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The Design Thinking Based Advanced Driver Assistance System Design and Implementation of Flight Control System on FPGA Based Adaption

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Abstract: -Advanced Driver-Assistance Systems (ADAS) can help drivers in the driving process and increase driving safety by automatically detecting objects, doing basic classification, implementing safeguards, etc. ADAS integrates multiple subsystems, including object detection, scene segmentation, lane detection, and so on. In this paper, we establish a framework for computer vision features, i.e., lane detection, object detection, object distance estimation and traffic sign recognition of ADAS. Modern machine learning algorithms like Canny edge detection for lane detection and a CNN-based approach are used for object detection. The system deployed aims to achieve higher (Frames Per Second) FPS for one channel of 55 FPS. The performance of FPGA is optimized by software and hardware co-design. Realization on the DE-10 Nano board with Cyclone V FPGA and a dual-core ARM Cortex A9, which meets real-time processing requirements. An increasing amount of automotive electronic hardware and software involves significant changes in the modern automobile design process to address the convergence of conflicting goals - increased reliability, reduced costs, and shorter development cycles. The prospectus to tackle car accident occurrences is making ADAS even more critical. This paper proposes an efficient solution for ADAS on FPGA. It is, therefore, necessary to formulate a system that is developed with a considerable amount of redundancy & fault tolerance. Thus, the main objective of this project is to design and implement a flight control system using a field programmable gate array (FPGA). The performance of the FPGA-based FCS system is better than that of the conventional microcontroller and the DSP chip-based UAV flight control system, and it has several useful applications and benefits. The entire flight control system is divided into four modules navigation control module, flight control module, sensor driver module, and Avalon bus control module.

Keywords: *Empathy, ideate, testing and validation, chip-based UAV flight control system, Sensor, VLSI Design, FCS System, microcontroller.*

Introduction

Self-driving cars use various applications and technologies to gain 360-degree vision, both near and far. That means hardware designs are using more advanced process nodes to meet ever-higher performance targets while reducing power and footprint demands. Conventionally, ADAS had been implemented on application-specific complex impromptu solutions built especially for automotives since they suppose a large market. [1]. This research aims to deploy an FPGA for implementing ADAS. Owing to the restrictions of software for allowing a real-time embedded system to be implemented an FPGA board is required for a level 5 autonomous vehicle, particularly one employing complex vision tasks. [5]. This paper proposes an efficient solution for ADAS on FPGA. Specifically, the objectives of this work are listed as follows. (1) We propose a framework for ADAS which integrates the tasks of lane detection, object detection, distance estimation, and traffic light recognition and achieves comparable precision with task-specific models. (2) We optimize the system performance through the joint optimization of software and hardware. The system will be deployed on Altera Cyclone V FPGA to achieve 55 FPS for one channel.

The FCS could have functionalities to ensure the airplane does not surpass its safe operational boundaries. Flight envelope protection features keep an eye on a number of variables, including the plane's speed and angle of attack, to prevent dangerous manoeuvres or stall situations [9]. An aircraft's safe and efficient operation depends on a flight control system. By incorporating advanced technology alongside automation systems as well as taking into account inputs from the pilot, can maintain stability and control across all stages of flight [10]. The process of designing and implementing a flight control system utilizing an FPGA necessitates the integration of several elements and algorithms to achieve stable and precise aircraft control [3,4]. The system specifications must be defined, which includes the desired flight dynamics, control modes, sensor inputs, and desired outputs. Interfacing the sensors with the FPGA, implementing control algorithms for stabilization and navigation, and interfacing the actuators with the FPGA are all essential steps in the process [7]. The interconnections, data busses, and control interfaces within the FPGA must be designed and implemented to form a complete flight control system [8]. A testing and verification plan to validate the functionality and performance of the FCS must be developed, and the system's performance must be analysed and optimized as needed. To ensure safety and reliability, redundancy measures such as redundant sensors, voting logic, and fault detection mechanisms can be implemented.

Existing System And Proposed Solution

The former is often considered superior to the latter due to several reasons like Accurate Edge Localization and Automatic Thresholding. This paper uses the Canny edge detection algorithm. Traffic light recognition is part of an autonomous system that is supposed to take appropriate decisions on-road— traffic light detection in complex urban environments. A combination of colour-based segmentation, pattern matching, and machine learning techniques like the YOLOv5 algorithm was employed to detect traffic lights. Using FPGA embedded systems, Noe' Monterrosa et al.'s research paper [11] from September 2017 described a flight controller based on a state machine technique. The controller responded quickly to stimuli from sensors and was adaptable in calibration. A dual-core UAV flight control system based on an FPGA chip's high-speed parallel processing capability and Altera's SOPC development tool Qsys [13] was presented by Kun Zhang et al. in April 2019. The system was highly integrated, robust, and had strong refactoring capabilities. The research [10] offers a power line identification system based on field-programmable gate arrays (FPGAs) and stereo vision technologies. The system's goal is to detect power lines in real-time, correctly and effectively. In the research [6], they provide a field-programmable gate array (FPGA) based video image monitoring system for bus lanes. The system's goals include providing real-time video analysis, processing, and efficient bus lane monitoring.

