Visorama

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Outline

1. Context: *A Little History*
2. Visorama: *What is IT?*
3. Initial Development: *Real Time Panoramas*
4. Fundamentals: *General Concepts*
5. Applications: *Suggestions of Projects*
6. Software: *Basic Library*
7. Links: *Related Work*
8. Future: *Ideas*

1 – Context: *A Little History*

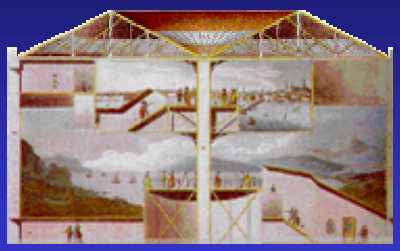
- Real Panoramas
- Virtual Panoramas
- First Generation Systems

Real Panoramas

- Paintings

- Photographs

Panorama Installations I

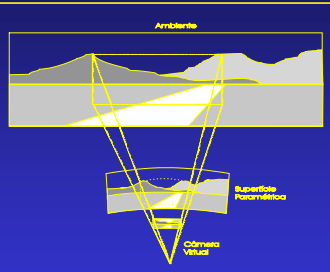


Panorama Installations II

Virtual Panoramas

- Mathematical Concept
  - Model
  - Visualization
- Computer Implementation
  - Hardware
  - Software
- Applications
  - Multimedia
  - Virtual Reality

Model of Panorama



Viewing a Panorama

- Camera Transformation

Warping

Current Panorama Systems

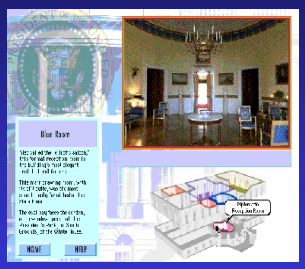
- Characteristics
  - Small Images, Embedded in Applications
  - Interactive, but Not Real-Time
  - Low Performance, Consumer Hardware
- Formats and Companies
  - QuickTime VR (Apple)
  - Real Space (Live Picture)
  - PhotoBubble (Omniview)
  - Surround Video (IBM)

Hardware

- Networked Personal Computer

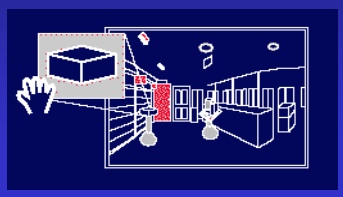
Software

- Multimedia (CD):
  - Director
- Web Applications
  - Netscape



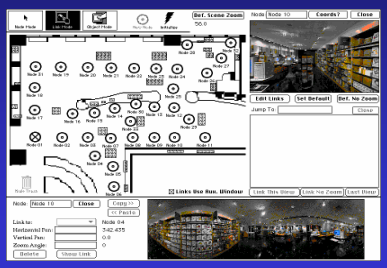
Navigation

- Hyperlinks (Hot Spots)
  - Moving Between Nodes
  - Ativate another Application



Production Tools

- Creation and Authoring



2 - Visorama: *What is IT?*

Definition:

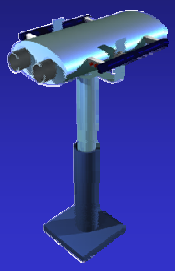
"A Virtual Reality System based on Panoramas"*

Visorama: A New Concept

- Virtual Reality based on Panoramas
  - Visual-Realism*
  - Immersive
  - Natural Interaction
- Complete System
  - Dedicated Hardware
  - Viewing Software*
  - Authoring Enviroment*

Equipment Design

- Binocular device
- Stereo Sound



- Degrees of freedom
  - Fixed viewpoint *
    (at a given time)
  - Pan and tilt rotation
  - Zoom

Human-Computer Interface

Same type of interaction as existing non-virtual devices

- Can be used like these devices
  - Augmented reality
  - Virtual reality
- Familiar interaction

Visorama is a good idea

Less is more philosophy:
Restricts navigation to a fixed point to increase immersibility

