



Michigan State University College of Engineering

ECE 480

Design Team 4

April 15th 2011

FPGA Image Processing for Driver Assistance

Camera

Design issues

Design Team:

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Introduction

In the United States there were more than five million car accidents in 2009, resulting in more than 30,000 fatalities. As a result, automotive manufactures are always searching for ways to make their products safer and safer. One way of making car's safer is to add an extra set of eyes, that never sleep or get tired. Computer vision is growing rapidly in automobiles due to being able to constantly monitor road conditions, detect collisions, and avoid accidents. Using computers and camera systems can make driving safer, not just for the driver, but for everyone else as well. The demonstrative nature of our project means that protection of intellectual property is not a large issue. In fact, many typical design concerns are non-issues for us.

With the sponsorship of Xilinx Design Team Four will attempt to help reduce this high number of accidents by creating a system that will alert drivers of pedestrians in the way of their vehicle. If we can detect a pedestrian in the way we can also stop the car without driver input. Our challenge is to design a system that can first accomplish this task but also be upgradeable through the life of the product and be recycled. The product must also be robust and functional and have high detection accuracy and not cause liabilities for automotive manufactures.

Product Lifecycle Management

Product Lifecycle Management (PLM) is the process of planning the whole lifecycle of a product. It represents a combination of all data related to the conceptual stage through the recycle and reuse stage. The processes of PLM include conceive, design and development, production, service, and reuse and recycle. The paper will focus on each process except conceive because it has been discussed in the final proposal paper.

Design and Development

The design of the product needs to ensure that the video does not appear to have any delay. This gives the user or viewer the ability to watch the processed video in real time (20 frames per second minimum). Design team four is using Xilinx's Xtreme Spartan 3A DSP board as our development board which is donated by Xilinx. The team is not using the top of the line



performing Field Programmable Gate Arrays (FPGAs) and the performance of the product will be mainly base on the algorithms created by the design team. The algorithms need to be carefully created to ensure accuracy and speed. Also, it was decided that the performance over accuracy is important, but the certain level of accuracy still need to be maintained. Therefore, the Histogram of Oriented Gradient (HOG) was chosen to compute the histogram of image, and use Support Vector Machine (SVM) as a classifier to detect the interested objects.

Production

The main goal of this project is to be able to distribute our algorithms to OEM manufacturers such as Ford, GM, Mitsubishi, and Toyota. If any of the automotive companies decided to purchase a Xilinx FPGA, it will be another part that will be installed when manufacturing the vehicle. However, it will not cost them any extra money for our algorithms. In order to meet the demands for manufacturers, this product have to be mass produced and be installed into millions of vehicles. Therefore, the product has to be cost efficient and easily producible for them.

Service

The product now only has a function to detect pedestrians, but the company would provide multiple update packages in the future. The update packages will enable the product to detect multiple types of objects at the same time such as pedestrians, traffic signs, and pets, or other vehicles. They also provide the product with a new functionality, so that the product measure the approximately distance between detected objects and camera. Once every update packages is released, the customers who purchase the first generation of the product can update their product from the selected automobile companies with a little cost. Furthermore, the newest generation of product will install the newest update packages when they are released on the market.

Reuse and Recycle

Since the company will release update packages every time period, there will be no problem with the durability of the system. The product will be reusable through the life of the vehicle and between automobiles as long as it stays up-to-date. Therefore, in order to keep the product's market and ensure it will not become out of date, the hardware need to be well-



designed and advancement of the algorithm. If the product needs to be recycled, it will not be an issue because there are no harmful materials in the product.

Standards

The main part of our design project is the Xilinx Spartan-3A DSP FPGA development board provided for Design Team Four, donated by Xilinx. The data sheet for the Spartan-3A states that, the board itself has to meet the industry recognized AEC-Q100 standard for an intergraded circuit. However, the design issue for Design Team Four is that since our project is targeting the image processing system inside automotive vehicles, we are concerned about the electric magnetic interference (EMI) produced by the FPGA board may cause various amounts of electromagnetic interference that will affect other electric systems in the car. The other possibility is that other systems in the car can interfere with the Spartan-3A board as well.

