Project Proposal

Machine Learning on FPGA on a Drone

ELEC 491 Capstone Team 109
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TODO: UBC and Client branding image here

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Revision History

Revision history written here.

Version #	Initials	Release Date	Changes Made
0.0	MH	2019-09-30	Initial skeleton of the document.

Contents

Terms and Abbreviations

Technical terms and abbreviations dictionary go here.

List of Figures

List of Tables

1 About This Document

Briefing for this section.

1.1 Purpose

FIXME (requires editing)

The purpose of this document is to solidify the project outline, objective and requirements. It is meant to

1.2 Intended Audience

The intended audience is the client so that the client can confirm the requirements of the project is as they expected. It is also intended for the instructors and the TAs of our capstone team, such that they may aid us accordingly.

Furthermore, the document is also intended for our own teammates as a reference throughout the duration the milestones of the project.

1.3 Reading Guide

How to read this document.

2 Background

This section outlines the context of the project. It will go over the background of the suitor, and the project the suitor is proposing.

2.1 Business Background

As the suitor proposing this project is not a business, the business aspects typical to real-world engineering projects should not be applicable.

The suitor of this project is a team of undergraduate students studying at University of British Columbia (UBC) under the name Skynet. The members of Skynet are all students in the Facutly of Applied Science in disciplines of Electrical and Computer Engineering. The members of Skynet are all students taking the fourth year Engineering Capstone course (ELEC491/CPEN491) at UBC, in which they have been assgined this engineering project. Relating to the context of the project, the members of Skynet all have experience working with FPGAs, and in RTL design.

2.2 Project Context

The proposed project is an examination of the feasibility of autonomous airborne object tracking through integration of Machine Learning (ML) into field-programmable gate arrays (FGPAs) on a independent mobile deployment vessel, such as a drone. The ML implementation will focus on video processing for the object tracking component of this project.

The grounds of the project is to expand on the application possibilites for ML. FPGAs offer faster performance against conventional software and GPU applications, as well as lower power consumption and the capbility of reconfiguration. This makes FPGAs desirable as an option for an autonomous computing platform. Implementing an FPGA for autonomous object tracking on a drone can streamline many potential proccesses, such as disaster response, wildlife management and demographic studies.

3 Objectives, Constraints, & Goals

This section elaborates the objectives to be pursued in the project, constraints that limit the project scope, and the goals to be achieved.

The definition that the student team will use will be as follows:

- **Objectives**: Also refered sometimes as *requirements*. These are a list of *yes-or-no* qualities that the student team would like to achive in order to consider the project as "successful".
- **Constraints**: The constraints are limiting factors that affect the variability of our success, and to what extent our goals can be achieved.
- **Goals**: Goals are quantitative specifications that would be ideal to achieve; they are the target specification the student team is aiming for, but is not necessary for the project to be considered successful.

3.1 Objectives

The objectives are:

Main objectives:

- ML implementation on FPGA - Video interception and processing on FPGA device - Adequate datapath and or (hard/soft)core processor to aid or facilitate fast and well-integrated data flow - Adequate integration of a suited machine learning, specifically computer vision, model on the FPGA such as CNN, RNN, or YOLO. - Video can be processed in real time with help of reduced frame rates and or resolution

- Integration of hardware on drone - The total package of the hardware impose viablility of such concept by being compact and easily deployable - Electronics power draw is not ridiculous - Electronics power output (heat) is not ridiculous

- Transmission of video to ground station - A separate video signal is streamed to the ground station along with the processed data, or, the video stream is being overlayed with machine learning data and is both transmitted to the ground station - Can receive video signal wirelessly - Does not need to be on the FPGA

3.2 Constraints

In pursuit of the objectives listed above, the main constraints relating each main objective is as follows:

FPGA ML:

- The FPGA is a highly adaptive device that can deliver almost-ASIC level speed but a large number of logic elements are required to implement a large model such as a machine learning - computer vision - model. The inherit constraints with FPGA RTL designs such as timing, area, and power constraints will ultimately limit the processing throughput of the video data. Bottleneck for limiting processing resolution and frequency (frame rate).

