Real Time Cinematic Effects on the PC

The 3dfx T-Buffer™

...“What makes the T-buffer different from an accumulation buffer I don't know,but hopefully they will explain on Monday. I will be disappointed if all we get is a marketing speech.”
   -Kekoa Proudfoot

3D Breakthroughs For Mainstream PCs

3dfx delivers 3D realism to affordable, mainstream PCs

Future

Real-time Photorealism:

Recreate Reality on the Consumer PC Platform

1999 T-Buffer

Full-scene AA (Real-time)

Cinematic Effects
85Hz 1280x1024

1998 Voodoo2 & 3

Multitexturing

Trilinear Mip-mapping

Detail Texturing

Projected Texturing

Triangle Setup
60Hz 1024x768

1997 Voodoo Graphics

RGBA Rendering & frame buffer

Real-time perspective-correct texture-mapping
30Hz 640x480

Immersive 3D: Suspension of Disbelief

— The viewer must perceive an image as realistic to become immersed in the content

— Inconsistent image quality or visual artifacts will jar the viewer from his/her immersed state

  ❍ Poor 3D experience

— Useful digital effects must offer consistent image quality and frame rate without artifacts like:

  ❍ Aliasing "jaggies"

  ❍ Polygon popping

  ❍ Inconsistent frame rate
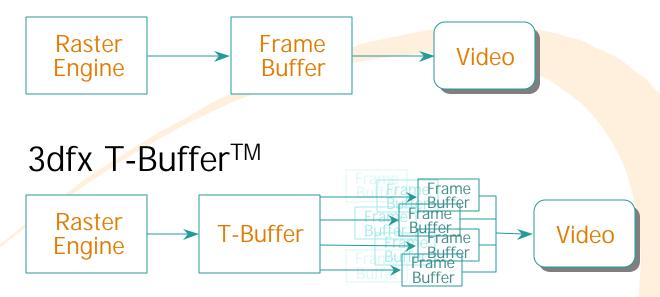
  ❍ Strobed animation

T- Buffer™ : The Problem It Solves

— The T-Buffer solves the general problem of <u>aliasing</u> in computer graphics

— Aliasing is the under-sampling of a source image that causes errors in the image finally drawn on the computer screen

— Under-sampling artifacts occur in:

  ❍ Space: jaggies and pixel popping

  ❍ Time: strobed or stuttered motion

  ❍ Focus: lack of realistic peripheral blur

What Is It?

Conventional PC Accelerator

```
Raster Engine  →  Frame Buffer  →  Video
```

3dfx T-Buffer™

```
Raster Engine  →  T-Buffer  →  Frame Buffer (x multiple)  →  Video
```

— Special rendering and video architecture

○ primitive rendering can go to one or more buffers
  • controlled via "writemask" capability

○ accumulates multiple renderings for supersampling

○ efficient video display

Some references

The Accumulation Buffer: Hardware Support for High-Quality Rendering

Paul Haeberli and Kurt Akeley

Computer Graphics, Vol 24, No. 4, Aug'90

Siggraph '90 Proceedings

Distributed Ray Tracing

Rob Cook, Tom Porter, Loren Carpenter

Computer Graphics, Vol 18, No. 3, Jul'84

Siggraph '84 Proceedings

Full-Scene Anti Aliasing: Implementation
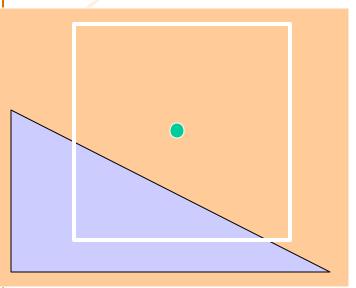
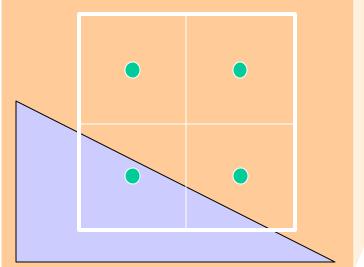- Single-pass implementation

