



Michigan State University College of Engineering
ECE 480
Design Team 4
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FPGA Image Processing for Driver Assistance Camera

Final Proposal

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Executive Summary:

Passenger safety is the primary concern and focus of automobile manufacturers today. In addition to the passive safety equipment, such as seatbelts and airbags, technology based active safety mechanisms are being developed and incorporated into all types of commercial and industrial vehicles and may soon be required by law. Current trends are requiring automobile manufacturers to include a multitude of technology based safety equipment including ultrasonic sensors and back-up cameras and even forward facing cameras. Historically, cameras placed in vehicles give the driver an unaltered view from behind the vehicle; however, with the sponsorship of Xilinx, Michigan State University's ECE 480 Team 4 has designed and implemented algorithms that will detect and classify objects, allowing the driver to be alerted.

This system draws the driver's attention to objects either behind or in front of the vehicle, by marking them with targets. In doing so, the driver will be less likely to overlook objects that may create a safety hazard. The team has combined the techniques of Histogram of Oriented Gradients (HOG) and Support Vector Machine (SVM) to create a system that will both accurately and efficiently detect and visually alert the driver to hazardous objects. Implementation of the algorithm utilizes Xilinx's Spartan-3A Field Programmable Gate Array (FPGA) development board and Xilinx's System Generator tools.



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Introduction

Back-Over crashes have become one of the main car accidents which cause fatalities globally. According to National Highway transportation (NHTSA), around 292 fatalities and 18,000 injuries occur each year as a result of back-over accident involving all types of vehicles, and children and elder are the most common victims. In order to prevent back-over crashes, the U.S. Department of Transportation proposed that automakers to install back-up camera in all new vehicles in 2014 to help drivers see into the blind zones directly behind vehicles. The proposal was designed to provide rear view when the vehicles are in reverse to keep drivers from running over pedestrians who might be crossing behind their vehicles. Even the proposal has not been passed by Congress, OEM and aftermarket has started to increase the placement of back-up camera in vehicles.

From the study of ISuppli, one of the leading market research firms, it showed that the selling rate of aftermarket back-up camera are growing at a steady pace with estimated sale of 182,000 units in 2010 from 125,000 in 2009. The current trend will not only affect the sales of aftermarket back-up camera, but also the sales of Original Equipment Manufacturers (OEM). ISuppli forecasts that the growth will continue until 2015 to reach 813,000 units for aftermarket and 3,352,000 units for OEM. From the facts that the increasing placements of the product in new cars and the noticeable selling rate, it indicated that the customer awareness is already gaining every year. Therefore, in order to improve the drivers' comfort and young drivers' confidence, Xilinx, a leader in programmable logic products, decided to update the current back-up camera into a next stage. With the help from Xilinx, Michigan State University's ECE 480 Team 4 was assigned to create an algorithm to visually alert the driver of vehicles seen within the back-up camera and approximate the distance in between using Xilinx's Xtreme Spartan-3A board. It is a continuous project from the previous team, and some of the tasks had been done such as edge detection and certain level of human detection. With the sponsorship by Xilinx, the team will be provided with the Xtreme Spartan-3A development, camera, and the company's copy written System Generator tools to develop a prototype. The ECE 480 Team 4 will optimize the algorithms which were done by previous team and move the design to the next level by creating new algorithms such as distance measurement and vehicle detection.

