Intelligent Brake Controller Based on Intelligent Highway Signs to Avoid Accidents on Algerian Roads

AHMED MALEK Nada, BOUDOUR Rachid
Embedded Systems Laboratory, Badji Mokhtar Annaba-University, Algeria

***Abstract*—Despite the considerable efforts of the Algerian authorities to reduce the high number of accidents, therefore, fatalities on the country's roads, the problem persists. To address this worrying situation, it is necessary to adopt new technologies and approaches that can assist Algerian drivers forcing them to comply with driving rules, thus putting an end to this concerned issue. This research aims to primarily assist Algerian drivers in reducing the mortality rate, which is primarily caused by speeding and poor road conditions, including outdated and inadequate road signs. To achieve this objective, a complete system consisting of two complementary subsystems: intelligent traffic signs and an interactive and smart speed limiter, has been proposed. Existing projects in this field have shown deficiencies, particularly in the context of real-time critical systems. This work offers improved precision, real-time responsiveness, adaptability to changes, and reduced infrastructure dependency compared to existing solutions. The new approach has been tested with the SUMO simulator, and a prototype based on Arduino cards has been developed approving its feasibility. However, the results obtained from this study demonstrate that the proposed system can significantly reduce the mortality rate on Algerian roads.**

Keywords*—Intelligent Transportation Systems (ITS); Intelligent System Adaptation (ISA); road accidents; intelligent road signalization; decision

I. Introduction

Every year, a significant number of accidents occur on roads, with speeding and unsafe road infrastructure being major factors; they are responsible for 29% and 3% of fatal road accidents respectively [1]. In 2021, Algeria experienced one of the worst road safety reports with 6195 accidents, of which 2294 were killed, equivalent to 192 deaths per month, and 9963 injured, without forgetting to mention the considerable economic losses caused by these accidents which amount to billions of dinars annually weakening insurance companies financially [2] (SAA, CAAR, CAAT, etc.). The government and authorities of road safety around the world devote considerable resources to deal with accident causes and reduce the number of fatalities on the roads. Particularly by the use of Information and communications technology for the construction of smart vehicles and infrastructures which can assist road users to respect traffic laws and enjoy safer traffic.

Several projects and initiatives are subscribed to improve safety on roads, including Intelligent System Adaptation which is known by the abbreviation ISA [3]. These systems assist drivers in maintaining speed limits or even prevent the vehicle to overtake them on all routes and at all times. Although they have proven their effectiveness in reducing the risk of accidents and their severity (i.e., saving lives), reducing emissions of carbon monoxide (environmental) as well as improving traffic flow (e.g., a gain of substantial time for users) [4], there are still some shortcomings that engineers are endeavoring to eliminate. In addition to communication between the vehicle and the infrastructure, smart road signalization is another aspect that can improve road accident statistics, by avoiding inconsistency of current signs with the state of the road and weather conditions, especially in underdeveloped countries [5].

This work focuses on addressing the problem of inappropriate speed limits and excessive speeding, both of which contribute significantly to the high number of accidents on Algerian roads. Despite this scourge which mourns thousands of Algerian families every year, no radical solution has so far been introduced; therefore, this work lays the foundation stone for the improvement of transportation and, ultimately, significantly reducing the number of deaths on our roads. By tackling these crucial aspects, this work aims to create a safer road environment and significantly reduce the mortality rate.

What sets this work apart from others is its interactive nature, where decisions are based on direct communication between the two subsystems. By integrating advanced technologies and intelligent systems, we create a seamless interaction between intelligent traffic signs and the interactive speed limiter which provides improved precision by enabling accurate transmission of speed limit information. Real-time responsiveness ensures quick adjustments to speed limits based on road conditions. The method is adaptable to changes, allowing for prompt updates in response to temporary modifications. It reduces infrastructure dependency by utilizing wireless communication, making it more cost-effective. Overall, this method enhances the effectiveness and efficiency of the speed limitation system, improving road safety.

In addition to the introduction and conclusion, this paper will be organized into three main sections. The initial section will present an overview of existing intelligent transportation systems for safety and address the criticisms associated with them. While the second section explains our proposal to reduce the number of road accidents on roads by introducing an intelligent road sign that can make a decision on the optimal speed and communicate it with an intelligent brake controller to monitor the vehicle speed. Our approach supposes that each highway sign allows continuous broadcasting of information such as speed limit, location, wind strength, road traffic, etc. Data is gathered and processed by the controller to assist the driver in the most efficient way possible, this may include visualizing messages, using text-to-speech technology, and applying the brakes in extreme cases. The last section, discusses the obtained results from simulation on SUMO and Arduino's prototype.

II. Related Works

A. ISA Systems

1) Presentation of ISA systems: Intelligent speed adaptation (ISA) is a generic term for a class of intelligent transportation systems (ITS) in which the driver is warned and/or the vehicle speed is automatically limited when the conductor moves above the authentic speed intentionally or inadvertently [5].

Essentially ISA continuously monitors restrictions on "local" speed as well as the vehicle speed and reacts in case of exceeding the limit. The type of the system depends on the reaction which can be either "passive", where the driver is warned, or "active", where an automated control over the vehicle speed is imposed due to embedded devices of ISA such as sensors of speed's knowledge.