- Avoids difficulties of virtual reality systems
- Based on panoramas *(effective metaphor)*

Fixed Point Restriction

Increases immersibility by simplifying interaction

- Prevents invalid operations
- No motion feedback required
- Simple and intuitive interaction
- Easy determination of focus of attention

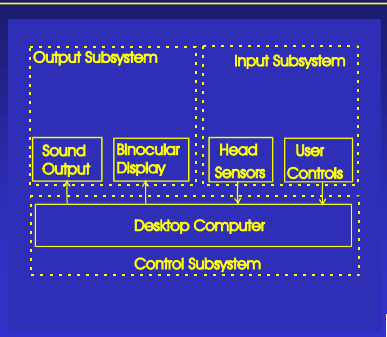
Immersive Visualization Requirements

- Synchronization with observation device
  - Constant and interactive frame rates
- Detailed virtual environment
  - Minimum screen resolution
  - Support large panoramic images
  - Adapted image resolution

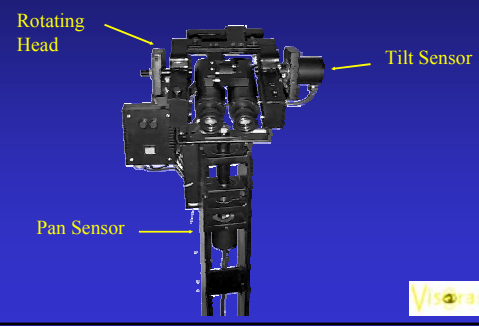
The Visorama System

- The Visorama Device
  - Executes during user interaction
  - Hardware and software components
- Authoring Environment
  - Creation of virtual world
  - Specification of user interactions

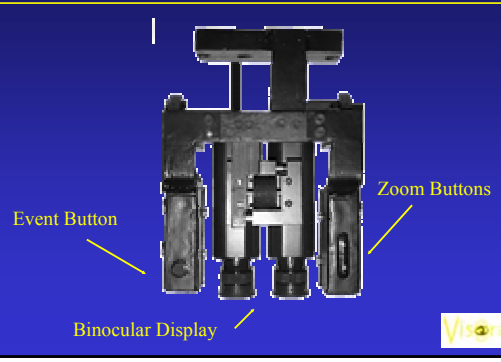
Hardware Architecture



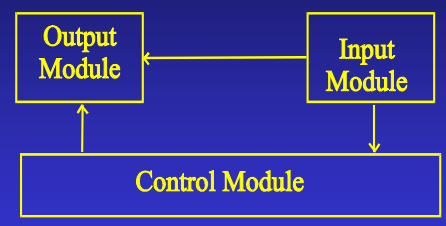
Observation Device



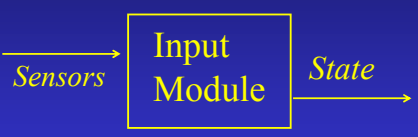
Rotating Head



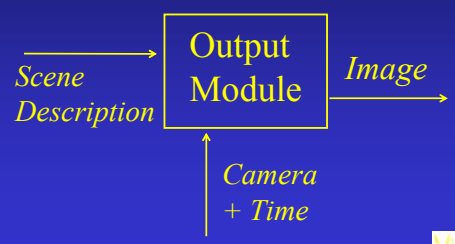
Software Architecture



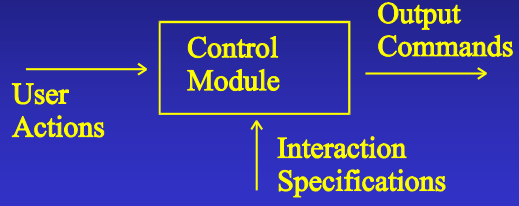
Input Module



Output Module



Control Module



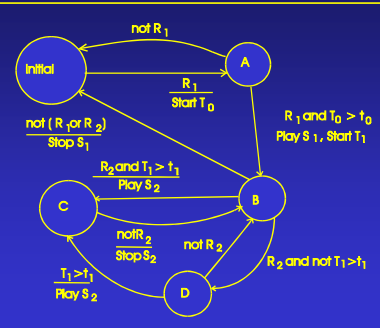
Elements for User Actions

- Viewing Parameter space (3 dimensional)
  - pan angle, tilt angle, zooming factor
- Basic Events
  - Button Pressed
  - Timer Expires
- Event Expressions
  - Complex Boolean Operations