Background

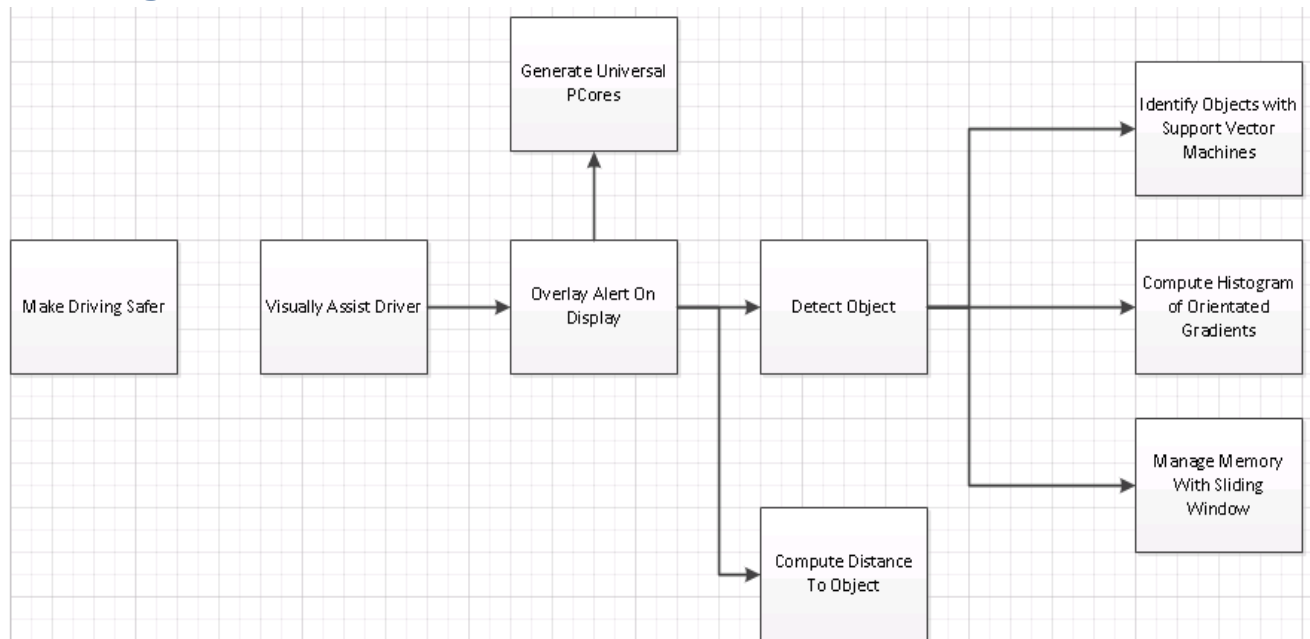
Automotive backup cameras are becoming a must have in today's automotive world. When used properly backup cameras will not only improve driver awareness by providing them with a video of what's behind them, but they will also monitor what is happening behind the vehicle at all times. Having camera's in the car will allow the vehicle to alert the driver of dangers they may not be aware of or in extreme situations stop the car if danger is detected. Such dangers include lane departure warning, as well as near object collision.

The use of cameras is likely becoming a safety requirement by the NHTSA (to be determined by ruling early 2011) and will likely require all passenger vehicles to be equipped with rear-view cameras.

Design Team 4 will be continuing research and algorithm development started by Design Team 3 from Fall Semester 2010. Design Team 3 was able to implement an edge detection algorithm as well as a skin detection algorithm using a combination of matlab/Simulink interface with Xilinx ISE Design Suite and Xilinx Video Starter Kit. Upon inspection of Team 3's design for algorithms Design Team 4 will increase the effectiveness of these algorithms while also creating new algorithms to advance the options available to Xilinx. Team 4 will also undergo the task of attempting to finish team 3's object detection from last semester.

Team 4 will also undergo research into adding an additional camera (inferred or depth cameras) to our current hardware spec. Adding a camera would allow for more information for the algorithms and help with object detection and monocular ranging.

Fast Diagram



Conceptual Design

Histogram of Oriented Gradients

A histogram of oriented gradients is a measurement of the direction of fine-grain gradients in an area. This representation of data is meant to allow the classification of specific types of objects, particularly when used as data for a support vector machine. It can also be used to identify image features, or non-specific objects.

To compute a histogram of oriented gradients, you first calculate x and y gradients for each pixel in an image. Then you group the pixels into 'cells' of some particular shape, and have each pixel contribute to the histogram of oriented gradients for that cell by 'voting' for the orientation which is centered on that pixel. Typically the pixels' votes are weighted with a function of the position of the individual pixel, and the magnitude of the orientation centered on it.

Support Vector Machine

A support vector machine is fundamentally a binary classifier. You feed it data of interest, and it uses that data to answer a yes-or-no question relevant to the data. Each element of the data vector is used in a series of computations which have a scalar value as a result. These computations are called kernels of the support vector machine. The scalar values are then added together, and their sum is evaluated. If the sum is above a certain threshold, the answer to the question is presumed to be yes. If it is below this threshold value, the answer is no.

Support vector machines can be 'trained' to identify arbitrary data sets, without any presumed knowledge of the data set. This makes them excellent at tackling problems with large quantities of data, and little theoretical knowledge linking the data to make any sense of it, such as image recognition. They are a near universal component of most classifier systems.

Monocular Ranging

Monocular ranging is the act of estimating range from a single image or a video from a static camera. It can be done easily by assuming the object is on the ground and taking into account the geometry and properties of the camera and its placement. More complex monocular range estimation can take into account the assumed properties of the scene, but is subject to the same 'tricks' humans are susceptible to, which are present in many optical illusions.

Proposed Design Solution

Design Team4 proposes that using Matlab and Simulink utilizing SVM toolboxes will allow the team to create a histogram of orientated gradients and a support vector machine is the best solution to



the problem of detecting and classifying important objects. The team believes that using the Matlab built in SVM is the most suitable way to complete the design because the hardest part of the task will be handled by Matlab. The Xilinx suite allows for configuration and hardware design of the Xilinx board and therefore must be used. Matlab is a known solution and works well with ISE Design Suite and has the ability to generate the models for the Xilinx hardware. The team is designing the Matlab and Xilinx software to work together so that transitioning from Matlab to Xilinx models is possible.

