Revista Iberoamericana de las Ciencias Computacionales e Informática
ISSN: 2007 - 9915

# Sistema de comunicación inteligente para la disminución de accidentes automovilísticos por colisión

## *Intelligent communication system for the reduction of car accidents by collision*

## *Sistema de comunicação inteligente para redução de acidentes de carro por colisão*

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## Resumen

Las Tecnologías de la Información (TICs) han evolucionado y eficientizado sistemas tecnológicos de diferentes sectores industriales, entre ellos el sector automotriz. Esta evolución es posible gracias a las líneas de investigación que abordan problemas a ser resueltos o innovaciones a ser implementadas. Uno de estos problemas tiene que ver, de manera general, con el diseño, el desarrollo y la implementación de sistemas de comunicación de vehículo a vehículo (car-to-car) y de forma particular, con el uso de los sistemas car-to-car como un medio para disminuir la incidencia de choques por alcance (rear-end collisions) entre vehículos. Trabajar en este problema es relevante si observamos que el número de accidentes anuales por alcance son alrededor de 1.7 millones, donde, alrededor de 1700 personas mueren y 500 quedan heridas, tan solo en Estados Unidos. En este sentido, en este artículo se presenta un sistema de comunicación vehicular basado en redes de comunicación inalámbricas, para el intercambio periódico de información entre vehículos con el fin de disminuir colisiones de este tipo.

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**Palabras clave:** Ad-hoc, Car-to-Car, wave.

## Abstract

The Technologies of Information (TICs) have evolved and improved technological systems of different industrial sectors, between them the automotive sector. This evolution is possible thanks to the lines of investigation that approach problems to being solved or innovations to being implemented. One of these problems must be seen by it, in a general way, with the design, development and system implementation of communication from vehicle to vehicle (car-to-car) and as a particular form, with the use of the systems car-to-car as a way to diminish the problem, incident, of crash for reaching (rear-end collisions) between vehicles. To be employed at this problem is relevant if we observe that the number of annual accidents for reaching are about 1.7 millions, where, about 1700 persons die and 500 remain wounded, only in the United States. In this respect, this article presents a system of traffic communication based on wireless networks of communication, for the periodic exchange of information between vehicles in order to diminish collisions of this type.

**Keywords:** Ad-hoc, Car-to-Car, wave.

## Resumo

As tecnologias da informação (TIC) evoluíram e melhoraram os sistemas tecnológicos de diferentes setores industriais, incluindo o setor automotivo. Esta evolução é possível graças às linhas de pesquisa que abordam problemas a serem resolvidos ou inovações a serem implementadas. Um desses problemas tem que fazer, de forma geral, o design, o desenvolvimento e a implementação de sistemas de comunicação de veículo para veículo (carro a carro) e, de maneira particular, com o uso de sistemas de carro a carro. como veículo para reduzir a incidência de colisões traseiras entre veículos. Trabalhar nesse problema é relevante se observarmos que o número de acidentes anuais por alcance é de cerca de 1,7 milhões, onde cerca de 1700 pessoas morrem e 500 estão feridas, apenas nos Estados Unidos. Neste sentido, este artigo apresenta um sistema de comunicação veicular baseado em redes de comunicação sem fio, para a troca periódica de informações entre veículos, a fim de reduzir as colisões deste tipo.

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**Fecha Recepción:** Febrero 2017 **Fecha Aceptación:** Julio 2017

## I. Introduction

The evolution of technology has impacted various sectors such as education, politics, social and commercial, transforming the forms of organization and work (Drucker, 2004). Thus, in this field the main factors of study have been the automation of services and the development of software driven by technological change (Arriola, 2008).

One of the main sectors of technological change focuses on the automotive industry. Since the early 1990s, efforts have been made to integrate the technology of transport systems to build "smart roads" that are capable of guiding vehicles to improve traffic safety. The effective use of such systems would have a great impact on global transport, and the probability of traffic accidents and loss of human lives is expected to decrease. (Shereen A. M. Ahmed, 2013).

