

COLLISION AVOIDANCE SYSTEM PROPOSED BY A MODEL USING NRF24L01 AND INFRARED SENSOR



Inspiring Excellence

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I, hereby declare that this thesis is based on results I have found by myself. Materials of work from researchers conducted by others are mentioned in references.

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ABSTRACT

Vehicular accident is tremendously increasing day by day around the world, especially in small and large urban areas. The resulting collision has become a key issue and emergency as a recent research topic in automation in Transportation. A collision avoidance warning system can realize wireless communication between vehicles. Vehicle to vehicle communication system can be very effective to reduce the collision. A new technology will be available, when all the vehicles are equipped with latest sensing technology integrated with wireless technology. In any safe or risky driving conditions the driver will be informed to drive carefully, effectively avoid the happening of the vehicle accidents. When the vehicle will be in a risk situation the system which is based on NRD24L01 and Infrared sensor will pass a signal to the driver through the LED light signal so that the driver can instant take a decision to make the vehicle in a safe mood, effectively avoid the happening of vehicle accidents.

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Chapter1

Introduction

In this paper, I discuss my research work briefly and proposed a model based on collision avoidance system. In this chapter all my analysis and prediction solution is given.

1.1 Introduction

Now a days, road accidents is becoming a common phenomena in our country. Everyday a huge number of accidents is occurring in different parts of the country. The major problem of this case is not getting proper signal and directions. Our drivers are always in a mood of driving in their sweet will not knowing the fact of collisions. One save step of them can avoid collisions as well as damages. Accidents is not only the matter of injury but also damage of the vehicles is also a part of accident. In this paper, I gave the information of accident of last few years. According to the report, a total of 3,412 people were killed and 8,572 others injured in 2,998 road accidents in 2016[1]. The country witnessed a 35% decrease in road accidents while around 45% fall in casualties in 2016 compared to the previous year, according to the report of the National Committee to Protect Shipping, Roads and Railways(NCPSRR). 470 women and 453 children were died according to the casualties. On the other hand in 2015 rate of the road accidents were 4,592 which killed 6,823 people, 781 women and 762 children including and 12,026 wounded. The percentage showed that 34% while deaths by 50% and injured 39% in the just concluded year in 2015. In 2017 road accidents across Bangladesh was 3472 where 4,284 people, 516 women and 539 children were killed and 9112 were injured[2]. Between January 1 and December 31 fatal accidents took place in several highways and national, inter-district and regional roads. Compared to 2016 and 2017 the number of accidents increased 15.82% and death 25.56%.

In figure 1 which is given below, road accidents fatalities is shown. January to June of 2016 and 2017 differences is shown here. The red bar shows the number of 2016 and the blue bar shows 2017 numbers of deaths through the road accidents. In January'16 the number of deaths was 340 and in January'17 the number increases 416. Same goes in February, 2016 it was 356 and 2017 it was 427. March'16 deaths was 309 and 2017 it was 362, April'16 deaths 309 and 2017 it was 349. A huge difference happened in May'16 and 2017, 2016 the deaths was 292 which was apparently a low amount but in 2017 May it was 410 which was so huge.

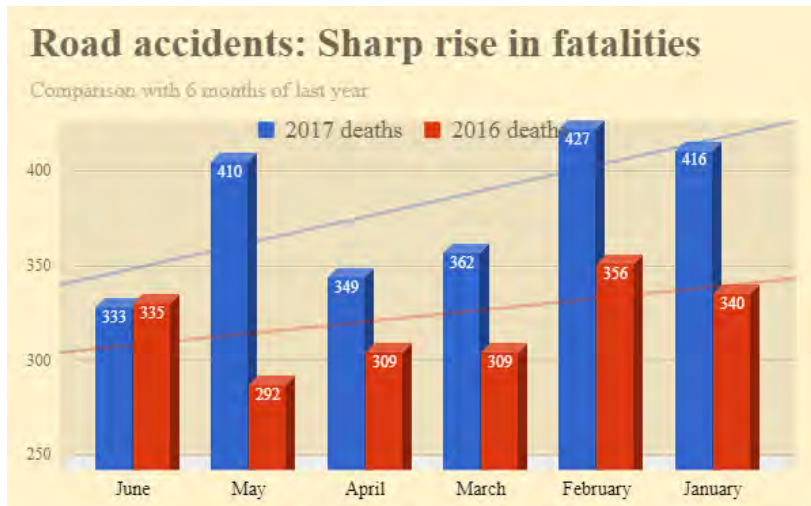


Figure 1: Road accidents: Sharp rise fatalities

Table 1: Road and accidents casualties statistics(2009-2016)

Year	Number of accidents	Death	Injury
2009	3381	2958	2686
2010	2827	2646	1803
2011	2667	2546	1641
2012	2636	2538	2134
2013	2029	1957	1396
2014	2027	2067	1535
2015	2394	2376	1958
2016(up to July)	1489	1422	1289

The data was collected from data.gov.bd

Road accidents and casualties statistics is given in Table:1 of 2009 to 2016. Number of accidents, deaths number and injured number is given here. The dataset was taken from source

data.gov.bd where estimation was shown. After viewing the statistics one thing is clear that the number of accidents is sometimes increasing and sometimes decreasing. Lots of steps and stands already taken but the control of the road accidents is not up to the marks. In 2009 the number of accidents was 3381, deaths 2958 and the injured number were 2686 and in 2016 up to July, 1489 was the total number of accidents and 1422 deaths number and 1289 was injured number. Half of the year of 2016 the number of accidents was too shocking. If we see in 2010 the number was 2827 after that the number of accidents were decreasing but in 2015 again it increase 2394, deaths 2376 and the injured 1958, the number of accidents and the deaths number was almost close. The accidents is becoming an alarming issues day by day, necessary steps should be taken in a very strict way.

Collision between vehicles are getting random and in a extreme position that it should come to an solution to avoid those collisions. This major problem is not only damaging vehicles but also taking a huge amount of lives. Damage things can be repaired but lives can't be back. A system must be needed where drivers can come to take a decision by having a signal of the upcoming situations to avoid the happening accidents. Lots of technologies are already working to reduce collision problems and make a new method which will be available and easy to use and understand. Efficient systems can make a nice revolution to avoid those collisions.

1.1.1 Vehicle to vehicle communication

Vehicle to vehicle communication is the wireless transmission of data between motor vehicles. The goal of v2v communication is to prevent accidents allowing vehicles in transit to send position and speed to one another. Depending upon how the technology is implemented, the vehicles driver may simple receive a warning should there be a risk of an accidents or the vehicle itself may take preemptive actions such as braking to slow down. V2V communication is expected to be more effective than current automotive original equipment manufacturer (OEM) embedded systems for lane departure, adaptive cruise control, blind spot detection, rear parking sonar and backup camera because V2V technology enables an ubiquitous 360-degree awareness of surrounding threats. V2V communication is part of the growing trend towards pervasive computing, a concept known as the Internet of Things (IoT).



Figure 2: Vehicle to vehicle communication.

V2V communication is now a very effective way to avoid collisions. In figure:2, the system is shown by a model how it will work in the road and how the vehicle will communicate with each other. V2V means that both vehicles will send signals to each other by using any wireless sensors which will connect them by communicating with their external environments[3]. The collisions avoidance system can reduce accidents and it also plays an important role to improve traffic systems[6]. By installing the sensor on the car that can give a signal to the driver by which the driver can be alert. Having the ideas of wireless sensor among all nRF24L01 sensor has both receiver and transmitter. Another sensor Infrared is also installed to give the signal direction of the other vehicles whether it is on the same direction or opposite.

1.2 Motivation

The main motivation behind the research was to make an effective way to avoid collisions. Lots of companies are already working to make different systems that can help to reduce collisions as now a days, it has become an alarming issue. The main goal of my research was to make a system which will minimize the amount of collisions. Applying the method of V2V communication a model I proposed which will be effective. After analyzing lots of methods come up with the sensor NRF24L01. This sensor will give signal to the driver by which the driver can take decision. An Infrared sensor is also including to the system by which the driver will come up with the information whether the vehicle is the same direction or opposite direction. NRF24L01 will be connected to the Adriano as well as the infrared sensor. NRF24L01 has a huge range to cover a standard range will be installed and five LED signals will be given. First five cars which will come to the range it will give signal to the driver and by that driver will take decision. My approach was to propose an model based on the alarming problem. At the last my proposed model will be compared with another model which is already working to give an idea which will be much effective to avoid collisions and bring safety.

1.3 Thesis contribution

By the research, with the sensor NRF24L01 and Infrared sensor to avoid collision can make a great contribution to the avoidance system. Lots of experiments had already done to make a solution of collision avoidance system. In this system, the combination of NRF24L01 and Infrared sensor it is different from the other system because it is giving the signal via LED lights which will be setup in-front of the driver so that the driver can easily see the signals and take the adequate decision to keep safe. Signals of the LED lights will be given by a Green and Red color. Green is the safety mood, Red is the not safe mood and if the light blink with Red signal mean it will give signal Red and also start blinking then it is the risky mood.

1.4 Problem and Solutions

The problem that I faced through the research and the experiment is that getting data. Some random data was generated to see whether the system is effective or not. Some ratios was

taken from different paper, cases to see how it will be effective to avoid a collision. Mathematical expression was also applied to see the system efficiency.

1.5 Methodology

NRF24L01 Sensor

This module based on Nordic nRF24L01, highly integrated, ultra low power (ULP) 2Mbps RF transceiver for the 2.4GHz ISM (Industrial, Scientific and Medical) band. Nordic nRF24L01+ integrates a complete 2.4GHz RF transceiver, RF synthesizer, and baseband logic including the Enhanced ShockBurst™ hardware protocol accelerator supporting a high-speed SPI interface for the application controller.

Table 2: Features and Specification of NRF24L01

Features	Specifications
1. Worldwide license-free 2.4GHz ISM band operation 2. 250kbps, 1Mbps and 2Mbps on-air data-rate options 3. Enhanced ShockBurst™ hardware protocol accelerator 4. Ultra low power consumption – months to years of battery lifetime	1. Power supply : 1.9~3.6V IO port working voltage : 0~3.3v / 5v 2. Transmitting rate : +7dB 3. Receiving sensitivity : ≤ -90dB 4. Transmission range : 250m in open area 5. Dimension : 15x29mm

In table:2, features and specification are mentioned of NRF24L01 sensor. NRF24L01 is a 2.4GHz ISM band operation, 250m range in open area 100m is the standard range but in the proposed model I used 50m as in roads there are sometimes buildings around for which signals sometimes can't be found. Enhanced ShockBurst™ hardware protocol acceleration is used.

Infrared Sensor:

There are two types of infrared (IR) detectors, active and passive. Active infrared sensors operate by transmitting energy from either a light emitting diode (LED) or a laser diode. An LED is used for a non-imaging active IR detector, and a laser diode is used for an imaging active IR detector. In both types of detectors the LED or laser diode illuminates the target, and

the reflected energy is focused onto a detector consisting of a pixel or an array of pixels. The measured data is then processed using various signal-processing algorithms to extract the desired information. Active IR detectors provide count, presence, speed, and occupancy data in both night and day operation. The laser diode type can also be used for vehicle classification because it provides vehicle profile and shape data.

Following are the characteristics of Infrared waves:

- Frequency Range: 300 GHz and 400 THz
- Wavelength Range: 1 mm to 750 nm
- Sensing range or distance: 10 to 30 meters.
- Data rate: 300 to 115200 bps (Serial Infrared), 4 Mbps (Fast Infrared)
- Number of devices: 2 in connection mode
- Modulation type: Pulse Position Modulation

1.6 Data

For my research, the data used was taken by National Highway Traffic Administration and I compared those data with my model by using it in calculation. To make the model I consider some scene of accidents that happened previously and want to make a solution how in all aspects my proposed sensor will overcome the situation.

1.7 Thesis outline

- Chapter 1 give a brief overview of my research, my estimated goal and what I gained.
- Chapter 2 discusses about the literature review and background study of my thesis, what perspectives I consider to make the system to avoid collision.
- Chapter 3 gives the idea about the proposed model I give for collision avoidance system and the reason behind choosing it.
- Chapter 4 give the steps of the experiments with a mathematical model and hardware implementation.
- Chapter 5 ends my paper with the conclusion and proposed future work for the system.

Chapter 2

Literature Review

The rear end collision is one of the major type of accidents that bring unnecessary casualties and property losses[8]. In this paper, a system was introduced to avoid collision based on the vehicle to vehicle communication with some driver behavior by using a car following model based on risk perception. Mainly the rear end collision avoidance system detects the risk situation based on the information collected by the radar and camera. The system will give a warning to the driver that the speed is not safe and it is on a risk situation and helps the driver to brake[8]. Car-following model is one of the most important gist for avoiding rear-end collisions system by connected vehicles the data obtains by subsystem includes speed, acceleration, heading position and other information collected by the on-board sensor. The GPS collects the information of position, speed and heading and the TP-link or Denso shares and receive the message of motion data, EVB can reduce the vehicle's speed, the screen and loudspeaker give the warning of danger to drivers[8]. After getting the information, the research should be focused on the way to avoid the collision, first step of avoiding rear-end collision, targetrecognition is the foundation of the danger identification. The following car needs to find out which car is the correct leading car, because that, the system receives two or more cars' motion data[8].

Now a days intelligent transport systems(ITS) using vehicle to vehicle(V2V) and vehicle to infrastructure(V2I) communications technology[9]. These systems allows vehicles allows to shared signal through the GPS-based information, such as speed position latitude longitude and heading as well as important data such as brake events, throttle position, turn signal status etc. A pre-crash detection and warning system in a host vehicle(vehicle of interest) needs to accurately determine not only the position of each remote vehicle in its vicinity, but also the contextof the driving environment because the context can provide important information about whether or not the remote vehicle poses a threat to the host. In this paper a real time algorithm is proposed that computes relative position and the driving position of all remote vehicles with a region of interest of the host vehicle[9].

V2V is a new system that helps the driver to avoid the danger as it is giving signals[9]. V2V communications use on board dedicated short range radio communication(DSRC) devices to transmit message about the vehicles speed position heading brake and other information of the other vehicles within the range and line-of-sight capabilities that exceed current sensor board vehicles safety system. The longer detection distance and ability to see around corners or through other vehicles helps V2V equipped vehicles perceive some potential crash scenarios sooner than sensors, cameras, or radar can and warn driver[9].They included some model about how the cars moves through lane wise[9]. The model is about changing lane of cars. Situation was like one car wants to change the lane but in front of the that particular car there are several cars and as well behind of it. By V2V communication that particular car can get the signals from other cars about there position speed etc and can take the decision what it will do. GPS board will pass those info among the cars. The GPS and communication-based technology offers the promise of expanding and enhancing the drivers field of view.V2V data was collected from the Michigan Mobility Transportation Center of drivers in and near Ann Arbor Michigan USA. There was total 1825 drivers in two days,

1.Vehicle Id. 2. Trip Id 3. GPS Latitude (5 decimal digits) 4. GPS Longitude 5. Time stamp 6. Vehicle speed (m/s)[9].