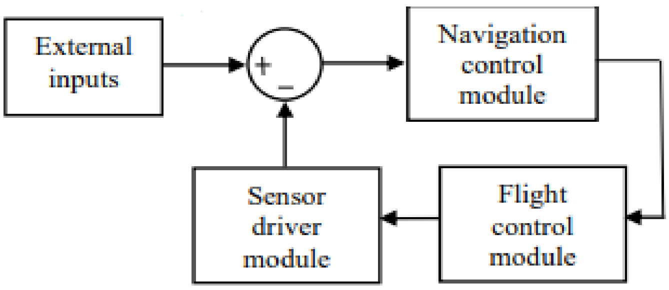

Fig. 1 Block diagram

The processing unit in an ADAS system is responsible for analysing the information from the sensors and making decisions based on that. Sometimes, this may involve running complex algorithms or machine learning models to interpret the data and determine the best course of action. The processing unit may be implemented using a microcontroller, a processor, or an FPGA, depending on the application's specific requirements. The FPGA used in this project is the Intel DE10 Nano. The DE10-Nano is a compact, low-power development board featuring an Intel Cyclone V FPGA. The DE10-Nano is equipped with a dual-core Arm Cortex-A9 processor, which can be used to run software applications.

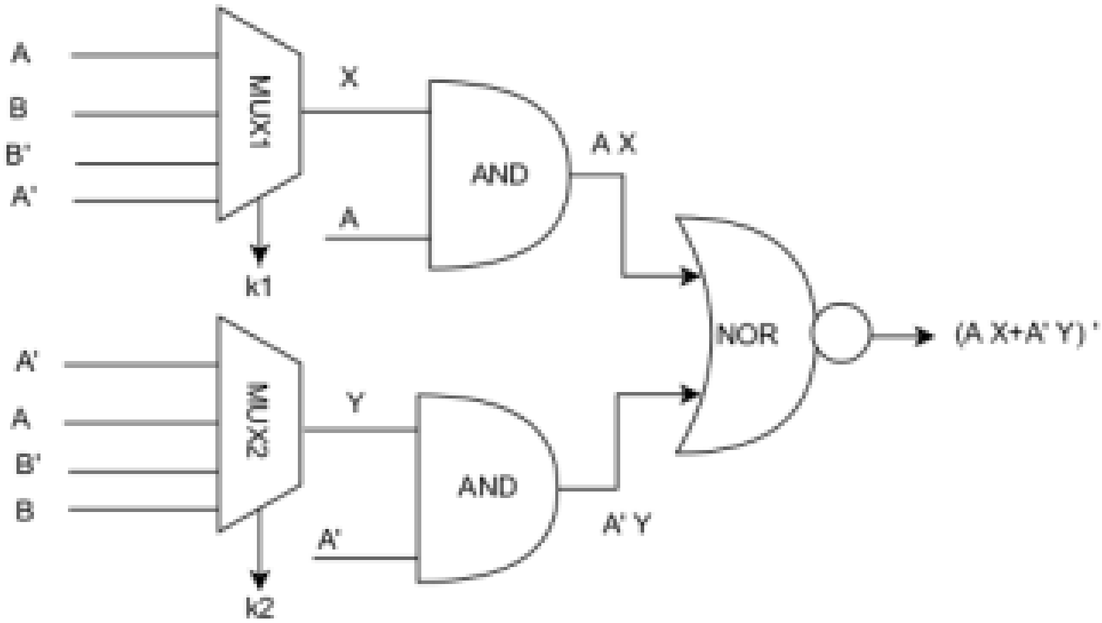

Fig 2: Gate diagram of the proposed method

The breakthrough of neural networks is that object detection no longer must be a hand-crafted coding exercise. Neural networks allow features to be learned automatically from training examples. The pipeline for object detection and distance estimation. This research uses the YOLOv5[7] architecture for object detection. Object detection, a use case for which YOLOv5 is designed, involves creating features from input images. These are passed through a prediction system to draw boxes called bounding boxes around objects and predict their classes.