Interaction specification

- Represented by a state diagram
  - Environment is always at a known state
  - Events cause transitions to different states
  - Actions can be executed during transitions

Example



Video Hipermídia

•Visorama Website

3 – *Initial Developments*

- Visorama Project
- Multidisciplinary Collaboration
  - VISGRAF: *Technology*
  - N-Imagem: *Applications*
- Funding
  - FINEP / Faperj / FUJB
- Main Goals
  - Real-Time Panorama Visualization
  - Applications in Historic Tourism

Rendering Panoramas in Real-Time

- Basic Requirement
  - Realism
  - Immersibitiy
- Mechanisms
  - Multiresolution Panoramas
  - Predictive Cache

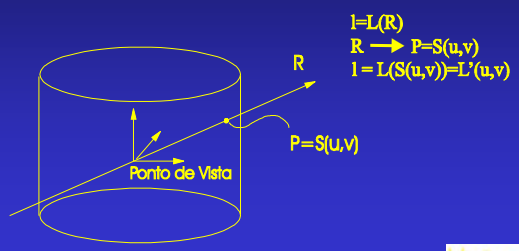
Software Solutions

Requirements met using a combination of techniques

- Hardware implemented texture mapping
- Cache management
- Multiresolution image representation

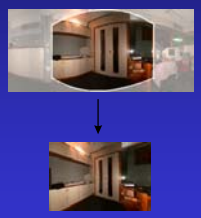
Rendering Panoramas

- 3D Visualization



Viewing Transformation

- Polygonal Model
- OpenGL Textures



- Virtual Camera

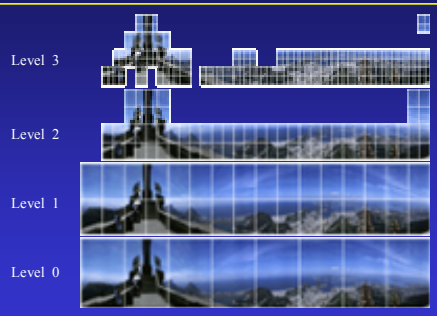
Multiresolution Panoramas

- Motivation
  - Arbitrary Levels of Detail (zoom)
  - Adapted Display Resolution

Image Pyramid

256 x 256 128 x 128 64 x 64 32 x 32

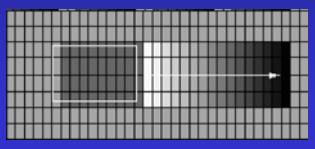
Adapted Multiresolution Tiling



Caches of Panorama Database

Predictive Texture Load/Unload

- Based on Viewing Window
- Criteria
  - Temporal
  - Spatial



Adaptive Level of Detail

Example: *Corcovado*

Applications

Visualization of Urban Landmarks

- Tourism
- Education
- Demonstrations

Future Work

- Authoring environment
- Spatial Audio
- Animated panoramas
- Improve ergonomics

4 – Fundamentals: *Concepts*

- World Scenarios
- Scene Types
- Navigation
- Graphics Technologies
- Visual Output
- Interaction Types
- Medias

World Scenarios

- Wall
  - *Restricted Planar 2 ½ D*
- Surround
  - *Unrestricted Spherical 2 ½ D*
- Spatial
  - *Full 3D*

Scene Types

- Static
  Discrete Change
  - Sequence of Places
- Dynamic
  Continuous Change
  - Animated Scenes
  - Video
  - Sprites

