

# High-Performance Graphics 2017

*Los Angeles | July 28-30, 2017*

## Research Impact Retrospective: MLAA from 2009 to 2017

Alex Reshetov, NVIDIA

Jorge Jimenez, Activision

# High-Performance Graphics 2017

Los Angeles | July 28-30, 2017

the original title

## MLAA Introspective: from 2009 to 2017

Alex Reshetov, NVIDIA

Jorge Jimenez, Activision

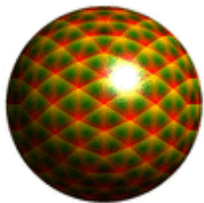
NEW ORLEANS, LOUISIANA, USA AUGUST 1-3 2009



HIGH-PERFORMANCE  
GRAPHICS  
Algorithms Hardware Systems

# 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)



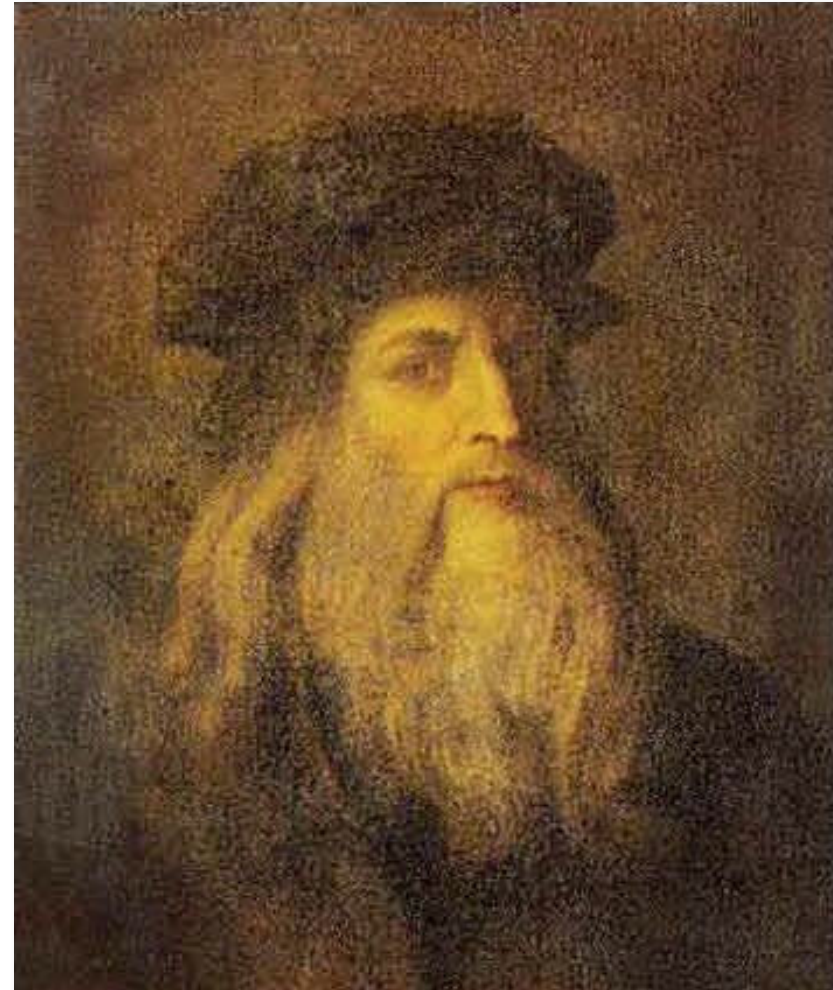
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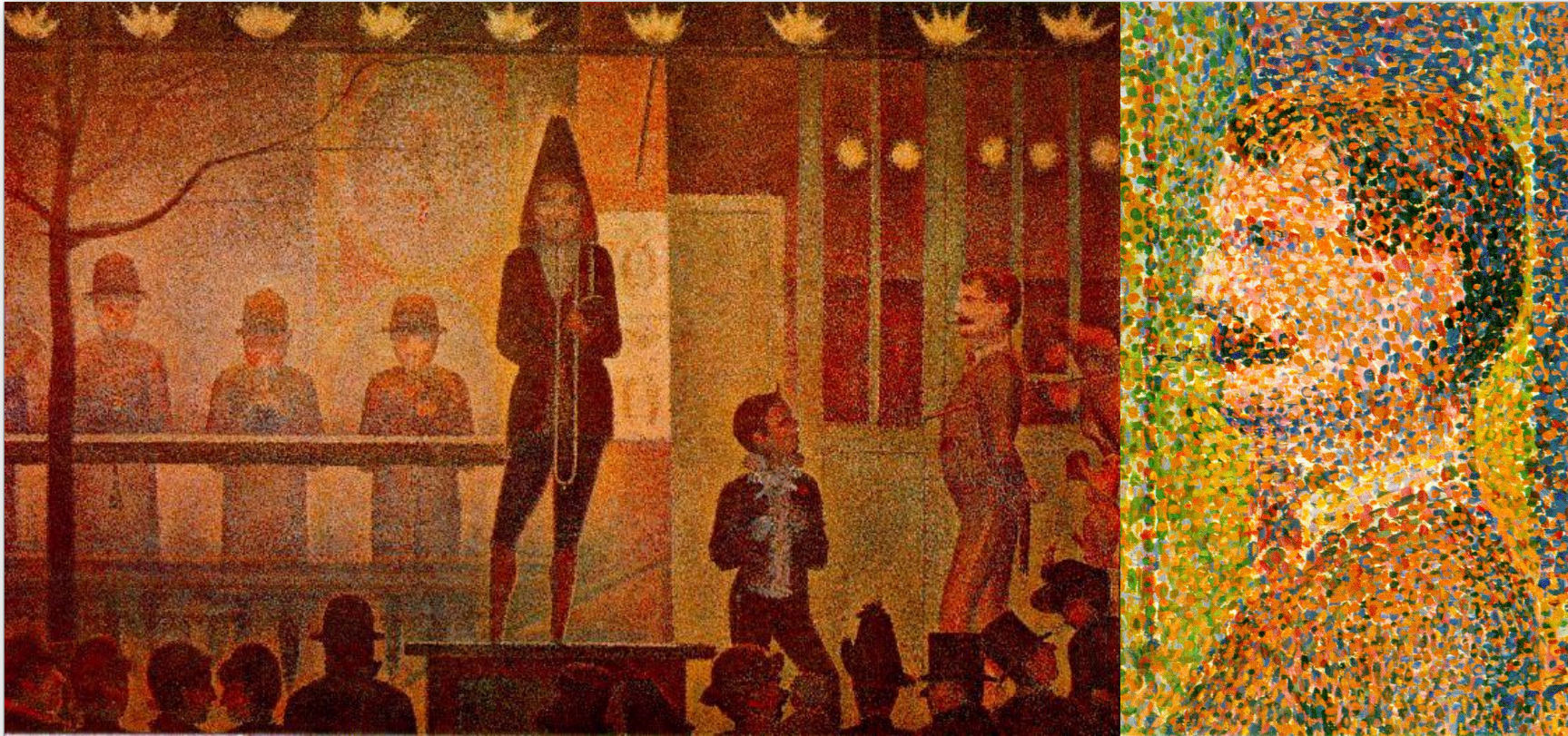
*sfumato*: painting technique  
“without lines or borders, in  
the manner of smoke or  
beyond the focus plane”



