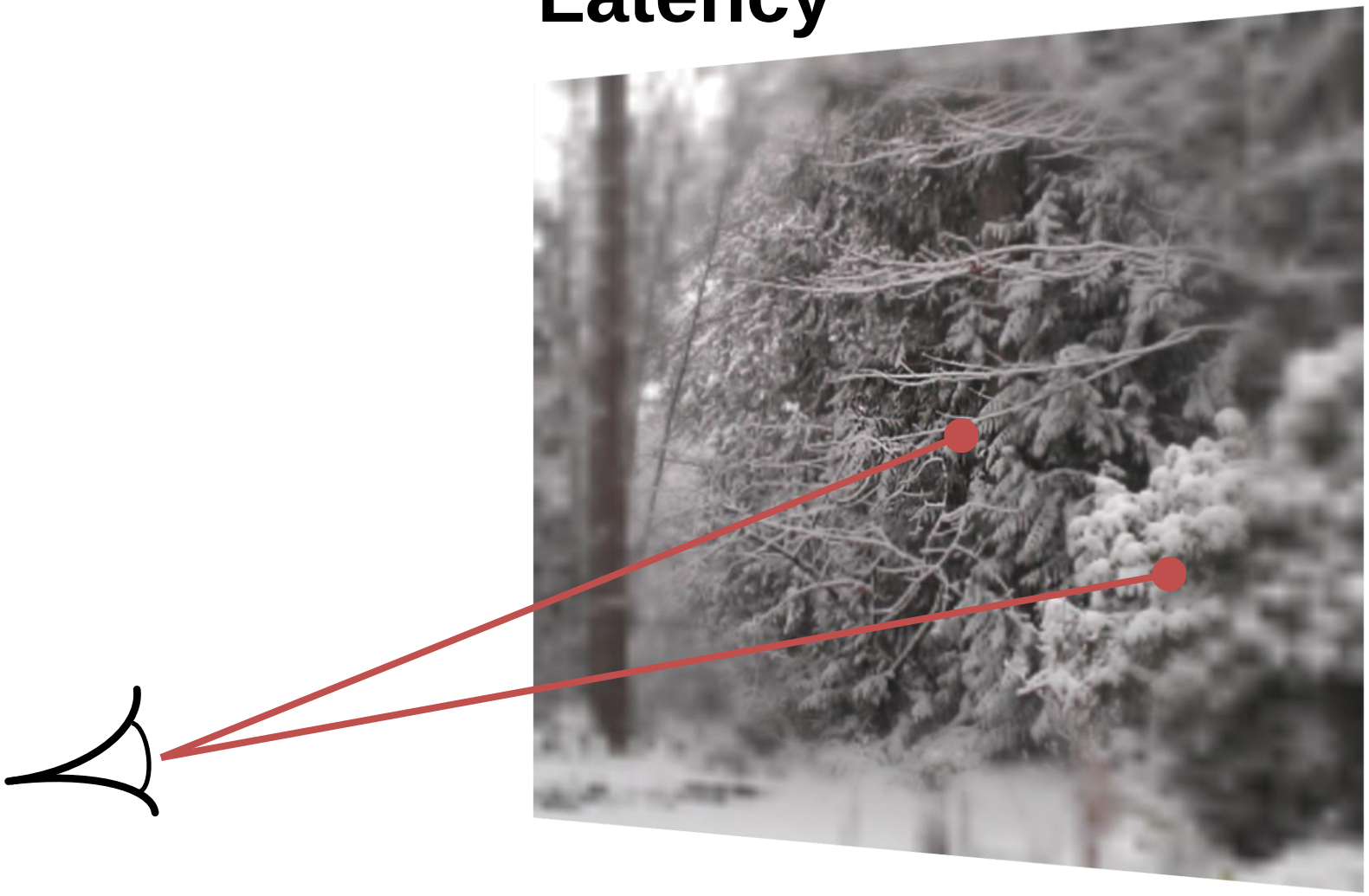
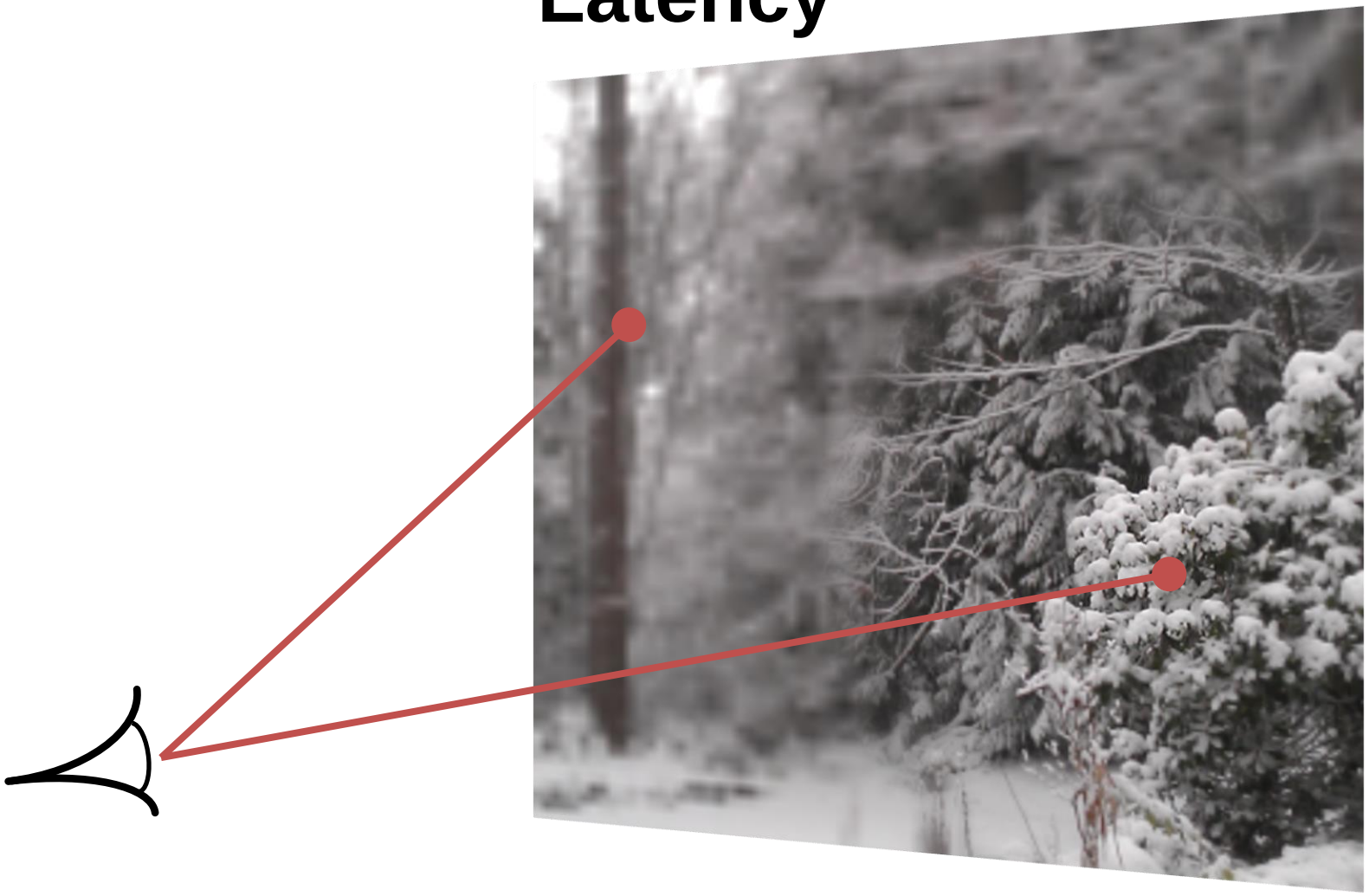
Challenges

- Latency
- Adaptable to general rendering
- Suitable for modern GPUs
- Aliasing
- Parameter selection

