Driver Sleep Detection and Alarming System

Project Proposal

ECE445: Senior Design

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1. Introduction

1.1 Project Overview

Title: Driver Sleep Detection and Alarming System

Feeling sleepy while driving could cause hazardous traffic accident. However, when driving alone on highway or driving over a long period of time, drivers are inclined to bored and feel sleepy, or even fall asleep. Nowadays most of the products of driver anti-sleep detection sold in the market is simply earphone making intermittent noises, which is quite annoying and inefficient. As such, there is a high demand for cheap and efficient driver sleep detection. Therefore, we came up with an idea to develop a driver anti-sleep alarm system, which could effectively meet this demand.

1.2 Objectives

1.2.1 Goals:

The goal of this project is to develop a system that can detect the sleepiness of the driver and make alarms accordingly. There will be a Kinect camera that constantly takes image of driver, a beagle board that implement image processing algorithm, and a feedback circuit that could generate alarm and a power supply system.

1.2.2 Features:

1. Daytime eye detection using RGB mode of Kinect.
2. Night time detection using IR mode of Kinect.
3. Eyelid distance tracking to detect the sleepiness.
4. Real time image processing more than 1 frame/second
5. Sound and flashing LED warning system to redraw driver’s attention

1.2.3 Benefits:

1. Affordable Cost of the application.
2. Sleepiness detection is efficient and alarms will be generated only when demanded.
3. Enhanced algorithm to ensure the darkness detection ability
4. Little inference and potential hazard to driver's normal driving
5. Portable size with car cigarette charger socket power supply