There are approximately 1.7 million collisions per reach on US roads each year. Around 1,700 people die in these crashes and another 500,000 are injured. Many of the most common car accidents could be avoided if automakers begin to build autonomous collision systems in their vehicles, said the National Transportation Safety Council (NTSB). (Halsey, 2015).

The NTSB estimated that 80% of deaths and injuries resulting from range collisions could be avoided by systems (Halsey, 2015).

There are intelligent transport systems (ITS) in different parts of the world. Some of the interests of the countries of the United States and Japan is to address the challenges of the transportation system such as congested roads and deteriorating infrastructure, building intelligent infrastructure to meet future demands and improve the transportation network and implement technologies to save lives, time, money and to maintain the environment (Mohammad Horani, 2012).

Currently cars have GPS system, for a better determination of destination routes, and there is even information exchange between vehicles. Satellite navigation maps with layers of additional information, which contains topical issues observed by vehicles and transmitted by car-to-car (C2C) for the exchange of information and not by a centralized infrastructure. Each car is a node in a dynamic network, which can communicate directly only with physically adjacent nodes within a certain range (Walter Balzano, 2014).

Car-to-car or vehicle-to-car (car-to-car) allows cars to spread their position, speed, steering position, braking status and other data to other vehicles within a few hundred meters (Knight, 2015 ).

In this sense, this information can be used to determine the position of different vehicles, if it is sent to a network in real time, to connect different vehicles and share the information. The WAVE protocol (Wireless Access in Vehicular Environment) is currently considered the most promising technology for vehicular networks. Its objective is to support the interoperability and robustness of security communications in a vehicular environment (Shereen A. M. Ahmed, 2013).

On the other hand, an Ad-hoc network is a wireless communication network that connects nodes to each other; This communication can be established through the IEEE 811 standard or other wireless technologies. Within this type of networks, a network can be established between isolated devices without requiring a base station, fixed routers, etc., or having an administrator of the system itself, because they are a type of adaptive network, low cost and self-configurable. sometimes two or three nodes are required for deployment (Broch, Maltz, Johnson, Hu, & Jetcheva).

In the car-to-car model the vehicle can share this information with other vehicles or roadside units (RSU); For each cooperative vehicle or RSU it is allowed to generate a "bird's eye view" of the local traffic situation. The infrastructure units of the Car2X system can help the driver in adapting to traffic (Proskawetz, 2016).

The study of this topic aims to reduce automobile accidents by collision with the exchange of information with vehicle to vehicle technology (car-to-car), through wireless communication networks.

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ISSN: 2007 - 9915

## II. Study dimensions

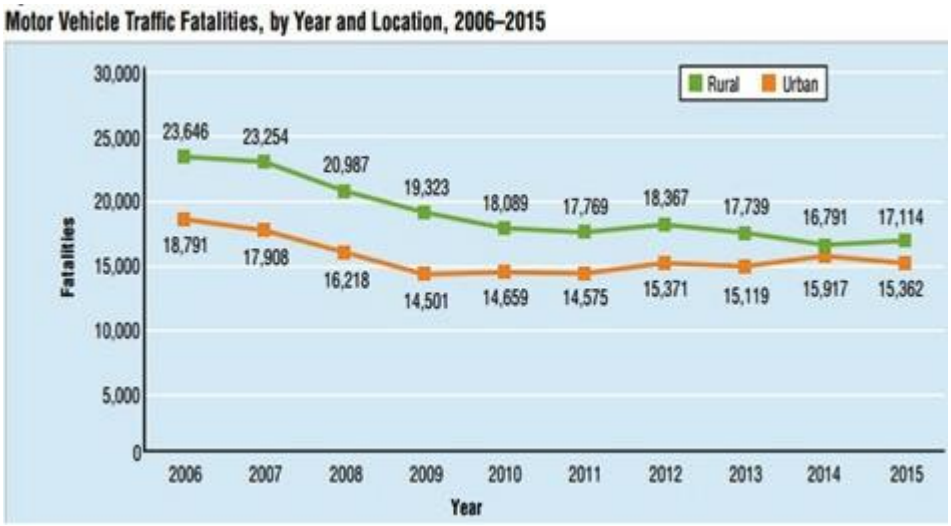
The stability program (ESP) opened the door to active safety. The latest driver assistance systems such as adaptive cruise control (ACC), emergency braking and lane assistance already help to prevent accidents or at least reduce the severity of unavoidable accidents. However, like radar sensors, laser scanners and cameras are of limited range detection and in the detection of complex traffic situations in the vicinity of the vehicle. To overcome these restrictions, the exchange of data between vehicles (Proskawetz, 2016).