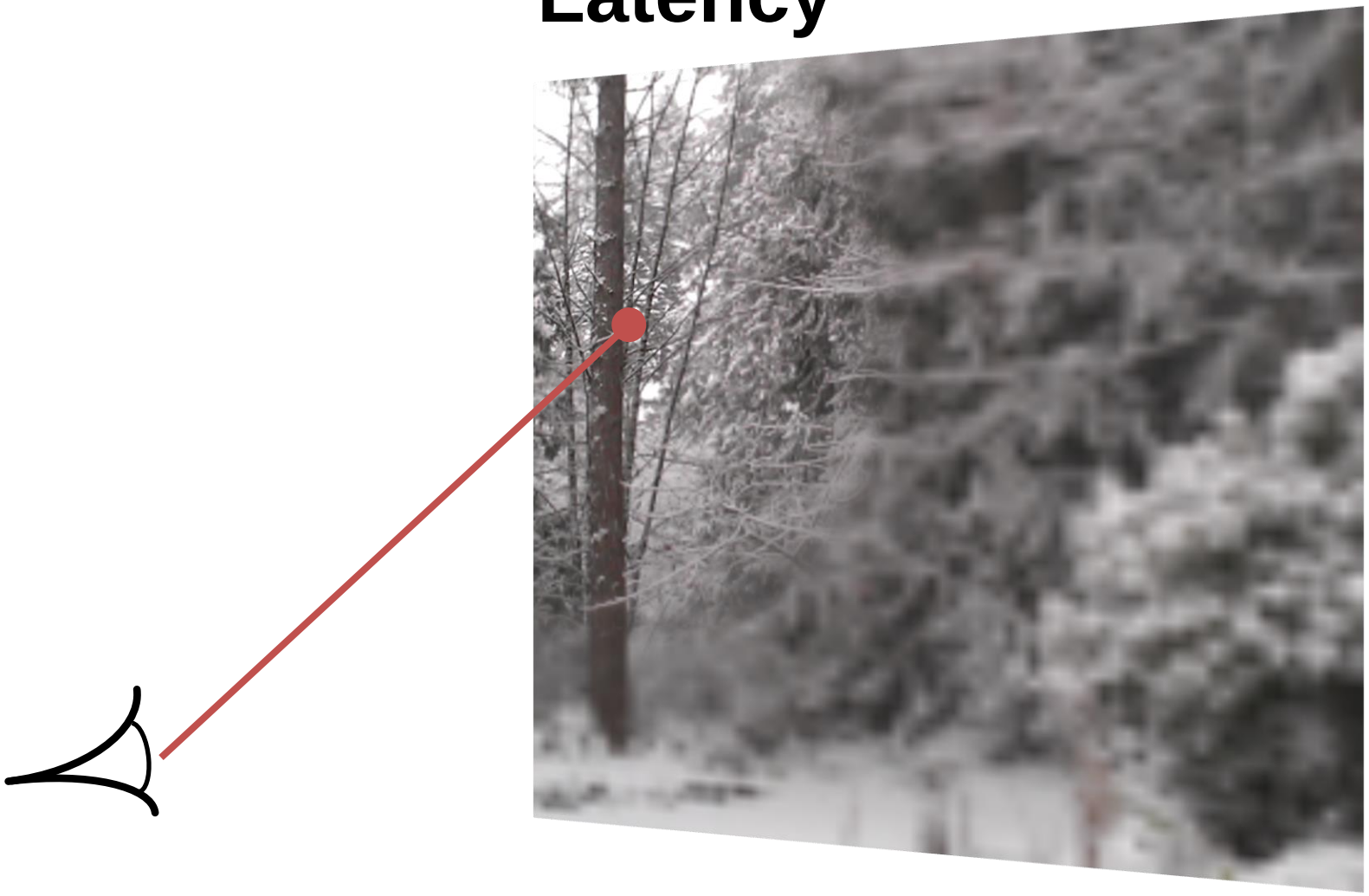
Latency



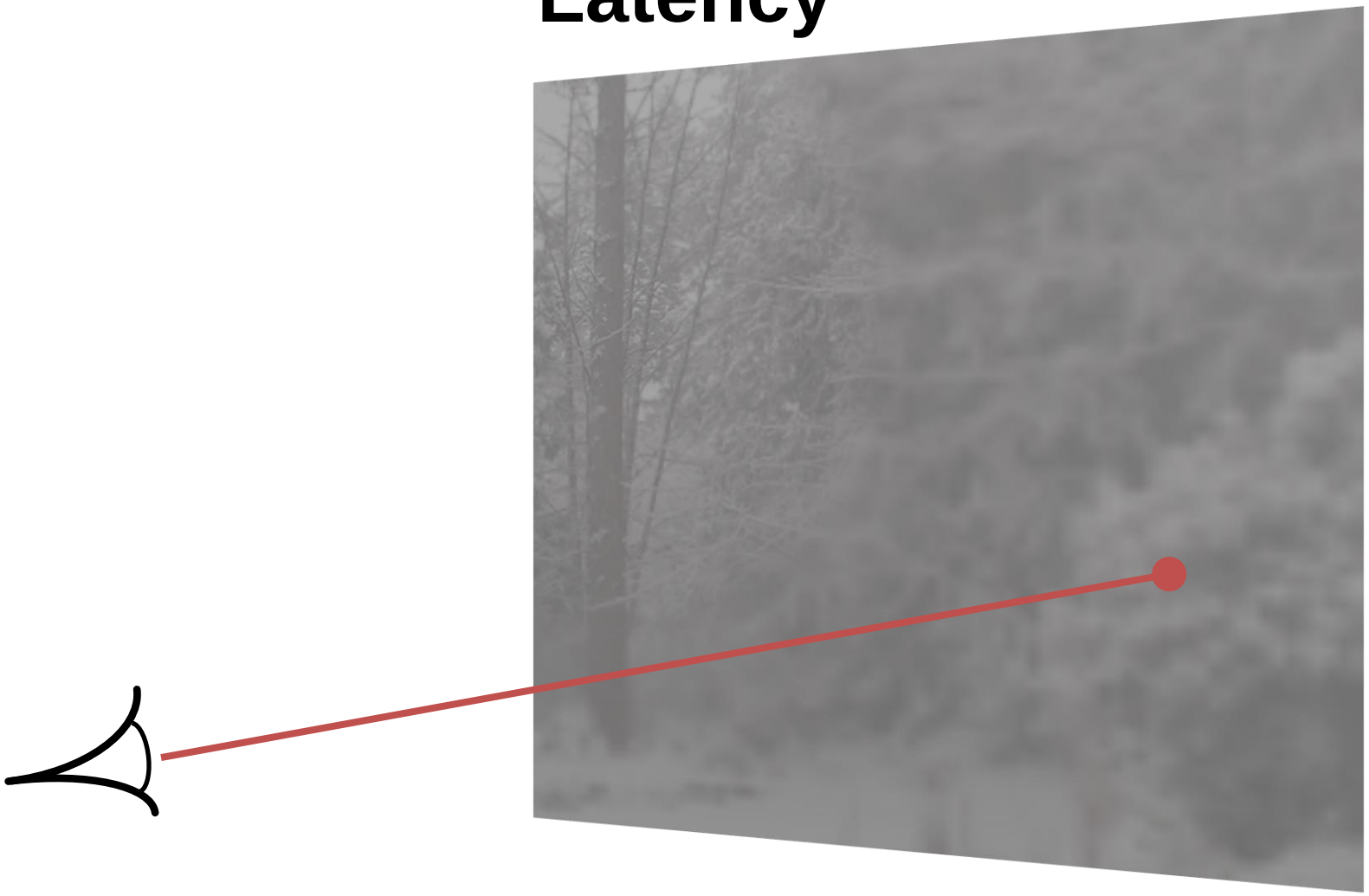
Latency



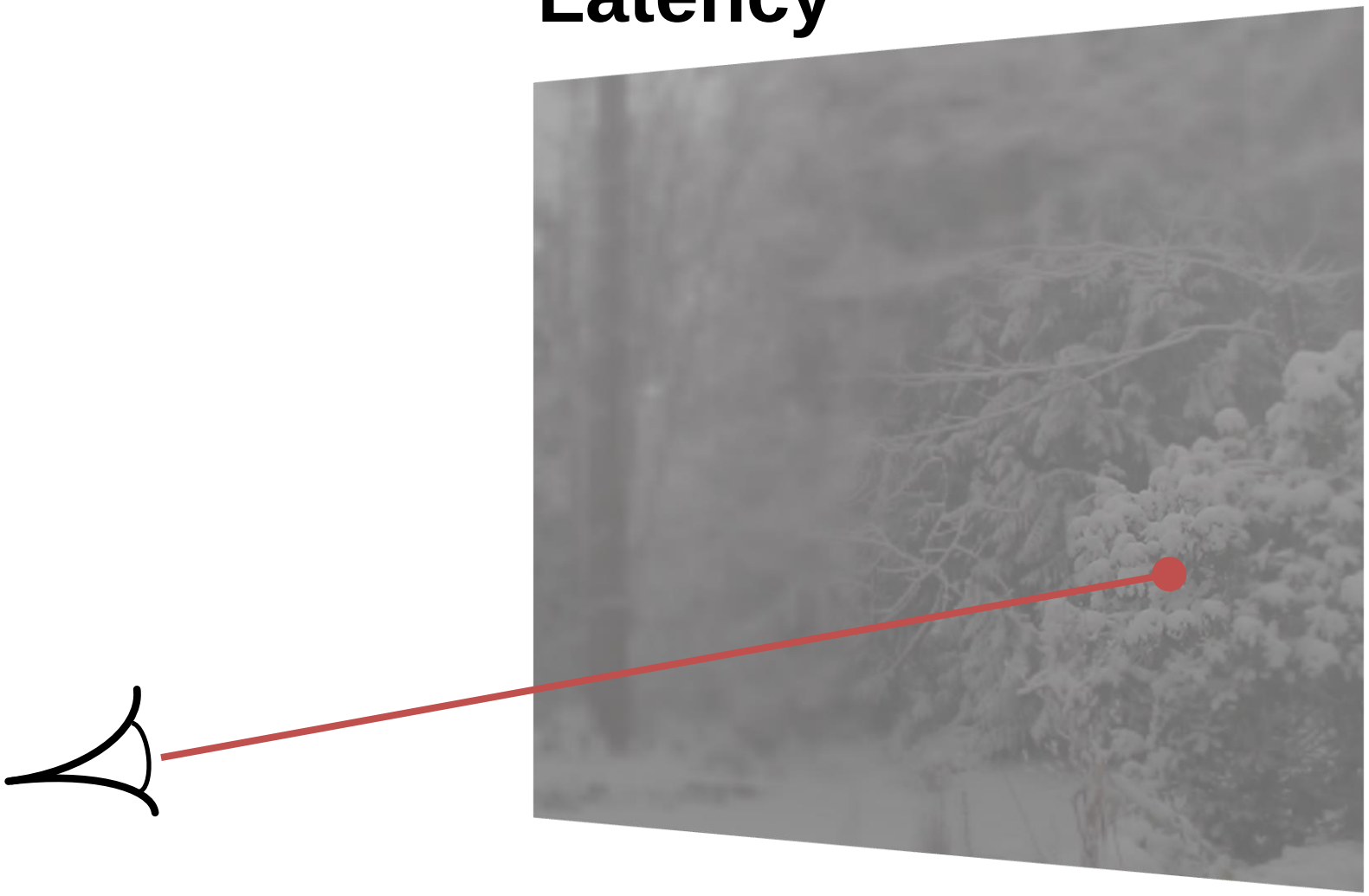
Latency



Latency



Latency



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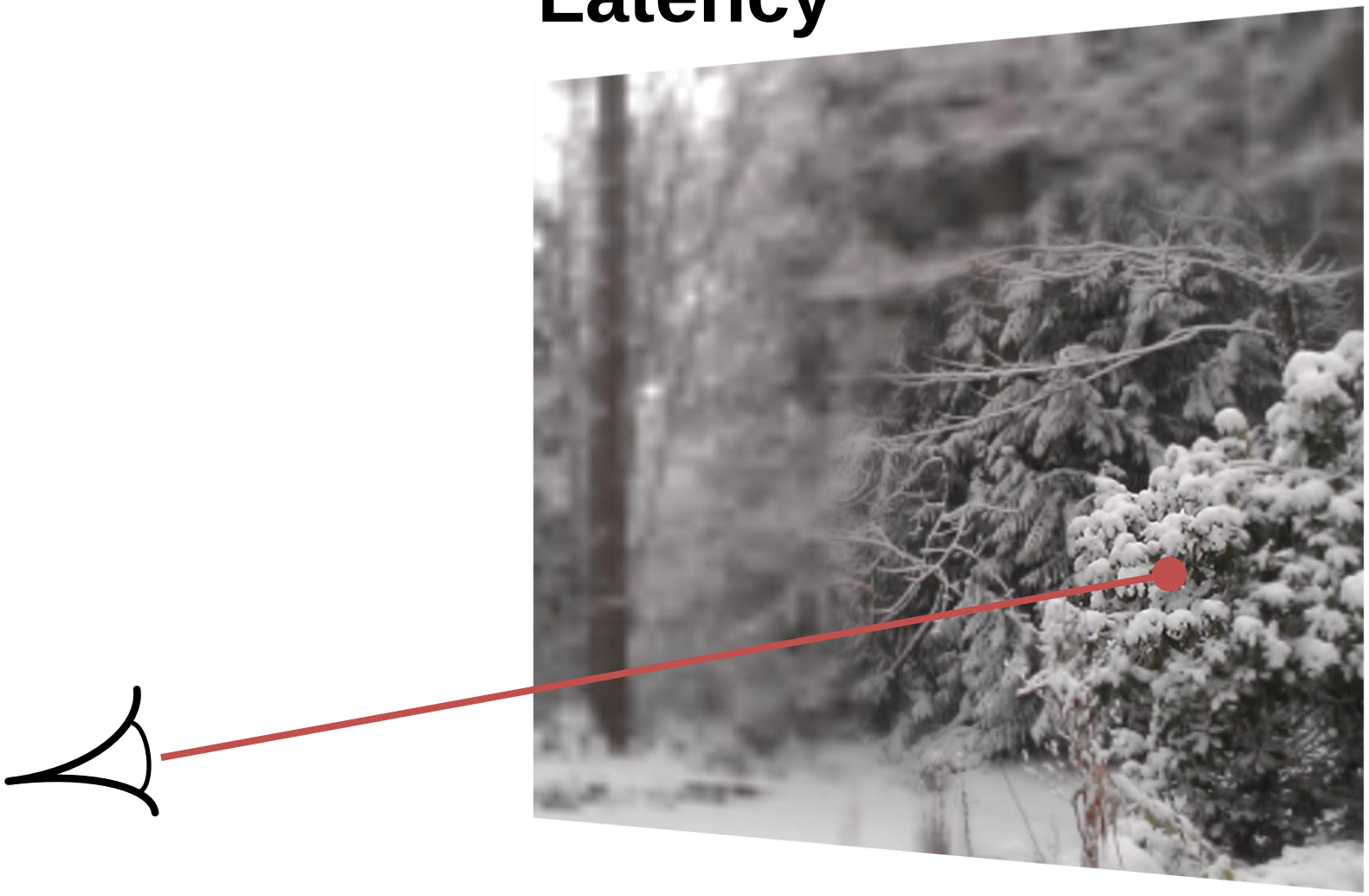
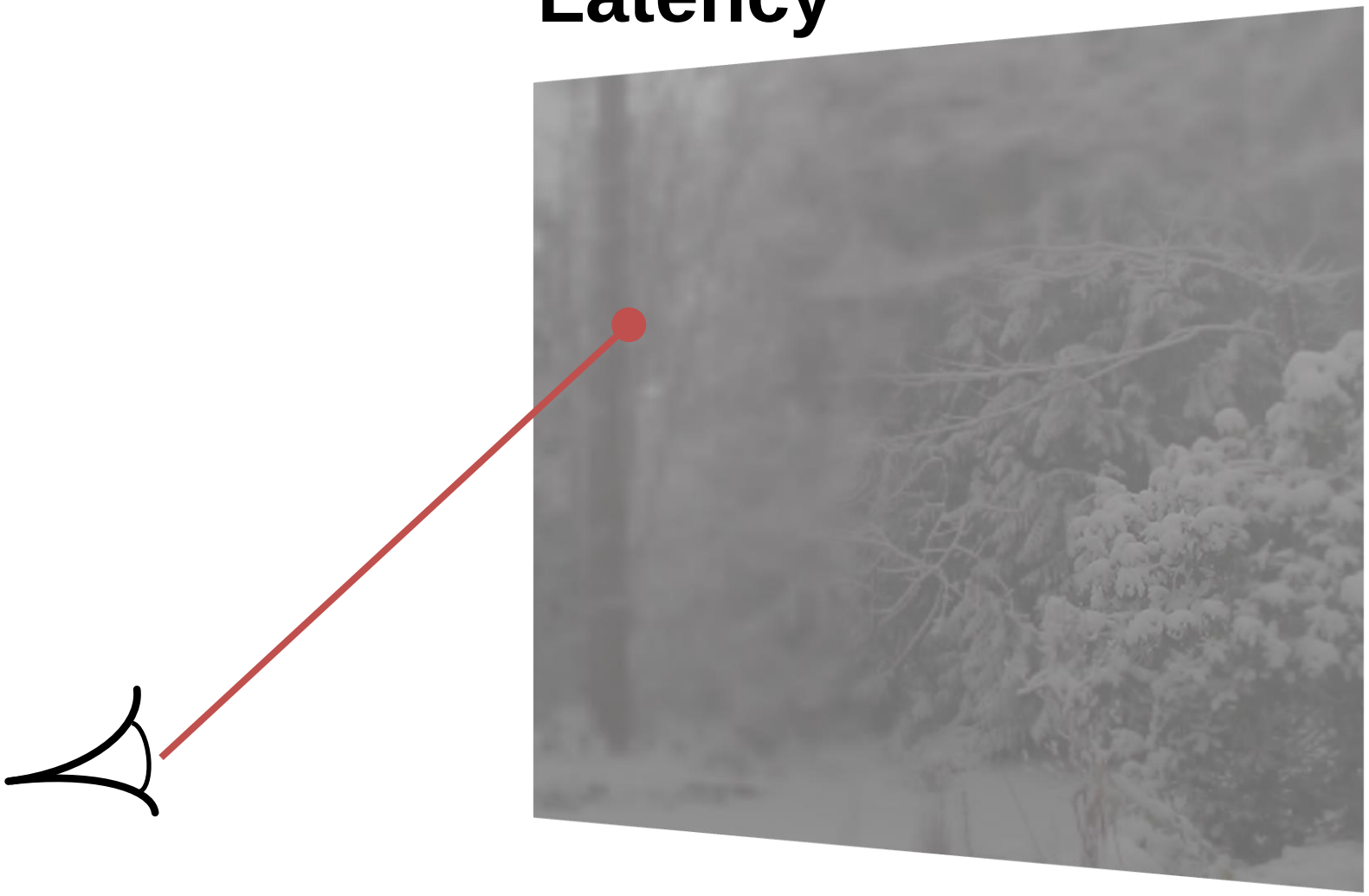
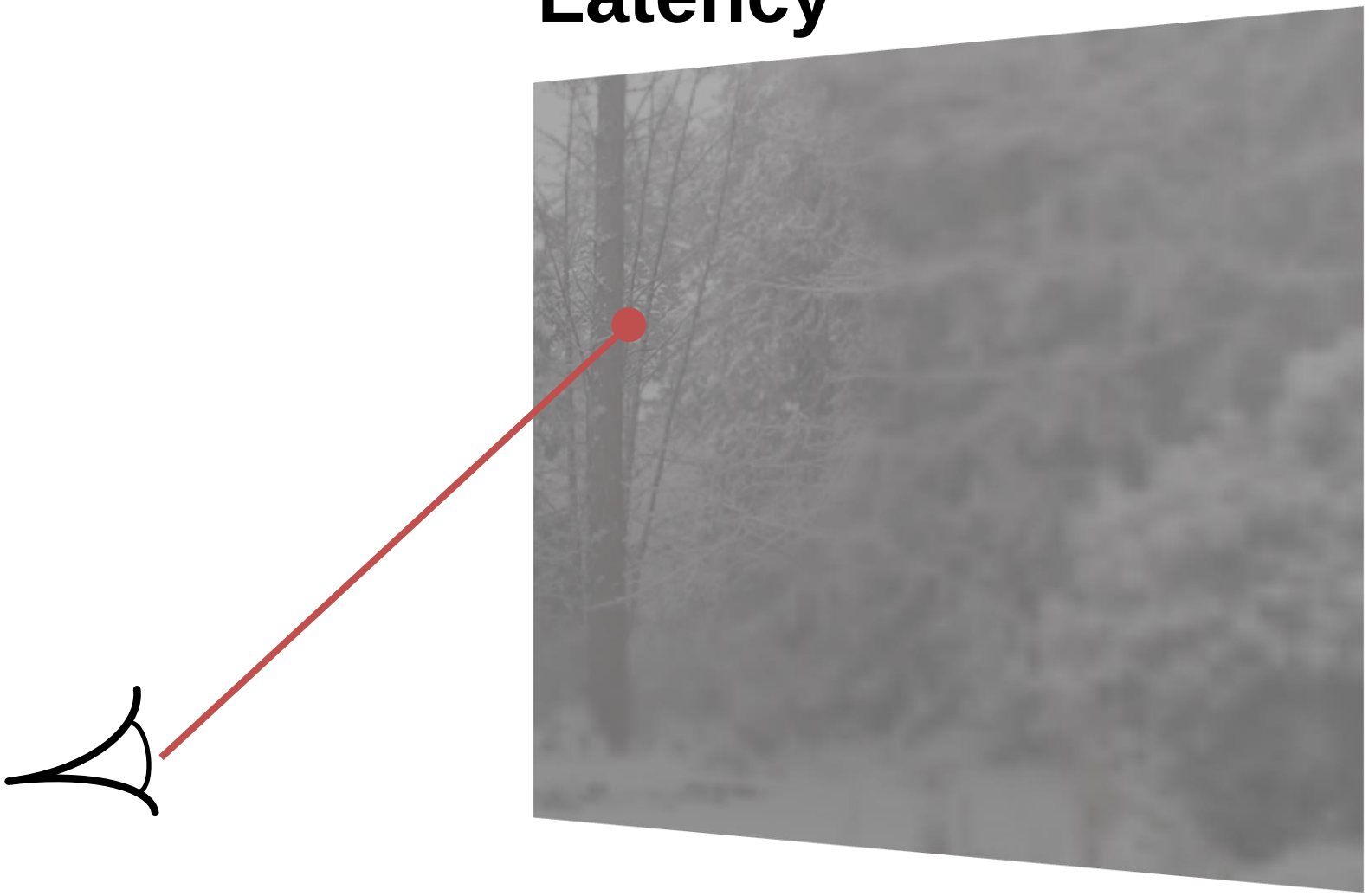
Latency



