Implementation of a Heterogeneous System for Image Processing on an FPGA.

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Introduction

- Embedded systems, we need more and more performance to compute faster and better. (Quick example on why they are useful).
- Heterogenous Systems
  - Everything is heterogeneous (Computers with network cards and HDD to supercomputer with GPGPU).
  - Why do they exist?
    - Better Energy efficiency under constraint
    - Better flexibility thanks to PMCAs
  - Why do we need them?
    - Autonomous systems
    - High processing power on ULP systems.

HERO Platform

- What is HERO? Why does this system exist?
  - Technical specs (configurations available: simulator + RISC/ Arm host + L1/L2 cache)
  - Toolchains / SdK
  - Goal of the project: Fully working platform, easier to experiment with heterogeneous systems.
- Quick presentation of OpenMP, and it's advantages/disadvantages.

Halide

- Presentation of Halide
  - Programmation model
  - Why this language is interesting for developpement

Simple Pipeline example

```
ImageParam A(type_of<int>(), 2);
ImageParam B(type_of<int>(), 2);
Var x, y;
Func matrix_mul("matrix_mul");
Func out;
RDom k( 0,A.width() );
matrix_mul(x, y) +=
      A(x, k) * B(k, y);
out(x, y) = matrix_mul(x, y);
```

```
out.tile(x,y,x_o,y_o,x_i,y_i,4,4);
out.parallel(x_o);
out.parallel(y_o);
out.fuse(x_i,y_i,xy);
out.vectorize(xy);
```

- Pipeline definition: Functions, variables and expressions.
- Schedule definition: Basic Idea on how to schedule + description of some primitives

How to compile to the hardware simulation

- Easiest way is to create a RISC-V object file.
- Add functions to the pulp-rt
- Then we need to create a wrapper application that will be compiled using gcc
- And we link the object file during compilation

What about performances, does Halide perform well ?

- Quick comparaison between Halide and OpenMP with the results in parallel and single threaded.
- good results on this application, but can we do better?

Optimization of a schedule

- Explain methodology, plus benchmarks
- Automated tool for optimizing schedule

Next step: Compiling for the full Hero System

- What we tried?
  - Using the risc V object file and linking it manually
  - Using the OpenMP pragma calls to tell the compiler the function will run on PULP, then use the object file
  - Output the code to C, and then include it

Conclusion

- What is working and what isn't
- Future work on Halide