General Purpose Programming on GPUs

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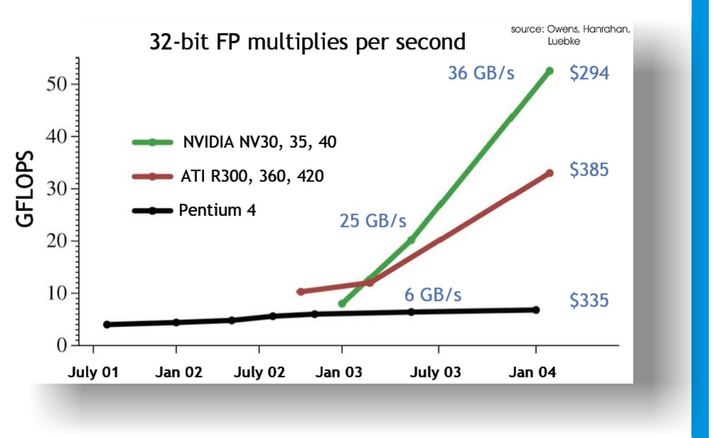
GPGPU

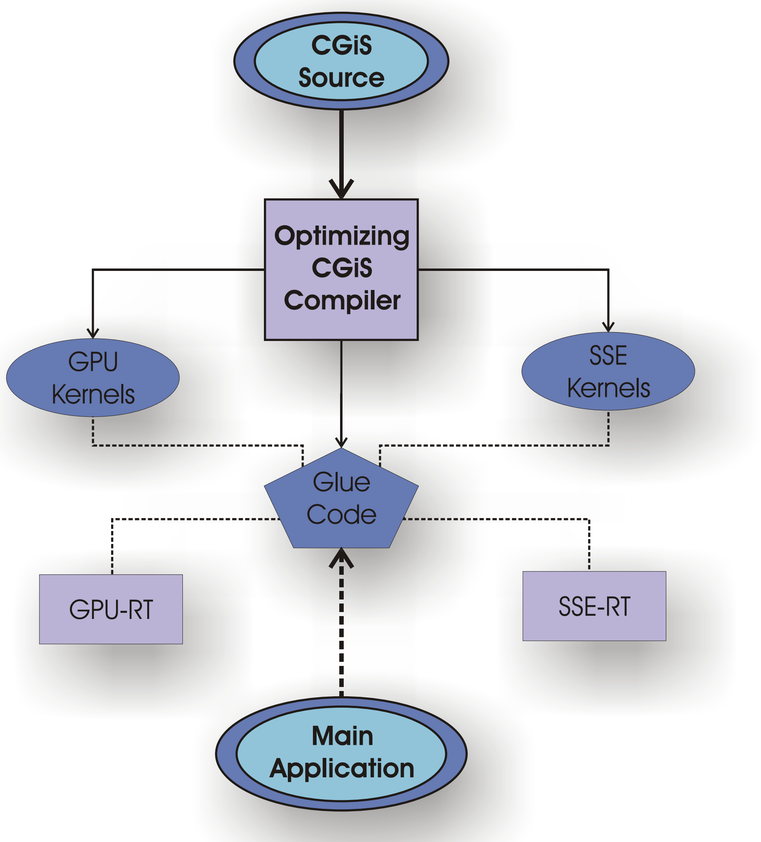
- Ongoing advances of GPU programmability
- Used for general purpose computations
- Good results, but tedious work
- High-level programming languages
  - Shading languages (Cg, HLSL, glslang)
  - Brook for GPUs
  - CGiS



Design Goals of CGiS

- Unified language
  - Algorithm expressable in a single language
  - Compiler takes care of distributing code, data
- Portability
  - Across GPU generations / vendors
- High abstraction
  - GPU is invisible
  - Efficient process of programming
- Usability
  - GPU accessible to non-graphics programmers
- Efficiency
  - Make use of features of new GPU generations
  - Occlusion query/early Z-kill etc.
- Familiarity

Compiler Structure



Example

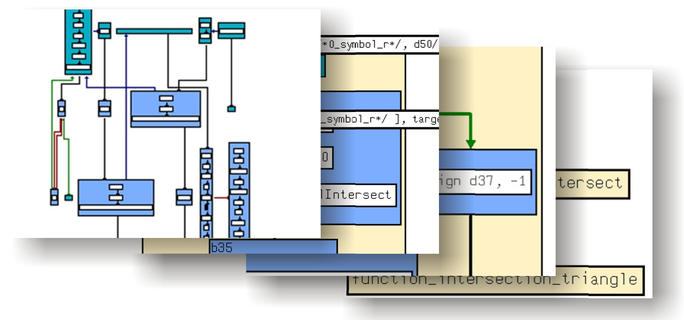
```
PROGRAM EarlyKillRayTriangleIntersection;

INTERFACE

typedef struct {
    float3 a, b, c;
    int id;
} tri_t;

typedef struct {
    float3 origin, direction;
    float near, far;
} raytype_t;

extern input raytype_t[,] raydata;
extern output int[,] rayhits;
extern input tri_t[] t_list;

CODE

function intersection_triangle
    (output int tid, input raytype_t ray, input tri_t t)
#HINT(GPU: pure, singlepass) {

    // Perform Möller-Trumbore
    //  intersection
    if (!intersect) {tid=-1; return;}
    tid = t.id;
}

function earlyKillIntersect
  (input raytype_t ray, output int tid,
  input tri_t[] triangleList)
#HINT(GPU: pure) {
    foreach (tri_t t in triangleList) do {
        intersection_triangle (tid, ray, t);
        if (tid != -1) break;
    }
}

CONTROL

forall (raytype_t r in raydata:2D; int tid in rayhits:2D) do {
    earlyKillIntersect (r, tid, t_list);
}
```

Language Features

- Parallel control structures
- Special vector operators
- Powerful data structures
  - Multi-dimensional
  - Array of structs
  - User-defined
- User-specified hints
  - Additional optimization
  - Guides for code generation
- GPU/SIMD-CPU code generation
  - Automatic SIMD optimization
  - Direct performance comparison
  - Easy debugging

Each stage fully visualizable

- Program visualization fully integrated into compiler



Differences to Existing Frameworks

- Cg/HLSL/glslang:
  - Different application domain, implementation of shading kernels
- Brook for GPUs
  - Abstracts the GPU as a streaming coprocessor
  - No light-weight communication (occlusion query)
  - No inputs through vertex parameters
  - One kernel corresponds to one fragment program
  - Algorithms decomposed into CPU part (C++) and GPU parts (Cg)
  - User has to decide which computations have to be done on the GPU

Project Status

- Language design and frontend finished
- Simple GPU backend working
- First few program analyses implemented
- Sponsored by DFG (Project WI 576/10)

Deutsche Forschungsgemeinschaft
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