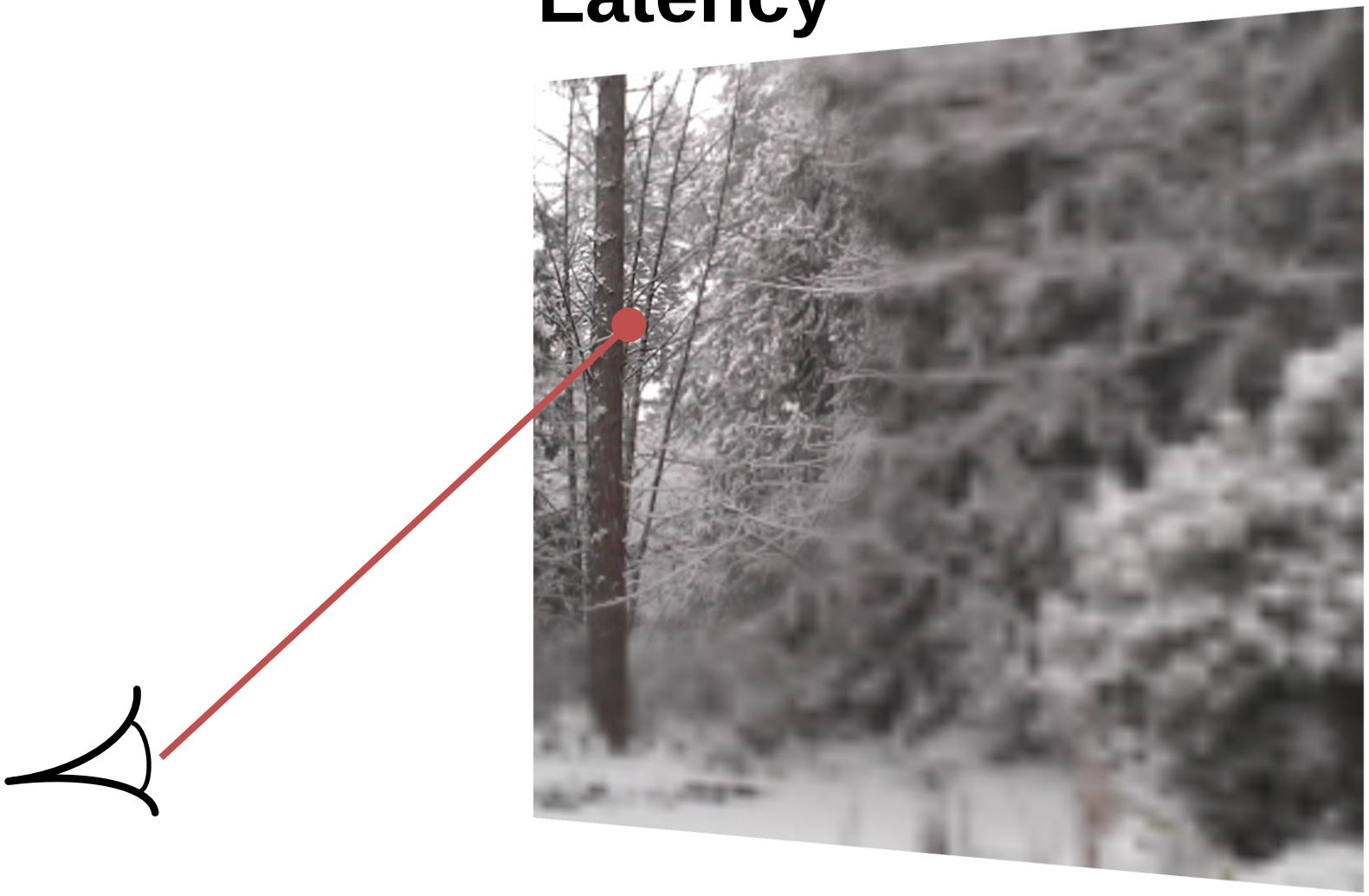
Latency



Latency



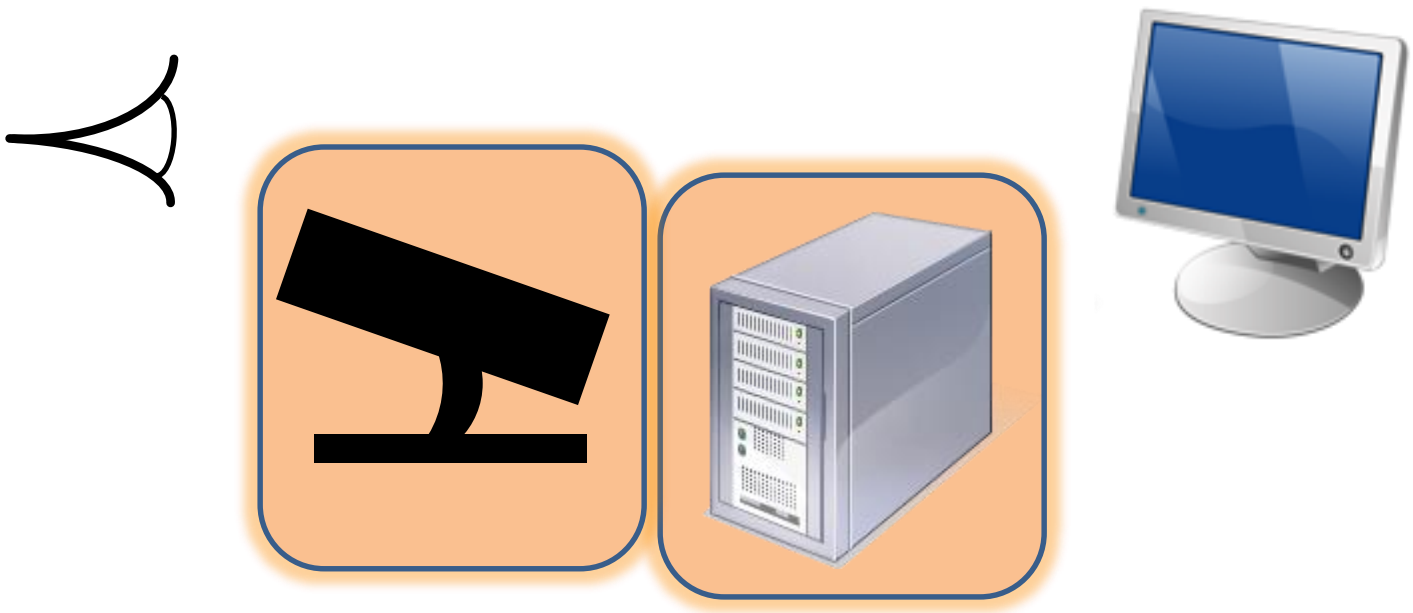
Latency



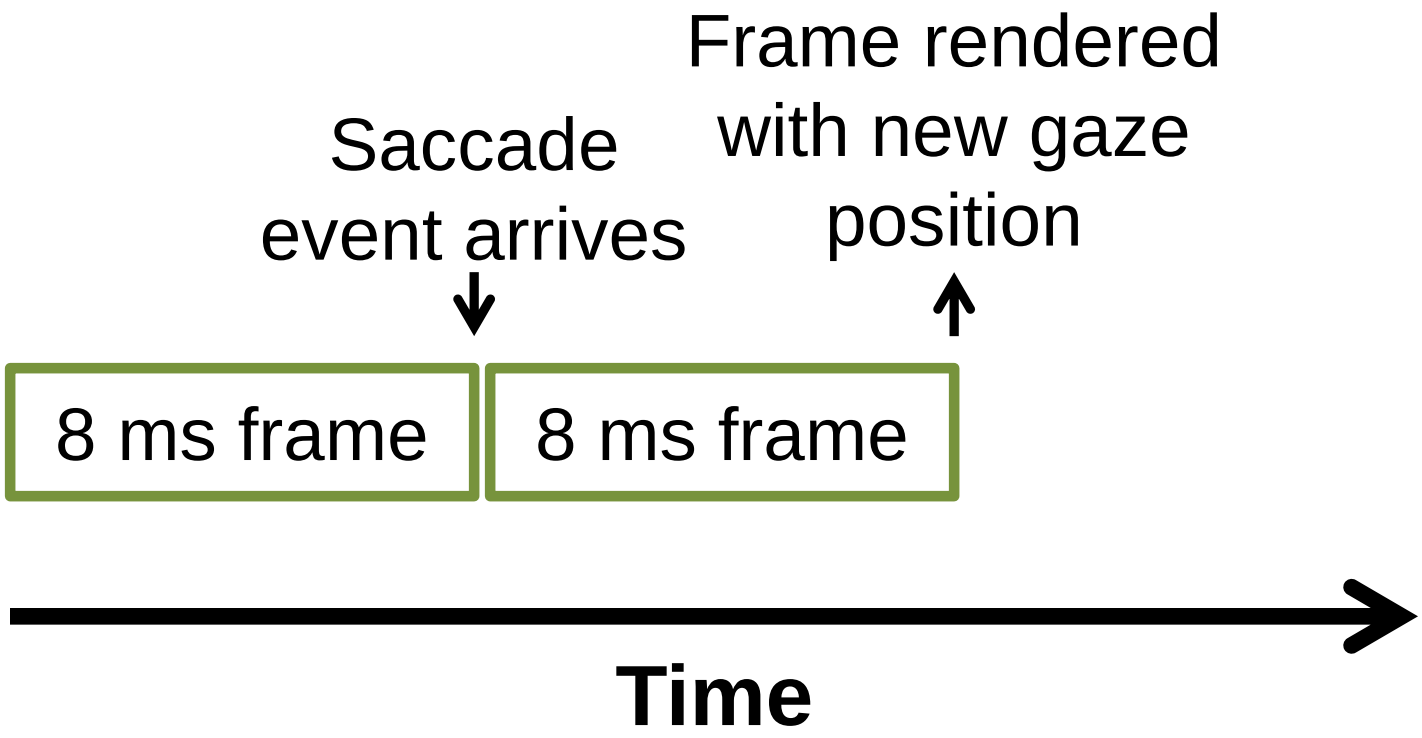
Latency

Tracker

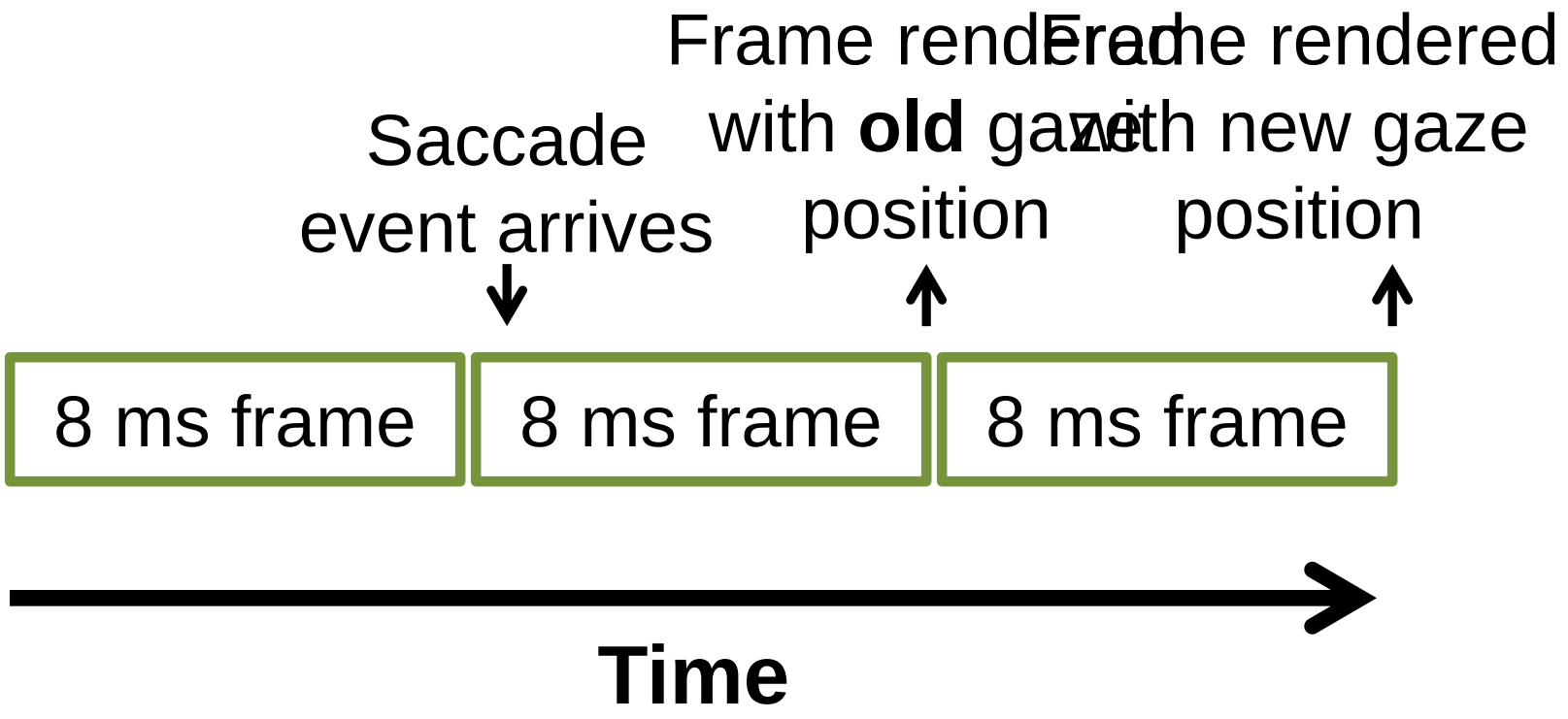
10 ms



Latency

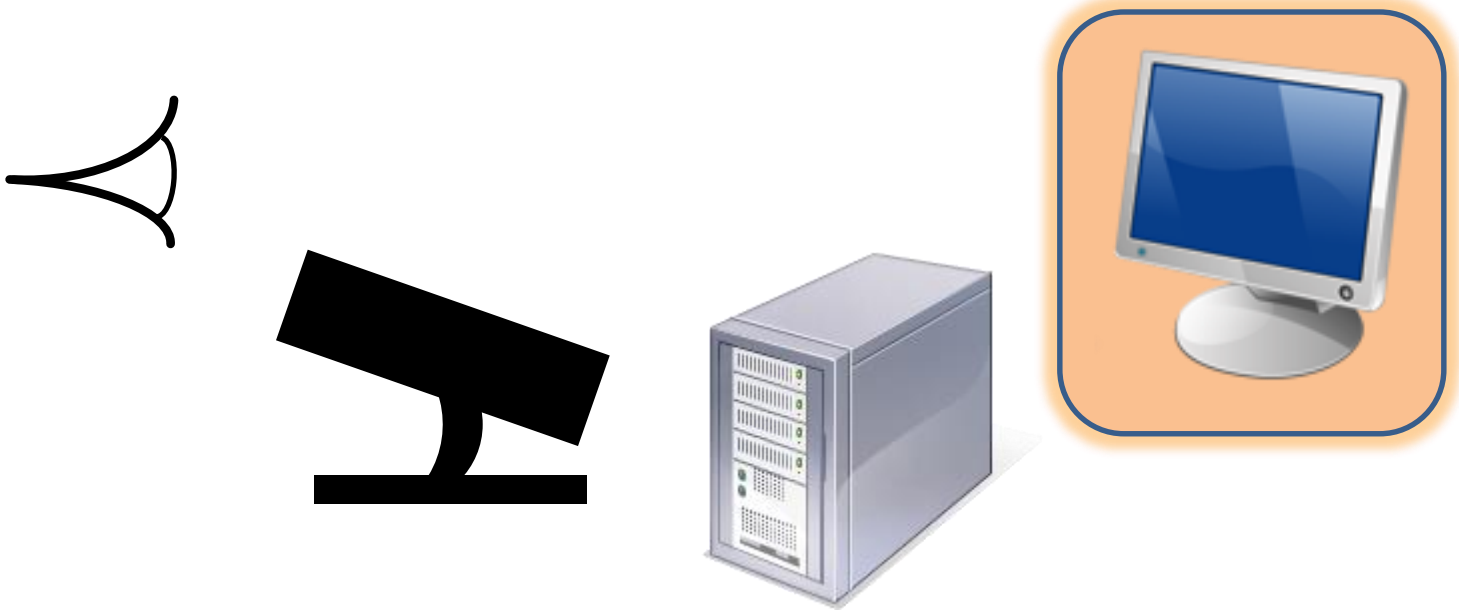

Frame rendered
with new gaze
position
Saccade
event arrives
8 ms frame
8 ms frame
Time

Latency


Saccade event arrives
Frame rendered with old gaze position
Frame rendered with new gaze position
8 ms frame
8 ms frame
8 ms frame
Time

Latency

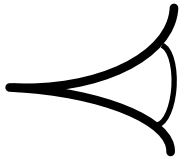
Tracker	Render	Scan out	Pixel switch
10 ms	16 ms	8 ms	6 ms

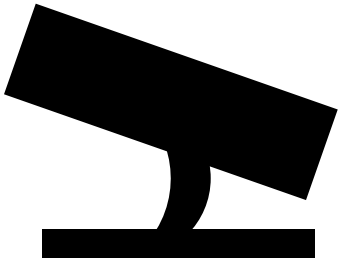


Generality

Commodity hardware

Gamer PC + eye tracker





Tobii TX300

GTX 580 GPU

2.67GHz CPU

120Hz
LCD

Generality

```
UpdateAll();

PushGlobalRenderState();

RenderAllObjects( currentCameraInfo );

PresentFrame();
```

Generality

```
UpdateAll();
PushGlobalRenderState();

foreach( layer in layers )
{
    layerCamInfo = PushLayer( currentCamInfo );
    RenderAllObjects( layerCamInfo );
    PopLayer();
}
CompositeLayers();
PresentFrame();
```

