

What is a smart road?

¿Qué es una carretera inteligente?

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A smart road is the planning of avenues or roads that become advanced intelligent platforms, which allow detailed infrastructure to embody or develop their functions (such as traffic signals and tolls). It allows vehicles to communicate and share an essential information base with deterministic characteristics between a system for receiving and exporting information. In this way, a driver can know in advance if a traffic accident has occurred or if weather conditions are making it difficult for vehicles to pass. This article documents several characteristic aspects of the functioning of each of the parts that make up the intelligent highway.

Keywords: Environment, intelligent road, solar panel, transportation, vehicle

Una carretera inteligente consiste en la planeación de avenidas o caminos que se conviertan en avanzadas plataformas inteligentes, que permiten que la detallada infraestructura plasme o desarrolle sus funciones (como señales de tránsito y peajes). Permite que los vehículos se comuniquen y compartan una base información esencial con características determinantes a los factores, entre un sistema de recepción y exportación de información. De esta manera, un conductor puede conocer con anticipación si se registró un accidente de tránsito o si las condiciones climáticas están dificultando el paso de vehículos. Este artículo documenta varios aspectos característicos del funcionamiento de cada una de las partes que componen a la carretera inteligentes.

Palabras clave: Carretera inteligente, medio ambiente, panel solar, transporte, vehículo

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Introduction

A smart road, someday we thought that mankind would have engineered every technology seen today when we used to think about the future as children, did we imagine a future like this? This is the beginning of the evolution of transportation mechanisms in different countries (Nallaperuma et al., 2019; Wolf & Korzynietz, 2019). Not only benefiting man but also to the planet earth causing less damage to the environment, its surroundings, people, among other factors, where one of its main functions is that they will be able to store large amounts of information on various factors of interest of the roads, in this sense will be able to develop elements of the roads that will serve to prevent, report and respond to certain circumstances such as weather changes, the volume of traffic on roads and occurrence of damage to them, locating every possible error preventing accidents or failures in its structure (Hernández et al., 2019).

It could be a global mechanism, but it is not economically feasible because it does not only concern a field, but also represents various models of use not only in roads, but also in other structures, involving the economy, the environment, resources, materials, and so on (Faieq et al., 2019). It requires a great deal of agility, dynamism, and the will and capability to move into new areas, with lower-cost products that can be followed by other sectors of activity.

This type of road functions as a mechanism for mobilizing vehicles and pedestrians, directly to road vehicles with their physical environment in the first place, to improve road safety (Gichaga, 2017). The technology is based on several disciplines, including transportation engineering, electrical engineering, automotive engineering, and computer science (Cohen et al., 2019). It specifically covers road transportation, although similar technologies are in place or under development for other modes of transportation (de Clercq et al., 2019). Aircraft, for example, use ground beacons for automatic guidance, allowing the autopilot to fly without human intervention. In highway engineering, improving the safety of a road can improve overall efficiency. Aim for improvements in safety and efficiency (Kim et al., 2015; Siuhi & Mwakalonge, 2016). Some readers may know the guidance system's loop opposite to its algorithms.

Smart road

The main goals of road sustainability, efficiency, and safety are that these avenues or roads become advanced platforms that allow infrastructure (such as traffic signs and tolls) and vehicles to communicate and share essential information between a system for receiving and exporting information (Jamroz et al., 2019). In this way, a driver can know ahead of time if there has been a traffic accident or if weather conditions are making it difficult for cars to

pass through a certain point, so the driver knows which road to take and if it is a good decision, so that, with the help of navigation systems, he can receive recommendations for alternative routes and reduce waiting times for people inside a vehicle, while also reducing gasoline consumption and the associated emissions.

Among the various features and functions that intelligent roads can provide for humans, one is that it helps the environment by reducing several compounds that harm it by polluting the air, soil, and producing poisoning, among other things. They contribute to more efficient and less polluting transportation management, lowering the carbon footprint, promoting sustainable mobility policies, and improving air quality by reducing emissions associated with traffic congestion.

They will be able to store large amounts of information on various road factors of interest, allowing them to develop road elements that will serve to prevent, report, and respond to certain circumstances such as weather changes, the volume of traffic on roads, and the appearance of flaws in them, locating every possible error preventing accidents or failures in its structure. Having a digital copy of the world is extremely useful because it allows us to measure faster, calculate more accurately, and plan in ways that were simply not possible two years ago.

This change is currently being developed by private entities, but more governments are getting involved with the new technology of the future, seeing the changes that can be generated, not only locally, but also globally, since as we know the world powers have a competition of superiority to determine which one has the best technological, economic, political and social advances.

The first postulation of this project was proposed as a traffic control mechanism indicating the function of preventing accidents such as stalemates resulting from human error, technology can ensure that response teams such as ambulance, firefighters, police, among others. Have priority in their movements, so that if it is an emergency to reach the destination optimally. Showing several aspects to have in front of the innovative project of the intelligent road generating a broad knowledge and timely basis, to support the feasibility and possibility of development in each country of the world involving costs and others, so that each ruler see the possibility that has this new acquisition of intelligent structures, identifying what benefits can acquire its territory.