Carsten et al [6,7,8] present a review of the various tests and estimate the effectiveness of ISA. They consider three levels of control: advisory, voluntary (active but the driver can turn it off), obligatory (active all the time), and three types of speed limits: fixed, variable and dynamic. In a fixed system, there is one speed per area, which is unchangeable, in the dynamic system; we opt for a fixed speed, suitable for several variables, such as weather conditions or unexpected events. In a variable system, an individual or an entity is responsible for the decision-making and taking actions (e.g., road construction).

For comparison, based on recorded data from the test of a passive ISA system working with fixed speed limits, Regan [9] estimated that the system can reduce fatalities by 8% and serious injury accidents by 6%. However, the author noted that they were likely to be underestimated.

2) Technologies used in ISA systems: All ISA systems are based on the knowledge of the authentic speed limit. This can be achieved through the use of the mentioned function according to different existing technologies, the main ones are:

- GPS Global Positioning System: GPS technique is based on the localization of the vehicle and the extraction of the related speed from the database of "speed cards", that are embedded in the vehicle [10,11,12].
- Despite its popularity, the GPS is submitted to a certain number of fundamental issues related to the precision of determining the position and the construction of the database
- RFID - The Radio Beacons: Radio beacons function by transmitting data to a receiver integrated into the vehicle. Tags emit continuous data, and the receiver captures it at each passage [13,14,15].
- Unfortunately, these systems can be used only for slow vehicles. For vehicles traveling at high speed, it is difficult to collect and process data in real-time, this is in addition to the constraint of the vehicle that must be close to the transmitter to determine the speed limit.
- Image Recognition: This system uses a camera mounted on the vehicle to capture continuous images on the road. The image is processed to find if there is a traffic signal. Once the sign is found, another algorithm is used to define the pattern of the image to recognize it. Following the recognized symbol the ISA system reacts.
- The major constraint of this system is the lack of recognition combined with the imprecision of items, especially during unfavorable weather conditions (heavy rain). Additionally, even in relatively simple situations, these systems are incapable of dealing with fixed obstacles reliably which can lead to erroneous conclusions [16,17,18].
- Dead Reckoning: Dead Reckoning (DR) uses a mechanical system linked to the drive unit to predict the path taken by the vehicle [19,20,21].
- This system requires the establishment of multiple sensors on the vehicle, which can be expensive. However, its reliability and accuracy remain uncertain since the user may at any time deviate from its originally estimated road based on information that can sometimes be wrong.

B. Intelligent Road Signs

The design developed on intelligent road signs is intentionally redundant because it currently serves research purposes.

We can classify technologies used to improve the road signs' deployment into:

- Deep learning methods: Given the emergence of deep learning, several works have been registered using it. This work is known as ATDR for Automatic Traffic Sign Detection, the ATDR is mainly used to recognize and classify the different forms of road signs on vehicles. They are mainly used to improve the driver's attention to avoid possible accidents. [22,23,24,25]

- Generally, these methods are inefficient in unfavorable weather conditions, reduced brightness. Furthermore, they may not be effective in dealing with speeders.
- Google Street View methods: these methods are used to solve some problems encountered using deep learning. Based on Google Street View (GSV) as the source image and database of road signs with relevant coordinates. [26].
- This promising approach unfortunately inherits large database and precise location problems, besides, they may not have the ability to deal with the speeders.
- In addition to the cited problems of the two aforementioned methods, neither of them takes into consideration the regulations during climate change or other incidents on the road.
- Systems multi-agent: this solution uses an agent architecture, based on virtual sensors at the agent's body, to perceive the environment [27]. This solution inherits the problems of multi-agent systems and only focuses on the case of fog.

III. System Description

A recent study was carried out to determine the main causes of road accidents in Yunnan Province mountain in China [28], which shows that despite complying with the speed limit the accident rate is still high. This raises the question of why this is the case.

Analysis of the prior study as well as the figures obtained from the road authorities in Algeria leads us to the realization that several factors including unfavorable weather conditions, peak hours, incidents, light, and the experience of the driver, must be taken into consideration. This eventually motivates us to believe that it is imperative to work quickly towards a radical solution taking into account at least the causes and aggravating factors of road accidents. Aiming to mitigate the problems previously mentioned, we suggested an intelligent system composed of a speed limiter and intelligent road signs communicating directly (I2V communication) through two devices, one installed on the panel and the other embedded in the vehicle.

This current solution can be implemented initially in high-risk areas before being generalized for the entire Algerian territory.

A. System Structure

The proposed system will be divided into two main parts:

1) Vehicle: The first part embedded in the vehicle is mainly composed of a communication unit: which is represented by a reception antenna of the signal that ensures the communication between the vehicle and the road sign; a decoding unit: which decodes the received signal, a treatment unit: which is made up of an ECU (Engine Control Unit) and a speedometer, being used to operate the speed limiter or the brake depending on the situation in which the vehicle is in (see next section). A limitation system: which is made up of a fuel injector and a brake, and it is responsible to decelerate the vehicle by acting either on the fuel's flow rate injected from the combustion room of the vehicle or on the brake pedal or even on both of them.

Besides the components described previously and taking into account the importance of human-machine interactions in the transport field, our system is equipped with a luminous indicator and a display screen.

