http://e-emoo.deviantart.com/art/Typography-123991952

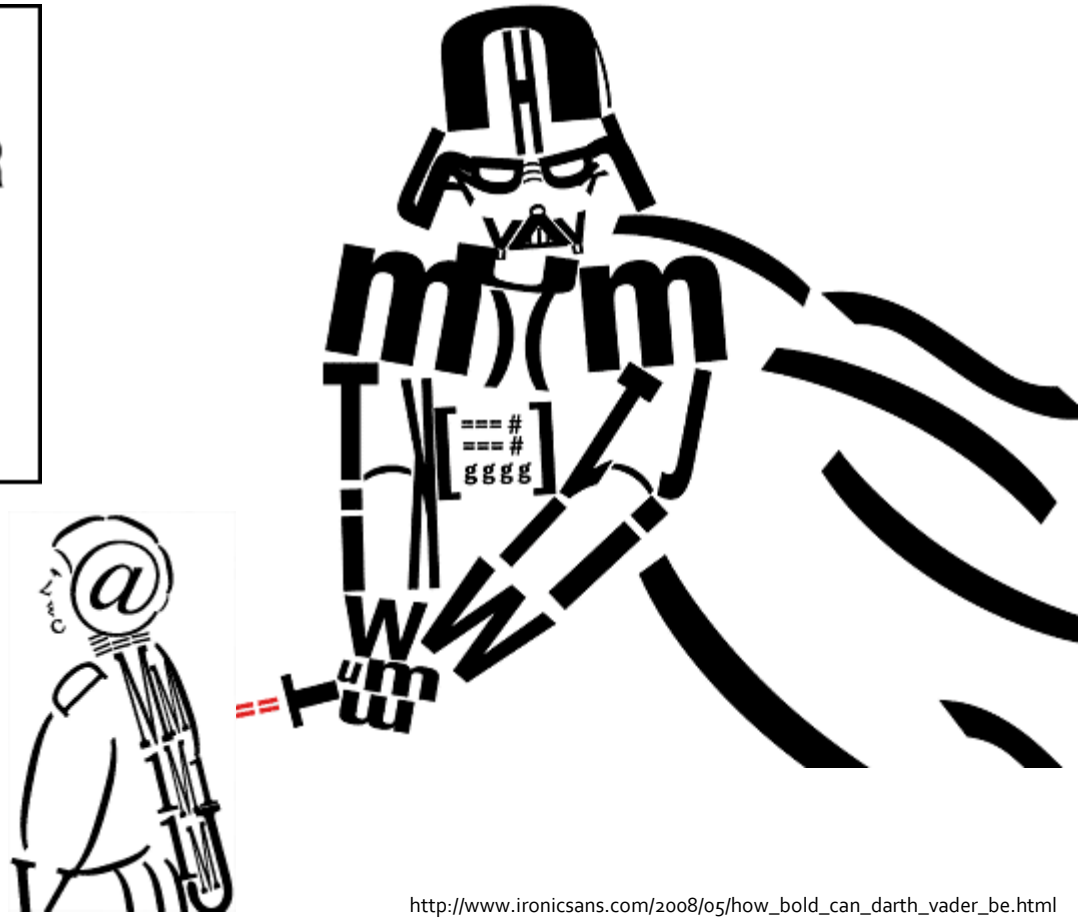
Part 1: Typography and Layout

CS 148, Summer 2012
Introduction to Computer Graphics and Imaging

Justin Solomon

Non-Technical Aspects

"Darth Vader. Only you could be so bold."



http://www.ironicsans.com/2008/05/how_bold_can_darth_vader_be.html

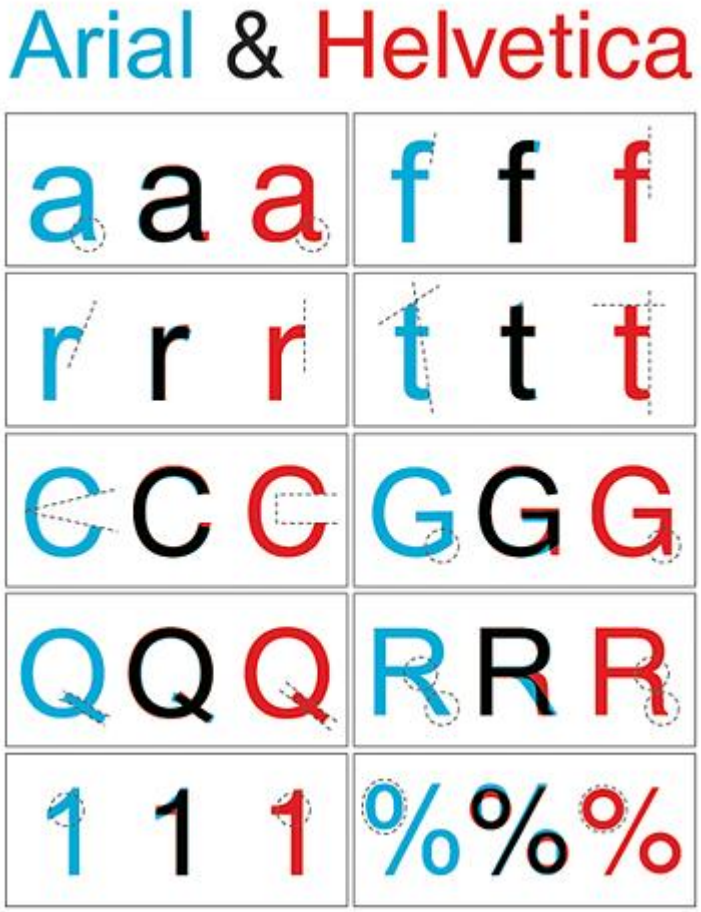
Intersection of art and design

Non-Technical Aspects

http://www.ironicsans.com/helvarialquiz/

Relatively fine points

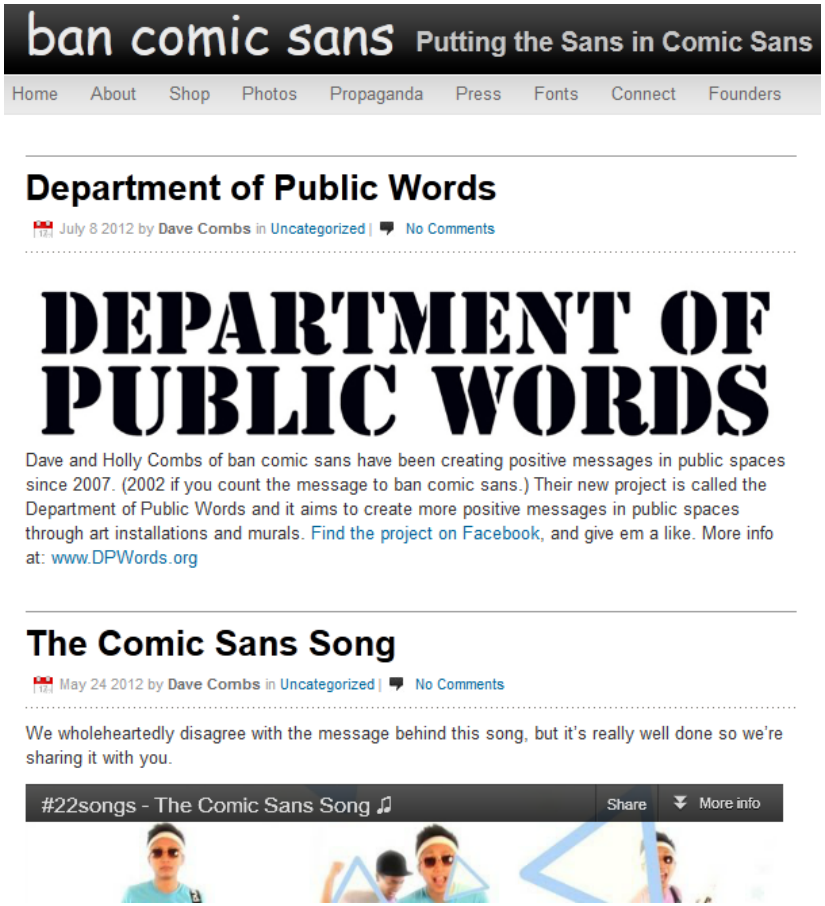
Non-Technical Aspects



http://blog.ocad.ca/wordpress/thegoldenage/files/2011/11/Helvetica_vs_Arial_by_harajukumatt.jpg
http://www.swiss-miss.com/wp-content/uploads/2009/09/d8a5033cb029c5c30d2a93d402def1ddba97582d_m.png

Relatively fine points

Non-Technical Aspects



Ideological battles

Non-Technical Aspects

ban comic sans Putting the Sans in Comic Sans

Home About Shop Photos Propaganda Press Fonts Connect Founders

Department of Public Words

July 8 2012 by Dave Combs in Uncategorized | No Comments

DEPARTMENT OF PUBLIC WORDS

The Comic Sans Song

May 24 2012 by Dave Combs in Uncategorized | No Comments

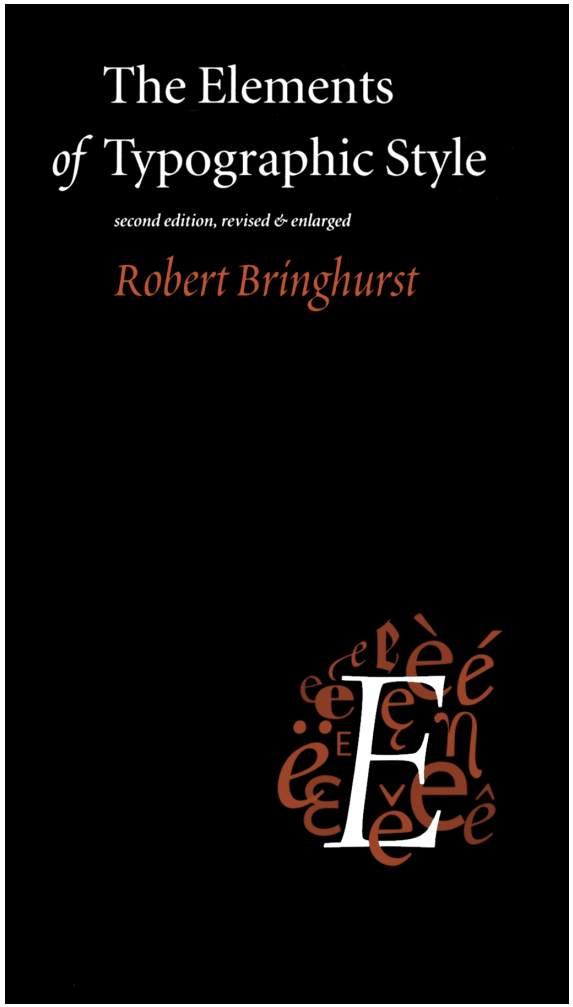
We wholeheartedly disagree with the message behind this song, but it's really well done so we're sharing it with you.

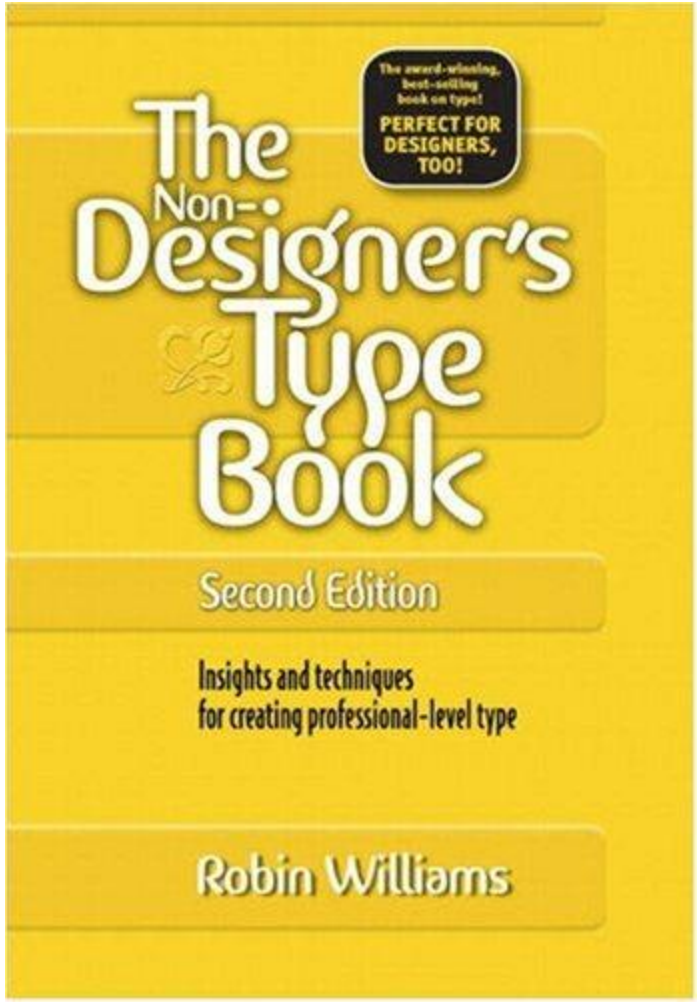
#22songs - The Comic Sans Song ♫ Share More info

Not going to cover this.

Ideological battles

References





http://imgs.abduzeedo.com/files/books/eots/elements-of-typographic-style-front-large.gif
http://photo.goodreads.com/books/1169685773l/41601.jpg

Typeface [**tahyp**-feys]:
Set of characters that share common design features; collection of glyphs.

http://en.wikipedia.org/wiki/Typeface#Types_of_typefaces

Font [font]:

A complete character set of a single size and style of a particular typeface.

http://en.wikipedia.org/wiki/Typeface#Types_of_typefaces

Font vs. Typeface

- Corbel

  Typeface

- 72-Point Bold Corbel

  Font

Typeface Variety

Serif (Minion Pro)

- Old Style (Adobe Jenson Pro)
- Transitional (ITC New Baskerville)
- Modern (Bodoni)

Slab Serif (Clarendon)

Sans serif (Myriad)

http://en.wikipedia.org/wiki/Typeface#Types_of_typefaces

Typeface Variety

Blackletter (Teutonic No. 1)

DISPLAY (LiquidCrystal)

Monospaced (Courier)

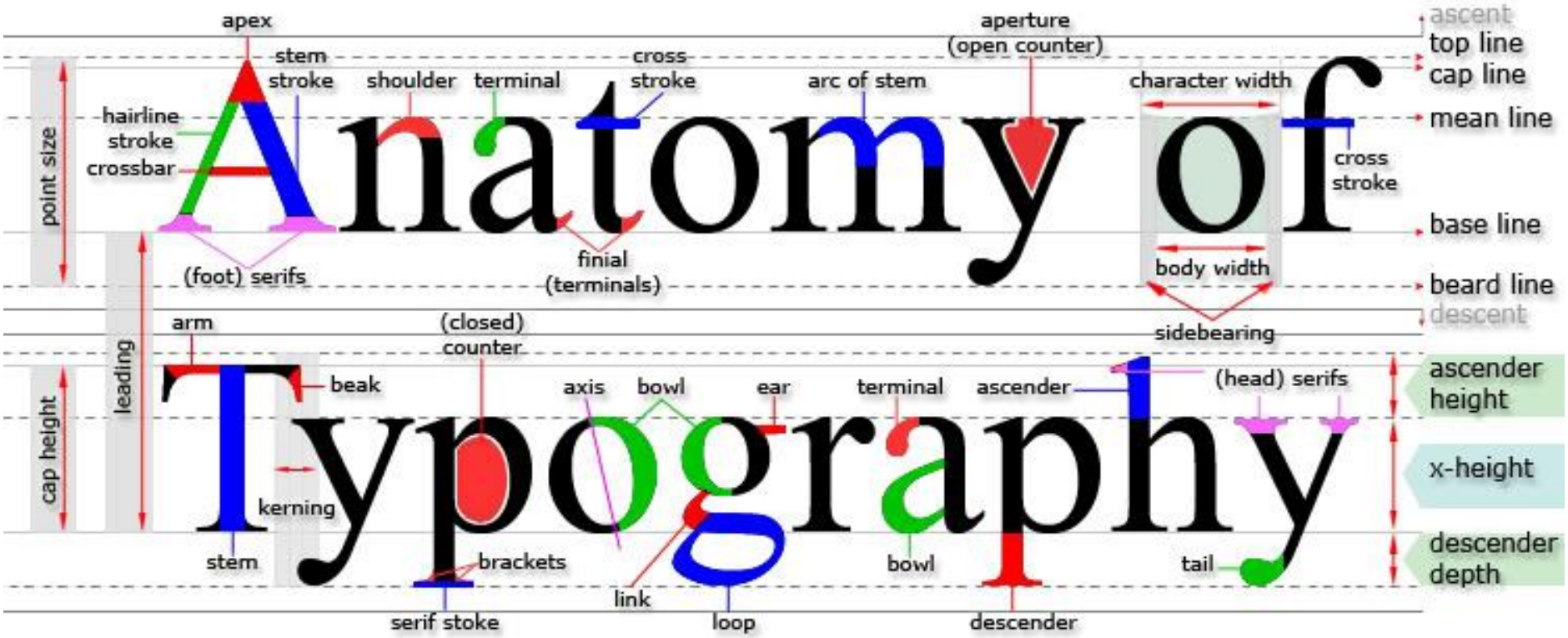
✤✻■✳❂❀▼

(ITC Zapf Dingbats)

(Dingbat)

http://en.wikipedia.org/wiki/Typeface#Types_of_typefaces

Typeface Anatomy



http://sirnaseniku.blogspot.com/

Legal Issues

Eltra Corp v. Ringer

1978

Typefaces are not eligible under copyright law as "works of art."

Legal Issues

Ex parte Tayama

1992

Novel and non-obvious typeface designs can be subject to a design patent.

http://en.wikipedia.org/wiki/Adobe_Systems,_Inc._v._Southern_Software,_Inc.

Legal Issues

Adobe Systems v. Southern Software

1998

Adobe's Utopia font protectable under copyright thanks to creative selection of control points

Legal Issues

"[T]ypefaces and the characters they contain are … utilitarian objects whose utility outweighs any merit that may exist in protecting their creative elements. [T]he computer file(s) associated with a scalable font will generally be protected even though the specific design of the characters is not. Furthermore, a rasterized representation … of the characters in a scalable font is not protected by copyright in the United States…. [T]ypography and calligraphy are not copyrightable in themselves in the U.S."

http://en.wikipedia.org/wiki/Intellectual_property_protection_of_typefaces,_fonts_and_characters

Legal Issues

"[T]ypefaces and the characters they contain are … utilitarian objects whose utility outweighs any merit that may exist in protecting their creative elements. [T]he computer file(s) associated with a scalable font will generally be protected even though the specific design of the characters is not. Furthermore, a digitized representation … of the characters in a scalable font is not protected by copyright in the United States…. [T]ypography and calligraphy are not copyrightable in themselves in the U.S."

Gray area.