The human being as a society will not be so difficult to adapt to these new roads, because nowadays, everything is digital. Society is already intimately related to any technological mechanism with various factors to meet the needs requested, including evolving to adapt to technological innovations that the automotive sector and transport systems demand, with the great possibilities that can generate by providing energy to vehicles, because the roads of the future

are not only intelligent due to their ability to communicate with other objects, but they can also supply energy to the vehicles that travel on them.

To achieve a true transportation revolution by 2030, 15% of vehicles could be autonomous, where sustainability, efficiency, and road safety will be the main objectives (Jochem et al., 2015). Sensors will be placed on these roads to measure traffic density and the speed at which vehicles circulate, thus changing the speed limits of the illuminated signs and adapting them to the flow of vehicles. The intelligent road is an ally of autonomous vehicles through recharging, without the need for fuel, projecting less burden on ecosystems.

Different types of smart roads

Different mechanisms have emerged from the intelligent roads one from the other, looking for better efficiency according to their location, demonstrating, which would adapt better to the situation posed by a country, of the different roads that may arise in the future and that already exist today, each with different functionality, but giving a benefit to all types of vehicle or system assigned, in such a way giving to know that there is not only a type of road but from them come other classifications according to the utility that presents or requests the location of this same (Toh et al., 2020).

The thinking of a society that is still based on the past and does not look to the future. But the basic mechanics are still there. The classic wheel, whether in natural rubber tires, synthetic tires, or futuristic proposals such as tubeless wheels, is still present in search of better development and thus continues to innovate in all kinds of mechanisms favored by nature, avoiding environmental destruction while assisting a man in the structure in the path of its path. One of them is the roads that were created by the Romans, this innovation in transport infrastructure are intelligent roads where they use photosensitive paints in road markings, which also have the function of climatology, generating informative symbols on the pavement of the roadway, road that allows to generate energy on the route itself and to recharge the batteries while driving the vehicle. Among other innovations over time are concrete, aqueducts, and floating bridges.

Solar roads and dynamic vehicle charging

We have been trying for quite some time to implement this type of structure that can be used in combination with other technologies embodied with the use of solar panels from an inexhaustible source of energy, which is the sun, since this asphalt absorbs these tensions very well, conducting it towards the whole system, where it detects the heat transforming it into energy in such a way making the capture of paintings or traffic signs in the hours of the night or during the day.

Through the use of LED lights in traffic lights, using solar energy without the need for other fossil energy, thereby drastically reducing carbon emissions (Xie et al., 2017). Solar panels are used to capture electromagnetic radiation from the sun for subsequent energy transformation. The dynamic charging of vehicles was tested in France to determine failures in the creation of this because there are problems in the load to vehicles by the power it generates or the speed of the vehicle while traveling the road, the fall of leaves to cover the solar panels preventing the best collection of solar rays, the deterioration of the road by the weights and vibrations caused by heavy vehicles, so it serves as an example to detect which areas to improve so that the next implementation of this is already complete and put for an indefinite time.

Smart pavement and connected roads

The modality of this intelligent road involves the interconnection between the road and the rest of the structure to improve the assistance that the security services or accident detection have, seeking to save lives, avoiding many pedestrian accidents, crossing red lights, with a sensor that facilitates the visualization of pedestrians, animals, and objects (Shi, 2020; Sun et al., 2018).

Along with the road, new materials are created or used for the construction of this, seeking to expand the knowledge of the use of more favorable resources such as plastic.

It initiated several projects in 2017 where plastic was used as a material to build roads (Appiah et al., 2017), constructing two private roads using the equivalent of 120,000 plastic bags. In addition to reducing pollution, plastic roads are more resistant to atmospheric weather and vehicles that deteriorate ordinary asphalt roads. It is estimated that they can last more than 50 years, three times longer than a conventional road, withstanding extreme temperature, protecting the solar panels or the technology involved in it, showing a different material than the conventional one.

In a didactic manner, using photographs or digitally formed pre-visualization, plans, and data tables, demonstrating the process and elements that comprise a normal road, next to an intelligent one, demonstrating the viability of both products launched to the market, putting into practice both models, highlighting which is more optimal for a society that is constantly changing, improving an economic model to a different and not-so-distant future (Xiao et al., 2017).

Road

A road has several components that are regulated by the amount of income provided for the work, determining the type of material, costs, location, among others, with the capacity to support heavy vehicles such as trucks, dump

trucks, tractors (Abed, 2020; Niestroj et al., 2018). Engineers are always looking to improve their construction and innovate society. Innovative materials for the construction of new roads, using potentially less polluting and more durable raw materials without the additional costs of cement and other expensive resources, demonstrating the process of plastic reduction and reusing in an autonomous manner. The concept of an environmentally friendly intelligent road is being proposed.

For the effective design of a road, there are certain requirements by the INVIAS entity, which is in charge of regulating the designs of these, these are the following:

- Physical elements of roads
- Right of way or right of way strip
- Number of lanes of the standard section
- Berms
- Pumps
- Superelevation
- Slopes, ditches and others

Energy types

Energy is fundamental to our civilization. There are two kinds of energy, renewable (photoelectric, solar, wind and biomass) and non-renewable (mechanical energy, heat energy) (Qi et al., 2018). The basic and main source of energy is found in the sun, since the origin of the universe is present, it provides us with light and heat, this exerts a strong gravitational pull on all the planets of the solar system, as a mechanism of energy in the application of another type, the traditional, showing an alternative for society and the earth.

