Karlsruhe Institute of Technology

Approximate Software for Accurate Hardware

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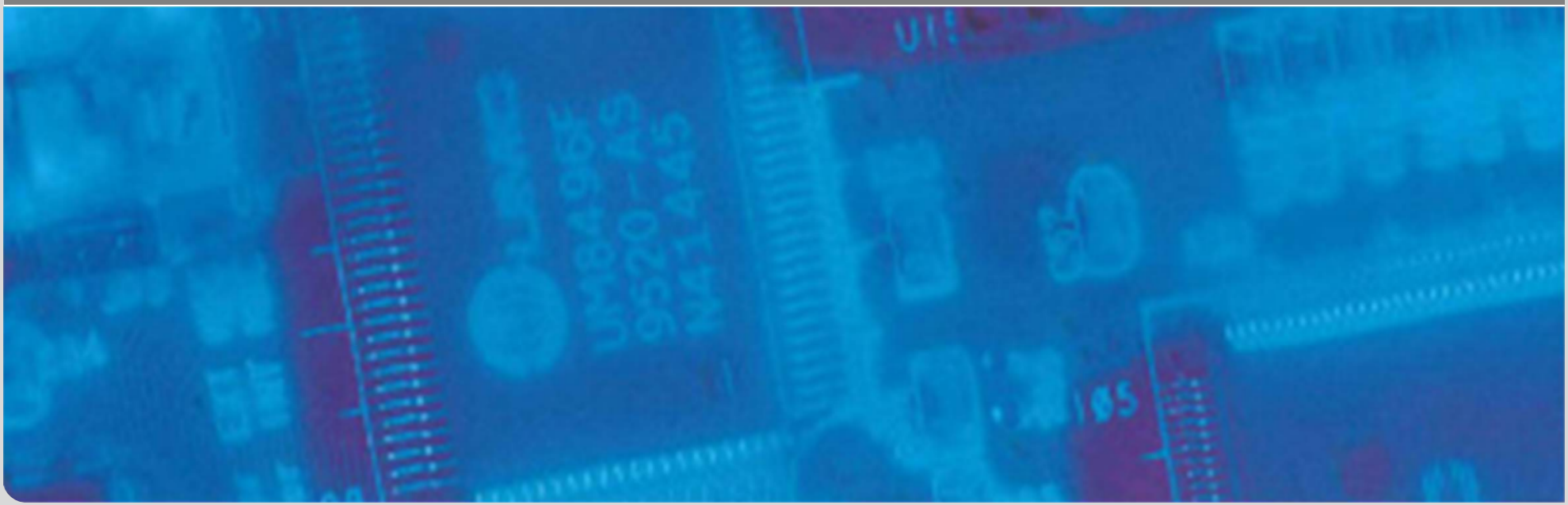
CES - CHAIR FOR EMBEDDED SYSTEMS



Outline

- Motivation.
- Proposed project.
- Current progress.
- Results.
- Future work.