2. **System Design**

2.1 **Block Diagrams**

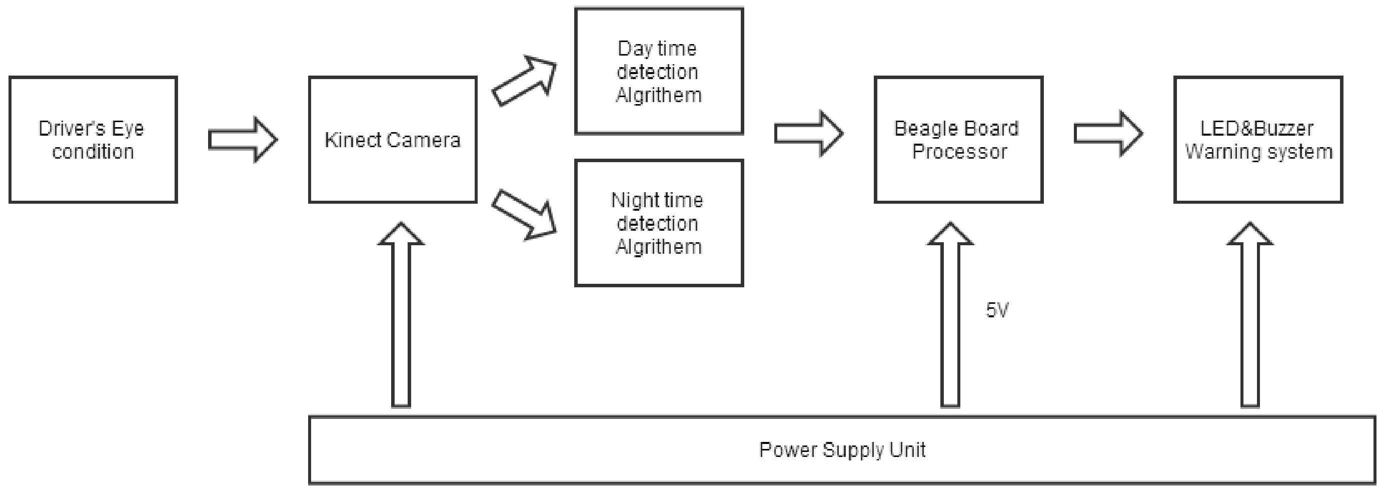

Figure 1. The systematic level block diagram

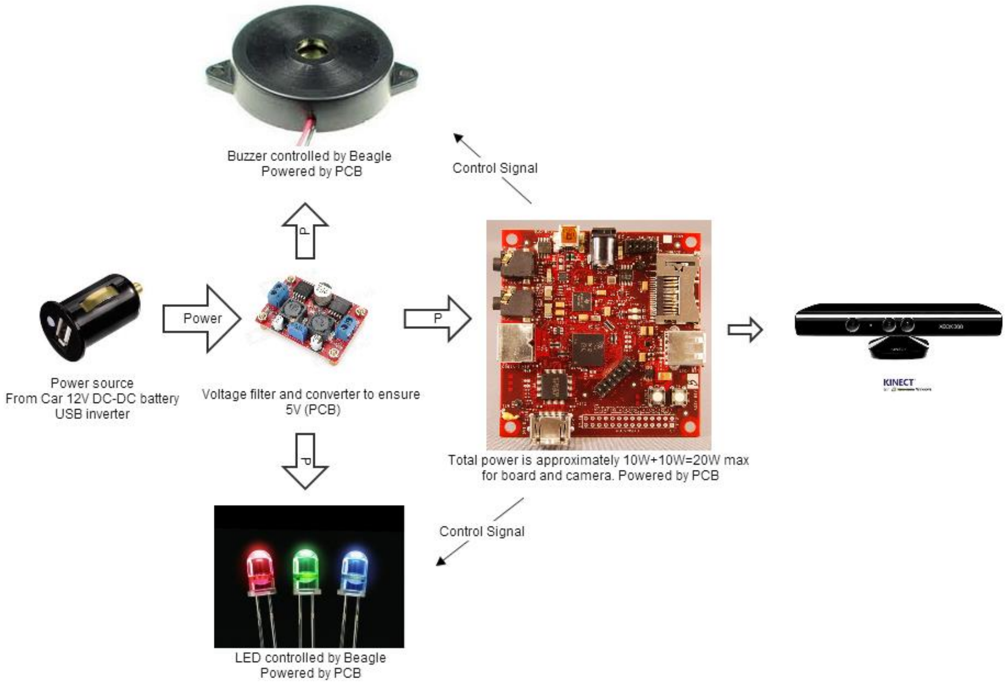

Figure 2. Systematic block diagram of real components prevision

2.2 Block Description

2.2.1 Kinect Camera

The Kinect Camera (Microsoft Kinect Xbox360) is used to monitoring the driver take image to capture the face images. The images area then sent to the Beagle board for processing. The camera will be placed on ceiling in front of the driver. Three modes are available for the Kinect: the RGB mode, IR mode, and Depth mode. Only the RGB and IR mode is required in this project.

2.2.2 Detection Algorithm

The coding and algorithm part will be built using OpenCV. The algorithm includes two parts: daytime detection and night detection. For daytime detection, the RGB mode is used; while for night detection, the IR mode is used instead. If IR mode fails to work, however, histogram equalization method will be used for night detection. The histogram equalization is a method to greatly expand the color range of the image. In this case, we need a light the slightly illuminate the driver.

The sleepiness is determined based on the change of drivers' eyelid distance or the black of eyes. For both daytime and night, the drivers' initial eyelid distance will be recorded as long as they get on the car. The record will be removed after drivers leave. During the driving, the camera will take 2 or 3 frames per second. Then the eyelid distance will be analyzed: if the distance remains small for several frame, the driver will be treated as fell sleepy.

2.2.3 Main Processing Unit: BeagleBoard

The BeagleBoard would operate as the controller for all other components. First, it will send and collect information from the Kinect. Then it would perform algorithms to determine the status of the driver. Last it will send out proper signals to LED array and buzzer to control them. In order to collect information, analyze data, and send out feedback, we need to install Linux and Kinect SDK on the board and build corresponding drivers for other components. This unit may consume at least 2A(10W) current supply.

2.2.4 Power Supply Unit

For the final design, in order to make the overall system portable, the power source is provided by the car cigarette power outlet, which typically has 12V DC supply. Occasionally it also provides 24 V DC. The power supply unit can tolerate 12 to 24 V inputs and provide a filtered steady 5 V output to supply the Beagle board and the camera. Also, it consists of one or two DC_DC voltage converter to obtain 3.3 V to power the Buzzer and 0.7 V to 3.3 V to illuminate the LED array. One or Two USB receptor ports will be used to retrieve power and one USB outlet will connected to Beagle board. The camera's power will draw from Beagle board.

2.2.5 Alarming devices

The design is composed of 6 to 8 LED. By forming an array, the flashing frequency and sequence can be presented to warn driver more efficiently. And frequency adjustment will depend on driver's eye close time duration. The control signal of the warning devices comes from Beagle board. Meanwhile, depending on the nature of the control signal, a D/A converter or a current amplifier are installed in order to ensure the appropriate function of the warning devices, as Fig 3 shows.