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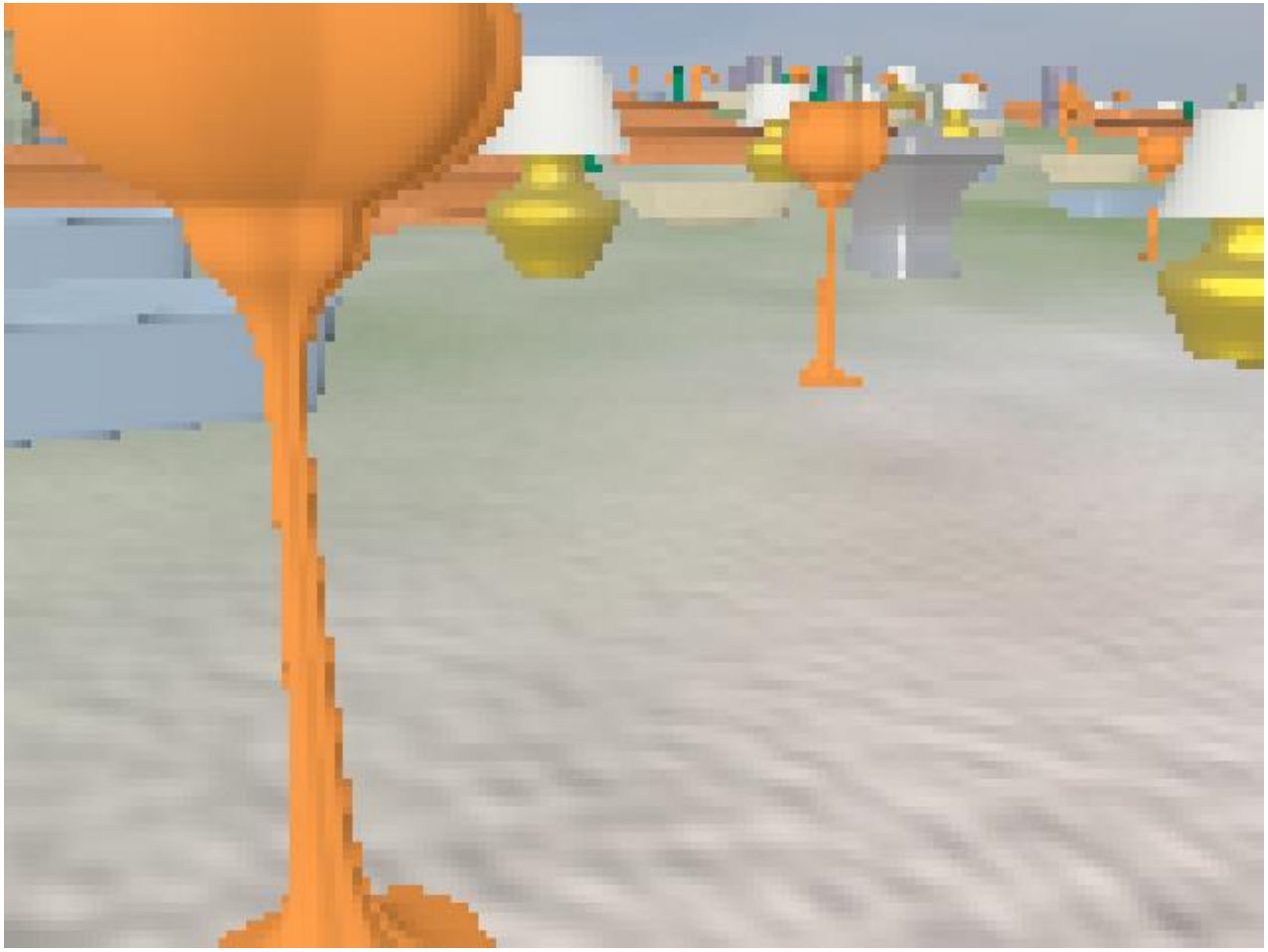
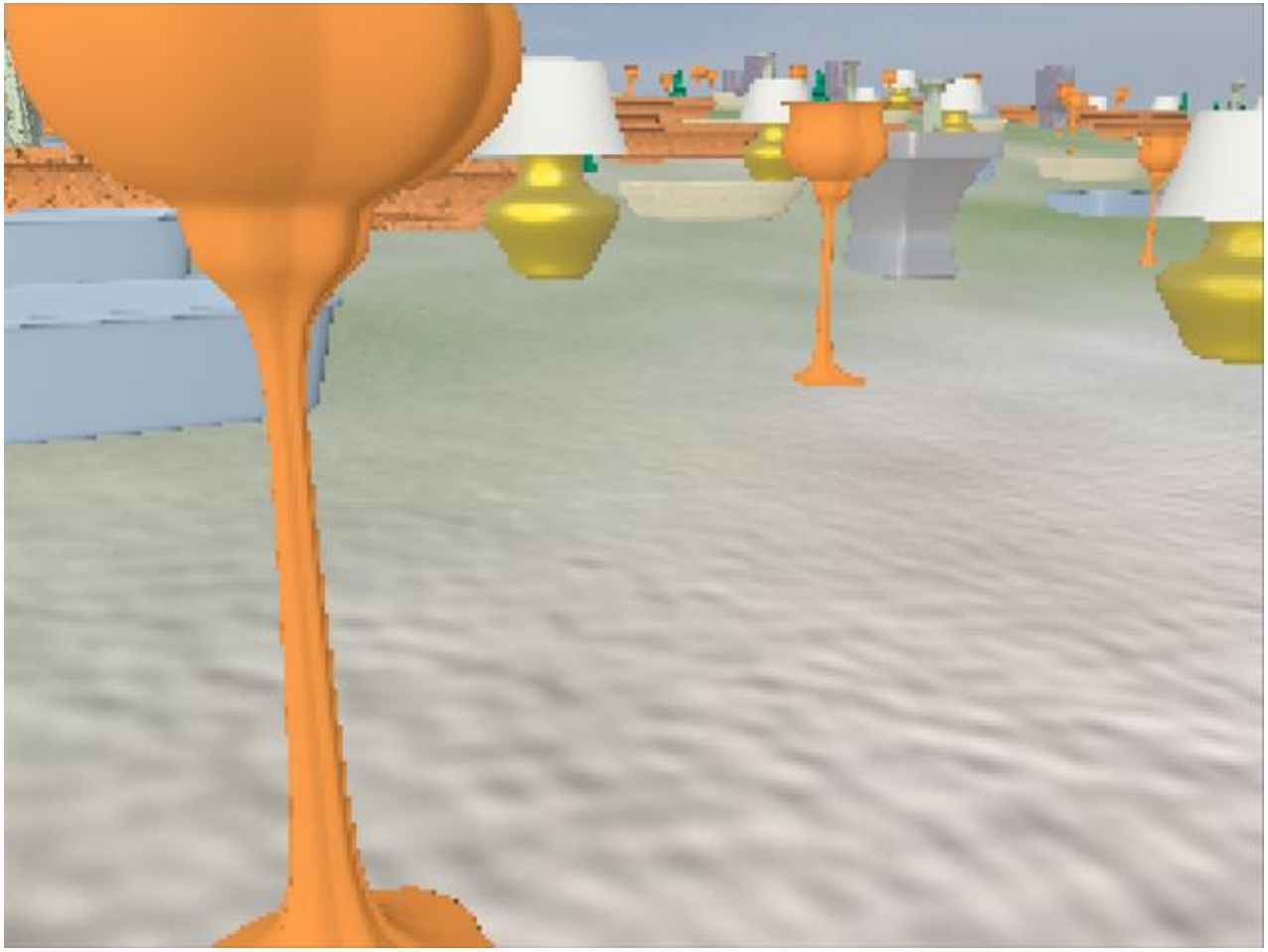
Aliasing



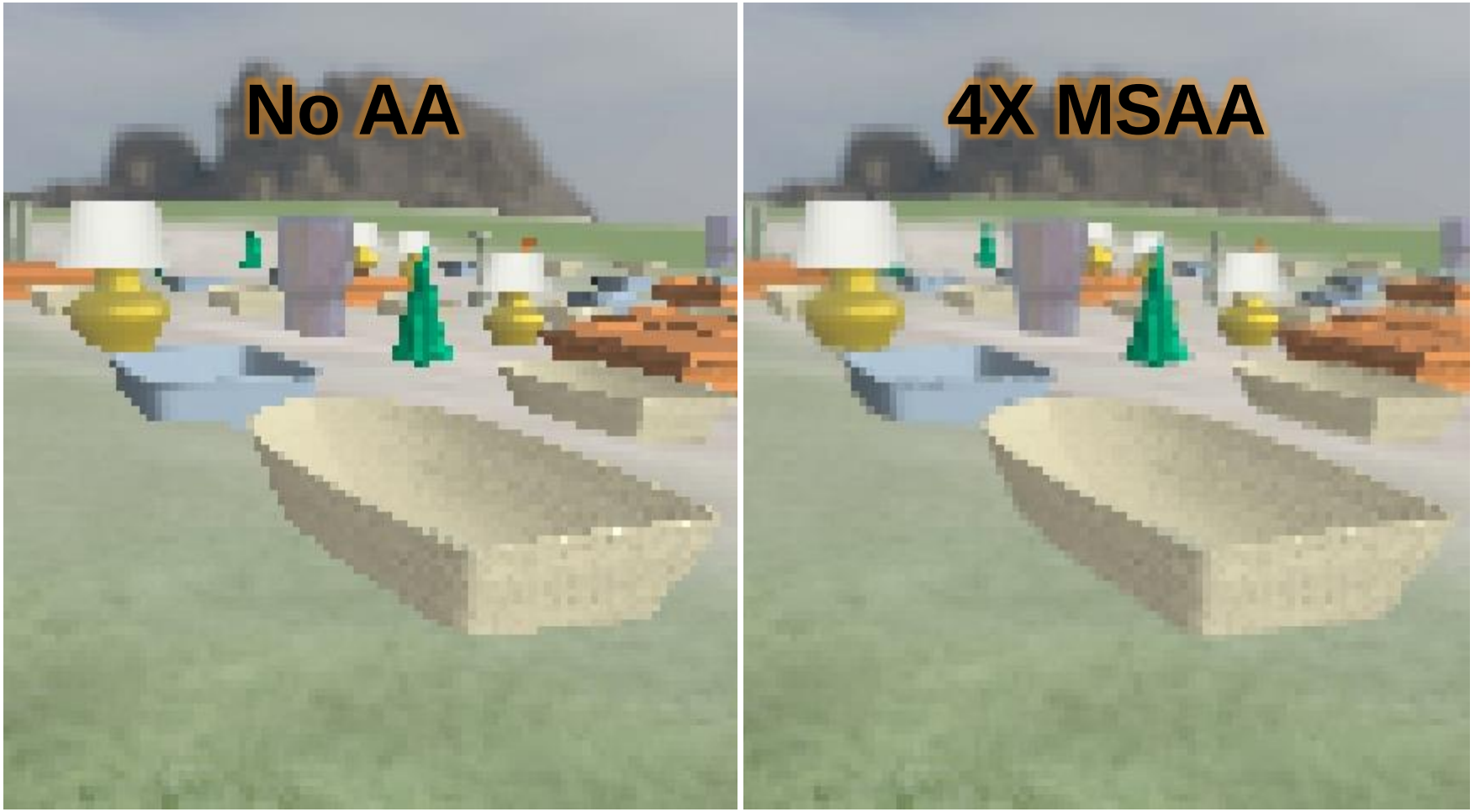
Aliasing



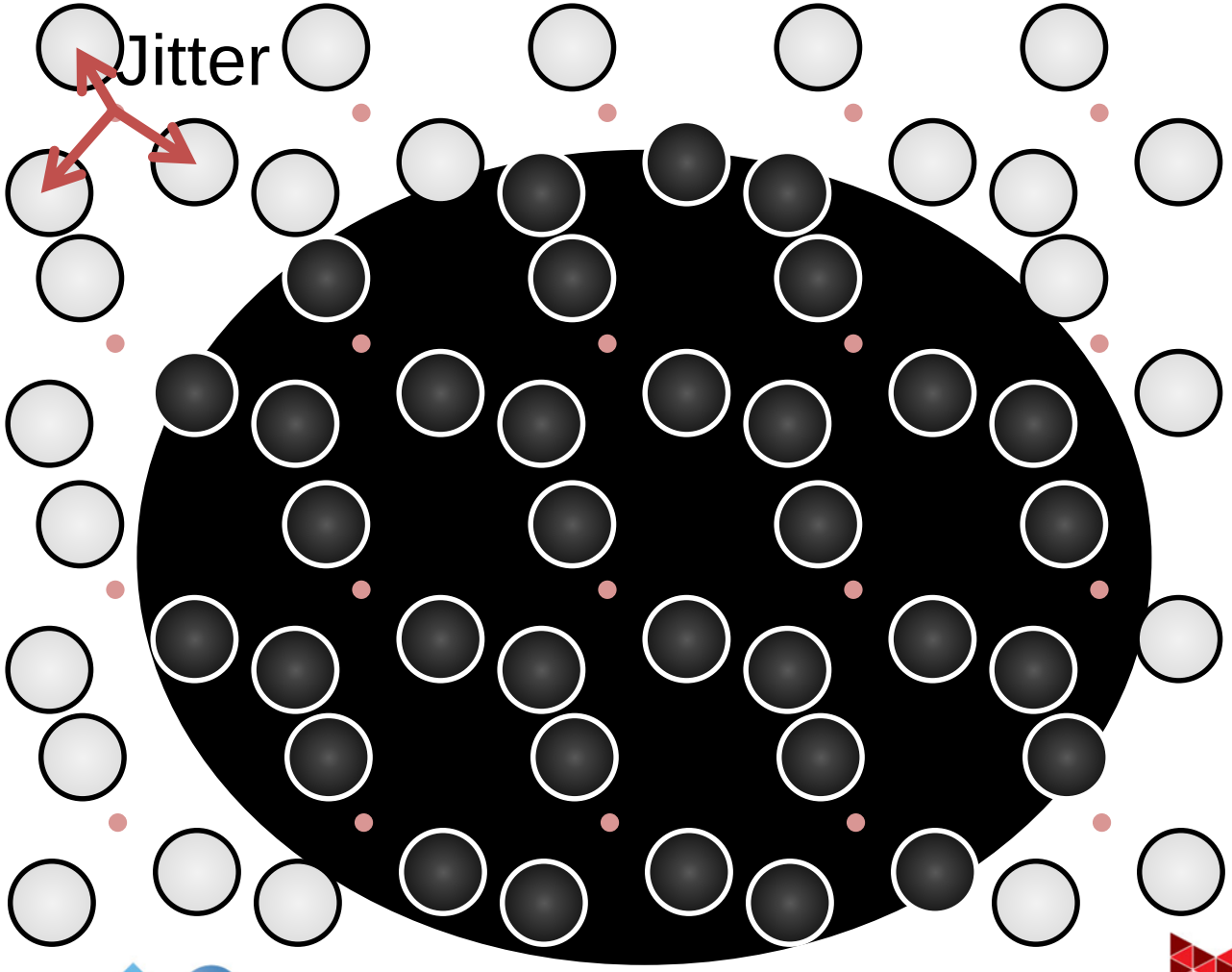
Anti-Aliasing Requirements

- Low impact on performance
- Not too blurry
- GPU friendly

Anti-aliasing



Temporal jitter



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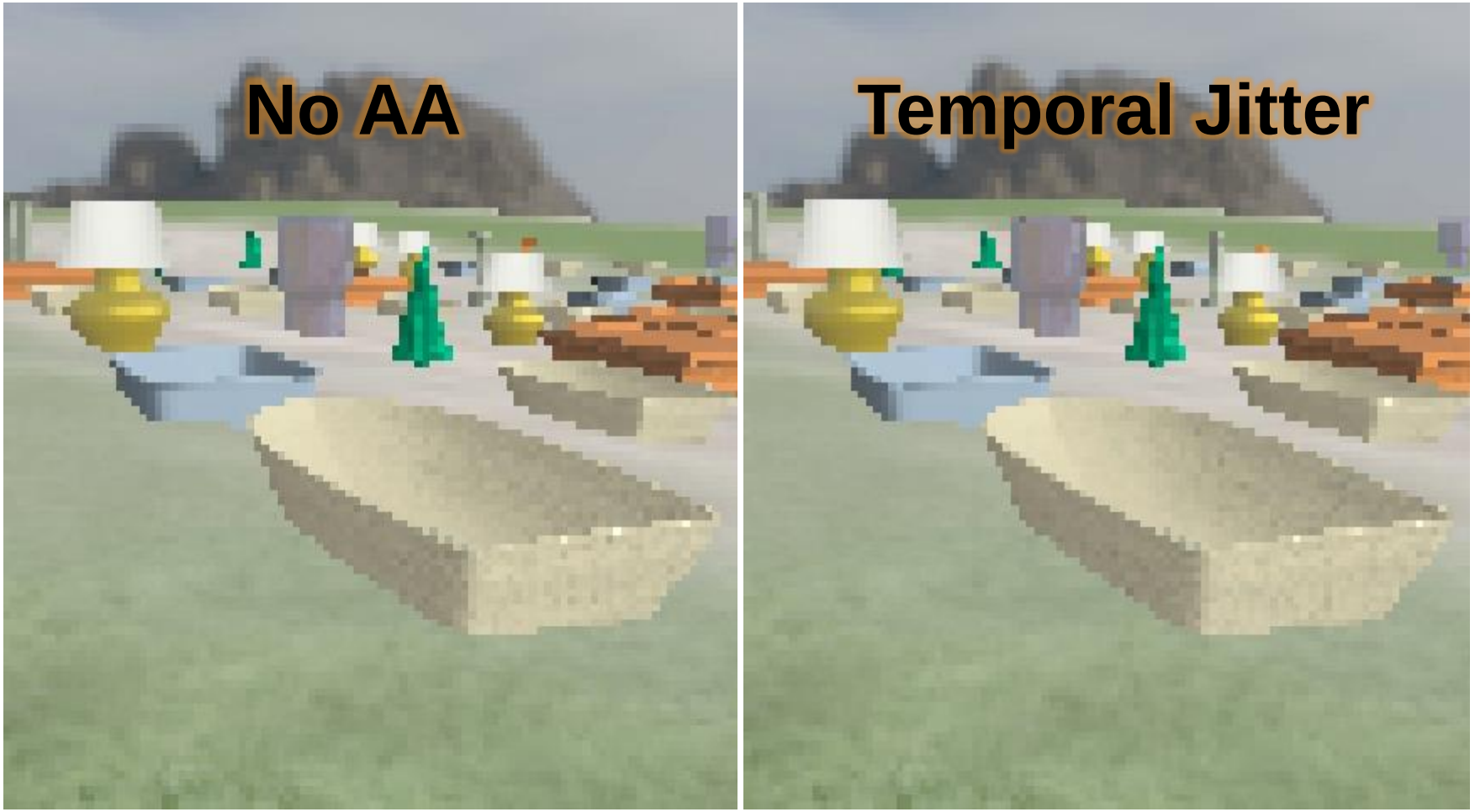
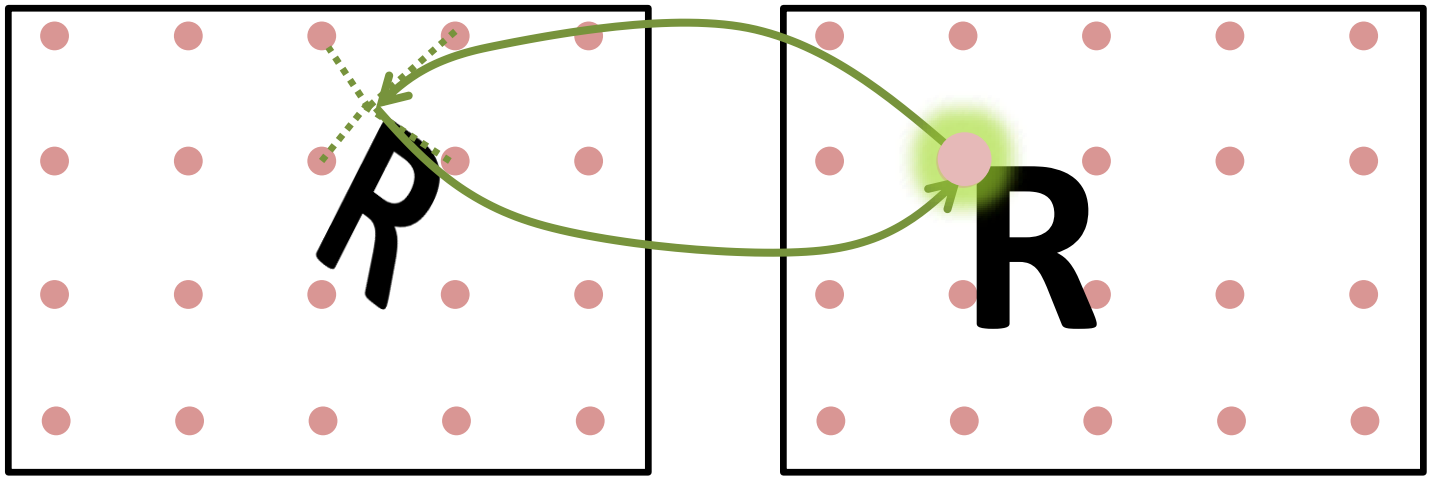
Anti-aliasing