Leonardo da Vinci – Inventor of Antialiasing

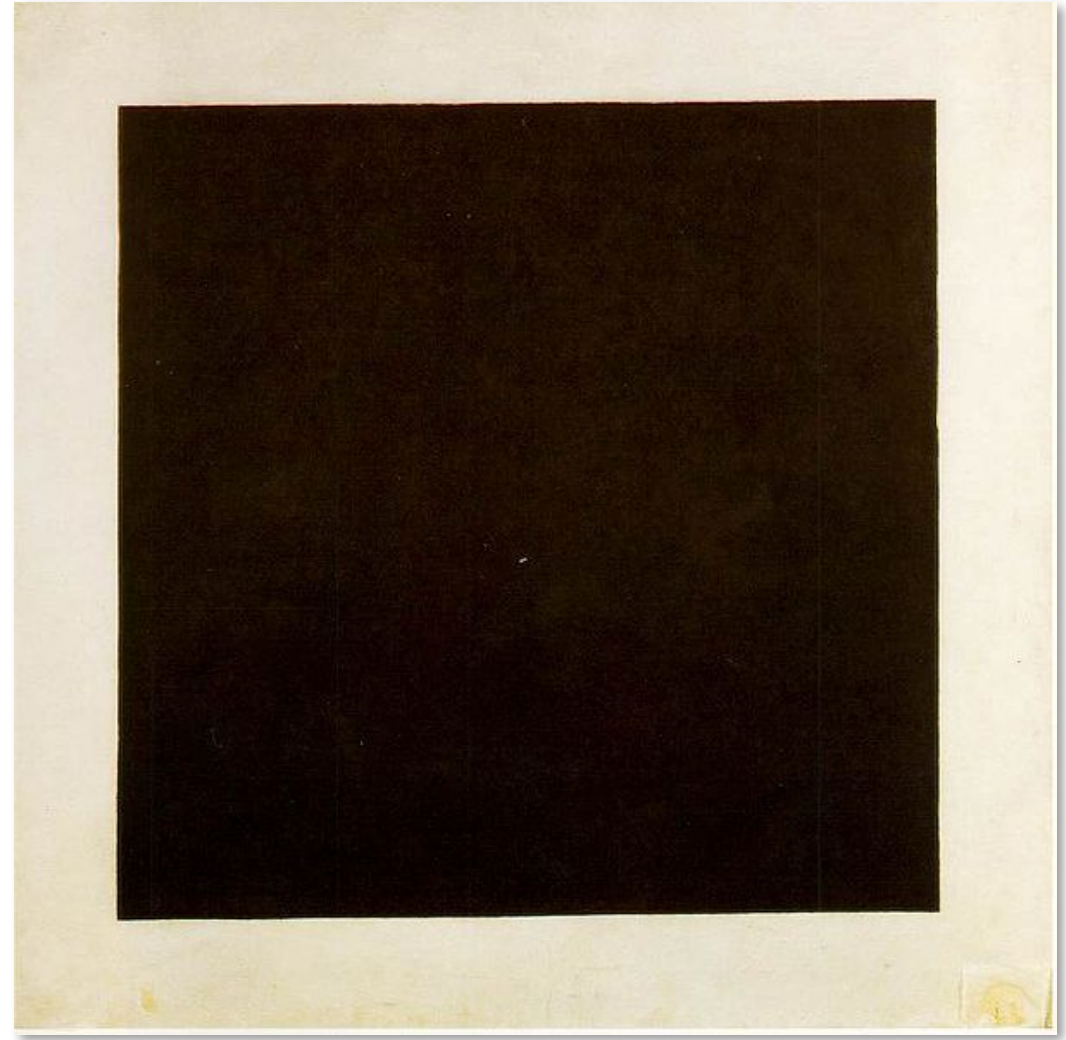
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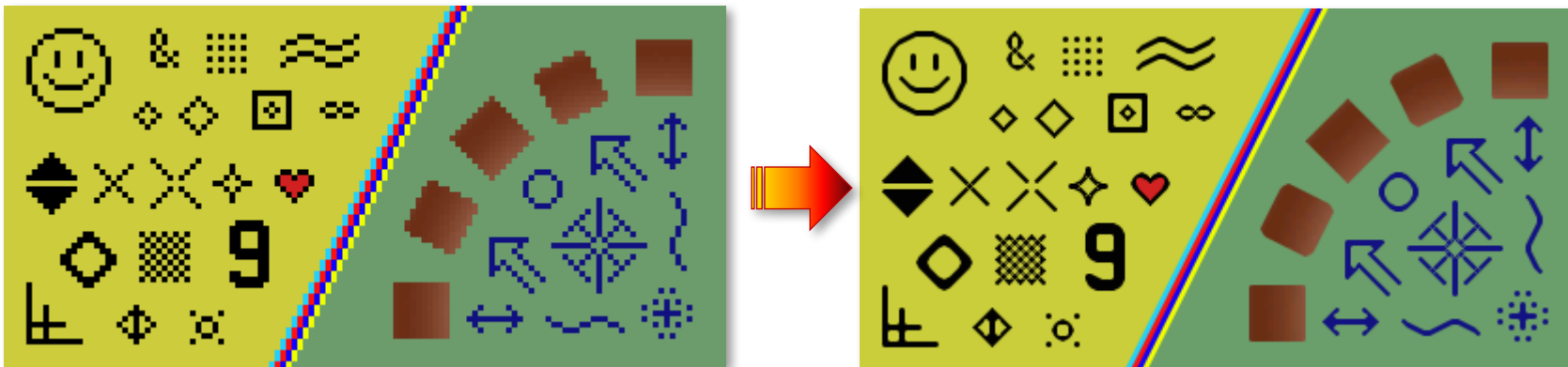
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- We would discuss Black Square of Kazimir Malevich





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- 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



Lindsay

- “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

## Morphological antialiasing

Wasn't developed with a clear goal in mind (I started working first on soft shadows by diffusion)

Many variations

Criteria of success was murky

Many limitations

Wasn't very happy with the result

Have a limited lifespan

Widely adopted by game developers

src code released

## A unistable polyhedron with 14 faces

An explicit goal to improve the previous best result (18)

Many variations

Couldn't be more clear

No limitations at all; valid in any corner of the Universe


Happy as a clam at high tide

Will remain in Wikipedia till year 3000

Has absolutely no practical value

src code released

# IMHO, this what makes success more likely <sup>1</sup>

- $\exists$  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 



<sup>1</sup> (for the research project)