In this journal they proposed an design that will use a camera in front of the car and a LEDscreen signal back side of the car[10]. By this the driver can easily see vehicles positions. While driving drivers need to know the positions of other cars around it. A particular car is moving now it want to overtake but don't know what is in front of that car. As a LED signal is there so by sending signals it can easily see what is in front of that car and can take decision while it will over take or not. LED Signal like red and green light can be included or a small screen can also be there by this the driver can easily see the front view.

Vehicle to vehicle one of the worlds frontier research in the field of road traffic safety, it is effective measure to solve the road traffic system[6]. To get a safety distance model a safety collision distance algorithm and drive lane localization algorithm was proposed. When the vehicle have a rick of collision, HMI can sound n alarm in time and simulate vehicle brake automatically, effectively avoid the happening of vehicle accidents[6]. A mathematical model was proposed based on a drive lane localization algorithm which in the basis of two-lane highway. Using vehicle position in the coordinate system and lane position rules and vehicle safety distance model. An warring will be occurred when it will face danger. If the distance is less then the safety distance the system will warn and if the distance is more then the system will again warn but that is the state is safe. When the vehicle will take the decision of lane

changing DSRC communication results obtains ahead vehicle's position, speed, steering wheel angle and follow vehicle's speed and position information[6]. The system accord to the near, medium and long range to classify various warning conditions which set appropriate warning mode and technological mode for each reminder warning condition. To prove the validity of the algorithm collision warning model in Simulink, using dSPACE to achieve HIL test.

Table 2:Highway warning classification

Warning distance	Short(0-200m)	Medium(200-500m)	Long(more than 500m)
Specific Conditions	Collision warning	Default of vehicle early warning	Weather warning
	Lane changing warning	Road accident warning(can pass)	Road condition warning
	Highway early warning	Road accident warning(can't pass)	Service station
	Highway export warning		
Warning method	High frequency alarm	HMI display, alarm	Low frequency alarm
Communications method	DSRC	DSRC	4G
Technical requirements	Minimum feq:10Hz	Minimum feq:10Hz	Minimum feq:1Hz
	Max latency: 50ms	Max latency: 100ms	Max latency:500ms
	Minimum positioning accuracy: 1m	Minimum positioning accuracy: 1m	Minimum positioning accuracy: 1m

In table:2 a highway warning classifications is given where in how the system will work is given. A warning distance is classified and which distance which type of alarm will be given is measured. The communication method is based on DSRC. Three type of distance is taken short, medium and long. Each type has its own nature and alarm system. Each type alarm system is also different from each other.

From industrial researches studied the effectiveness of a rear-end collision avoidance system capable of working on both straight and curved sections of highway. They identified four key elements: forward looking sensor (laser radar), path estimation, collision prediction and automatic brake control. Fujita et al. [7] proposed a radar-based automatic braking system to prevent the vehicle from a rear-end collision or to reduce the impact speed without adverse effects on normal driving. Araki et al. developed a rear end collision avoidance system by integrating CCD cameras, a laser radar and a fuzzy learning algorithm from the driver's brake timing. Barber et al. presented two collision warning algorithms based on time-to-collision, range, range rate and relative acceleration. Seiler et al. derived a collision warning algorithm using parameters estimated from a tire-road friction estimation scheme.

The two-second rule (also known as the three-second rule in some states) is a rule of thumb by which a driver may maintain a safe trailing distance at any speed. The rule is that a driver should ideally stay at least two seconds behind any vehicle that is directly in front of his or her vehicle. It is intended for automobiles, although its general principle applies to other types of vehicles. The two seconds is not a guide to safe stopping distance. It is more a guide to reaction times. The two-second rule is useful as it can be applied to any speed. It is equivalent to one vehicle-length for every 8 km/h (5 mph) of the current speed, but drivers can find it difficult to estimate the correct distance from the car in front, let alone to remember the stopping distances that are required for a given speed, or to compute the linear equation on the fly. The two-second rule gets around these problems, and provides a simple and common-sense way of improving road safety. The practice has been shown to considerably reduce risk of collision, and also the severity of an accident, if an accident occurs. It also helps to avoid tailgating and roadrage for all drivers. The risk of tailgating is largely caused by the accident avoidance time being much less than the driver reaction time. Driving instructors advocate that drivers always use the "two-second rule" regardless of speed or the type of road. During adverse weather, downhill slopes, or hazardous conditions such as blackice, it is important to maintain an even greater distance.

2.1 Background Research

In background research, I describes about how NRF24L01 sensor and Infrared sensor can avoid collision. Some major types of accidents is found and some crash avoidance features information I got from national Highway Traffic Safety Administration. In this chapter I

showed an research about how my system will work on those types of accidents and features to make a solution about collision avoidance.

2.1.1 Major types of accidents

Road accidents is now becoming a major problems in our country. Car accidents can happen in any time. Studies showed that most of people are involved in car accidents when they are less then 5mills from home[4]. Traffic accidents occurs when vehicles collide with each other. Some major types of accidents is found the common types of traffic accidents are rear end collisions, side impacts collisions, vehicle rollover, sideswipe collisions, head on collisions, single care accidents, multiple vehicle pull-ups[4].

- **Rear-end collisions** — These types of traffic accidents are often caused by sudden deceleration (slowing down or braking). In some cases, another driver is following too closely or accelerates to a higher speed than the car in front of it. Whiplash is a common injury that occurs in a rear-end collision and usually affects drivers and passengers of the impacted car. Fault is usually attributed to the driver of the car that rear-ends the other vehicle.
- **Side-impact collisions** — Side-impact collisions can cause grave injuries. Often called "T-bone" or "broadside" collisions, side-impact accidents occur when the side of a vehicle is hit. It can be impacted by the front or rear of another vehicle or in some cases a fixed object. Vehicle damage is often severe and drivers or passengers on the impacted side of the vehicle usually sustain far worse injuries than they would in another type of crash.
- **Sideswipe collisions** — Sideswipe collisions occur when two cars that are parallel touch. In many cases, the damage is only minor, as the cars have just "swiped" each other. Injuries and damages are typically minimal, unless one of the drivers loses control of the vehicle as a result of the collision.
- **Vehicle rollover** — Vehicle rollover accidents are extremely dangerous and frightening. A rollover occurs when a vehicle literally flips over onto its side or roof. Any vehicle can be involved in a rollover accident, but cars with a high center of gravity such as SUVs (sport utility vehicles) are especially prone to this type of accident. Often caused by sharp turns at high speed, rollover accidents can lead to serious injuries, including spinalcordinjuries and brain trauma.

- **Head-on collisions** — These types of collisions are often fatal. Head-on collisions are exactly what they sound like they occur when the front ends of two vehicles impact each other.
- **Single-car accidents** — Accidents involving only one vehicle are also common. They occur when a vehicle strikes an object such as a pole, a tree, a fire hydrant or a wall. In some cases, they may involve pedestrians and other innocent bystanders. Single-car collisions can result in driver and passenger injuries, pedestrian injuries, and often extensive property damage.
- **Multiple vehicle collisions** — Multiple vehicle collisions are sometimes referred to as "pile-ups" and often occur on busy roads such as highways and freeways. They can involve many vehicles and be the most dangerous. Vehicles can be impacted multiple times and it may be difficult to escape. It is also difficult to determine fault in these cases.
- **Hit-and-run accidents** — An accident where one driver leaves the scene is known as a hit-and-run accident. It can be very difficult to determine the identity of the driver or vehicle.

In those types of accidents, each types each methods was used to avoid it. But using the NRF24L01 and Infrared sensor things can be easier to reduce collision. One system can be connected to all the types to prevent collision. NRF24L01 sensor can easily give the result of the position, distance of other vehicles as well as it can calcite the speed of the closer vehicle and give signal whether the situation is in normal or risk mood. Infrared sensor can give the direct of the closer vehicle that the vehicle is coming from which direction forward or backward side.

2.1.2Wireless sensors

Now a days, technologies are helping mankind with new methods to avoid collision and saved lives. V2V(vehicle to vehicle) communication is identified the most potential method to avoid

collisions. To make the system efficient V2V is a good option by using wireless sensors. There are different types of wireless sensors we can find. Five major wireless sensors that can communicate with other controllers are Wifi, Bluetooth/BLE4.0, Zigbee, GSM/GPS, Radio RF. The data was collected from [openelectronics](#).^[5].

- **Wifi:** ESP8266 WiFi Module is a WiFi serial transceiver module, based on ESP8266 SoC. This chip implements a full TCP/IP protocol stack and the very interesting feature is that it has also a great computational power onboard. That means that can use this board as a simple WiFi connection board, offloading the main processor of your controller from the WiFi communication management. Or can exploit its full power by implementing the logic inside the board itself. Thus can manage sensors and elaborate autonomously their signals and measurements. Hosting simple applications onboard can make a very compact IoT solution.
- **Bluetooth:** Bluetooth is and will be one of the most used wireless protocols in IoT specifications, especially with the recent introduction of Bluetooth Low Energy extension, also known by Apple users as iBeacon. The benefits of BLE protocol became widespread understood when Bluetooth 4.0 release implemented them into the mainstream core. The advantage of this standard is its extremely low power consumption, which helps the making of full battery powered boards with a working time longer than 1 or 2 years in some cases. Another feature, already implemented on many smartphone, is the possibility to embed the management protocol directly at kernel level without requesting any intervention by the users. This facilitates the setup of a mesh network of Bluetooth devices, with lower latency and higher range respect to standard Bluetooth.
- **ZigBee:** is a specification for a suite of high-level communication protocols used to create personal area networks (WPAN) built from small, low-power digital radios. ZigBee is based on IEEE 802.15.4 standard. Though its low power consumption limits transmission distances to 10–100 meters, ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (since it is supporting 128 bit encryption): home automation, healthcare, industrial control applications with short range and low bitrate.

Among all the SoC and solutions available on the market, one of the most appreciated and best performing is the Microchip MRF24J40MA, a certified 2.4 GHz IEEE

802.15.4 radio transceiver module. The MRF24J40MA has an integrated PCB antenna, matching circuitry, and supports the ZigBee™, MiWi™ and MiWi P2P protocols. The MRF24J40MA module connects to hundreds of PIC® microcontrollers via a 4-wire SPI interface and is an ideal solution for wireless sensor networks, home automation, building automation, and consumer applications.

- **GSM/GPS:** is must for many remote controlled or remote communication projects.
- **Radio RF:** is any of the electromagnetic wave frequencies that lie in the range extending from around 20 kHz to 300 GHz, roughly the frequencies used in radio communication. The term does not have an official definition, and different sources specify slightly different upper and lower bounds for the frequency range. RF usually refers to electrical rather than mechanical oscillations.

2.1.3 Six of the common new technologies about crush avoidance systems

- Forward collision warning
- Auto brake
- Lane departure warning
- Lane departure prevention
- Adapting headlights
- Blind spot detection

Information of the availability of features comes from the manufactures. For forward collision warning and auto brake contained in our front crush prevention ratings, which is based on IIHS auto brake tests and National Highway Traffic Safety Administration criteria for forward collision warning. In those features forward collision warning can also be reduce by using NRF24L01 sensor and Infrared sensor. Lane departure warning and prevention can be done by having an angle which will also be detected by NRF24L01 if the car wants to change the lane at that moment it will give signal that whether other cars are near or not, a result mast be given by the signal should it change the lane or not.

Chapter 3

Proposed Model

In this chapter, I briefly explained about the model that I proposed and the reason behind proposing it. The reason why I choose to work with on collision avoidance system and the system I proposed will be efficient.

3.1 Proposed Model

Road accident is most unwanted thing to happen to a road user, though they happen quite often. The most unfortunate thing is that we don't learn from our mistakes on road. Most of the road users are quite well aware of the general rules and safety measures while using roads but it is only the laxity on part of road users, which cause accidents and crashes. Main cause of accidents and crashes are due to human errors. To avoid collisions because accidents is not only about deaths but also damage is also the part of the accidents. Lots of systems, algorithms, models are working on this alarming issues. But in the perspective of Bangladesh road accidents I wanted to work on this case of accidents and want to make a system to avoid collisions. About started working I had to do some case studies, some background researches, went through lots of sensors what can be fit for the system which is will effective and also cost efficient. Which system can make the driver used to was the first challenge. After all those steps I came with the proposal of collision avoidance system using NRF24L01 sensor and Infrared sensor. In the system I used two sensors because to have the accurate signal and the driver can also get it clearly. One sensor is enough for the signals but sometime drivers might get confused about which signal signed what sense. To avoid those confusion I used two sensors. There are many reasons and advantages why you would choose this frequency over others. When considering if 2.4Gz wireless is suitable for your projects, some of the considerations you would look at include, cost, ease of use, availability, range and bandwidth. One of the most common wireless modules around today is the nRF24L01. It is not only cheap, but relatively easy to use and can be used for short or long range communications. Some of the advantages of infrared detectors are that they can be operated during both day and night, and they can be mounted in both side and overhead configurations. Disadvantages are that infrared detectors can be sensitive to inclement weather conditions and

ambient light. The choice of detector materials and construction of the system, as well as sophisticated signal processing algorithms, can compensate for the disadvantages.