2) Infrastructure: The second part has been installed on traffic signs, which can communicate with a vehicle that is equipped with a limitation system. The sign panel includes a location unit: which is used to locate the position of the sign (in front of a school, on motorways, in built-up areas, on mountains, and so on.). Generally, to recover the coordinates, the location unit uses GPS (Global Position System). It includes also Sensors: for gathering information from the external environment such as (sensors for snow, temperature, rain, fog, pavement condition, and camera). A communication unit: represented by a unidirectional transmitting antenna covering a distance of at most 300 m, which serves to broadcast the suitable speed. A Decision unit: this is the main component responsible for processing the collected information and performing the necessary calculations to obtain the required speed. A coding unit: to code the limit speed as a signal and transmit it to the vehicle. The energy source is necessary for the functioning of the system, it can be obtained from public lighting poles, solar energy, or others.

B. System Architecture

Fig. 1 includes all the components of our system along with the various possible interactions between them. These interactions are denoted by numbered arrows.

Firstly, the system starts collecting initial information concerning the road's nature, road number, and incident (for example works, collision, congestion), using GPS coordinates to define the initial speed (in normal situations). After that, the installed sensors gather information about weather and road conditions (arrow 1) and then transmit it to the decision unit, the decision unit treats all the collected data so that the system can determine the appropriate speed (arrow 2), then it codes the signal (arrow 3) before displaying it in real-time, and sends it via the antenna to the road users (arrow4). Secondly, the vehicle antenna receives the information and transmits it to the engine control unit (ECU), which decodes the information and compares it to the vehicle's speed (arrow 5).

Lastly, if the vehicle's speed is higher than that of the sign (comparison effected by arrow 6), the ECU operates the fuel injector to reduce the speed (arrow 7); in other situations, for example, downhill, the fuel injector only is not enough to reduce the speed, we need the intervention of the ECU on the brake.

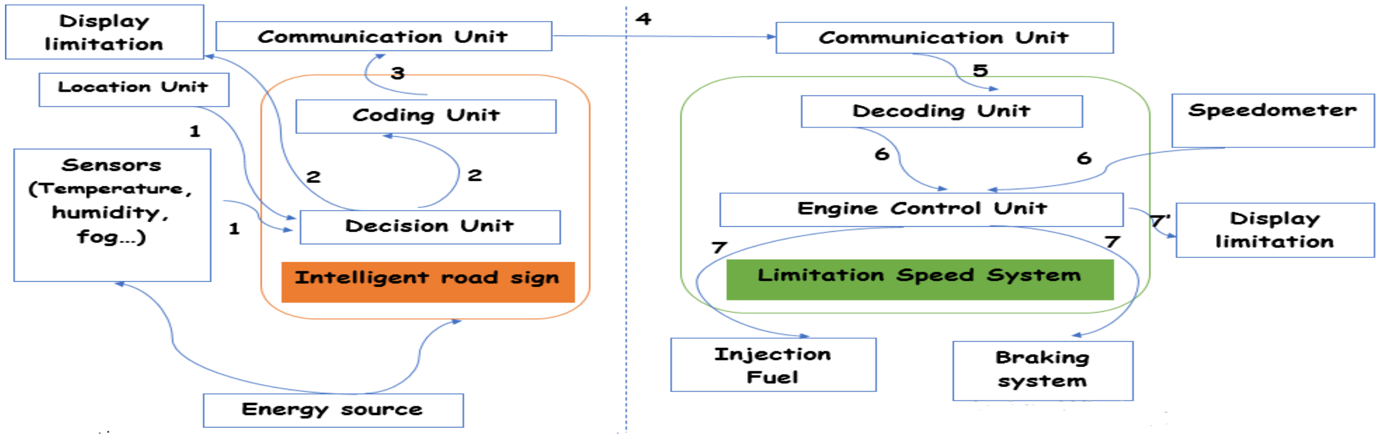

Fig. 1. Proposed system's components and communication.

Information is displayed in real-time on the vehicle's console (Screen LCD) and a beep sound will be played to alert the driver (arrows 7').

C. General Functioning

1) Operating scenarios on vehicles: Before implementing the proposed system, we surveyed to know people's opinions about autonomous vehicles and especially voluntary and obligatory ISA systems.

On a population of 820 Algerians, we obtained these results summarised by the histogram shown in Fig. 2.

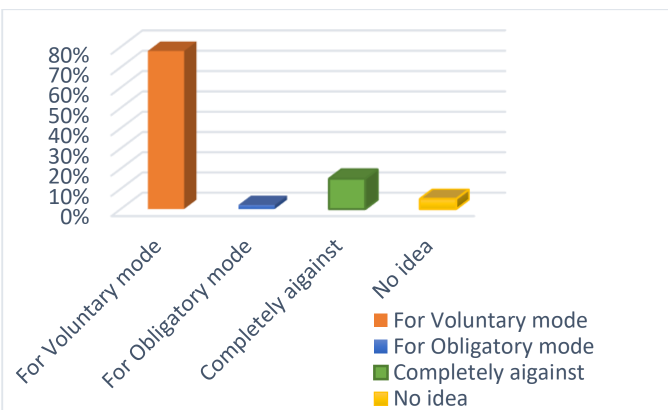

Fig. 2. Histogram representing survey results.