Proceed with caution.

http://en.wikipedia.org/wiki/Intellectual_property_protection_of_typefaces,_fonts_and_characters

Measuring Fonts

Points (pt)

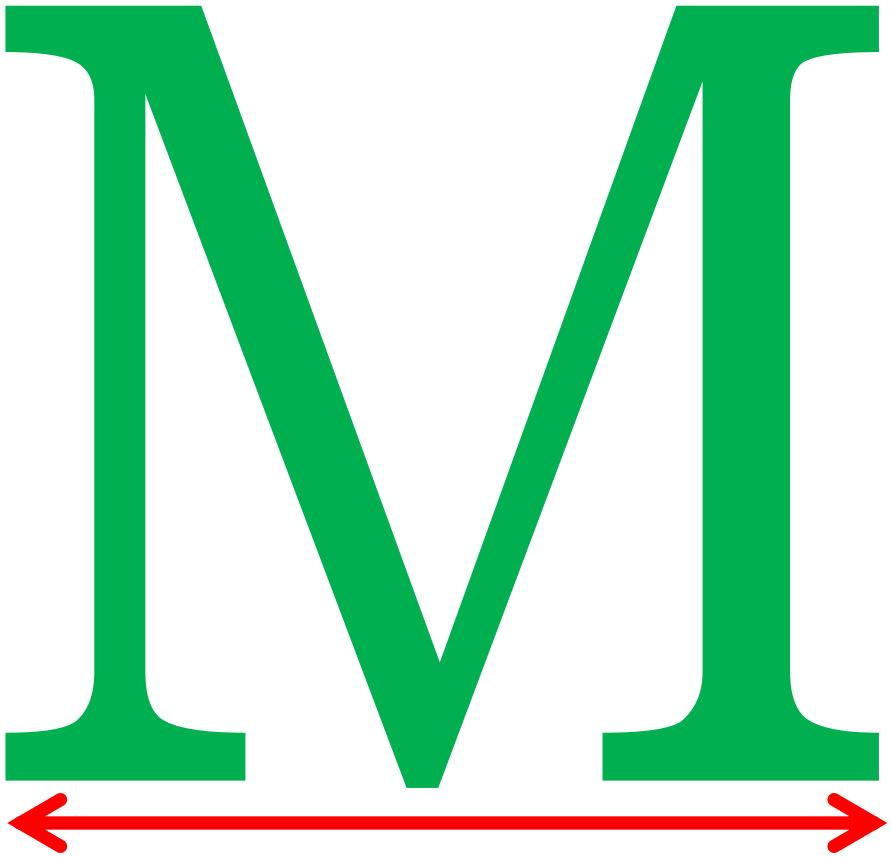
72 points = 0.996 in

72 points = 1.0 in (for Adobe)

Picas (pc)

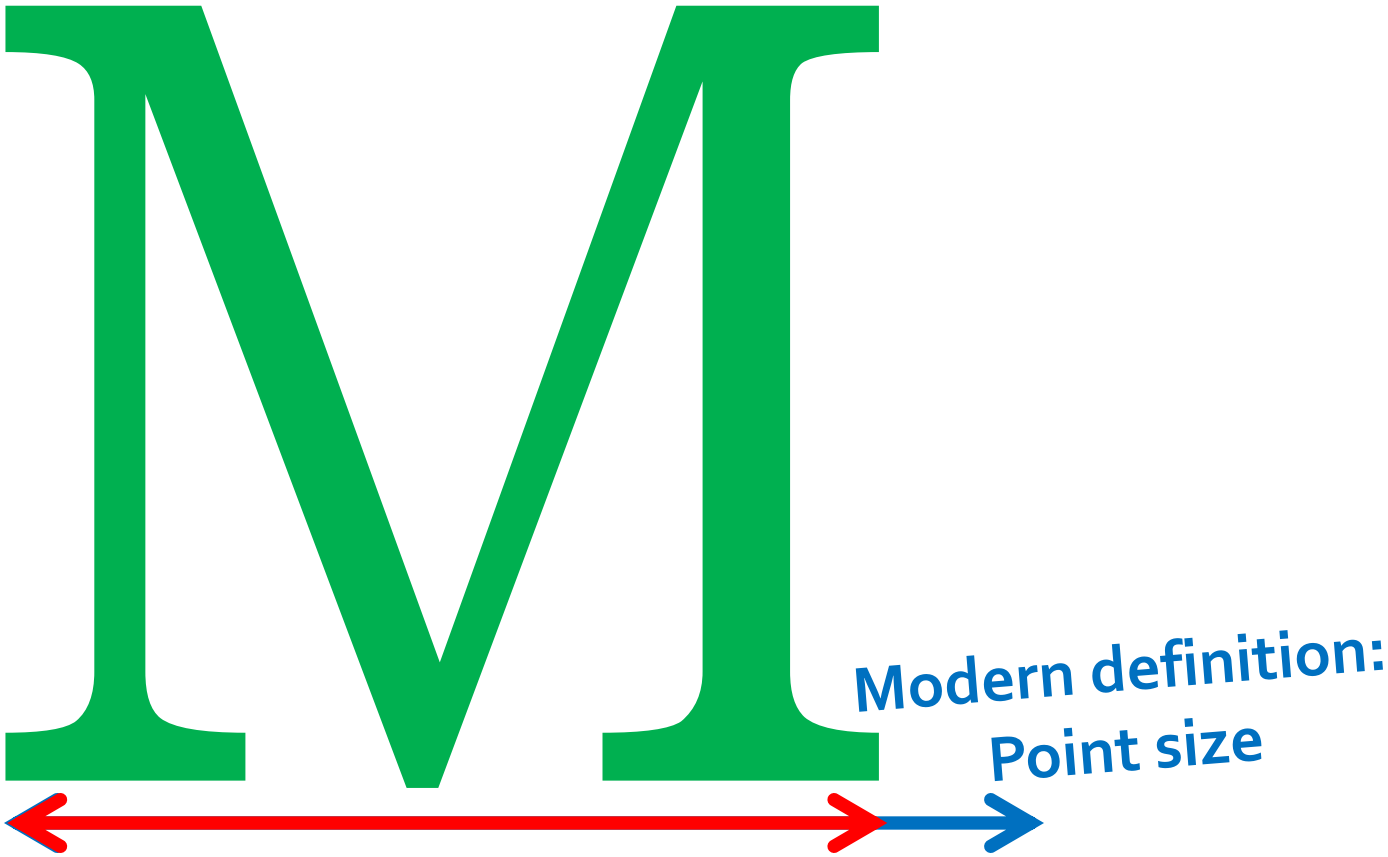
12 points = 1 pica

Measuring Fonts



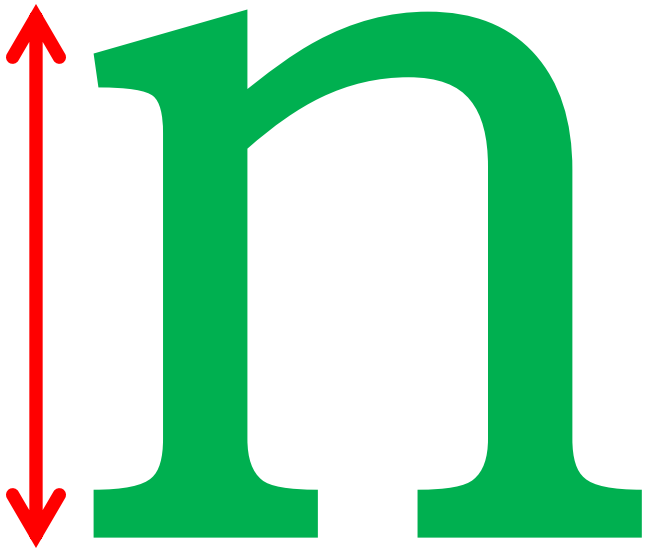
Em

Measuring Fonts



Em

Measuring Fonts



En = Em / 2

Common Catch

Font size should *not* be measured in pixels.

Common Catch

Font size should *not* be measured in pixels.

"Pixels per inch" (PPI)

Storage: ASCII

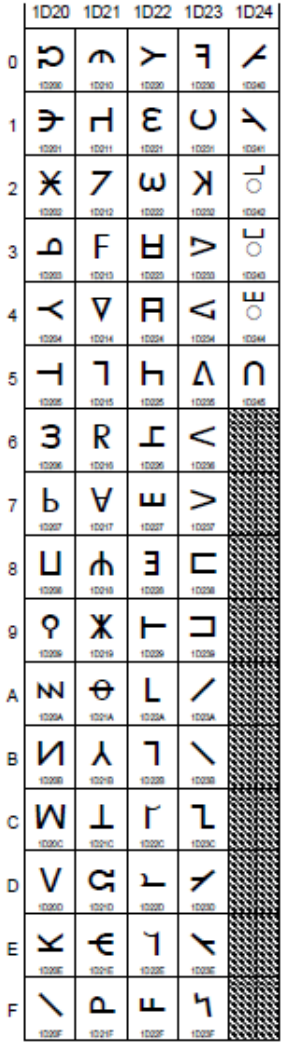
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	DEL

http://en.wikipedia.org/wiki/ASCII

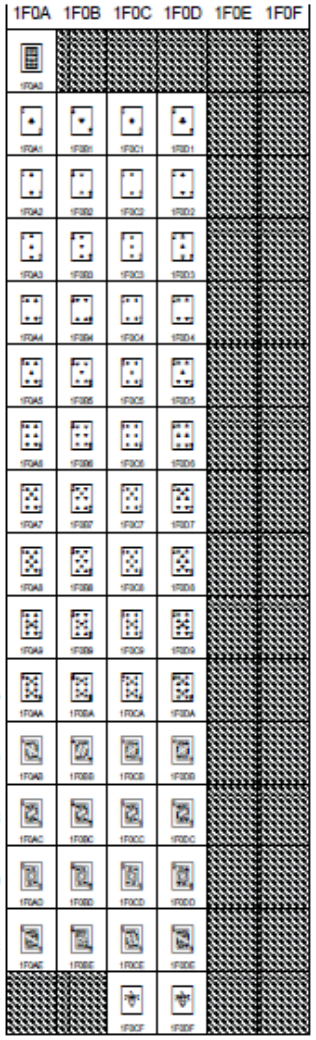
American Standard Code for Information Interchange

Storage: Unicode

Ancient Greek Musical Notation



Playing Cards



Supplemental Arrows-B

2600 Miscellaneous Symbols 26FF

http://www.unicode.org/charts/

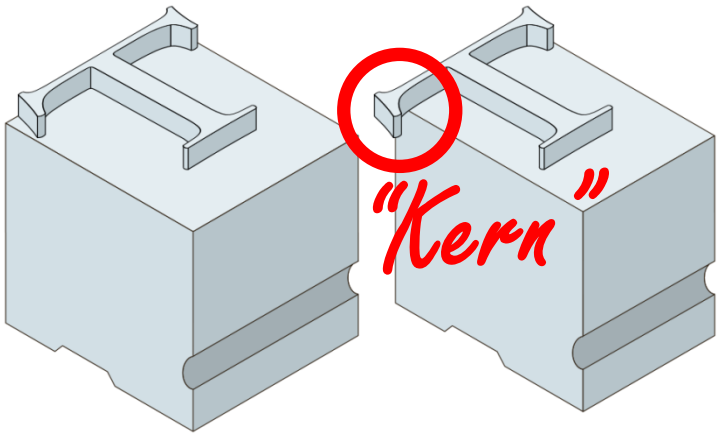
Storage: TrueType

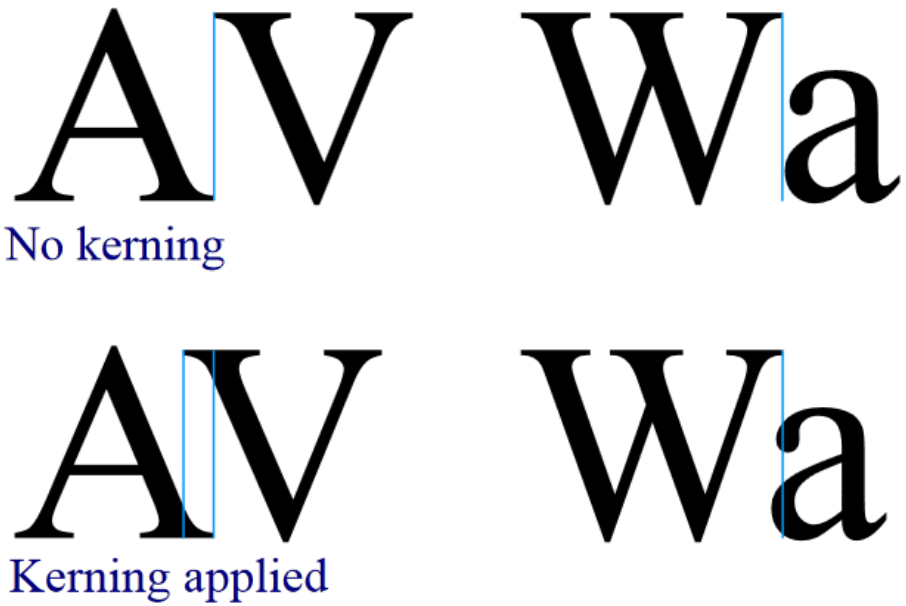
- **Character map**
  Unicode to glyph
- **Glyphs**
  Quadratic Bézier curves
- **Hinting**
  Short programs in fonts

Storage: OpenType

- **Character map**
  Unicode to glyph
- **Glyphs**
  Cubic Bézier curves
- **Glyph metrics**
  To help with layout

Text: Words/Sentences

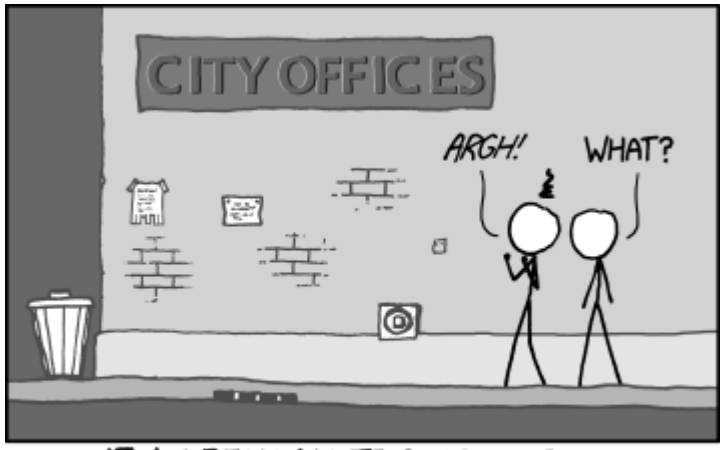




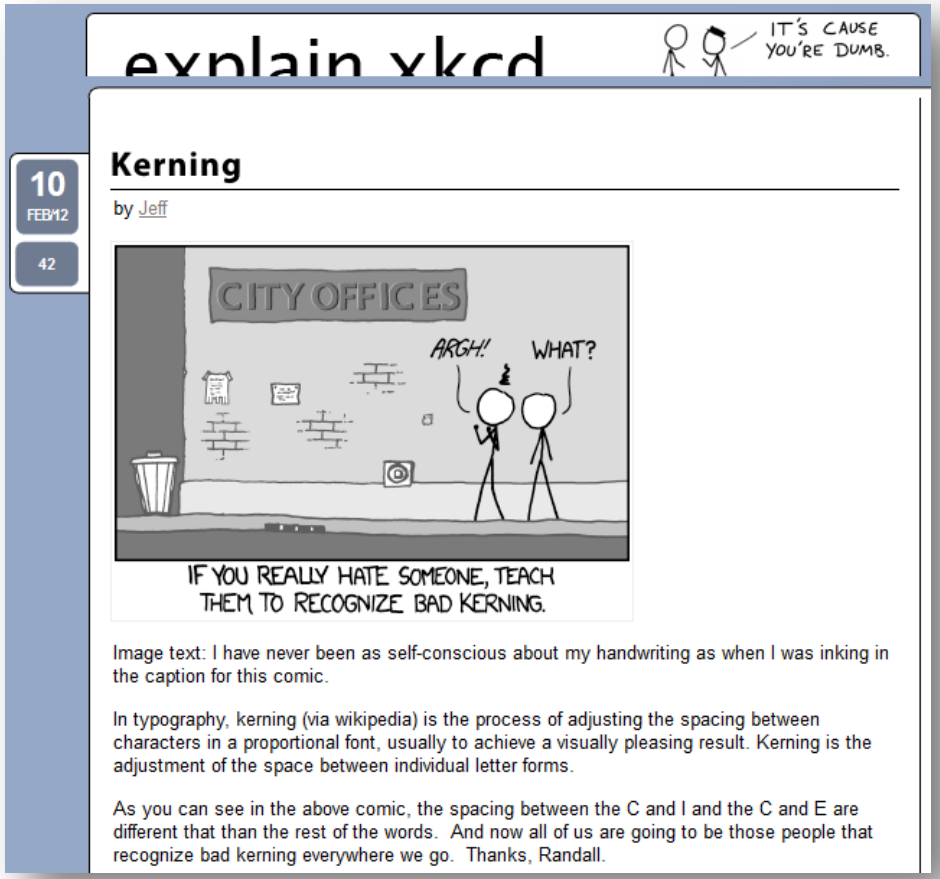
http://en.wikipedia.org/wiki/Kerning

Kerning

Text: Words/Sentences



IF YOU REALLY HATE SOMEONE, TEACH THEM TO RECOGNIZE BAD KERNING.



explain xkcd

IT'S CAUSE YOU'RE DUMB.

10 FEB/12

42

Kerning

by Jeff

IF YOU REALLY HATE SOMEONE, TEACH THEM TO RECOGNIZE BAD KERNING.

Image text: I have never been as self-conscious about my handwriting as when I was inking in the caption for this comic.

In typography, kerning (via wikipedia) is the process of adjusting the spacing between characters in a proportional font, usually to achieve a visually pleasing result. Kerning is the adjustment of the space between individual letter forms.

As you can see in the above comic, the spacing between the C and I and the C and E are different that than the rest of the words. And now all of us are going to be those people that recognize bad kerning everywhere we go. Thanks, Randall.

http://xkcd.com/1015/
http://www.explainxkcd.com/2012/02/10/kerning/

Kerning

Text: Words/Sentences

Good

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Vestibulum tortor quam, feugiat vitae, ultricies eget, tempor sit amet, ante. Donec eu libero sit amet quam egestas semper. Aenean ultricies mi vitae est. Mauris placerat eleifend leo.

Bad

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac

turpis egestas. Vestibulum tortor quam, feugiat vitae, ultricies eget, tempor

sit amet, ante. Donec eu libero sit amet quam egestas semper. Aenean ultricies

mi vitae est. Mauris placerat eleifend leo.

Bad

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac
turpis egestas. Vestibulum tortor quam, feugiat vitae, ultricies eget, tempor
sit amet, ante. Donec eu libero sit amet quam egestas semper. Aenean ultricies
mi vitae est. Mauris placerat eleifend leo.

http://www.webdesign.org/img_articles/21830/01.png

Leading

Text: Words/Sentences

AE → Æ

ae → æ

OE → Œ

oe → œ

ff → ﬀ

fi → ﬁ

ij → ij

st → ﬆ

ft → ﬂ

et → &

fs → ß

ffi → ﬃ

http://upload.wikimedia.org/wikipedia/commons/6/6e/Ligatures.svg
http://betatype.com/cms/system/files/ligatures.png

Ligatures

Layout: The TeX Approach

hw1_rasterization.tex - TeXworks

File Edit Search Format Typeset Scripts Window Help

pdfLaTeX

```
  pdfborder={0 0 0},
}
\usepackage{units}

\newcommand{\R}[0]{\mathbb{R}}
\newcommand{\Z}[0]{\mathbb{Z}}

\newtheorem{theorem}{Theorem}
\newtheorem{lemma}{Lemma}
\newtheorem{problem}{Problem}

\usepackage{environ}
\NewEnviron{killcontents}{}
\let\proof\killcontents
\let\endproof\endkillcontents

\begin{document}
\maketitle

\begin{center}
\fbox{\begin{minipage}{.8\textwidth}This is the first homework assignment for CS 148. We will have weekly assignments
except when there are exams; check the course website for due dates, assignment materials, and the late day policy.
Assignments like this are half written and half coding.

Note that algorithms like the one we are discussing in this assignment are well-known and probably easy to find online;
copying code or math from any such source is \emph{strictly forbidden}. \end{minipage}}
\end{center}

In Lecture 2, we derived Bresenham's algorithm for rasterizing lines. In this assignment, we are going to derive and
implement a similar algorithm for rasterizing circles. In particular, we will rasterize the quadrant of the circle
$x^2+y^2=R^2$ where $x,y\geq0$ and positive integer $R$.

One obvious way you could attempt to rasterize such a circle would be to iterate over each $x$ corresponding to a pixel
center and light up the pixel closest to $(x,\sqrt{R^2-x^2})$.

\begin{problem}[10 points]
Why is this approach bad? Provide at least two reasons.
\end{problem}
\begin{proof}[Solution]
Evaluating the square root $\sqrt{\cdot}$ is expensive, and the resulting curve may have gaps in places with steep slope.
\end{proof}

Instead, we will imitate our development of Bresenham's algorithm for rasterizing lines. In fact, we can simplify matters
somewhat: We can employ the symmetry of the circle to reduce the number of pixels we have to rasterize. Then, each
time we rasterize a pixel we will also light up its symmetric counterpart.
```

Line 1 of 130; col 0

hw1_rasterization.pdf - TeXworks

File Edit Search View Typeset Scripts Window Help

Homework 1: Rasterization

Introduction to Computer Graphics and Imaging (Summer 2012), Stanford University
Due Monday, July 2, 11:59pm

This is the first homework assignment for CS 148. We will have weekly assignments except when there are exams; check the course website for due dates, assignment materials, and the late day policy. Assignments like this are half written and half coding.
Note that algorithms like the one we are discussing in this assignment are well-known and probably easy to find online; copying code or math from any such source is *strictly forbidden*.