### *A. Vehicular accidents*

In 2015:

- There were 32 166 vehicular accidents.
- Of these 32 166 fatal traffic accidents, 15 293 (48%) occurred in rural areas, 14 414 (45%) in urban areas and 2459 (8%) in unknown areas (Analysis., 2017).

**Figure 1:** Index of fatal car accidents 2006-2015.




Source: Figura adaptada de Washingtonpost

### B. *Hypothesis*

The hypothesis is constructed from the Car2X model, inferring a relationship of two variables.

*A.* Descriptive, because it measures and evaluates various aspects, dimensions or components of the phenomenon to be investigated.

*B.* Experimental, since it relates the experiments and applications to verify the communication between raspberrys and Raspberry-PC (both cards are used for the acquisition of data), by means of Ad-hoc networks.

H1: The design and implementation of a communication system with the car-to-car model will allow to prevent vehicular accidents by collision.

## III. MATERIAL AND METHOD

For the realization of the present work, applied research was taken into consideration, because it seeks the application or use of technology knowledge and technological advancement that are acquired.

This type of research depends on the results of basic research, so that what interests the researcher are the practical consequences caused by observation.

### A. *Procedure*

For the development of the design and implementation of a communication system, a series of processes was followed that, together, will fulfill the desired objective. Here are the steps to follow in the investigation.

- Operating system settings on the data acquisition card (Raspberry).
- Ad-hoc network configurations.
- Installation of the VNC server-client program in raspberry 1 assigned as Client and raspberry 2 assigned as server.

- Installation and configuration of the Ultrasonic Sensor MB7076 in Raspberry Pi 2B through the Arduino interface.

The development and implementation of an integrated system for the prevention of automobile traffic accidents. The system works on an Ad-hoc network where 2 Raspberry Pi 2B is transmitted in real time.

For the possible obstacles that appear in front of the vehicle to which the raspberry is connected, the Ultrasonic Sensor MB7076 was used.

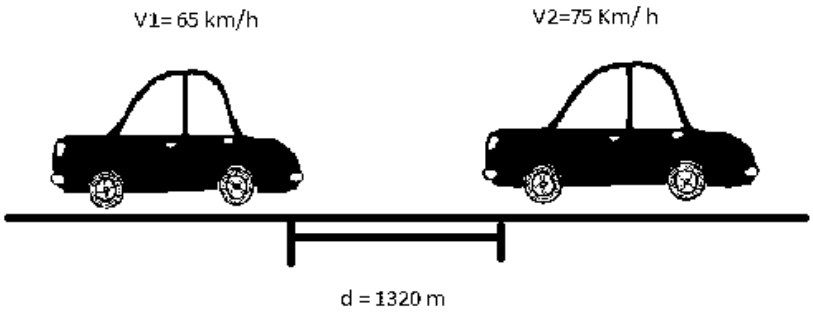
## IV. RESULTS

The capture of transmission data with the ultrasonic sensor was made, with a variation of time, which were used to calculate the transmission rate.

The process was carried out in four operations, calling them different scenarios, to obtain different transmission values with which I give the following data as shown in the following table.

***Stage 1***

**Figure 2.** Distance of prototype vehicles (V1-V2).




**Source:** Autoría propia

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Revista Iberoamericana de las Ciencias Computacionales e Informática
ISSN: 2007 - 9915

The first vehicle (v1) circulates at an approximate speed of 65 km / h, in this is the raspberry data acquisition card assigned as a server.

The second vehicle (v2) circulates at a speed of 75 km / h. In it, there is the raspberry data acquisition card assigned as a client, in this vehicle we have adapted the communication prototype, with the sensor, which will indicate the distance we have between vehicles,

The distance between v1 and v2 is approximately 1320 m.

d = 1320 m distance between vehicles

$v1$ = 65 km/h speed at which the first vehicle is located.