- Render to all samples in parallel

Aliased Image
- No sub-samples stored
- Pixel is not drawn

Anti-Aliased Image
- Sub-samples stored
- Pixel is drawn at 1/4 intensity

Full-Scene High-Quality Spatial AA

— The T-Buffer™ enables true full-scene anti-aliasing with :

❍ No software driver or application overhead

- Just flip a bit and it works

- 100% compatible with Glide, Direct3D, and OpenGL APIs

- Users will automatically upgrade their entire 3D application library

❍ Rendering primitives go to all buffers

❍ Real-time frame rates and interactivity

Full-Scene Spatial AA Images

* Images Copyright 1998, Mango Grits, Inc.

Spatial AA Demo

T-Buffer™ Benefit: Motion Blur (Temporal AA)

— Motion Blur simulates objects' motion during the period of time that a "camera shutter" is open
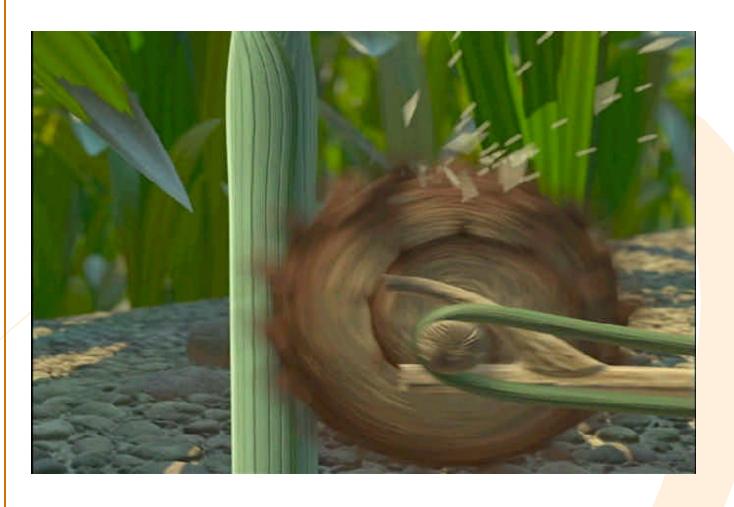
— Motion Blur Benefits:

　○ Removes jerkiness from computer-generated motion: each frame smoothly blends into the next

　○ Creates illusion of speed and motion

　　• Relative motion: primary object in scene (eg: a car) remains sharp while background is blurred

　　• Primary object in scene is itself blurred to convey incredible speed

— T-Buffer^{TM} delivers multiple samples of a scene, or even an object in a scene, at many points in time enabling Motion Blur

Motion Blur Image

*Image from " A Bug's Life," copyright 1998, Pixar Animation Studios

T-Buffer™ Benefit: Depth Of Field Blur (Focal AA)

– Depth of field (DOF) blur simulates the blurring of objects at varying distances from the focal point of a lens (like a camera or your eye)
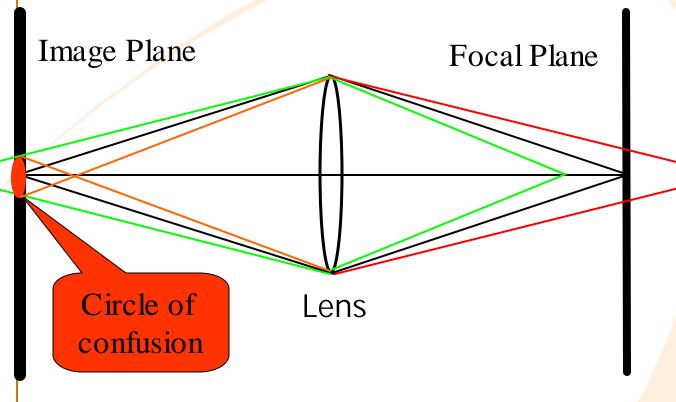
– DOF blur benefits:

❍ Enables "aperture" affect for cinema-like image quality
- Important cinematography effect until now unavailable on a PC
- Heavily used by directors to draw attention to specific points in a scene