In Lecture 2, we derived Bresenham's algorithm for rasterizing lines. In this assignment, we are going to derive and implement a similar algorithm for rasterizing circles. In particular, we will rasterize the quadrant of the circle $x^2 + y^2 = R^2$ where $x, y \geq 0$ and positive integer R.

One obvious way you could attempt to rasterize such a circle would be to iterate over each x corresponding to a pixel center and light up the pixel closest to $(x, \sqrt{R^2 - x^2})$.

Problem 1 (10 points). *Why is this approach bad? Provide at least two reasons.*

Instead, we will imitate our development of Bresenham's algorithm for rasterizing lines. In fact, we can simplify matters somewhat: We can employ the symmetry of the circle to reduce the number of pixels we have to rasterize. Then, each time we rasterize a pixel we will also light up its symmetric counterpart.

Problem 2 (10 points). *Suppose we are given (x, y) on the 45° arc of the circle between $(0, R)$ and $(R/\sqrt{2}, R/\sqrt{2})$. Find a corresponding symmetric point on the 45° arc from $(R/\sqrt{2}, R/\sqrt{2})$ to $(R, 0)$ that takes no additional operations to compute.*

For deriving methods like Bresenham's algorithm, it is often more convenient to use *implicit* forms of curves. So, we define $F(x, y) = x^2 + y^2 - R^2$. Then, our curve is given by $F(x, y) = 0$. Note that $F(x, y) < 0$ when (x, y) is inside the circle and $F(x, y) > 0$ when (x, y) is outside the circle.

Just as in our method for rasterizing lines, we will be marching from left to right. Let's say we are at a pixel whose center is (x, y). Then, neighboring pixel centers are given by $(x \pm 1, y \pm 1)$. Our algorithm will make a local decision about which neighbor to choose next in its walk around the circle.

Problem 3 (10 points). *Show that the slope of the circle in the 45° arc we are drawing satisfies $-1 \leq dy/dx \leq 0$. Use this fact to justify why if we trace pixels in increasing x along the circle, it is sufficient to consider only the neighbors $(x + 1, y)$ and $(x + 1, y - 1)$ of (x, y).*

1

74.26% page 1 of 2

Boxes and glue

Layout: The TeX Approach

Box:

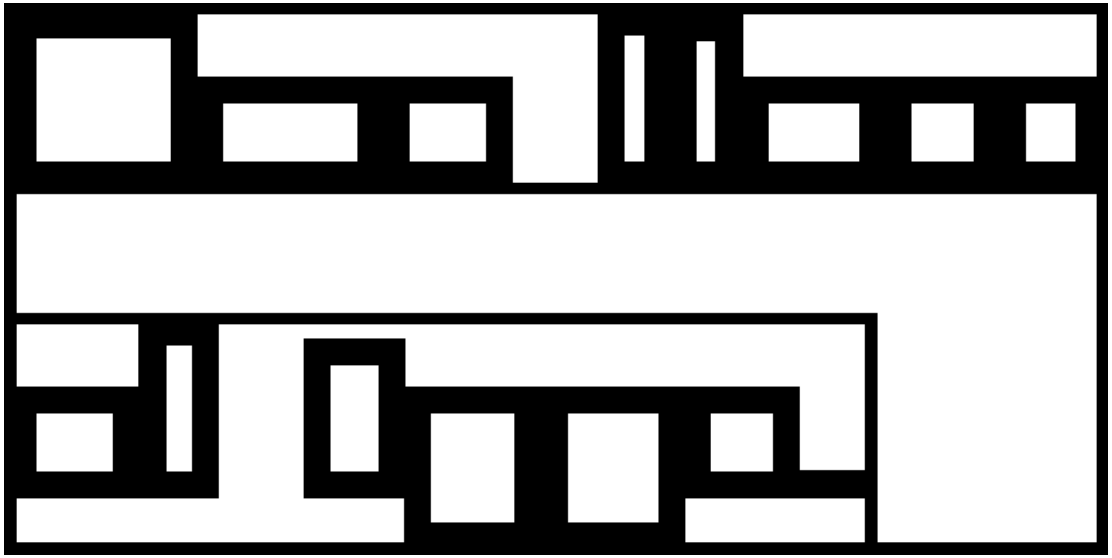
- **Width**
- **Height**
- **Depth**

http://codinghorror.typepad.com/.a/6a0120a85dcdae970b0120a86d7c73970b-pi
http://makingtexwork.sourceforge.net/mtw/ch01.html

Boxes and glue

Layout: The TeX Approach

hbox

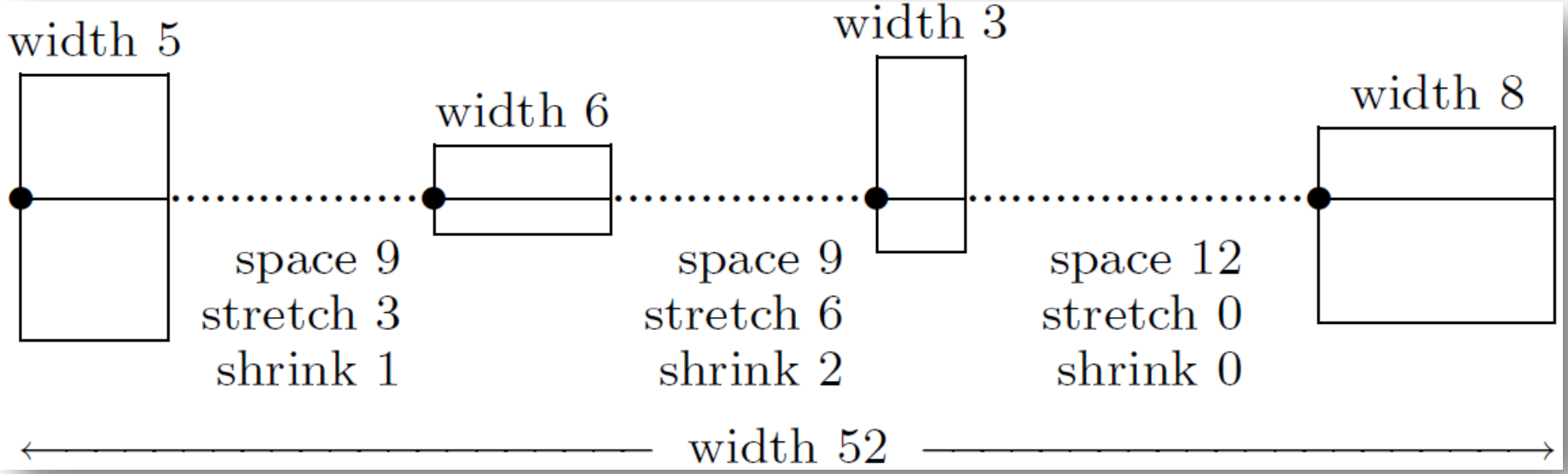


vbox

http://net.ytu.edu.cn/share/%D7%CA%C1%CF/texbook.pdf

Boxes and glue

Layout: The TeX Approach



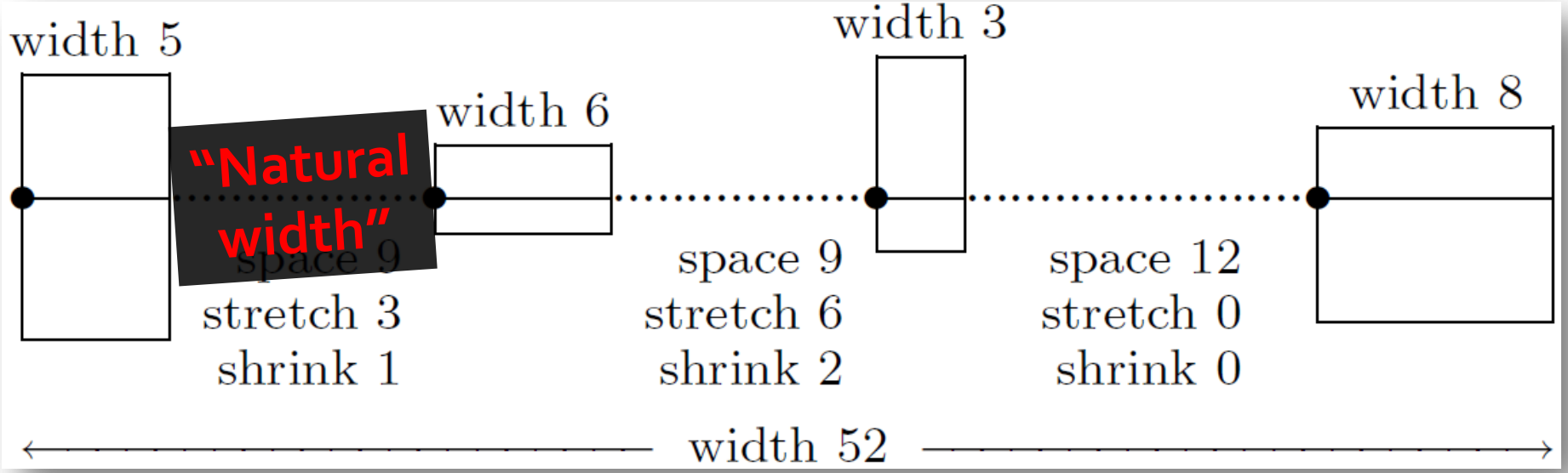
Glue:

Space, stretch, and shrink

http://net.ytu.edu.cn/share/%D7%CA%C1%CF/texbook.pdf

Boxes and glue

Layout: The TeX Approach



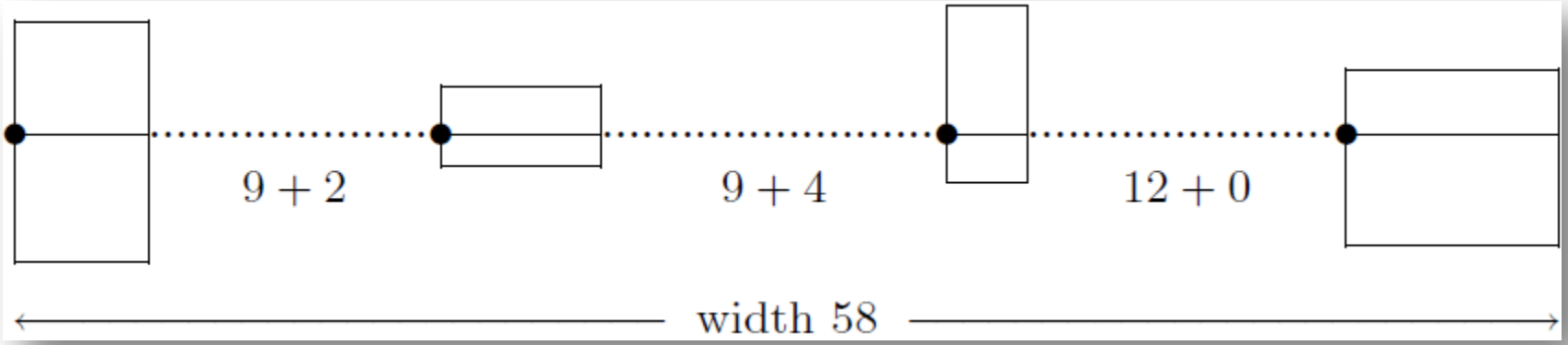
Glue:

Space, stretch, and shrink

http://net.ytu.edu.cn/share/%D7%CA%C1%CF/texbook.pdf

Boxes and glue

Layout: The TeX Approach



Glue:

Space, stretch, and shrink

http://net.ytu.edu.cn/share/%D7%CA%C1%CF/texbook.pdf

Boxes and glue

Layout: The TeX Approach

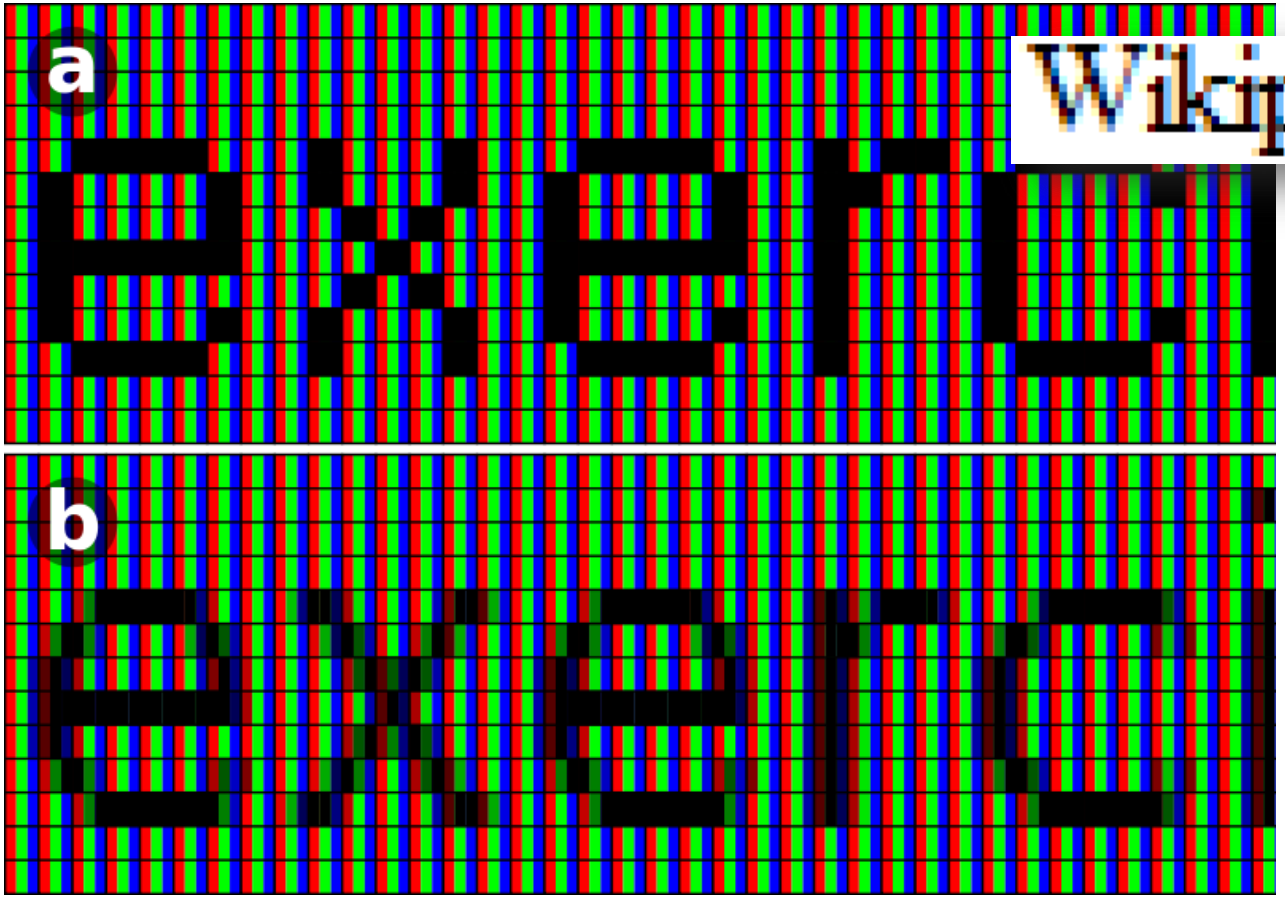
- Vertical mode. [Building the main vertical list, from which the pages of output are derived.]
- Internal vertical mode. [Building a vertical list for a vbox.]
- Horizontal mode. [Building a horizontal list for a paragraph.]
- Restricted horizontal mode. [Building a horizontal list for an hbox.]
- Math mode. [Building a mathematical formula to be placed in a horizontal list.]
- Display math mode. [Building a mathematical formula to be placed on a line by itself, temporarily interrupting the current paragraph.]

http://net.ytu.edu.cn/share/%D7%CA%C1%CF/texbook.pdf

Boxes and glue

Recall:

ClearType (Microsoft, 1998)