**Table 1.** Resultado del primer escenario.

| Datos | Fórmula | Resultado |
|---|---|---|
| **d= 1320m** | $t = \frac{d}{v}$ | $\boldsymbol{t}$ = 1.21 $\boldsymbol{min}$ |
| $\boldsymbol{v1}$ **= 1083 m/s** | | |

**Source: Autoría propia**

Figure 1 shows the detection of v2 with the sensor; the red color shows the range at which the alarm sent data of possible collision.

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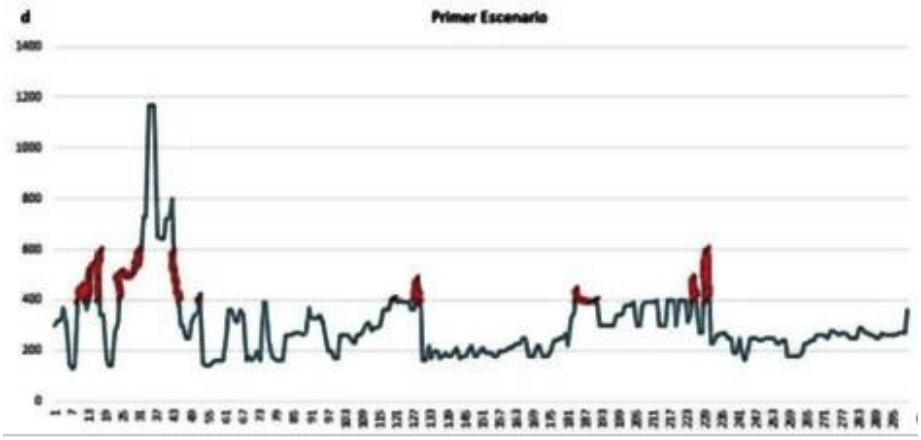
Iberoamericana de las
Ciencias Computacionales
e Informática
ISSN: 2007 - 9915

**Graph 1.** Detección de colisión del escenario 1.




**Source:** Autoría propia.

***Stage 2***

First vehicle (v1) circulates at a speed of approximately 40 km / h, and in this is the raspberry data acquisition card assigned as a server.

The distance between v1 and v2 is approximately 1200 m.

d = 1200 m distance between vehicles

$v1$ = 40 km/h speed at which the first vehicle is located

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ISSN: 2007 - 9915

**Table 2:** Resultado del primer escenario

| **Datos** | **Fórmula** | **Operación** | **Resultado** |
|---|---|---|---|
| **d = 1200 m**<br>**$v$ = 40 km/h** | $t = \frac{d}{v}$ | $t = \frac{1200\,m}{.66\,\frac{m}{min}}$ | $\boldsymbol{t = 1800\,min}$ |

Source: Autoría propia

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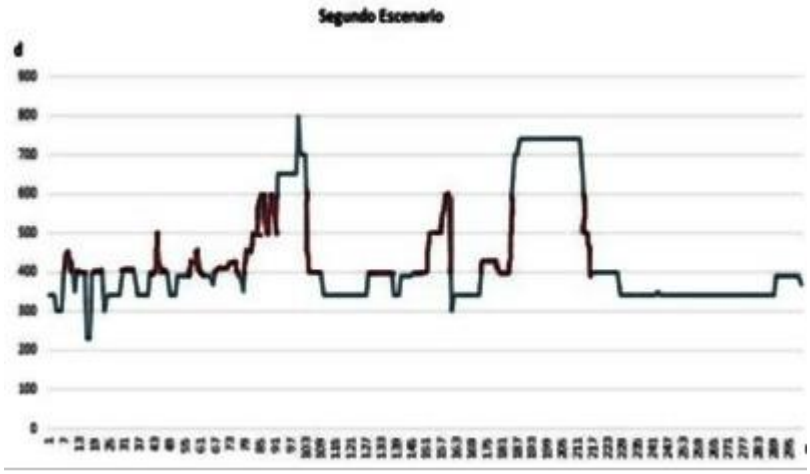
ISSN: 2007 - 9915

Graph 2 shows the detection of v2 with the sensor, and the red color shows the range at which the alarm sent possible collision data.