- Based on the survey results, we proposed two operating processes: the half-automatic mode which is an informative mode. It is used to alert the driver by a sonar or luminous signal if the maximum authorized speed is exceeded, and the limiter mode which plays the role of a reducing speed device that prevents vehicles from exceeding the authorized speed.
- So once the system is started, the half-automatic mode is required by default since it is a familiar mode with the usual operation of the vehicle and it is controllable by the driver, who can change the mode constantly and at any time.
- Once we are in the half-automatic mode, if the speed is higher than the road regulation by 10 km/h, the system will automatically switch to automatic mode (forced deceleration) to decrease the risk factors of serious accidents. This decision was taken based on the following findings: 50% of the drivers operate above the authorized speed limit [29]. Generally, the drivers exceed the speed limit lower than 20 km/h, and a number of them exceed the limits of more than 20 km/h, which does not measure the incurred serious risks at all, nor the consequences caused by these excesses. Consequently, it is estimated that approximately 10% of the victims could be prevented if most motorists who usually drive at speeds higher than 10 km/h were encouraged to respect limitations. Approximately 20% of the victims could be prevented if all the vehicles respected the speed regulations.
- we have also taken into consideration the scenarios that may encounter our system, which include:
- First scenario: (highways, tunnel):
- At the entrance of a tunnel or on the exit of a highway, we generally notice the presence of an indication for a specific way (Fig. 3). So, to support this specificity we can use a directional antenna at the entrance of the tunnel at the exit of the highway.

Fig. 3. Specific way limited by 80 km/h.

- Second scenario: (intersections):
- We locate the presence of an intersection by the presence of directional signs or priority of a street sign, pedestrian crossings, and traffic lights. So, the sign read transmits the relative information to the taken road. It carries also information about nearby crossroads.
- Fig. 4 illustrates an intersection, where the driver can continue on the same path, or change direction. It is supposed that the white car is on the way which RW320 A, the red car is on the way to RN48B and the yellow one is on RN48A. The four panels carry information about the roadways of the intersection: if the white car turns left through the detection's sensors to determine the direction of the path, the system saves information RN48B and ignores the others.
- The vehicle can change directions by updating its information with those received from the panel.

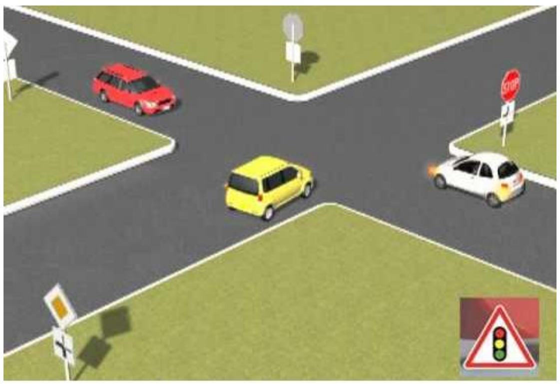

Fig. 4. An intersection.

- Third scenario: (different speed limit according to the class of vehicle):
- Fig. 5 illustrates the situation. In this case, we add information containing the class range of the vehicle (example: A: for motorcycles, B: for light vehicles, and C: for heavy vehicles), we also include the same class range information of the vehicle in the signal code for the speed limit.
- When the vehicle receives data, the system compares the category and decides which one concerns it.

Fig. 5. Different speed limits according to the vehicle category.

2) Operating scenarios on infrastructures: In this subsection, we are going to present the architecture of the proposed decision unit, including the different components involved in its functioning: We suggest using a hybridized CBR method to the AHP method to get an optimal limitation by using the approach described in [30], the decision can be improved by adding an order of priority to the determining factors. we first apply the CBR process during the calculation of the similarity value after, we add the weights and then, we apply AHP to have a more reliable decision.

The different proposed speeds in studied cases are proposed according to Algerian norms.

IV. Results, Analysis, and Discussion

This work can be divided into two main parts:

The first clarified the process of detecting the optimum speed taking into consideration: the geometry of the road, the road surface, the weather conditions, the road traffic situation.

The figure below (Fig. 6) illustrates and summarizes the detection of the optimal speed process.

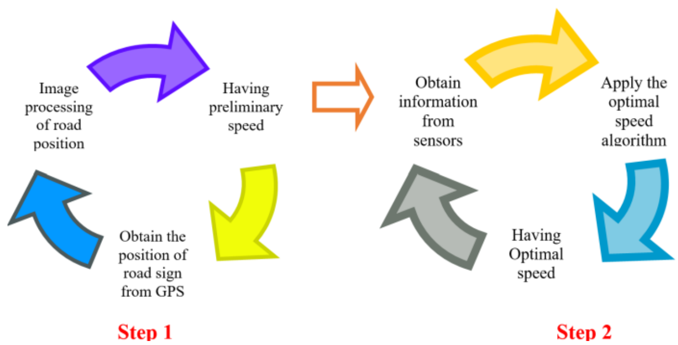

Fig. 6. Process to have the optimal speed.

Initially, we ensure that the panel is placed accurately by utilizing GPS technology, which provided us with the Latitude and Longitude coordinates, we have used Google Static Maps API to capture a personalized image of the geographical map of the location.