Wikipedia

http://en.wikipedia.org/wiki/ClearType

***Subpixel* antialiasing**

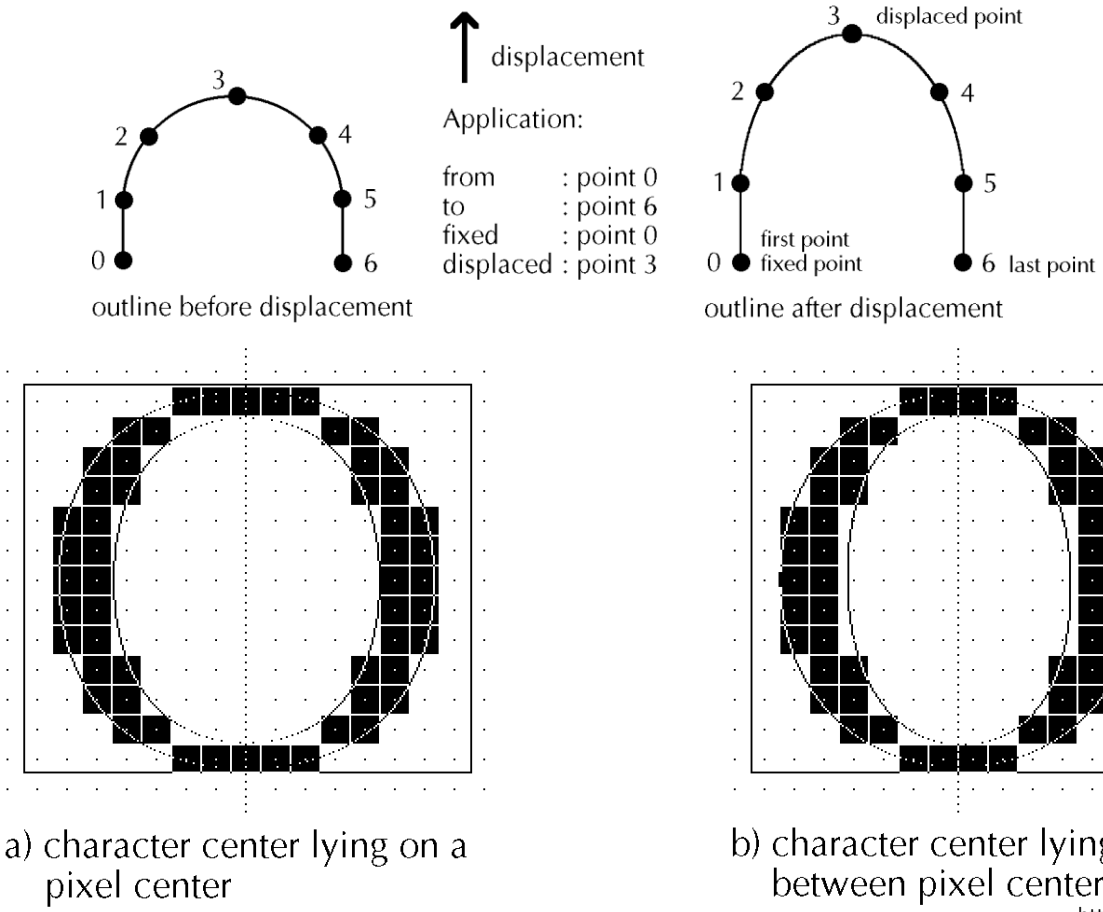
Font Rasterization

1. Outline grid-fitting
2. Outline scan conversion
3. Filling

http://infoscience.epfl.ch/record/99768/files/frsa.pdf

Adjust for readability

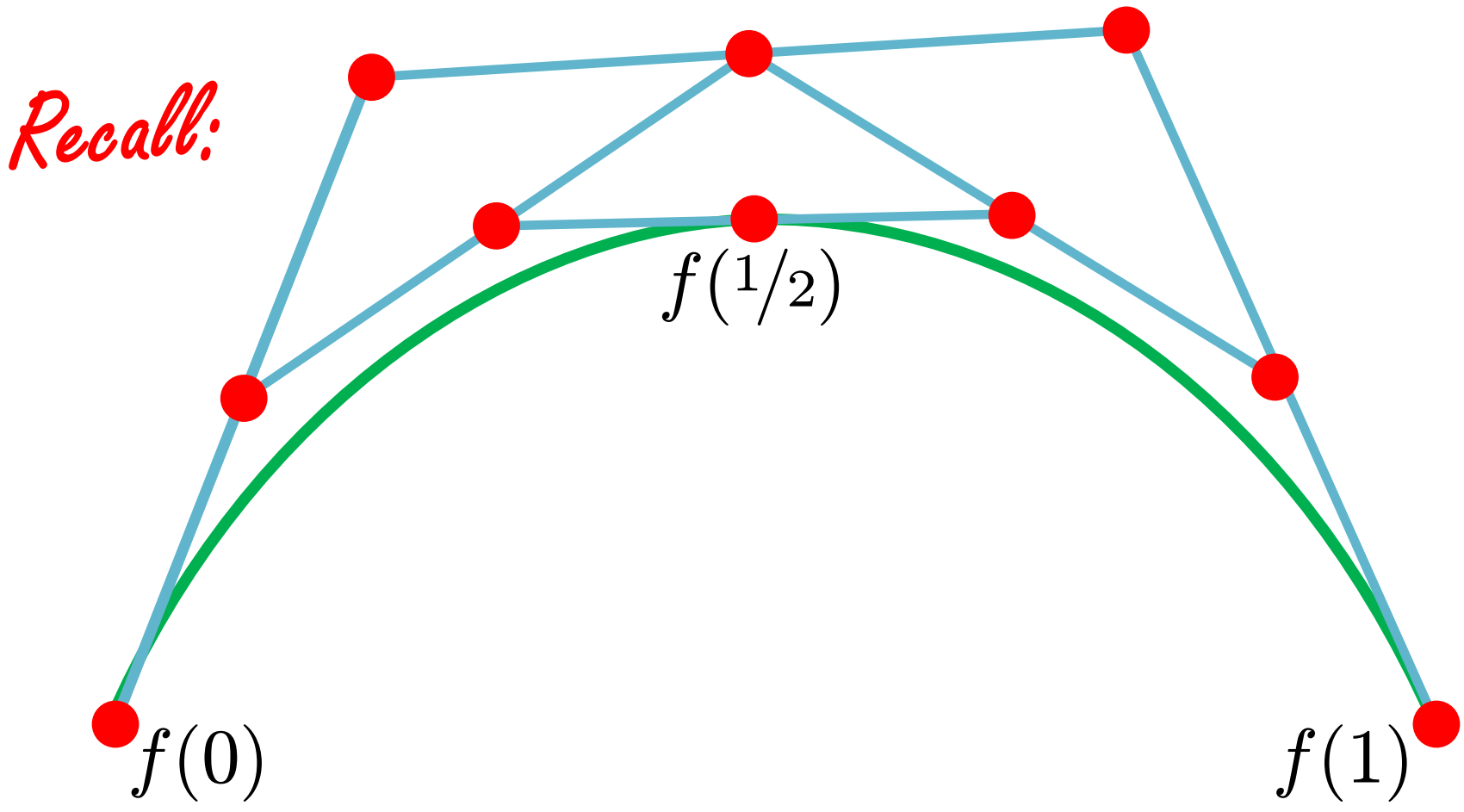
Font Rasterization



http://infoscience.epfl.ch/record/99768/files/frsa.pdf

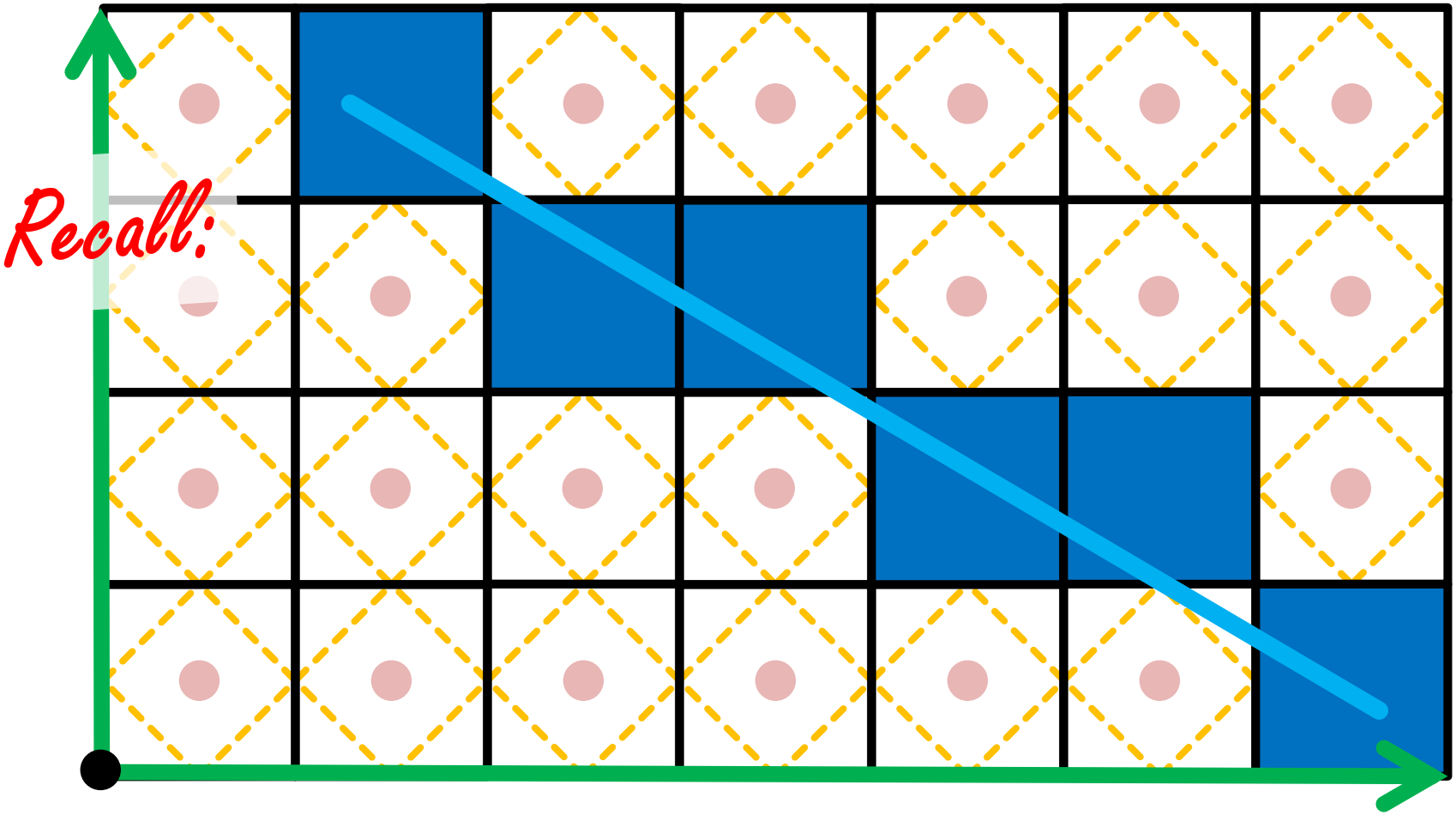
Outline grid-fitting

Font Rasterization



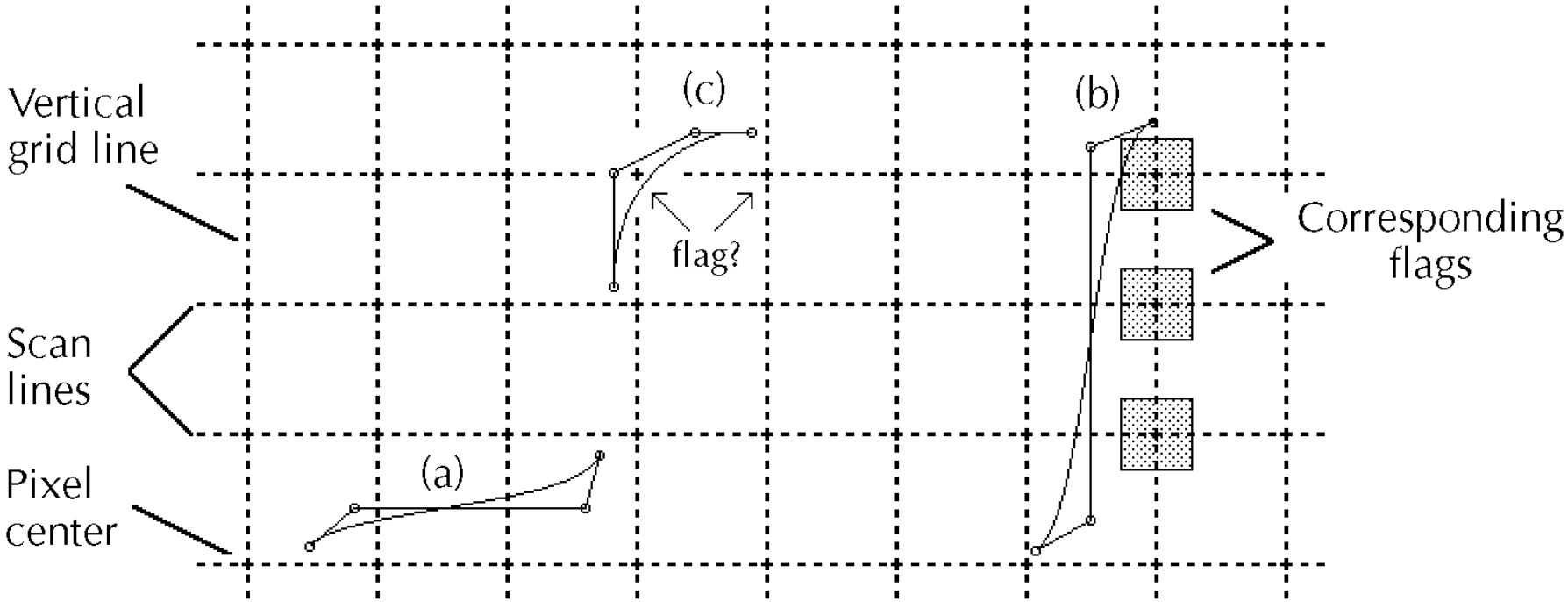
Outline scan conversion

Font Rasterization



Outline scan conversion

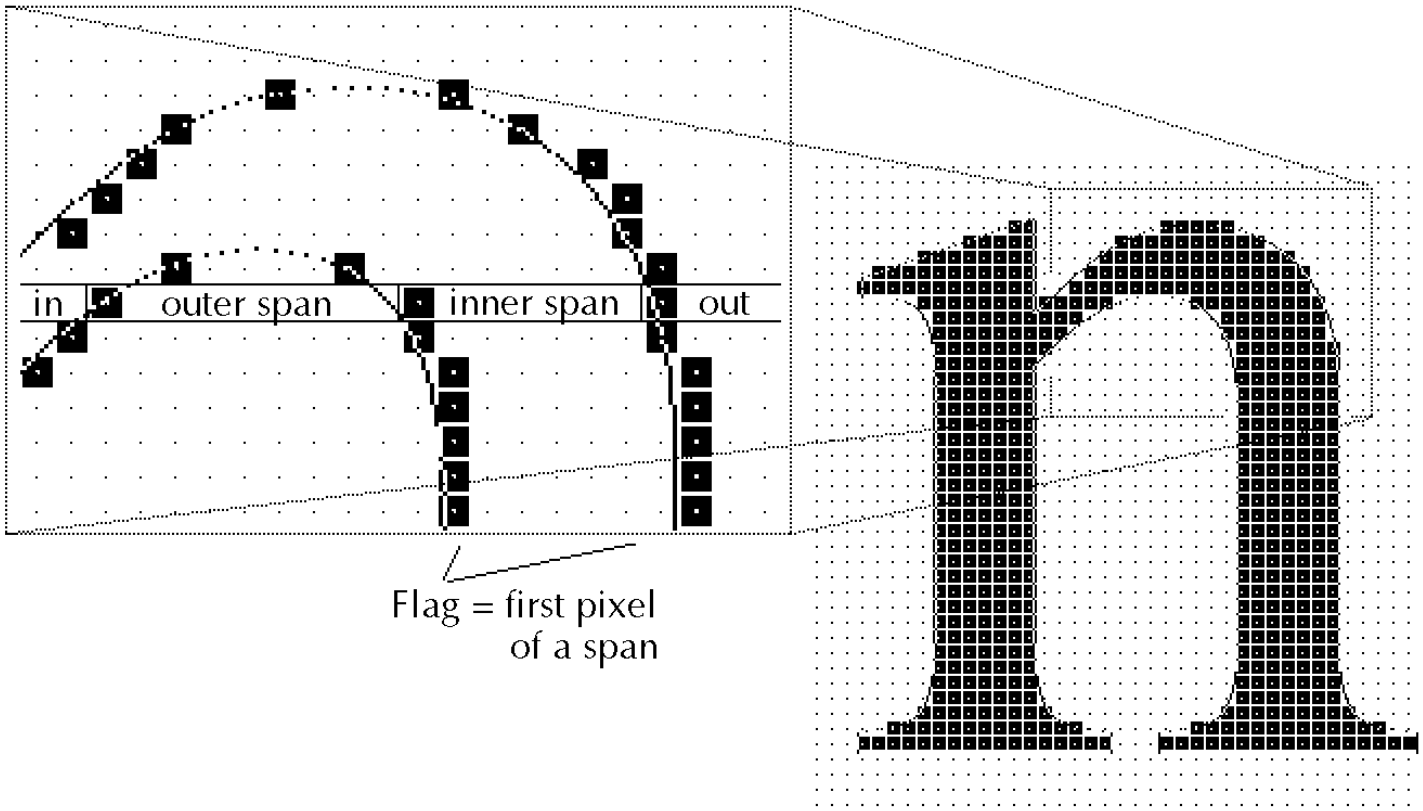
Font Rasterization



http://infoscience.epfl.ch/record/99768/files/frsa.pdf

Outline scan conversion

Font Rasterization



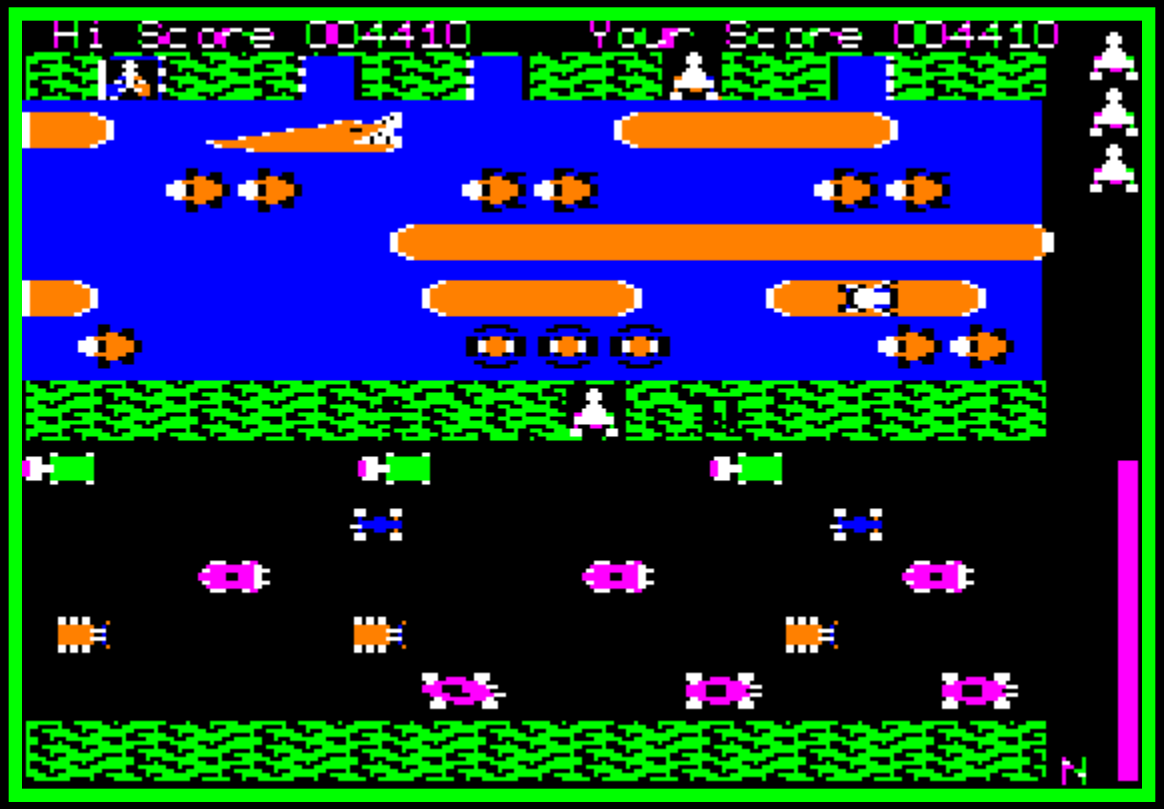
Flag image memory

Bit map

http://infoscience.epfl.ch/record/99768/files/frsa.pdf

Filling

http://www.mobygames.com/images/shots/l/45594-frogger-apple-ii-screenshot-gameplay-on-the-second-levels.gif



Part II: Game Programming Techniques

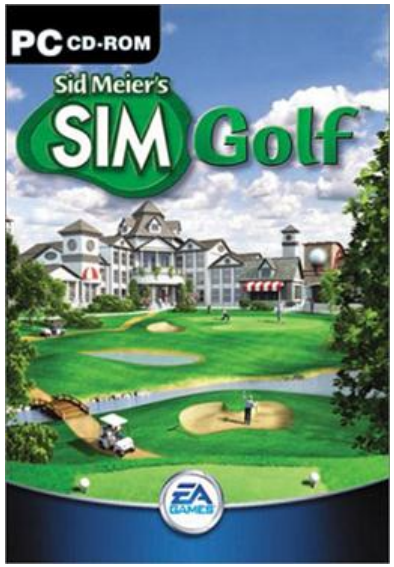
CS 148, Summer 2012
Introduction to Computer Graphics and Imaging

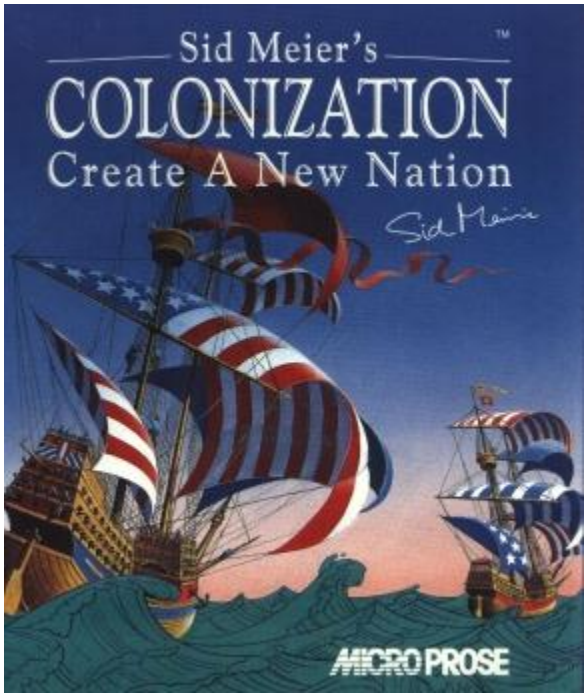
Justin Solomon

Game Design

"We don't make big game design documents, rather, we start by creating a playable prototype.... From there, we take an iterative approach to development, in which we play and improve, play and improve for as long as it takes to make a great game."

- Sid Meier, Firaxis Games





http://www.bradcook.net/games/articles/2008/05/sidmeier/

Ludonarrative

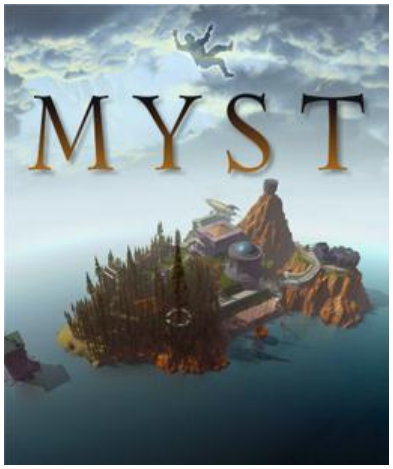
[loo-doh-**nar**-*uh*-tiv]:

Aspects of storytelling in a video game that are controlled by the user.

http://en.wikipedia.org/wiki/Ludonarrative

Variety of Requirements

First person shooter



Adventure

Role playing game

2D puzzle

Sports

Strategy

http://vglounge.com/wp-content/uploads/2011/03/FirstPersonShooter.jpg http://en.wikipedia.org/wiki/Myst http://www.crunchbase.com/assets/images/original/0010/3903/103903v1.png
http://s.pro-gmedia.com/videogamer/media/images/pub/large/top10rpg9.jpg http://www.blogcdn.com/www.parentdish.com/media/2007/01/madden.jpg

Game Loop

```
While (user doesn't exit)
    Check for user input
    Run AI
    Move enemies
    Resolve collisions
    Draw graphics
    Play sounds
End while
```

http://en.wikipedia.org/wiki/Game_programming

Considerable Challenge

Many platforms

Considerable Challenge

Many platforms

Scaling [**skey**-ling]:
Adjusting graphics quality in response to system capabilities.