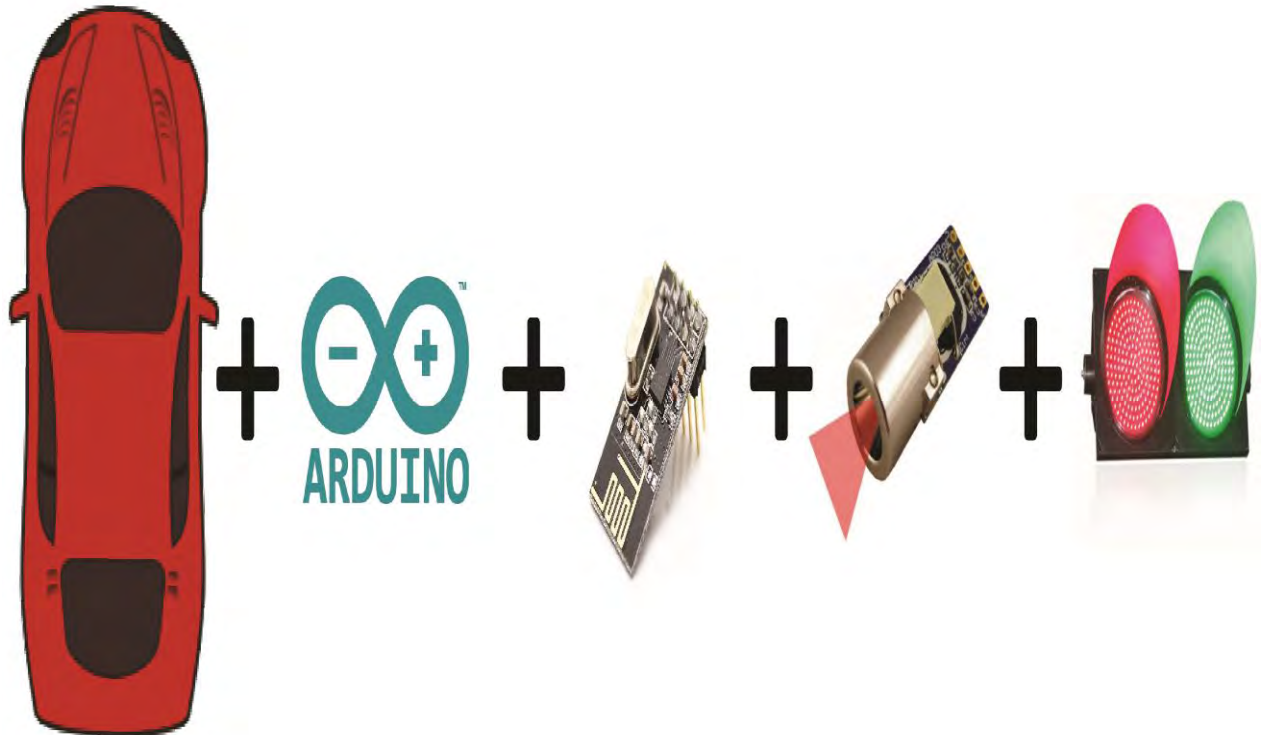


Figure 3: The implementation process.

In the hardware implementation part, which sensor will be installed and how I give a view image in Figure 3. In the car the system is designed like, in aArduino bored the NRF24L01 sensor is connected. NRF24L01 sensor worked both as a receiver and the transmitter. After that The Infrared sensor is connected and this sensor will give the signal about the direction of the vehicle whether vehicle is on the same direction or opposite direction, coming from back side or front side. Then the signal will be shown by the LED light signals. These two sensors will collected all the signals and finally getting all those the LED light signals will show whether the vehicle decision will be based on the situation of safe, not safe and risky.

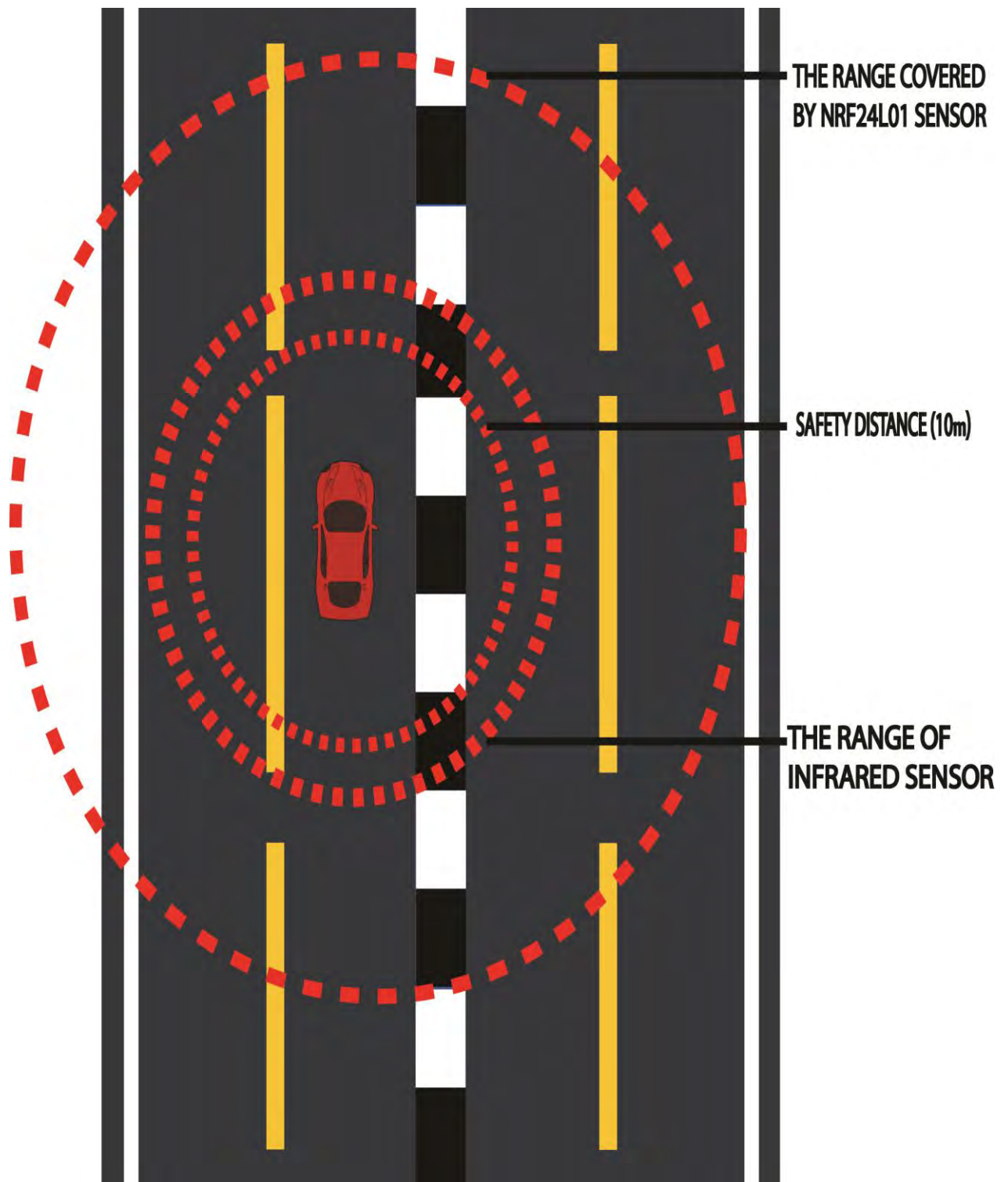


Figure 4: Working Process of NRF24L01 sensor and Infrared sensor.

In figure:4, I designed the model how the car will work with NRF24L01 sensor and the Infrared sensor. Basically the NRF24L01 sensor can cover the range around it about 100m but in my proposed system I fixed the range about 50m. the NRF24L01 sensor will cover 50m

around it. the safety distance is fixed 10m as every vehicle must have a safety distance because if any vehicle will cross the safety distance the alarm will be generated about giving the signal Red light and when the vehicle will come a more closer to the other vehicle it will generated Red light with a blink it means the light signal will be Red and start blinking. In Figure:5, the model is shown how the signal will be generated in the vehicle to vehicle communication.

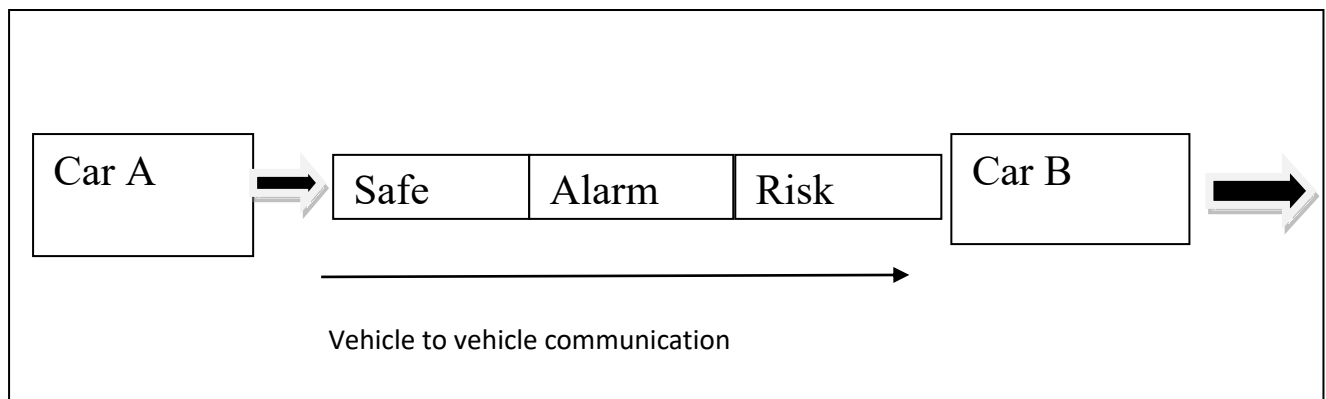


Figure 5: Model of the measurement of safe, alarm, risk V2V communication.

Below in Figure:6, I give the whole idea in one image that how the system will work on the road. How it will communicate with the other vehicles. The Red car in the model is the main car by which I m going to explained the whole procedure of the model and the system.

- Firstly, when the car started driving it will on the first moment will get all the signals of the NRF24L01 rooming around of it. It will cover the 50m range and started to give the first five vehicles signals which will be the near one or come to range first. By the position of the vehicles the signal will give signal step wise. Closer one will be the first signal and the far one will be the last signal of the LED light signal board.
- After that it will give the signal about the vehicle which will come to the safety distance. The car whose position will be around the safety distance that cars signal will be shown in the board first. The first LED light signal will be shown Red because the vehicle is almost to the safety distance. On Note point, if the first car which is not close on the safety distance but no other car is around then the signal will be shown Green.
- Additionally, when a car will cross the safety distance then the signal will started blinking. Mainly the signal first become RED and when the car will crosses the safety

distance 10m and come closer to the Red car the signal board will generated Red LED light signal and also stated blinking so that the driver can come to know that now the situation is in the risky mood so the drive had to take a decision to make the car safe. Either it will slow down the speed and give the car to overtake it or it will speed it up make a distance with the upcoming car.

- Infrared sensor will give the signal of 15m to the drive whether the car is coming from which side. Either from the front side or from the back side. Mainly, car direction is a major part of the accidents issues. If the driver get the information about which direction the car is coming like same direction from behind or opposite direction from the front side so that the driver can have time to take decision what to do. In the car the Infrared sense will be implemented both side of the car front and back. If any car is coming from front straight direction then the front side Infrared will give the signal so that the driver will get it same goes with if any car is coming from the back side then the back one Infrared sensor will give the signal.
- LED light board signal working process

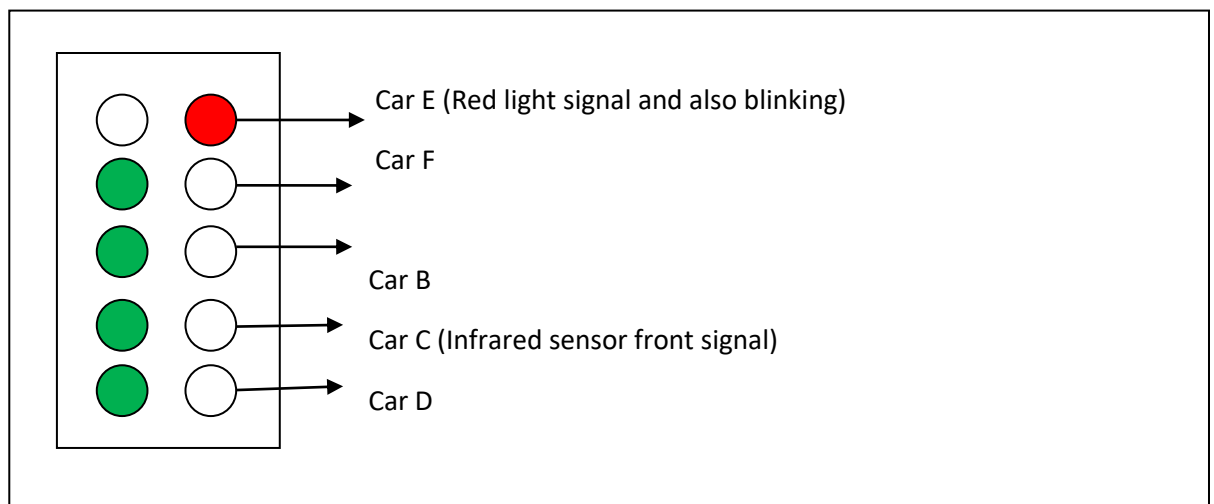


Figure 6: LED Light Signals working process.