Among others it is found in the wind and water and even by the movement energy is generated, it is necessary for the development of mankind, in all fields of its technological activity, demonstrating in its percentage usefulness around the world.

Solar panel

Solar is inexhaustible and renewable energy, for the production of electricity or the production of heat. It can be stored with solar thermal collectors. They absorb radiation from the sun thanks to the set of crystals of a semiconductor material such as panels or mirrors to absorb and concentrate solar heat, transfer it to a fluid and conducted through pipes for use in buildings, brings advantages such as non-polluting, contributes to sustainable development and employment generation.

It is a reusable energy mechanism, in favor of recharge by heatwaves, as a mechanism of reception and adaptation to

generate a basic function of a structure, giving rise to a new sense of use to various technologies. According to NASA, solar energy will never die because the sun still has 6.5 billion years of life left (Corkish et al., 2016).

Operation

Devices that capture solar electromagnetic radiation for later use and transformation into various forms of useful energy, such as thermal energy.

Solar panels absorb radiation from the sun thanks to the set of crystals of semiconductor material that compose them: crystalline silicon, and that when connected respond to the photovoltaic effect, according to which certain matter can emit electrons when bombarded with electromagnetic radiation, this element, as a generator of a new body, capable of transforming it into energy projected to a mechanism with a particular function.

The important role of the civil engineer in the development

The advancement of civil engineering has been and will continue to be a determining factor in the development of mankind, as the primary factor in the innovation of architectures or constructions under a government-agreed-upon regime of standards that evolves in tandem with technology, where it employs a variety of implementation tools to advance and improve the efficiency of modern seismic-resistant constructions. When it comes to determining the primary role of the civil engineer in the field of civil engineering, innovation has evolved into an attitude.

Among the works built in the last century, perhaps the most responsible for having contributed greatly to the environmental deterioration of the country was the construction of the road network that today connects part of the territory and that often constituted new and uncontrolled fronts of deforestation and colonization. There is about 45,000 km of roads, built mainly in the last 80 years. However, what was at the base of the construction of most of them was the previous existence of isolated communities, settled and rooted in the most diverse places of the national geography and that legitimately aspired to enjoy access and vehicular communication. Therefore, it can be said that what failed in many cases was not the layout and construction of the highways but the capacity of the State to rationally order and control the use of the territory and to protect numerous areas whose vocation and strategic use was the conservation of their natural state, generating awareness about the evolution of civil engineering in Colombia, with previous and future projections, generating a process of professional ethics that incorporates environmental values and that puts the interests of society in general, including future generations, before private interests.

Therefore, it can be said that what failed in many cases was not the layout and construction of the roads, but the State's capacity to rationally order and control the use of the territory and to protect numerous areas whose vocation and strategic use was the conservation of their natural state.

The orientation that influenced the evolution of Colombian infrastructure, as in most engineering projects, was to reduce investment and maintenance costs, but without taking into account the environmental impacts, which are not assumed by the project executors but directly by the people and communities affected.

Smart Roads: Technology cocktail

When we say smart road, we think of prioritizing the environmental study in the development of its road projects to generate the least impact on the site and reduce emissions in transportation. Some examples are the design of layouts capable of reducing traffic accidents that promote traffic jams, situations that cause the highest pollution peaks.

Furthermore, we carry out the prevention, healing, and conservation of the environments in which we work, integrating replacement tasks around the project with the planting of trees and shrubs while respecting the environment's flora, fauna, and cultural heritage.

The commitment to these technologies helps to reduce accidents and improve the safety and security of travelers and infrastructure, making them more efficient and optimizing the use of public resources, and assisting in the management of less polluting transportation, reducing the carbon footprint by promoting sustainable mobility policies, improving air quality due to emissions associated with traffic jams (Fig. 1). One of the goals on the agendas of governments and administrators around the world is to develop sustainable mobility, this idea of sustainable mobility is important, given that in 2050 more than 70% of the world's population will reside in large cities, needing to mitigate the problems of congestion, lack of capacity, pollution and road safety problems favoring the protection of people.

By incorporating intelligent technology for incident management, the system guides the operator to act correctly in each case, making the daily operation simple and efficient. The rise and need for safe and green mobility have prompted companies to include these technologies and developments in future projects by detecting traffic intensity in real-time and providing data such as traffic density, vehicle type, occupants, and other variables to support fare calculation.

One of the artificial intelligence is Big Data where it can be applied to traffic and flow prevention, but also to intelligent fleet management, providing real-time information on positioning, waiting for times and schedules of the public transport network, there is also BIM which is a building model that allows the management of large amounts

Figure 1

Remote sensor (Valerann, 2020).



of data and the generation of a digital twin of the physical structure to analyze its behavior.

Among its many applications on the road, these include dynamic pricing solutions, detection of occupants in vehicles at high speed or in remote control, management and maintenance of control centers and operators on the road, improving safety and efficiency levels. A distributed acoustic sensor is capable of converting tens of kilometers of fiber optics into thousands of vibration sensors to classify events, generating different types of alarms such as activity and construction, vehicles, intrusion of people. This can be especially true in automated tolls, taking care of payments that are transmitted properly, without errors, electronically where not only the connectivity of the systems is guaranteed but also its low latency; therefore, the network and computing helps the connected devices to be functional and efficient at any time.

