אוניברסיטת אריאל בשומרון
המחלקה להנדסת חשמל ואלקטרוניקה

Soldier vs. Civilian Embedded Vision System

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Project Objective

This project presents a real-time embedded AI system for distinguishing between soldiers and civilians using deep learning. A YOLOv8 model was trained on a custom dataset to detect individuals based on uniform and visible equipment, and deployed on an AMD-Xilinx Kria KR260 board to provide live time visual and audible classification feedback through LEDs and a buzzer.

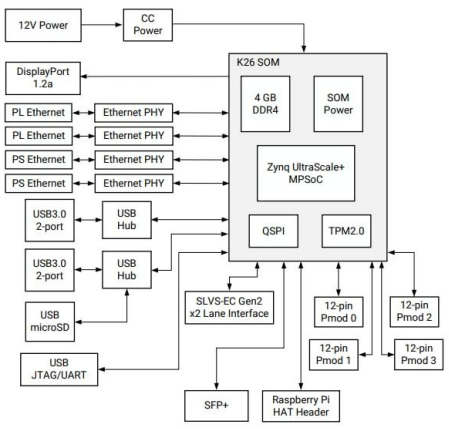

Figure 1 - Block Diagram Kria Kr260

Introduction and Background

The system integrates computer vision, deep learning, and embedded systems to enable intelligent edge detection without reliance on cloud processing. Using YOLOv8, an advanced convolutional neural network, the system performs detection in a single pass, achieving high accuracy and real-time performance. The project explores how lightweight AI can be embedded on FPGA hardware to achieve reliable object detection in constrained environments.

System Description

The system consists of three primary components: (1) the trained YOLOv8 model, (2) the ONNX Runtime environment, and (3) the Kria KR260 hardware with GPIO interface for real-world outputs. The YOLOv8 model was exported to ONNX format and executed via Python and PYNQ on the KR260. The hardware design in Vivado included a Zynq MPSoC, AXI interconnect, and GPIO module connected to LEDs and a buzzer for detection response.

When the system detects a 'soldier,' a green LED is activated. When a 'civilian' is detected, a red LED and buzzer are triggered. This physical response demonstrates real-time embedded inference, bridging AI classification and immediate hardware control.

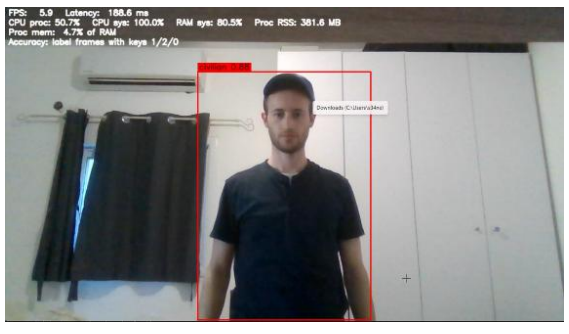

Figure 2 - Detected Civilian

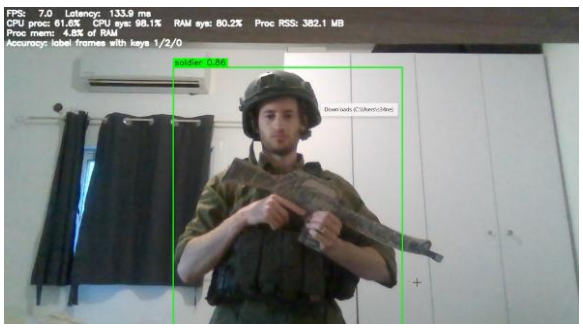

Figure 1- Detected Soldier in Full Gear

Results

The YOLOv8 model achieved strong detection performance, with metrics demonstrating high accuracy and reliable generalization across test scenarios. During live testing, the system consistently identified and distinguished between classes with precision, successfully integrating GPIO control for real-time LED and buzzer feedback, while maintaining stable frame rates on the KR260 platform.

Figures below show model evaluation metrics and system setup.

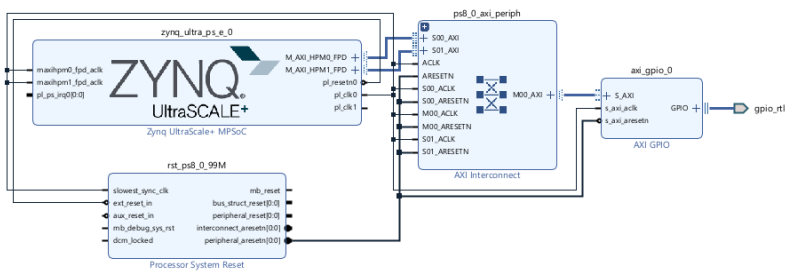

Figure 4- Block Design in Vivado

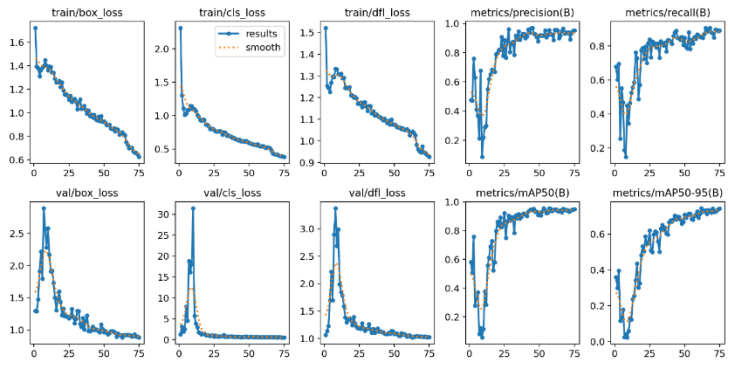

Figure 5- Training and Validation Performance Metrics

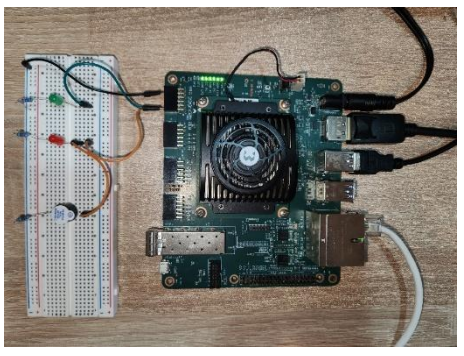

Figure 6 - KR260 Board with GPIO setup

Conclusion and Future Work

The project demonstrates the potential of combining deep learning and FPGA-based embedded systems to create intelligent, real-time safety applications. Future improvements may include integrating the Vitis AI DPU for hardware acceleration, expanding the dataset, and enhancing model robustness. The work provides valuable experience in deploying AI on reconfigurable platforms for defense and security-oriented applications.