Driver Sleep Detection and Alarming System Design Review

ECE445: Senior Design Project

Team No.15

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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 are 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
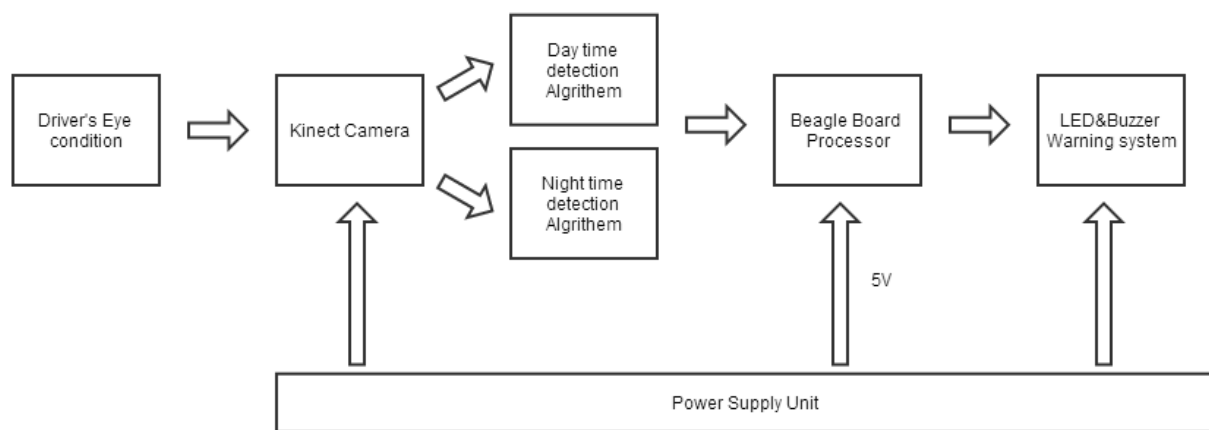
2. **System Design**

2.1 **Block Diagrams**
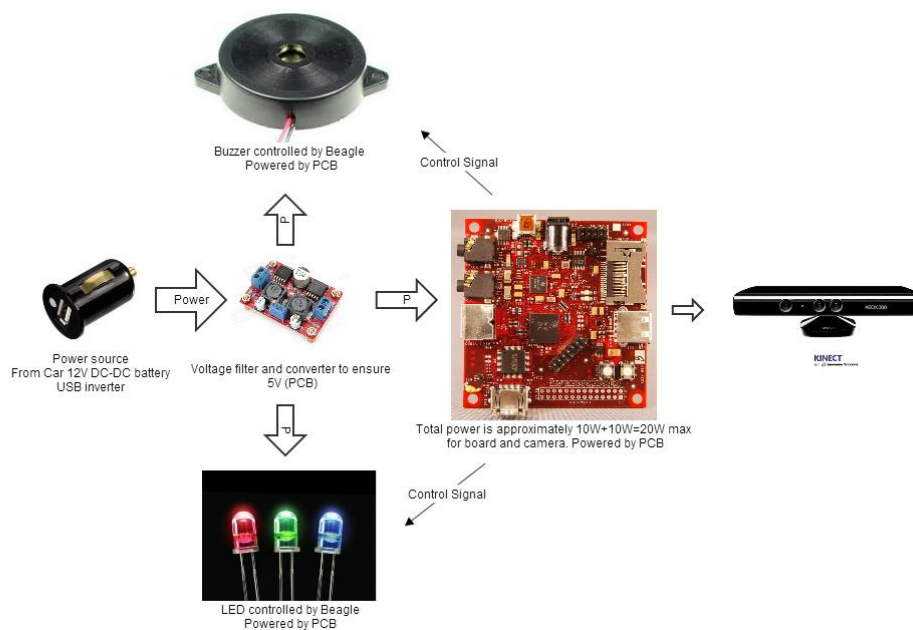

Figure 1. The systematic level block diagram

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 Beagle Board 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 openCV on the board and build corresponding drivers for other components.

2.2.4 Power Supply/Control 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 is used to power up the Buzzer and to illuminate the LED array by connecting appropriate resistors. 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. This module also provides two control signals to beagle board managed by the pushbutton. The pushbutton will control the beagle board and camera to take users' initial photos when it is pressed. The estimated working power consumption for the beagle board and camera is estimated to be 12 W, which is 2.4 A maximum current with output voltage of 5V. Additionally, a slide switch is installed in order to disable the alarming system when it is not needed.

2.2.5 Alarming system

The design is composed of 4 LED and one buzzer. 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 and this control voltage (5V) sent by Beagle board will drive a series of NMOS to achieve the switching purpose. The maximum current draw of the alarming system is 1.2 A.
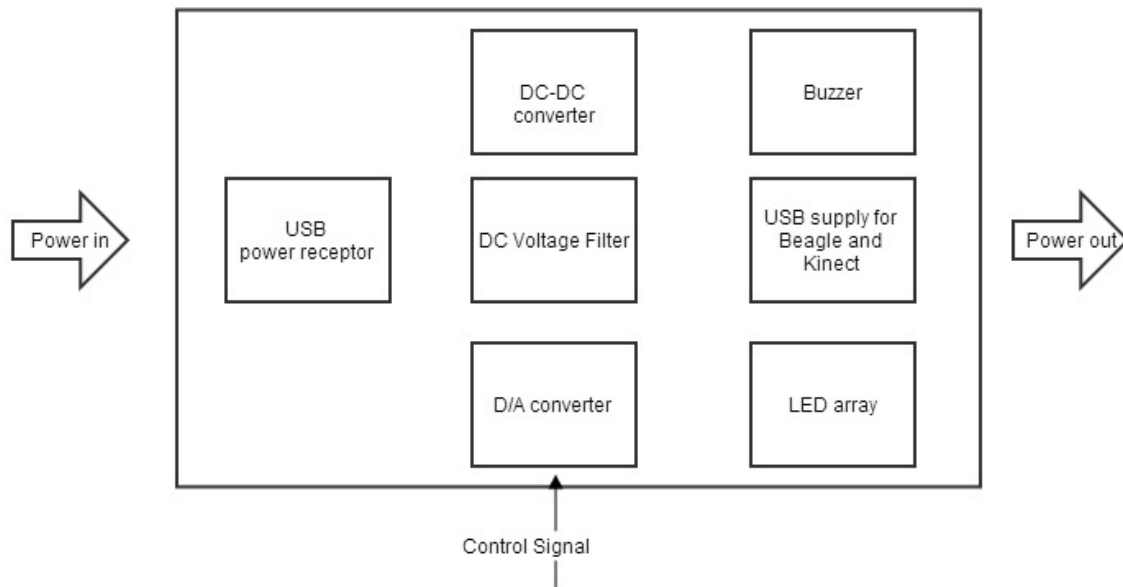
Figure 3. The PCB hardware design block diagram (The D/A converter is replaced by NMOS gates)