The smart road involves the interconnection between the road and the rest of the infrastructure, as well as with vehicles and pedestrians giving emerging mobility solutions as it will adapt to the infrastructure maintaining conversations with each other, this is a key piece in smart roads, as this will inform the driver that a pedestrian is crossing the street that has not yet been accessed, avoiding many road accidents, especially when there is no human contact.

The potential effectiveness of intelligent road knowledge directed to a few lucky countries for pilot tests, detouring several flaws discovered today or potential problems in the future, where this new technology is not implemented in the world, resulting in technologically backward cities that are unprepared for change and remain in a backward loop.

Countries where smart roads have been implemented

The intelligent road has only been implemented in a few selected countries where they work to determine the quality tests to these same and be improved over time, including England, Japan, France, and the United States, among others,

to exploit the best qualities of the intelligent road (Collier & Weiland, 1994).

It is predicted that in a future time the whole world will be able to install these intelligent roads, improving the economy of a country, the environment, influencing the knowledge of engineers and architects, so that they can manufacture them effectively, placing them in certain cities. Society wants to look for a better alternative for all, but the population does not look for a solution, they let the leaders choose the best for them because the people do not know what is an intelligent road, functions, application, development, among others; since the rulers have not embodied this type of information so that the people begin to investigate and know this technological structure, some countries fail to see the importance of implementing these new technologies for fear that could mean losses for them, but for the people, it would be a benefit. A problem to handle is that the population does not know what an intelligent road is.

What is a smart road?

The smart road is a form of evolution of a new technology to serve society, thus improving several aspects to the driver and taking care of the environment, through sensors and electric vehicle charging, also preventing accidents and thus decreasing deaths from crashes on roads. The road will enable technological integration in existing transportation roads, including functions such as power generation via solar panels, integration with autonomous vehicles and sensors, and structural maintenance monitoring systems, among others. It contributes to the improvement of vehicular mobility in large cities by constantly seeking to evolve and improve in all the determining aspects that are generated over time, thereby satisfying specific human needs. A study in the United States found that between 1996 and 2011, more than 12,000 people died as a result of winter-related precipitation (Black & Mote, 2015). More than 500,000 accidents occur each year as a result of winter weather, resulting in a variety of benefits.

A major function is the reduction of automobile fatalities, accidents, government and insurance costs, economic losses, and personal expenses. Vehicles communicate and share essential information between a system for receiving and exporting information. Know in advance if a traffic accident has occurred or if weather conditions are making it difficult for cars to pass through a certain point. It is also possible to receive recommendations for alternative routes and can reduce waiting times for people inside a vehicle. It reduces gasoline consumption and the consequent emissions derived from the use of fossil fuels. Consequently, it helps the environment by mitigating several compounds that deteriorate it by polluting the air, soil, producing poisoning, among others.

These systems allow storing large amounts of information on various factors of interest of the roads. With this information, it is possible to prevent, inform and respond before certain circumstances such as weather changes, traffic volume on roads, and the appearance of damage on them, locating every possible error, preventing accidents or failures in its structure. Specific benefits include:

- Coordination of response teams such as ambulance, fire, police.
- Illuminated pavement.
- Increased safety on highways underwater.
- Solar panels on the road.

Reasons for use

To know the aspects surrounding intelligent highways, as a method of improving a country, with a more accessible economy, seeking greater resistance or quality of materials when used in buildings.

- Know and interpret positively all the operations of intelligent highways.
- Recognize and identify the qualities that a civil engineer presents, looking for better use of the tools using technology.
- Recognize the environmental impacts that civil engineering can have with intelligent highways, determining if it is a good option to be used worldwide.
- Learn the importance of the civil engineer in seeking to always improve the quality of buildings.

Intelligent roads in Colombia

The problem lies in several aspects developed by events in Colombia regarding the intelligent road, the population is unaware of these types of concepts, since they do not know what is a road of this type and speculates around its function determining the possible causes that lead to this circumstance, it does not cause them any interest to deepen the reality of the subject, mainly because they doubt, The population is not aware of several factors that happen around the world, being biased national TV channels, demonstrating that it can be an intelligent road.

The intelligent road has received little attention or investment around the world because it was chosen for the project by a small number of countries, as previously stated, and thus cannot be used by entities that are not linked, but at the time does not receive the necessary support to which it is requested, there is no knowledge of this structure, generating lack of information by channels or other issues of television connections, but is still present in magazines as recognized articles or social networks sponsoring.

First smart road to open by 2030

The opening of a smart road is proposed for 2030 for postulation to unconnected countries because it will be proposed globally from that date (Aldegheishem et al., 2018). The high cost of producing and maintaining the current road network has compelled governments in many countries to take steps to reduce these costs. For this reason generating the idea of a smart road being an event presented to a way of changing the world, opening a new opportunity for society to produce less environmental pollution, motivating people to buy rechargeable vehicles in this way not only benefits the government but society itself, saving on harmful fuels for the ecosystem around us, giving opportunities to services such as police, ambulances, firefighters and others, from 2030 all economic model will change with greater efficiency and speed, showing a change never thought before. It seeks to expand the knowledge we have about smart roads, so that the idea is developed where it can be used in our country, seeking greater economy, and less pollution in the established constructions, seeing how all this important scheme is confirmed.

