Optical Communication Based Vehicle Collision Avoidance System(TCAS)

National institute of Technology, Rourkela

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Project Abstract

Keywords— Road Mishaps, Li-Fi, Optical Communications, Energy Efficient, Driver-Independent, IoT, Pulse Position Modulation(PPM),Visible Light Communications

The major cause of deaths in Indian roads is due to collision of vehicles. This is a direct consequence of driver error, vehicle failure, amongst other reasons. Most of these catastrophic accidents occur during night time, when the human mind is least aware and the reflex time is at its minimum. In order to address the persistent problem, the proposal is to design a communication systems for vehicles by virtue of which they would be able to "Talk-To" each others on the roads. Instead on concentrating on costly hardware, the proposal uses pre-existing infrastructure to design the Alarm System. The merits of
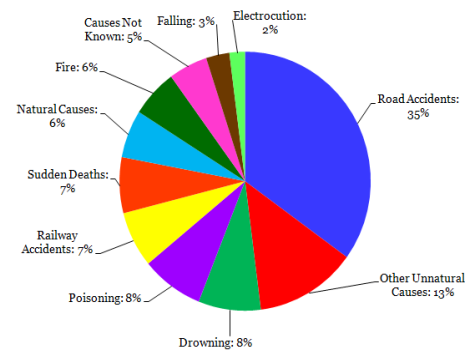
BLOOD ON ROADS

PERSONS KILLED IN CRASHES DUE TO MANOEUVRING

Overtaking	26,829
Diverging	21,385
Crossing	18,078
Turning right	9,442
Turning left	7,153
Merging	7,081
Making U-turn	5,624
Stopping	4,745
Stationary	4,656
Reversing	4,125
Parked	3,462

Licence	Crash	Fatalities
Regular	3,89,974	40,488
Learner's	50,815	8,347
No licence	39,314	7,573

Various Causes Of Accidental Deaths In India In 2011

- Causes Not Known: 5%
- Falling: 3%
- Electrocution: 2%
- Fire: 6%
- Natural Causes: 6%
- Sudden Deaths: 7%
- Railway Accidents: 7%
- Poisoning: 8%
- Drowning: 8%
- Road Accidents: 35%
- Other Unnatural Causes: 13%

Total Number Of Accidents: 390,884

Source: National Crime Records Bureau

Optical Wireless Communication was demonstrated by Mr. Harold Hass in a TED event. And we realized that since all vehicles have light bulbs, the same bulbs may be used as a wireless communicator.

The proposed system modifies or replaces the bulbs with LED lamps so as to make them transmit a continuous signal when switched ON. A photo detector receives the data transmitted from other vehicles and determines their approach speed and relative orientation. In case of impending collision, an alert signal is given to the drivers of all involved vehicles to take the final evading action, thereby preventing a collision.
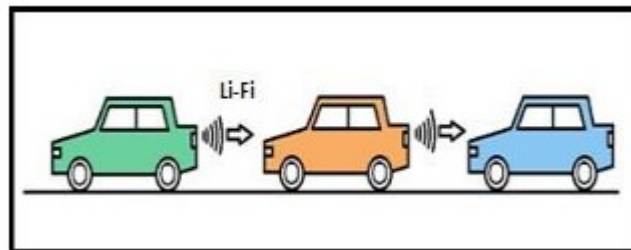
The solution thus achieves a high level of automation and demands human action only when absolutely necessary. The system thus implemented is affordable, robust and would definitely help in bringing down accident-related deaths on Indian roads.

Team Members – Roles & Responsibilities

S.No.	Student Member Name	Role (Choose one of the following – Marketing, Technical, Operations & Other Roles as applicable)	Justification
1	Sagnik Basu	Technical	Outstanding Technical proficiency i Undertaken many similar projects Currently working on networking and wireless communications
2	Sambeet Sahoo	Technical, Operations	Currently working on PV based power electronics. Technical head of Plugged_In Working in operations team of BSI,NITR
3	Mahesh Ku. Guin	Marketing, Operations	Working in management team of FSAE, NITR Experience in organizing various workshops like TI event in NITR

Market Analysis

A. Customer Need Identification:

1. All drivers will use **roads** safely and cautiously to help keep themselves and others safe.

2. An automatic system which needs least human efforts.

3. Saves Life, Money and Property.

4. High level of accuracy in all conditions.

B. Serviceable Addressable Market (SAM)

Total Addressable Market(TAM) : All the vehicles may be equipped with the device.