2.3 Schematics and Simulation

2.3.1 Algorithm

The coding and algorithm part will be built using OpenCV on the Ubuntu System. The algorithm should work all the time to detect the sleepiness of the driver. While daytime detection is accomplished by taking RGB images, nighttime detection is done by taking IR images. If IR mode fails to work, however, histogram equalization method will be used for night detection, which could effectively expand the color contrast of a local area in the image. In this case, we need a LED to slightly bright the driver.
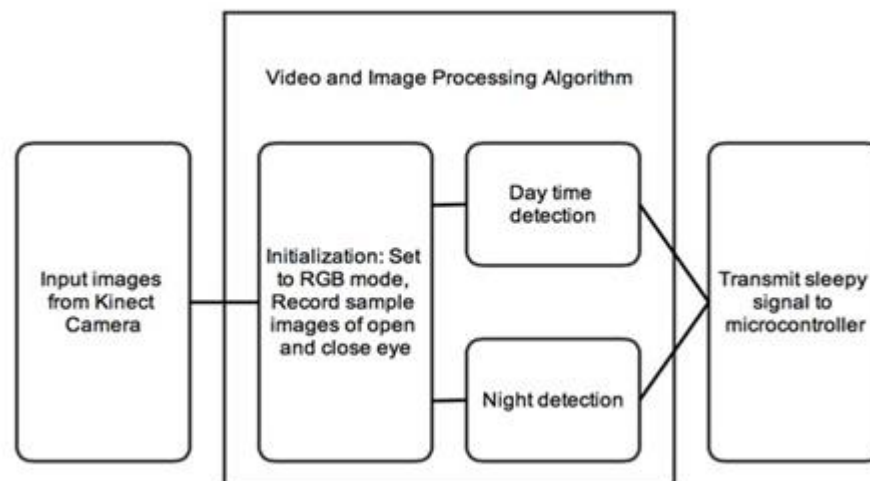
Figure 4. High level diagram for algorithms

The sleepiness is determined based on the openness of the drivers' eye. Initially, for both daytime and night, the driver needs to record his/her own eye open and close image before driving. The record will be removed after drivers leave. During the driving, the camera will take images at the rate of 3 frames per second. The Haar classifier will extract the eye part of each image and compare it with the initial record of open and close eye. Decision of whether driver feels sleepy will then be made based on the comparison of images. The driver will be deemed as sleepy if the images matches with the close eye record in consecutive three images and a sleepiness signal will be generated and sent to the Beagleboard. Otherwise, there will be no signal of sleepiness generated. The overall algorithm flow chart is shown in figure 5 on next page.
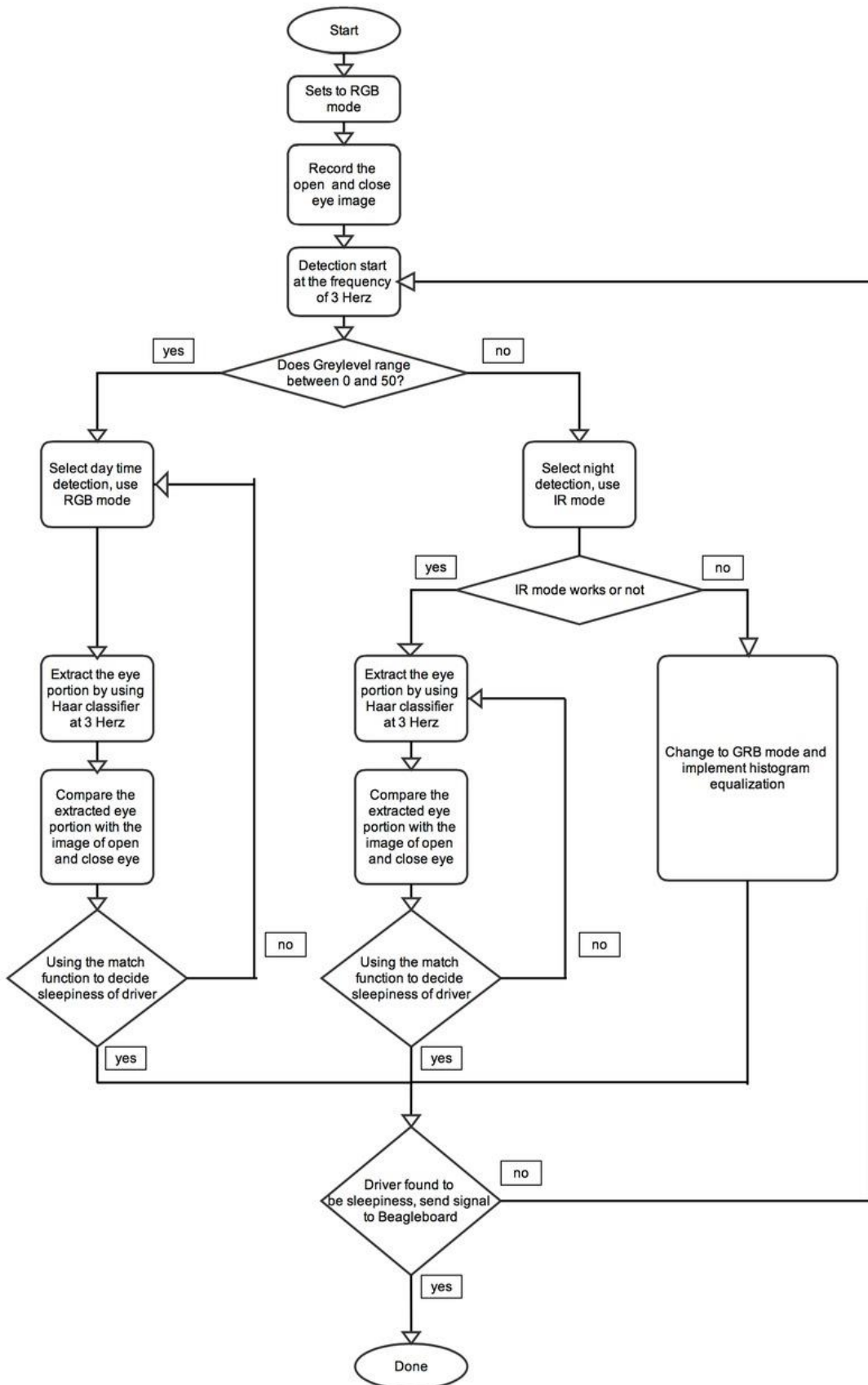
Figure 5. Flow chart for detailed algorithms

2.3.2 Histogram Equalization

Histogram Equalization will be used at night detection if IR mode fails. Basically this method increases the global contrast of images, by effectively spreading out the most frequent intensity values. The basic idea of it is to spread the low contrast image pixel values to the entire 0 to 255 color range, according to the frequency of each pixel value in the image. The detailed algorithm flow chart is shown below in Figure 6.