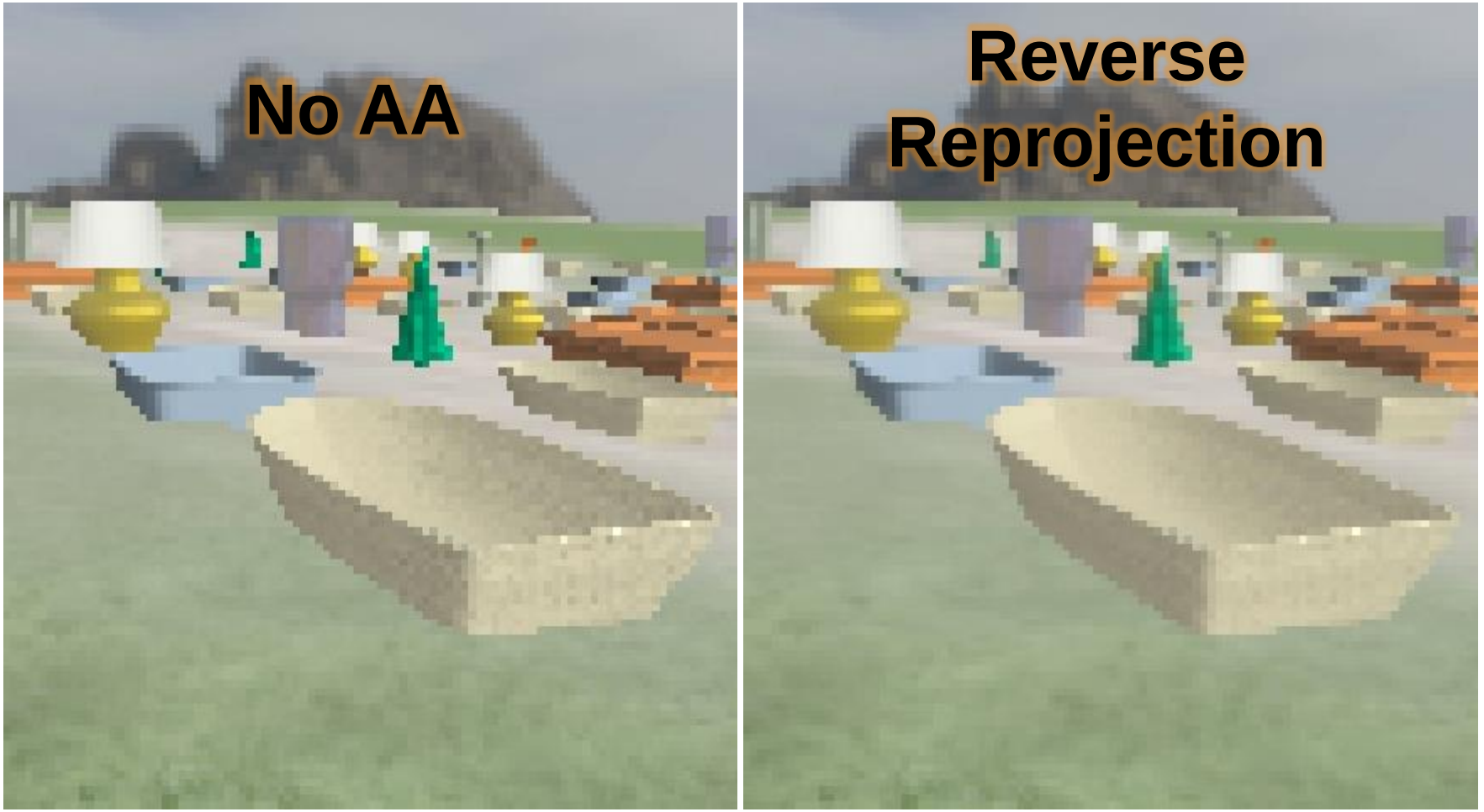
Temporal Reverse Reprojection



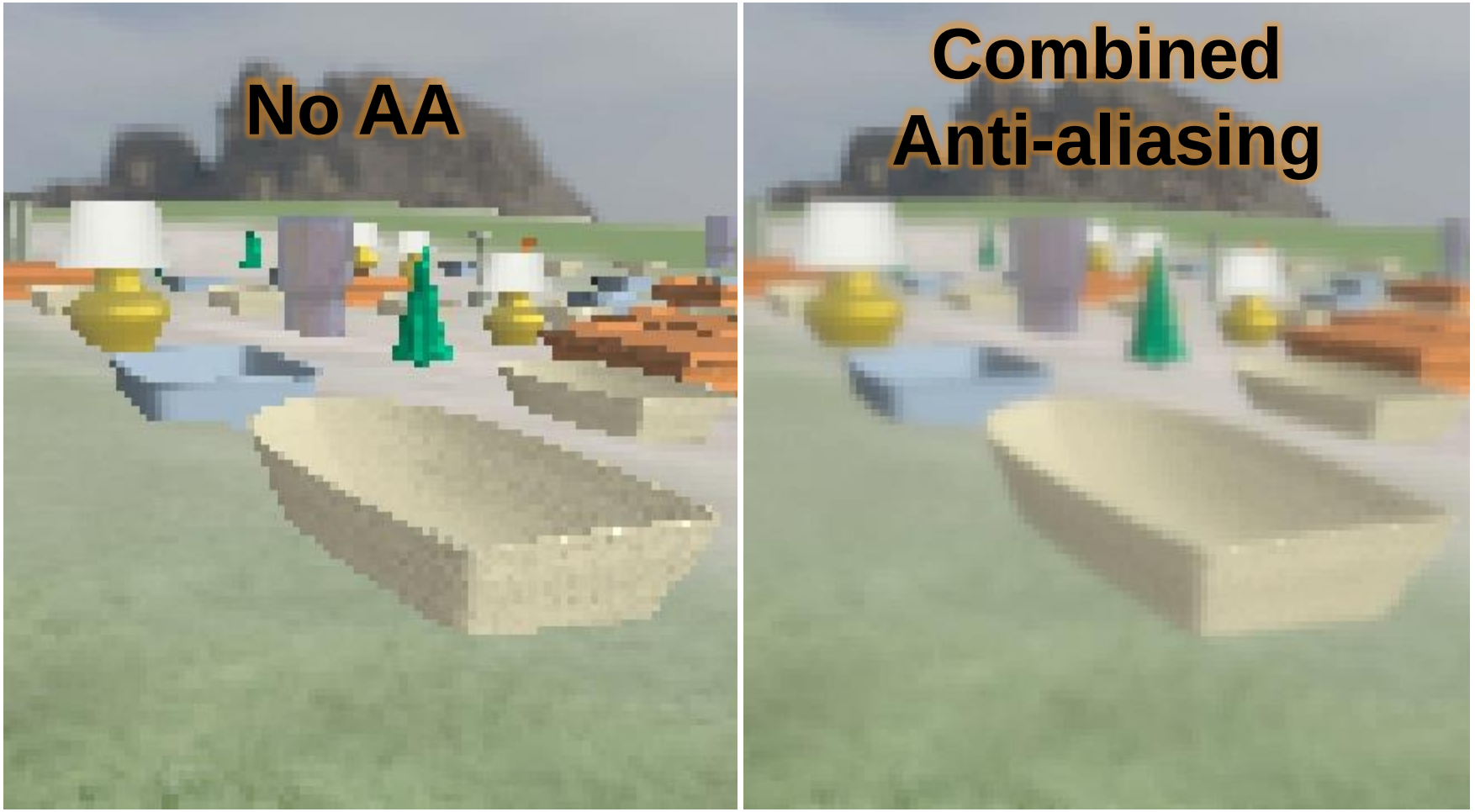
Previous Frame

Current Frame

Anti-aliasing

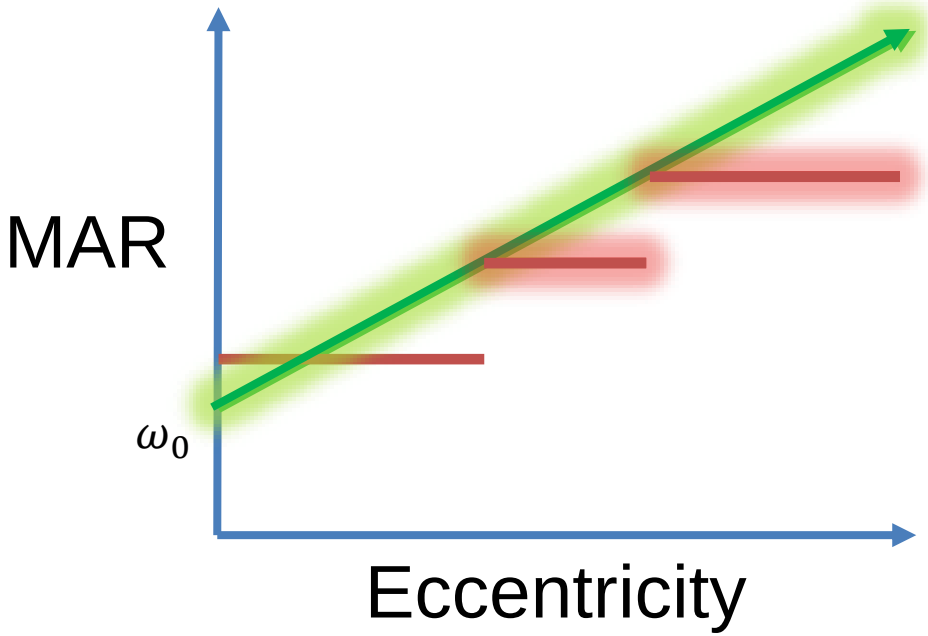


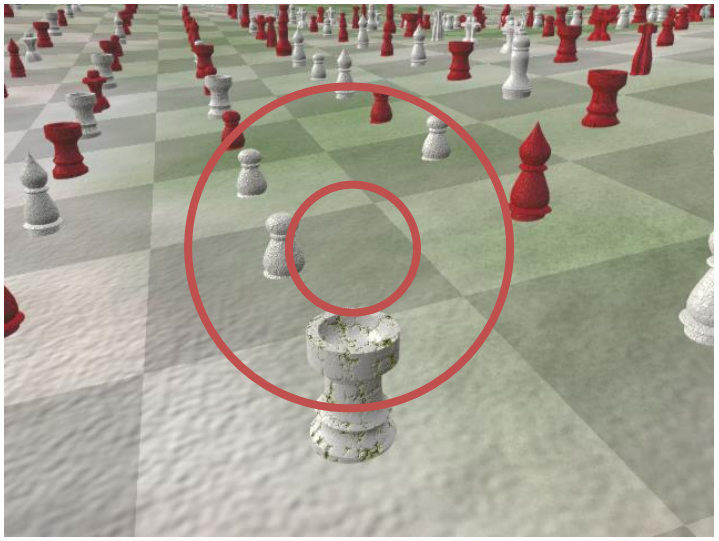
Anti-aliasing



System parameters

Foveated 3D Display





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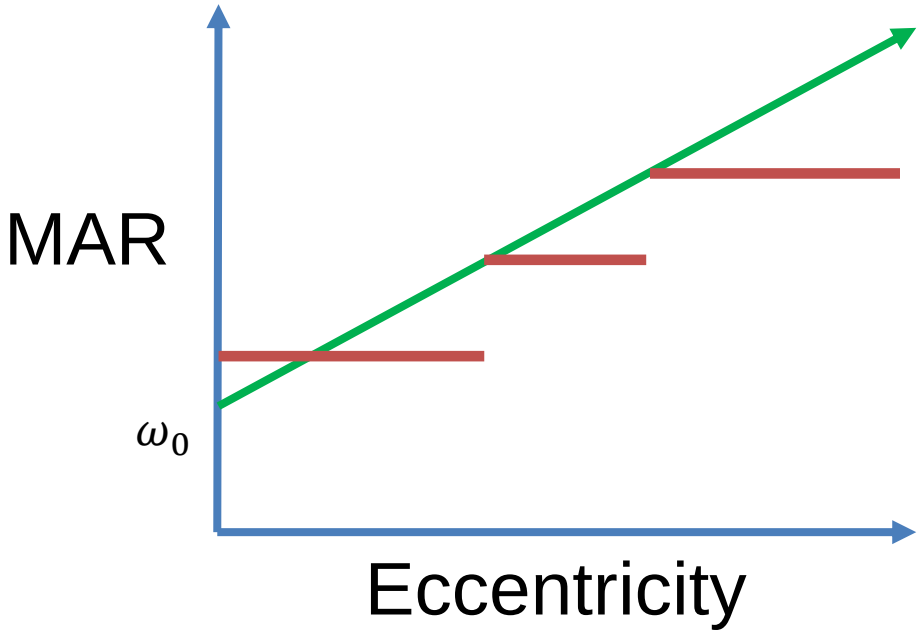

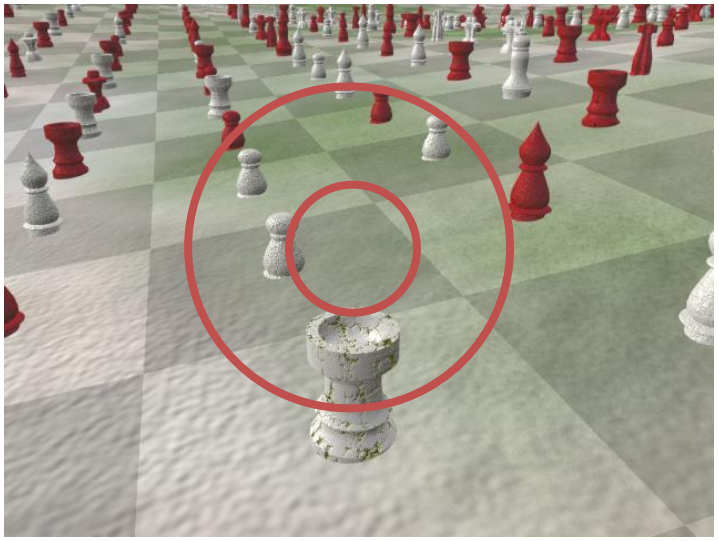

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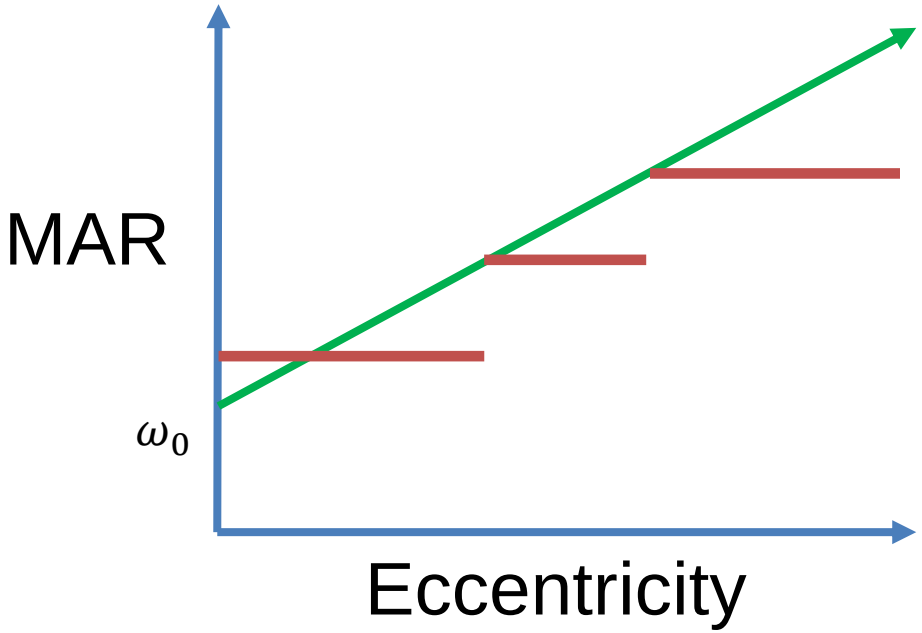