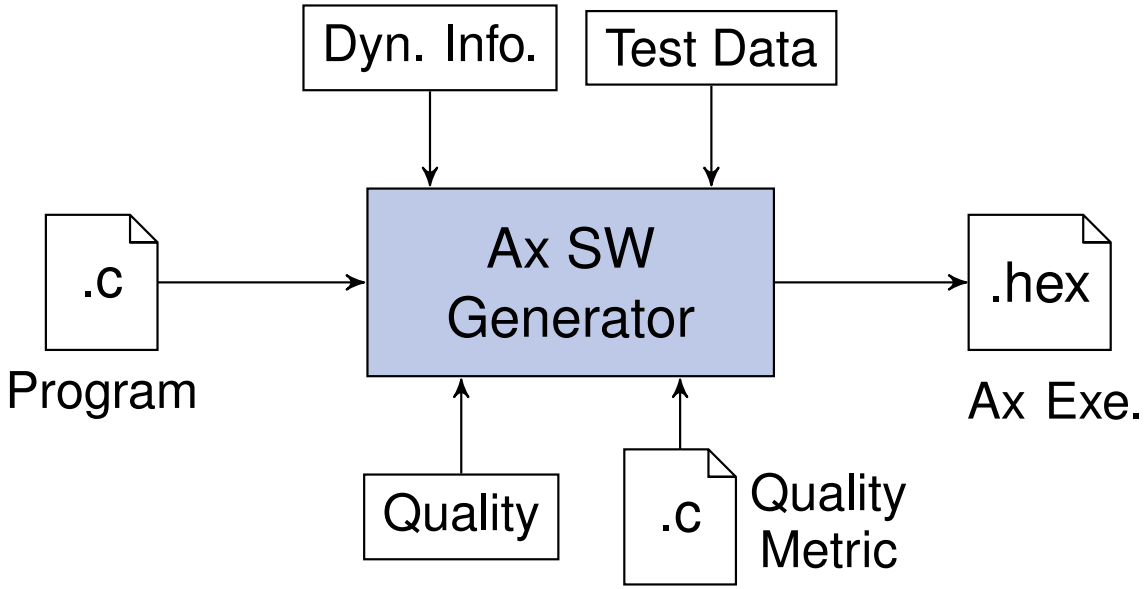
Motivation

- Goal of *Approximate* and *Transprecision Computing*: reduce the computational *effort* by exchanging computational *accuracy/quality*.
- Many existing computing systems can not afford hardware modifications to embrace proposed non-precise computing techniques.
- Remaining exploitable layer: **software**.

Motivation

- But...
  - Proposed techniques are isolated (one at the time).
  - Results have been driven by *accuracy* rather than *quality*.
  - Not available as open-source contributions to be used and to build on top.

Proposed project



- Develop a tool to generate approximate executable code from accurate implementations for a given a quality constraint.

Loop Perforation

- Transform loops to execute only a subset of the original iterations.
- New approaches to dynamicly apply this technique.
- Before

```
for (i = 1; i < LIMIT; i++)
```

- Then

```
for (i = 1; i < LIMIT; i=i+2)
```

Variable Replacement

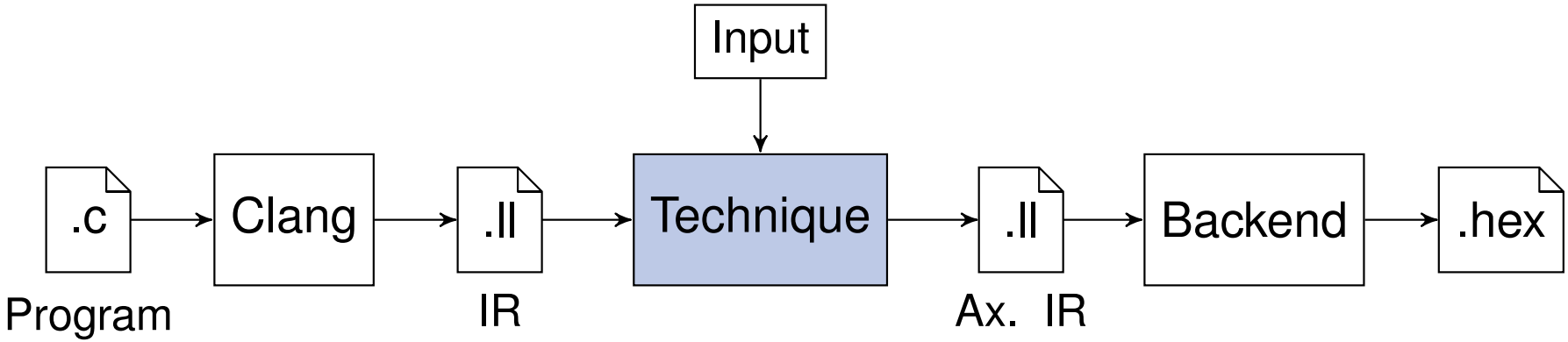
- In some functions, variables can be replaced by other variables as their values are very similar.

```
int foo(int a, int b, int c, int d) {
  int b2 = b * 2;
  int d2 = d * 2;
  int s1 = a + b2;
  int s2 = c + d2;
  ...
}
```

- If *d* is similar *b*

```
int foo(int a, int b, int c) {
  int b2 = b * 2;
  int s1 = a + b2;
  int s2 = c + b2;
  ...
}
```