Total Serviceable Market(TSM) : We are targeting the vehicles mostly associated with highways and those commuting at night. These vehicles represent the market where the

product would see maximum sales.

C. Product Differentiation w.r.t. Competition & Justification

The road safety market is expected to be worth 3.63 billion USD by 2020.
(source : marketandshares.com)
Since India is a very large market , both for production and consumption of
vehicles, we are certain that India shall have a major percentage in the above
expectations. India had **182 million registered vehicles** in March 2013.

All existing technologies concentrate on using GPS and modem.
The problem lies with inaccuracy associated with GPS which gives distance within
a certain range. This is problematic in case of collision systems.

The proposed solution does not use RF frequency and hence does not conflict with
spectrum sensing. By using visible light communication , interference with these
devices is avoided.

Understanding of customer & user

For the proposed product, the user and customer are the same, and refer to the
person who purchase and install the system in their vehicles.

1. Low power consumption, no additional battery packs
2. Highly modular approach in product designs makes it easily adaptable
3. Can be added to any vehicle
4. No interference with User's wireless network
5. Almost zero maintenance

D. Distribution Channel Identification

As a jump start, special kiosks would be set up to upgrade the existing
vehicles.

Considering its small size and minimum changes in vehicle designs, vehicle
manufacturers will be encouraged to have the system installed in the
production lines itself. This would ultimately lower the user-end cost of the unit,

while maximizing the benefits for the manufacturing company as the cost saved in transportation, maintenance of stores and employees is saved, thus adding to the net profit margin

A dedicated website will provide all related information and virtual training for the user. All customers would be entitled to lifetime bug-fixes and security patches for the system and all updates would be serviced by the website.

Proposed Design

A. **Objective** -

To address the very high rate of deaths in Indian roads owing to vehicle accidents. The proposal aims to design a system which is based on wireless optical communication principles and hence implement a collision alarm system.

B. Proposed Solution:

The solution of the above problem statement is achieved by simply implementing a system on all vehicles that relays it's PRESENCE status to all other vehicles in its vicinity.
The system thus designed would have the following major subsystems:

1. A Transmitter: This is implemented using simple LED lamps, programmed to transmit a unique vehicle identification number (henceforth called as ID). The distinct advantage is that LED switching can be modulated at a very fast rate, thus having no effect on its intensity as sensed by a human eye. And with Li-Fi offering a much bigger bandwidth compared to radio waves, the device will be able to operate at any desired range.Modulation techniques like Pulse Position Modulation(PPM),VPPM etc will be used for modulating the light signal.
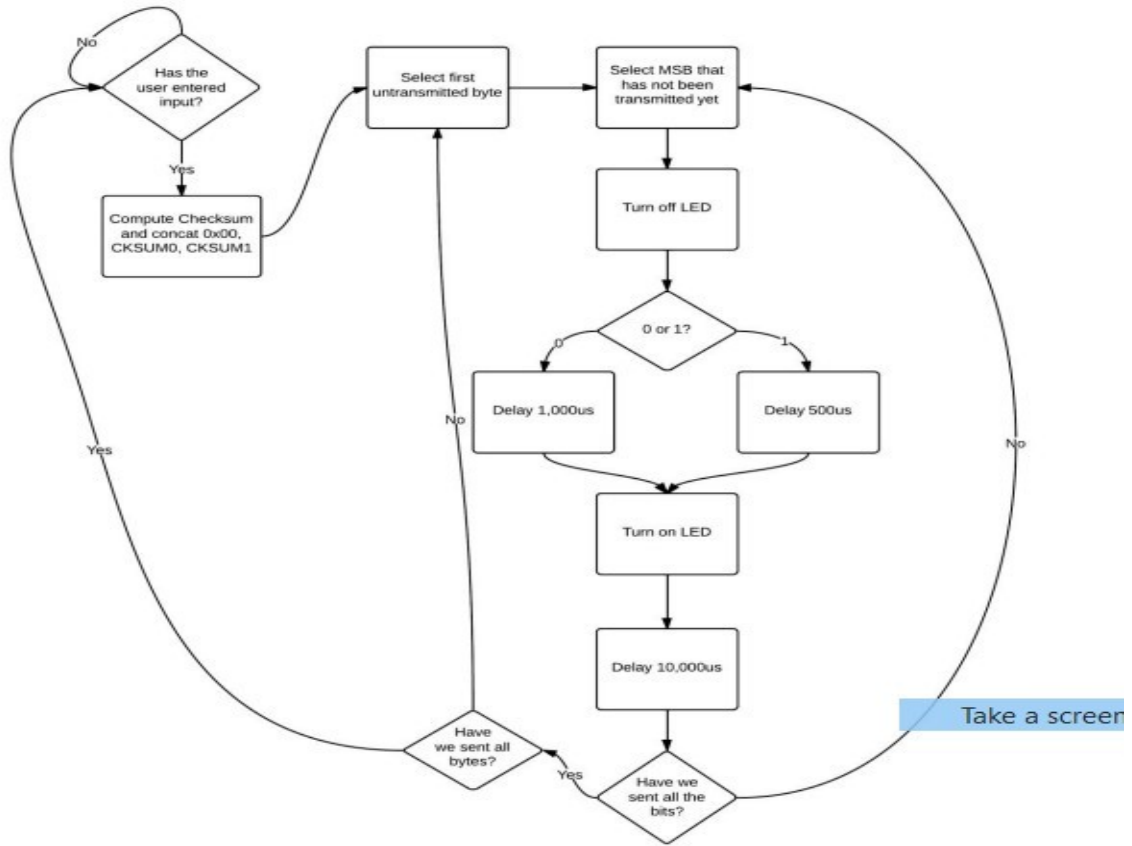
2. A Receiver : This is the receiving unit of the system. The ID transmitted will be received and hence the distance of the nearby vehicles would be monitored. Depending on the distance, only the nearest vehicles would be tracked for they pose the most immediate collisioncourse. This monitoring will be updated regularly,
as the vehicles move relative to each other.
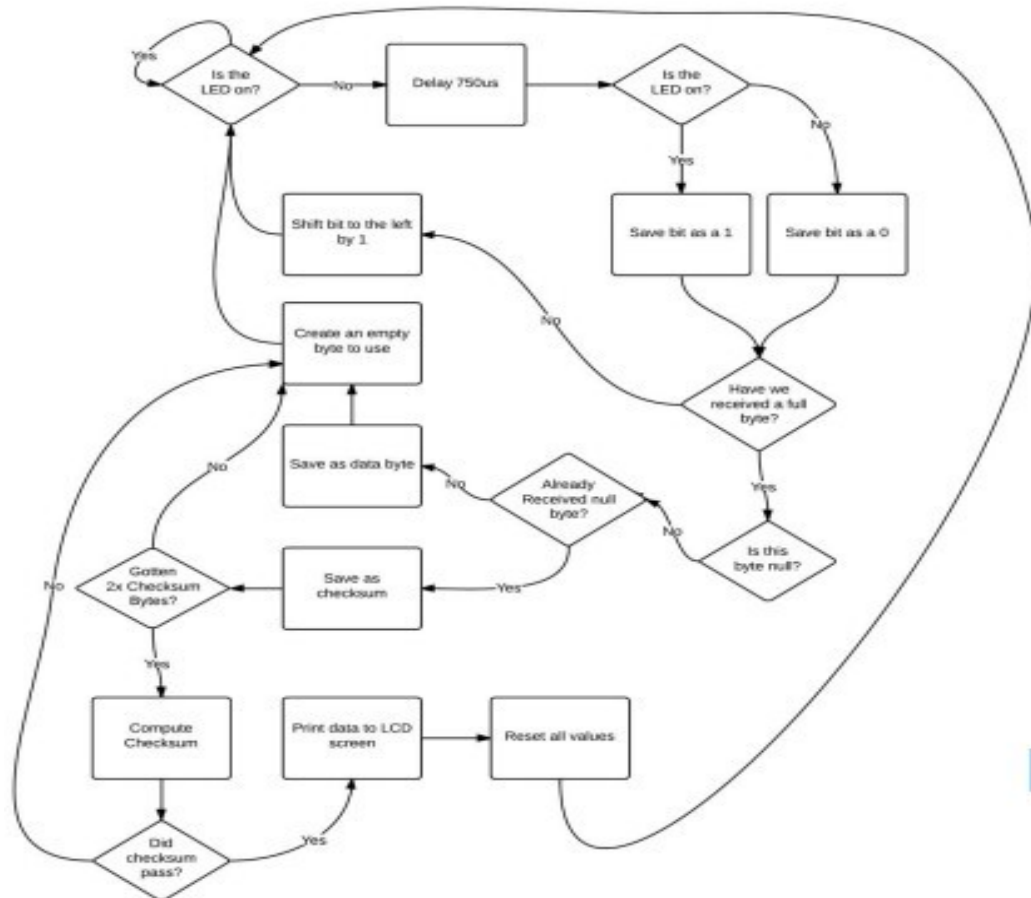
(Source : DATA TRANSFER USING LIGHT, RYAN SUAREZ)