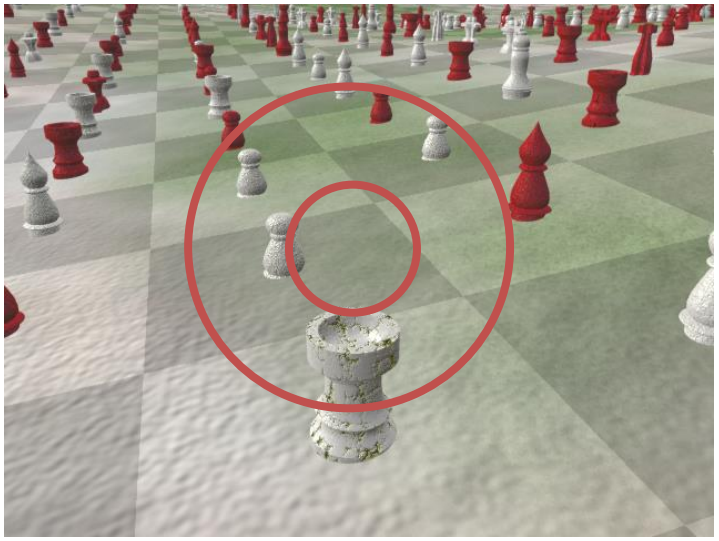

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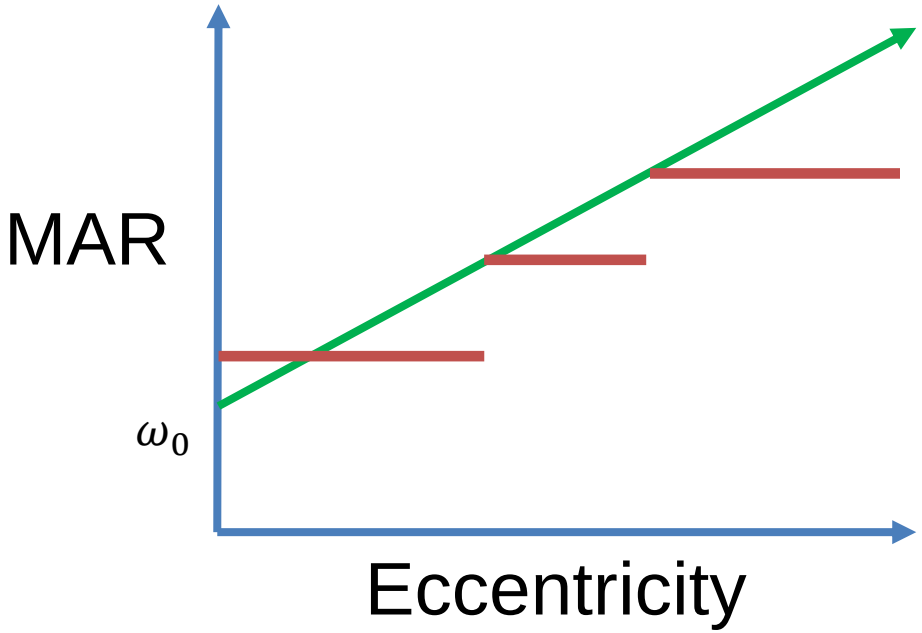
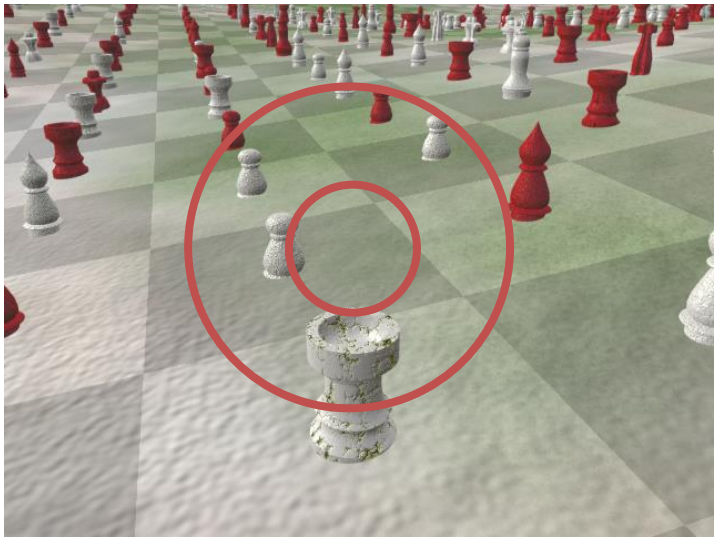
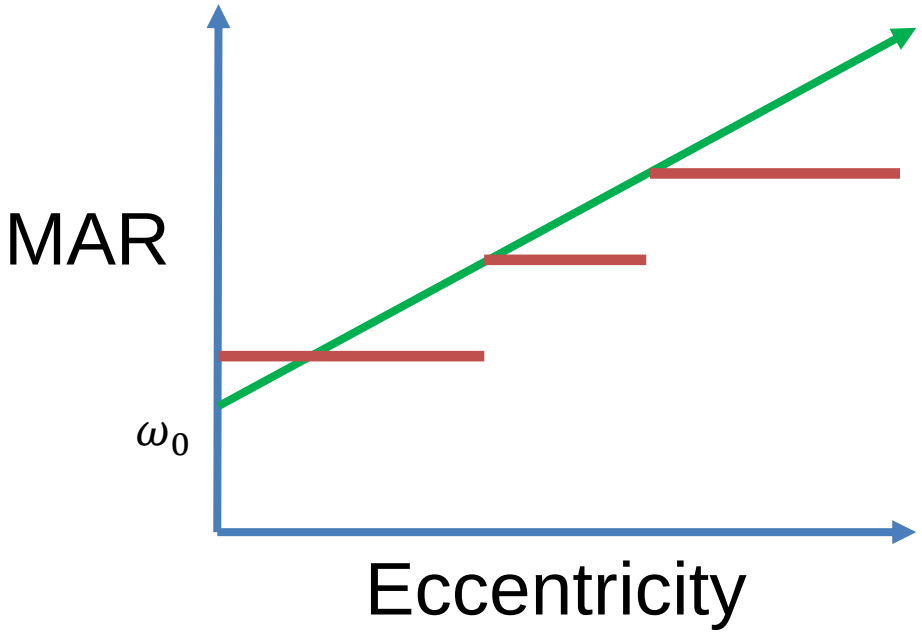
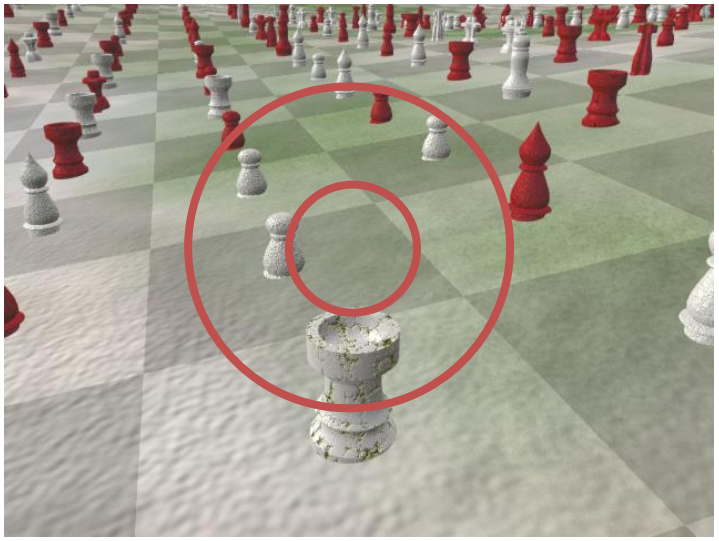




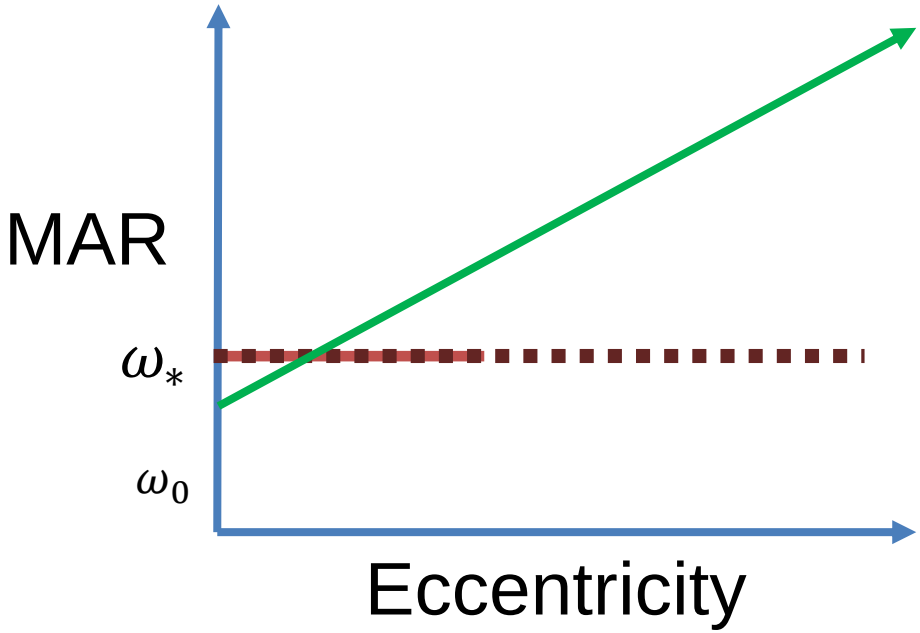
Foveated 3D Display

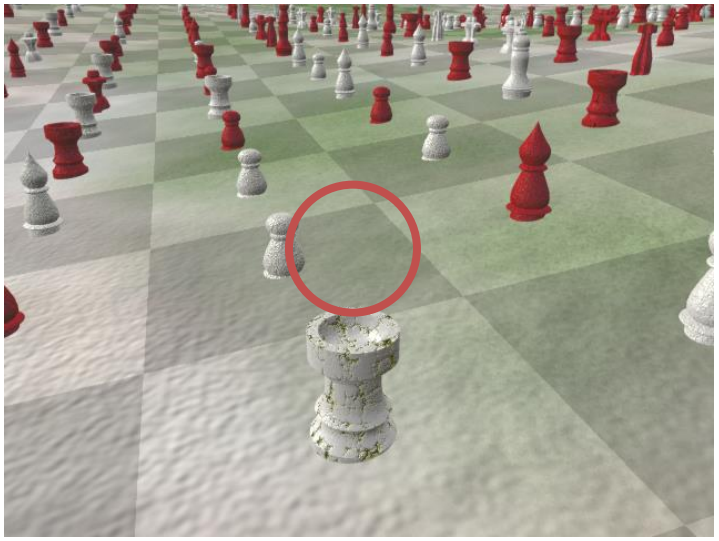




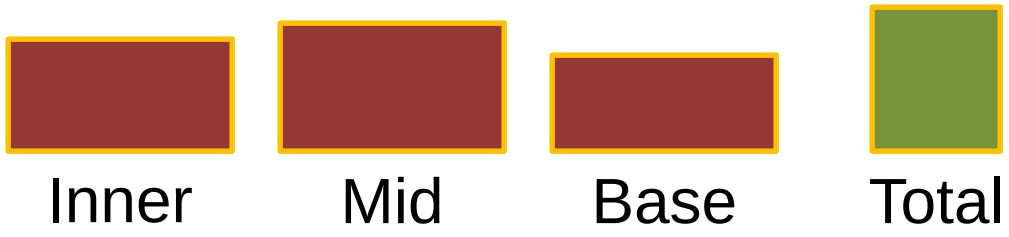
Foveated 3D Display

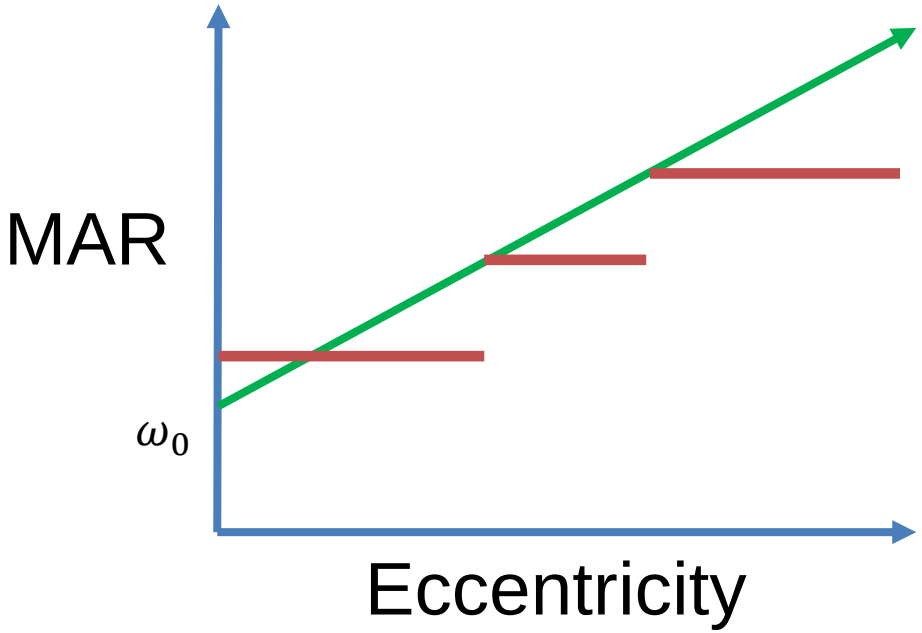
$$\omega_* = native\ display\ acuity$$

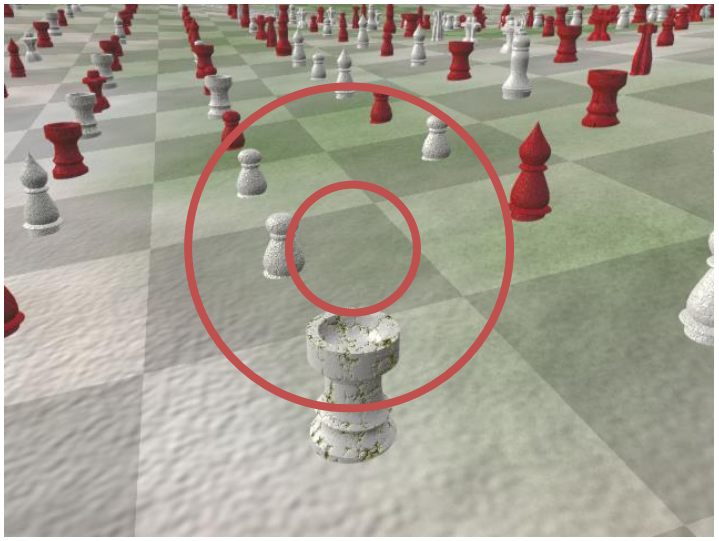




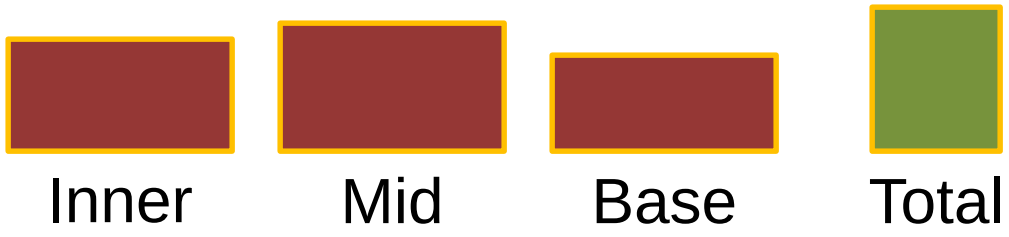
Pixel load per layer

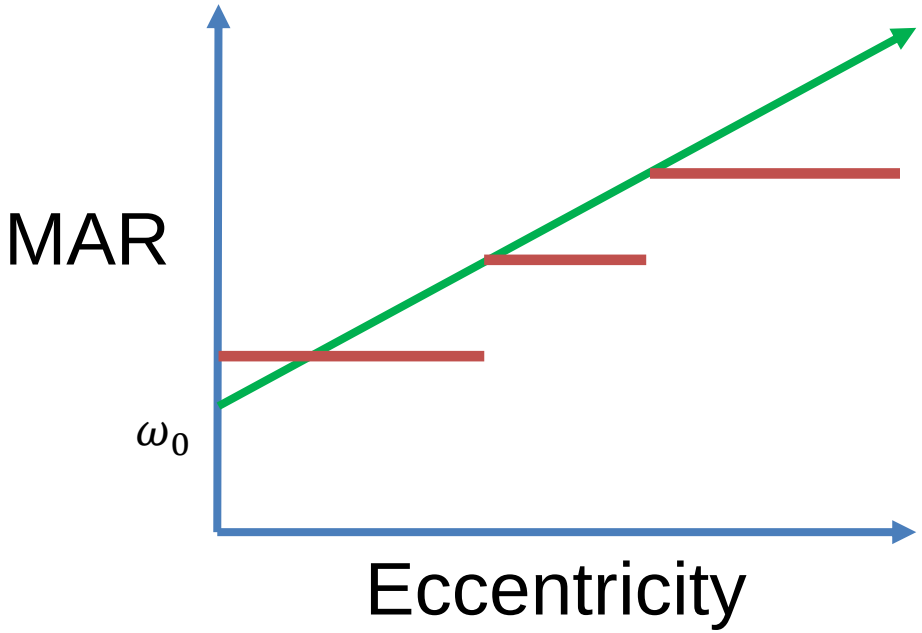


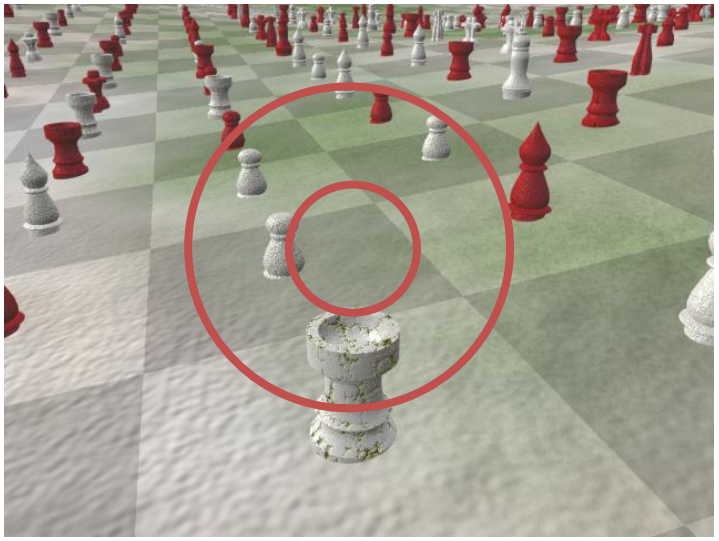




Pixel load per layer







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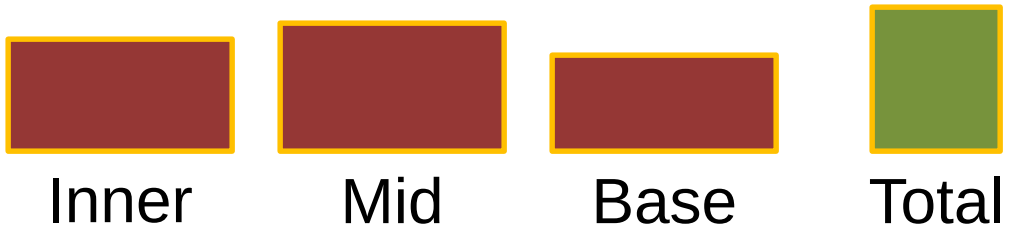