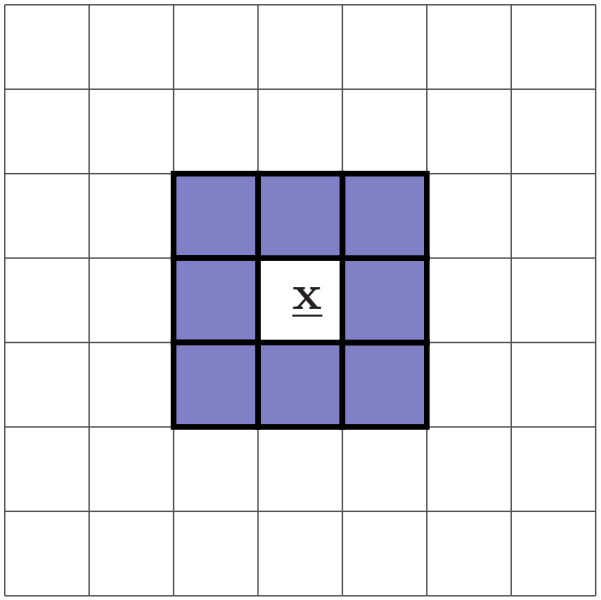
Current Implementation



- Currently testing on Freedom E310, RISC-V from SiFive (HiFive1 Rev. B)
- Using LLVM-based toolchain for code modifications and GCC-based toolchain to generate executable for assembly.

Results

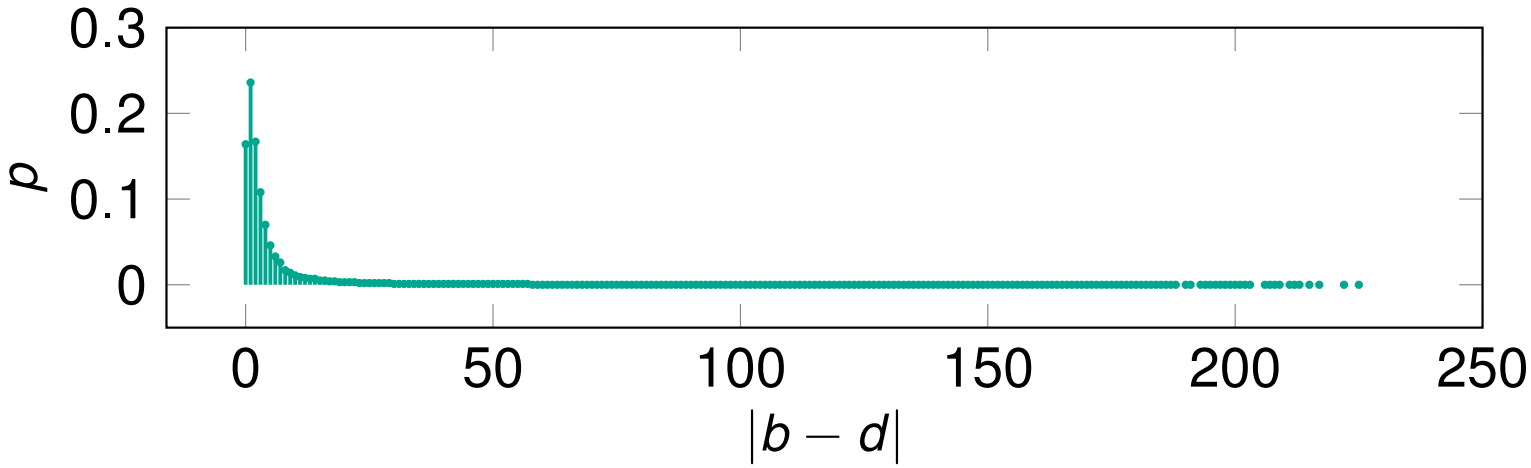
- Image processing kernels.
- Pixel value correlation (spatial correlation)