Navigation

- Fixed Viewpoint
  Look Around / In + Out
  - Spatial Hyperlinks
  - Temporal Transitions
  - Zoom / Traveling Motion
- Free Viewpoint
  Fly
  - Relative 3D Motion

Visual Output

- Monoscopic
  Fixed View
  - Planar Words
  - Surroundings Far Away
- Stereoscopic
  Free View
  - 3D Worlds
  - Close Objects

Interaction

- Single User
  - Narrator
- Multi User
  - Avatars

Graphics Technologies

- Geometry-Based
  - 2D or 3D Models
- Image-Based
  - Images or Panoramas
- Mixed
  - Background (*images*)
  - Foreground (*models*)

Audio Technologies

- Media
  - Recorded
  - Synthesized
- Type
  - Simple
  - 3D
- Devices
  - Headphones
  - Speakers

5 – Suggestion of Projects

- Observation Deck
- Periscope
- Armored Vehicle
- Telescope
- Microscope
- Binocular

- Audio
- Games

Observation Deck

Observation Deck (*Images*)

Periscope

Periscope (*Visual*)

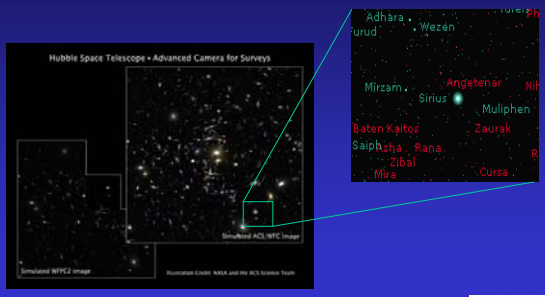
Armored Vehicle

Armored Vehicle (*Visual*)

Telescope

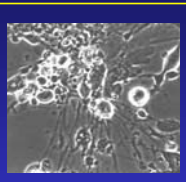
Telescope (*Images*)

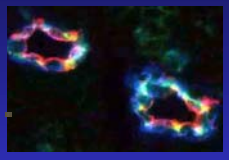
Telescope (*Annotated Images*)

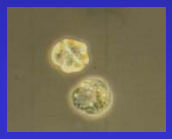


Microscope

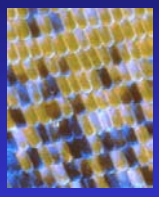
Microscope (*Images*)



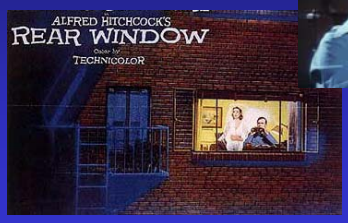




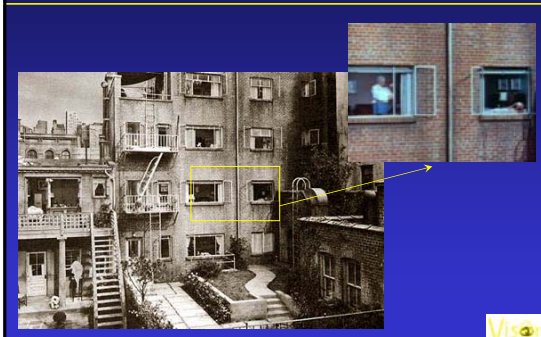
Microscope (*Simulation Images*)



Binoculars



Binoculars *(Video)*



6 – Software: *Device Toolkit*

- Design Goals
- Example of Application
- Basic Structure
- API

Design Goals

- Simple
- Easy to Use
- Work with Visorama and Mouse
  (same interface)