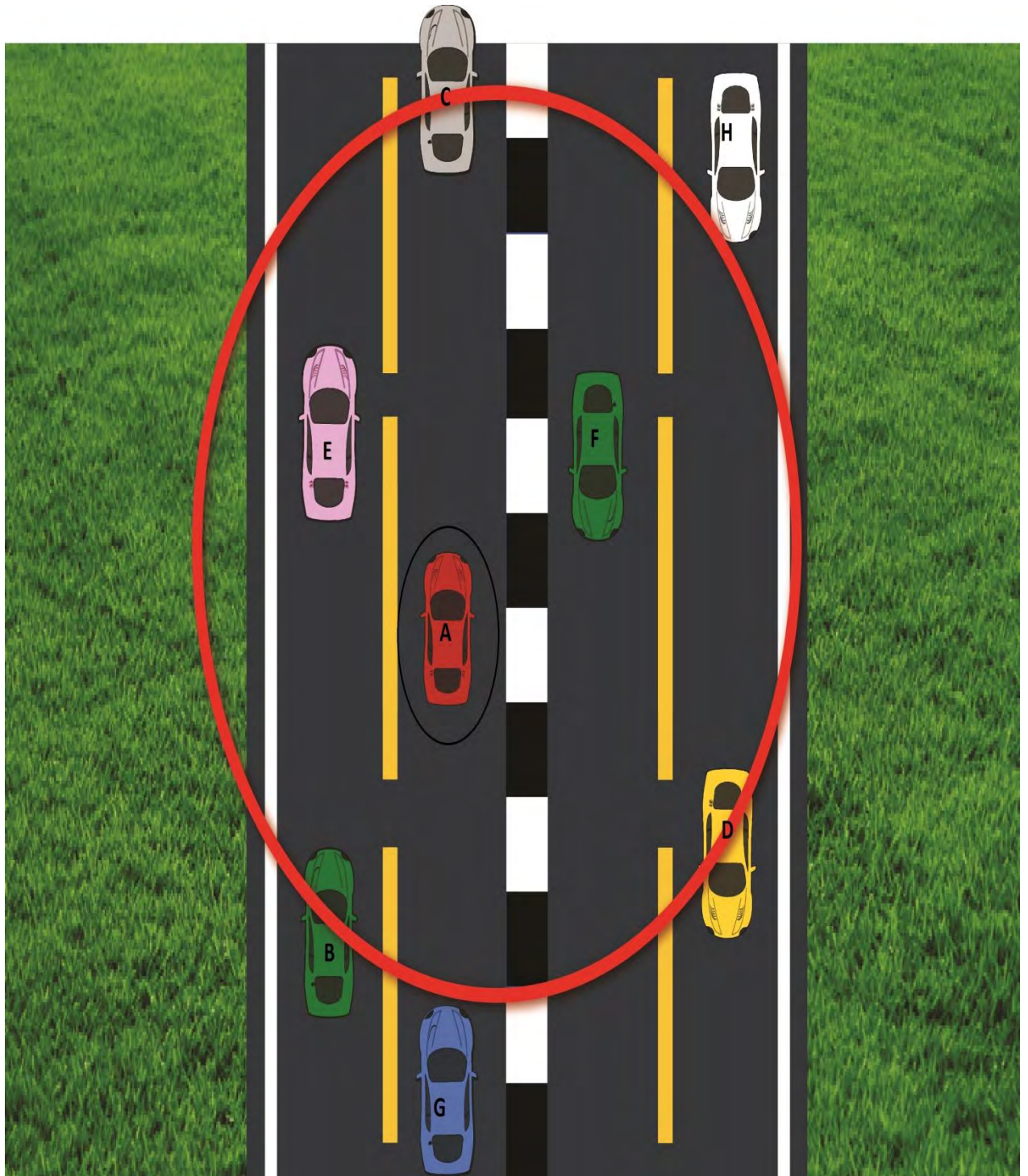


Figure 7: The model of the system how the car will get signal and shown in the LED light.

Chapter 4

Experiment and Result

In this chapter, I briefly explain the working procedure including a mathematical expression and an comparison with another model .

4.1 Signal passing

V2V communication is mainly passing message between vehicles which has the same sensors installed it. The main task of the V2V system is enables communication between vehicles by giving information by passing signal via vehicle to vehicle. The Arduinomega board was connected with the system. For the communication between vehicles we used Arduino mega board, wireless sensor NRF24L01 and Infrared sensor. Arduino is the based which is connecting NRF24L01 and Infrared sensor and also passing signal via LED lights. Bluetooth is also helping to make a connection between those systems. Infrared sensor is using to detect whether the car is in the same direction or opposite direction. The whole same system will installed in other vehicles so that vehicles can pass signals via it and make a safety environment.

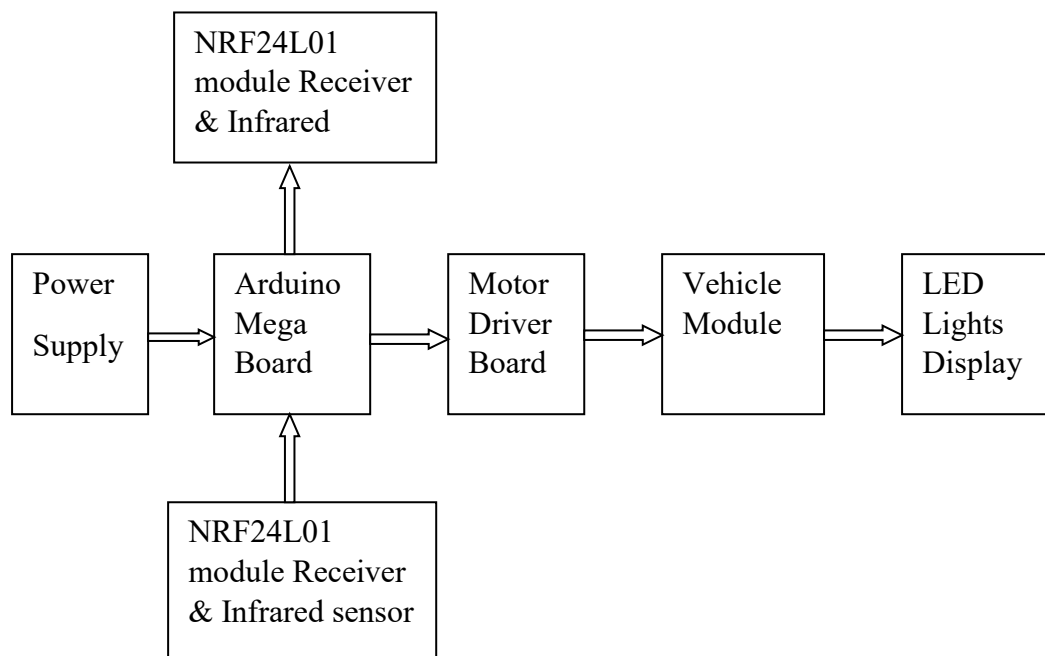


Figure8: Block diagram of single vehicle with NRF24L01 and Infrared sensor

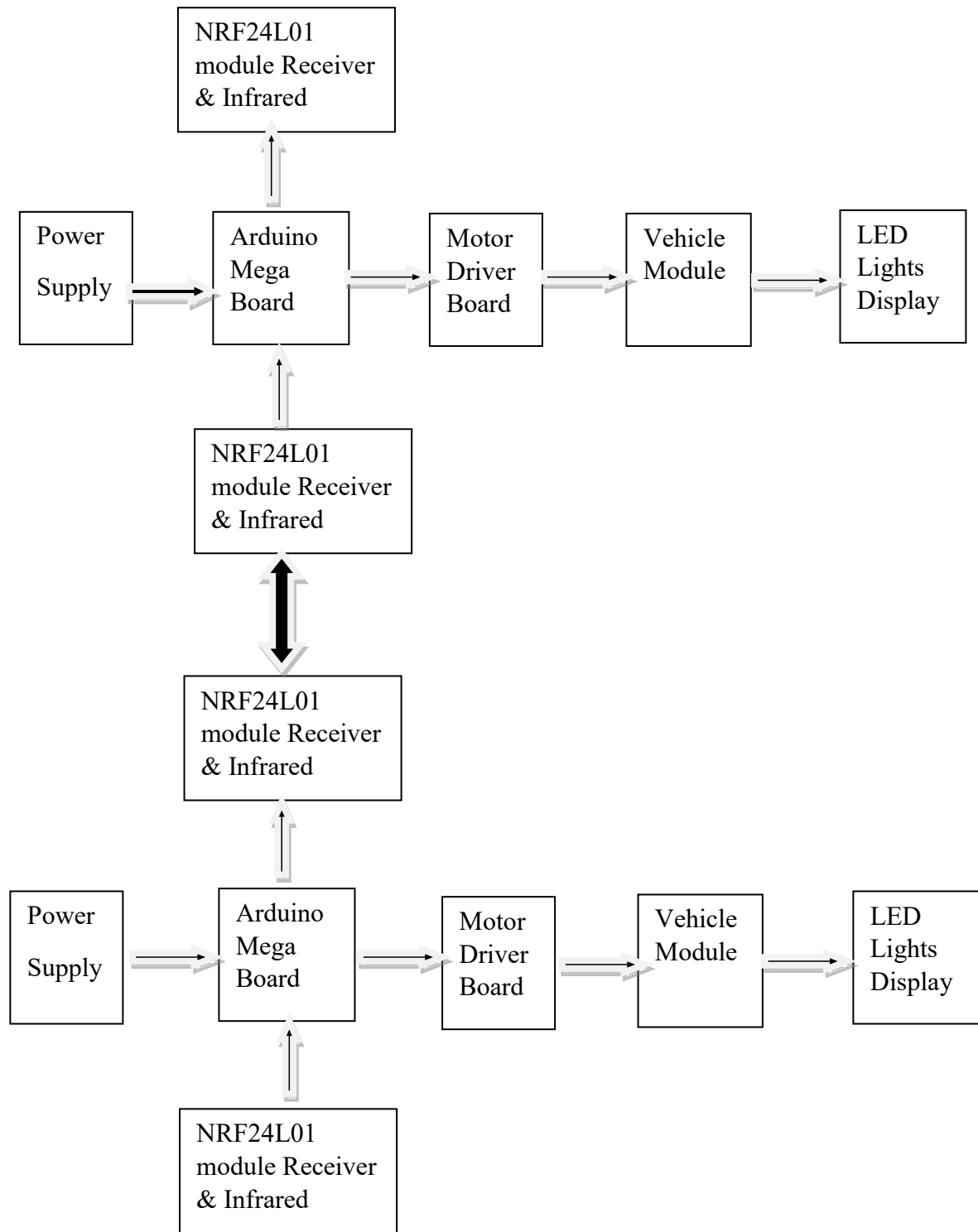


Figure 9:Block diagram of vehicle to vehicle communication.

In figure:8, the model was shown about the working process of the vehicle using NRF24L01 and Infrared. In the vehicle, the system will be installed in Arduino mega board. In Arduino mega board NRF24L01 and Infrared sensor will be placed and it will be placed both in front and back side of the vehicle. Both NRF24L01 worked as the receiver and transmitter.

Basically front side NRF24L01 worked as a receiver and back side NRF24L01 worked as transmitter. Receiver will received the signal and pass it through the motor drive to vehicle module and the signal will be shown to the driver by the LED light display. Green light is safe mood, Red light is not safe mood and the Red light which will blink is the risky mood. Infrared sensor will worked to give the signal whether the vehicle is coming from backward or forward.

In figure:9, a block diagram was shown which is the signal passing of vehicle to vehicle using NRF24L01 and Infrared sensor. How the both vehicle will pass signal is shown by the block diagram. System will be remain same in each vehicle.

4.2 RX and TX Connection

TRANSMITTER SIDE:

Table 4: NRF24L01 and Arduino connection

NRF24L01	Arduino
Vcc	3.3V
Gind	Gind
CS	Pin 7
CSN	Pin 8
SCK	Pin 13
MOSI	Pin 11
MISO	Pin 12

In Table:4, the connection of Transmitter side is shown how NRF24L01 sensor and Arduino is connected in the system. VCC of the NRF24L01 will be connected to the 3.3V of Arduino. Gindpoint will be grounded both in NRF24L01 and Arduino. CS is connected to the Pin7, CSN is connected to the Pin8, SCK with Pin13, MOSI is Pin11 and MISO in Pin 12.

RECEIVER SIDE:

Table 5:NRF24L01 and Arduino connection

NRF24L01	Arduino
Vcc	3.3V
Gind	Gind
CS	Pin 7
CSN	Pin 8
SCK	Pin 13
MOSI	Pin 11
MISO	Pin 12

In table:4 Receiver side connection is shown between NRF24L01 and Arduino. Same as the transmitter side the connection is connected as NRF24L01 worked as a transmitter and receiver so the connection stayed same. Vcc is connected with 3.3V, both Gind is grounded. CS with Pin7, CSN with Pin8, SCK with Pin13, MOSI with Pin11, MISO with Pin 12.Let's take a closer look at the NRF24L01 transceiver module. It uses the 2.4 GHz band and it can operate with baud rates from 250 kbps up to 2 Mbps. If used in open space and with lower baud rate its range can reach up to 100 meters.The module can use 125 different channels which gives a possibility to have a network of 125 independently working modems in one place. Each channel can have up to 6 addresses, or each unit can communicate with up to 6 other units at the same time.Three of these pins are for the SPI communication and they need to be connected to the SPI pins of the Arduino, but note that each Arduino board have different SPI pins. The pins CSN and CE can be connected to any digital pin of the Arduino board and they are used for setting the module in standby or active mode, as well as for switching between transmit or command mode. The last pin is an interrupt pin which doesn't have to be used.

So once we connect the NRF24L01 modules to the Arduino boards we are ready to make the codes for both the transmitter and the receiver. First we need to download and install the [RF24 library](#) which makes the programming less difficult.



Figure 10: Vehicle to vehicle communication using NRF24L01 sensor.

In figure:10, shown the system how the vehicle to vehicle communication held using the NRF24L01 sensor. Each vehicle had this system. Each vehicle is covering its own area when another vehicle entered to that area it will give the signal based on the safety mood. Green signal for the safe mood, Red signal for the not safe mood and the Red signal which will blink is the risky mood. 50m is the whole range that is given to the NRF24L01 to covered. 10m is the safety distance.

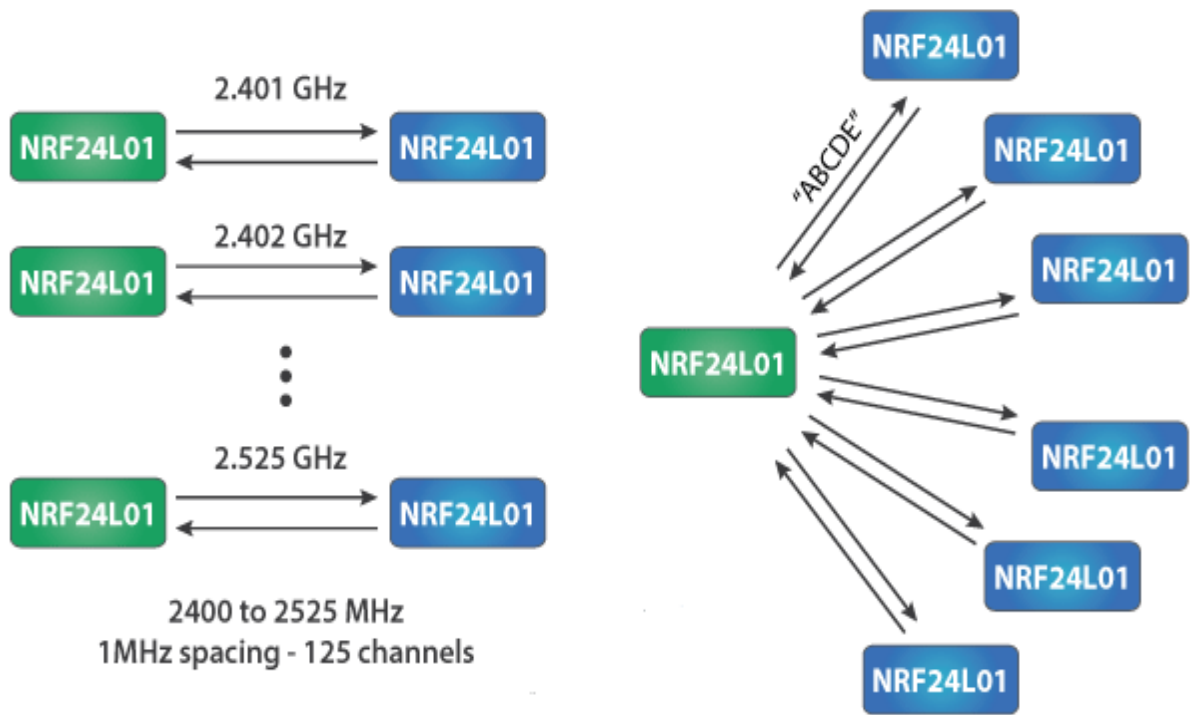


Figure 11: NRF24L01 and NRF24L01 communication

In figure 11, the communication method is shown how both NRF24L01 is communication as both worked as receiver and transmitter as well. One can communicate with other which will come to the range of the given range. After getting is the range each will pass the signals to others. In this model I showed six NRF24L01 communications with each other. 2.525 GHz is the range of the communication.