Start

initialize i=0, j=0
w = width of image
h = height of image

Convert RGB to Greyscale
0 <= (R+G+B)/3 <= 255
for each individual pixel

Generate the CDF of the image
for each pixel,
cdf(pixel_val) = Sum[p(x)] from 0 to pixel_val

For each pixel, the value being histogram equalized is
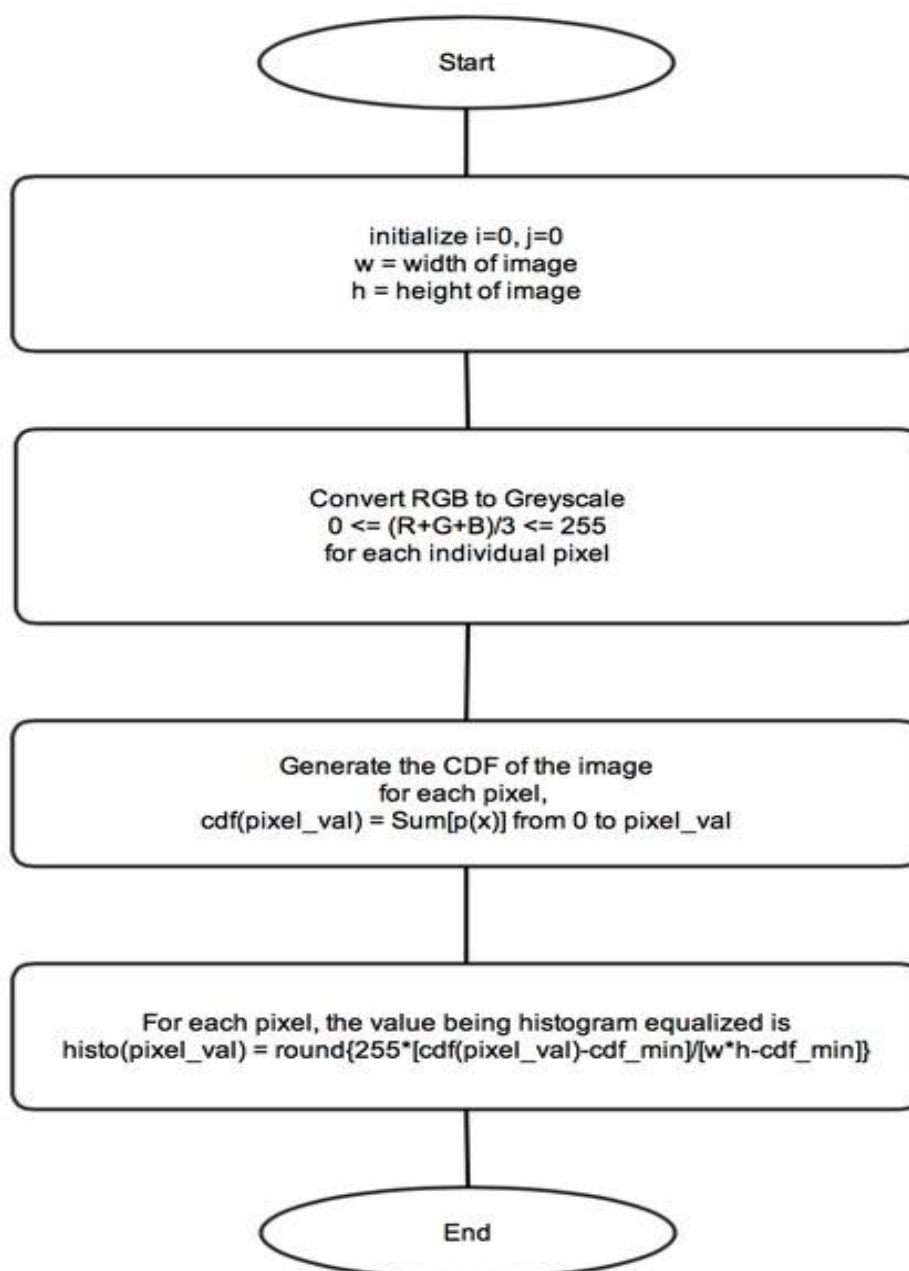histo(pixel_val) = round{255*[cdf(pixel_val)-cdf_min]/[w*h-cdf_min]}

End

Figure 6. Flow chart for Histogram Equalization

2.3.3 BeagleBoard

Even though power to BeagleBoard can be supplied via the USB OTG connector, the USB Host ports cannot supply power to our Kinect camera. Therefore we plan to use the DC power jack to supply power for BeagleBoard, using a Generic USB to 5.5 mm/2.1 mm 5 Volt DC Barrel Jack Power Cable.

Our BeagleBoard will power and communicate with Kinect camera using one of the four USB Host ports. We'll install Ubuntu on the board and openCV to run our algorithms. Even if it doesn't work, we still have alternative plans with Angstrom and/or openNI.

As for the input from buttons and output to alarming systems, we plan to use GPIO pins on the Beagleboard. When one button is pressed, our system would be programmed to identify which button it is and perform corresponding action. And when a dangerous signal is discovered by our algorithm, the program would change corresponding pins of the LED and buzzer to notify user.
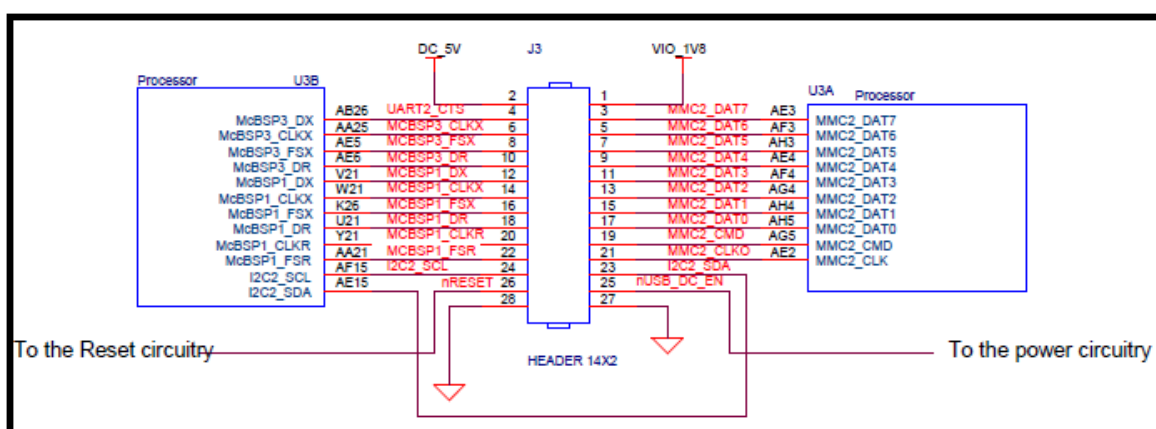