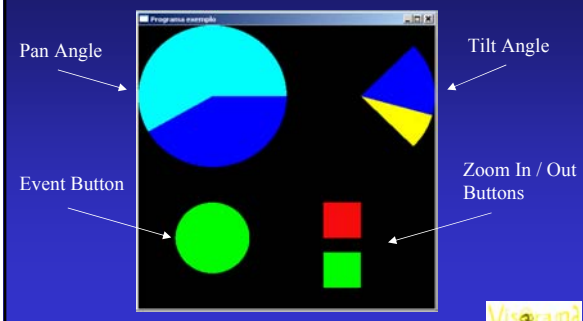
- C++ (Visual C)
- OpenGL
- GLUT and WINAPI

Example of Application

- Read and Display Device State

- Visorama Parameters:
  - Pan Angle
  - Tilt Angle
  - Zoom Button
  - Event Button

Application Demo



Main Program (WINAPI)

```
int main (void)
{
  STARTUPINFO  Startup;
  GetStartupInfo(&Startup);

  BinoculoApp  App(WHandle,  WDef, 500, 500, "Exemplo");

  App.DisplayWindow();
  return  App.MainLoop();
}
```

Binoculo Device

```
class BinoculoApp : public GlWindow {
private:
  SerialPort      *SerialMonitor;
  Binoculo        *EventMonitor;
  InputDevice     *Device;
  BinoculoParam *param;

public:
  BinoculoApp (HINSTANCE h, int Show, unsigned w, unsigned h, char *WinTitle);
  virtual void OpenGlRendering (HWND hwnd);
  virtual void InitAppObjects (HWND hwnd);
  virtual void InitMenu (HWND hwnd){}
  virtual void Destroy (void);
  virtual void Draw (void);
  virtual void Resize (unsigned w, unsigned h);
  virtual void MouseEvents (unsigned x, unsigned y, MouseState ms);
  virtual void KeyBoardEvents (KeyBoardState kbs) {}
  virtual void ControlEvents (WPARAM wParam, LPARAM lParam) {}
};
```

Device Parameters

```
struct BinoculoParam
{
  float MinPan, MaxPan; // Interval of Pan angles
  float MinTilt, MaxTilt;   // Interval of Tilt angles
  float TiltAng, PanAng;  // Current angles
  bool ZoomIn;            // Current state of Zoom In button
  bool ZoomOut;           // Current state of Zoom Out button
  bool Select;            // Current state of Select Button
};
```

Using the API

```
void BinoculoApp::Draw (void)
{
  this->UpdateBinoculoParam();
  hDC = GetDC (hWindow);
  wglMakeCurrent (hDC, hRC);

  glClearColor (0.0,0.0,0.0,0.0); glClear (GL_COLOR_BUFFER_BIT);
  glViewport (0, 0, WinWide, WinHeight);

  // draw base
  glCircle (-0.5f, 0.5f, 0.5f, param->MinPan, param->MaxPan, 0.0f, 0.0f, 1.0f);
  ...
  // draw current
  glCircle (-0.5f, 0.5f, 0.5f, param->MinPan, param->PanAng, 0.0f, 1.0f, 1.0f);
  glCircle (0.5f, 0.5f, 0.5f, param->MinTilt, param->TiltAng, 1.0f, 1.0f, 0.0f);
  if (param->ZoomIn) glRect (0.25f, -0.25f, 0.5f , -0.5f, 1.0f, 0.0f, 0.0f);
  if (param->ZoomOut) glRect (0.25f, -0.6f, 0.5f , -0.85f, 1.0f, 0.0f, 0.0f);
  if (param->Select) glCircle (-0.5f, -0.5f, 0.25f, 0.0f, 360.0f, 1.0f, 0.0f, 0.0f);

  glFlush();
  SwapBuffers (hDC);
  wglMakeCurrent (NULL, NULL);
  ReleaseDC (hWindow, hDC);
}
```

7 – Software for Panoramas

- Surface Type
  - Cylindrical
  - Spherical
  - Cubical
- Image Type
  - Photographic
  - Synthetic

Cylindrical Panorama: *Shooting*

- Image Capture and Pre-processing

Shooting → Registering

Cylindrical Panorama: *Assembly*

- Stitching the Panorama

Spherical Panorama: *Shooting*

- Fish Eye Lens:

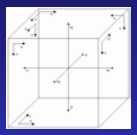
Spherical Panorama: *Assembly*

- Convert to Polar Coordinates

- Stitch and Make Latitude / Longitude Map

Cubical Panorama

- Cube Map



Fotorama

- Java Viewer

Cuberama

- OpenGL Viewer

http://w3.impa.br/~morph/cd-morph/docs/software/cuberama.htm

7 - Links

- André Matos: Visualizador
- André Matos: Master Thesis
- Aldo Nogueira: Tech Report

8 – Ideas

- Stereoscopic Panorama
- Interactive Workbench
- Super Hi-Resolution
- Total Integration

Cache Management for Real-Time Visualization of 2D Datasets

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Outline

- Tendencies and Motivation
- Principles of Cache Management
- Cache in Computer Graphics
- Algorithm for Processing of 2D Datasets
- Application: a Virtual Panorama System
- Experimental Results
- Conclusions and Current Work

Next Generation Graphics

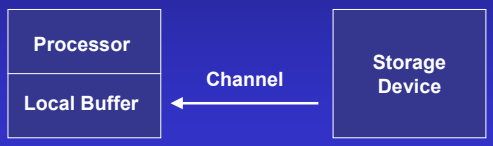
- Tendencies
  - Fast Rendering Engines
  - High Capacity Storage Devices
  - Client-Server Architectures
- *"Killer"* Applications
  - Virtual Reality
  - Visual Simulators
  - CAD, GIS
  - Medical Imaging

Motivation

- Challenges
  - Very-Large Databases
  - Real-Time / Interaction
- Solutions
  - Multiresolution
  - Cache Management

Cache Management

- Resource Optimization
  - Local Memory Size: ***cs***
  - Channel Bandwidth: ***bw***



Cache Mechanisms

"Just-in-Time Data"

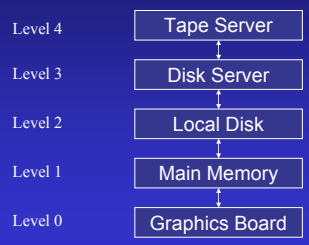
- Strategies
  - Pre-Fetch Items
  - Replace Items
- Decisions: *Oracle*

  Which data elements (Items)?

  * *Application Dependent*

Levels of Cache

- Same Problem in Cascade



Caching and Graphics

- Standard Algorithms
  - No Assumptions about Data (Sequential Fetch)
  - Exploit Usage Patterns (Least Recent Used)
- Computer Graphics Applications
  - Spatial Data Structures
  - Exploit Coherence :
    - Model (*spatial*)
    - Viewpoint (*temporal*)

* *We can do much better in Graphics...*

Caching for Real-Time Graphics

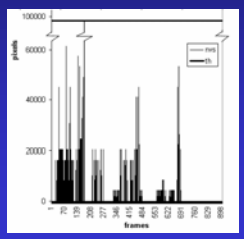
- System Response Time:
  Frame Time = Load Objects + Render
- Assumptions:
  - Objects *must be* in Cache for Rendering
- Real-Time and Interaction
  - Frame Rate ≈ Constant
- Goal of Cache Management
  - Minimize *Load* Time for All Frames

Standard Cache Management

- Algorithm:
  for each Frame *i*
    Load New Objects (nvs_i)
    Replace using LRU
    Render All Objects
- Throughput:
  $max_i(nvs_i) < th$

Typical Visualization Sequence

- Drawback:
  $\boldsymbol{nvs_i}$ exhibits large variations from frame to frame



Using Pre-Fetching

- Strategy:
  - *Select* Objects and *Pre-Fetch* whenever Possible (i.e. when there is time left)
- Object Selection:
  1. Assume Sequence is *known*
  2. Use an ***Oracle***
- Optimal Solution (case 1):
  - Maximize Response (Throughput)
  - Minimize Load Time per Frame (Latency)