    3. Alarm System : In case two vehicles approach each other beyond a   threshold safe distance, the alarm would be   triggered for the user.

    4. Micro-controller Unit : (henceforth called as MCU) :
        A low power MCU (ARM - based) \ DSP board would run all the algorithms and monitor the transmitter and receiver.
        Data packet generation , exchange and reception is handled.
        In case of collision, alarm is triggered for final correction by the user.

Data Packets:

The following Data would be exchanged between the vehicles(called participants)

1. ID of each participant
2. Encryption bits.
3. Checksum

The ID would uniquely identify each vehicle. Each vehicle would generate an ID for recognition. This would be encrypted with a 16-bit AES encryption code whose key shall be with all devices. To prevent errors while transmission, a security checksum would be appended to each data packet.

On the reception side, from the data packet, the ID would be extracted, following decryption and checksum completion. Once a two-way communication is established, the distance of their relative approach must be calculated for the alarm mechanism. In order to achieve this, the participants would communicate with PINGs and ACKNOWLWDGE(ACK) bits from which distance is calculated with a simple algorithm.

C. Components Used:

TI Part Number (link all the parts to their respective	How is it being used in the proposed solution? Explain its role/functionality

product page on the TI website)	
OMAP DSP kit http://www.ti.com/tool/tmdslcdk138	For implementing various signal processing algorithms
SITARA AM57x kit http://www.ti.com/lsds/ti/processors/sitara/arm_cortex-a8/am335x/overview.page	Micro-controller for PWM generation,data packet processing
TLC592x http://www.ti.com/product/TLC5940	LED driver
TLV2372 http://www.ti.com/product/TLV2372	Rail-to-Rail Operational Amplifier for signal conditioning.
OPT101 http://www.ti.com/product/OPT101	Photo diode. For receiver part of module.
DAC9881 http://www.ti.com/product/DAC9881	To be used on transmitter side .
LMZ31704 http://www.ti.com/product/LMZ31704	Power supply design for our product
TI LOG114 http://www.ti.com/product/LOG114	Logarithmic amplifier for analog signal conditioning

Non - TI Parts	How is it being used in the proposed solution? Explain its role/functionality
SPI TFT LCD	For visual display
PIEZO ALARM	For alarming system
CREE X Lamp	For trasnmitting light pulses
Photo-Transistor	Receive side
Bi-directional LED **TSOP**	

USB PCB Adapter	To interface USB connector with circuit board

Innovativeness of the Proposed Solution:

Using Light for communications is a very effective means for designing a traffic safety system. Li-Fi technology combines spectral efficiency with power efficiency and allows very high speed data communications to be reliably achieved using LED lighting infrastructure as the transmission channel. The concept of Li-Fi is currently attracting a great deal of interest because it offers a genuine and very efficient alternative to radio based wireless. It solves issues such as shortage of radio frequency bandwidth. This new Visible Light Communication (VLC) technology has grown in practical application like Smartphone, Laptops. In future we will not have 14 billion light bulbs, we may have 14 billion Li-i's deployed worldwide for a cleaner, greener and even a brighter future.

