

# Working Title - Hardware Acceleration: CNN Inference for an Emergency Vehicle Classifier

Juan Palacios

*Electrical and Computer Engineering*  
*Grand Valley State University*  
Grand Rapids, Michigan  
palacioj@mail.gvsu.edu

*Abstract*— This paper demonstrates the deployment of an emergency vehicle classifier on an embedded device. Distracted driving poses a serious risk to the public’s safety and can prevent emergency services from reaching those in need. To address this issue, a machine learning model is used to alert the driver of incoming emergency vehicles. Traditional machine learning models are trained with high-performance Graphical Processing Units (GPUs) with a high degree of accuracy. To achieve similar performance on low-power embedded devices, hardware accelerators are used to outsource heavier computational tasks. Field Programmable Gate Arrays (FPGA)-based accelerators offer reconfigurability to deploy a lightweight Convolutional Neural Network (CNN) model. The following objectives are laid out for this paper: the development of a machine learning model for emergency vehicle classification, deployment of this model to run on a low-power embedded device, and assessing the real-time model performance. This research showcases the feasibility of inferring a lightweight model on a low-power embedded device with the help of an FPGA-based hardware accelerator.

*Index terms*—hardware acceleration, computer vision, machine learning, neural network

## I. INTRODUCTION

The purpose of this project is to explore the field of computer vision to implement object tracking on a Gentex Full Display Mirror® (FDM®). This product offers an unobstructed rearward view of the road. At a high-level, a camera feeds video onto the rearview mirror device. The goal of this project is to implement a neural network capable of detecting object movement across a screen over time. This novel feature has the potential of alerting drivers to moving objects while reserving their vehicle or identifying emergency vehicles in the rearview mirror. This project has three objectives:

1. Develop and train a machine learning model to track objects over time (Python development)

2. Deploy the model onto hardware using a combination of microcontroller and FPGA (HLS/HDL development)
3. Assess the performance on a Gentex FDM® for viability

Computer vision is a powerful tool enabling a computer to mimic the way humans see. The modern implementation of computer vision relies on machine learning. A sensor device captures an image and processing is done on an interpreting device. A neural network algorithm performs the processing, providing useful information about the image [1]. There are four main categories of computer vision applications: image classification, object detection, object tracking, and optical character recognition [1]. For our purposes, we are focused on object tracking. First, an object must be detected in a single image. Next, our object must be followed throughout subsequent images. Finally, our device provides useful information in order to perform specific tasks based on our object tracking data [2]. There are several ways of implementing a model onto an FPGA: using kernel managed by a CPU (HLS), or writing a model in VHDL (HDL). FPGA kernels are not just instructions, but digital circuits (hence why we have pragmas, subset of C/C++).

## REFERENCES

- [1] Microsoft, “What Is Computer Vision? | Microsoft Azure --- azure.microsoft.com,” 2023. (\url{https://azure.microsoft.com/en-us/resources/cloud-computing-dictionary/what-is-computer-vision/#:~:text=Computer%20vision%20is%20a%20field,tasks%20that%20replicate%20human%20capabilities.})
- [2] “What is Computer Vision? | IBM --- ibm.com,” 2023. (\url{https://www.ibm.com/topics/computer-vision})