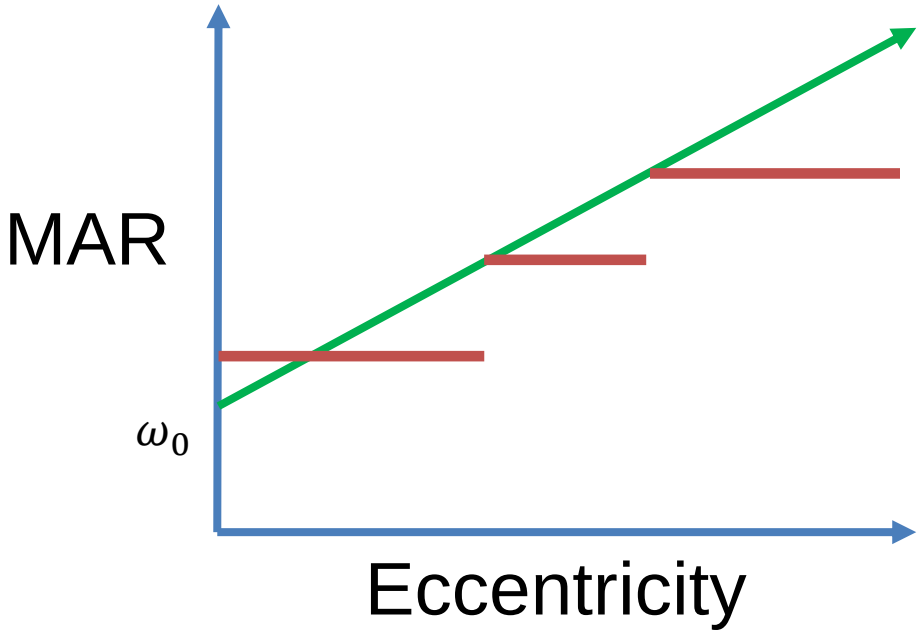

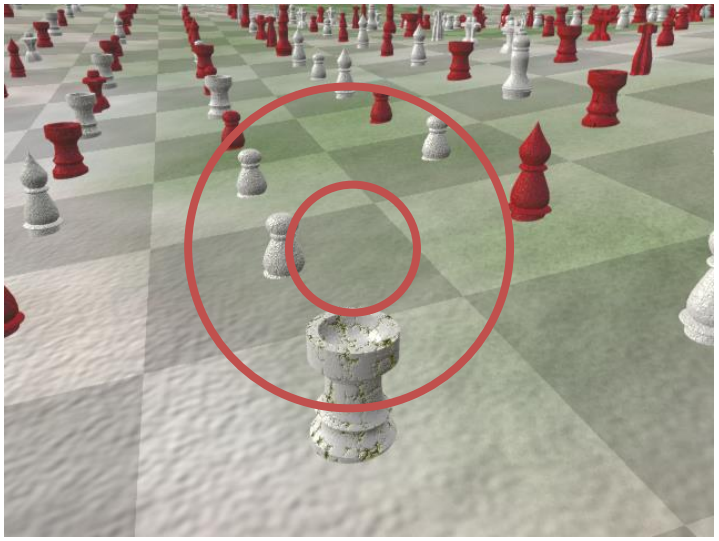

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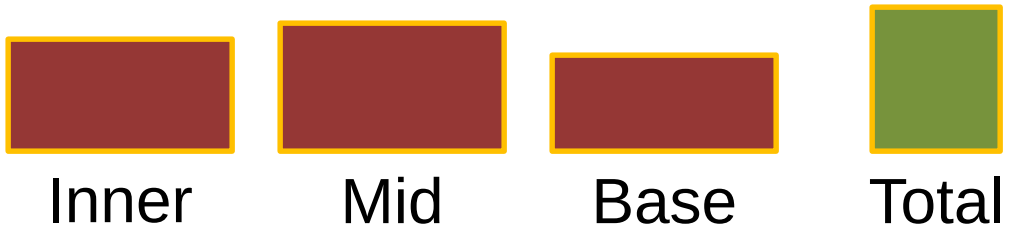
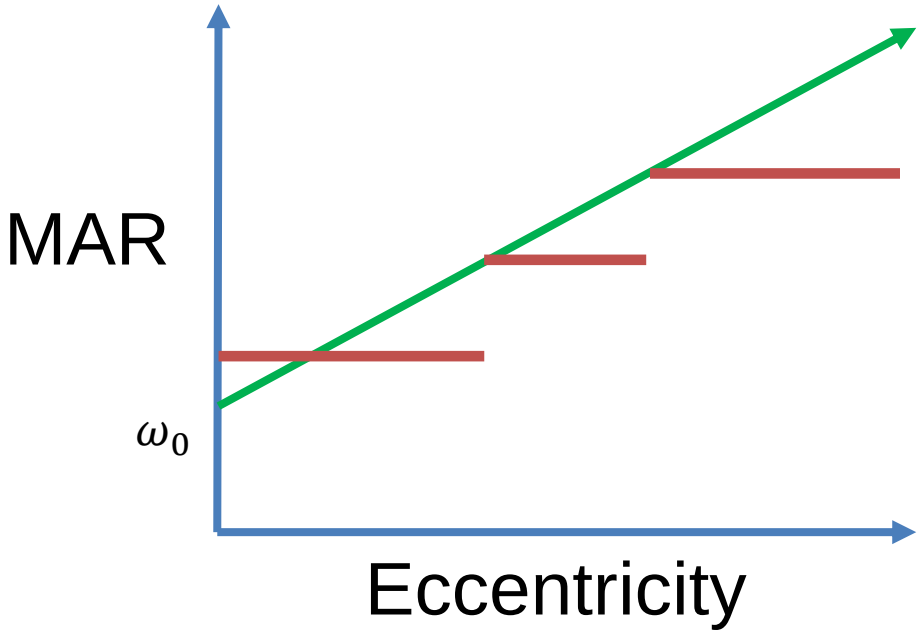
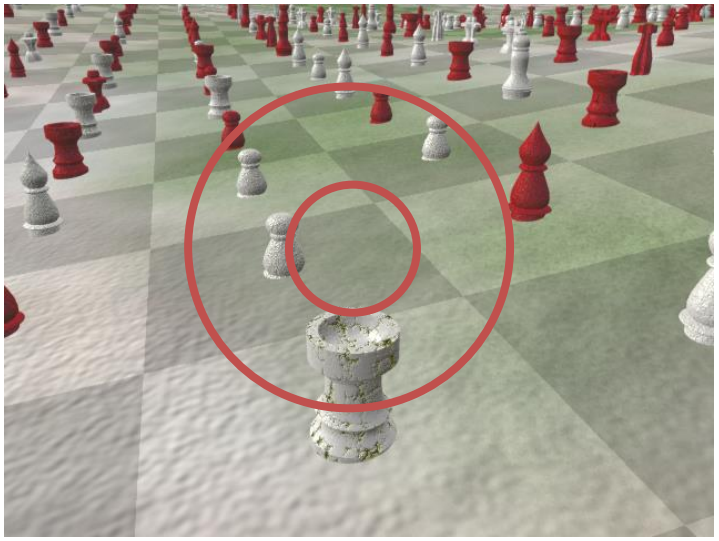
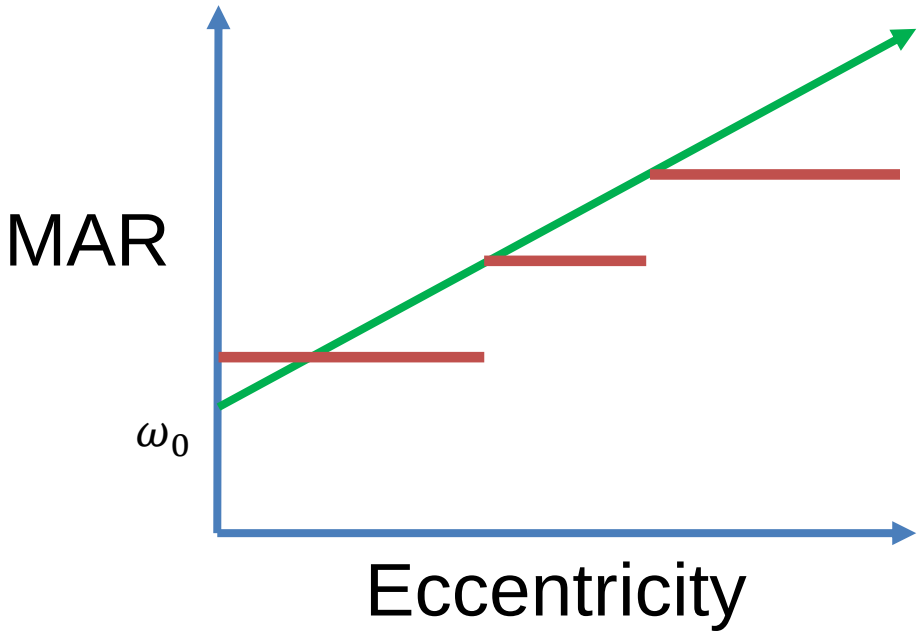
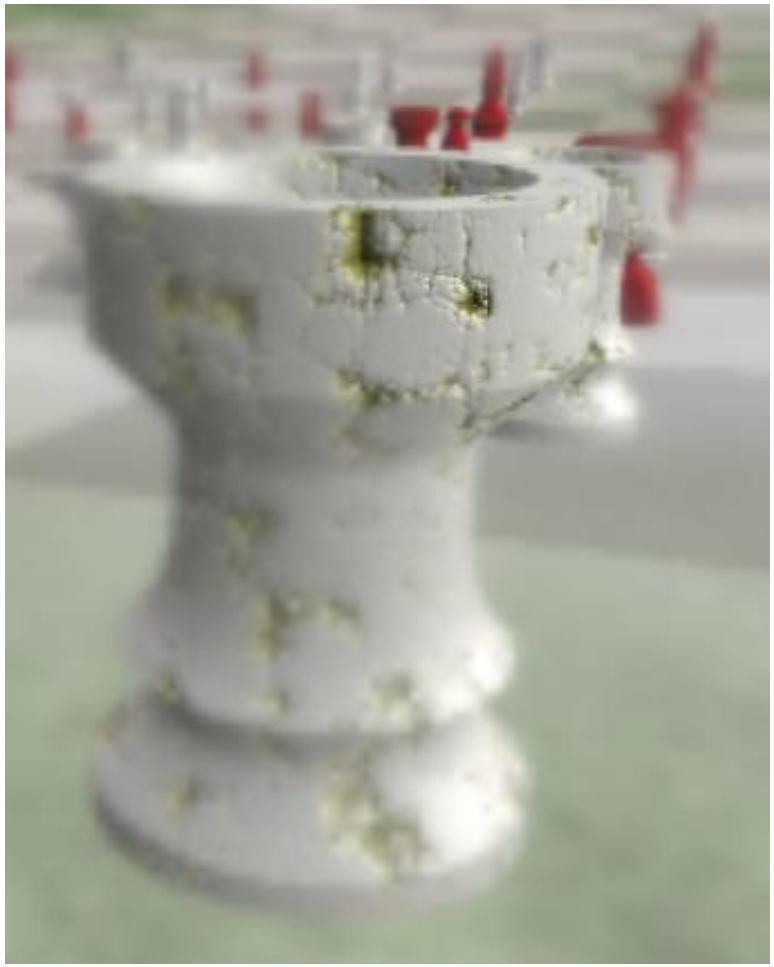