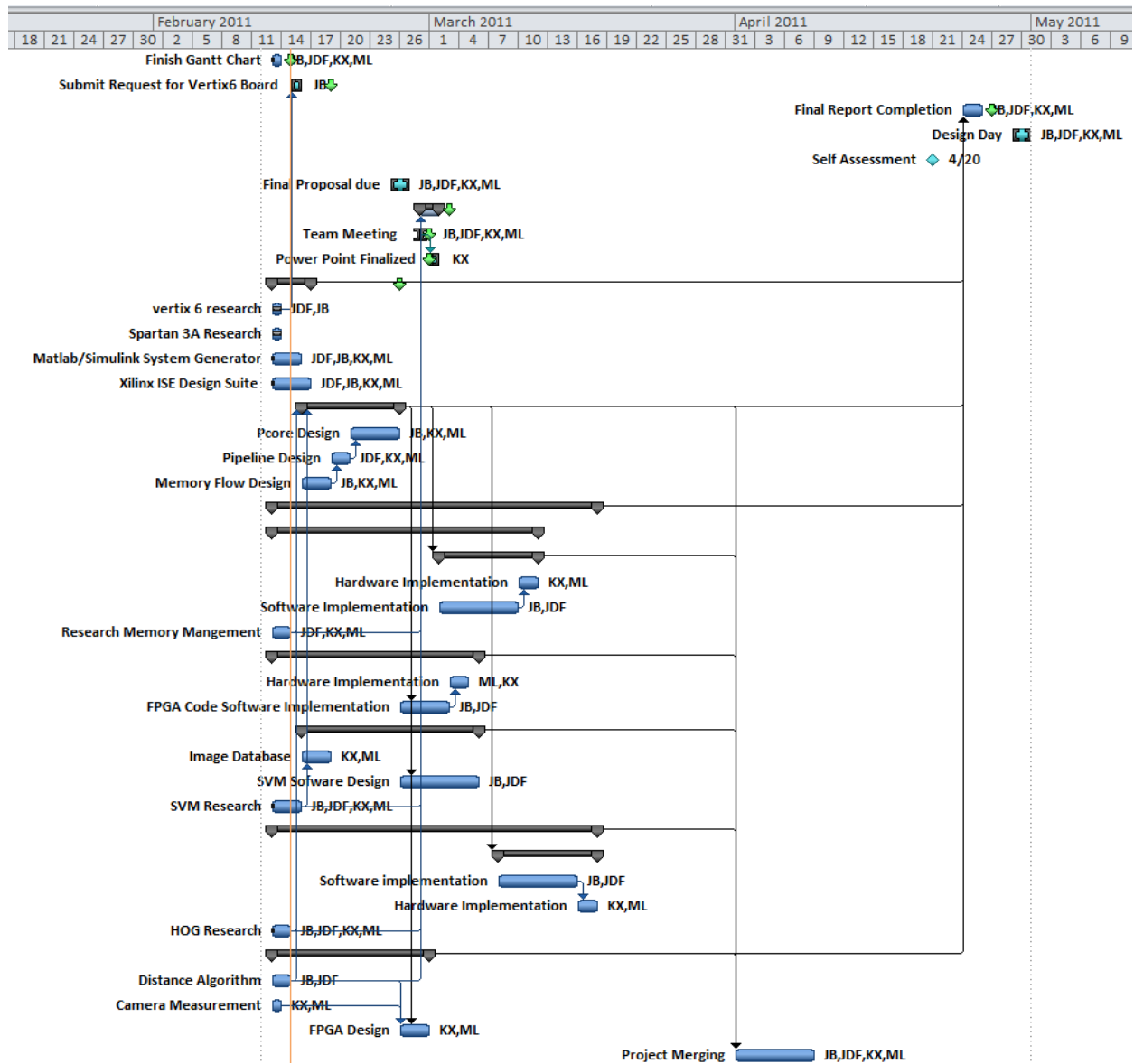
Risk Analysis

- Our project is based on an development board that is pre-build by Xilinx, according to the report from the last semester, the voltage on the development board has never exceed 5 volts, the risk of hazard by the board is very low.
- However, our main concern to our project is the malfunction caused by our software algorithm. From the last semester's report, there were little time for the team to do failure testing and redirection, this will be one of the major tasks our team will be working on this semester to insure that real-time proper detection is achieved.
- On the other hand, our team is still working on using new types of camera on the development board, we expect new compatibility problem will be encountered but we will be doing a lot of testing and new coding for the new hardware to make sure it works within the range designed.

Budget

All parts are donated from Xilinx and there is no need to spend any additional money. The purpose of the project is to use hardware available from Xilinx.

Gantt Chart





References

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