Report on FPGA architecture for ADAS solution for an EV vehicle
BATCH-5

Introduction

The architecture design for ADAS in electric vehicles utilizing FPGA technology involves a systematic approach to ensure real-time processing, scalability, and reliability. The ADAS functionality is divided into modular subsystems such as sensor interfaces, data fusion, decision-making, and control, allowing for easy scalability and upgrades. To enhance performance, pipelining is used to increase throughput, and parallel processing units are implemented for the simultaneous execution of multiple tasks.

FPGA Architecture

Data Flow and Connections:

1. **Sensor Interfaces:**
    - LiDAR, Radar, Cameras, and IMU each have dedicated interfaces on the FPGA. These interfaces are designed to handle the specific data format and communication protocol of each sensor. (Ex: LiDAR might use Gigabit Ethernet, Cameras might use MIPI CSI-2).
2. **Preprocessing Unit:**
    - Raw sensor data enters the preprocessing unit, which performs initial filtering and noise reduction. This unit might use dedicated logic blocks or low-power processors within the FPGA fabric.
    - Preprocessed data is then formatted and routed to the main processing unit.
3. **Processing Unit (Main FPGA Fabric):**
    - The heart of the system, it can be divided into two regions:
        - **Hardware Accelerators:** These are custom-designed logic blocks optimized for specific ADAS tasks. Examples include:
            - Object Detection Accelerators: Analyze camera/LiDAR data to identify objects like vehicles, pedestrians, and traffic signs.
            - Lane recognition Accelerators: Process camera data to detect lane markings and road boundaries.
            - Path Planning Accelerators: Use sensor data and vehicle dynamics to calculate a safe path for the EV.
        - **Softcore Processors:** These are embedded CPUs within the FPGA fabric, ideal for running control algorithms and decision-making logic. They can be programmed to:
            - Fuse data from various sensors (camera, radar, LiDAR) to create a comprehensive picture of the environment.
            - Execute pre-trained machine learning models for tasks like object classification and behavior prediction.
            - Trigger control outputs based on the processed data and safety rules.

4. **Postprocessing Unit:**
    - Refines the data from the processing unit. This might involve tasks like:
        - Smoothing and filtering final outputs
        - Data compression for efficient communication
5. **Communication Interfaces:**
    - The FPGA connects to other vehicle control systems like steering and braking using interfaces like CAN bus or Ethernet. These interfaces transmit control signals generated by the ADAS system for real-time vehicle adjustments.

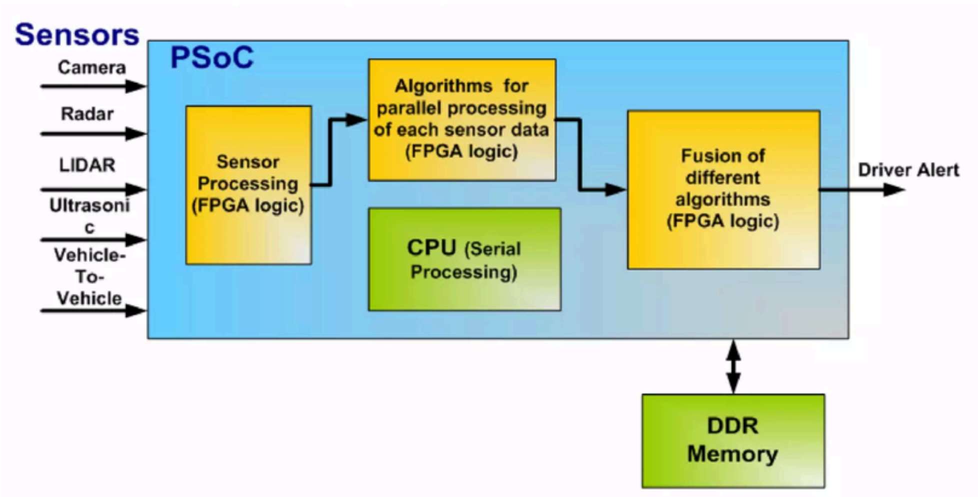

Figure 5: Sensor Fusion ADAS using PSoc

Outputs:

- Object detection and classification: Passing information about detected objects (type, location, speed) to the driver information system or triggering warnings if necessary.
- Lane recognition: Providing steering wheel adjustments to keep the vehicle within lane boundaries.
- Path planning: Sending control signals to the steering and acceleration systems to navigate the vehicle safely.

Conclusion

Overall, the FPGA architecture enables a flexible and powerful platform for processing sensor data in real-time, allowing for advanced driver assistance features in EVs.

Reference: `doi:10.1145/2463209.2488852`