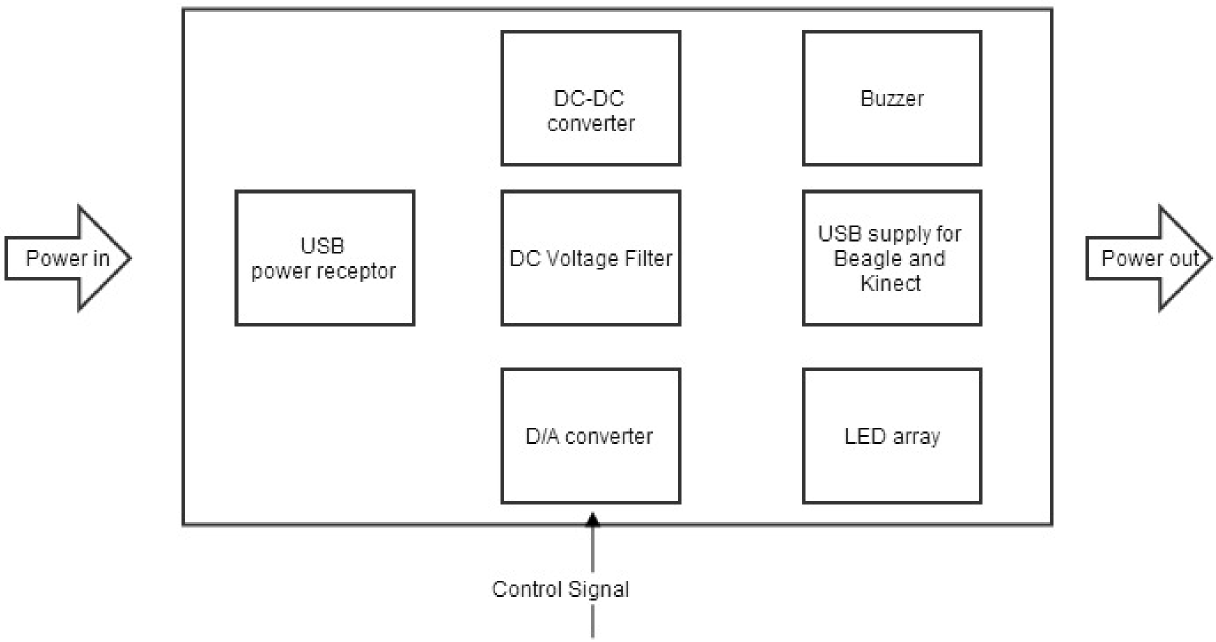

Figure 3. The PCB hardware design block diagram (The D/A converter might be replaced by current amplifier)

3. Requirements and Verifications

3.1 Requirements	3.2 Verification
3.1.1 Kinect Camera and Algorithm: I. The eyelid distance should be completely extracted from simple images. II. The detection should work both at daytime and at night. III. Able to effectively detect the sleepiness of the driver.	3.2.1 Kinect Camera and Algorithm: I. Initial algorithm testing will be done on computer instead of Beagle board. The camera will be connected to the computer and the code will run using visual studio. After the success test, the OpenCV and Linux will be installed on Beagle board to run the algorithm. II. With light provided, stand in front of the camera and test the daytime detection effectiveness. III. Without light provided, stand in front of the camera and test the night detection effectiveness.
3.1.2 BeagleBoard: I. Able to communicate with Kinect and collect images from it. II. Able to run algorithms to determine whether the driver is sleepy or not based on data collected. III. Able to send control signals to	3.2.2 BeagleBoard: I. Send images collected to computer and display to check if it's correct II. Send outputs of the algorithm to computer to compare with the expected results

LED array and buzzer to notify driver.	III. Check if the LED array and buzzer behave correctly when the algorithm gives either negative or positive results
3.1.3 Power Supply Unit: I. Able to receive control signals from BeagleBoard via pins. II. Able to supply constant filtered 5V voltage with maximum current limit 5A via USB socket. III. Able to provide sufficient power for the alarming LED array and buzzer.	3.2.3 Power Supply Unit: I. The communication and connection between the beagle board and the alarming circuit should be verified by the LED and buzzer's functionality. II. Voltage filter: Filtered 5V DC voltage provided by car charger inverter. The operation of the filter can be verified by supplying a noised 12 V DC to the USB port from a function generator. An oscilloscope is needed to obverse the filtered voltage. III. DC to DC Converter: Effectively step down 5V DC to 3.3 V for buzzer and required voltage for LED array. The operation of the converter combined with the controller can be verified by testing voltage across the designated terminal for LED array and buzzer/speaker. The required voltage should be achieved for two warning devices.