Most communications toda use the RF spectrum. However our spectrum is limited and every year number of wiress devices are connected to RF are increasing exponentially. Also most wireless sensor networks communicate by using spectrum sensing technology and in case of a busy channel they may fail to transfer their data. All these constraints are not available in VLC communications. Also there is no license on visible light frequency spectrum,hence manufacturing devices using such frequency will be quite less.
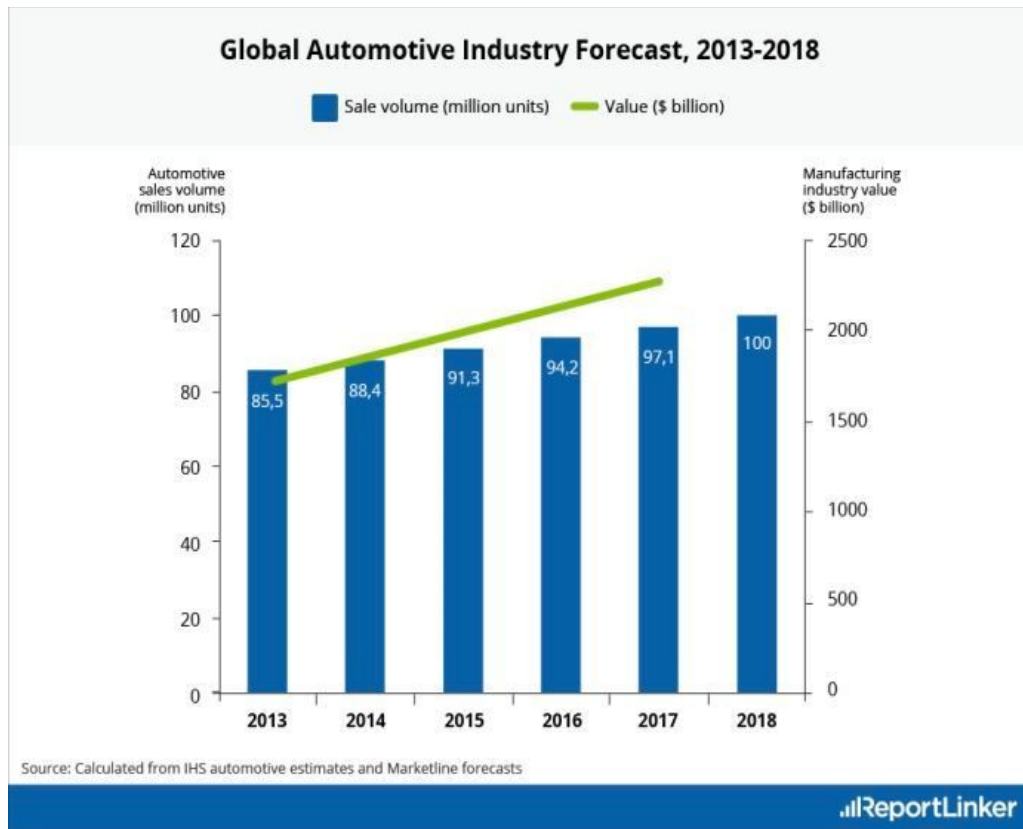
Impact of the proposed solution:

Today, various institutions all around the world spend huge capital for road safety equipment. With increasing population , urban roads are bound to be crowded and in such case road safety are of paramount importance. There is a paradigm shift from conventional means to more technologically superior and smart systems which provide better security to both the driver and his surroundings. Market research analysts predict substantial growth for manufacturers of collision avoidance systems with an overall market growth rate of over 22% until 2019. Analysts expect the demand and sales of collision avoidance systems to increase considerably during the forecast period.

Global Automotive Industry Forecast, 2013-2018

Source: Calculated from IHS automotive estimates and Marketline forecasts

From the bar graph above ,we can see the rising sales in automobiles every year. Hence if our concept is proven and becomes marketable, it will become a profitable venture.

Our key target audience will be ;

- Government agencies
- Road Safety OEMS
- Road safety service provider
- System integrator
- Consulting firms
- Research organization
- Resellers and distributors
- Investment/Equity research firms