**Graph 2.** Detección de colisión del escenario 2




Source: Autoría propia

***Stage 3***

First vehicle (v1) circulates at a speed of approximately 80 km / h; in this is the raspberry data acquisition card assigned as a server.

The distance between v1 and v2 is approximately 740 m.

d = 740 m distance between vehicles

$v1$ = 80 km/h speed at which the first vehicle is located

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ISSN: 2007 - 9915

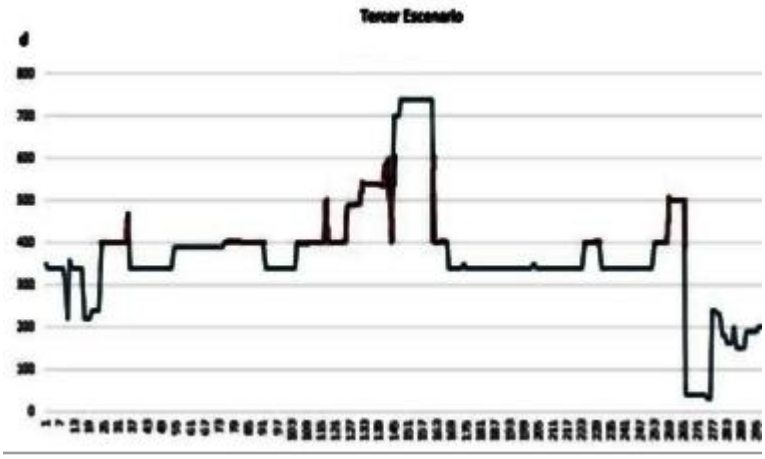
**Table 3.** Resultado del tercer escenario

| Datos | Formula | Operación | Resultado |
|---|---|---|---|
| **d = 740m** | $t = d$ | $t = 740\ m$ | $\boldsymbol{t}$ = 563.9 |
| | $v$ | 1.333 | $\boldsymbol{min}$ |
| $\boldsymbol{v}$ = **80 km/h** | | $m/min$ | |

Source: Autoría propia

Graph 3 shows the detection of v2 with the sensor, and the red color shows the range at which the alarm sent possible collision data.

**Graph 3.** Collision detection of scenario 3




Source: Autoría propia

***Hypothesis check:***

In the graphs, we can observe the results of the items, where we can see that the system has a good response time; In this way, we can corroborate the hypothesis put forward.

H1: The design and implementation of a communication system with the car-to-car model will allow to prevent vehicular accidents by collision.

## Conclusion and recommendation

The review and interpretation of the data allow us to conclude in the validation and affirmative verification of the presented hypothesis; however, the system may have some improvements, which we analyze below.

It is concluded that for the communication system there are certain factors that intervene in the synchronization, for example: connection between raspberrys, difference in speed at which the vehicle circulates and finally the communication range of 10 m - 15 m, resulting in a system connection time of 10 s.

When implementing the Ad-hoc communications network, an in-depth analysis of the characteristics and possible configuration alterations should be carried out, such as the Xbee communications network, whose objectives are focused on the exchange of information.

This system can be applied in intelligent next-generation transport systems in which there is an exchange of information between all the vehicles interconnected in the same network that allows obtaining details about the characteristics of the road, the state of the road and the climatic conditions. of the environment.

For the implementation of a communication system between data acquisition cards (raspberry), it is necessary to know the configuration characteristics and operating systems that can be adapted for the applications that you want to perform.

## Bibliography

Álvaro Cuervo-Cazurra, M. A. (2014). Building Chinese Cars in Mexico: The Grupo Salinas-FAW Alliance. *innovar*, *24*(54) 219-230. Recuperado de http://www.scielo.org.co/pdf/inno/v24n54/v24n54a15.pdf

Analysis., N. C. (2017). Traffic Safety Facts. Report No. DOT HS 812 393. Rural/urban comparison of traffic fatalities, Recuperado de https://www.washingtonpost.com/news/dr-gridlock/wp/2015/06/08/there-are-about-1-7-million-rear-end-collisions-on-u-s-roads-each-year-heres-how-to-stop-them/?utm_term=.a10036e3b8ed.

