Research Impact Retrospective: MLAA from 2009 to 2017

Alex Reshetov, NVIDIA
Jorge Jimenez, Activision
MLAA Introspective: from 2009 to 2017

Alex Reshetov, NVIDIA

Jorge Jimenez, Activision
Morphological Antialiasing

- Alexander Reshetov
- Intel Labs
What we’re talking about

this one is antialiased ➔

↔ this one is not

(if you can read it, you can see it)
If you were in N.O. in 2009 you would learn…

• What *sfumato* is
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*sfumato*: painting technique “without lines or borders, in the manner of smoke or beyond the focus plane”
If you were in N.O. in 2009 you would learn...

• What *sfumato* is

• How Georges-Pierre Seurat worked on his paintings (pointillism)
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• We would discuss Black Square of Kazimir Malevich
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- We would discuss Black Square of Kazimir Malevich
- and early Pixel Art
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• We would discuss Black Square of Kazimir Malevich

• and early Pixel Art

• 畫意能達萬言
However...

• You would learn nothing about deferred shading

• In fact, this term was never mentioned in neither
  • The MLAA paper
  • The ‘09 presentation

• But 1 out of 4 reviewers guessed it right
I only make predictions in retrospect.
• “The Americans have need of the telephone, but we do not. We have plenty of messenger boys”
Sir William Preece, Chief Engineer, British Post Office, 1878

• “There is not the slightest indication that nuclear energy will ever be obtainable. It would mean that the atom would have to be shattered at will”
Albert Einstein, 1932

• “There is no reason for any individual to have a computer in his home”
Ken Olson, president, chairman and founder of Digital Equipment Corporation (DEC), in a talk given to a 1977 World Future Society

• “In short, never use BVH”
Gordon Stoll, Siggraph 2005 Course on Real-Time Ray Tracing
Would it be nice though…

• ...If we could predict outcome of our research (is significance/risk == const?)
• Eventually, DL will take care of it, but now,
• using MLAA as an example, I will
  • describe ‘under the hood’ details of the project,
  • speculate what makes research successful,
  • and what ‘success’ actually means
• Jorge will talk about the advanced features and the current status of MLAA (is it dead yet?)
## In fact, I’ll talk about 2 research projects

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<thead>
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<th>A unistable polyhedron with 14 faces</th>
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IMHO, this what makes success more likely

• ∃ need for something
  • Usually it is not crystal clear, this is why it is “research”
• Universal approach
  • Breadth beats depth
• Real-world tests (GOD mode in COD)
• Exposure to CG community
  • Long live HPG!
• Code availability
  • 2 days to evaluate research papers
• Name

1 (for the research project)
Segue to Jorge’s talk: MLAA details

image enhancement technique (screen-space post-processing)
Morphological Antialiasing

1. Somehow find silhouettes in images (and hope that it will correspond to real objects)
2. Blend (aka filter) colors around the silhouettes
Find axis-aligned lines separating pixels with different colors
Reconstruct silhouette lines connecting pixels adjacent to both horizontal and vertical separation lines while...
• resolving ambiguity in favor of the longer silhouettes
• and taking into account the resulting shapes
• For each pixel intersected by the silhouette lines, its color is blended with the color of the pixel on the opposite side of the separation line with weights proportional to the trapezoid areas.
Pros and cons

pros
• Reconstructs the simplest possible edges (*lex parsimoniae*)
• Independent from the rest of graphics pipeline

cons
• It is not physically based
  • Edges are hallucinated
  • Nyquist issues (in spatial and temporal domain)
  • Threshold-based behavior
  • Processing @ image border
Increasing quality

Increasing amount of information

Single sample to find AA

Jin et al'09:
various discontinuities ⇒ more rays

Whitted'80:
color variation ⇒ more rays

Multiple samples to find AA

SSAA:
gold standard

MSAA/CSAA:
coverage ⇒ color blending

Silhouette approximation/
analytical

Sen and Cammarano'03/04:
shadow silhouette
maps ⇒ improved hard shadows

Bala et al'03:
projected silhouettes ⇒ constraint color interpolation

MLAA

beams, cones, pencils, covers, pyramidal rays
Linked slides (do not remove)
• “The Americans have need of the telephone, but we do not. We have plenty of messenger boys”
  Sir William Preece, Chief Engineer, British Post Office, 1878

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Call of Duty as a testbed (came free with graphics card)
Extra slides


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MLAA in a one sentence

• (1) detect all pixels that are different from neighbors to 
  (2) approximate silhouettes and then 
  (3) blend colors around these silhouettes 

• Steps 1 and 2 allow innovation and differentiation 

• If we know more, we could get better results 
  – subpixel discontinuity data 
  – original 3D data 
  – previous frames 
  – domain knowledge
• http://www.geniusstuff.com/blogs/10-accidental-inventions10.htm
2:00 Introduction
2:05 A Directionally Adaptive Edge Anti-Aliasing Filter
2:20 Morphological Anti-Aliasing (MLAA)
2:35 Jimenez's MLAA & SMAA (Subpixel Morphological Anti-Aliasing)
2:50 Hybrid CPU/GPU MLAA on the Xbox-360
3:05 MLAA on the PS3
3:35 The Saboteur Anti-Aliasing (SPUAA)
3:50 Break
4:00 Subpixel Reconstruction Antialiasing (SRAA)
4:15 FXAA 3.11 in 15 Slides
4:30 Distance-to-edge Anti-Aliasing (DEAA)
4:45 Geometry Buffer Antialiasing (GBAA)