Limited Resources

- Fill command buffer with GPU commands to prevent "GPU starvation"
- Carefully measure frame rate (easy on fixed hardware)
- Allocate heterogeneous resources

Processing time

Limited Resources

Textures and geometry are expensive!

- Size: Amount of space
- Latency: Time between request and fulfillment (blocking or non-blocking)
- Bandwidth: How much data you can transfer at once

Storage

Limited Resources

Implementation is hard, deadlines are tight!

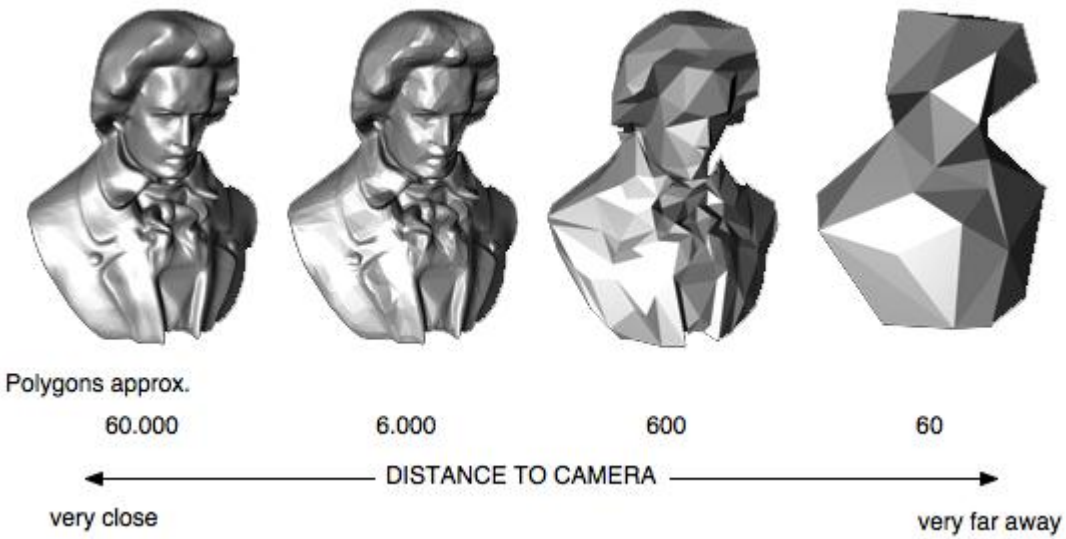
Game Engines

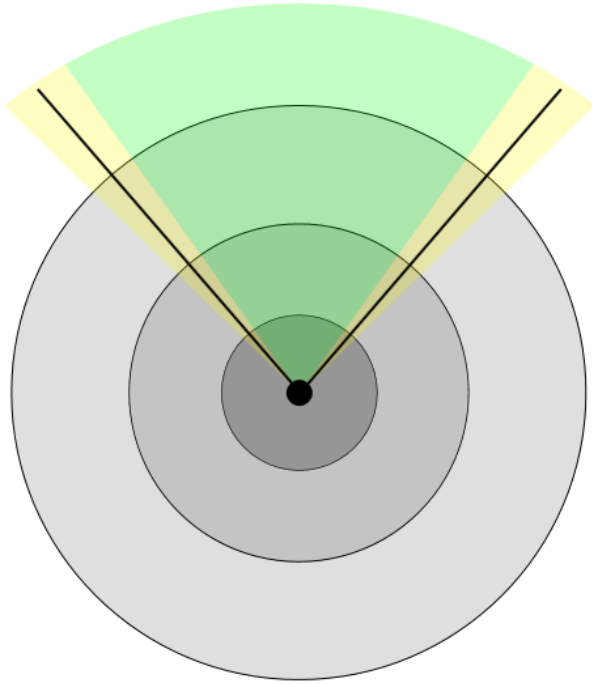
- Abstract hardware
- Simplify common rendering tasks
- Maintain scene graph
- Deal with sound and other media
- Provide physics, AI, networking, threading, other features

Primary Bottleneck

Shaders.

Reducing Rendering Load



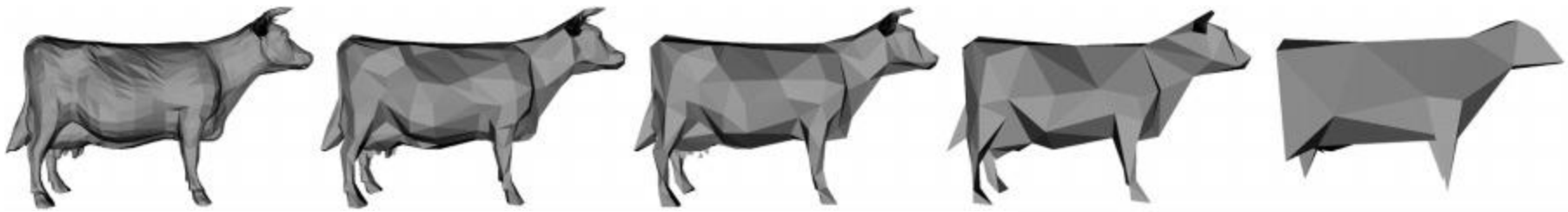


Use distance to determine model.

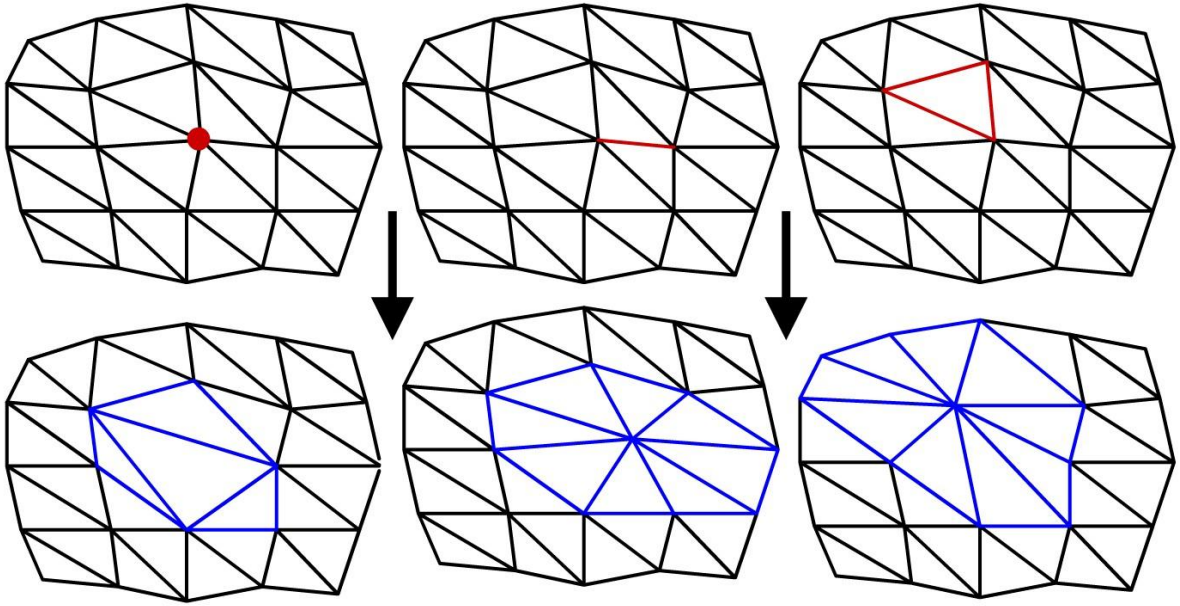
http://www.opensg.org/wiki/Tutorial/OpenSG2/NodeCores

Level-of-detail (LOD)

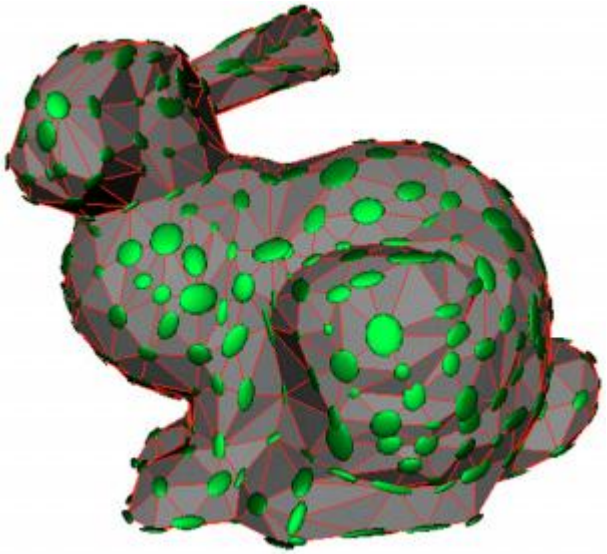
Offline Simplification



Original Mesh Segment



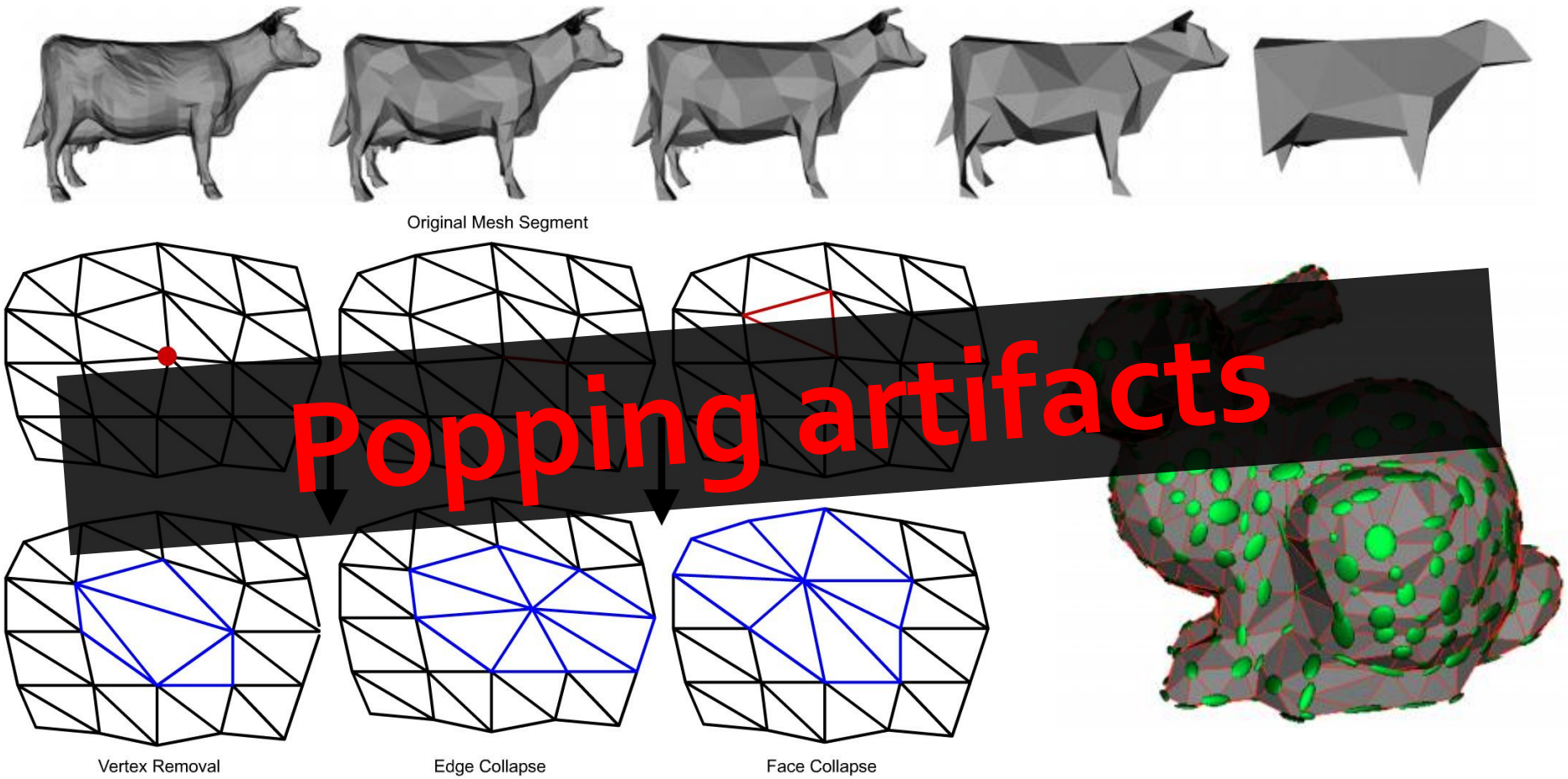
Vertex Removal Edge Collapse Face Collapse



Garland/Heckbert: Quadric Error Metrics

http://www1.cs.columbia.edu/~cs4162/html05s/garland97.pdf
http://johnrichie.com/V2/richie/simp/images/types1.jpg

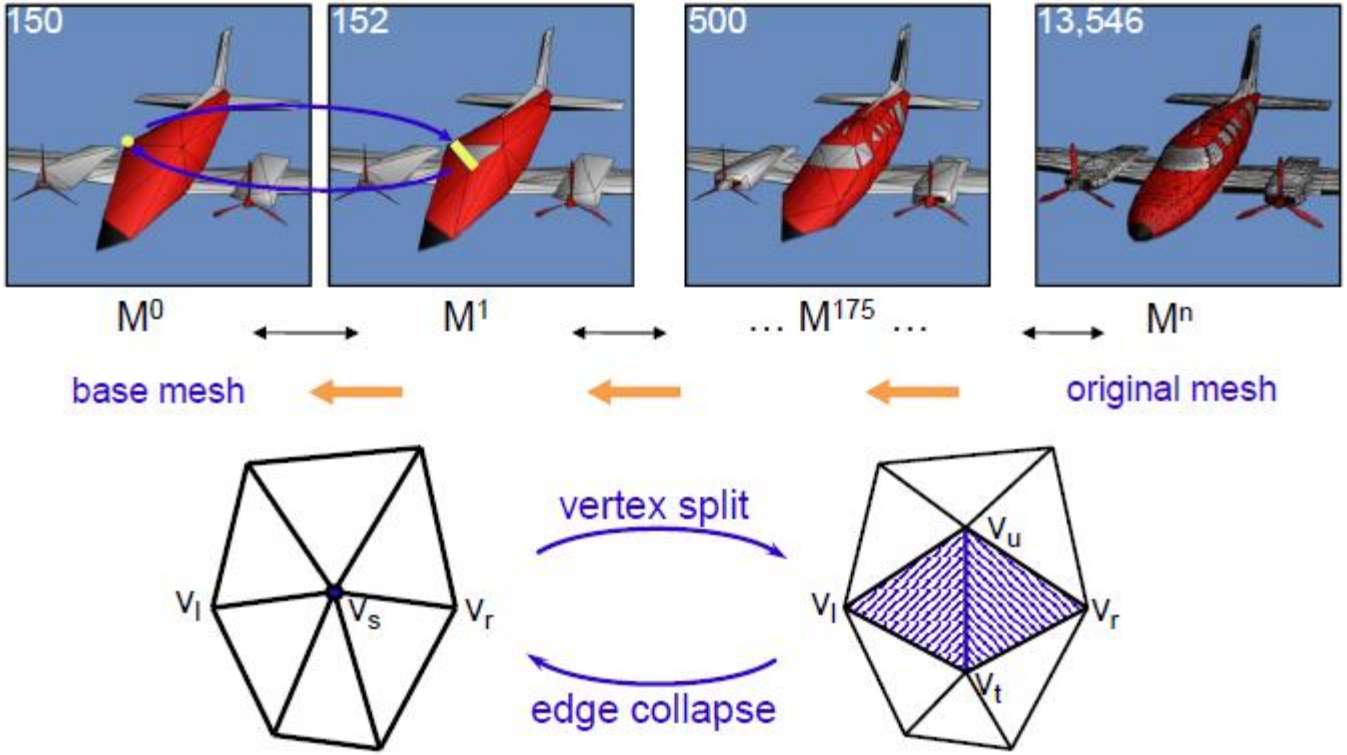
Offline Simplification



Garland/Heckbert: Quadric Error Metrics

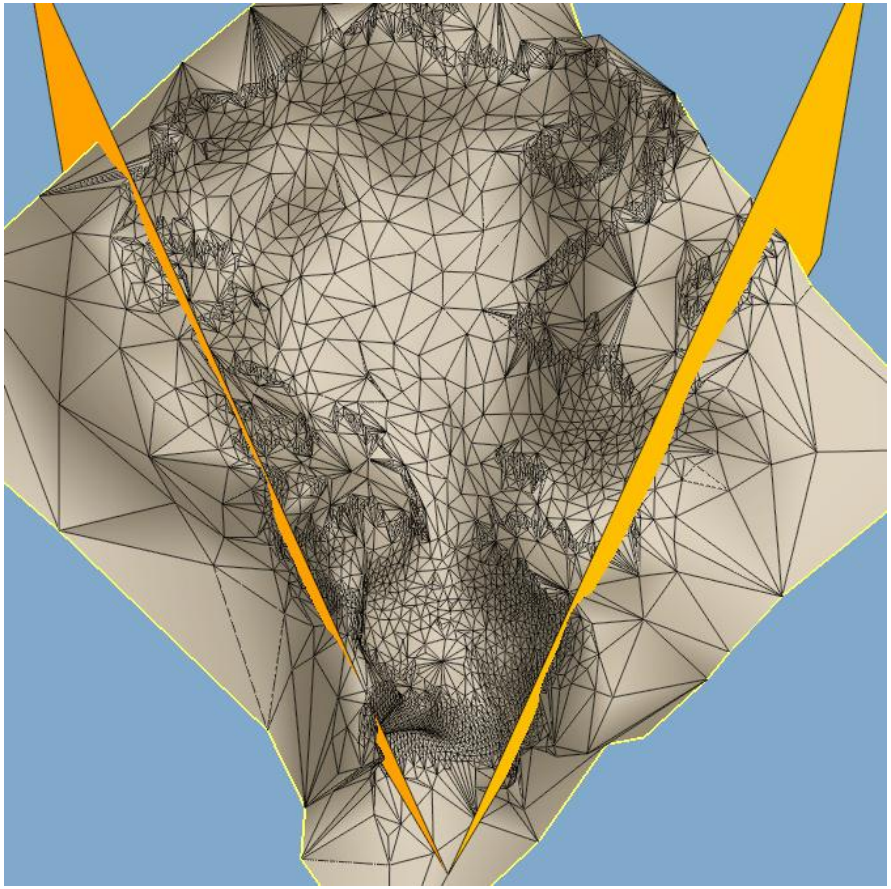
http://www1.cs.columbia.edu/~cs4162/html05s/garland97.pdf
http://johnrichie.com/V2/richie/simp/images/types1.jpg