Scope and limitations

It could be a mechanism used globally, but it is not feasible for economic reasons, since it does not only concern a field, but represents various models of use not only in roads but also in other structures, involving the economy, the environment, resources, materials, among others.

But technology evolves exponentially every day, generating promoted events, making known what is a smart road, which it is acknowledged that new technological developments are permeating all aspects of human life, and transportation is no exception but is not known due to a lack of societal interest, thinking that it will be more difficult and higher cost at the time to translate it into a near reality, although the project is embodied over 10 years, which also causes this kind of disinterest in the launch date, and when it is known would already be in the future more embodied to the presentation of these.

Currently, cyberspace is the second digital and technological revolution, which consists of the globalization of information where it is captured, stored, reported, managed, and monitored all the news that is in their environment, to help humans to optimize all activities in their daily lives.

For the development of intelligent roads, we must be clear about some concepts such as technologies, software, and tools for the development of this using electronics, i.e. communication technologies.

Mobile communication networks

Both the transmitter and the receiver are or may be in motion. The mobility of these two elements at the extremes of communication makes the use of wires for communication at these extremes not feasible. The basic components of the mobile communication system are detailed below:

- Base Station (BS): These are fixed stations that are controlled by a control unit, these are low power transmission and reception equipment of various frequencies or channels, which fulfills the management of radio communications with some degree of signal processing through a radio link.
- Control Station (CS): These are fixed programmable control stations that automatically control data emissions and the operation of another fixed station, such as a base station; they are responsible for ensuring the integrity of the system and compliance with requested diagnostics.
- Repeater Station: (RS): These are stations used to retransmit received signals, increase coverage in low traffic areas, and allow coverage in an area not accessible by the base station.
- Station (MS): It is a station equipped for mobility that uses FM transmission.

WiFi networks

This means of communication is very useful for the development of everyday life, as it allows connectivity between wireless devices within the same network without the need to connect them by cables.

HOC networks

They are considered as temporary wireless networks of mobile nodes, since the network structure varies dynamically, as well as having a flexible communication system and routing services that retransmit packets between nodes that do not have direct wireless communication.

Wireless Sensor Network (WSN)

The network is composed of four essential elements such as sensors, nodes, gateway, and base stations. Sensors have two important characteristics: they are responsible for transforming data into electrical signals, and in turn are physically considered as nodes, which send the information received to a base station (responsible for receiving the data sent). Likewise, the nodes have three states: *Sleep*, a state that keeps the sensor in energy-saving mode; *Wake Up*, a transition state from *Sleep* to active mode; and *Active* is the state in which the sensor operates transmitting the information.

Cellular levels

Cellular levels are highly dependent on the coverage and capacity required in the area to implement a cellular network. The following are found:

- **Micro Cells:** It is one of the fundamental communication models within a cellular network since it has the main characteristic of increasing the capacity of the network, whose coverage range is between 100 to 1 km, thus being able to have a very low transmission power, greater traffic handling, relatively low cost, and high efficiency.
- **Macro Cells:** It is one of the most operational communication models in a cellular network, whose coverage ranges from 1 to 30 kilometers; more common in users who are on the move (high speed).
- **Pico Cells:** It is a communication model that is characterized by increasing the traffic handling capacity, being used in areas where there is high packet traffic whose coverage range is less than 100 meters.

Programming components

- **HTML:** HyperText Markup Language, is a programming language that consists of text and tags used to define a web document with HTML or HTML extension, used to create web pages to give structure and shape to the content to be displayed.
- **PHP:** It is a widely recognized open-source programming language; it is used to generate dynamic web pages that can be embedded in HTML. It is used more in servers since they are in charge of receiving, reordering, and processing the data sent from a web address in a browser, making all this dynamic and interactive procedure and not in a static way.
- **Python:** It is an object-oriented programming language regardless of the development platform to be used, such as Unix, Windows, OS/2, Mac, among others. It is available for any type of program, Windows applications, network applications, and web pages for free; it was designed to generate script codes that can have fewer lines than its similar ones such as C or Java, which does not need to be compiled to be executed.
- **JSON:** can be read by any programming language, that is, it can be used for the exchange of information between different technologies, they do not need to speak the same language, the sender can be Java and the receiver PHP, each programming language has its library to encode and decode JSON strings.

- **Database Manager:** This system is completely free being of great utility, since it is not necessary to install some software, it can be found in most of the shared servers of web pages.
- **Google API of web type:** It is a visual interface programming application that provides access to a set of complete functions of general use for the customization of map information, which has lines of code in different languages such as Java Scripts ready for use.