The card is retrieved in general, and to determine its type and style. For this, we have used the following types of cards, see Fig. 7:

- Terrain which specifies a physical relief map image, displaying topography and vegetation, this type of map was used to detect whether the location is a built-up area.
- Roadmap which specifies a standard road map image to detect the type of the road (a turn, a straight road).

Fig. 7. Terrain (left) and roadmap (right).

- After retrieving the necessary images, we proceed to the image processing phase:
- The Terrain type image: it is a two-color image where one color is for space and the other one is for man-made structures. After the indexing of the image, we obtain a matrix of 300x300 which contains two possible values 0 or F.
- 0 for the structures and F in hexadecimal for the void if the count of pixels containing the value 0 in the matrix exceeds a certain threshold, the location is then located in an Agglomeration zone, otherwise, it is considered to be located outside the built-up area.
- The Roadmap type image: it is a two-color image. A color for the void, and another for the roads, after the indexing of the image we obtain a matrix of 300x300 which contains two possible values: 0 for the roads and F in hexadecimal for the void. (Step 1. A).

To determine the shape of the road a form recognition is necessary. To expedite this process, we have created a database of 200 images containing roads, each with the appropriate speed according to Algerian regulations. Then we calculated the distance between the indexing matrix of the Roadmap type image and the matrices of our pre-indexed images stored in the database (Step1.B).

The recognition of the shape of the road is done by calculating the distance (color/location) between each image in the base and the image retrieved from the road.

The base image that has the smallest distance from the retrieved image represents the closest image. Each image in the base has an associated proposed speed, which is applied to the road that has the smallest distance from the base image; it is called the preliminary speed (Step1.D).

After completing the image processing phase by calculating the preliminary Speed as a result of the previous phase, the next step is to calculate the optimal speed. This is achieved by using the values obtained from sensors and environment by applying the hybridized algorithm CBR-AHP (Step 2. A). At the end of this step, we have the optimum speed.

The second main part focuses on how the vehicle receives the final optimal speed, as shown in Fig. 8. The process involves transmitting the speed from a transmission antenna to a receiving antenna on the vehicle. Once received, the speed is limited by a speed limiter system integrated into the car, the steps mentioned above are carried out by information processing software systems. The next figure summarises the process.

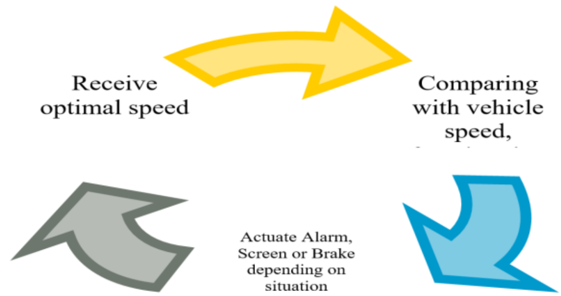

Fig. 8. Process to actuate screen, alarm, or brake depending on the situation.

To validate our approach, we opted for a simulation with SUMO (Simulation of Urban Mobility), which is a widely used traffic simulation software that enables the modeling and analysis of transportation systems in urban areas. By utilizing SUMO, researchers, and transportation planners can simulate real-world scenarios and assess the impact of different factors on urban transportation systems [31].

The following figure (Fig. 9) is an extract of Annaba's street roads in Algeria. The cars in green are vehicles respecting the limitation, those in light blue operate under the semi-automatic mode, while those in dark blue do not comply with the law, therefore the automatic mode activates automatically.

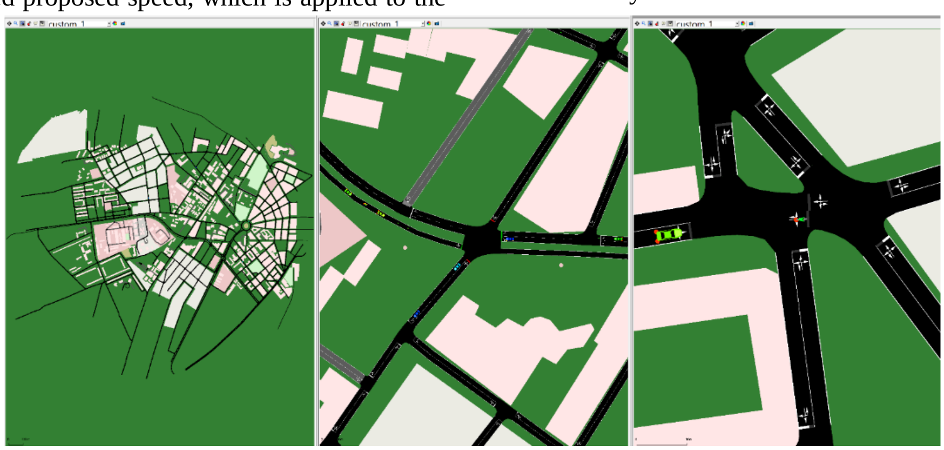

Fig. 9. Annaba's street roads-Algeria from SUMO simulator.

To check our method once again, we opted for a simulation of the same environment with the same conditions, and the same number of vehicles and pedestrians twice. The first time, the vehicles circulate in a random way not subjecting to any regulation obligatorily (like the actual situation in Algeria). However, in the second simulation, vehicles were forced to submit to the principle previously proposed and described by this article.

