Bristol Graphics Computer

Radiance on Small Screen Devices

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Overview

- Research overview
- Background
  - SFF Devices
  - Visual Perception
- Psychophysic experiment
- Rendering solution
- Future Work

Research Overview

- Optimising graphics for future mobile devices (SFF)
  - collaboration with STElectronics
- Goal: Realism in Real-time
- Adaptation of high fidelity techniques for SFF
- Exploit properties of HVS, optimise rendering effort

Two stages:

- Analysis of perceptual characteristic of devices
- Develop novel rendering strategies

SFF Devices

- SFF devices are ubiquitous, flexible, and can be taken anywhere
- Target Applications:
  - Interactive exhibit exploration
  - Navigational tools
  - Multi-user mobile games
- Limitations:
  - Small, low spatial and colour resolution
  - Unfavourable viewing conditions: lighting + movement
  - Limited computational power, bandwidth and memory
  - Battery life constraints

SFF Devices - II

- Why High-Fidelity on SFF devices?
  - Future systems, superior quality
- Problem!
  - High-Fidelity rendering is extremely costly
- How will it work?
  - Great saving due to low spatial resolution
  - Perceptually-based optimisation

Visual Perception + Attention

- Visual perception
  - Detect and decipher light signals
  - Not passive viewers, actively interpret
- Visual attention
  - Attention functions similar to a spotlight
  - Sweeping region with greater clarity
  - 2º foveal region of the retina

Visual Perception + Attention - II

- Impossible to know precise perceived representation
  - Can identify characteristics + limitations
- Factors to visual perception
  - What is being perceived (quality, size, etc)
  - Actual scene details
  - Conditions for viewing (lighting, interaction)
  - Surrounding environment (distractions)
- Must be certain fundamental limitations
  - How much detail can be perceived?
  - Saving!

Perceptually-based Rendering

High Quality

Selective / Low Quality

Psychophysics Experimentation

- Investigate perceptual characteristics through psychophysics experimentation
- Factors to visual perception
  - What is being perceived (quality, size, etc)
    - Rendering thresholds
  - Actual scene details
  - Conditions for viewing (lighting, interaction)
  - Surrounding environment (distractions)

Rendering Threshold-Overview

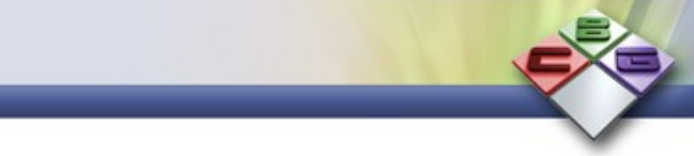
- Investigate perceived rendering threshold of supersampling
- Hypothesis: Larger angle subtended from eye per pixel indicates higher fidelity graphics required for SFF devices

Rendering Threshold-Procedure

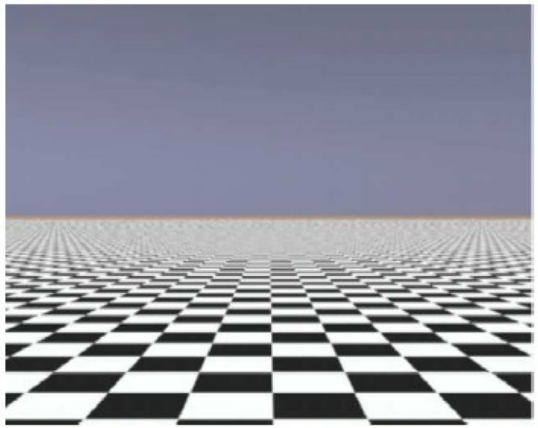
- Carried out on six static scenes
- 20 participants
- GP2X device
  - 320 x 240, 24bit, 3.5”
- Image pairs
  - $\{n^2 : 1 \leq n \leq 5\}$ rpp
  - 2AFC
  - Choice of superior rendering quality

1 ray-per-pixel

25 rays-per-pixel



Rendering Threshold-Scenes



Rendering Threshold-Hypothesis

- 1 degree FOV ~ 288 microns on retina ~ 120 cones
  - 17” monitor at 50cm ~ 16 degrees (~1.5 cones pp)
  - SFF held at 35-60cm ~ 6.8-11.6 degrees (~2.5-4.3 cones pp)
- Greater number of neurons per pixel in SFF device
  - Higher fidelity required?

Rendering Threshold-Results

	Art Gallery		Checkerboard		Corridor		Kalabsha		Library		Office	
No. of Rays	x^2	p	x^2	p	x^2	p	x^2	p	x^2	p	x^2	p
1	1.758	0.200	**15.172**	**0.001**	**7.025**	**0.010**	**10.989**	**0.001**	**6.144**	**0.025**	**10.989**	**0.001**
4	0.416	1.000	**7.033**	**0.010**	0.107	1.000	0.902	1.000	0.417	1.000	**5.013**	**0.050**
9	0.102	1.000	2.558	0.200	0.000	1.000	0.404	1.000	0.417	1.000	2.506	0.200
16	0.100	1.000	0.000	1.000	0.404	1.000	2.506	0.200	0.400	1.000	0.102	1.000
25	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000