❍ Advanced effects like double/triple-vision:
get hit on the head and your vision gets blurred.
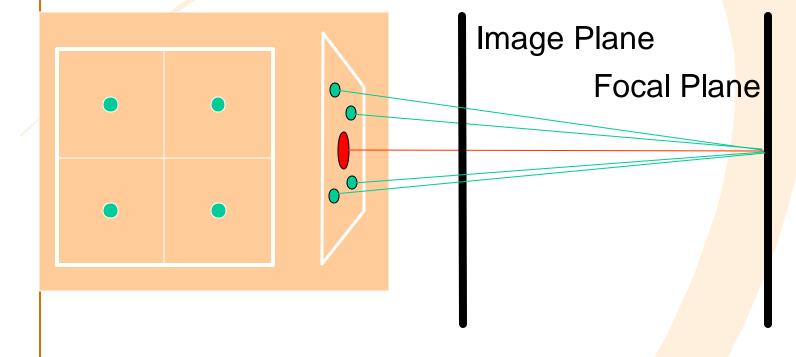
Depth of Field, Some Theory

For a given lens aperture and focal plane, objects at the focal plane are in focus on the image plane (the black lines), objects behind and in front of the focal plane are in focus behind and in front of the image plane (red and green lines) and are out-of-focus on the image plane.

Image Plane

Focal Plane

Circle of confusion

Lens

Depth of Field, Implementation

Each sub-sample views the focal plane from a slightly different angle, and each is translated so the focal plane is in focus

Image Plane

Focal Plane

Depth Of Field Image

Foreground focus

Background focus

*Images from "A Bug's Life," copyright 1998, Pixar Animation Studios

T-Buffer™ Benefit: Soft Shadows

- Soft Shadows show the effect of area lights that create a "soft" edge on real shadows

- Implemented using multiple light samples, each of which is a point light

- Soft Shadow Benefits:

  ❍ Significantly enhances realism

  ❍ Hard shadow edges, such as those created only with stencil buffers in 1 rendering pass, look artificial.

T-Buffer™ Benefit: Soft Reflections

– Soft reflections are the result of a surface being uneven at a very fine level, literally having a distribution of normals or micro-facets

– Soft reflection benefits:

  ❍ Much greater realism for common "semi-gloss" surfaces
  - satin finished wood
  - stainless steel

  ❍ glass and perfect mirrors only have 1 normal, therefore Soft Reflections effect does not apply
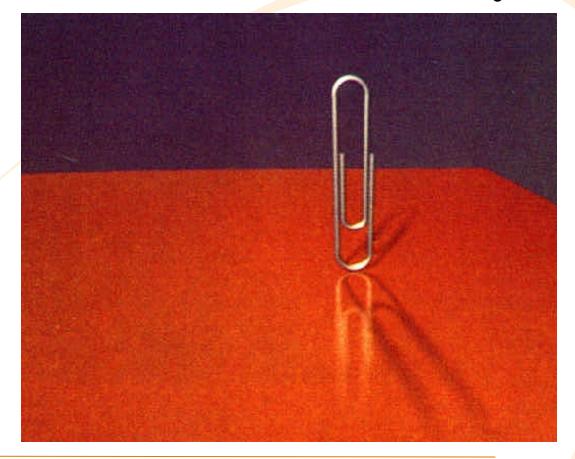
– Implemented by rendering multiple times with varying normals if you have ray tracing hardware; or can be "hacked" by rendering perturbed reflections...

Soft Shadows/Reflections Image

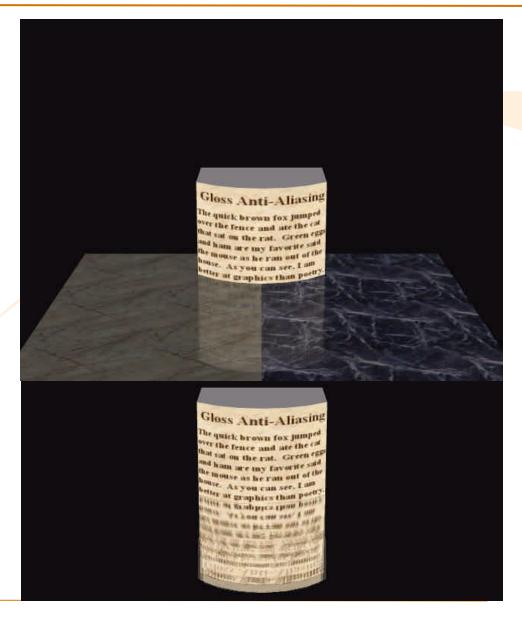— Soft reflections delivers a realistic reflection from real-world surfaces