Figure 7. Main expansion header processor connection

2.3.4 Power Supply/Control Unit

2.3.4.1 Car cigarette charger

In order to reach the portable and automobile used propose, a car cigarette shape inverter is required. The technical data is shown in Table below. The charge contains overcurrent protection and a power inverter. It contains two USB type outlets and each of which can support up to 2.4 A. The charger will retrieve power from cigarette power

supply on the car.

Table 1. Car charger outlet electrical data

Input Voltage	12VDC-24VDC
Output Voltage	4.5V DC to 5 VDC
Output Current	0A to 4.8A max
Over-current Protection	6A

2.3.4.2 DC-DC switching regulator TI 61030-32

In order to supply the beagle board and camera with a stable and smooth 5V DC, a voltage regulator chip is used. This chip is initially designed for power management of batteries. This converter generates a stable output voltage that is able to be adjusted by an external resistor divider.   It provides high efficient power conversion and is capable of delivering output currents up to 4500 mA at 5V. It serves as a voltage boost converter and a noise filter of the power supply unit. The estimated power consumption for the beagle board and camera is up to 15W, which is in the capability of the switching regulator. Under special circumstances, with the load increasing dramatically or the car power supply malfunctioning, the output voltage from the car power supply can drop significantly. The voltage regulator can ensure the power supply for beagle board and keep the whole system functional. An additional table is provided below of the relevant electrical data of this regulator.

Table 2. Partial specification of DC-DC regulator

DC/DC STAGE					
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_I Input voltage range		1.8		5.5	V
V_O TPS61030 output voltage range		1.8		5.5	V

2.3.4.3 USB port

In order to make connection with car charger and also potentially with camera, two USB ports are chosen.   The figure 8 below shows the shape of the port. The figure 9 shows the pin arrangement of the typical USB type A port.   Only Pin1 and Pin 4 will be used since transmitting the power the only major concern in this application. Figure 10 shows the footprint design for the two layer USB port.
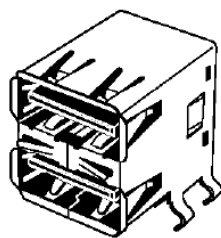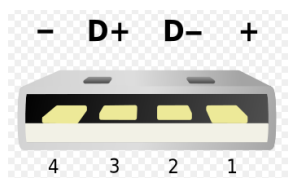
Figure 8. Shape the chosen USB port

Figure 9. USB port pin assignment. Pin 1 and Pin 4 are Vcc and GND respectively
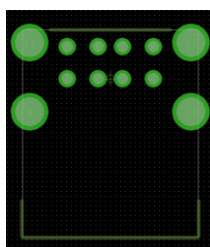

Figure 10. Two layer USB port footprint

2.3.5 Alarming system

2.3.5.1 Buzzer

The buzzer can work under 4V to 7V DC with 2.4 KHz alarming sound. It will directly connect to the power bus but not DC-DC converter output since it has a relatively large tolerance of functional voltage. Also, it can mitigate the load of the regulator.

2.3.5.2 LED device

There will be five LED on the PCB board in total. One red LED is used for indicator of the power supply and other 4 LED will be used for alarming purpose. There are two orange LED and two red LED put in series. In color selection is based on the minimum inference of driver by warm color light. The typical working voltage of these LEDs is 2.1 V. The power supply of LED will from the power bus connected from USB input. In order to limit the voltage, a series resistor is used to prevent LED from high voltage.

In order to achieve the adjustable frequency of the LED flashing, each LED is controlled by a NMOS switch, which is described as below.
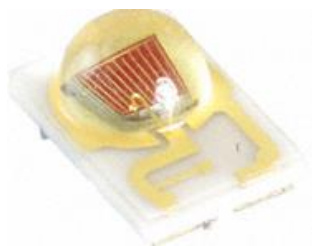

Figure 11. Sample view of Surface mount LED device (Orange)

2.3.5.3 NMOS switch

The control signal of the Gate for NMOS directly comes from Beagle board. The beagle board can provide a digital signal up to 5V. Therefore, this voltage is able to drive the NMOS to implement on-off behavior to control the LED. The same design is used for buzzer. The only different for buzzer design is that resistor is not required for voltage limit purpose.
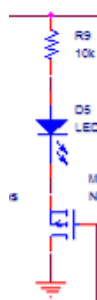
Figure 12. The LED circuit implementation

2.3.5.4 Mechanical switches

Two types of mechanical switches would be used in the design. As the figure 13 show on the left, the slide switch is used to control the power of whole system. It serves the power on-off button. Two push buttons are used in order to send commend signals to Beagle board for information acquisition purpose. The system power switch has current limit up to 6A and the signal buttons have the limit of 100 mA (Off-MOM). The resistor is needed to limit the current flow for the signal buttons.