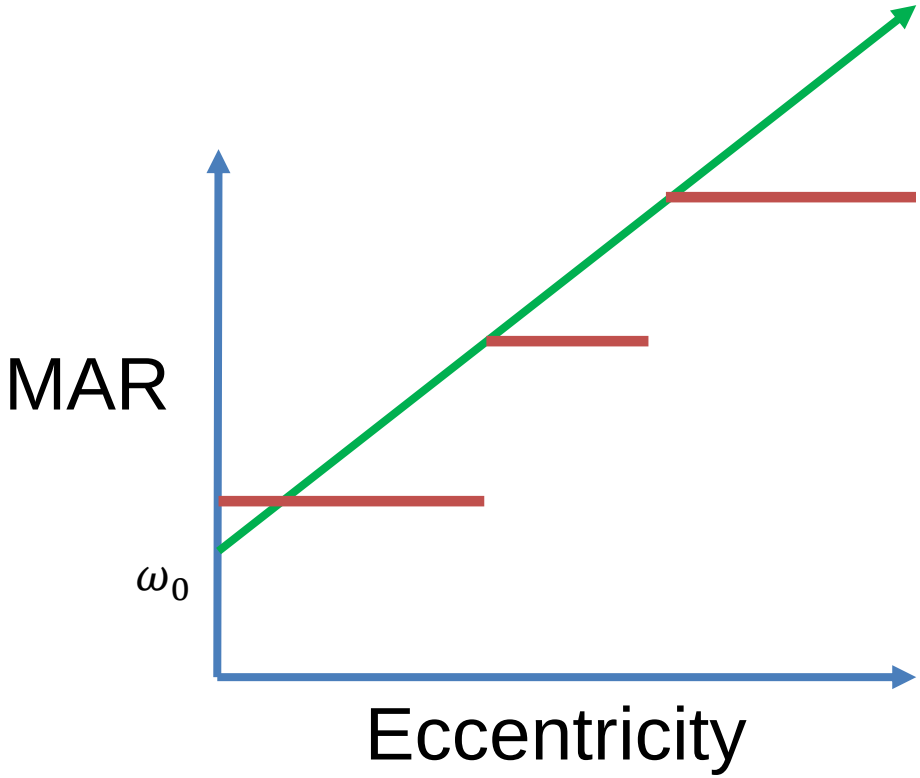


$$\frac{Performance}{Quality} \propto MAR\ Slope$$

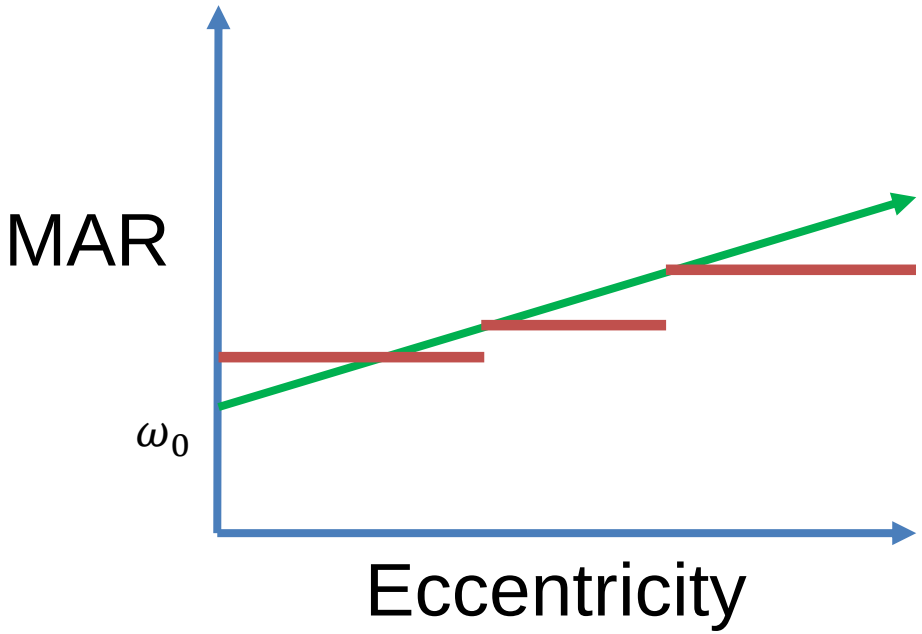


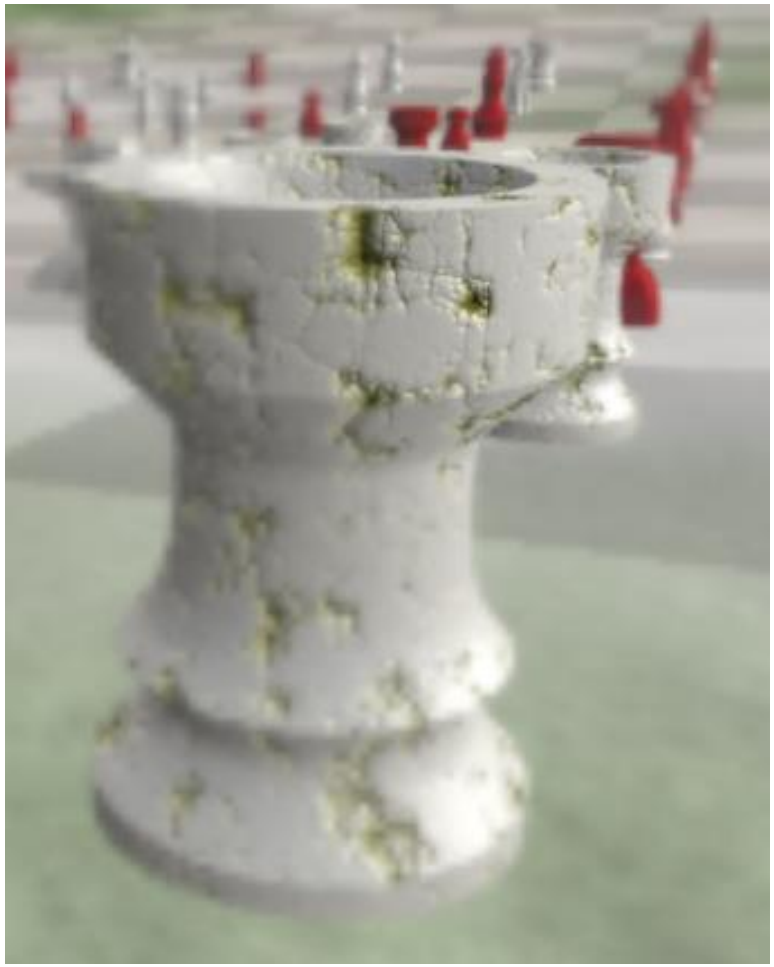


$$\frac{Performance}{Quality} \propto MAR\ Slope$$



$$\frac{Performance}{Quality} \propto MAR\ Slope$$





User Study

- System Effectiveness

User Study

- System Effectiveness
- Validate Model
- Optimize Parameterization

Measuring Quality

Quality

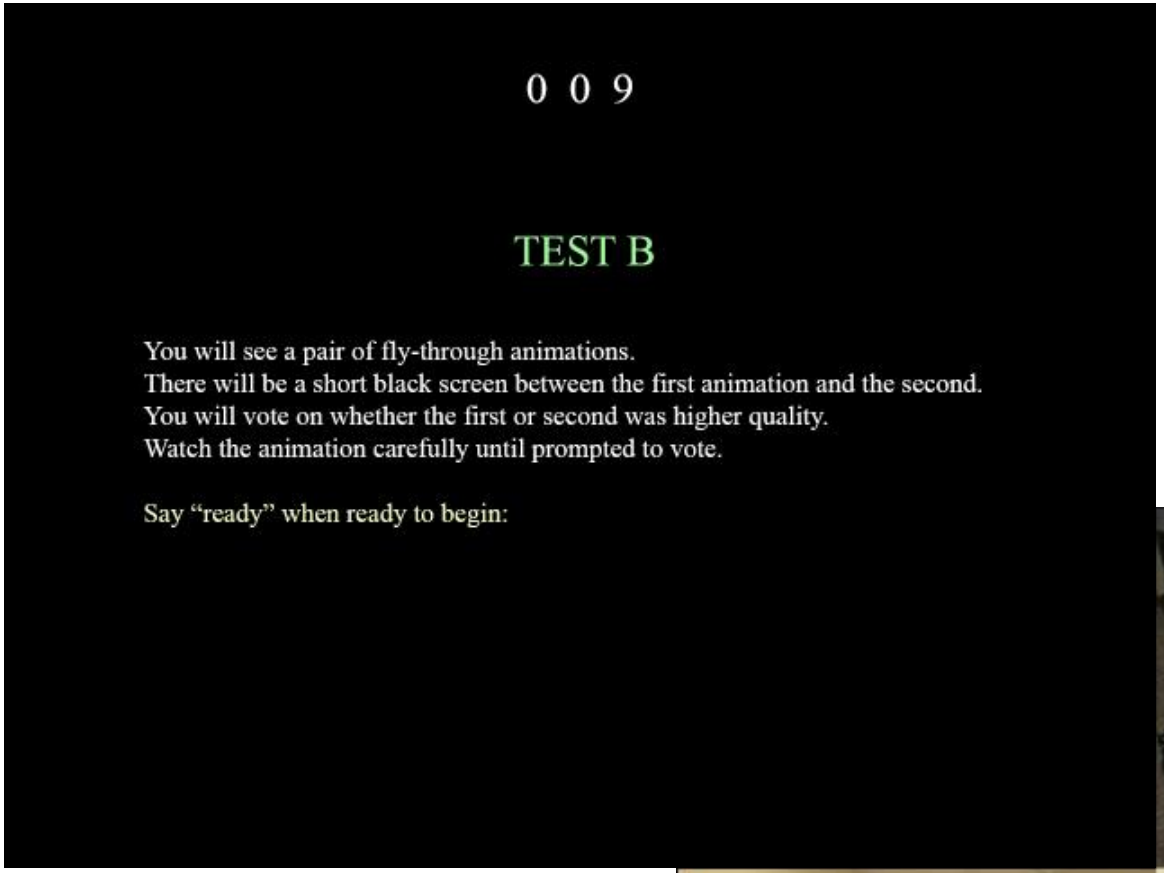
Speed

Visually indistinguishable

Equal quality

Acceptable quality

Impact on task performance



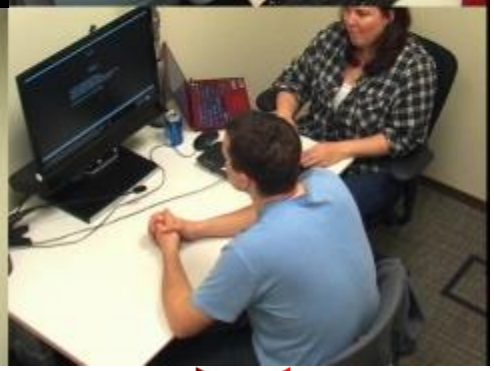
A/B Comparison

0 0 7

TEST C

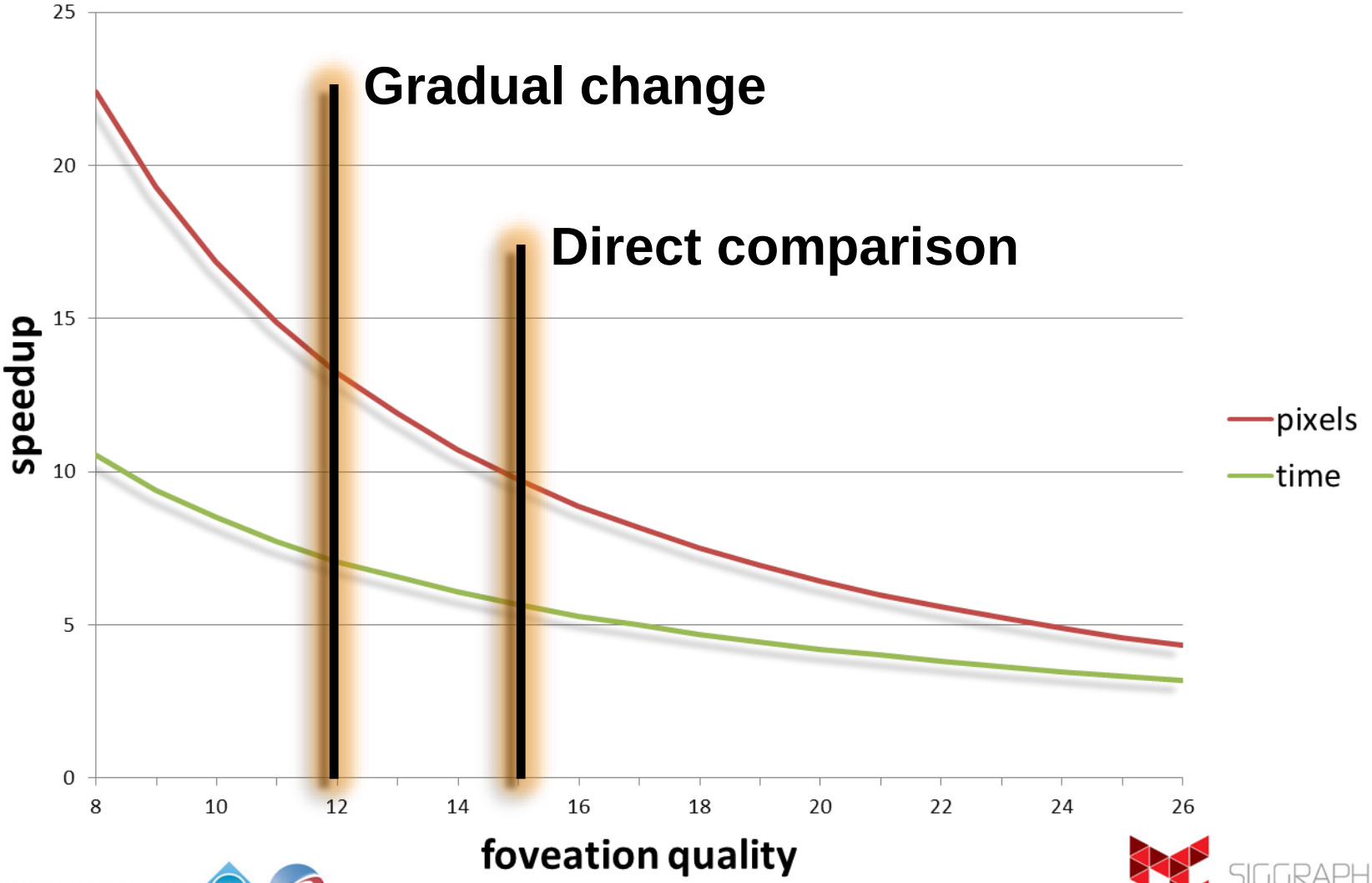
You will see an animated fly-through.
Every few seconds the settings will change.
Determine whether the quality was better at the beginning or end.
Watch the animation carefully until further instructions.

Say “ready” when you are ready to begin:



Ramp Test

User Study Results



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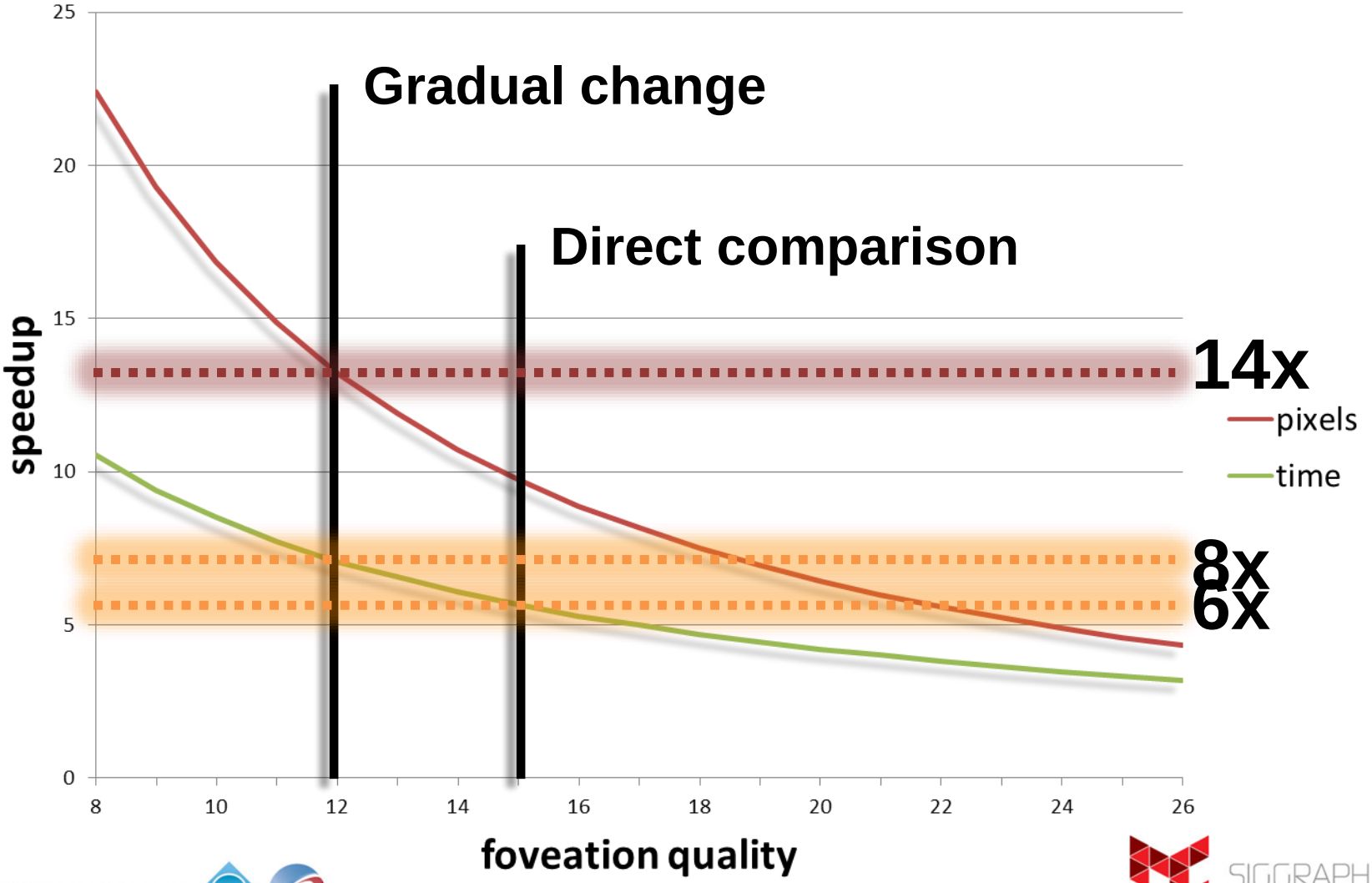
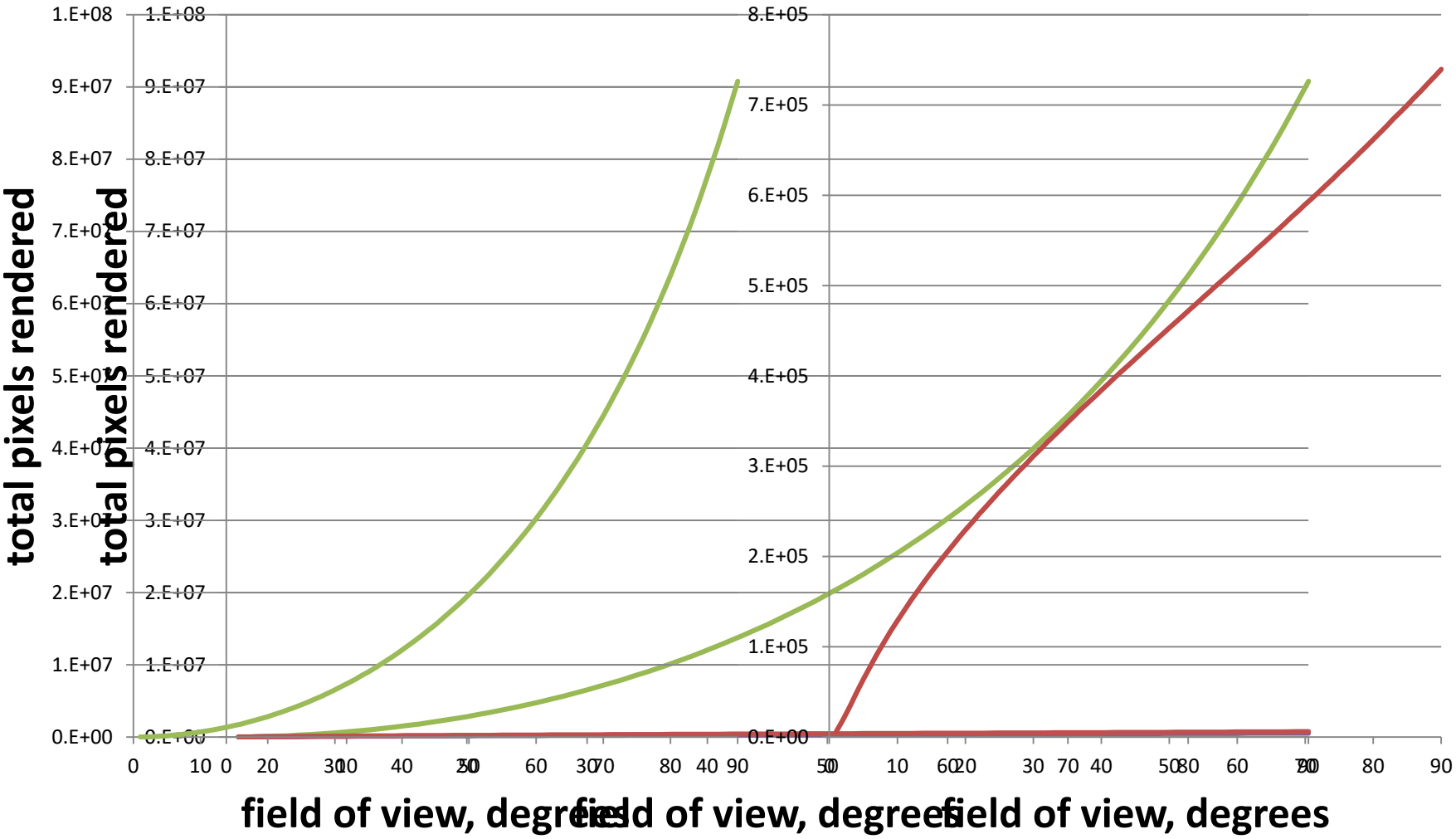
User Study Results



Projected Performance Gains



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Conclusions

- More pixels
- Cheap, robust eye tracking
- Higher visual quality
- Less hardware horsepower
- Lower power consumption

Thank you

Project page:
http://research.microsoft.com/FoveatedDisplay

Contact Mark Finch:
mafinch@microsoft.com

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