4.3 LED Lights

When vehicles will come in the range that will be fixed the LED lights will be on Green light. If any of the car is in high spend then others so that cars positional LED will give Red light signal. First five cars signal the LED light will give according to their position. Any risky situation the particular positional light will blink.

4.4 System Design

The system is designed in three steps

- a) NRF24L01
 - Speed

- Distance (50m full range cover and 10m safety distance)
 - Position (First five cars position will be detect first)
- b) Infrared sensor
- 10m distance (Safety distance)
 - Forward position
 - Backward position
- c) Signals
- Risky situation (Light will blink)
 - Safe distance 50m (Light will be Green)
 - Vehicles come in the safety distance 10m (Light will be Red)
- d) LED Light (Five paired lights)
- Green Light (Safe mood)
 - Red Light (Not safe mood)
 - Light will start blinking (Risky situation)

For the experiment I took two cars one is 'A' and another is 'B'. I assumed A is my car and B in another car by which I will get the signals when we both come to the range of 10m NRF24L01 installed range. 10m is the safety distance that we installed. As NRF24L01 is a radio frequency it can cover 50-100m area. For the experiment 50m range is given. When cars which is carrying NRF24L01 sensor will come into the range my car A will have the signals by the LED lights which is placed in-front of the driver seat. A board that have Five paired up LED Lights.

4.4.1: Based on car A getting signal from car B

Car A is designed with two NRF24L01 sensor, one is in-front of the care and another is backside of the car. Bothe sensor will work as a Receiver and Transmitter as this is the main feature of NRF sensors. Car A is moving and another B car is coming from behind.

First, the sensor will detect the Signal via NRF and it will send the signal to the system so the first step is done getting signal.

- In the experiment, when the sensor come across the safety distance they passed signal '1' which means which means both cars are now in the safety distance 10m.
- When the sensors are taking away from each other and out of 10m the stop passing signal '1'. By this the system passed signals via vehicle to vehicle.

Secondly, the system will see the Position of the car B. If it is in the range 50m the LED will signal Green light. When the car will enter the safety distance 10m the LED will give signal Red. 10-50m the position is safe considered but when the car come into the range of 10m it will consider as a risk situation.

Thirdly, the receiver will calculate the Speed of the car which is coming from behind. Speed is the major factor for any accidents, so keep safe speed calculation is must. Between both cars speed will be calculated first.

- If the car A and B has the speed which is between the range the signal will remain normal it will give Green signal.
- If the speed of the car B is more then the speed of car A then car A will get the signal Red as higher speed will have the priority.
- Higher speed car will get the priority then the lower speed car.
- When the higher speed car will pass the lower speed car then the lower speed car will have a signal Red and it will be blinking after that car passed the safety distance.

4.4.2: Overtaking situation

In the overtaking situation , if any car is coming from behind of my car or I want to overtake at that moment same procedure will be checked by the NRF24L01 sensor. Calculating speed, position and distance the sensor will give signal to the driver. By that signal driver will take decision whether it will overtake or not.

- Higher speed car will get the priority then the lower speed car.
- When the higher speed car will pass the lower speed car then the lower speed car will have a signal Red and it will be blinking after that car passed the safety distance.

For the overtaking situation, I consider four senses where overtaking condition is considered. Vehicle A wants to overtake but four conditions came now what will be the decision and how the signal will be get that is show in a flow chart.

Scene 1: Vehicle A wants to overtake vehicle B which is in front of it. the future position means after overtaking in which position A will be that position is clear means no barriers on overtaking B. So in this case, A can overtake B.

Scene 2: Vehicle A wants to overtake vehicle B both are in the same lane but from opposite lane vehicle C is coming so in this case overtaking will be dangerous.

Scene 3: Vehicle A wants to overtake vehicle B but the future position where A will be after overtaking already there is vehicle E. So in this case, no free space for A so no overtaking.

Scene 4: Considering one way road having 2 lanes, vehicle a wants to overtake B and the future position after overtaking there is no other vehicle. But from back side vehicle H is coming with a high speed in the same direction of vehicle A. So in this case, first speed must be considered high speed vehicle will get the priority. If vehicle A had high speed it will overtake and if vehicle H which is coming from backward had the speed high than vehicle A will not overtake at that time and give space to H to go forward.

Based on these four scenes of decision making while overtaking situation a flow chart is given below in figure 12.

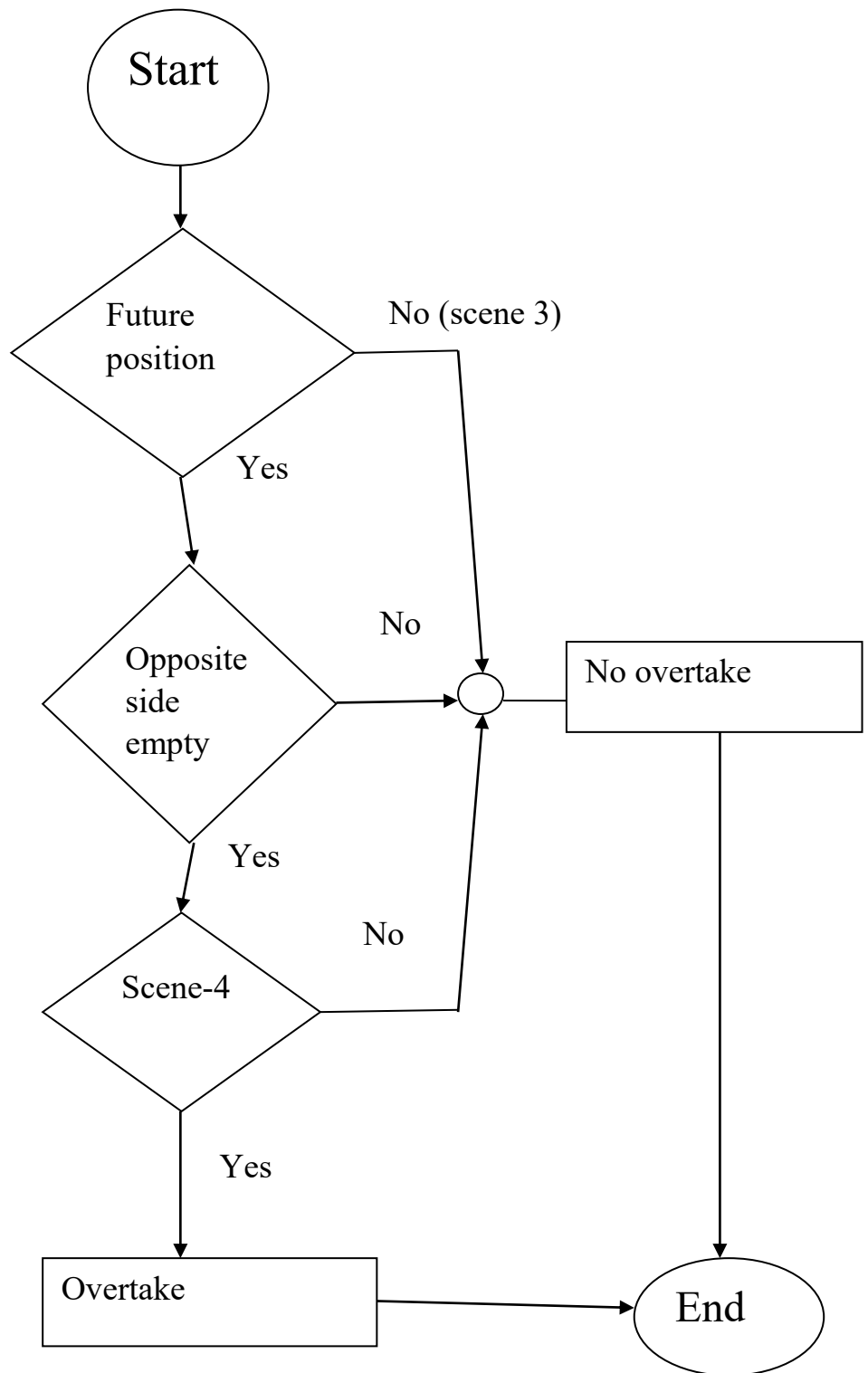


Figure 12: Flow chart of overtaking decision making based on the four scenes.

Algorithm 1 Overtaking

```
1: function OVERTAKING( $A, f$ ) ▷ Where A - array, f - future position
2:   if  $f$ -future position is free then
3:     if other vehicle coming from opposite lane then
4:       "Do not overtake"
5:     else if other vehicle coming from behind then
6:       if other vehicle speed is greater then
7:         "Do not overtake"
8:       else
9:         "OVERTAKE"
10:      end if
11:    end if
12:  else
13:    "Do not overtake"
14:  end if
15: end function
```

4.4.3: Infrared sensor to detect cars direction Forward or Backward

One of the major factor is the cars position whether is coming from backward of my car or else from the forward direction. To detect the direction I used Infrared sensor which will detect this case and give my car the signal. The Infrared sensor will be installed both side front and back side of the car like NRF24L01 sensor. For that Infrared sensor can detect the cars position.

- If the car is coming from behind the signal will be given by the back side sensor that it will back mood light will be on and when the car will cross the safety distance the signal will become Red and it will blink.
- If the car is in the forward direction and coming towards my car then the signal will be Red the front side sensor will give a Red light signal and when the car will cross the safety distance it will start blinking.
- Basically the opposite directional signal will be Red and when it will come near and cross the safety distance it will start blinking.

Table 6: Infrared sensor signal passing

Distance	Front side signal	Back side signal	Decision
10(safety distance)	1	0	Major
15(fixed range)	0	1	Very Dangerous
20	0	0	Normal Alert
25	0	0	Normal mood

In the experiment, I took four distances to check about the sensors response which is shown in table:5. As 10m is the safety distance between vehicle to vehicle. When a car is coming from front side and it is in the safety distance it will ON the front side sensor by giving the signal RED, a Major situation will be indicate by it. After that, in the distance of 15m which is the range fixed to the Infrared sensor, when a car will come across to this distance if the car is from back side the back side Infrared sensor will be ON by giving the Red light signal and the

situation will indicate the Very Dangerous mood. After 15m range all the signals will be normal, at that situation Infrared sensors both side of the car will not give any signal to the driver.

4.4.4 :LED Light Signals

The LED light is designed like

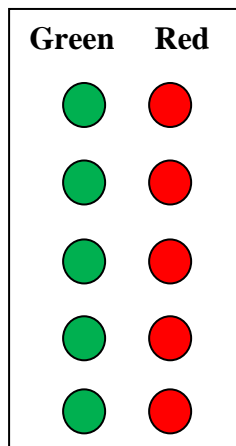


Figure 13: LED Light Board

This LED Light Board shown in figure:12, will be fixed or setup in-front of the driver so that by those signals the driver can take decision what to do in that situation.

- Green signal will indicate safe distance according to the cars position, 1st five cars signal the LED light will give detect and showed in the Light board. Closer one will lighten up 1st. Like this the serial will maintain as the far one will be the 5th position of the light board.
- Red signal will indicate the not safe mood. If the car has higher speed then my car then I will get the Red signal. If any car will come across the safety distance it will give Red signal. Position wise the signal will lighten up.
- Red signal will blink when the car is in the risky mood. If any car already cross the safety distance the signal is already in Red and it will start blinking.

In table:6, which is given below LED light signal will give Green and Red light the situation of the collisions. If the vehicle is in the safety distance it will show Green light. When the vehicle will entered the safety distance 10m it will show the Red light. Red light signal will blink if the vehicle cross the safety distant and have a speed more than the particular vehicle. If the current distance is less than or equal to the actual vehicle remind warning distance

(safety distance) the system into remind alert level at this moment will show the Red light signal. If the system after reminder alarm, the vehicle distance narrowed, until less than or equal to the risky early warning distance it will started blinking to make alert the driver strongly.

Table 7: LED light Color and Signal

Color	Signal
Green	Safe mood
Red	Not in safe mood (already in the safety distance)
Red signal and Blink	Risky mood(crossed the safety distance/ coming with a high speed/coming from the opposite direction)

Flow of vehicle to vehicle communication using NRF24L01 and Infrared sensor

Step 1: Start the program

Step 2: Initialize the vehicles

Step 3: Initialize the NRF24L01 both sides of the car of car A and B

Step 4: Check the conditions if the vehicles can receive signals and transmitter can transmit the signal

Step 5: Program such as follow the standard vehicle to vehicle communication rules by passing signals.

Step 6: Check Infrared sensor signal condition getting signal from forward and backward side.

Step 7: Implement the hardware device

Step 8: End of process.