# Segue to Jorge's talk: MLAA details

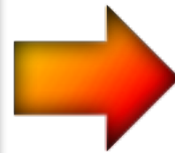
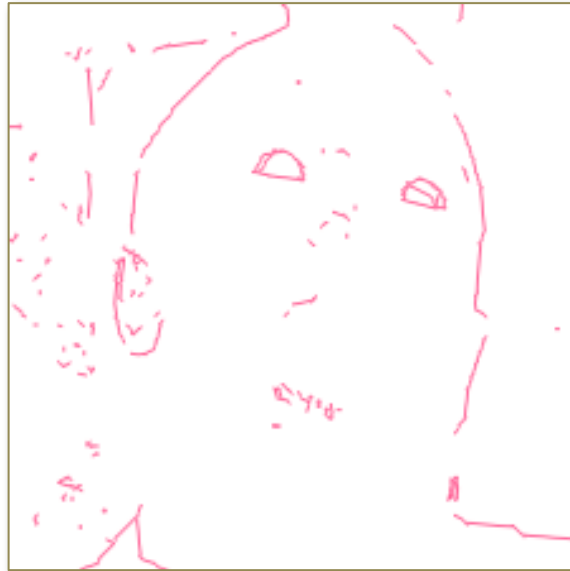
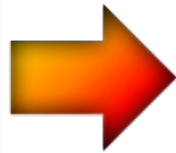


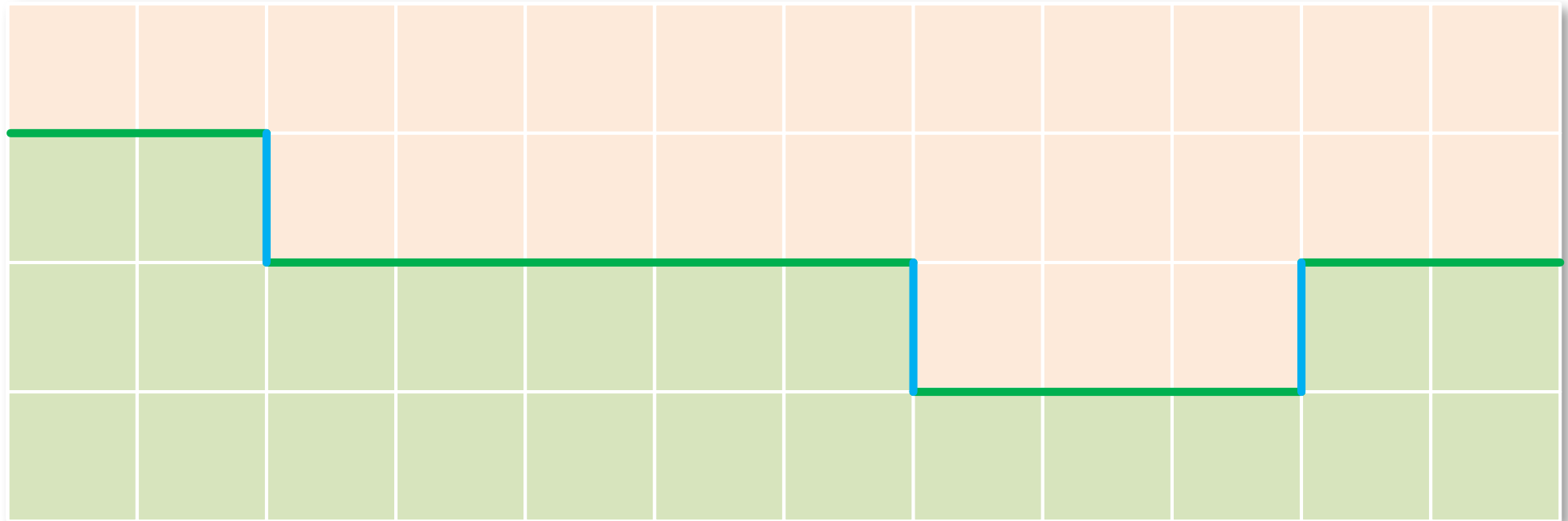
image enhancement technique  
(screen-space post-processing)



