INSTITUTO SUPERIOR DE ENGENHARIA DE LISBOA

Advanced Computing Architectures – 2023/2024

Project I – Design Space Exploration of 2D Convolution using HLS

Objective: The aim of this project is to explore multiple implementations of 2D convolution using HLS pragmas. Each design should have a different tradeoff between performance (clock cycles) and area (number of resources).

Description:

Convolution is a mathematical operation on two functions that produces a third function expressing how the shape of one is modified by the other (see Figure 1).
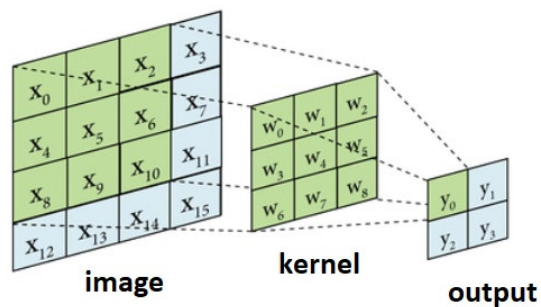

Figure 1 – Convolution of a kernel with an image

For a 2D image H and a 2D kernel F, the convolutional operator is given as

$$G[i, j] = \sum_{u=-k}^{k} \sum_{v=-k}^{k} H[u, v]F[i - u, j - v]$$

The convolution operation can be parallelized.

Development:

Describe the convolution operation in HLS. Then, explore three types of optimizations:

- Pipeline;
- Loop Unroll;
- Array partition.

In the design space exploration, you should consider the following:

- Different image sizes;
- With and without pipeline;
- Different unroll factors;
- Different partition types.

The design points must be characterized in terms of total number of cycles, and number of resources.

The expected time to complete the project is 2 weeks (deadline: 9th April). The project development and results must be described in a report.