4.5 Mathematical Model

4.5.1. Construction of mathematical model

When developing the mathematical model, three parameters have been identified as the key factors governing the alert time while driving. Those are,

1. Reaction time of the driver
2. Speed of the vehicle
3. Distance between the vehicles.

4.5.2. Derivation of safe distance between vehicles

To determine the safe distance we define two vehicles A and B running in the same direction one after the other at velocities of V and U respectively. Assume that A is leading. Since we are concerned of the rear vehicle the relative velocity with reference to the vehicle B can be given by equation (1).

$$V(A,B)=V-U \quad (1)$$

A collision is possible only if U is greater than V. This could be caused by either acceleration of vehicle B or deceleration of vehicle A. In case where vehicle A starts to decelerate at $t = t_1$ and stops at $t = t_4$. Assuming vehicle B detects the front vehicle deceleration and starts decelerating at $t = t_2$ and stops at $t = t_3$. The deceleration rates of vehicle A and B can be given by following equation (2) and (3) respectively. The deceleration rate is assumed to be constant over the time.

$$\frac{V-0}{t_4-t_1} = a \quad (2)$$

$$\frac{U-0}{t_3-t_2} = b \quad (3)$$

The safe distance (d) can be defined as, (Travel distance of vehicle B from $t = 0$ to $t = t_4$) – (Travel distance of vehicle A from $t = 0$ to $t = t_3$)

$$d = \left[Vt_2 + \frac{1}{2} \frac{U}{(t_3 - t_2)} (t_3 - t_2)^2 \right] + \left[Vt_1 + \frac{1}{2} \frac{V}{(t_2 - t_1)} (t_2 - t_1)^2 \right]$$

$$d = \frac{(t_3+t_2)U}{2} + \frac{(t_2-t_1)V}{2} \quad (4)$$

Substituting (2) and (3) in (4) gives,

$$d = 0.5 \left(\frac{U^2}{b} - \frac{V^2}{a} \right) + Ut_2 - Vt_1 \quad (5)$$

Since the vehicle B can only measure the relative velocity and its own velocity the equation (5) can be written in terms of U and V(A,B). Using (1) and (5),

$$d = 0.5 \left(\frac{U^2}{b} - \frac{(U + V(A, B))^2}{a} \right) + U(t_2 - t_1) + V(A, B)t_1$$

Relative velocity calculation can be expressed in terms of time and distance measurements. The distance sensors of the rear vehicle measure and the distance to the forward vehicle at two consecutive instances. The relative velocity will be the ratio of distance travelled during the two time instances to the time elapsed. This process is continuously done in order to detect the relative velocity change which indicates a possibility of a collision.

4.5.3. Setting parameters of the safe distance formula

The time taken to apply brakes after hearing the alert is the reaction time of the driver and it is used as 1.5 s (National Highway Traffic Safety Administration (NHTSA), 1998). Most researches state that 90 percent of the drivers are decelerating the vehicles at a rate of 3.4 ms⁻² (Officials, 2001). Also it is acceptable that the rate of deceleration is comfortable for the drivers to stay within the driving lane and maintain the steering control on a wet surface also. For design purpose we assume the forward vehicle deceleration as 4.5 ms⁻² which is higher than that of normal value. Therefore testing parameters for the model are listed as follows, a = 3.4 ms⁻², b = 4.5 ms⁻², (t₂ - t₁) = 1.5 s, t₁ = 1.5 s, initial distance travelled d₀ = 5 m

4.5.4. Result and Discussion

The model itself gives the safe distance at any given speed of the vehicle. The parameters have been set to meet the critical condition by considering the extreme values. This model has been tested using a simulation tool by manually applying distance values and time values as

given by the sensors in the real situation. Table 1 shows the data set used to test the model. The data set includes four consecutive distance measurements. The velocity of the vehicle is assumed to be at $18 \text{ ms}^{-1} = 64.8 \text{ kmh}^{-1}$.

Table 8. Sample data set for testing the model

Test case\Data	$U(\text{ms}^{-1})$	d1 (m)	d2 (m)	d3 (m)	d4 (m)
V1<V2	18	101	102	101	103
Current D>Safe D	18	102	103.6	103.8	104.8
Current D<Safe D	18	102	103.6	99.8	100
Current D>Critical D	18	29.4	32	33	34
Current D<Critical D	18	19	21	22	23

When the data is applied to the model the safe distance is calculated and it can be given to generate an alert by the system. Table 8 shows the calculated values for the given data.

It is clear that the alert will be activated when the distance is less than the safe distance and the critical alarm will be activated when the distance is less than the critical distance. According to the safe distance defined by NHTSA the test results gives a valid warning to prevent collisions. Table:9 gives the recommended safe distance data.

Table 9. Test Result

Test case/Result	V1	V2	d4 measurement	Warning alarm distance	Calculate Critical distance	Critical distance	Critical alarm
V1<V2	5	10	0	0	7.536	0	No
D>safe D	8	5	104.8	0	28.37	0	No
D<safe D	8	1	100	100	41.04	41.04	No
D>critical D	13	5	34	34	28.37	28.37	No
D<critical D	10	10	23	23	28.37	28.37	Yes

Total Braking Time = Driver reaction time + Braking time

Table 10: Recommended safe distance by NHTSA

Speed (km/h)	Thinking distance (m)	Braking distance(m)	Safe distance(m)
40	27.8	18.4	46.2
50	34.8	28.7	63.5
60	41.7	41.3	83
70	48.7	56.2	104.9
80	55.6	73.4	129
90	62.6	92.9	155.5

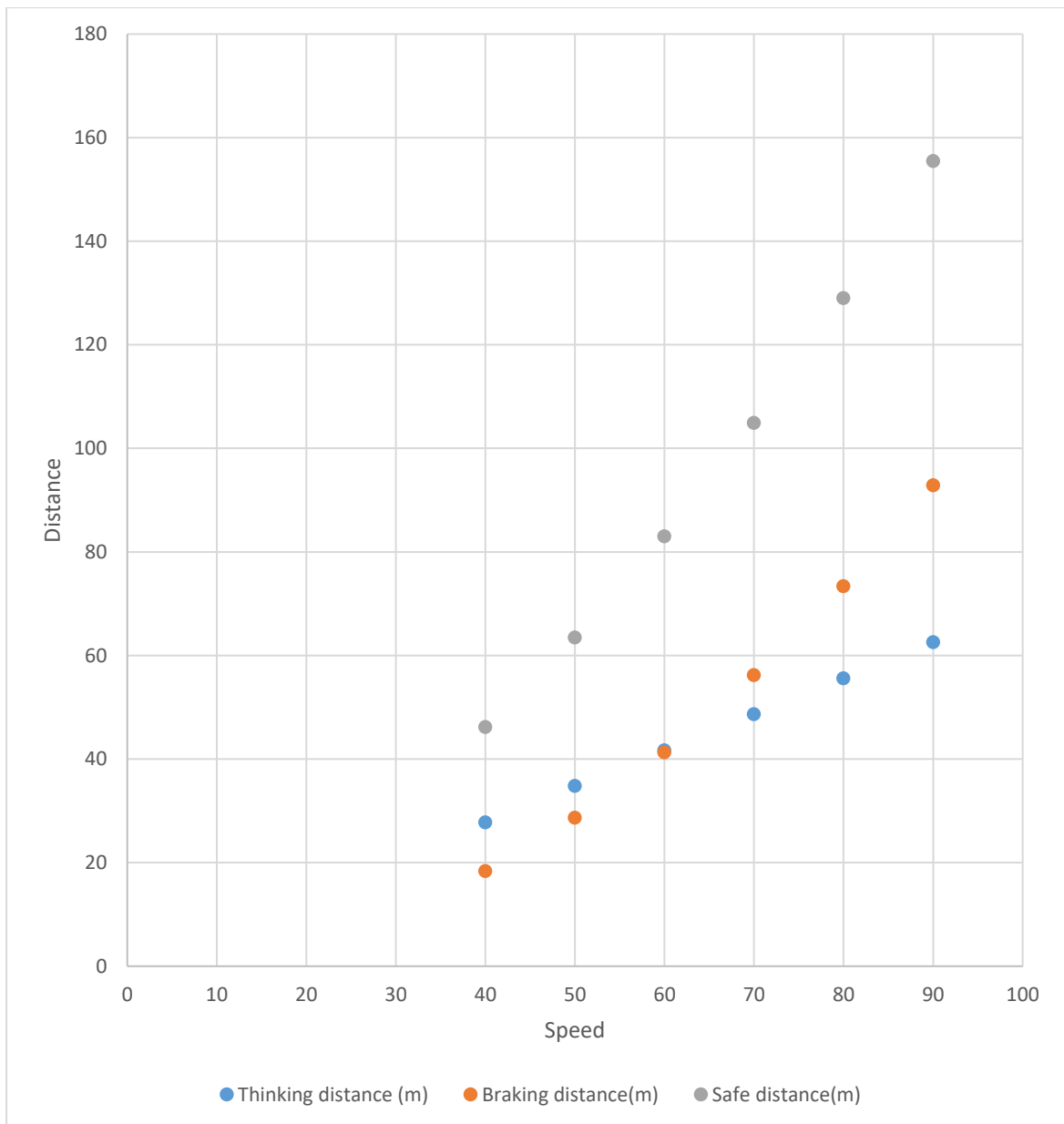


Figure 14: Graphical expression of the safe distance.

In figure 14, the speed and the safety distance are in the same node. That's mean in the for a particular speed a particular safety distance is measured. Each speed has its calculating safety distance with the thinking distance and the braking distance. By the calculation it can be seen that the system is quite applicable for the collision avoidance system.

4.6 A comparison between two model one proposed model of this paper and another estimated model is given here.

Model A: Proposed model of this paper, Collision avoidance system using NRF24L01 and Infrared sensor.

Model B: Optical vehicle to vehicle communication system using LED transmitter and camera receiver.

Both model are made for the safety of vehicle on road to avoid collisions.

Table 11: Comparison of model A and model B

Model A	Model B
1. Cost efficient	1. A bit expensive
2. Easy for the drivers to get signal while driving as the signal is generated through a LED light board which will give Green signal while it is in the safe mood and Red signal when it will be in the not safe and risky mood.	2. It can be tough for the drivers to make a concentration towards the screen while driving because looking throughout the screen while driving drives can lost their concentration.
3. Weather cannot make any difficulties while driving.	3. In bad weather it will tough for the driver to see the screen of the other cars which is located in the back side of the car while driving.
4. Easy way to use this system in the perception of Bangladesh	4. Conceptual it is a good model but not in every aspects.
5. The driver will get the signal around of it where in which position the other cars are.	5. Only the driver which is behind will come to know what is going in front of that particular car but not the other situations can be get while driving.
6. NRF24L01 sensor can give the data about the speed, distance and position. Infrared sensor can give the signal about the direction of the vehicle if it is in the same or opposite direction. Led light will give the signal about the situation of the safe, not safe and ricky mood.	6. In front of the car there is a camera which will capture the view and beck side of the car there will be the screen which will show the view what is captured from the front side camera.

4.7 Hardware implementation

In the hardware implementation I used to make this system

- Arduino
- NRF24L01
- Infrared sensor
- Led Light signal

In the Arduino board the connection is connected as NRF24L01 worked as a transmitter and receiver so the connection stayed same, Vcc is connected with 3.3V, both Gnd is grounded. CS with Pin7, CSN with Pin8, SCK with Pin13, MOSI with Pin11, MISO with Pin 12. For explaining the wireless communication the first one will be sending a simple “a” message from one Arduino to another via NRF24L01 and after sending the signal the LED light turned ON and show that the signal had passed. The power consumption of this module is just around 12mA during transmission, which is even lower than a single LED. The operating voltage of the module is from 1.9 to 3.6V, but the good thing is that the other pins tolerate 5V logic, so we can easily connect it to an Arduino without using any logic level converters. So once we connect the NRF24L01 modules to the Arduino boards then it is ready to make the codes for both the transmitter and the receiver.

- So we need to include the basic SPI and the newly installed RF24 libraries and create an RF24 object. The two arguments here are the CSN and CE pins.
- Next we need to create a byte array which will represent the address, or the so called pipe through which the two modules will communicate.
- On the other side, at the receiver, using the `radio.setReadingPipe()` function we set the same address and in that way we enable the communication between the two modules.
- Then using the `radio.setPALevel()` function we set the Power Amplifier level, in our case I will set it to minimum as my modules are very close to each other.
- Next we have the `radio.stopListening()` function which sets module as transmitter, and on the other side, we have the `radio.startListening()` function which sets the module as receiver.

Then the Infrared sensor will be connected as it will give the signal about the vehicle direction of the same lane whether it is coming from the forward or backward direction, same or opposite direction. Later the LED light sensor will be connected to the system by which the driver will come to know the signal of the safe, not safe or risky mood.

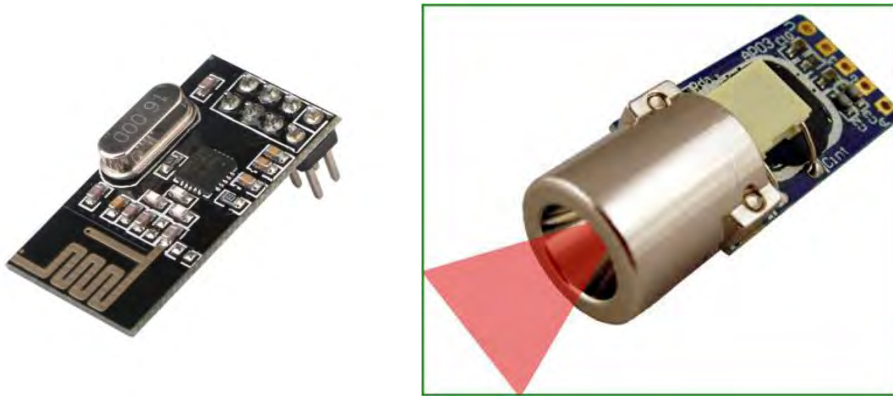


Figure 15: NRF24L01 sensor and Infrared sensor

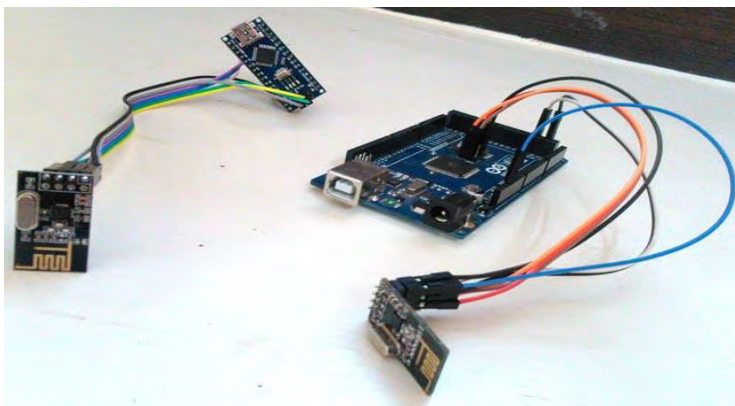


Figure 16: Connection view of the Arduino board and NRF24L01 sensor.