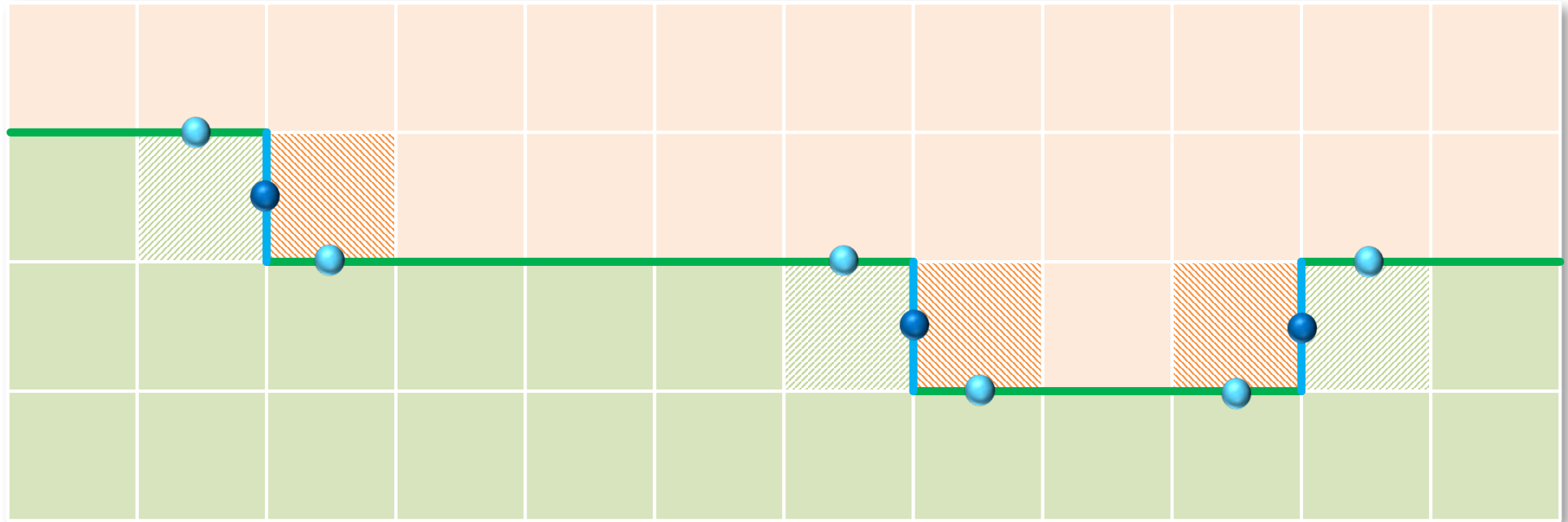
# Morphological Antialiasing

1. Somehow find silhouettes in images  
(and hope that it will correspond to real objects)
2. Blend (*aka* filter) colors around the silhouettes