- Common machine learning models for computer vision is designed for GPU to maximize parallel computing. The FPGA cannot match GPU data throughput, thus the limited amount of logic elements would also constrain our architecture design.

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3.3 Goals

4 Project Plan

4.1 Final Milestone & Ultimate Deliverables

The project will conclude on **April 3rd, 2020**, at which point the following project deliverables will be provided to the project stakeholders (the Client and Instructors):

1. The drone prototype, a (unified) device which:
   (a) Captures video using an on-board camera,
   (b) utilizes FPGA-based neural network accelerators to processes the captured video using an FPGA (optionally with an embedded hard-processor) - computing the position of one or more (human) pedestrians in the captured video,
   (c) transmits the captured video and the associated pedestrian-location metadata to an external base-station,
   (d) and is mounted to a drone which is controlled remotely by a human and is capable of flying at least 5 minutes.
2. The base-station prototype, a device which:
   (a) Receives the wirelessly transmitted video and the associated pedestrian-location metadata,
   (b) displays the video on a screen, overlaying the pedestrian metadata in the form of *bounding boxes*,
   (c) and stores the video for further research/analysis
3. A technical dossier comprising of the following documents:
   (a) *Requirements Specification* - Outlining the functional/non-functional requirements of the product
   (b) *Design Specification* - Describing the high-level architecture and designs for technical subsystems
   (c) *Validation Specification and Results* - Describing system test architectures and results
   (d) *Operations, Maintenance, and Upgrades Specification* - Outlining FAQs, installation instructions, recommended maintenance, and troubleshooting steps
   (e) *List of Deliverables*
4. A video describing and demonstrating the product
5. A presentation and accompanying poster outlining the project
6. All source code and generated netlists

4.2 Intermediate Milestones

In order to mediate and review the project's progress as it progresses, three intermediate project milestones have been defined. In addition to the additional deliverables described below, all milestones necessitate the delivery of in-progress key documents (Requirements, Design, Validation, Operations, and List of Deliverables) in addition to an oral presentation summarizing progress to date.

4.2.1 Milestone I

Milestone I (**October 15th, 2019**) requires the production of a Project Proposal (*this document*), which outlines the baseline agreement among all stakeholders with regards to what is to be accomplished.

4.2.2 Milestone II

Milestone II (**November 25th, 2019**), the first prototype review, will outline our initial progress in implementing both video capture and neural accelerator circuitry on our selected FPGA platform. Depending on our progress, we will either demonstrate each of these components separately (i.e. displaying captured video on a screen while processing an unrelated ML task) or, preferably, demonstrate these components in a unified fashion (i.e. display captured video and process it to some extent using our ML infrastructure).

4.2.3 Milestone III

Milestone III (**February 10th, 2020**), the second prototype review, will demonstrate our continued progress in improving our video capture/neural accelerator, in addition to presenting our initial platform-mobility implementations: especially focusing on our video transmission and power-supply circuitry (including battery packs).

4.3 Major Responsibilities

4.3.1 Team Resposibilities

The student team is responsible for both day-to-day and overarching operations of the project, including (but not limited to):

- Ultimate construction of the prototype(s)
- Researching related and pre-existing solutions
- Financial management, including purchasing all required materials and devices
- Creation and maintenance of requisite deliverable documentation
- Documentation and coordination of group and client meetings

4.3.2 Client Responsibilities

The client is expected to:

- Be available to meet in-person or online given reasonable notice (72 hours)
- Provide additional education/training on machine learning and neural networks, if required
- Provide additional financial support, if required (see budget section)

4.4 High-Level Tasks

4.4.1 Team Tasks

4.4.2 Client Tasks

4.5 Schedule

4.6 Budget

The specifics of budget is not determined. But we do get $650 for the entire capstone team to start.

4.7 Quality Goals

4.8 Risk Profile

5 Approval

5.1 Acceptance Statement

5.2 Client Identification

5.3 Capstone Team Identification

References