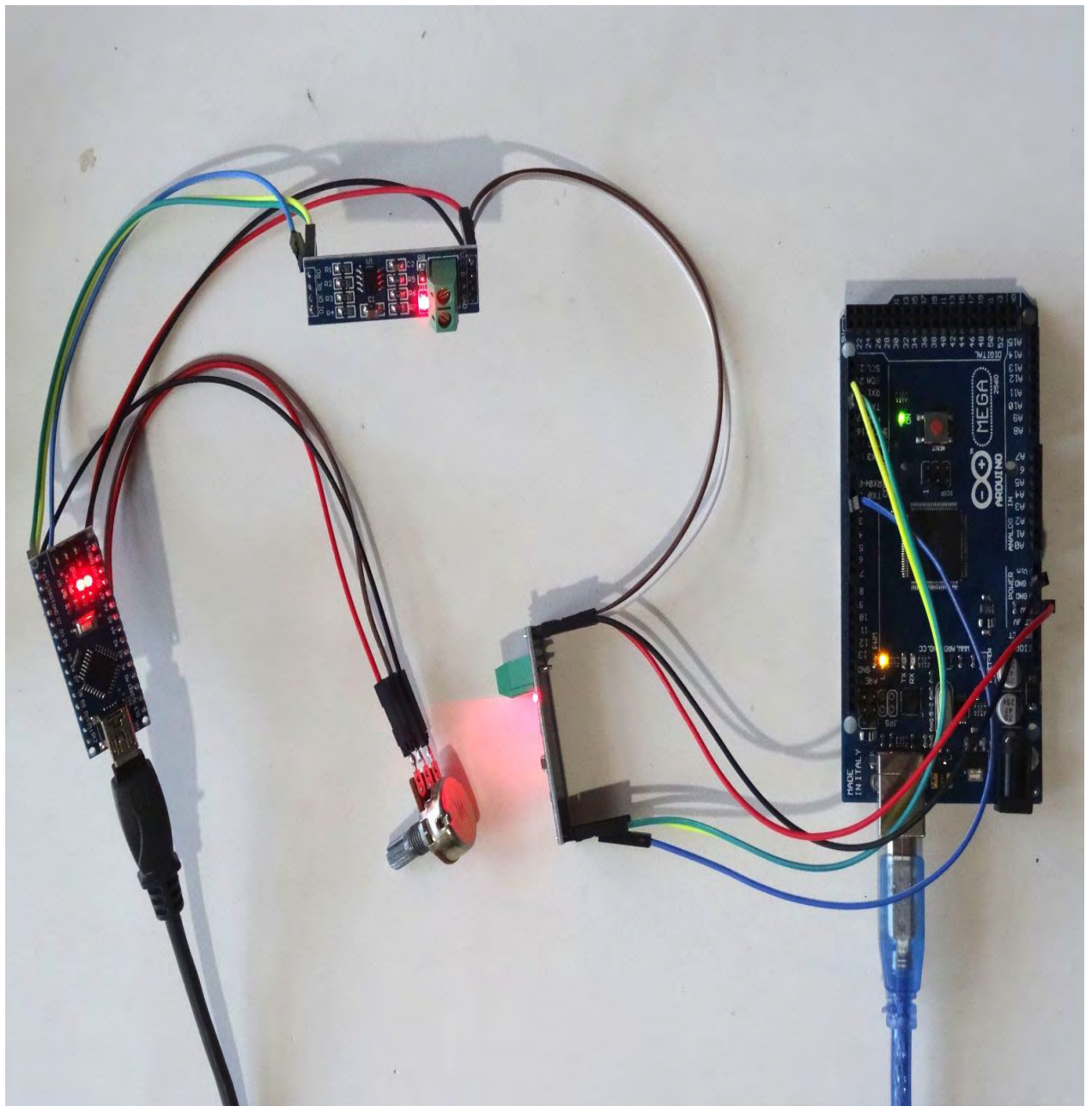


Figure 17: Signal generation between Arduino and NRF24L01 sensor.

Figure:17, shows the implementation of the NRF24L01 sensor with the Arduino board. Signal passed will be “a”. When the signal “a” will be passed the LED light will turn On and on the other hand when the signal will go far from each other they will stop passing “a” and the LED light will turn OFF. This board features a reverse polarized SMA connector for maximum RF range. And there is the PA and LNA circuit on board, with the external antenna it can reach long distance then the one without these part. NRF24L01 sensor worked both as receiver and transmitter. NRF24L01 received the signal passes through it to the LED light signal via Arduino.

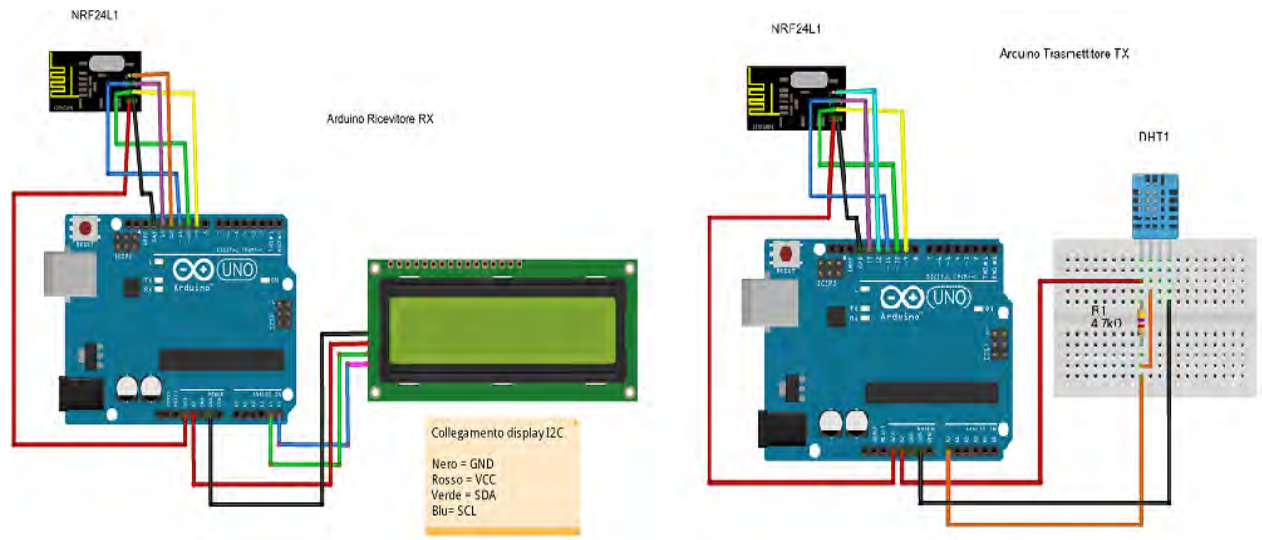


Figure 18: Circuite diagram of the NRF24L01 sensor and the Arduinoborad.

In figure: 18, the connection between the NRF24L01 and Arduino board is shown. Transmitter and the receiver side of the NRF24L01 has the same connection because both of them work as same collecting data and passed it through the signal.

- Connect VCC of NRF24L01 module to Arduino Nano's 3V3 pin
- Connect GND of NRF24L01 module to Arduino Nano's GND pin
- Connect CE of NRF24L01 module to Arduino Nano's Digital Pin 7
- Connect CSN of NRF24L01 module to Arduino Nano's Digital Pin 8
- Connect SCK of NRF24L01 module to Arduino Nano's Digital Pin 13
- Connect MOS of NRF24L01 module to Arduino Nano's Digital Pin 11
- Connect MISO of NRF24L01 module to Arduino Nano's Digital 12
- Leave the IRQ pin of NRF24L01 module unconnected. The NRF24L01 Tranceiver modules with their respective colored jumper wires attached to their pins

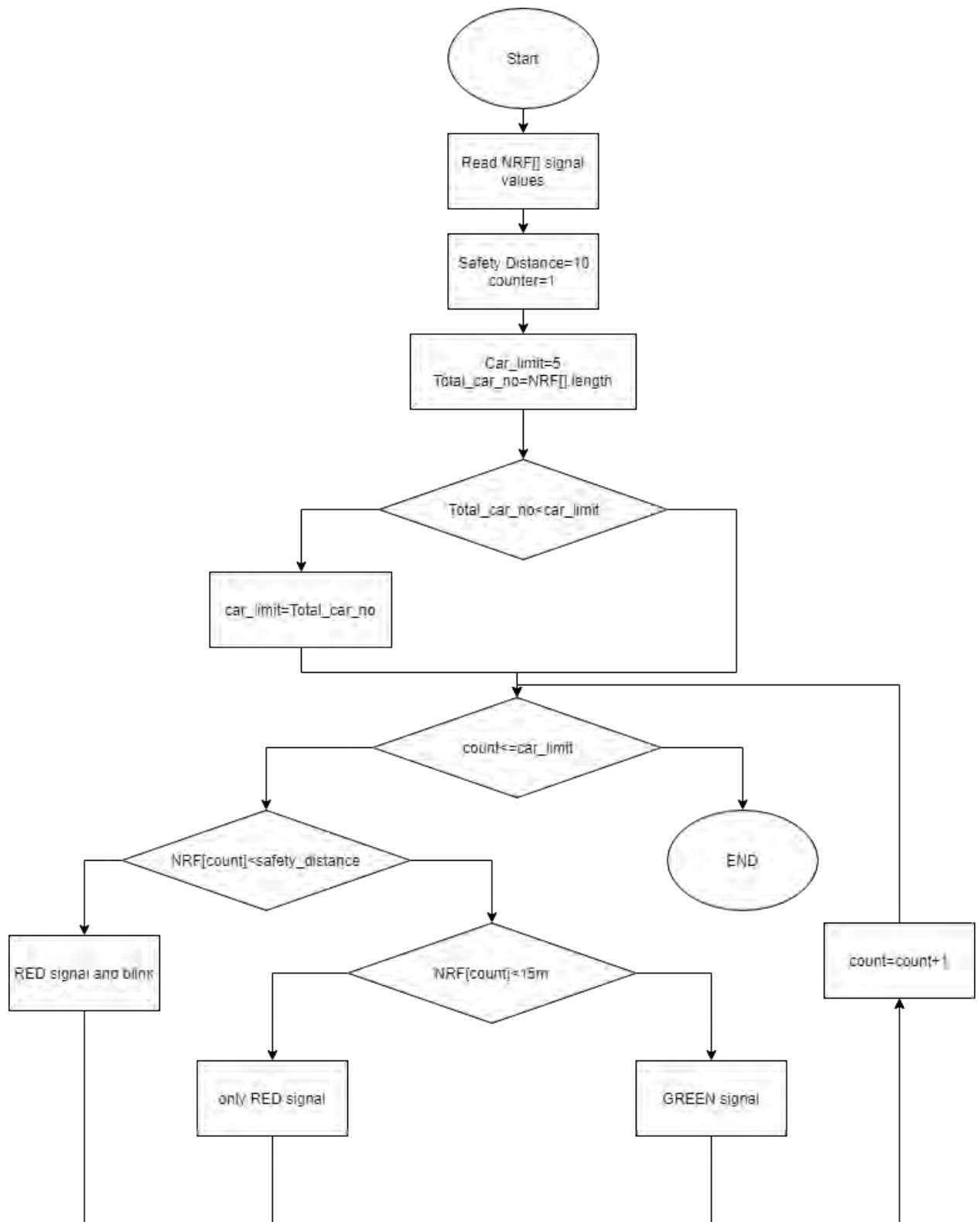


Figure 19: Flow chart of the whole working process of the proposed model

Algorithm 1 Alert

```
1: function NRFREADING( $A, s, l$ ) ▷ Where A - array, s - safty distance, l - car limit
2:    $signal = ""$ 
3:    $arrayLength = A.length()$ 
4:   if  $arrayLength < l$  then
5:      $l = arrayLength$ 
6:   end if
7:   for  $count = 1$  to  $l$  do
8:     if  $A[count] < s$  then
9:        $signal = "RED signal with blink"$ 
10:    else if  $A[count] < 15m$  then
11:       $signal = "only RED signal"$ 
12:    else
13:       $signal = "GREEN signal"$ 
14:    end if
15:  end for
16: end function
```

4.8 Graphical simulation of the proposed model

In this section a graphical simulation is shown about the proposed model to make the system efficient. That how the signals are generated is given here. For the simulation some data was

taken to show the signals generating. In this data safety distance 10m and another safety distance 15m is fixed. 10m safety distance is the system range. As in the proposed model the LED light signal will give signal of the five first vehicles which will come to the range of 50m as the NRF24L01 sensor will cover the area around of it is 50m. so the vehicles signal will be generated through there position. The closer one will be the first signal of the LED light board. In the table 12, five cars are taken according to each car one graphical simulation is generated. Three signal will be generated blink Red light (risky mood), Orange (not safe mood), and Green (safe mood). Each vehicle will get five positional vehicles according to their positions the signal will be generated.

Table 12: Data sheet of the graphical simulation

VEHICAL	NO OF CAR IN RANGE	POS	POS	POS	POS	POS	SAFE_DIST	SAFE_DIST2	BLINK_RED	RED	GREEN
A	5	10	16	5	20	18	10	15	1	1	0
B	5	8	35	10	22	20	10	15	1	1	0
C	5	12	25	18	28	22	10	15	0	1	0
D	5	30	18	25	30	50	10	15	0	0	1
E	5	50	40	28	35	45	10	15	0	0	1