Electrical Magnetic Interference (EMI) can be caused in two different ways. The first being radiated emission produced by the electric device itself in the internal components of the board and second conducted emission carried along the circuit can contain electromagnetic waves that can multiply signals and then be transmitted to other sensitive devices in the car. This is extremely important to reduce these signals in the car as there are a large number of electric devices inside of modern cars. In the past many accidents have occurred due to the conducted interference within large electronic systems.

According to the Spartan-3A specification sheet, the FPGA can produce a wide range of clock signals from 12MHz USB clock all the way up to a 200MHz FPGA clock. At such a high frequency, it's highly possible to cause interferences within the car. The Federal Communications Commission (FCC) state that all electronic devices in excess of 9000 pulse (cycles) per second (9K Hz) and use digital techniques should meet the standard set of rules created by the FCC as to not cause problems with other national communication methods. An additional organization known as the CISPR (The French translation meaning International Special Committee on Radio Interference) also has a set of standards to follow if the device will be sold in the European countries. To broaden the market for our produce we should also take these rules into account.



Since we are working with an electrical system for automobiles, the device should match the regulation of the class B standard set by FCC and CISPR. In such class, for radiated emission at 200MHz, the electric field should be less than 33 dB μ V/m which is set by the FCC and less than 30 dB μ V/m set by the CISPR. Both organizations measure the radiated emission at 10m. For conducted emission, the regulations for both the FCC and CISPR state that the highest frequency generated can be no greater than 1.705MHz.

To be able to meet the standards, our final design will possibly need some fine tuning in order to control the radiated emissions. The FPGA board will be packaged inside of a metal box, possibly made from aluminum. Aluminum is usually used first for good shielding of EMI effect and second for its light weight property. We do not plan to use more than the box shielding as the board itself has already packaged well by Xilinx. It's a very difficult task to change the design of a circuit to reduce EMI, however shielding should take care of any EMI emissions we will produce. It is also difficult to reduce conductive interference, due to the same reasons previously stated, we cannot change much on the board's reference design, however, we can put filters on the power cables in and camera cable out to filter out all the high frequency signals carried on line, on the other hand, we can measure the cable length so that it's does not match with the half wave length of the signal which could cause the antenna effect.

With all the shielding and filters in place, the product will still need to go through EMC (Electromagnetic Chamber) testing. The process places the produce in a closed room, runs the product at various loads, and records all the various amounts of radiation that is radiated from the board. This is then compared against the FCC and CISPR standards.

Product Liability

Our software package will be provided by Xilinx to automotive companies, who will further develop object detection systems. These object detection systems may be classified as a safety device, and will certainly be used in conjunction with safety devices, which may lead some consumers to believe that they are safety devices, even if they are not legally classified as such. This means that many different circumstances could lead to various forms of legal or ethical liability on the part of Xilinx, or us.

Federal standards mandate that rear view cameras be placed in all new cars in the next couple of years. The standard intends to make typical blind spots to the rear of the car visible. Currently, our



detection system alerts the driver visually, which may interfere with the visibility of various objects, especially if the detection system is occasionally faulty. This could obstruct the driver's view of actual objects, and cause an accident. If drivers become reliant on the system, and the system fails to report an obstacle, this could also cause an accident. Although the current system is only a prototype, it may suggest to other developers to use the same sort of visual display. The current system should probably be modified to provide either a visual alert in a second video device, or an alert of a different modality (e.g. audio, or LED).

Although liability in general should be limited by the preliminary nature of our work, there are currently few safety standards for automotive visual alert devices. If our prototype fails to meet future safety standards, and is relied on too heavily upon by future developers, Xilinx may be pulled into a legal case whether or not they are responsible. Xilinx should make it clear to automotive developers that receive the package that is not intended to be a safety device, or a component in a safety device as is.

Conclusion

The design process for new products must take in many considerations about not just the product, but the environment it will be used in. Not only must the design of our product efficiently use our hardware but it also has to be able to be upgradeable and recycled. The product must also pass all the standards for emitting EMI set by the FCC and CISPR. The product must reduce the liability of manufactures not create more liability. The goal for Design Team Four and Xilinx is to improve overall occupant safety and reduce accidents and fatalities on the road by designing a product that can be used in a wide variety of vehicles.