Arriola, O. y. (2008). Sistemas integrales para la automatización. *Acimed, 18* (6) 109-117. Recuperado de http://scielo.sld.cu/scielo.php?pid=S1024-94352008001200009&script=sci_arttext.

Broch, J., Maltz, D. A., Johnson, D. B., Hu, Y.-C., & Jetcheva, J. (s.f.). A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols. Computer Science Department, Recuperado de https://classes.soe.ucsc.edu/cmpe257/Spring03/papers/broch98performance.pdf

Drucker, P. (2004). La Sociedad Poscapitalista. Colombia: Editorial Norma.

Halsey, A. (2015). There are about 1.7 million rear-end collisions on U.S. roads each year. Here's how to stop them. The Washington Post, Recuperado de https://www.washingtonpost.com/news/dr-gridlock/wp/2015/06/08/there-are-about-1-7-million-rear-end-collisions-on-u-s-roads-each-year-heres-how-to-stop-them/?utm_term=.a10036e3b8ed.

Knight, W. (2015 ). Car-to-Car Communication. MIT Technology Review. *The University of Michigan.*

Mohammad Horani, A. S. (2012). Emerging Technologies Comparison in the United States, Europe, and Japan. AutomotiveWorld, recuperado de https://s3.amazonaws.com/automotiveworld/presentations/V2V+Car2Car+Comparison.pdf

Proskawetz, O. (2016). Cooperative Intelligent Transport Systems and Services (C-ITS) - Car2Car and Car2Infrastructure Communication facilitates a huge potential for intermodal and sustainable mobility. Managing Director of ITS Niedersachsen GmbH. Recuperado de https://eu-smartcities.eu/sites/all/files/docs/best-practice/Car2X_topic_description.pdf.

Revista Iberoamericana de las Ciencias Computacionales e Informática
ISSN: 2007 - 9915

Schütze, D. T. (2011). Automotive Security: Cryptography for Car2X. Rohde & Schwarz, Recuperado de http://www.torsten-schuetze.de/reports/ieee1609-2_security.pdf.

Schwarz., C. f. (2011). Overview of Wireless Access in Vehicular Environment . Indian Journal of Science and Technology.

Shereen A. M. Ahmed, S. H. (2013). Overview of Wireless Access in Vehicular Environment (WAVE) Protocols and Standards. *Indian Journal of Science and Technology*, *6*(7) Recuperado de http://www.indjst.org/index.php/indjst/article/view/34355.

Walter Balzano, M. R. (2014). A Smart Framework for GPS Trajectories' Segmentation. International Conference on Intelligent Networking and Collaborative Systems.

Revista Iberoamericana de las Ciencias Computacionales e Informática
ISSN: 2007 - 9915

| Rol de Contribución | Autor(es) |
|---|---|
| Conceptualización | EMMANUEL CONTRERAS MEDINA “IGUAL” JORGE RAFAEL AGUILAR CISNEROS |
| Metodología | “PRINCIPAL” EMMANUEL CONTRERAS MEDINA |
| Software | EMMANUEL CONTRERAS MEDINA |
| Validación | EMMANUEL CONTRERAS MEDINA |
| Análisis Formal | EMMANUEL CONTRERAS MEDINA |
| Investigación | EMMANUEL CONTRERAS MEDINA “IGUAL” JORGE RAFAEL AGUILAR CISNEROS |
| Recursos | EMMANUEL CONTRERAS MEDINA |
| Curación de datos | EMMANUEL CONTRERAS MEDINA |
| Escritura - Preparación del borrador original | EMMANUEL CONTRERAS MEDINA |
| Escritura - Revisión y edición | EMMANUEL CONTRERAS MEDINA |
| Visualización | EMMANUEL CONTRERAS MEDINA |
| Supervisión | “PRINCIPAL” JORGE RAFAEL AGUILAR CISNEROS |
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ISSN: 2007 - 9915