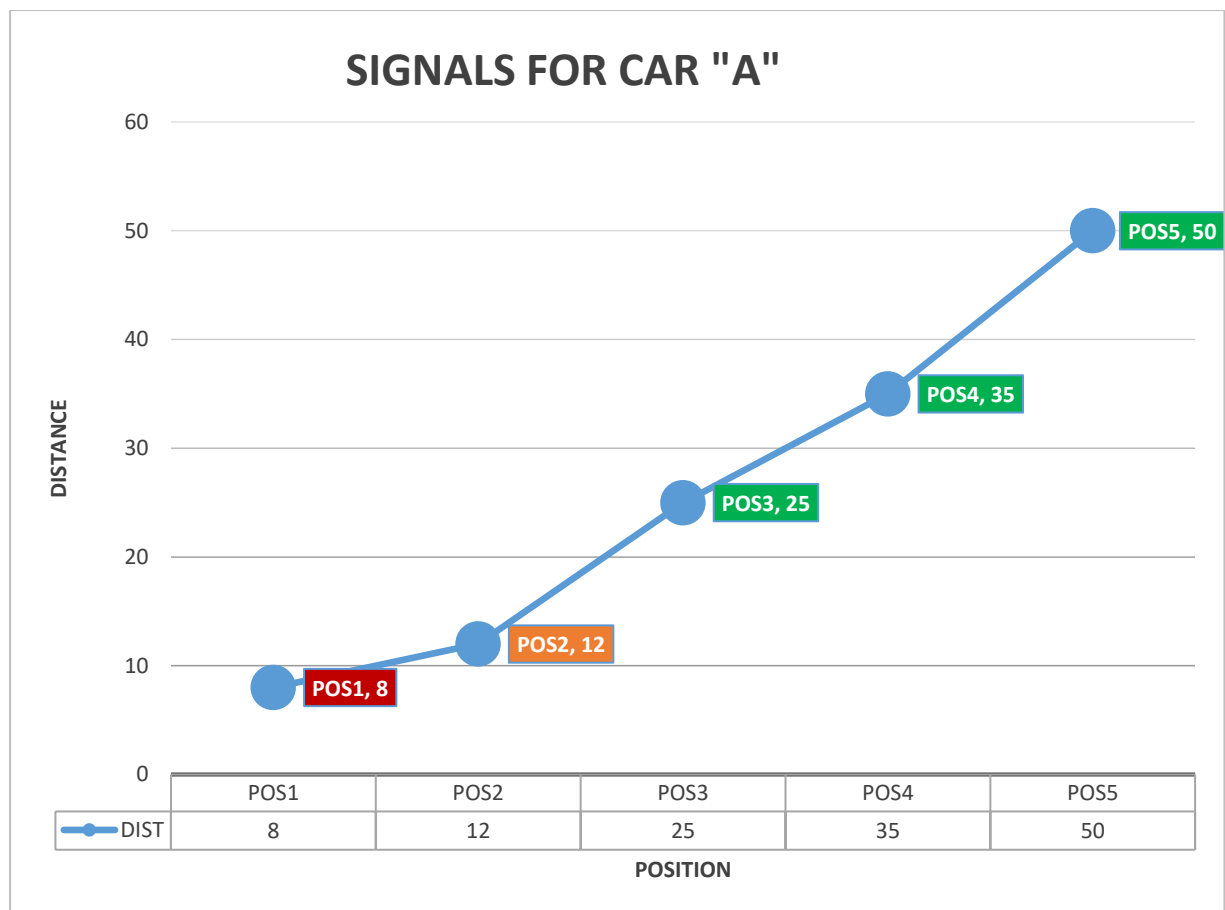


Figure 20: Signal for car A

In this figure: 20 five vehicles position is shown. Position 1 is giving a Red signal as it came to the safety distance 10m and after that position 2 is showing Orange signal as it is in the range of 15m. Other positional vehicles are in the safe mood and those are also in the range of 50m which range is fixed for the NRF24L01 sensor the area it is covering. If any vehicle will come to this 10m the signal will generate Red light and it will also start blinking as it in a risky situation. On the hand, if any vehicle come to the range of 15m then it will show the signal Orange as it is not the safe situation.

In figure 21 and figure 22, the same situation goes on. When the vehicle is below 10m its showed Red signal which is risky mood and when it is lower then 15m it shows Orange signal which is not safe mood.

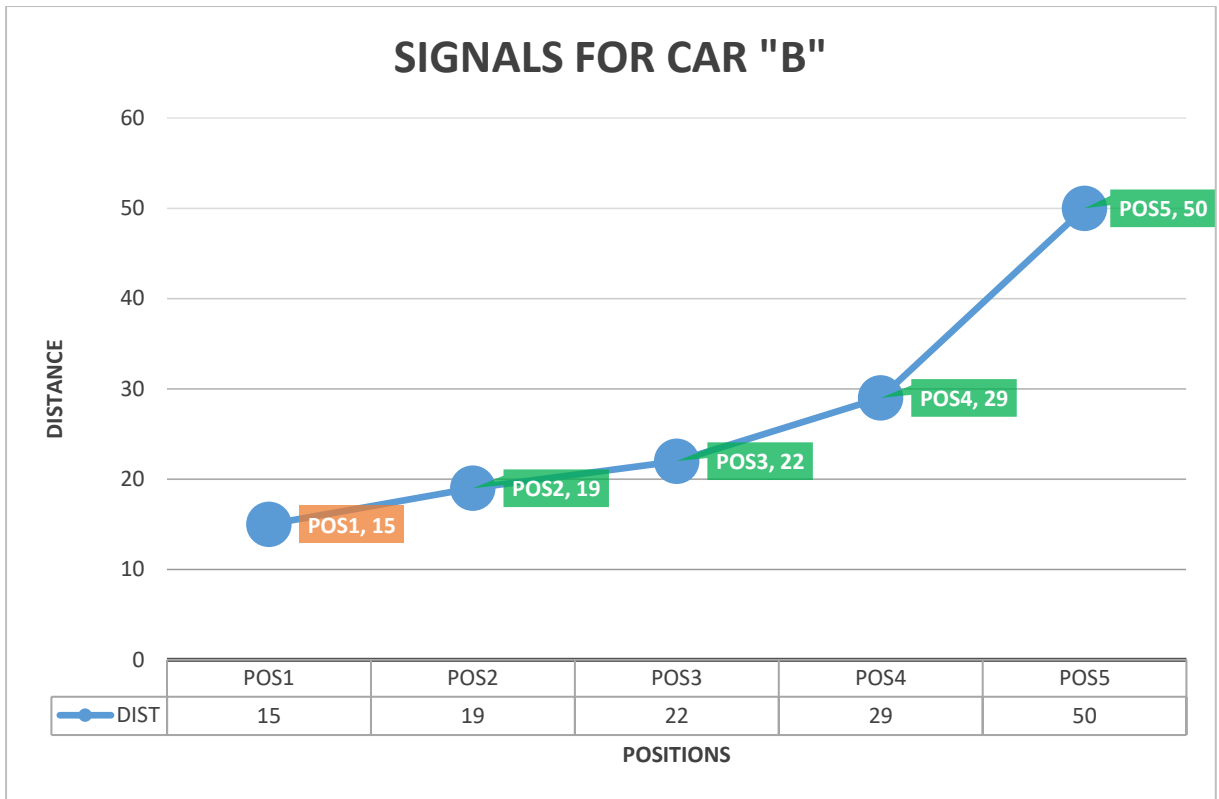


Figure 21: Signal for car B

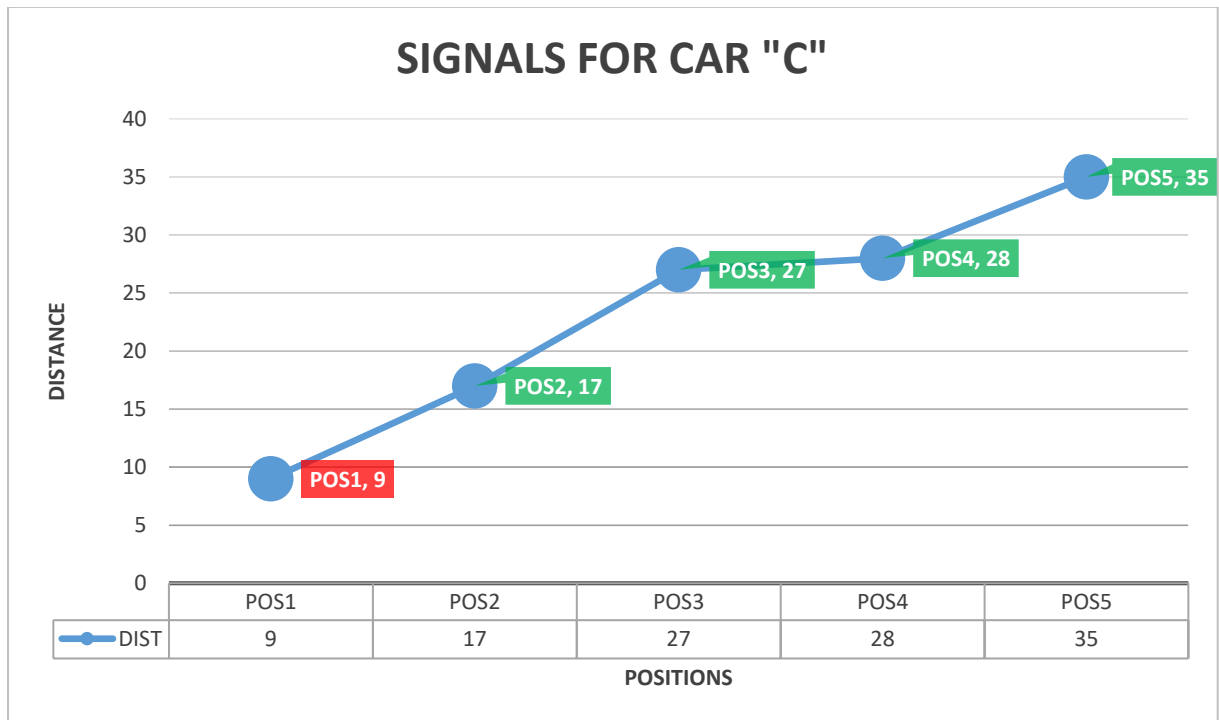


Figure 22: Signal for car C

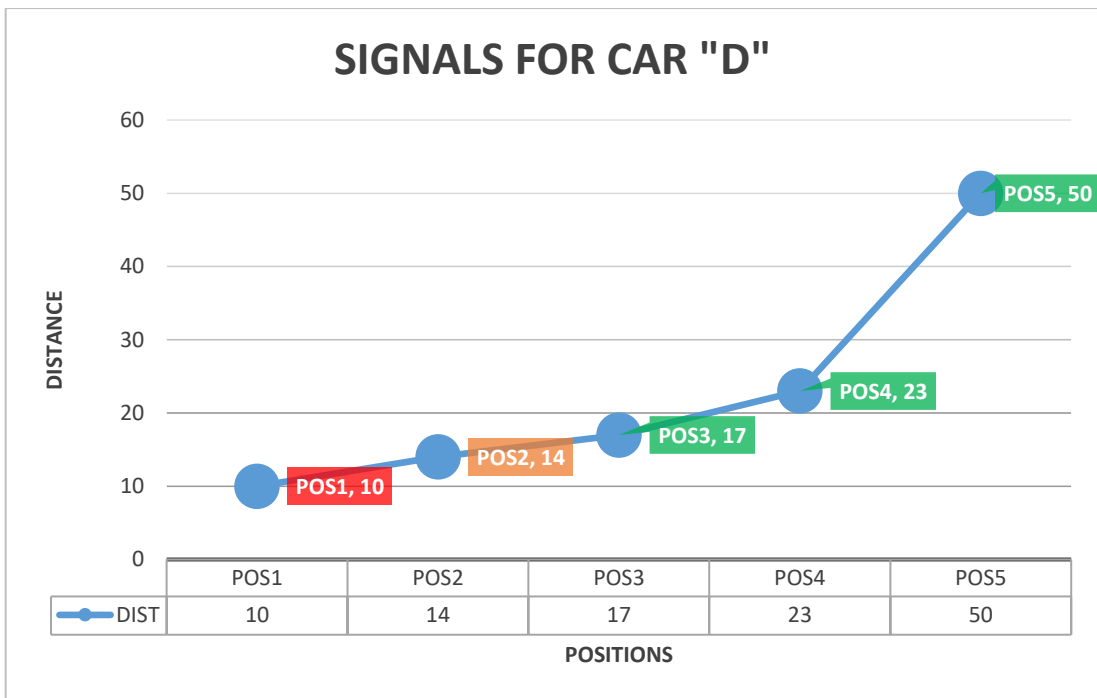


Figure 24: Signal for car D

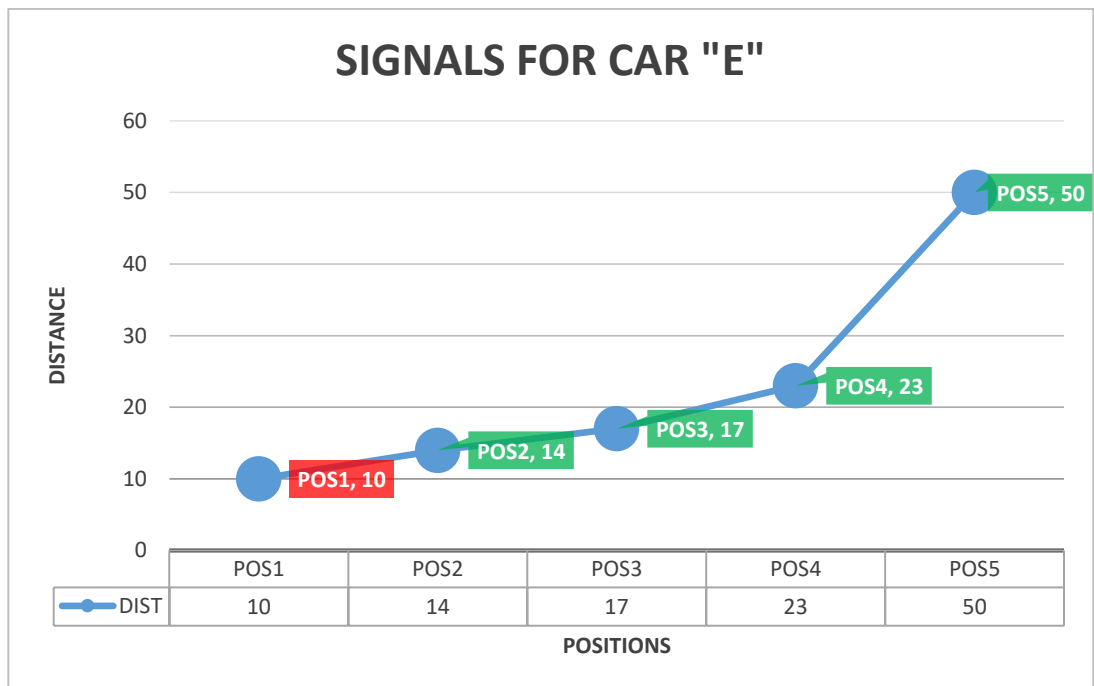


Figure 25: Signal for car E

In figure 24 and figure 25, the cases are running same like the previous cases. When the vehicle is going through or lower then 10m the signal is providing Red and the Orange signal is indicating about the not safe mood when the vehicle s are in the 15m. by the simulation it shows that if the system runs they way the system is designed then the signal will provide the

accurate signal the way it is fixed. In the long run of the system it will generate new approaches to the technology.

Chapter 5

Conclusion and Future work

In this research, I tried to give an efficient way to ensure a smooth driving without collision and a easier way so that the driver can get alert by having signal from the NRF24L01 sensor and Infrared sensor. The system is proposed to avoid collision of vehicle to vehicle communication using NRF24L01 and Infrared sensor which is disciplined way to prevent the violation of rules to a maximum extent. Future work includes adding a LED display to the car by which the result can be seen the sensor using vehicle to vehicle cars signal, position and direction will be clear on that. Another major point is lane detection already some of the algorithm is working on that but in one system if all the aspects can be included then that will the best system to avoid the collisions that is increasing in a very high rate. In addition, a braking sensor can be also included after a specific speed it will give a reminder to the driver to control the speed. This type of result can help to reduce the accident and cooperating driver system for performance improvement.

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