VERTIPH:
A Visual Environment for Real-Time Image Processing on Hardware

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Abstract

This thesis presents VERTIPH, a visual programming language for the development of image processing algorithms on FPGA hardware. The research began with an examination of the whole design cycle, with a view to identifying requirements for implementing image processing on FPGAs. Based on this analysis, a design process was developed where a selected software algorithm is matched to a hardware architecture tailor made for its implementation. The algorithm and architecture are then transformed into an FPGA suitable design. It was found that in most cases the most efficient mapping for image processing algorithms is to use a streamed processing approach. This constrains how data is presented and requires most existing algorithms to be extensively modified. Therefore, the resultant designs are heavily streamed and pipelined.

A visual notation was developed to complement this design process, as both streaming and pipelining can be well represented by data flow visual languages. The notation has three views each of which represents and supports a different part of the design process. An architecture view gives an overview of the design's main blocks and their interconnections. A computational view represents lower-level details by representing each block by a set of computational expressions and low-level controls. This includes a novel visual representation of pipelining that simplifies latency analysis, multiphase design, priming, flushing and stalling, and the detection of sequencing errors. A scheduling view adds a state machine for high-level control of processing blocks. This extended state objects to allow for the priming and flushing of pipelined operations.

User evaluations of an implementation of the key parts of this language (the architecture view and the computational view) found that both were generally good visualisations and aided in design (especially the type interface, pipeline and control notations). The user evaluations provided several suggestions for the improvement of the language, and in particular the evaluators would have preferred to use the diagrams as a verification tool for a textual representation rather than as the primary data capture mechanism.

A cognitive dimensions analysis showed that the language scores highly for thirteen of the twenty dimensions considered, particularly those related to making details of the design clearer to the developer.

To my family

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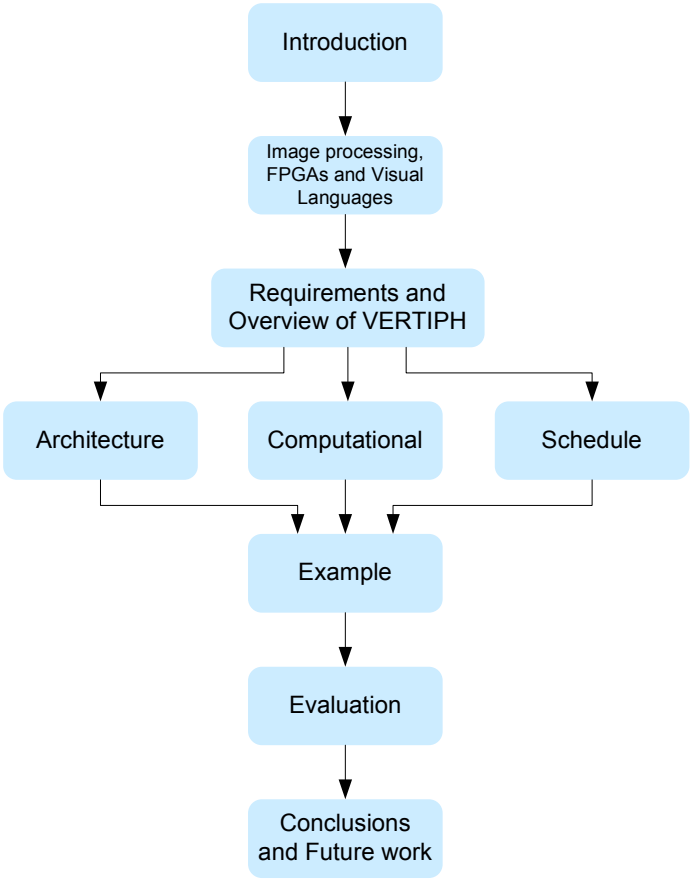

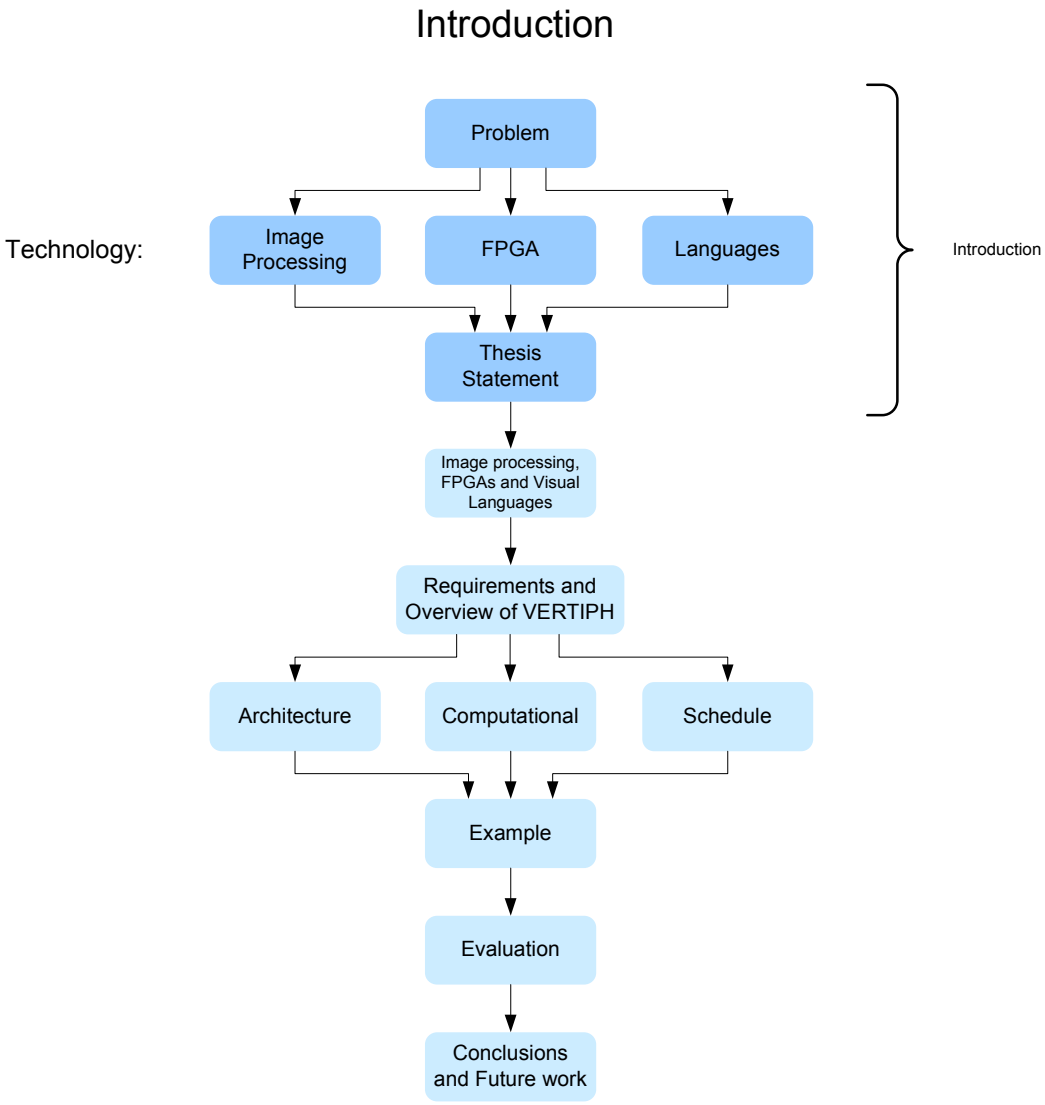
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