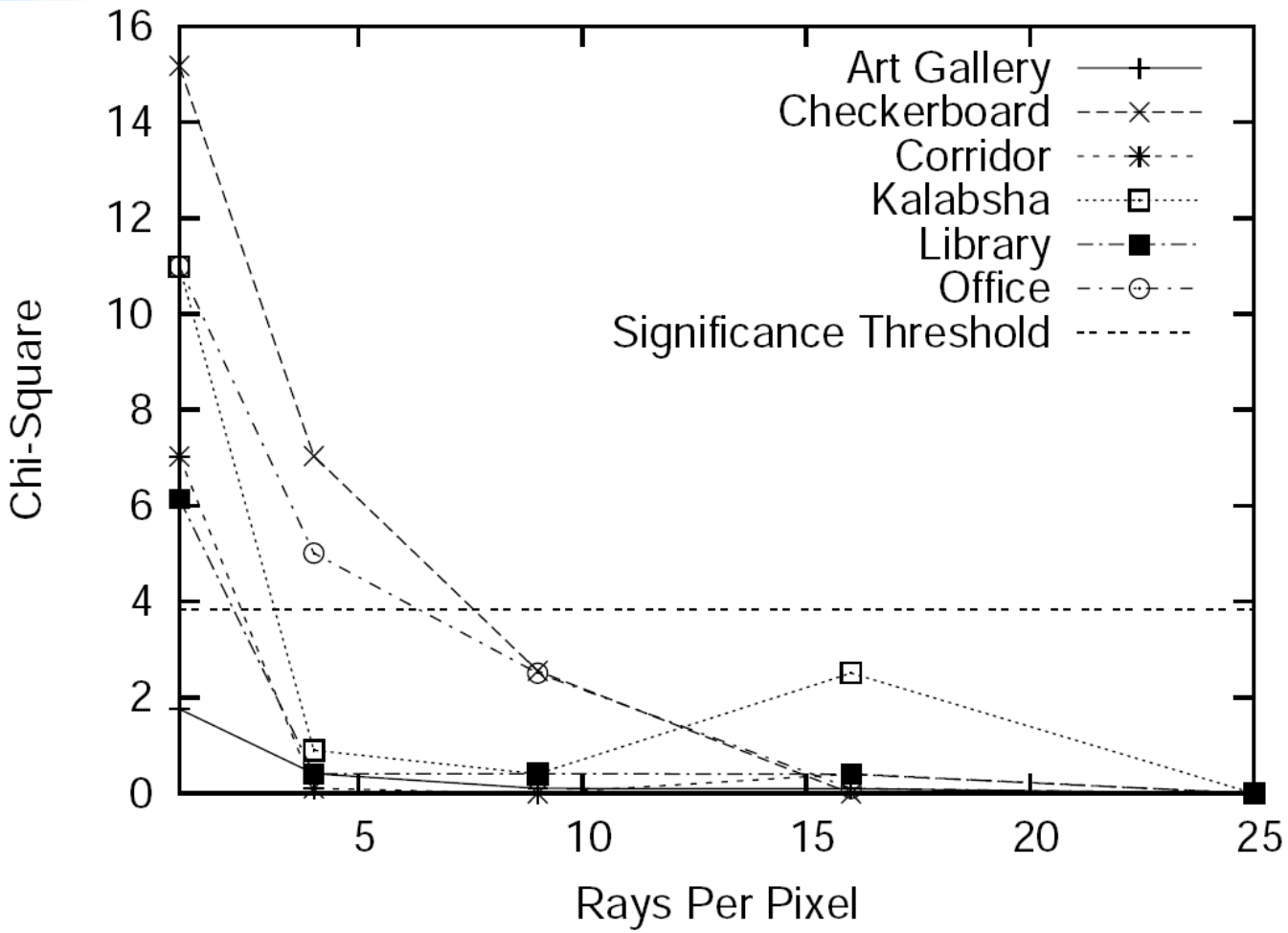
Table 2: *Chi-Square Analysis (df=1; critical value 3.841 at 0.05 level of significance). Significant results in bold.*

Traditional display produces LOS of 4rpp for all except 9rpp for art gallery and 16rpp for checkerboard

No. of Rays	Art Gallery	Checkerboard	Corridor	Kalabsha	Library	Office
1	4.003	2.625	34.881	4.974	45.301	47.503
4	14.516	9.018	153.173	12.573	162.364	191.069
9	32.110	19.636	343.214	26.973	373.449	430.734
16	56.732	34.543	599.502	67.321	570.727	786.811
25	88.896	53.513	790.539	78.003	792.939	1,380.559

Table 1: *Time taken to trace scenes in seconds.*

Rendering Threshold-Results



A graph of statistical significance levels of scenes

Rendering Threshold-Conclusion

- Different to traditional displays
- Possible to further reduce sampling compared to traditional displays
- Seems to indicate ray tracing is more viable than we thought
  - Save computation, time and energy
  - Real-time more feasible?

Research Platform

- Experiments and development on GamePark Holdings' GP2X
- Dual-core CPU:
  - 200MHz ARM920T host,
  - 200MHz ARM940T
- NAND Flash ROM: 64 MB
- RAM: SDRAM 64 MB
- 320×240 3.5”, colour TFT LCD
- Linux-based OS

Renderer

- Selective renderer under development based on Radiance
  - Incorporates perceptual findings
- Renderer images based on the contents of a saliency map by varying # rays per pixel
- Example speedup for Corridor:
  - 3% rays of Gold standard required, 20% of 4rpp
  - According to VDP, only 0.45% average error and merely 0.35% of the pixels were in error
  - Perceptually indistinguishable

Future Work

- Further psychophysic experimentation
- Eye-tracking experiments
  - Verification and investigate further perceptual characteristics
- Incorporate results into selective renderer

- Thanks: Veronica Sundstedt for scenes
- Futher information: aranha@cs.bris.ac.uk