Figure 13. Slide switch (left) and push button switch (right)

2.3.6 Simulation circuit and result

The initial simulation is done in Spice for the TI 61030 dc dc regulator. The recommended inductor and capacitor value is calculated. The figure 14 shows the recommended connection in order to deliver maximum power at 5V with current limit up to 4A.
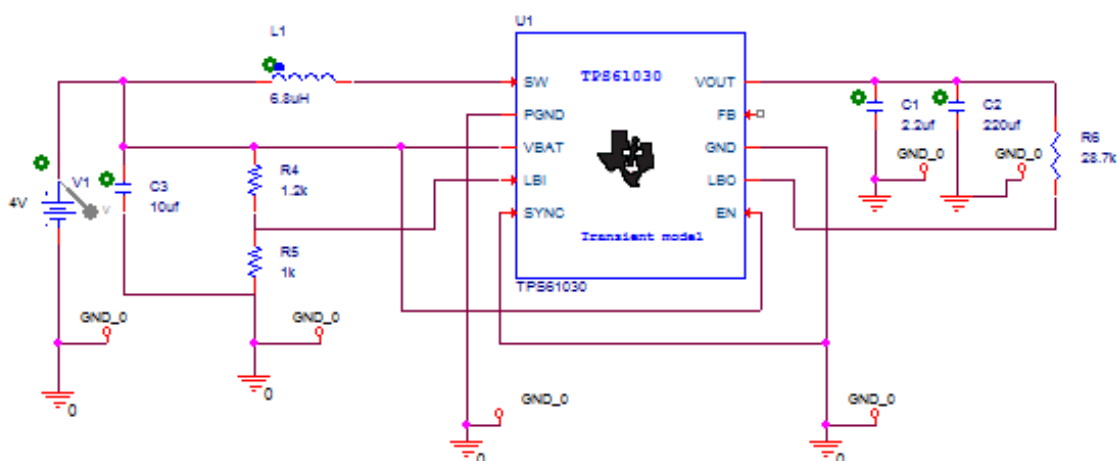
Figure 14. TI TPS61030-32 Chip Spice simulation circuit in Spice

There are tally 5 simulation finished and three of five are shown from figure 15 to figure 17. The power supply is changed from 1.8V to 5V to simulate the extreme conditions. A sinusoidal function generator is used to emulate the high frequency noise possible delivered from car charger inverter. As the graphs show, the output from the chip can be stabled at 5V regardless of the noise and the input voltage value. Moreover, the noise of the signal is filtered apparently in the output. The simulation is conducted with a load approximated 10 W.

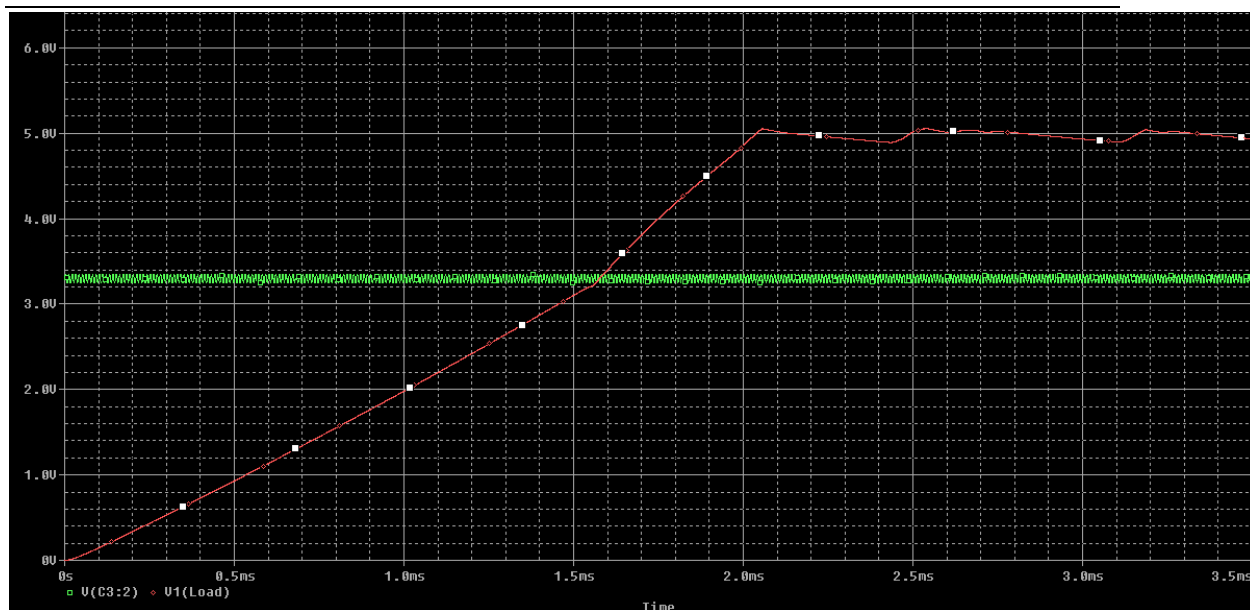Figure 15. The voltage output (Red) while the input is at low value 3.3 V with small
noise with magnitude 0.1 V (Green)
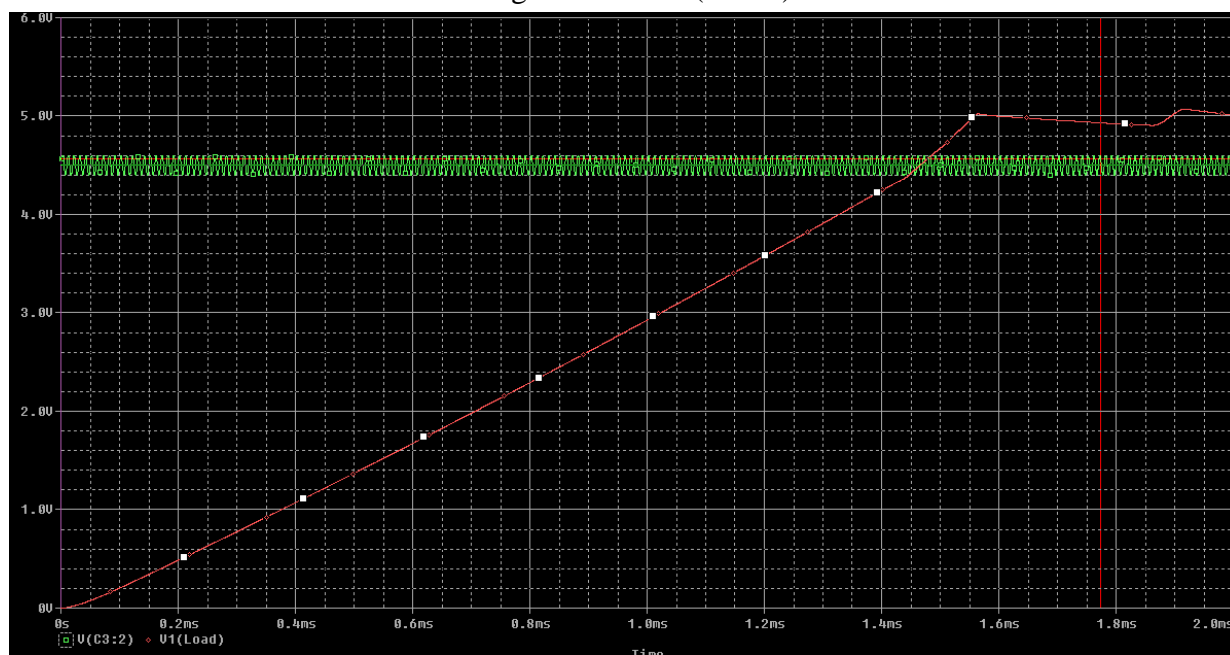
Figure 16. The voltage output (red) while the input is at low value 4.5 V with small
noise with magnitude =0.1 V (Green)
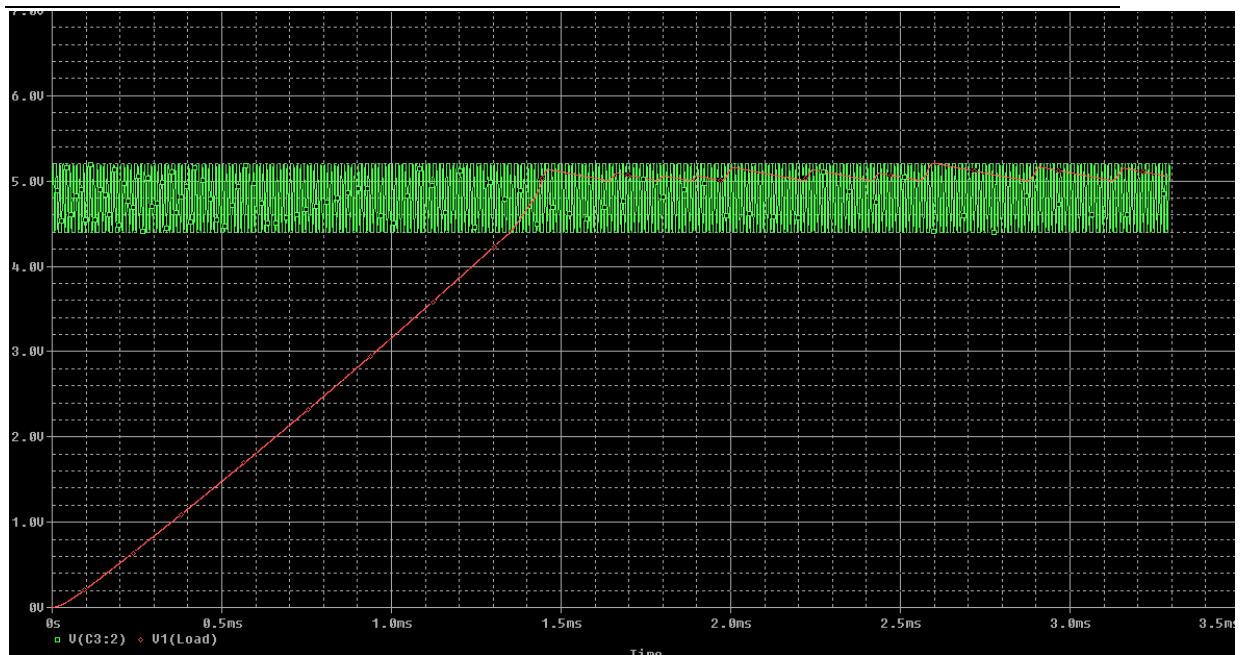
Figure17. The voltage output (Red) while the input is at low value 4.8 V with large noise with magnitude =0.5V (Green)