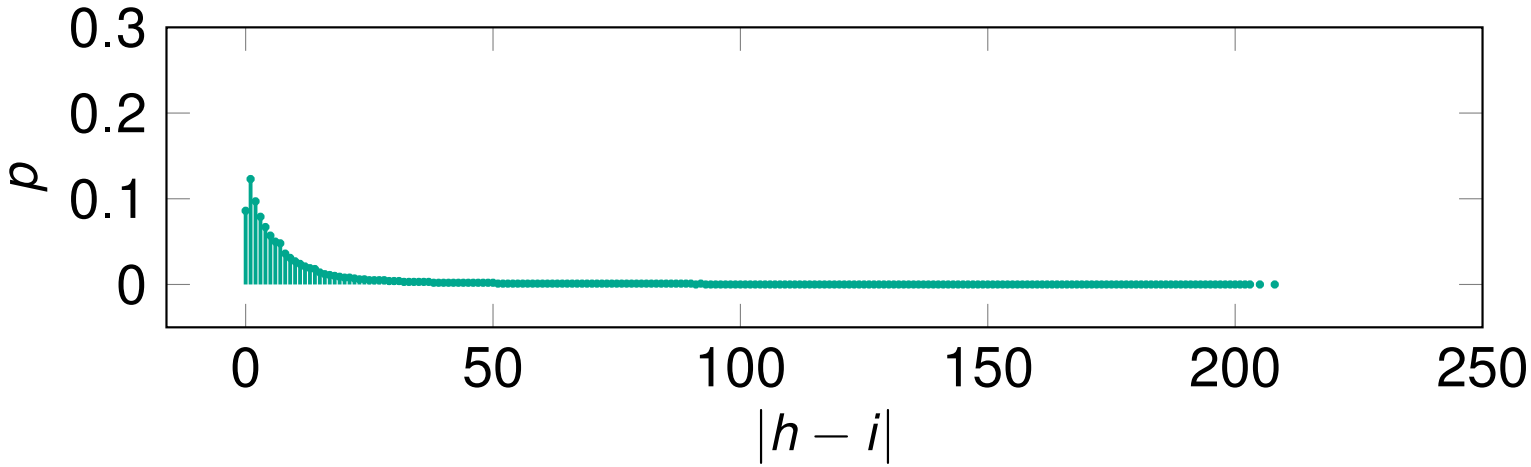


Results

- Considering 3×3 kernels

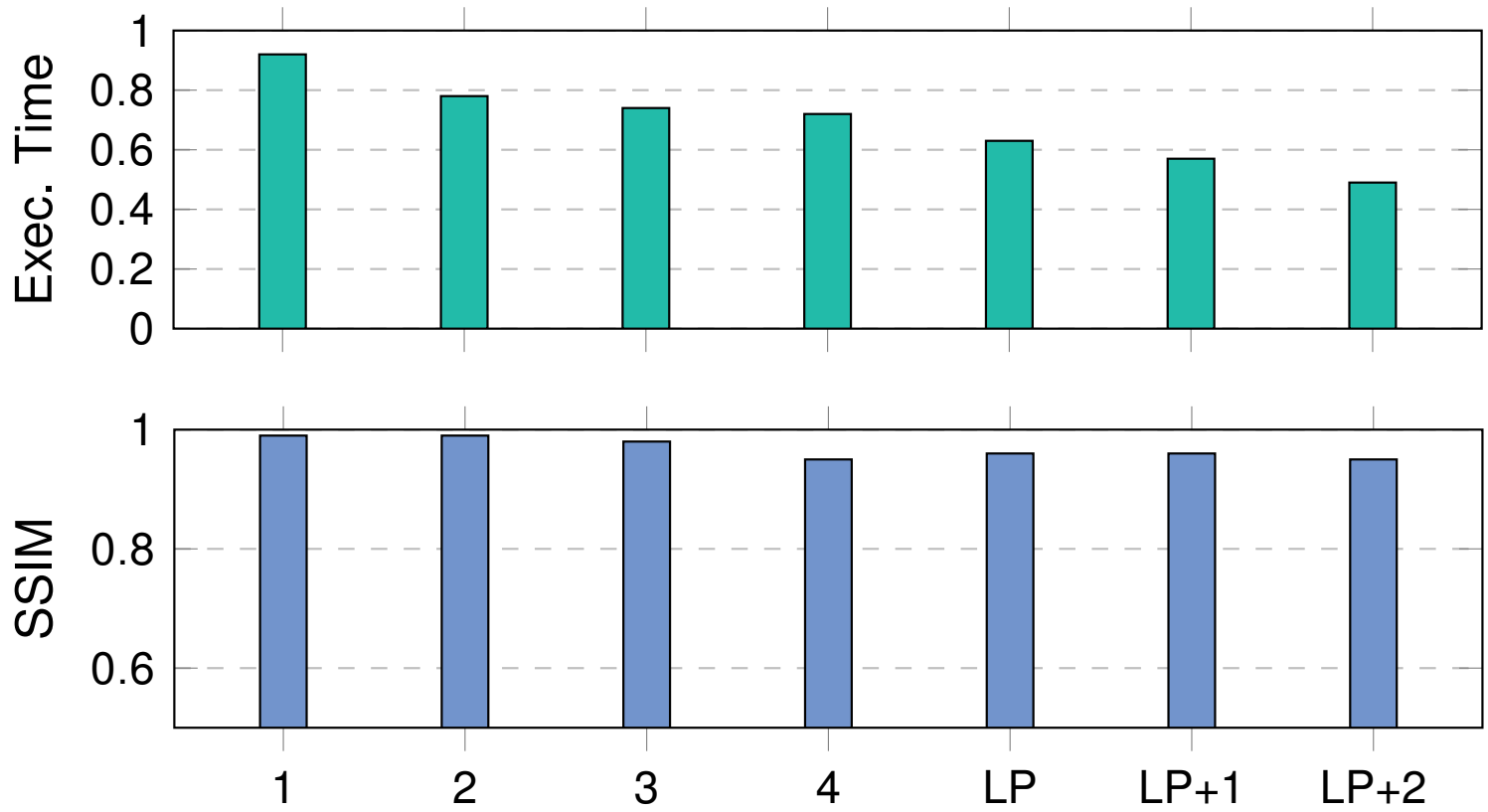
$$\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$$