3.1.4 Alarming devices: I. Able to arouse drives attention with appropriate lights and sounds II. Do not interfere or cause potential distraction of driver III. Respond effectively to the control signal in terms of flashing format variation	3.2.4 Alarming devices: I. LED array and buzzer: The design is composed of 6 to 8 LED. By forming an array, the flashing frequency and sequence can be presented to warn driver more efficiently. The buzzer serves as a sound warning device. II. Peripheral circuit: An analog to digital converter might be used to drive the LED and buzzer warning system. Provide LED and buzzer control signals and power supply. Consider the output signal for Beagle board will be digital, a D/A converter might use. If the Beagle is able to provide an analog signal, then a current amplifier can be used instead of D/A conversion. III. Physical demonstration can verify the effectiveness of the device

3.3 Tolerance Analysis

The most important part of our software is the correctness of the algorithms both under normal situations and extreme circumstances. We'll try to keep at least 80% rate of correctness and aiming for 90%+. In order to complete this we have to test all possible situations and reduce the false positive and false negative rate as much as possible.

The major part of the hardware is the control and communication speed between the Beagle board and alarms, which significantly affects the response time of the system. Also the energy consumption rate and varied control over the LED and buzzer are critical concerns for the PCB board design. The output regulated voltage should have ± 0.2 V.

4. Project Cost and Schedule

4.1 Total Cost Estimation

4.1.1 Laber cost

Name	Rate/hour ($)	Hrs/week	Weeks	Total (Rate×2.5× Hrs/week×Weeks) ($)
Chenyang Xu	40	15	12	18000
Xiangyu Chen	40	15	12	18000
Yixiao Nie	40	15	12	18000
Total				54000

4.1.2 Parts cost

Item	Part Number	Quantity	Unit Cost ($)	Total Cost($)
BeagleBoard-xM	--	1	150	150
Kinect for Xbox 360	--	1	99.99	99.99
Buzzer	CT-1205C-SMT	1	6	6
PCB manufacture	--	2	40	80
LED	ASMT-QWBF-NKL0E	5	4	20
Vehicle charger inverter	--	1	20	20
USB ports	A31726-ND/ 1175-1021-ND	3	10	30
Inductor	--	2	8	16
DC_DC switching	ADP2303ARDZ-5.0-	2	10	20

regulator	R7DKR-ND			
Capacitor (SM)	--	5	4	20
Resistor (SM)	--	20	1	20
Other filter related components	--	--	--	~20
Total ($)	495.99			

4.1.3 Grand Total

Labor Cost ($)	Parts Cost ($)	Grand Total ($)
54000	495.99	54495.99

4.2 Individual Schedule

Week	Chenyang	Xiangyu	Yixiao
9/2	Research on Hardware related and write RFA	Research on Kinect camera and write RFA	Research on Microcontroller/ARM board and Write RFA
9/9	Work on proposal and research on PCB design software	Work on proposal and get Kinect	Work on proposal and get BeagleBoard-xm
9/16	Research on power converters	Research and study eye-tracking algorithm	Install Linux system and Kinect SDK
9/23	Determined the electrical components needed for hardware	Get Kinect working with BeagleBoard	Test basic functionality of Kinect on Beagleboard
9/30	Design PCB board schematic	Work on algorithms of eye tracking	Learn BeagleBoard specification and help with PCB design
10/7	Design PCB layout and send to	Work on algorithms tracking closed eyes at	Optimize the algorithms of tracking closed eyes

	fabrication	daytime	and test
10/14	Obtain PCB Hardware debug for power supply unit	Work on algorithms of histogram equalization	Work on algorithms for eye tracking at night
10/21	Test communication between Beagle board	Improve performance of all tracking algorithms	Test communication between BeagleBoard and components on PCB
10/28	Hardware debug and revise the board design	Debug and test corner cases of algorithm	Debug and test corner cases of BeagleBoard
11/4	Revised board Soldering	Week for adding extra work or handling emergency	Final check of algorithm and improve the efficiency of algorithm
11/11	Debug& Alarming system test	Kinect and tracking algorithm testing	BeagleBoard function and interaction testing
11/18	Final integrated testing with beagle board	Final integrated testing	Final integrated testing
11/25	Thanksgiving Break	Thanksgiving Break	Thanksgiving Break
12/2	Demo and final presentation	Demo and final presentation	Demo and final presentation
12/9	Final paper and checkout	Final paper and checkout	Final paper and checkout