Electronic programming software

- **Servo Blaster:** It is software that provides an interface that can control multiple servo motors through the GPIO pins of the Raspberry Pi. Servo motors usually need a high active pulse of between 0.5 ms and 2.5 ms, where the pulse width controls the servo position, which must be repeated approximately every 20 ms, having a high criticality since it directly drives the servo positioning.
- **IDE: Arduino** It is an integrated development environment known as IDE (Integrated Development Environment), which is sophisticated for the compilation and execution of a series of previously programmed codes, the same that uses a USB type serial communication to be loaded into the integrated to be used.
- **Proteus:** It is an integrated software, which was designed to perform different construction projects of electronic equipment in all its stages, such as design, simulation, debugging, and construction, it is currently useful in almost all electrical and electronic projects.
- **MikroC Version 6.6.1:** It is an integrated development environment known as IDE (Integrated Development Environment) used to compile and execute a series of previously programmed codes, these are written in ANSI language understandable for any PIC microcontroller. It allows to generate files with extension .hex and code in assembler language being these compatible with other compilers.

From all the knowledge about the operation of the intelligent highway, as it has been possible to demonstrate an optimal operation in detail in the use of each part of this structure, the question arises: how can we make people know about intelligent highways? To solve these questions, it is necessary to know everything about the intelligent highway and the aspects that it involves.

The intelligent road, what is it? It is determined that by its characteristic name has many different functionalities, taking us to a technological future previously embodied as science

fiction, but at this pace of evolution of humanity, we can bring here the phrase *reality beats fiction* leading us to a new world, but there is not only a type of intelligent road, there is variety, but a problem raised is a term little known locally and globally, because a smart road is directed to several points in specific, this mechanism will not only benefit man, its purpose or functionality goes further, knowing that it will also help the planet earth causing less environmental damage, being indispensable for economic, political and social development adapting to the changes of its exterior, using them as tools to evolve improving the situation of several countries or major cities, showing that the roads are the veins of a heart called country, as self-sustainable roads.

Intelligent roads were already destined for a year of presentation to the public, but it is still not clear what it is? Which is a form of evolution in the application of existing technology in various branches of self-sustaining generating service to society, improving various aspects related to vehicles such as the driver, mechanics, if the car and its environment caring for the environment, with its sensors and battery recharging electric vehicles (which in the year 2020, is gaining strength, for reasons that the vast majority of vehicles developed from 1839 begin to be electric, the road was mainly designed to prevent traffic accidents, involving pedestrians or if drivers *thus decreasing deaths* by crashes on roads. Life on Earth would be impossible without the energy provided by the sun, and without other energies, the development of our activity and progress would be impossible, helping to improve vehicular mobility in large cities, the human being always seeks to evolve improving in all possible aspects that are generated through time and history, satisfying human needs selective to each culture or present difference, a clear example of the lack of these roads and mistakes made by people. A study in the United States found that between 1996 and 2011, more than 12,000 people died as a result of winter-related precipitation. Every year, more than 500,000 accidents occur as a result of winter weather (Pisano et al., 2008).

Society does not allow new knowledge if they do not see the advantages developed, at first sight, generating ignorance of what is an intelligent road? They are uninterested in learning about this project because of the economic loss to their economy, a community's thinking that is still based on the past and does not look to the future. The basic mechanics are still present, as is the classic wheel, whether in natural rubber tires, synthetic tires, or even futuristic proposals such as tubeless wheels. Technology evolves, but the first archaic technologies are still present; it is a different way of looking at the community; the technologies developed today are derived from anything; these mechanisms have historical precedents, which can be shown that technology improves from one that no longer meets the needs requested for the current time (it does not disappear, it evolves creating new

utilities showing that everything has an origin starting from an ancestor) because in this way to continue innovating in all type of mechanism favored by the nature avoiding the destruction of the home of each one of the people, which is the planet earth.

Helping the man in the structure of the trajectory of his path. We find the roads that were created by the Romans and was evolving until today, this innovation in transport infrastructure are intelligent roads, one of the main functions that can be evidenced is where they employ photosensitive paints on road markings for greater visibility, which also have as a function of climatology determining the changes that can happen warning the driver, generating informative symbols on the pavement of the roadway, also the road allows us to generate energy on the route itself and to recharge the batteries while driving the vehicles.

Main factors for lack of awareness of smart roads

The factors presented below are taken from the point of view of an average Colombian (Bogota).

- The population does not see the importance of a mechanism such as the intelligent highway because it is such a distant event.
- They consider that the manufacture of these large structures will affect the country's economy, and consequently their pocket, showing a preference to get used to the minimum and not to move forward, developing fear of change.
- They consider that it is impossible to generate intelligent roads all over the world, being an indicator of the country where they live with inequality.
- Most people make excuses among themselves, showing a lack of importance to the environment because if they see that the place is being polluted with materials such as plastic, coming from packages, groceries among others. They will not see the importance of taking care of the environment or the project itself *saying that if a group of people throw garbage in this place why not them.* - Society does not care about what is external to their country.

Not all the inconvenience of knowing what is the intelligent road is to the lack of interest of the beginning of renewable structures that is directed to the way of thinking of a society, this lack of knowledge is also due to the way it has been reflected in different media or amounts of reports of this generating information.

- The companies in charge of this structure belong to the private sector, making the information of the whole program not visible to the public.