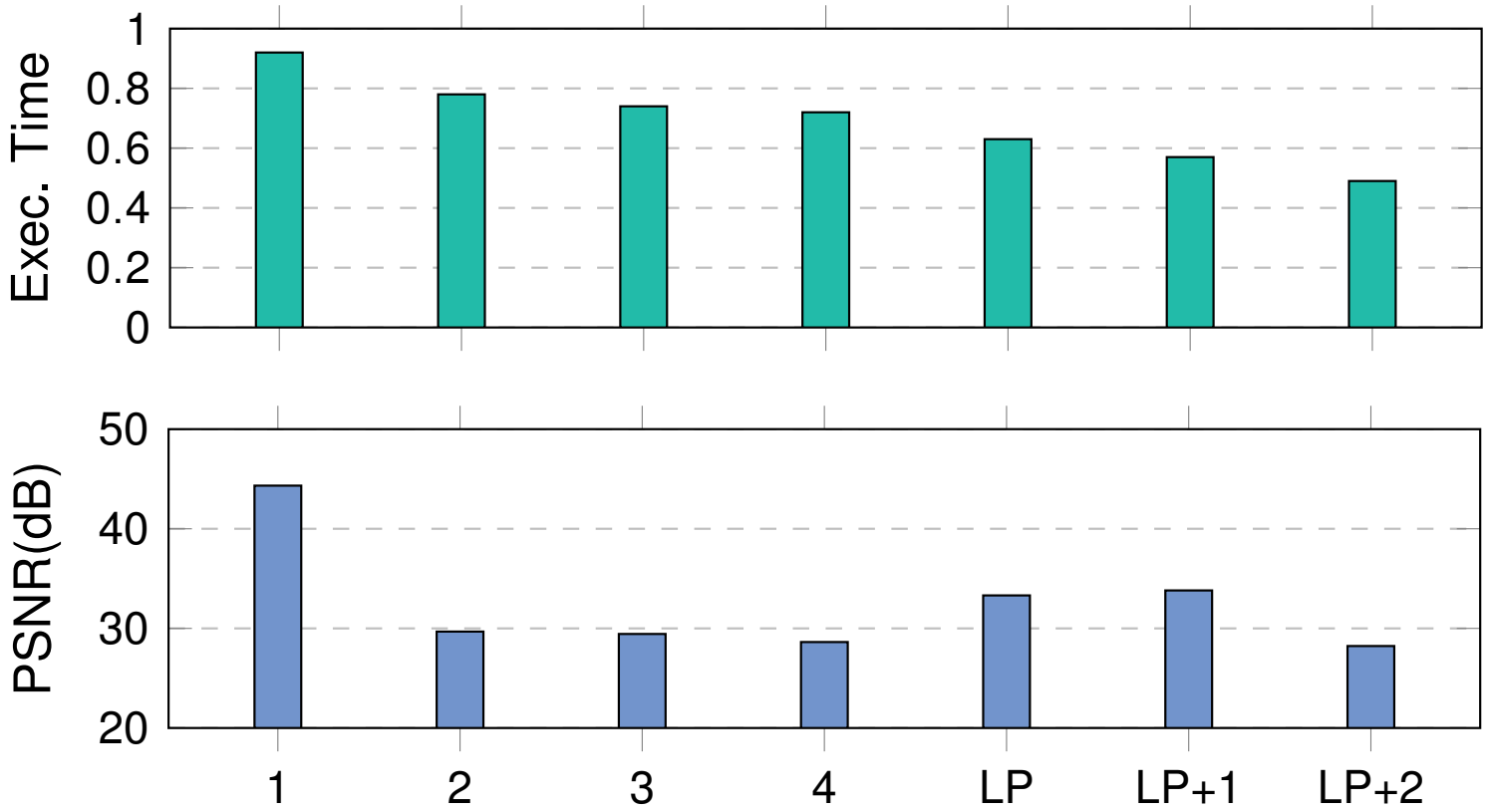
Results

- Gaussian filter (Lena image).



