Enabling a Richer Multimedia Experience with GPU Compute

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What is GPU Compute

Operating System and most application processing continue to reside on the CPU and can be accelerated through multi-core and NEON technologies.

The GPU is now programmable through C-like languages and APIs such as OpenCL™ and Android™ RenderScript.

The GPU enables cost effective, efficient, and high performance floating point and parallel computation.

The GPU can be used as a computational accelerator or as a companion processor.

Use cases offloaded to the GPU can include:
- Traditional 2D/3D graphics
- Advanced image processing
- Acceleration/complement of ISP functionality
- Offload of video codec functional blocks
- Acceleration of physics computation

GPU Compute Definition
The use of the GPU for offload and acceleration of non graphical computational tasks.
The Evolution of Mobile GPU Compute

**OpenGL ES 1.1**
Fixed pipeline

- Mali-55

**OpenGL ES 2.0**
Programmable pipeline

- Mali-200
- Mali-300

**OpenGL ES 3.1 Compute Shaders**
GPU Compute within graphics pipeline

- Mali-400 MP

**OpenCL Full Profile / RenderScript**
Portable Heterogeneous Parallel Computation

- Mali-T600 Series

**Mali-T700 Series**

- 2007
- 2009
- 2010
- 2012
- 2013
## GPU Compute: Improve Existing and Enable New Solutions

| Increased system-level energy efficiency | • Complement CPU processing  
• Enable choice of best processor for the job |
| Better load-balance across system resources | • Use heterogeneous compute APIs designed for concurrency |
| Free up CPU resource | • Offload non-graphical computational tasks to GPU |
| Flexibility, portability and programmability | • Software solution leveraging CPU+GPU subsystem  
• Industry standard portable APIs |
| Improve User Experience | • Remove computational barrier to improve visual quality, responsiveness, accuracy within existing compute & energy budgets |
| Reduce cost, risk and TTM | • Enable new applications using existing silicon design |
ARM Mali: The Leader for GPU Compute

- Architecture designed from the ground up for Mobile GPU Compute
- First to ship in real products (Google Chromebook, Google Nexus 10, Insignal Arndale)
- First to support Android RenderScript Compute on GPU
- Proven benefits through real applications and use cases by third parties
  - Advanced imaging, computer vision, computational photography and media codecs
  - Improved performance and energy efficiency measured on consumer devices

- ARM is leading the heterogeneous computing industry
  - Tight integration and aligned roadmap with other system components
  - Actively contributing to Khronos OpenCL, OpenVX and Camera WGs
  - Founding member or HSA Foundation
  - Member of the Embedded Vision Alliance
Example use cases for GPU computing

### Mobile
- Computational photography
- Moving and still image real-time stabilization
- Information extraction: object detection, classification and tracking
- Imaging: correction, improvement, consolidation
- Content and context understanding
- ISP pre- and post-processing
- Augmented reality
- Physics in games
- HEVC/VP9 decoding

### DTV/STB
- 2D to 3D conversion
- Super resolution
- Video pre- and post-processing
- Camera based gesture UIs
- Trans-coding
- Information extraction and superimposition

### Automotive
- Lane detection
- Smart head-light
- Road sign recognition
- Night vision
- Object classification
- Pedestrian, vehicle and collision detection
- Vehicle detection
- Dynamic cruise control

100s GFLOPs of efficient processing power: improve existing use-cases, enable next generation use-cases
Third Party Adoption and Enablement Timeline

- Real-time Image Stabilization
- CLBenchmark and RSBenchmark
- Image processing and video editing
- Gesture UI
- iHDR sensor processing (ISP offload)
- EyeSight
- Gesture UI
- HEVC decode 1080p
- HEVC and VP9 decode 1080p
- Gesture UI
- Up-scaling and soft-HDR
- Assertive Display (ambient computing)
- Low-energy HPC
- JPEG Photo apps
- HEVC and VP9 decode 1080p
- Face, gender, age detection
- Image processing

PARTIAL LIST OF ARM MALI PARTNERS
Proven Benefits for Image Processing

OpenCL Enabled JPEG Decoder

Power Consumption Comparison

- OpenCL Fast
- Neon

[4]

[1] Acceleration compares RenderScript compiled on device (LLVM) on dual-core ARM Cortex™-A15 and ARM Mali-T604 on a stock Google Nexus 10 device


[3] Battery drain test measured on Google Nexus 10 (30 iterations of de-shake transcoding)

[4] Measured on InSignal Arndale developer platform
Proven Benefits for Computer Vision

- Increased robustness and detection accuracy in poor lighting conditions
- Multi-user face feature detection and analysis accelerated using OpenCL on Mali-T600 GPU

Face Detection relative comparison:
- On average, 8.7x performance improvement
- On average, 83% energy reduction

 Tested on an instrumented InSignal Arndale Community Board
Algorithm based on OpenCV Face Detection example
OpenCL kernels re-written and optimized for Mali-T604
Average results represented, permitting CPU and GPU operational frequencies
Why GPU compute for HEVC decode?

- High resolution HEVC decoding on CPU creates high loading
- GPUs are traditionally idle during video playback
- GPU architecture suits acceleration of parallel codec blocks
- Offloading computation to the GPU frees up the CPU to perform other (system) tasks
- Combining CPU (NEON) and GPU Compute enable most efficient HEVC decode

“Mali GPUs are well suited for video acceleration with significant power/performance benefits”

“Mali acceleration opens up the possibility of 1080p @ 60 fps and 4K x 2K @ 30 fps HEVC decode on mobile devices without dedicated HW”

Source: Ittiam Systems
Proven benefits for HEVC decode

- ARM is collaborating with several codec vendors
  - Ensuring widest availability of HEVC across multiple ARM platforms
  - Enabling HEVC early, in software, through ARM NEON™ and GPU Compute
  - Multiple partners developing OpenCL-enabled HEVC codecs for Mali-T600

![Graph showing CPU load, performance, and energy consumption comparison between CPU Only implementation and With OpenCL/GPU. The graph indicates up to 50% reduction in CPU load, up to 2x in framerate uplift, and 20-30% reduction in battery consumption.]
Mali GPU Compute Partners Represented at Today’s Event

- ArcSoft
- eyesight™
- Ittiám
- ALVA Systems
- ThunderSoft
Conclusions

- Modern compute APIs enable efficient and portable heterogeneous computing
  - Use the best processor for the task
  - Balance workload across system resources
  - Offload heavy parallel computation to the GPU

- GPU Compute with ARM Mali GPUs brings tangible advantages for real world applications
  - Reduced cost and time to market
  - Improved performance and user experience
  - Improved performance and energy efficiency measured on consumer devices
  - Used for advanced imaging, computer vision, computational photography and media codecs

- The Mali Ecosystem is making GPU Compute a reality today
  - Industry leaders take advantage of ARM Mali GPU capabilities to innovate and deliver
  - Be one of them!
Thank You

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