The results of the collisions that occurred during the two simulation runs are summarized in Table I.

Based on the obtained results, it is evident to notice that a significant decrease in the number of crashes has been observed, with the rate dropping from 33.01% during the first simulation to 19.23% in the second one. This remarkable drop can be mainly attributed to the change in the method of vehicle circulation, where, they were forced to respect the regulations, which seems encouraging. The findings prompted us to create a prototype with Arduino cards, implementing the functionalities of our desired system, to prove its feasibility.

The next illustrations represent the realized prototype. For this, we used several modules including Driver motor L293D, which is used to activate the rotation motor, Bluetooth HC-05 module, which is used to assure the communication between the panel and the vehicle.

Fig. 10 illustrates the prototype produced, part A represents the vehicle equipped with an LCD screen to display the speed and the operating mode; a Bluetooth to receive the speed of the panel.

Part B illustrates the smart panel equipped with several sensors and electronic components such as GPS, water sensor, light sensor, and temperature sensor. It describes the external conditions that can play a role in the decision process for example day or night, sunny or rainy.

The realized prototype controls the speed under the two modes described above.

In summary, despite being in the modeling and prototyping stage, the approach described in this paper has a lot of potential and yields encouraging results.

The originality of this work lies in the creation of a complete speed control system that encompasses both traffic signs and vehicle's speed limiter. This distinguishes it from previous works on smart panels in many aspects. First, it is more comprehensive, incorporating all the Algerian traffic standards (Each country can adapt the model according to its standards) as well as all the environmental factors leading to the change in speed. Without forgetting to mention that this hardware solution shows great potential compared to software solutions (such as a method with multi-agent systems) since ultimately it is a critical system that does not support a long waiting time.

TABLE I. RESULTS OF SIMULATION

	FISRT SIMULATION	SECOND SIMULATION
Pedestrians number	99	99
Vehicle number (Cars, Bus, Motorcycles, Bicycle)	1522	1522
Vehicle collision with pedestrians	12	7
Vehicle collision with another vehicle	318	192
Percentage of collisions with pedestrians	12,12%	7,07%
Percentage collisions with another vehicle	20,89%	12,16%
Total percentage collision	33,01%	19,23%

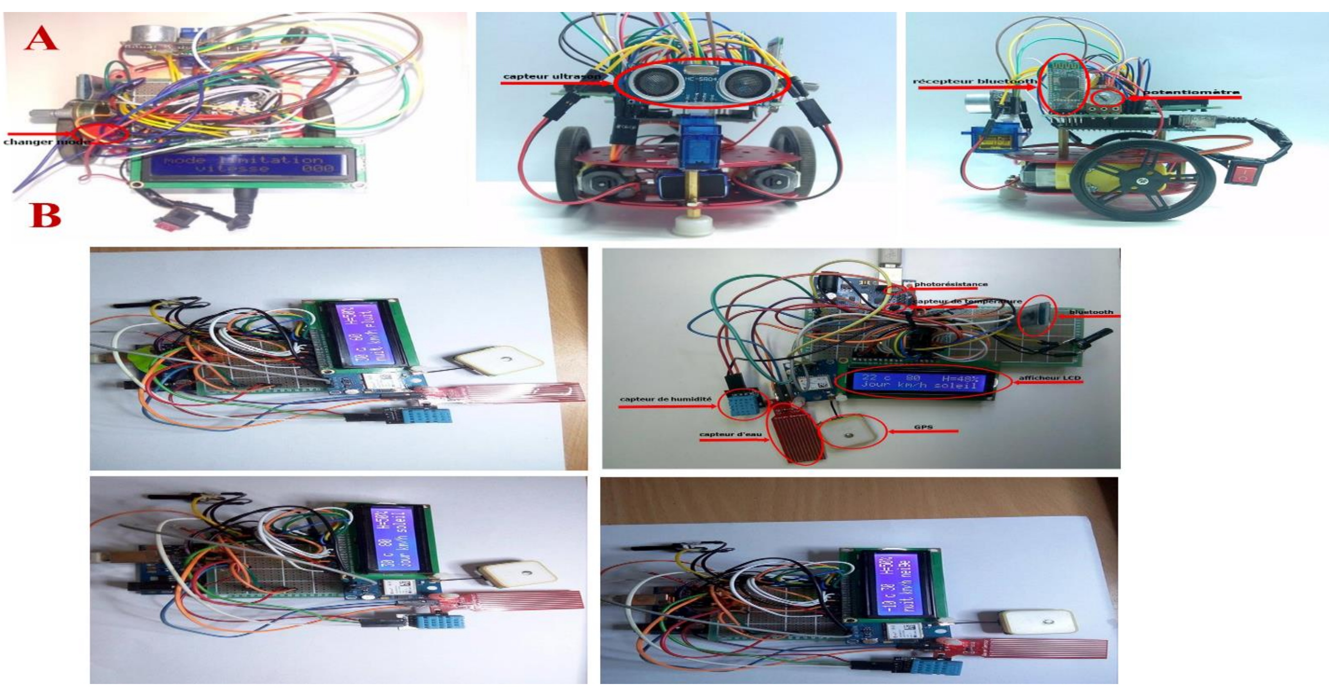

Fig. 10. Prototype with arduino cards.