- This road test has only been implemented as a means of testing in a few countries selected as optimal for testing.
- There is very little information about these technological advances in the web networks, for reasons that recently started and is not allowed to communicate any progress (it is confidential).
- There is no guiding plan of how this road is planned to be structured, only indicating the functions and what energy is going to be used, but no details are known yet.
- The project is launched to the public for 2030, which does not generate urgency of this knowledge, because there are still 10 years to go if there are no delays due to inconveniences.

We can instill to the society that it is an intelligent road by information mechanism, not only present in informative web pages, presenting itself as articles or critical diagnostics because to know about the road, you have to go visualizing its development through the time raised, determining that we are in the XXI century, and everything moves is through social networks, where sales and promotion are not placed in flyers and others, but by advertisements presented in social networks more elapsed, mitigating the lack of interest and through these, the population is more interested in entering the attached web pages.

The intelligent road and its term can lead to what it is and its function, determining that it can be determined by its composition and functionality that it may have over time and raising doubts. The first postulation of this project was raised as a traffic control mechanism indicating the function of preventing accidents such as stalemates product of human error or possibly the deterioration of the roads where the vehicle transcurrer, promoting the technology with the purpose that can ensure that response teams such as ambulance, fire, police, among others assisting the injured present taking them to the best possible care. Having priority in their displacements, in such a way that if it is an emergency to reach the destination optimally.

Showing several aspects to have in front of the innovative project of the intelligent road generating a wide knowledge and opportune base, to sustain the viability and possibility of development in each country of the world involving costs and others, in such a way that each governor see the possibility that possesses this new acquisition of intelligent structures, identifying that benefits can acquire its territory.

Construction materials

- Asphalt. It is a kind of viscous bituminous substance or material of black color, constituted mainly by asphaltenes, resins together with oils, used for the manufacture or resistance of these roads.
- Asphalt Cement. Application in heat to this substance, combined with cement, causes consistency and hardness capable of supporting heavyweights.
- Asphalt Emulsion. It is defined as the combination of three main substances: asphalt, water, and a specific amount of an emulsifying agent, which allows the mixing of two substances.
- Asphalt lowered. It is a distinctive material of soft or fluid consistency, whose maximum limit that can be presented in the structures is 300. It is also called cutback asphalt composed or formed of a finely ground mineral, the standard color present is gray, extracted from limestone rocks.
- Rock. It is a substance of primordial characteristic to give a leveling or balance between the road and the subway soil at the level of its structure so that this does not sink or cause unevenness and this structure deteriorates.
- Sand. It is mainly used to compose other substances and to give greater compression or absorption of the unified materials because it is constituted by small grains hardly visible coming from a mineral that is detached from the rocks and accumulated in beaches forming a layer on a land.
- Brick. It is an object made in the shape of a rectangular prism with different functions composed of baked clay, used in the construction of walls, pillars, and roads.
- Sensors. It is a mechanism that is implemented to the intelligent road to meet the needs raised, because it is a device that captures physical magnitudes, highlighting the trajectory of vehicles. This device has the functionality to capture (light variations, temperature, sound, etc.) or other alterations to its environment.
- Batteries. A form of vehicle recharging presentation as an electromagnetic device capable of accumulating electrical energy collected from the sun, to which it is exposed, being able to supply it; it is usually formed by lead plates.
- Solar panels. They are structures mainly for solar energy, which is the one that has the main function of intelligent roads being a device that generates a large amount of heat or electricity. They absorb radiation from the sun thanks to the set of crystals of semiconductor material.

- Photovoltaic. They are a multitude of cells, called photovoltaic cells, which convert solar radiation into electricity.
- Communicators. They are those who possess a great ability to transmit to others their information by connecting with people or databases, especially the person who has a public activity.
- Reflective paint. The substance of different colors and liquid or thick texture is a demonstration for traffic signs, which energy allows it to renew its luminosity at night.
- Connecting cables. The entire smart highway must be composed of connector cables, either subway or overhead, which are input/output connectors with the functionality of interfaces to connect devices via cables.
- Reinforced plastic. Glass-reinforced plastic, or also being reinforcement for the road component, it is possible to reuse every plastic scrap in a reusable way to create a more rigid layer for greater strength.

The human being as a society will not be so difficult to adapt to these new roads, because today, everything is digital, society is already closely related to all technological mechanisms with various factors to meet the needs requested. We must evolve to adapt to the technological innovations that the automotive sector and transportation systems require, with the vast possibilities that can be generated by providing energy to vehicles because the roads of the future will be intelligent not only because of their ability to communicate with other objects. They are also intelligent because they can supply energy to the vehicles that travel on them.

The intelligent road is being highlighted primarily by the development and interface of various processes that can happen internally in the structure giving us to know that it is the intelligent road, this is called the interaction and automated reaction of electronic components such as wireless sensors, microcontrollers, cameras, engines turn, among others; using an advanced and effective communication to any event occurred. This is formed by points or nodes strategically located in certain sections, with their corresponding protections, which process and transmit information per second in case of accidents of a low, medium, high priority, with cameras monitoring 180 degrees remotely controlled.

To detect an obstacle on the road, the sensor first sends an ultrasound signal at a frequency of 40 kHz, followed by a computer agent, which consists of the report notified by several of these, for this depends on a system where it controls and monitors remotely from the command center.