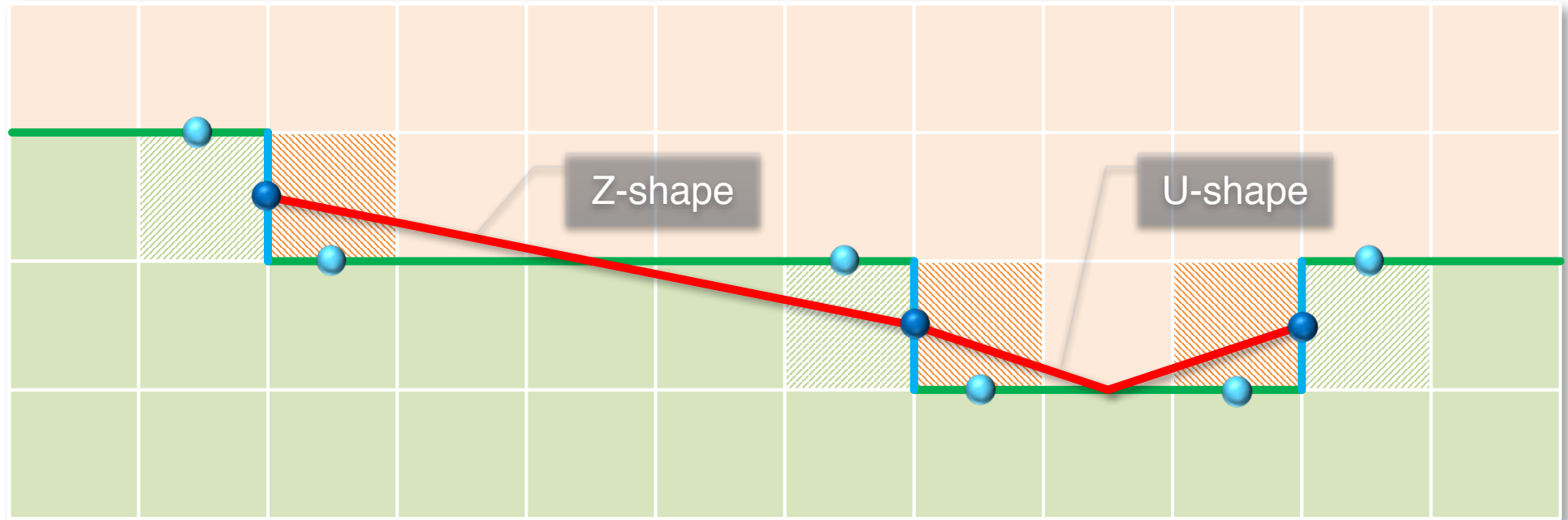




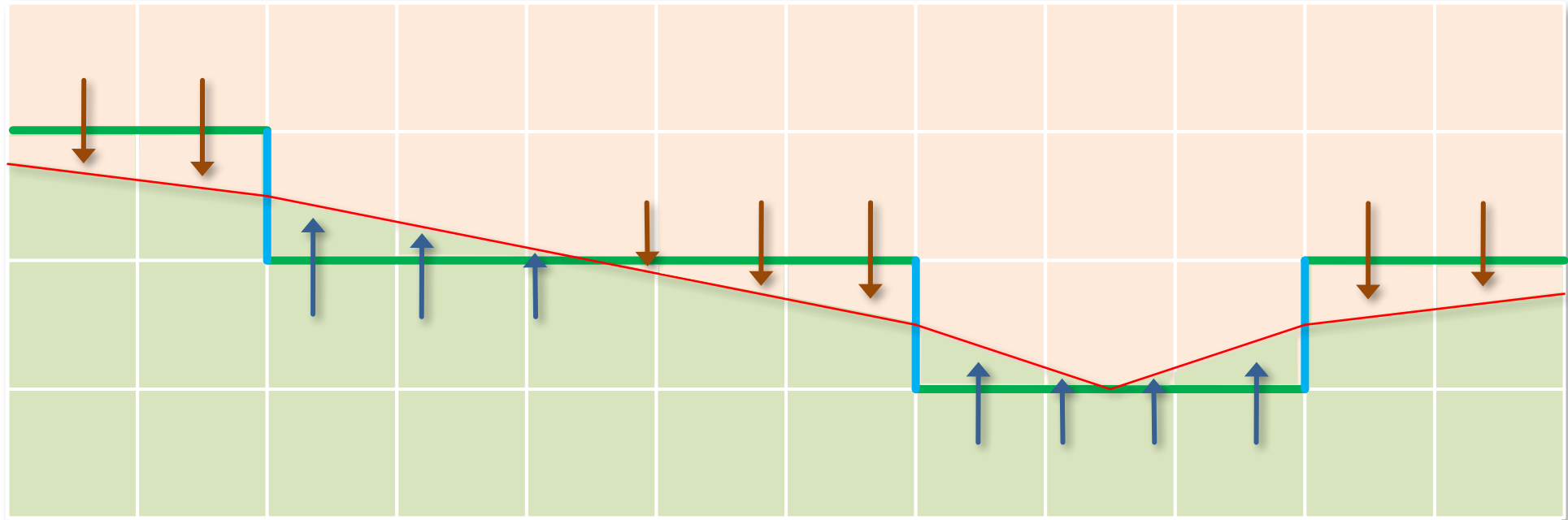
Find axis-aligned lines separating pixels with different colors