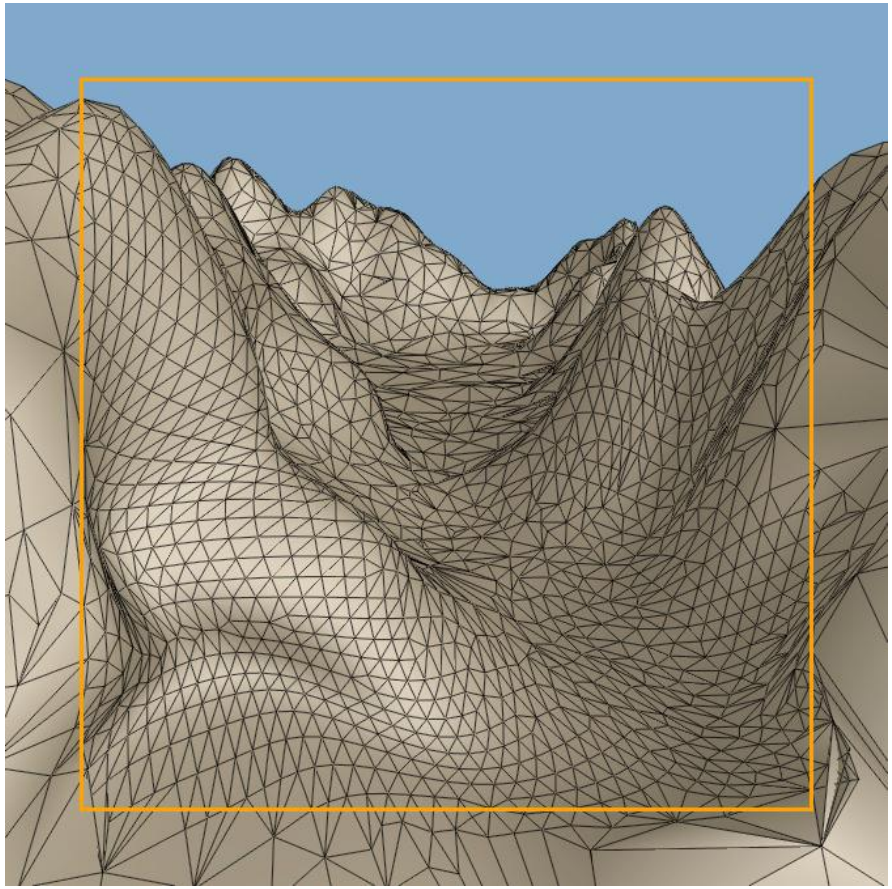
Progressive Meshes



http://graphics.stanford.edu/courses/cs468-10-fall/LectureSlides/09_Progressive_Meshes.pdf

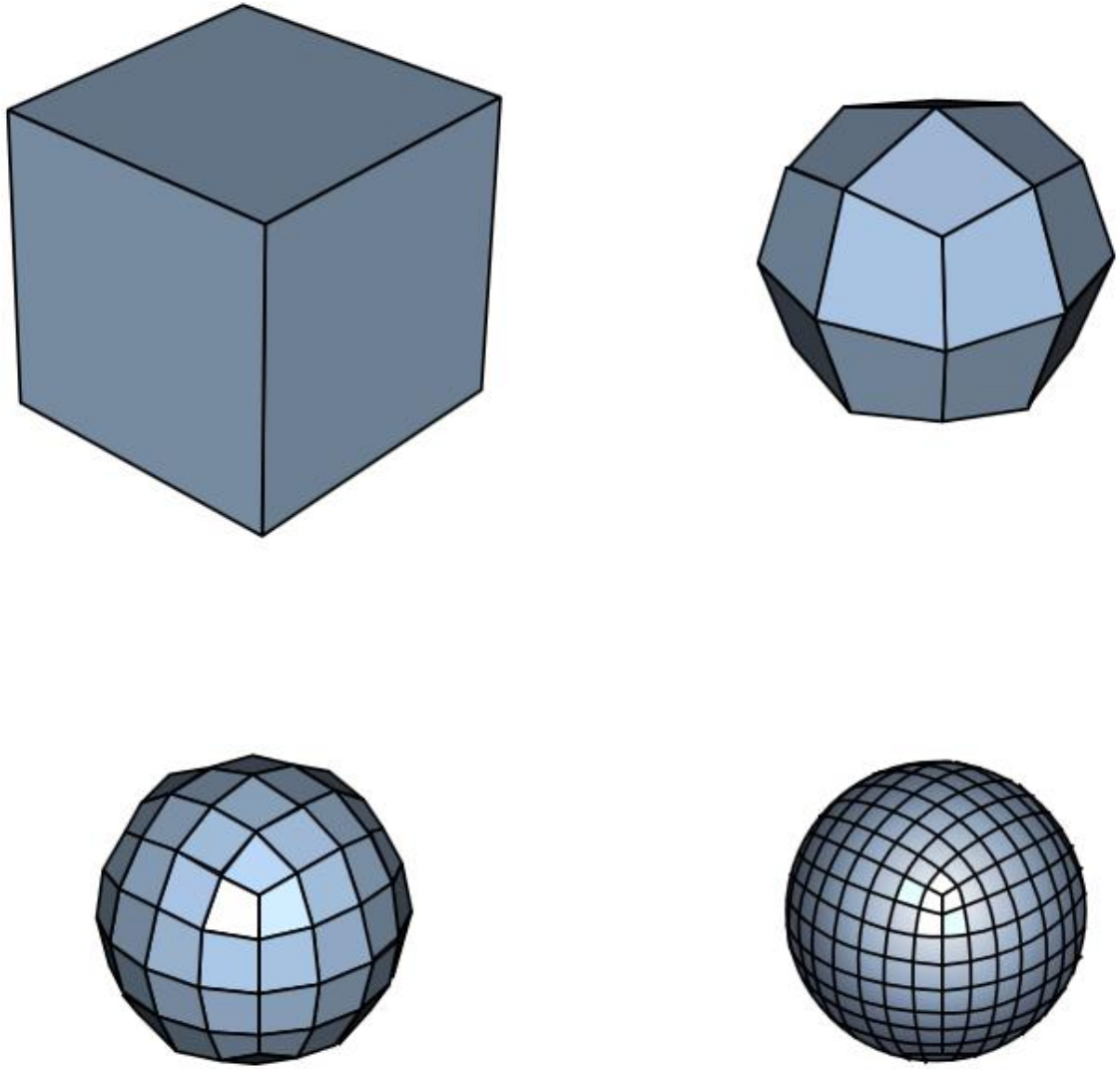
Progressive Meshes





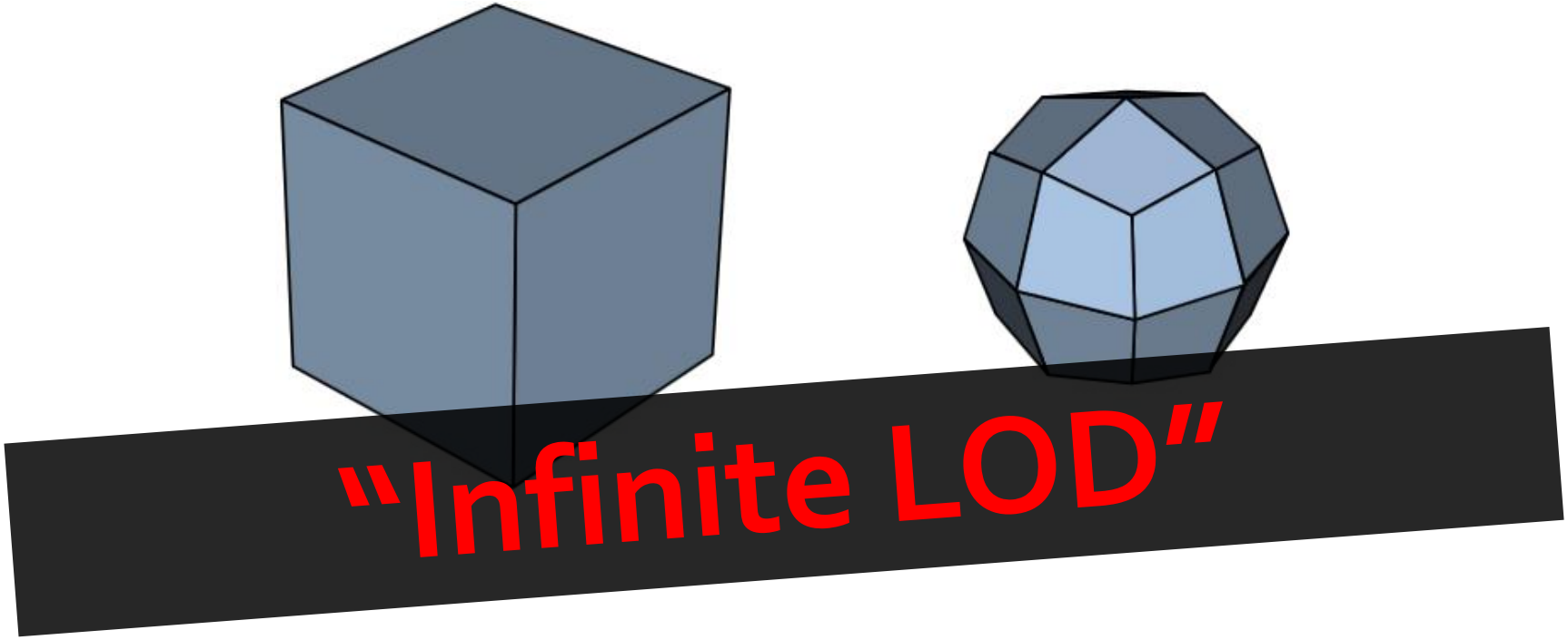
http://research.microsoft.com/en-us/um/people/hoppe/proj/pm/

Recall: Subdivision Surfaces



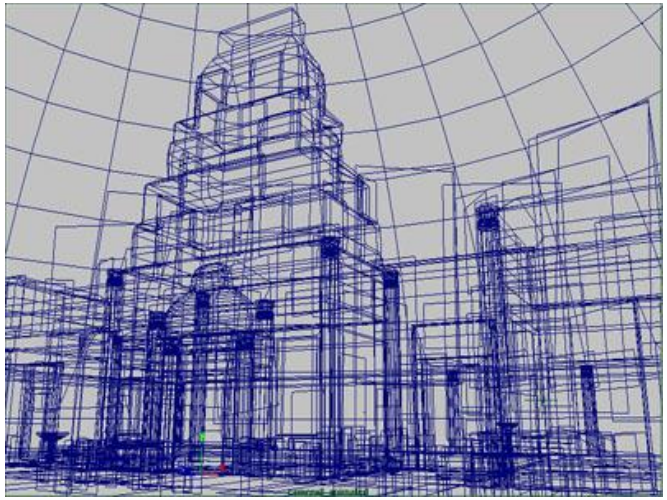
http://upload.wikimedia.org/wikipedia/commons/3/33/Catmull-Clark_subdivision_of_a_cube.svg

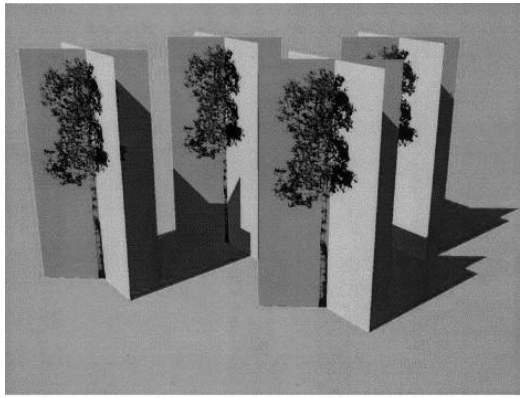
Recall: Subdivision Surfaces

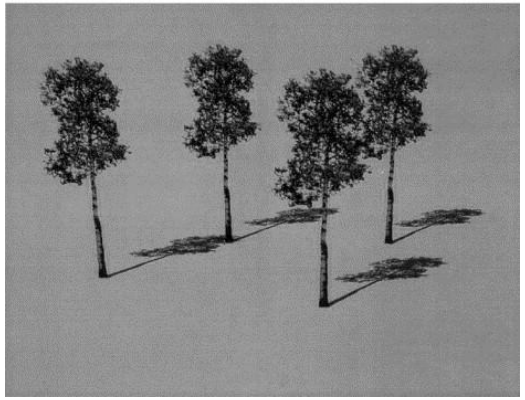


http://upload.wikimedia.org/wikipedia/commons/3/33/Catmull-Clark_subdivision_of_a_cube.svg

In the Background





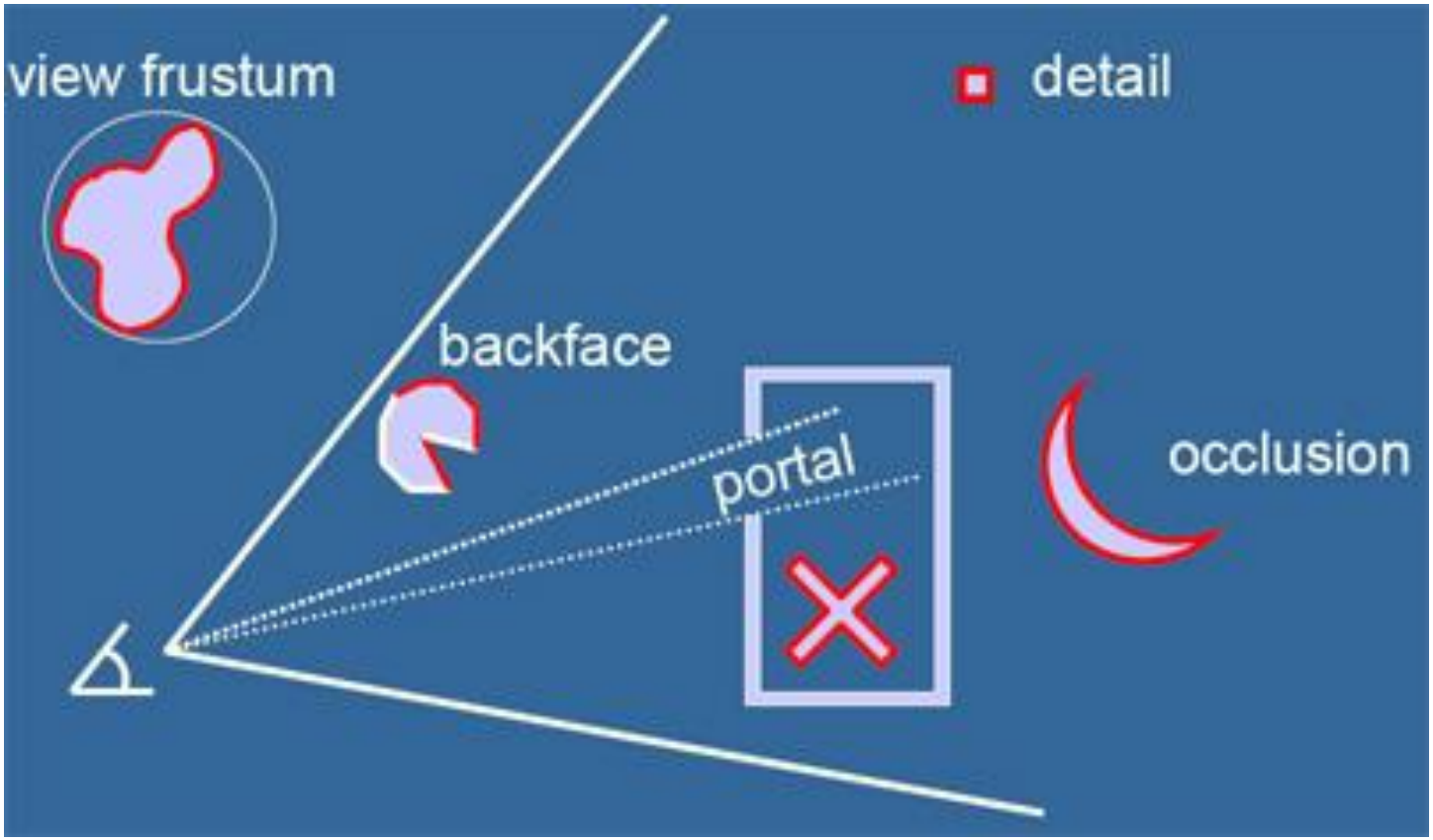


http://www.escapistimagery.com/geekpage.htm
http://ars.els-cdn.com/content/image/1-s2.0-S0169204601001220-gr3.jpg

Sprites and billboards

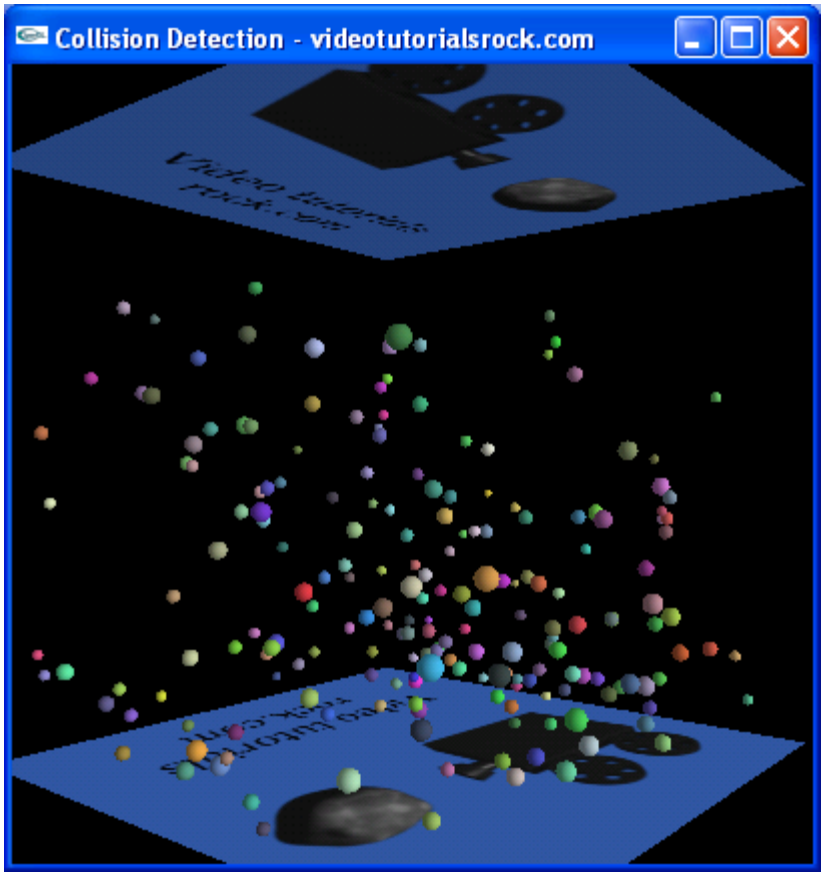
Recall:

Culling Techniques



http://www.gamerendering.com/category/optimizations/culling-optimizations/

Related: Collision Detection



http://www.videotutorialsrock.com/opengl_tutorial/collision_detection/screenshot.png
http://www.riemers.net/images/Tutorials/XNA/Csharp/Series2/XNA%20Tutorial%209%20-%20Collision%20detection.jpg

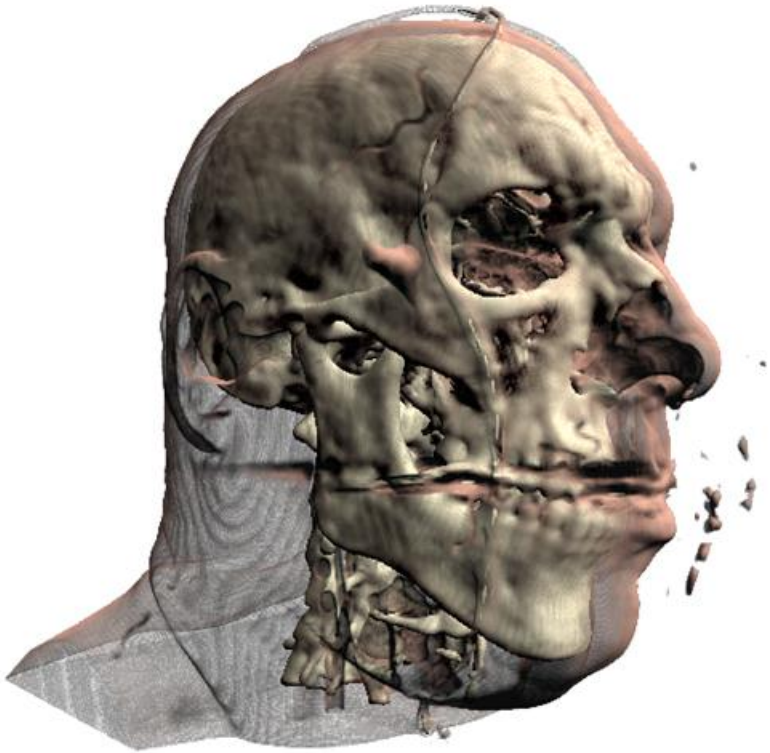
Intersect objects instead of frustum

Problem: Transparency

http://media.bestofmicro.com/ray-tracing-rasterization,M-9-214641-13.png

What values should be in depth buffer?