To control from the web the rotation of several cameras connected simultaneously at 180 degrees, it is done through servomotors where the communication between server and client is linked, this will take connected multiple cameras, to obtain real-time video locally and remotely using a compatible camera, which is connected to the software where it allows the flow of images per second, being captured sequentially in real-time.

When the user enters the website, it is possible to visualize in real-time on a map provided by Google, the administrator can make any change in the control and monitoring system, either by closing or opening a road, each section has an associated sensor which is represented with a green light bulb on the interface that indicates that the section of the road is enabled and red expresses that the road is disabled. In case the user does not know the web portal for consultations, intelligent signage is provided at the beginning of each section of a transit road, to inform the user in advance if the transit road is available or not and in turn, provides information on the optimal route in case one of them presents problems. This signage reacts and updates, with a delay of approximately 12 seconds, after the person who is monitoring the system wants to enable or disable the road that presents some inconvenience.

The idea of implementing a purely informative system on the availability of the different routes in the country in real-time generates satisfaction, reliability, and safety for users when moving from one place to another. The purpose of implementing an intelligent decision-making system on a map is to provide information on the second-best route to take after the main route has had a mishap. Despite the development of new technologies and systems, these cannot decide on any inconvenience presented, for this human interaction is needed, in this case, it was possible to validate the closure or opening of a road through a visual monitoring system controlled from the web.

Illuminated roads

The luminous roads work thanks to a special paint that absorbs sunlight and is released at dusk, with a duration of 10 hours, with this is achieved to illuminate large roads avoiding energy expenditure, while minimizing the supply of electricity, blackouts and is environmentally friendly. Another type of paint acts as a sensor that responds to changes in temperature. It appears invisible when it is hot, but when the temperature drops, it distinguishes itself from the pavement, warning drivers that the surface is icy or slippery.

Work is underway to study the light output required for the signage to be effective in such thick fog. A combined solution to this problem is proposed, using several ideas, on the one hand, to dissipate the fog and, on the other hand, to improve driving safety, where large extractors are provided to

absorb the water particles from the fog by placing luminous tiles flush with the asphalt through the provision of a small slit.

It is common for some drivers to drastically reduce speed in foggy conditions. Some even stop, causing danger to following vehicles. Therefore, a motion sensor is being designed to detect sudden slowdowns or stops. This will cause the horizontal signage to turn red to warn of the danger of a rear-end collision. In conjunction with this, several intelligent concepts are being developed on the ecological side, such as temperature-sensitive paints that change color to alert drivers when the roads are icy interactive lights that turn on when cars approach and turn down after they pass *wind lights* powered by small windmills that rotate using current from passing vehicles priority lanes that have induction coils for recharging electric cars.

Vehicle infrastructure integration

Vehicle infrastructure integration (VII) is an initiative that fosters research and application development for a range of technologies that directly link road vehicles to their physical environment, primarily to improve road safety. The technology draws from several disciplines, including transportation engineering, electrical engineering, automotive engineering, and computer science. VII specifically covers road transport, although similar technologies are in place or under development for other modes of transportation. Aircraft, for example, use ground beacons for automatic guidance, allowing the autopilot to fly without human intervention. In highway engineering, improving the safety of a road can improve overall efficiency. VII points to improvements in safety and efficiency.

Structural Health Monitoring

Structural health monitoring (SHM) refers to the process of implementing a damage detection and characterization strategy for engineered structures. Here the damage is defined as changes in the material and/or geometric properties of a structural system, including changes in boundary conditions and system connectivity, that adversely affect system performance. The SHM process involves observing a system over time using periodically sampled dynamic response measurements from an array of sensors, extracting damage-sensitive features from these measurements, and statistically analyzing these features to determine the current state of the system's condition.

Intelligent Transportation Systems

An intelligent transportation system (ITS) is an advanced application that, without incorporating intelligence as such, aims to provide innovative services related to different modes of transportation and traffic management and allows users to

be better informed and make them safer, more coordinated, and smarter. Use of transport networks.

Photovoltaic pavement

Photovoltaic pavement is a form of pavement that generates electricity by harvesting solar energy with photovoltaic power. Parking lots, walkways, driveways, streets, and highways are all candidate locations where this material could be used. The technology is used in combination with asphalt and can be used on new construction or existing surfaces. The paving material may contain solar panels that are transparent or colored (such as green) to improve aesthetics, sunlight absorption efficiency, and reduce bird hazards.

Conclusion

The intelligent road is destined to be a mechanism with a projection that will change the world, allowing to advance in all the technological aspects present in the mobility located using public or private transport, demonstrating that the society is in constant change looking for constant improvement, where the intelligent road is divided into several types, its function is determined by according to the method that facilitates the population, where it is proposed where its location is exposed, demonstrating that there is not only one type of intelligent road but a diversity, according to the capabilities that present its main operation, lights, recharging, monitoring, Collector, Transmitter, among others.

Smart roads are the arteries of a country, thanks to them, you can mobilize and bring the foreign population to the interior, thus growing trade, this is a drastic change for a society that is increasingly familiar with virtual platforms, but at the time few people know about the subject, for reasons that very little information is present generating ignorance and lack of interest, but this proposal for the year 2030 wherewith certainty will take greater power and will be of global knowledge for acquisition.

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