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

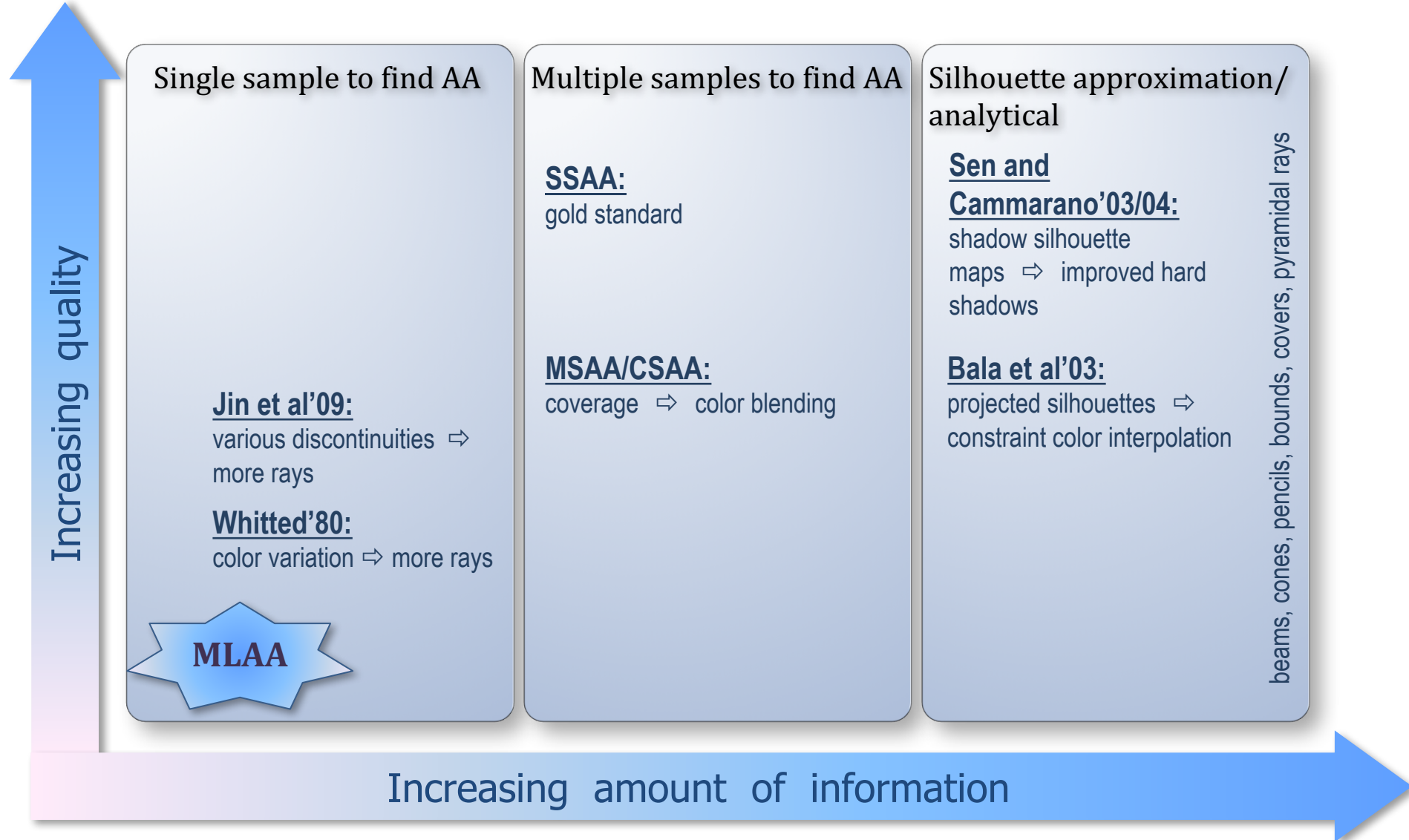
## pros

- 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

# Conclusion: slide from the '09 talk





**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
- “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”  
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# Call of Duty as a testbed (came free with graphics card)

