ECE4007 Project Summary

Project Title	**Early Warning System for Collision Avoidance**
Team Members (names and majors)	Graham Fletcher (EE) George Yuchi (CompE) Ryan Baker (EE) Garrett Chinsomboon (EE)
Advisor / Section	Dr. Erick Maxwell / L03
Semester	2011 Fall Final
Project Abstract (250-300 words)	The team designed and built a system that detects and alerts drivers of impending collisions in order to reduce the number of accidents due to inattentiveness on the highway. According to published statistics, 26.5% of all collisions are front-to-rear, and 64% of those are due to driver inattention. The team's design reduces rear-end collisions by ensuring that the driver is alerted of potential collisions ahead of time. The system searches for conditions likely to result in a rear-end collision with a leading vehicle by calculating the current time headway and comparing it to a safe time headway. If a possible collision scenario is detected, the system warns the driver with an audio alert well before the collision becomes inevitable, giving the driver plenty of time to react. The design includes a laser rangefinder that allows the system to detect vehicles up to 300 yards away, and its output is relayed to the system laptop. An Arduino embedded microcontroller also interfaces with temperature, humidity, and rain sensors, and reports all of the acquired data to the controlling laptop computer, which is responsible for estimating the current headway times. The system processes the input from a USB camera using computer vision algorithms to detect vehicles and augment car detection from the rangefinder data. Alerts are issued via an Android mobile device, which is connected to the Arduino and mounted onto the dashboard of the user's vehicle. The mobile device displays a time headway progress bar and plays audio alerts through the vehicle's speakers. This system improves upon existing systems by taking into account road and environmental conditions, and uses both computer vision and laser range tracking as two independent vehicle detection systems. The final outcome of the design is a fully-functional prototype that costs approximately $1800 including all hardware expenses.

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List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	The codes and standards which affect our project are mainly the technology standards for communications and guides on traffic safety. These standards greatly affect the design since we are using these methods to communicate between different hardware components. **1. RS232 or Serial Port is a 25-pin serial connector** which communicates data from the laser rangefinder to the rest of the system. It features ● Highly customizable pin conventions ● 8-bit data transmissions **2. USB (Universal Serial Bus)** is a ubiquitous 4-pin serialized connector and handshake standard for communication between the webcam, Arduino, and computer. It features ● Self-powering connector ● Vast interoperability, library interface to Arduino ● 480 Mbit/sec transmission rate **3. I2C (Inter-Integrated Circuit or two-wire interface)** interfaces the temperature/humidity sensor to the Arduino and is a popular IC-level interconnect between micro-controllers and device drivers. It features ● 400 Kbits/sec data transmission ● Configurable master/slave instances ● Supported by the Arduino "Wire" library for rapid prototyping **4. The Class 1 (eye-safe) laser standard** applies to the laser emission cavity in the laser rangefinder. It specifies ● A laser wavelength of 905 nm +/- 10nm ● Low enough power output to prevent harmful exposure **5.** ***Manual on Uniform Traffic Control Devices***, published by the U.S. Department of Transportation, outlines: ● Normal pavement markings are "4 to 6 inches wide" ● "Broken lines should consist of 10-foot line segments and 30-foot gaps" ● Minimum highway lane width of 12 feet **6. ISO-9141-2** is an OBD-ii protocol used by Chrysler and many European and Asian vehicles. Communication occurs on a single, bidirectional line without handshake signals. ● Operates at 10.4 Kbaud ● Message length is restricted to 12 bytes, including CRC
List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	1) **Monetary & time constraints**: the laser rangefinder was chosen as the distance detector for our project mainly due to our limited budget. The preferred radar development kit was too expensive and the team members lacked the expertise to construct it within a semesters' time. The narrow field of view of the laser makes it difficult to detect the lead car during turns and along curvatures of the highway. The implementation of the servo for the rangefinder based on computer vision is also deemed unrealistic given the time available to complete this project. 2) **Conditions for computer vision & range detection**: Another debilitating limitation of the Early Collision Avoidance System is the conditions necessary for adequate visibility. Computer vision cannot operate under low visibility conditions such as fog. Also, the laser rangefinder is also limited by surfaces with poor reflectivity (dirty cars or dark-colored cars). The laser would sometimes return false or invalid readings. Other objects that may share the road with vehicles include cyclists and pedestrians but they may not be recognized by the system.

Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	1) **Laser instead of Radar**: Radar technology would have been the ideal technology to work with instead of laser but the price is way beyond the scope of this project. The development of the radar could be a senior design project in itself. The development kits available are extremely expensive. This technology would be able to have a wider field of view than the laser and is more like to detect the leading vehicle. 2) **Weather detection method**: Currently the group is using a series of temperature/humidity and rain sensors to determine weather conditions. Another option is to use a weather service in place of weather sensors to detect weather conditions. This would be done through enabling the GPS on the android phone, and through wireless communication, obtain the weather conditions of the vehicle's current location in real time. The advantage of this is it would be able to obtain the outside conditions which may not be picked up by the sensor system and factor that into the final alert. These conditions include icy roads, fog, mist, hail and etc.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** tradeoffs, interfaces, and/or interactions. *Complete if applicable; required if team includes CmpE majors.*	In terms of the hardware, a laser rangefinder, a USB webcam, an Arduino Mega ADK, a rain sensor, a temperature sensor, an Android device and a laptop computer will be used. Apart from the computer vision component, much software is needed to have all these components communicating. Moreover, the master controlling thread needs to oversee all these processes. Here is a list of hardware and software components 1) Laser rangefinder. The data rate of 10Hz (calibrated) ensures that the distance measurements are constantly up to date. This rate is crucial for especially for high speeds where there may be large discrepancies between each sampling. 2) The USB camera is used for vehicle detection. It is to be mounted up behind the windshield on the inside of the vehicle. The sensor resolution provides adequate clarity of vehicles ahead of it and compensates for closer vehicles that extend behind the minimum distance of detection of the laser rangefinder. 3) The Arduino ADK allows the microcontroller to interface with an Android device and a computer through the USB protocol, the laser rangefinder through RS232 serial communication, and the temperature/humidity sensors through serial communication. 4) The rain sensor, attached to the windshield of the vehicle, uses its infrared beams to detect the presence of rain. 5) The temperature/humidity sensor is used to determine if the environmental conditions are cold enough to warrant precautions against icy roads. 6) Software for computer vision, analyzing the captured video in real time 7) Software for communication: rain sensor-Arduino, temperature sensor-Arduino, Android-Arduino, laser rangefinder-laptop 8) GUI development for user. There is the GUI on the Android that will issue the alert and the GUI on the laptop showing real time video and information Since the laser rangefinder reports distance readings to anything ahead of it, not just vehicles, and we must determine whether or not the data is valid. This will be accomplished using computer vision. First, the current lane will be detected. Next, vehicles will be detected by searching for Haar-like features that match characteristics found in our training data. When a vehicle is detected, its location will be followed for several frames, and if it is determined to be in the same lane as the following vehicle, it will be classified as the lead vehicle and the method for predicting collisions will be employed. It is possible that the laser may provide the system with an invalid reading; in that case, we will employ a Kalman filter to predict the position of the lead vehicle based on previously obtained results. The primary function of our system is to calculate the headway time, and once that time falls beyond a certain threshold, our system will notify the driver with an alert.