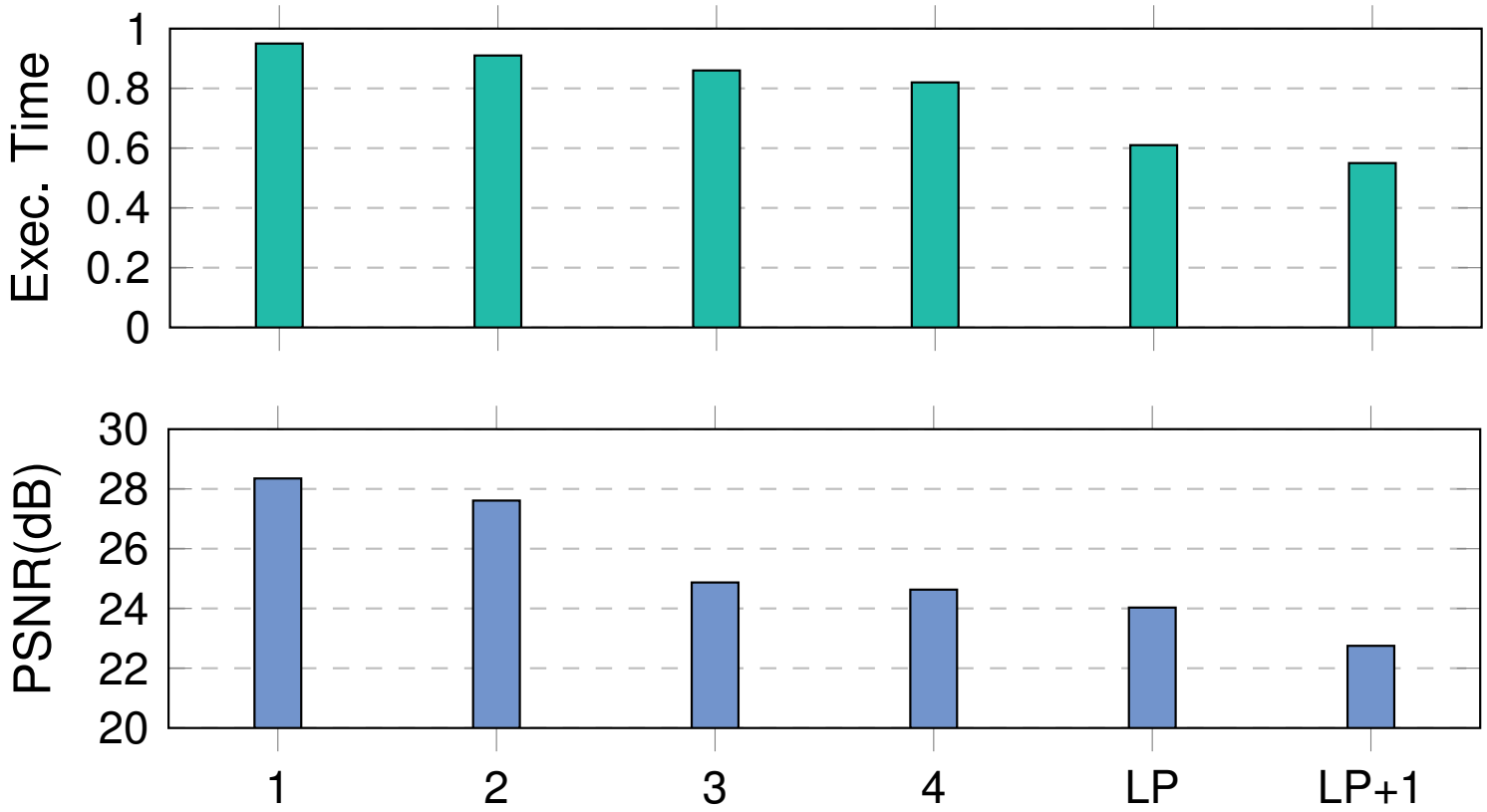
Results

- Gaussian filter (Lena image).



Results

- Sobel filter (Plate image).



Future work

- Define and implement other individual techniques.
- Design an algorithm to test and determine the best combination of techniques for a given code.
- Perform JIT execution to assess quality degradation.
- If interested, please stay tuned in `https://git.scc.kit.edu/CES`

Thanks for your attention!