Part 2.2

Mobile Graphics Trends: Applications

Marco Agus, KAUST & CRS4
Applications

- **Wide range of applications**
  - Cultural Heritage
  - Medical Image
  - 3D object registration
  - GIS
  - Gaming
  - VR & AR
  - Building reconstruction
  - Virtual HCI
Mobile 3D interactive graphics

• General pipeline similar to standard interactive applications
Remote rendering

- General solution since first PDAs
Remote rendering

• 3D graphics applications require intensive computation and network bandwidth
  – electronic games
  – visualization of very complex 3D scenes

• Remote rendering has long history and it is successfully applied for gaming services
  – Limitation: interaction latency in cellular networks
Mixed Mobile/Remote rendering

- As mobile GPUs progress...
Mixed Mobile/Remote rendering

- Model based versus Image based methods
- Model based methods
  - Original models
  - Partial models
  - Simplified models
    - Couple of lines
  - Point clouds

- Eisert and Fechteler. Low delay streaming of computer graphics (ICIP 2008)
- Balsa et al., Compression-domain Seamless Multiresolution Visualization of Gigantic Meshes on Mobile Devices (Web3D 2013)
Mixed Mobile/Remote rendering

- Model based versus Image based methods
- Model based methods

Point clouds organized as hierarchical grids. Tested on PDAs

- Point clouds

Mixed Mobile/Remote rendering

- Model based versus Image based methods
- Model based methods

Transfer couple of 2D line primitives over the network, which are rendered locally by the mobile device

- Couple of lines
- Point clouds


Mixed Mobile/Remote rendering

• Model based versus Image based methods
• Model based methods
  – Original models

Eisert and Fechteler. **Low delay streaming of computer graphics** (ICIP 2008)

Intercept and stream OpenGL commands
Better performances with respect to video streaming
Limitation: clients need powerful GPU
Mixed Mobile/Remote rendering

- Model based versus Image based methods
- Model based methods
  - Original models
  - Partial models
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    - Couples of lines
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Eisert and Fechteler. **Low delay streaming of computer graphics** (ICIP 2008)


Balsa et al., **Compression-domain Seamless Multiresolution Visualization of Gigantic Meshes on Mobile Devices** (Web3D 2013)


More details in Part 4
Mixed Mobile/Remote rendering

• **Image based methods**
  - **Image impostors**
  - **Environment maps**
  - **Depth images**
Mixed Mobile/Remote rendering

• **Image based methods**
  - **Image impostors**
  - **Environment maps**
    - Image representations are created by the server, and warped in real time by the client to account for user interaction
  - **Depth images**
Mixed Mobile/Remote rendering

- Model based vs Image based methods
  - Constraints: rendering quality, bandwidth, interactivity

<table>
<thead>
<tr>
<th>Model based</th>
<th>Image based</th>
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- Network bandwidth
- Client computation
- Rendering quality
- Occlusion warping limitations
## Mobile visualization systems

- **Volume rendering**

  
  
  

- **Point cloud rendering**

  - Balsa et al. *Interactive exploration of gigantic point clouds on mobile devices*. (VAST 2012)
  
  - He et al. *A multiresolution object space point-based rendering approach for mobile devices* (AFRIGRAPH, 2007)
Mobile visualization systems

• Volume rendering


• Point cloud rendering

  Balsa et al. *Interactive exploration of gigantic point clouds on mobile devices* (VAST 2012)

  He et al. *A multiresolution object space point-based rendering approach for mobile devices* (AFRIGRAPH, 2007).
Mobile rendering

• Nowadays...

MOBILE DEVICE

DATA ACCESS

RENDERING

DISPLAY

INTERACTION

Scene

Frame
Mobile rendering

• Or better...

MOBILE DEVICE

SERVER

DATA ACCESS

NETWORK

Scene

Frame

RENDERING

DISPLAY

INTERACTION
Mobile rendering

- Or better...

Chunk-based data streaming (like HuMoRS Balsa et al. 2014)

Limitations: bandwidth consumption (for now)
Mobile rendering with capture

- Exploiting mobile device sensors...
Mobile rendering with capture

- Exploiting mobile device sensors...

Kolev et al. *Turning Mobile Phones into 3D Scanners* (CVPR 2014)

Tanskanen et al. *Live Metric 3D Reconstruction on Mobile Phones* (ICCV 2013)
Mobile rendering with capture

- Exploiting mobile device sensors...

Example:
Google Tango
https://www.google.com/atap/projecttango/#project
Mobile rendering with capture

- Exploiting mobile device sensors...

See section 5 for more applications of sensor integration.
Trends in mobile graphics

• Hardware acceleration for improving frame rates, resolutions and rendering quality
  – Parallel pipelines
  – Real-time ray tracing
  – Multi-rate approaches
SGRT: Real-time ray tracing

- Samsung reconfigurable GPU based on Ray Tracing
- Main key features:
  - an area-efficient parallel pipelined traversal unit
  - flexible and high-performance kernels for shading and ray generation

Shin et al., Full-stream architecture for ray tracing with efficient data transmission. 2014 IEEE ISCAS

Adaptive shading

• Triangles rasterized into coarse fragments that correspond to multiple pixels of coverage
• Coarse fragments are shaded, then partitioned into fine fragments for subsequent per-pixel shading


Mobile rendering with capture

- Exploiting mobile device sensors...

![Diagram showing data access, capture, rendering, display, and interaction in the context of mobile device rendering with capture.](image)
Examples: Physical simulations

- Framework for physically and chemically-based simulations of analog alternative photographic processes
- Efficient fluid simulation and manual process running on iPad

Examples: Correcting visual aberrations

• Computational display technology that predistorts the presented content for an observer, so that the target image is perceived without the need for eyewear
• Demonstrated in low-cost prototype mobile devices

Conclusions

• **Heterogeneous applications**
  – driven by bandwidth and processing power

• **Trends**
  – desktop software solutions tend to be ported to the mobile world
    • gaming
    • modelling and 3D animation
    • complex illumination models

• **Sensor integration open new scenarios**
  – examples: live acquisition, mHealth (using sensors and cameras for tracking and processing signals)
Next Session

GRAPHICS DEVELOPMENT FOR MOBILE SYSTEMS