This is very important for custom tasks because the set of bounding box sizes and locations may be dramatically different from the pre-set bounding box anchors in another dataset. The YOLOv5 network predicts bounding boxes as deviations from a given set of anchor box dimensions to make box predictions. This model is trained on the FLIR dataset. The distance between the camera and a target object in the surrounding environment is determined using size-based distance approximation. [9] This model is trained on the KITTI dataset. The force which was taken as the output from the motor or propeller block was fed as an input to the linear dynamic block, which gave linear acceleration as the output. . Linear acceleration on further integrating gave linear velocity, which was made to pass an integrator block and give us the linear position. A drag disturbance block was created with wind gusts as the input along the three axes to understand better the disturbances that will affect the flight controller. Disturbance, which was the disturbance block's output, was used as the linear dynamic block's input to produce an exact linear position. Since the navigation control module can only accept voltage as an input, we used a human control block to convert attitude variables such as yaw, pitch, and throttle to voltage

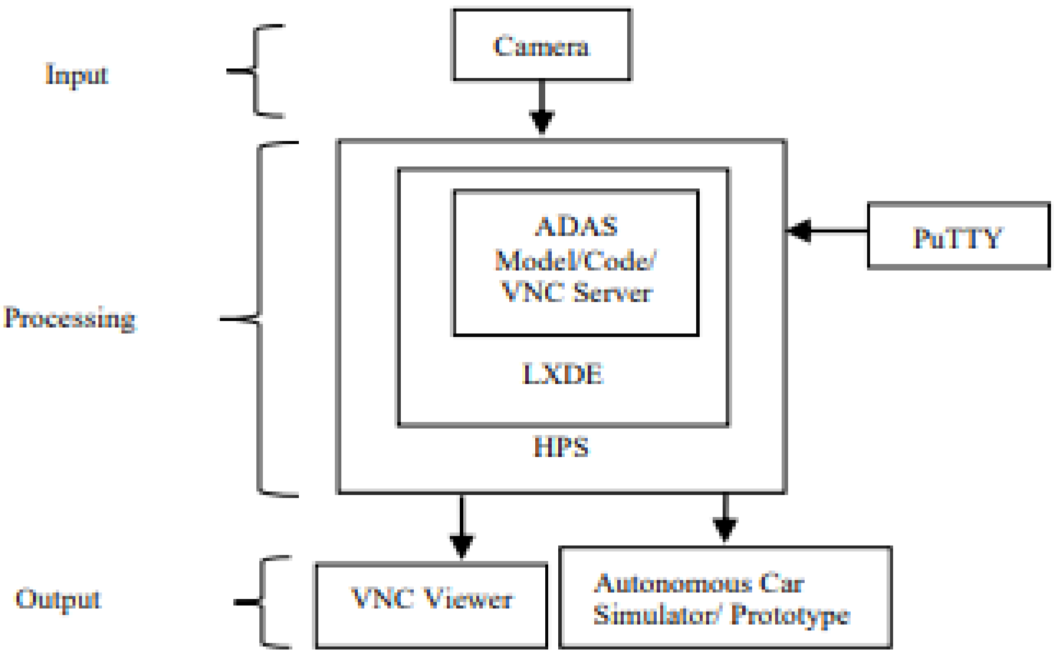

Fig 3: Proposed method block diagram

. The values for yaw, pitch, roll, and throttle are fed manually. The linear position is fed back to the summer, which performs the desired calculation required for flight movements. The PID controller block quickly implements all the corrections required for the block.

Results And Discussions

The simulated output of the FCS is shown in Figures 3 and 4, where the flying position is visible under three different conditions. The first type of drag is a positive drag, where the linear position is in a downward or negative direction.