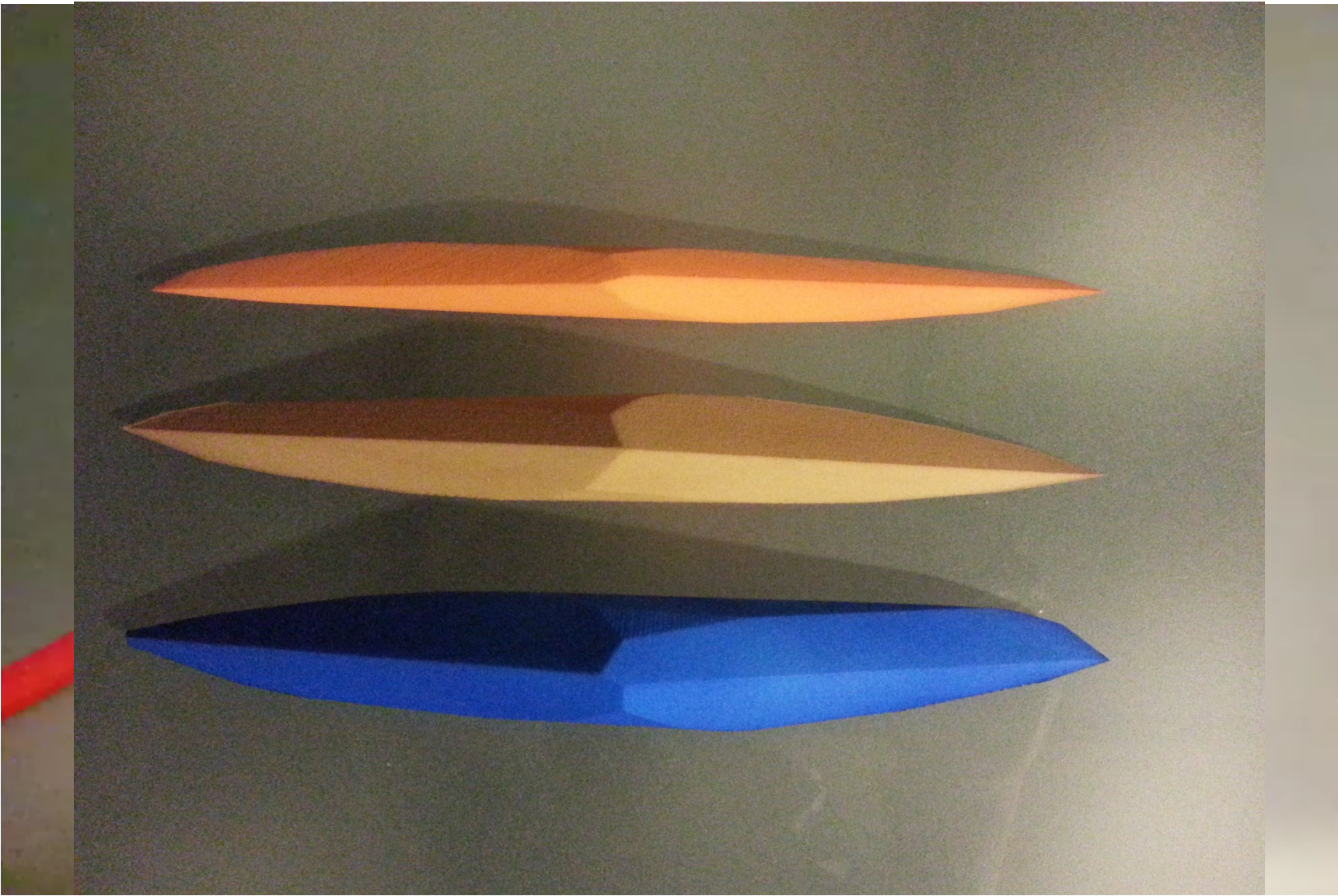


63. No AA



MLAA

**Extra slides**



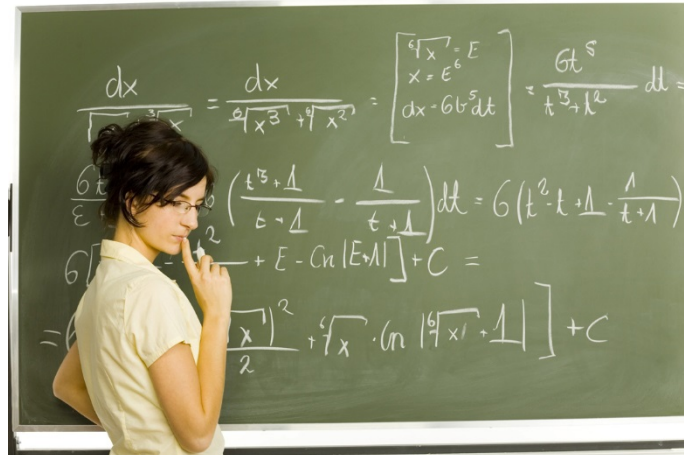
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Wasn't developed with a clear goal in mind (I started working first on soft shadows by diffusion)	An explicit goal to improve the previous best result (18)
Many variations	Many variations
Criteria of success was murky	Couldn't be more clear
Many limitations	No limitations at all; valid in any corner of the Universe
Wasn't very happy with the result	Happy as a clam at high tide
Have a limited lifespan	Will remain in Wikipedia till 3000
Widely adopted by game developers	Has absolutely no practical value
src code released	src code released

# 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>



*ACM SIGGRAPH 2011 Course*  
[Filtering Approaches for Real-Time Anti-Aliasing](#)

2:00	Introduction	<b>Diego Gutierrez</b>
2:05	A Directionally Adaptive Edge Anti-Aliasing Filter	<b>Jason Yang</b>
2:20	Morphological Anti-Aliasing (MLAA)	<b>Alexander Reshetov</b>
2:35	Jimenez's MLAA & SMAA (Subpixel Morphological Anti-Aliasing)	<b>Jorge Jimenez</b>
2:50	Hybrid CPU/GPU MLAA on the Xbox-360	<b>Pete Demoreuille</b>
		<b>Cedric Perthuis</b>
3:05	MLAA on the PS3	<b>Tobias Berghoff</b>
3:35	The Saboteur Anti-Aliasing (SPUAA)	<b>Henry Yu</b>
3:50	Break	
		<b>Morgan McGuire</b>
4:00	Subpixel Reconstruction Antialiasing (SRAA)	<b>Timothy Lottes</b>
4:15	FXAA 3.11 in 15 Slides	<b>Hugh Malan</b>
4:30	Distance-to-edge Anti-Aliasing (DEAA)	<b>Emil Persson</b>
4:45	Geometry Buffer Antialiasing (GBAA)	