2.3.7 Calculation of circuit parameters
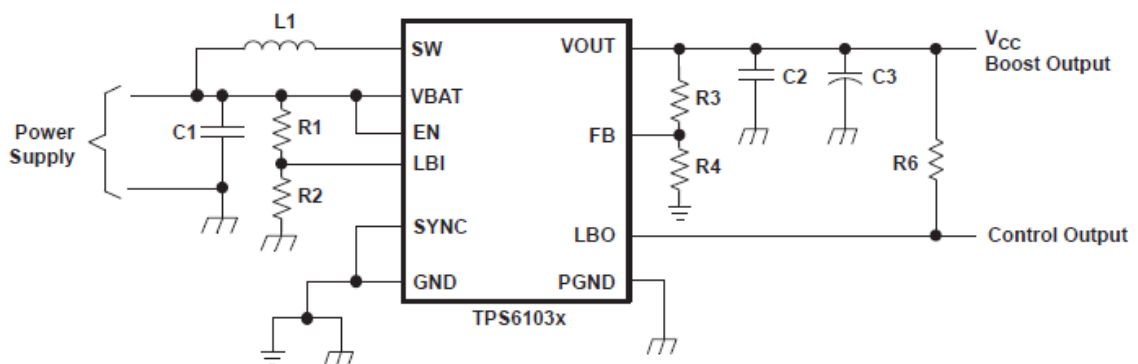
Figure 18. Recommended connection for 5V DC output

The parameter need to be determined include the R1, R2, R3, R4 and the inductor L. The C1 C2 C3 are selected based on the recommendation figures from the datasheet. It denotes C2 is 2.2uF, C3 is 220uf and C1 is 10uf to achieve the best filter and energy conversion result under 5V output condition.

 Resistor selection

The DC_DC regulator requires the voltage on FB and LBI no large than 500 mV. Moreover, the current through the resistive divider is required to be about 100 times

greater than the current into the FB pin. The typical current into FB is 0.01 uA according to datasheet. To fulfill all these requirements and keep the divider current more than 1 uA, the R4 is chosen to be 180 kΩ. To achieve 5V output, according to the equation below, it requires the R3 to be 1620K Ω. Thus, the total resistance on output current divider is 1800 K Ω. The current flow through the branch is 2.5 uA which is greater than 100 times of 1uA. The voltage on FB pin is 500 mV as required. The output is programed to be 5V.

$$R3 = R4 \times \left(\frac{V_O}{V_{FB}} - 1 \right) = 180\ k\Omega \times \left(\frac{V_O}{500\ mV} - 1 \right)$$

The LBI pin is reference voltage threshold generated on-chip. The lowest possible voltage supply, that is, Vbat in the equation below is 3 V as the lowest input voltage. In order to fulfill the current requirement, the R2 is recommended to be 390K Ω.

$$R1 = R2 \times \left(\frac{V_{BAT}}{V_{LBI-threshold}} - 1 \right) = 390\ k\Omega \times \left(\frac{V_{BAT}}{500\ mV} - 1 \right)$$

Therefore, the R1 is calculated to be 1950 K Ω.The current flow through is 2.13uA. The exact value selection of the R1 R2 R3 R4 is not rigid. Only the ratio, current limit and voltage limit should be considered to implement the desired output.

Resistor for LED

The typical current for LED is 350 mA. With the 5V voltage supply the series resistor for the LED is calculated by ohms law. $\frac{5V}{350mA} = 15\ \Omega$.