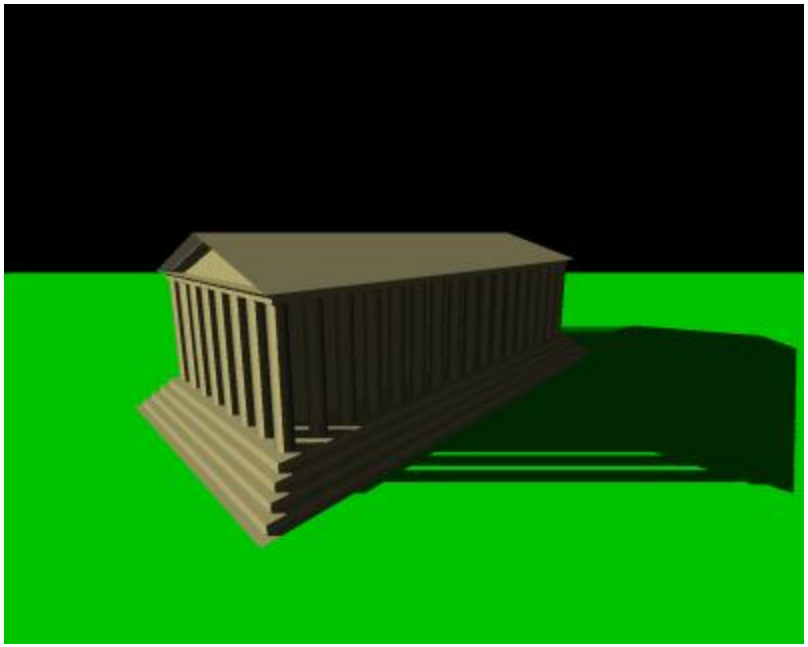
Depth Pre-Pass



http://lh3.ggpht.com/_VelpN_FHzhk/S-JC-jH6tAI/AAAAAAAAAqI/frWXNeyGx6w/s1600-h/no_alpha_errors%5B6%5D.png

Render opaque objects into depth buffer first

Shadows

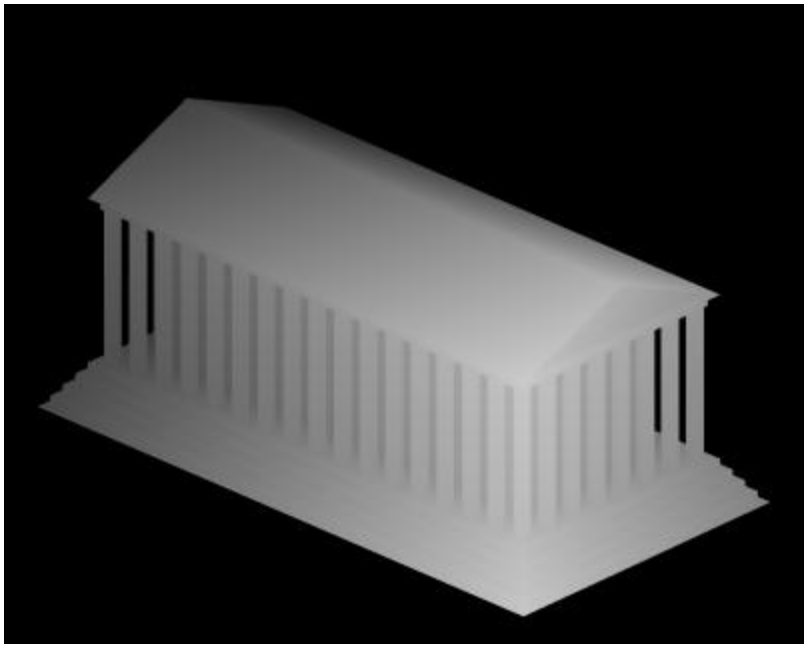


Goal: Render shadows that conform to shape

http://en.wikipedia.org/wiki/Shadow_mapping

Shadow maps

Shadows

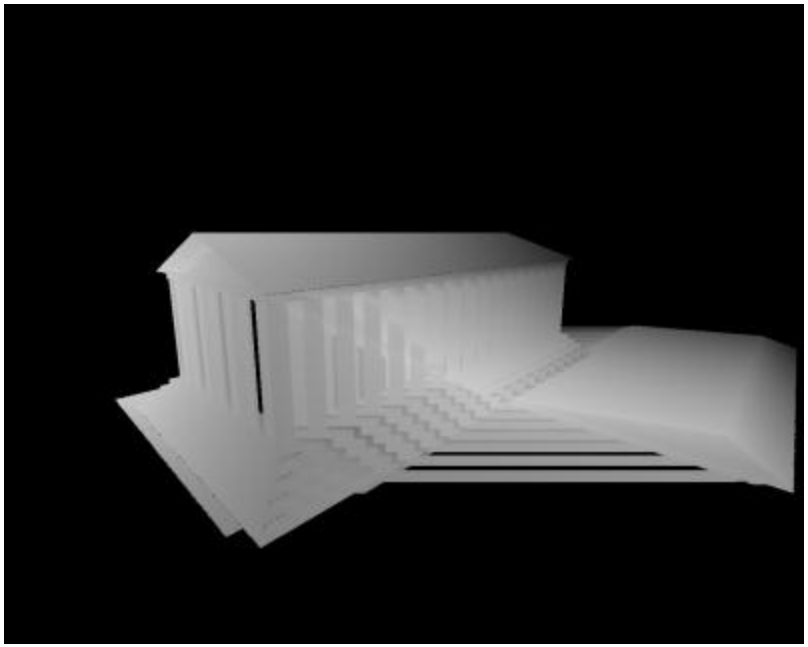


Render depths from light's point of view.

http://en.wikipedia.org/wiki/Shadow_mapping

Shadow maps

Shadows

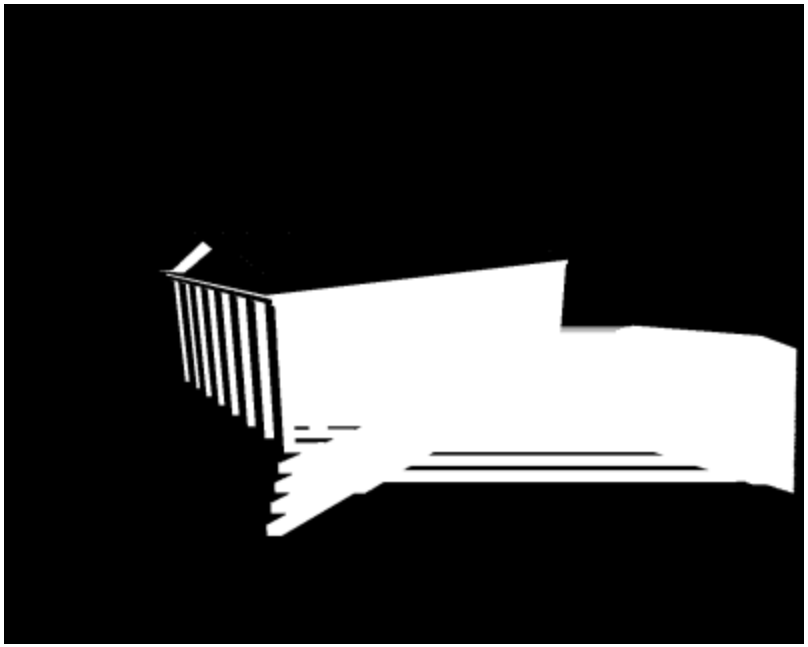


Apply matrix transformation to map to camera space.

http://en.wikipedia.org/wiki/Shadow_mapping

Shadow maps

Shadows

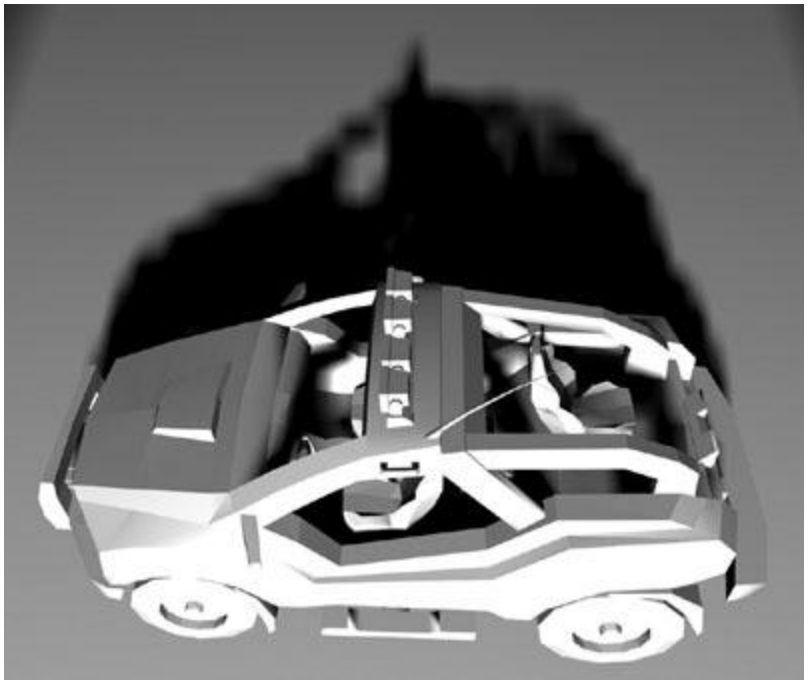


Find shadows.

http://en.wikipedia.org/wiki/Shadow_mapping

Shadow maps

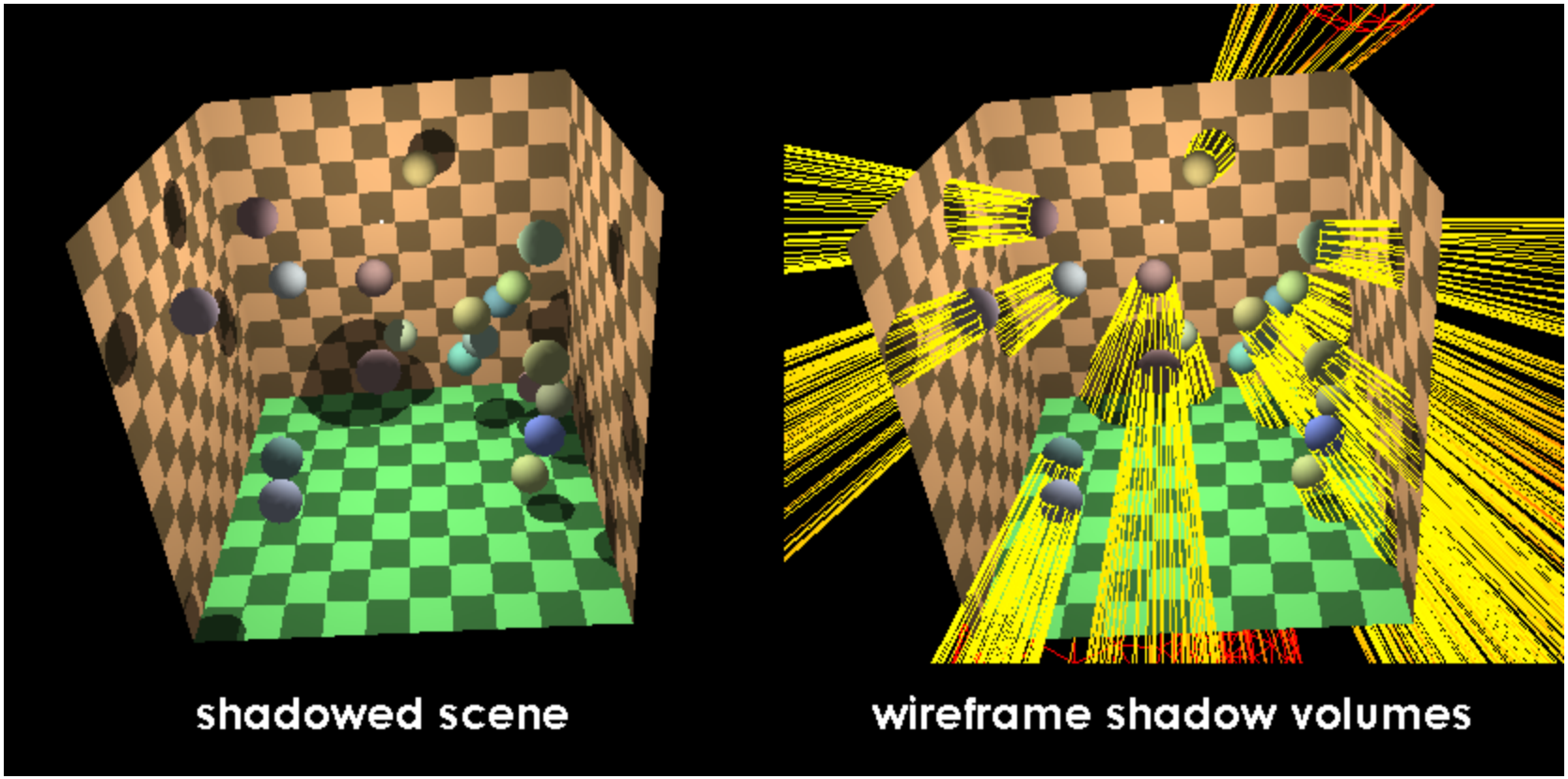
Shadows



http://http.developer.nvidia.com/GPUGems3/elementLinks/08fig09.jpg
http://www.phoesion.com/_/rsrc/1300357721993/features/lighting/shadowmaps/shadow.png

Shadow maps

Shadows



http://en.wikipedia.org/wiki/Shadow_volume

Shadow volumes

Recall:

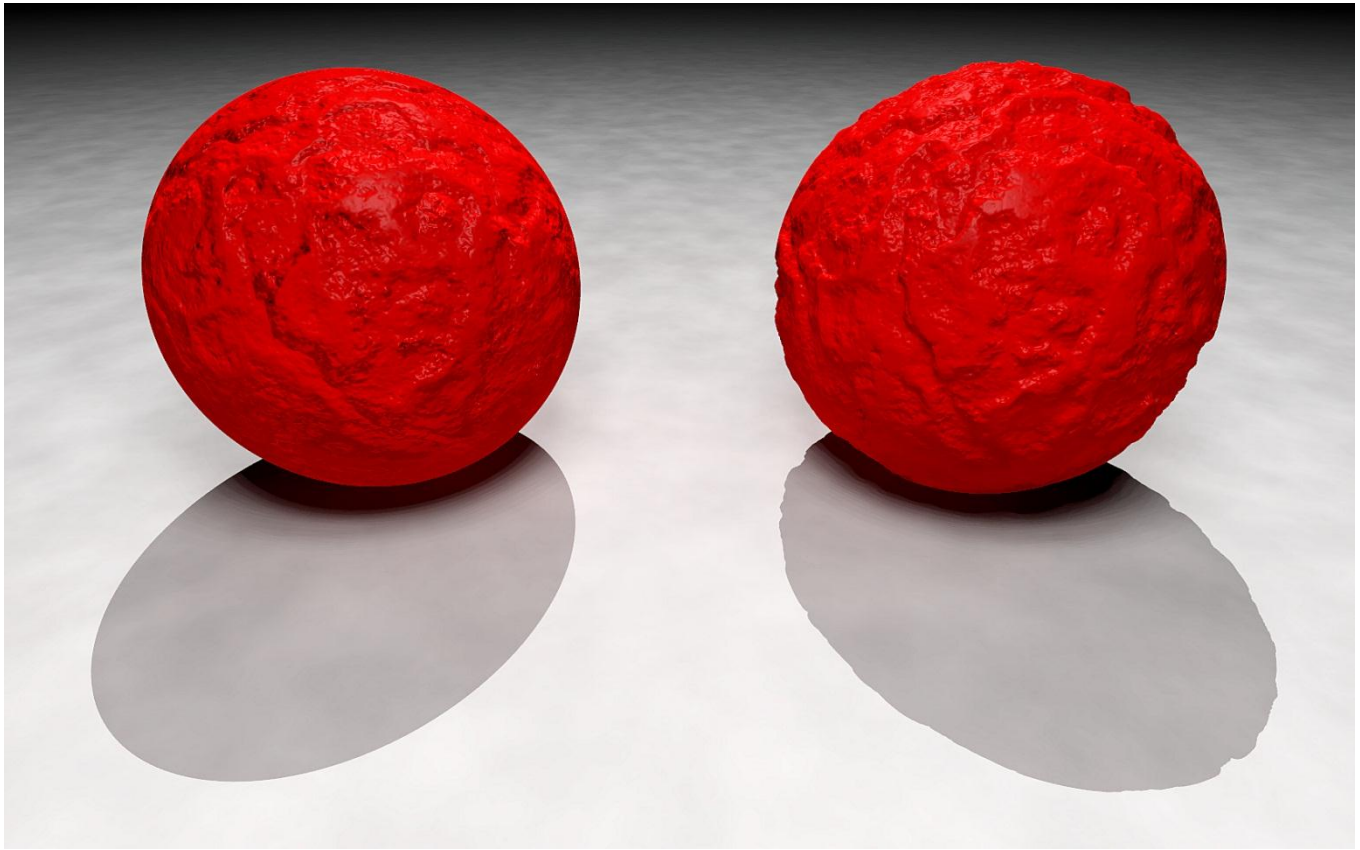
Silhouette Edge Condition

$$(\vec{k}_o \cdot \vec{N}_0)(\vec{k}_o \cdot \vec{N}_1) \cdot \quad 0$$

Face normals on either side of edge change direction relative to eye.

Recall:

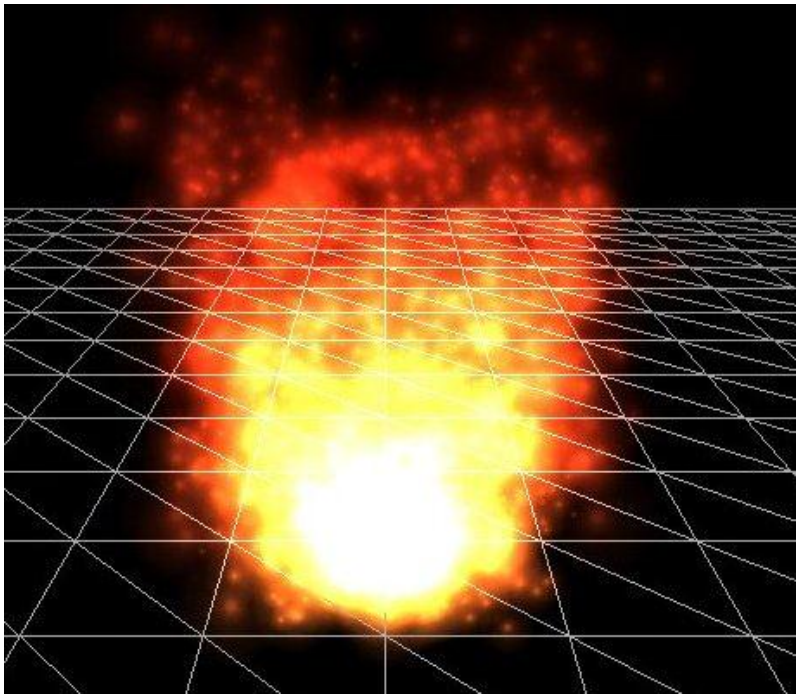
Common Shader Tasks

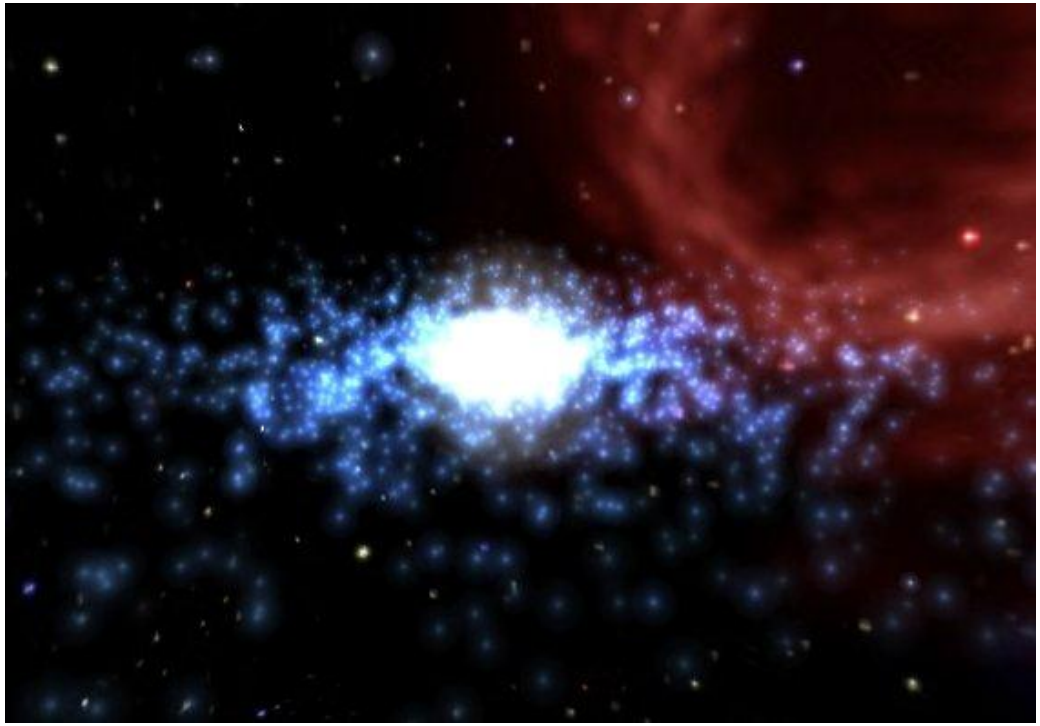


http://upload.wikimedia.org/wikipedia/commons/4/4e/Bump_map_vs_isosurface2.png

Bump/normal mapping

Game Physics

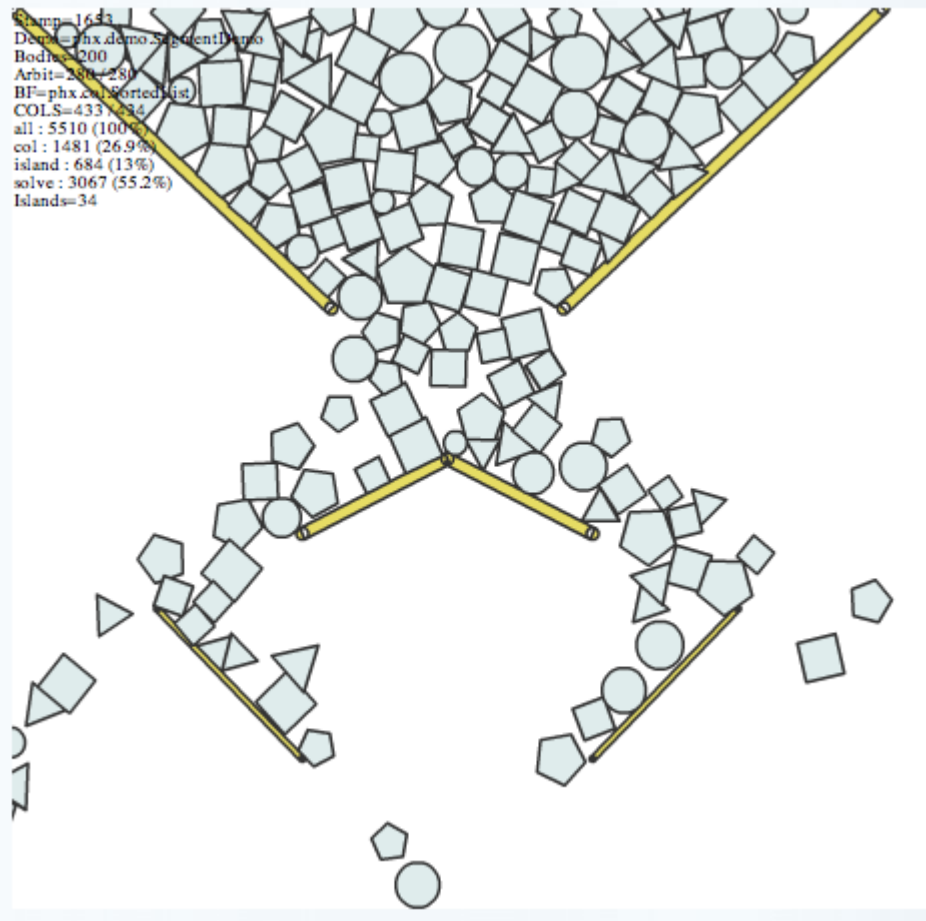


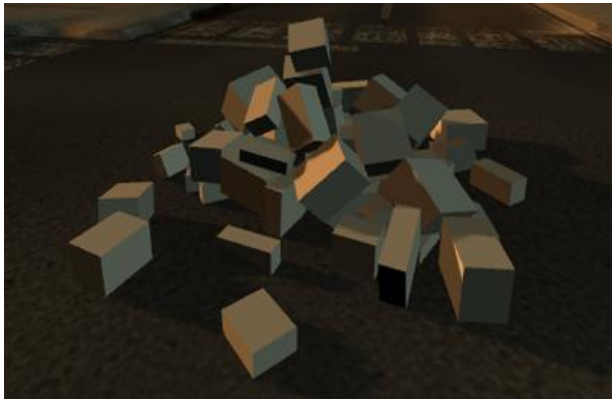


http://upload.wikimedia.org/wikipedia/commons/f/f2/Particle_sys_fire.jpg
http://upload.wikimedia.org/wikipedia/commons/7/70/Particle_sys_galaxy.jpg

Particle systems

Game Physics





http://rockonflash.wordpress.com/2008/04/07/physaxe-rigid-body-physics-for-haxe-flash-9/
http://static.wolfire.com/legacy/ODEthumb.jpg
http://www-scf.usc.edu/~chiaminc/index_files/image002.jpg

Rigid body systems

Game Physics

$$\vec{F} = m\vec{a} \longleftrightarrow \frac{d^2\vec{x}}{dt^2} = \vec{a}(\vec{x})$$

Leapfrog integration

Rigid body systems

Game Physics

$$f'(t) \approx \frac{f(t + \Delta t) - f(t)}{\Delta t}$$

Leapfrog integration

Rigid body systems

Game Physics

$$f'(t) \approx \frac{f(t+\Delta t) - f(t)}{\Delta t}$$

Choose relative to frame rate

Leapfrog integration

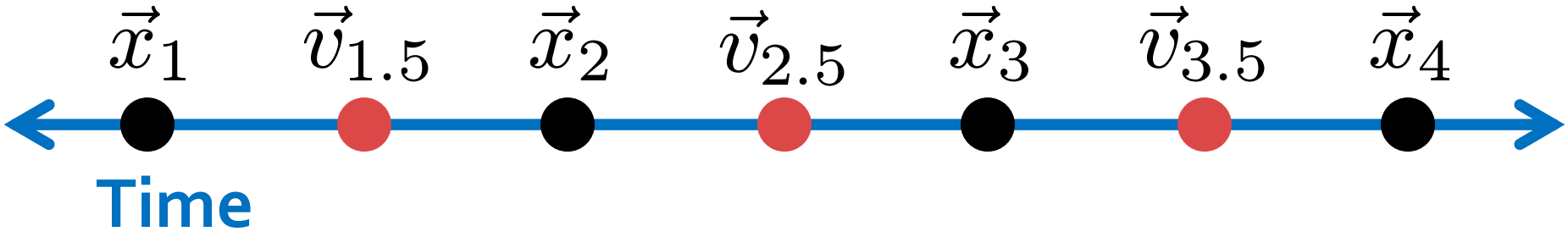
Rigid body systems

Game Physics

Leapfrog integration

Rigid body systems

Game Physics

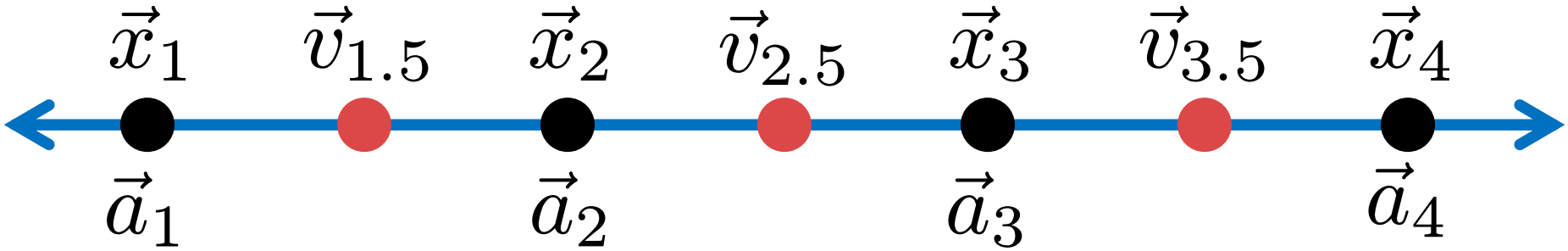


$$\boxed{\vec{v}_{i+0.5} = \frac{\vec{x}_{i+1} - \vec{x}_i}{\Delta t}}$$

Leapfrog integration

Rigid body systems

Game Physics



$$\boxed{\vec{a}_i = \frac{\vec{v}_{i+0.5} - \vec{v}_{i-0.5}}{\Delta t}}$$

Leapfrog integration

Rigid body systems

Game Physics

$$\vec{v}_{i+0.5} = \frac{\vec{x}_{i+1} - \vec{x}_i}{\Delta t}$$

$$\vec{a}_i = \frac{\vec{v}_{i+0.5} - \vec{v}_{i-0.5}}{\Delta t}$$

$$\frac{d^2\vec{x}}{dt^2} = \vec{a}(\vec{x})$$

Leapfrog integration

Rigid body systems

Game Physics

$$\vec{v}_{i+0.5} = \frac{\vec{x}_{i+1} - \vec{x}_i}{\Delta t}$$

$$\vec{a}_i = \frac{\vec{v}_{i+0.5} - \vec{v}_{i-0.5}}{\Delta t}$$

$$\frac{d^2\vec{x}}{dt^2} = \vec{a}(\vec{x})$$

$$\vec{x}_{i+1} = \vec{x}_i + (\Delta t)\vec{v}_{i+0.5}$$

Leapfrog integration

Rigid body systems

Game Physics

$$\vec{v}_{i+0.5} = \frac{\vec{x}_{i+1} - \vec{x}_i}{\Delta t}$$

$$\vec{a}_i = \frac{\vec{v}_{i+0.5} - \vec{v}_{i-0.5}}{\Delta t}$$

$$\frac{d^2\vec{x}}{dt^2} = \vec{a}(\vec{x})$$

$$\vec{x}_{i+1} = \vec{x}_i + (\Delta t)\vec{v}_{i+0.5}$$

$$\vec{v}_{i+0.5} = \vec{v}_{i-0.5} + (\Delta t)\vec{a}_i$$

Leapfrog integration

Rigid body systems

Game Physics

$$\vec{v}_{i+0.5} = \frac{\vec{x}_{i+1} - \vec{x}_i}{\Delta t}$$

$$\vec{a}_i = \frac{\vec{v}_{i+0.5} - \vec{v}_{i-0.5}}{\Delta t}$$

$$\frac{d^2\vec{x}}{dt^2} = \vec{a}(\vec{x})$$

$$\vec{x}_{i+1} = \vec{x}_i + (\Delta t)\vec{v}_{i+0.5}$$

$$\vec{v}_{i+0.5} = \vec{v}_{i-0.5} + (\Delta t)\vec{a}_i$$

$$\vec{a}_i = \vec{a}(\vec{x}_i)$$

Leapfrog integration

Rigid body systems

Game Physics

1. $\vec{a}_i = \vec{a}(\vec{x}_i)$

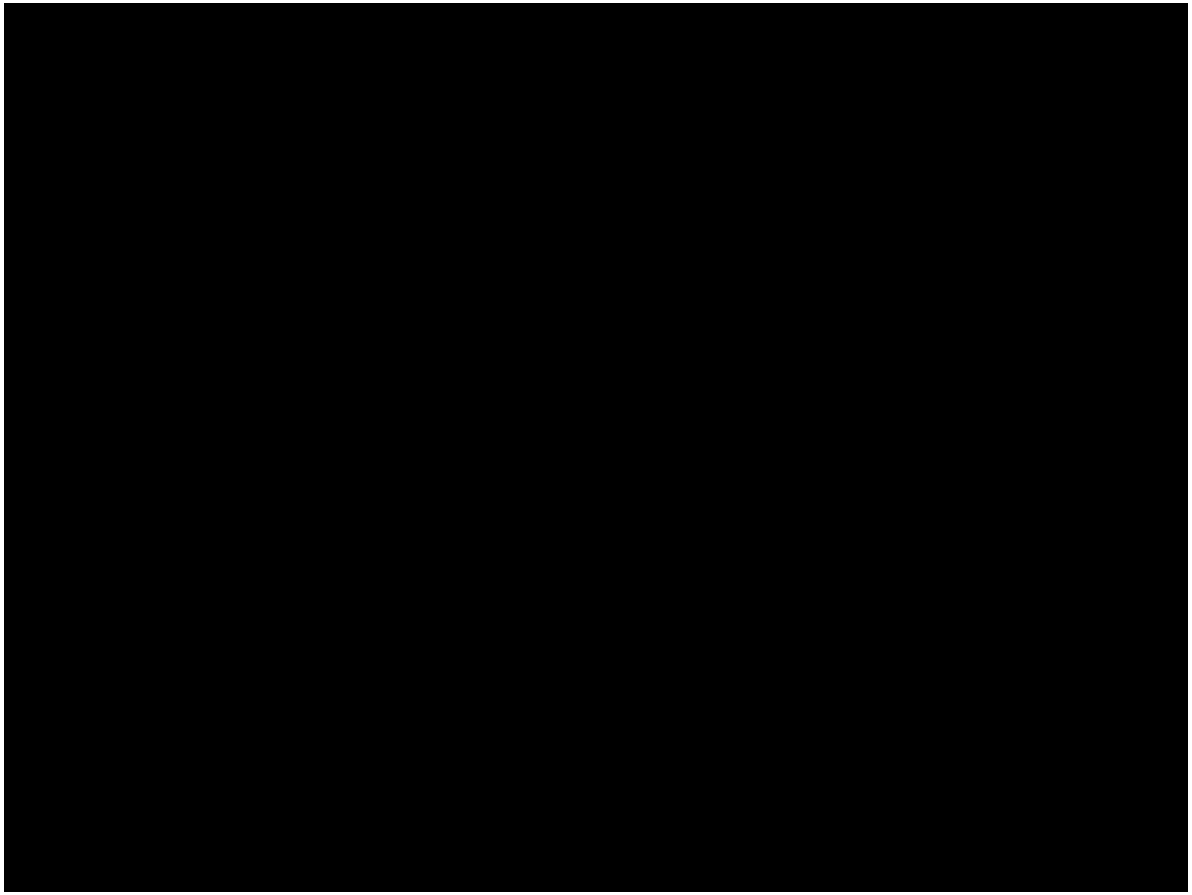
2. $\vec{v}_{i+0.5} = \vec{v}_{i-0.5} + (\Delta t)\vec{a}_i$

3. $\vec{x}_{i+1} = \vec{x}_i + (\Delta t)\vec{v}_{i+0.5}$

Leapfrog integration

Rigid body systems

Game Physics



http://www.youtube.com/watch?v=JncQOCg9FSo&feature=relmfu

Rigid body systems

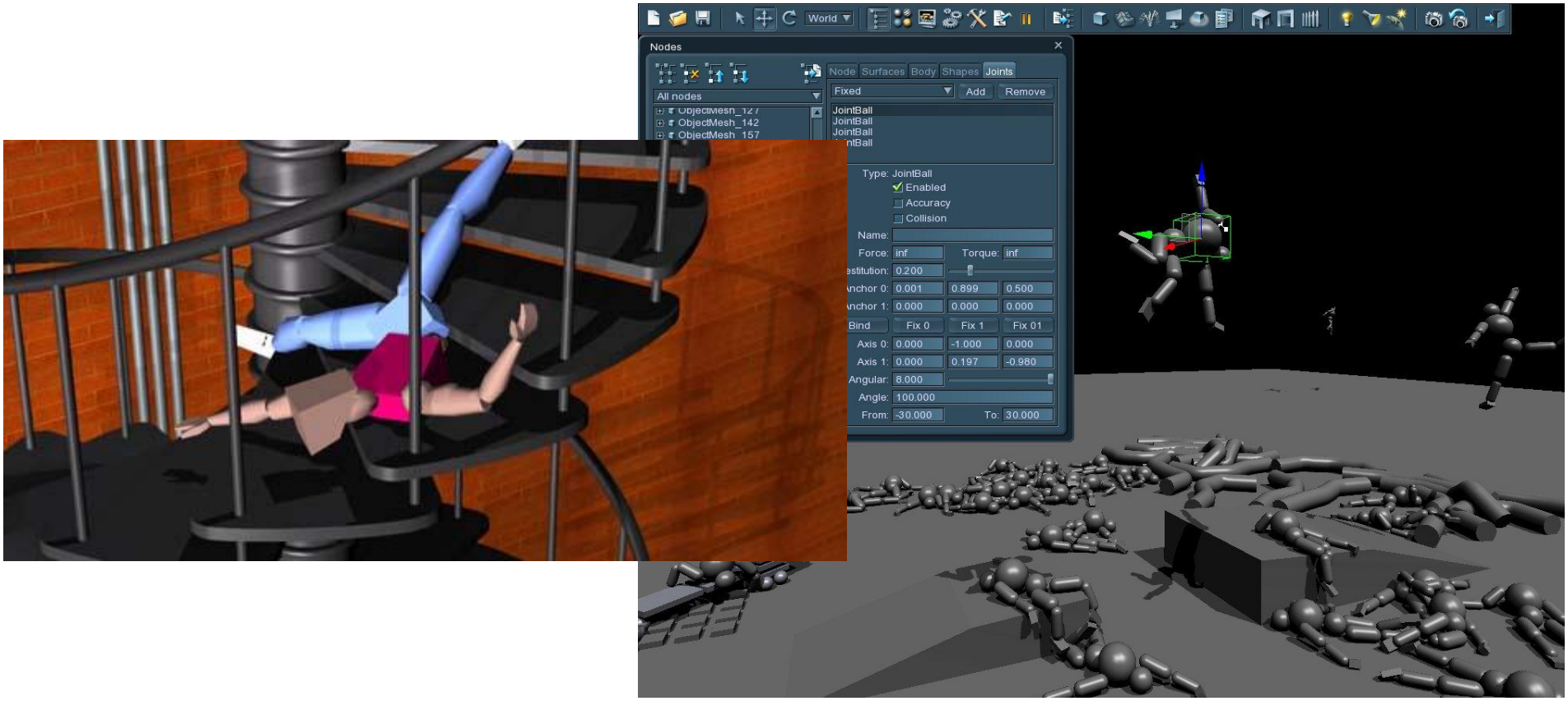
Game Physics

$$\Delta t$$

Be careful!

Rigid body systems

Game Physics



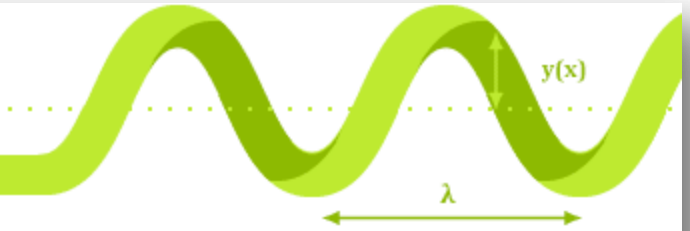
http://upload.wikimedia.org/wikipedia/commons/d/d8/Animatsragdollphysics.jpg
http://unigine.com/devlog/070513-ragdoll.jpg

Ragdoll systems

Game Physics

WIRED SCIENCE BLOGS /

DOT PHYSICS



The Gravitational Force in *Angry Birds Space*

By Rhett Allain March 29, 2012 | 12:11 pm | Categories: Dot Physics, Science Blogs

Follow @rjallain

Now that *Angry Birds Space* is actually available on various platforms, I realize I made some mistakes. Just to be clear, my previous analysis was based ONLY on a preview video. Now that I actually have the game, I can do a much better job.

The first thing I have noticed is this stuff that I thought was the atmosphere or something.

http://www.wired.com/wiredscience/2012/03/the-gravitational-force-in-angry-birds-space/

Fictional physics

http://e-emoo.deviantart.com/art/Typography-123991952
http://www.mobygames.com/images/shots/l/45594-frogger-apple-ii-screenshot-gameplay-on-the-second-levels.gif

Part I: Typography and Layout

Part II: Game Programming Techniques

CS 148, Summer 2012
Introduction to Computer Graphics and Imaging

Justin Solomon