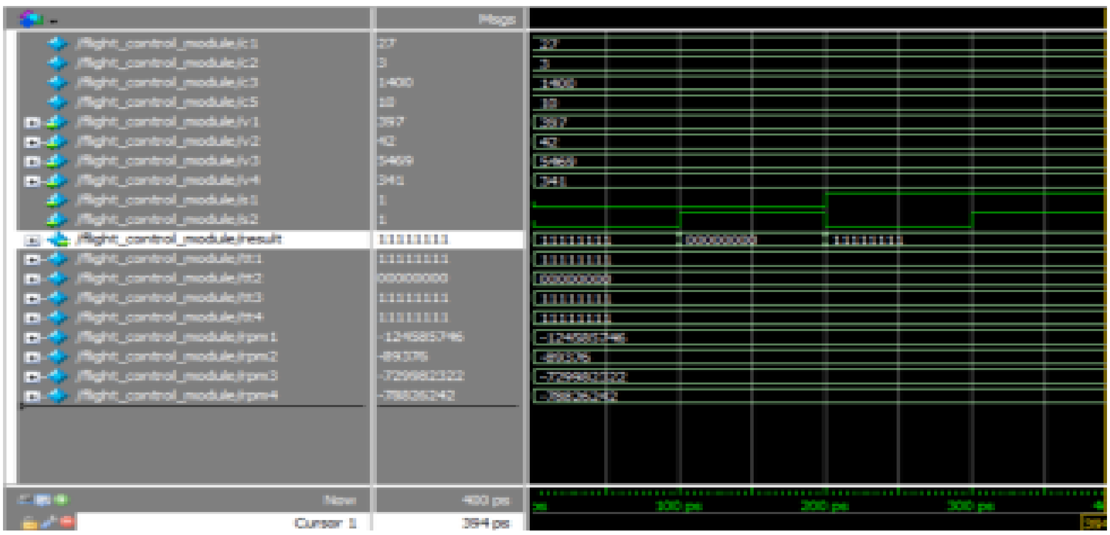

Fig 4: Coding part of the proposed method

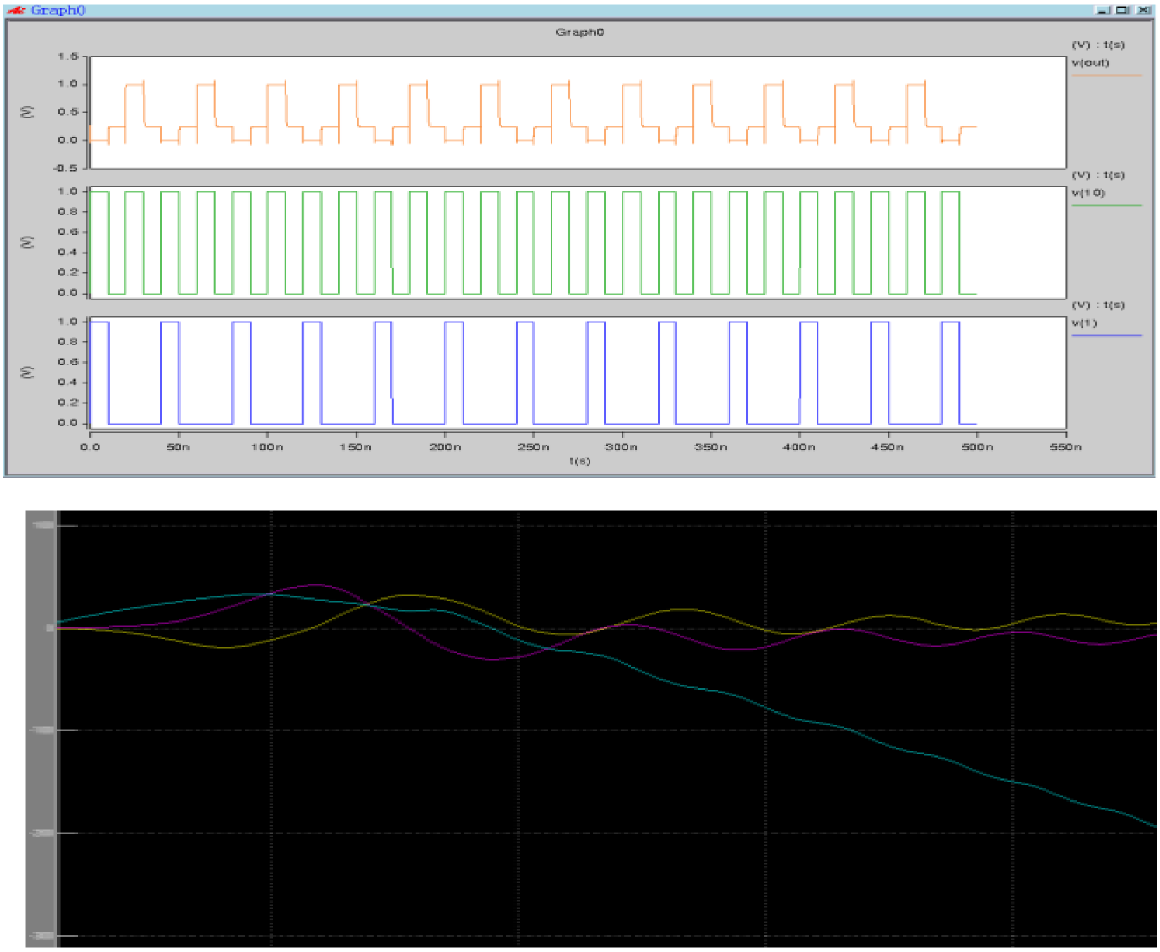

Fig 5: Simulation output of the proposed method

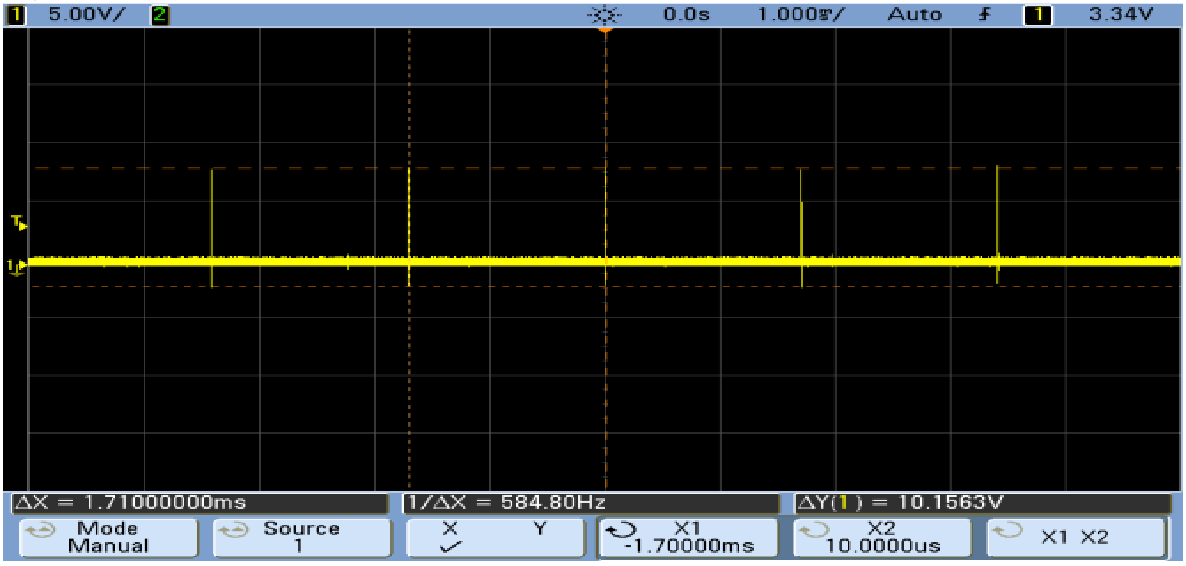

Fig 6: Output at CRO

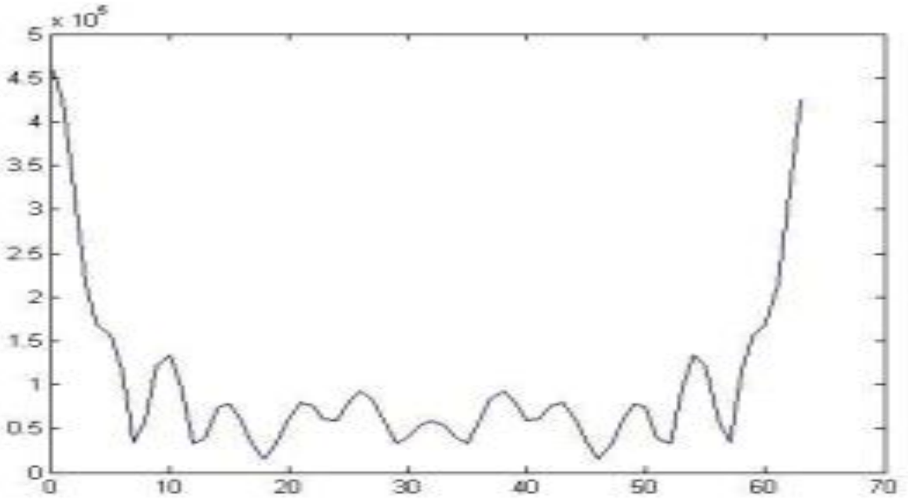

Fig 7: Power spectral density calculation

For better waveform simulation, visual editing of logic circuits, and hardware description, Quartus Prime has an implementation of VHDL and Verilog. This software is used to get RTL view and implement it on hardware.

Conclusion

The FCS, which was used in earlier days like the mechanical and microcontroller based, the designed one is more efficient. The mechanical-based flight control systems were found to be heavy. They also required careful routing of cables. Since the routing had to be done cautiously, there was a need for redundant backup, which increased the weight of the FCS. Microcontroller-based flight control systems have less capacity for on-board processing of autonomous real-time image processing for path planning and avoidance. The implementation of ADAS on FPGA comes with advantages like parallel processing capabilities of FPGA, low power consumption and better throughput, along with a great deal of cost reduction.

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