Inductor selection

Using same calculations shown below, inductor value can be chosen. The Vbat is using 3V and the frequency of the chip is 600KHZ. The delta I_L is maximum the current ripple, which is 10% of 3A according to our design. The output voltage is 5V.

$$I_L = I_{OUT} \times \frac{V_{OUT}}{V_{BAT} \times 0.8}$$

$$L = \frac{V_{BAT} \times \left(V_{OUT} - V_{BAT}\right)}{\Delta I_L \times f \times V_{OUT}}$$

The calculation result of the current through inductor is 6A and the required inductor is 6.7 uH. In the simulation, the value of inductor is set to be 6.8uH due to the availability of the inductor. This effectiveness of this value is validated by the simulation result.

2.3.8 PCB schematic and layout design

The PCB design tool is Cadence Orcad and allegro. All the parts are surface mount components, which means the area of whole board will be comparable small. The following figure 19 demonstrates a draft schematic design of PCB board, version 1. A revised version is considered if the first prototype has critical defects. The power outlet socket type has been determined to be a USB to 21mm Power Jack connector. In addition, another power outlet will be provided as the Pin format for debugging purpose.
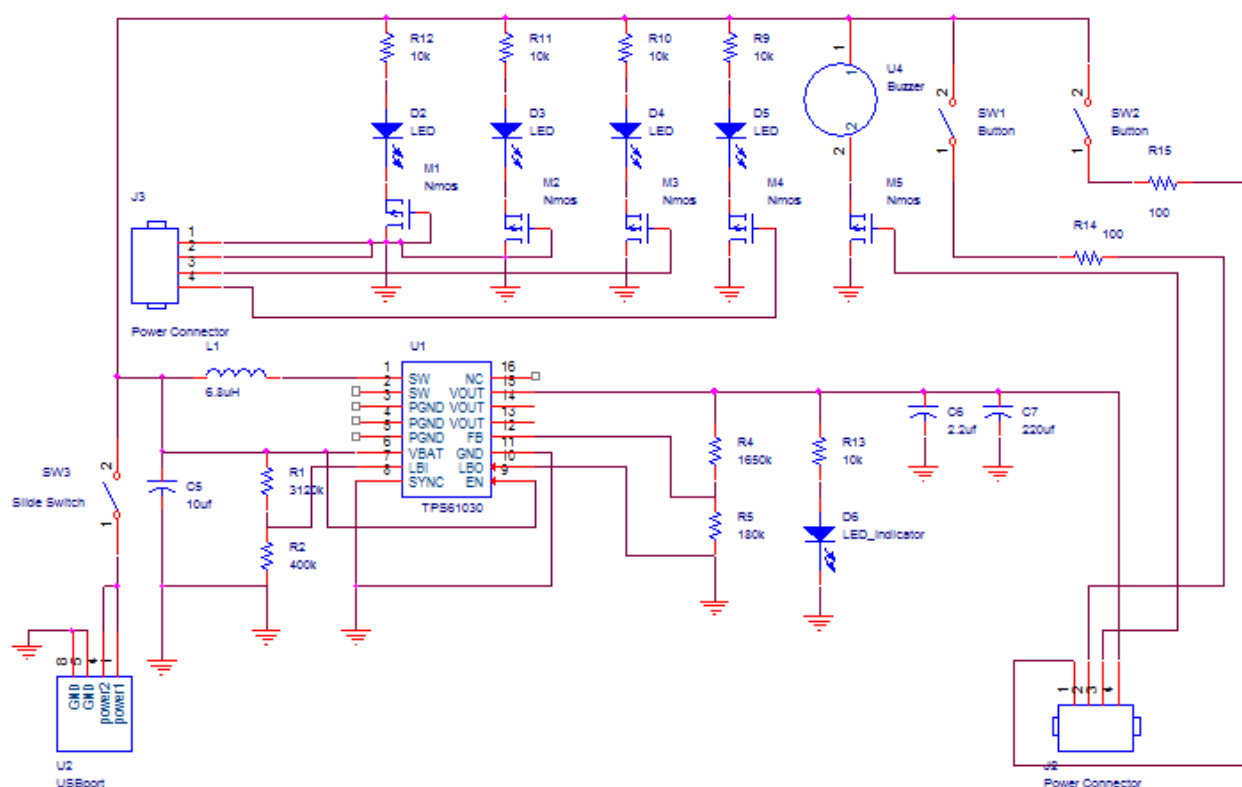
Figure 19. The first version of the schematic design the PCB board

3. Requirements and Verifications

3.1 Requirements	3.2 Verifications
3.1.1 Kinect Camera and Algorithm:	3.2.1 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.	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 LED array and buzzer to notify driver. IV. Able to respond correctly when buttons are pressed.	3.2.2 BeagleBoard: I. Send images collected to computer and display on monitor to check if it's correct II. Send outputs of the algorithm to computer to compare with the expected results. Make sure the errors are less than 20% at least, 10% or less would be better. III. Check if the LED array and buzzer behave correctly when the algorithm gives either negative or positive results IV. When LEDs are verified to be working, link the button to LED and check if LED lights when button is pressed. Also for buttons that represent

	photo taking, make sure a photo is taken and is stored.

3.1.3 Power/Control Unit:
 	
   I. Able to receive/sent control signals from BeagleBoard via GPIO.
 	
   II. Able to supply constant, clean 5V voltage with maximum current up to 5A via USB socket when input voltage is lower than 5V.
 	
   III. Able to provide sufficient power for the alarming LED array and buzzer.
 	
   IV. Able to turn off the alarming system by switch.
 	
   V. Able to send control signal to Beagle board to take initial pictures for driver for reference.
	3.2.3 Power/Control Unit:
	
	   I. Input pin of Beagle board and input pins of PCB connector should obtain have voltage when signal is sent.
	
	   II. A 5V voltage with 5% tolerance should be delivered to output USB port when input of the Power supply unit drop below 5V. High frequency signal noise in the supply voltage should be rejected by the regulator into 10% magnitude of noise.
	
	   III. The LED can illuminate normally with 57 lm ~ 62 lm under typical voltage 2.1V and the buzzer can make sound 88dB under 5V. Voltages are measured by oscilloscope.
	