Pre-Fetch Performance

- *Throughput*:

$$\max_k\left(\frac{\sum_{i=1}^{k} nvs_i}{k}\right) < th$$

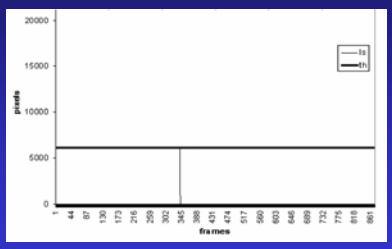
- *Latency* (Accumulated) :

$$err = \sum_{i=1}^{n} e_i$$

with

$$e_i = \begin{cases} 0 & \text{if } ls_i \le th \\ ls_i - th & \text{if } ls_i > th \end{cases}$$

Same Sequence with Pre-Fetching



Basic Algorithm

for each Frame *i*

Classify Objects o_i using *Oracle*

c_i = time to render o_i

Replace *th* Objects in the Cache

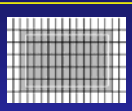
Remove o_i with largest c_i

Load o_i with smallest c_i

Render Objects

Oracle for 2D Datasets

- 2D Visualization:
  - Viewing Window (Rectangular Region)



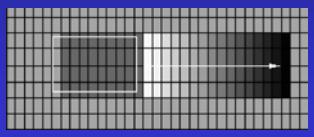
- Uniform Decomposition of Plane
  - Data Item is a *Tile* (Object)
- Classification Criteria for Tiles:
  - Temporal
  - Spatial

Temporal Criteria

- Tile Classification:
  - Number of Frames to Enter View Window

* Based on View Window Trajectory

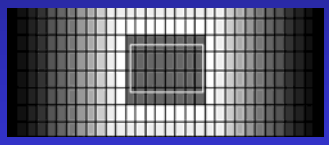
- 2nd Order Prediction (Velocity / Acceleration)



Spatial Criteria

- Tile Classification:
  - Distance from Current View Window

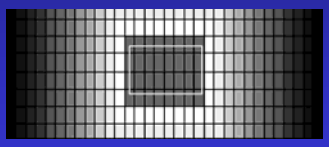
* Solves Problem of Sudden Motions



Spatial Criteria

- Tile Classification:
  - Distance from Current View Window

* Solves Problem of Sudden Motions



Application

- Visualization of Virtual Panoramas

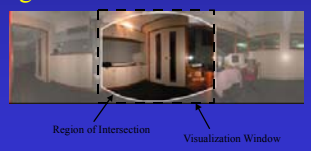
Panoramic Surface

Viewing Projection

Processing Panoramic Images

- Tiling

- Rendering

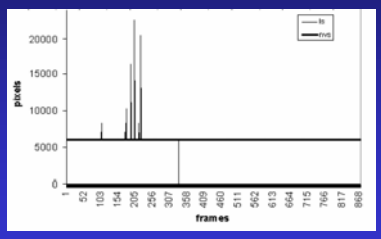


Implementation Details

- Hardware
  - Pentium II, with 128 Mb RAM
  - Fire GL 4000, with 16 Mb Texture Memory
- Cache: level 0
  - Cache: Texture Memory
  - Storage: Main Memory
- OpenGL Rendering
  - Loading Tiles: Draw in back-buffer
  - Unloading Tiles: GL Texture Priorities

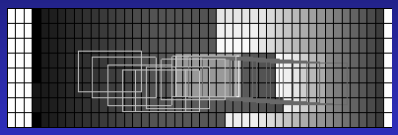
Experimental Results

- Close to Optimal



Demonstration

- Video



Conclusions

- Caching for 2D Datasets
  - Optimal Algorithm
  - Oracle for 2D Visualization
  - General Applicability (GIS, Medical, IBR)
- Extensions
  - Multiresolution
  - Multiple Levels of Cache
  - Surfaces, Volume Data