— Soft shadows delivers realistic shadows from area lights

* Image Copyright The Association For Computing Machinery
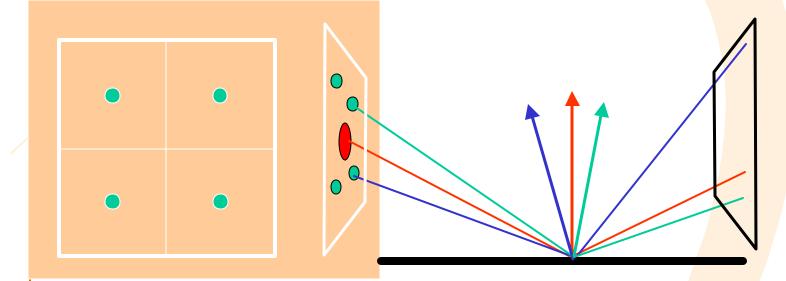
Soft Reflections "hack"

Soft Reflections, Implementation

– Each sub-sample represents the scene reflected about a slightly different normal

All at once now...

— All effects can be done simultaneously

❍ like an accumulation buffer

— Scene is rendered multiple times

❍ each rendering goes to only one buffer (sample)

❍ each sample is offset in

- pixel space (spatial anti-aliasing)
- time (motion blur)
- viewing frustum (depth-of-field blur)
- etc.

Programming Optimizations

— Blurred effects, e.g. motion and DOF

  ❍ lower polygon count models can be used to keep scene polygon complexity constant

— Selective motion blur

  ❍ static objects rendered once into all framebuffers moving objects rendered multiple times into subset

  ❍ accumulation buffer would require depthbuffer saves/restores and bounding box operations

— Selective reflection blur

Compare and Contrast

— Motion Blur - contrary to what's appeared on the net last week, this cannot be done by multi-pass alphablending

- ❍ sorting issues because of the blending

- ❍ depthbuffering issues
  - • have to update depthbuffer so moving object is properly rendered with HSR
  - • but then the next rendering in time will "collide" with previous rendering in the depthbuffer

Compare and Contrast...
Full-Scene Anti-Aliasing

Accumulation Buffer

❍ requires 'n' passes

❍ # of passes is practically unbounded

T-Buffer

❍ requires 1 pass

❍ # of samples depends on implementation limits

Compare and Contrast... Selective Motion Blur

— Accumulation Buffer

  ❍ requires 'n' passes for <u>all</u> geometry

— T-Buffer

  ❍ requires 1 pass for all static geometry

   • both scenery and objects

  ❍ multiple renderings for moving objects

   • could be 2-4 for slow moving objects

   • more for fast moving objects

T-Buffer Demo

T-Buffer™ Effects: Vital for Realism

— Spatial AA: highly noticeable, especially in fine details

— T-Buffer™ enabled effects introduce important subtleties to 3D content that greatly enhance realism

— Once experienced, these effects are indispensable

— The T-Buffer™ technology provides these effects with the consistency of image quality required to maintain the viewers' immersive experience

— Available in affordable, mainstream 3dfx products this Fall

  ○ Concurrently available in advanced configurations from Quantum3D

Presentation Credits

— T-Buffer Emulation Demo System

❍ Quantum3D Mercury System

— Images

❍ Kodak, Pixar / Disney

❍ Mango Grits

❍ The Association For Computing Machinery

— T-Buffer White Paper

❍ Mace Labs

— T-Buffer Demo

❍ 3dfx Voodoo Porting Group

conclusion

interactive