	   IV. The alarming system stops working when slide switch is off.
	
	   V. The Beagle board is able to behave and execute designed functions when button is pressed.

3.1.4 Alarming devices	3.2.4 Alarming devices:
I. LEDs are able to have different frequency and lighting sequences of flashing (4 LED in total). II. Under the 5V input voltage. The buzzer is functional when it is excited.	I. The communication between the beagle board and the alarming LED/buzzer should be verified by the LED and buzzer's functionality in real time. The LED is able to flash with designated frequency and sequences defined by Beagleboard observed by naked eye. II. The buzzer sound can arouse significant attention from users who are closed to it with 0.5m.

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.

In addition, without owning a car for all of group members, a real power output (battery) on the car can be more complicated and unpredicted compared to the voltage

source in the lab. The estimated power consumption for the Beagle board and camera is 15 W. However, the power consumption varies significantly with the computational strength. Two regulators possible are required to provide enough current under limit.

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 name	Quantity	Unit cost ($)	Source	Part Number
BeagleBoard-xM	1	149	http://beagleboard.org/Products/BeagleBoard-xM	NA
Kinect for Xbox 360	1	99.99	http://www.xbox.com/en-US/xbox360/accessories/kinect/KinectForXbox360	NA
PCB manufacture	2	40	NA	NA
DC-DC switching regulator	1	4.15	http://www.digikey.com/product-detail/en/TPS61030PWPR/296-14416-1-ND/550629	TPS61030-32
Buzzer	1	3.64	http://www.digikey.com/product-detail/en/CT-1205CL-SMT/102-1267-1-ND/610975	CT-1205CL-SMT
Orange LED	2	3.17	http://www.digikey.com/product-detail/en/LXM2-PH01-0060/1416-1025-1-ND/3961130	LUXEON Rebel
Red LED	3	2.57	http://www.digikey.com/product-detail/en/XPERDO-L1-	XLamp XP-E LEDs

			R250-00501/XPERDO-L1-R250-00501CT-ND/2137037	
PMOS switches	5	0.35	http://www.digikey.com/product-detail/en/DMG1013UW-7/DMG1013UW-7DICT-ND/2183252	DMG1013UW
USB plug	2	2.35	http://www.digikey.com/product-detail/en/XM7A-0442A/OR1070-ND/2755612	XM7
Resistor	10	~0.2	Obtain from ECE store	
Capacitor	4	~0.8	Obtain from ECE store	
Inductor	1(6.8uH)	~0.1	Obtain from ECE store	
Power input socket	2 (4pins)	~0.5	Obtain from ECE store	
Mechanical push button Switch	2	1.49	http://www.digikey.com/product-detail/en/ESE-20C423/P12345S-ND/593508	ESE-20C
Slide Switch	1	2.00	http://www.digikey.com/product-detail/en/S101031SS03Q/CKN10054-ND/2043289	S Series Slide Switches
Diode	1	2.37	http://www.digikey.com/product-search/en?k=6TQ045S&mnonly=0&newproducts=0&ColumnSort=0&page=1&stock=1&quantity=0&ptm=0&fid=0&pageSize=25	6TQ045S
Car cigarette charger	1	15	NA	NA
Generic USB to 5.5 mm/2.1 mm 5 Volt DC Barrel Jack Power Cable	1	1.72	http://www.amazon.com/Generic-Volt-Barrel-Power-Cable/dp/B00304DZ7I	NA

4.1.3 Grand Total

Labor Cost ($)	Parts Cost ($)	Grand Total ($)
54000	387.65	54387.65

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	Gather and study information about BeagleBoard-xm
9/23	Determined the electrical components needed for hardware	Set down initial flowchart of algorithms and research on Histogram Equalization	Look into reference and schematic for BeagleBoard and how it would communicate with other devices
9/30	Design PCB board schematic	Work on algorithms tracking and identifying eyes	Install Linux system on BeagleBoard and get openCV on it
10/7	Design PCB layout and send to fabrication	Work on algorithms distinguishing closed eyes and opened eyes	Work on the communication between Beagleboard and Kinect
10/14	Obtain PCB Hardware parts. Simulate regulator	Work on algorithms for eye tracking at night with	Set down GPIO pins for input and output and write

	functionality	Histogram Equalization	drivers for handling them
10/21	Test communication between Beagle board and PCB	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	Debug and test corner cases
11/4	Revised board Soldering Completed	Week for adding extra work or handling emergency	Week for adding extra work or handling emergency
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

5. Ethics and Safety

5.1 Ethics

1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

By using our Driver Sleep Detection and Alarming System, customers would be warned when his/her physical condition is not good enough for driving and thus prevents dangerous behaviors from happening. It is consistent with the safety and welfare of the public.

3. to be honest and realistic in stating claims or estimates based on available data;

By collecting real time data and compare using algorithm, we try our best to give correct feedbacks and warnings to users.

5. to improve the understanding of technology; its appropriate application, and potential consequences;

By using openCV and related libraries, we try to develop and improve algorithm for eye closeness detecting. We then apply this technology to our application in order to help drivers achieve a better and safer driving condition.

6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;

We keep improving the algorithms for eye closeness detection and verify the results by real experiments. We'll also collect data from the results to analyze and state all the limitations that the application has.

7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

We consult Professor and TAs for review advices and improve, seek online resources to help correcting errors, and properly cite the contributions of other people.

9. to avoid injuring others, their property, reputation, or employment by false or malicious action;

We design our product using qualified components and follow proper safety rules, avoid wrong actions happening to other people.

10. to assist colleagues and co-workers in their professional development and to

support them in following this code of ethics.

We collaborate with teammates and help each other with their work in development. We also share the code of ethics among the group and remind us to follow.

5.2 Safety

When building PCB and soldering:

Due to all components are surface mount, the heat gun is required. The temperature of the heat gun is up to 370 C. Therefore, cautionary measure should be advised during the soldering process.

The upper voltage is 12V DC. This level of voltage can exert slight shock feeling but not detrimental. Electrical safety such as do not touch exposed wires is required.

When testing and using system:

Before driving, be sure to put the product at a smooth surface and stabilize it. Do not put it in front of driver since it would block the driver's sight. Plug in the USB convertor, use suitable length USB cable to connect it and out product.

For testing, first take pictures of closed eyes and opened eyes using buttons on the products. Then keep the car in parking, try closing eyes for a few seconds and see if the warning system reacts. Next start driving, make sure you have another partner in the passenger seat with you. During driving, stay focused and do not close eyes for too long a period, make sure the alarming system doesn't sound to disturb you from driving. Note, it is not advised to test the correctness of our system by closing eyes for too long a time while driving, instead, test it when the car is stopped.

For normal driving, make sure to open the device when you are about to drive for a long period of time (ex. longer than 1 hour on highway). When stop using the device, make sure it is turned off before leaving. Otherwise it may give consistent annoying warning.

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