Second, all existing ISA systems are based on the knowledge of the authentic speed limit often determined using GPS technology as we mentioned previously in Section II, which is due to its low cost and widespread availability. However, despite the popularity and functionality of GPS, there are fundamental problems with this system, most of which are related to the accuracy of the determined GPS has inherent inaccuracies due to uncertainties in satellite ephemeris, propagation errors, timing errors, multiple signal propagation paths, and reception noise, which can be particularly problematic in areas with a high-speed road adjacent to lower-speed residential streets. Additionally, GPS signals can be completely blocked in tunnels or under large structures. Updating the database with new road works data also presents a significant challenge. These issues highlight the need for a more comprehensive and robust speed control system, which the proposed hardware solution aims to address.

This work offers a mechanical solution that addresses the challenges faced by existing methods combining two sub-systems; it provides a flexible, intelligent, and complete system that effectively addresses the problem of speeding. This new approach overcomes the limitations of existing methods, such as the inaccuracies and constraints of GPS, and offers a more reliable and adaptable solution. Overall, this work promises to provide a coherent and effective solution to the problem of speeding on the road.

TABLE II. COMPARISON WITH RELATED WORKS ON ISA SYSTEMS

Solution	Advantages	Disadvantages
GPS	- Access to precise and global positioning data. - Wide availability of map data.	- Dependency on a stable GPS signal. - Limited accuracy in dense urban areas.
RFID	- Access to specific information from traffic signs. - Precise use of speed limits on specific road segments.	- Difficult to collect and process data in real-time for vehicles traveling at high speed. - Vehicle must be close to the transmitter
Image processing	- Utilization of onboard cameras or existing sensors. - Adaptability to different types of traffic signs.	- Dependency on visibility conditions and image quality. - Requirement for sufficient computational power for real-time image processing.
Dead reckoning	- Less dependency on external signals.	- Limited accuracy over time and distance traveled. - Accumulation of measurement errors. - Need for regular calibration and recalibration of sensors to maintain accuracy.
Antenna communication	- Improved precision of speed limit information. - Real-time responsiveness for speed limit updates. - Adaptability to temporary changes in speed limits.	- Dependency on reliable wireless communication. - Need for integration with existing traffic signs.

TABLE III. COMPARISON WITH EXISTING WORKS ON PANELS

Solution	Deep learning	Google Street Map	multiagent system	hardware-based
Real-time capabilities	Limited	Limited	Limited	Strong
Speed of processing	Fast	Fast	Fast	Fast
Adaptability	Moderate	Moderate	Moderate	High
Accuracy	High	High	Moderate	High
Robustness	Moderate	High	High	High

For better readability and by comparing the method used here with the existing ones, the tables (Table II and III) summarize the advantages and disadvantages of all approaches and techniques in the two subsystems.

V. CONCLUSION

This work falls under the continuity of seeking works to improve road traffic and reduce the amount of mortality. We are mainly interested in the problem of traffic accidents due to speeding. Despite this scourge that touches thousands of Algerian families every year, no radical solution has so far been introduced, therefore this work lays the foundation stone for the improvement of transport and the significant reduction in deaths on our roads. Based on a new system ISA, which communicates directly with the smart road signs, the proposed system has been simulated with SUMO, and a prototype is realized with Arduino to prove its validity.

Several perspectives could be considered to extend this work. We cite without limitation, the realization of a physical system, which will highlight our expectations and estimations.

Additionally, integrating radar functionality into the smart panel could increase its productivity and effectiveness, ultimately leading to a solution for addressing speeding drivers.

REFERENCES

[1] World Health Organization, “Global status report on road safety 2018: Summary” Switzerland,2018.

[2] Report of Algerian National Gendarmerie on road accidents, Mars 2022.

[3] B. Karthikeyan, M. Tamileniyan “Dynamic Data update for Intelligent Speed Adaptation (ISA)” System International Journal of Computer Applications (0975 –8887) Volume 11– No.1, December 2010.

[4] “Intelligent Speed Assistance -Myths and Reality ETSC position on ISA” ISBN NUMBER: 90-76024-23-5.

[5] Oliver Carsten, “Speed management through vehicle measures/ Intelligent Transport Systems”, Institute for Transport Studies, University of Leeds.

[6] O. Carsten "ISA: the Best Collision Avoidance System?", Proceedings of 17th Conference on the Enhanced Safety of Vehicles, Netherlands.

[7] O. Carsten "ISA - From Fields Trials to Reality", PACTS conference Targets 2010: No Room for Complacency, London, 10 February 2004.

[8] Carsten O, Tate F "Intelligent Speed Adaptation: Accident Savings and Cost-Benefit Analysis", Accident Analysis and Prevention 37, 2005.

[9] Regan M, Triggs T, Young K, Tomasevic N, Mitsopoulos E, Stephan K and Tingvall C "On-road Evaluation of ISA, Following Distance Warning, and Seat Belt Reminder Systems: Final Results of the TAC Safecar Project", Monash University Accident Research Centre, September 2006.

[10] Abdulsalam Ya'u Gital and al. “Review of GPS-GSM Based Intelligent Speed Assistance Systems: Development and Research Opportunities”,

International Conference on Intelligent Communication and Computational Techniques (ICCT) 2023.

[11] Shaik Mohammad Ali, Shaik Mulla Zubair, Zafar Ali Khan N, "Vehicle control speed based on GPS matching posted speeds/images "International Journal of Research Publication and Reviews, Vol 3, Issue 6, June 2022.

[12] Vera Roberts, “External Vehicle Speed Control/Intelligent Speed Adaptation“, Casebook of Traumatic Injury Prevention, January 2020.

[13] Z. Yatao, W. Jiangfeng, C. Sijie, G. Zhijun and H. Haitao, "Multi-tag Information Interactive Communication Model based on Precise Position Detection in Vehicle-Infrastructure Collaboration Environment," 2020 IEEE 5th International Conference on Intelligent Transportation Engineering (ICITE), Beijing, China, 2020.

[14] Irina Popova, Elena Abdullina, Igor Danilov, Aleksandr Marusin, Alexey Marusin, Irina Ruchkina, Alexander Shemyakin, « Application of the RFID technology in logistics, » Transportation Research Procedia, Volume 57.

[15] Z. Meng, Y. Liu, N. Gao, Z. Zhang, Z. Wu, and J. Gray, "Radio Frequency Identification and Sensing: Integration of Wireless Powering, Sensing, and Communication for IoT Innovations," in IEEE Communications Magazine, vol. 59, no. 3, pp. 38-44, March 2021.

[16] Y. Liu, X. Meng, and X. Huang, "Route Planning Strategy of intelligent car Based on Camera Sensor," 2022 IEEE Asia-Pacific Conference on Image Processing, Electronics and Computers (IPEC), Dalian, China, 2022.

[17] S. Gao, G. Kang, L. Yu, D. Zhang, X. Wei and D. Zhan, "Adaptive Deep Learning for High-Speed Railway Catenary Swivel Clevis Defects Detection," in IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 2, pp. 1299-1310, Feb. 2022.

[18] Masatoshi Ishikawa "High-Speed Vision and its Applications Toward High-Speed Intelligent Systems", Journal of Robotics and Mechatronics, October 2022.

[19] Biao Yu and al. "A Dead Reckoning Calibration Scheme Based on Optimization with an Adaptive Quantum-Inspired Evolutionary Algorithm for Vehicle Self-Localization", Entropy, August 2022.

[20] Maxim Freydin, Barak Or, "Learning Car Speed Using Inertial Sensors for Dead Reckoning Navigation", IEEE Sensors Letters, September 2022.

[21] Martin Brossard, Axel Barrau, Silvère Bonnabel, "AI-IMU Dead-Reckoning" IEEE Transactions on Intelligent Vehicles, March 2020.

[22] Canyong Wang “Research and Application of Traffic Sign Detection and Recognition Based on Deep Learning” International Conference on Robots & Intelligent Systems (ICRIS),2018, Changsha, China.

[23] Domen Tabernik, Danijel Skočaj “Deep Learning for Large-Scale Traffic-Sign Detection and Recognition”, IEEE Transactions on Intelligent Transportation Systems 2019.

[24] Bao-Long Le, Gia-Huy Lam, Xuan-Vinh Nguyen, The-Manh Nguyen, Quoc-Loc Duong, Quang Dieu Tran, Trong-Hop Do & Nhu-Ngoc Dao “A Deep Learning Based Traffic Sign Detection for Intelligent Transportation Systems”, International Conference on Computational Data and Social Networks, CSoNet 2021: Computational Data and Social Networks pp 129–137.

[25] Rajesh Kannan Megalingam, Kondareddy Thanigundala, Sreevatsava Reddy Musani, Hemanth Nidamanuru, Lokesh Gadde “Indian traffic sign detection and recognition using deep learning”, International Journal of Transportation Science and Technology, Available online 26 June 2022.

[26] Andrew Campbell, Alan Both, Qian Sun “Detecting and mapping traffic signs from Google Street View images using deep learning and GIS”, Computers Environment and Urban Systems 77, June 2019.

[27] Fatma Outay, Stéphane Galland, Nicolas Gaud, Abdeljalil Abbas-Turki, “Simulation of connected driving in hazardous weather conditions: General and extensible multiagent architecture and models”, Engineering Applications of Artificial Intelligence 104 (2021) 104412, Available online 6 August 2021.

[28] Shu Gong & Gang Hua, “Decision Making Analysis of Traffic Accidents on Mountain Roads in Yunnan Province”, International Conference on Machine Learning for Cyber Security ML4CS 2022: Machine Learning for Cyber Security pp 228–237.

[29] International Transport Forum, “Speed and crash risk”, International Traffic Safety Data and Analysis Group, Research Report,2018.

[30] Fernando Ramos, Efraín Tovar-Sánchez, Hugo Saldarriaga, Héctor Sotelo-Nava, Juan Paulo Sánchez-Hernández, María Luisa Castrejón-Godínez, “A CBR–AHP Hybrid Method to Support theDecision-Making Process in the Selection of environmental Management Actions”, Sustainability 2019.

[31] Documentation - SUMO Documentation (dlr.de) https://sumo.dlr.de/docs/index.html