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AUTOMATION AND ROBOTICS-BASED TECHNIQUES FOR ROAD SAFETY

Computer Science

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ABSTRACT

Automation and Robotics, a technology experiencing rapid growth, are being utilized in different areas, such as accident prevention systems. Hilly areas with sharply curved roads are often accident-prone because of blind turns and bad road conditions. Therefore, automation and robotics technology used for road safety in hilly areas can provide great advantages in identifying possible road dangers and avoiding deadly accidents. The suggested system relies on automation involving programming and algorithms to detect and warn of potential accidents in mountainous and difficult terrain areas.

KEYWORDS

INTRODUCTION:

In the modern world, roads and transportation have become essential for all individuals. Everyone is a road user in some way or another. The current transportation system has reduced the distances traveled, but at the same time, it has raised the risk to one's life. Every year, millions of lives are lost and millions of people suffer serious injuries as a result of road crashes. Car crashes are a major reason for fatalities and injuries on a global scale, impacting millions annually. Despite the diligent work of police, educational programs, and technological advancements, the figures are still on the incline. Yet advancements in robotics and automation technology may decrease the occurrence and seriousness of car accidents, ultimately leading to saving lives on the road.

In this article, we will examine how these progressions are influencing the future of driving and establishing safer roads for all. To better understand the problem, let's look at some statistics on car accidents. Road Transport data shows that car accidents cause more than 1.35 million deaths worldwide every year, along with 20-50 million people sustaining non-fatal injuries. Around 80,000 individuals lose their lives in traffic accidents annually in India, accounting for 13% of global fatalities. These incidents have significant repercussions, affecting individuals, their loved ones, and the entire community. The costs linked to car accidents, such as property damage, medical bills, and lost productivity, create a significant financial burden.

The driver is a crucial factor in the majority of accidents. Crashes often happen because of carelessness or lack of road safety awareness by the road user. Human error is a leading factor in many car accidents. Distractions while driving, speeding, and driving while intoxicated are major contributors to the issue.

As per Ministry of Road Transport and Highways (MoRTH) total road accidents in the year 2022 was 461k and resulting in total person injured 443k and fatalities of 168k (Figure 1). Fatal accidents and Grievous injury account for 64.9% (Graph 1).

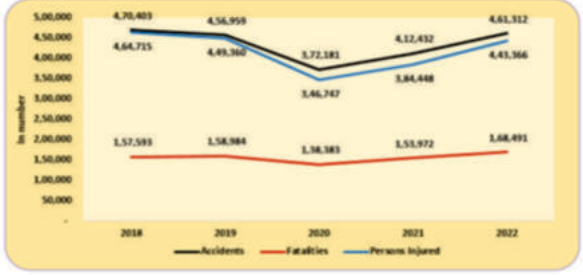

Figure 1: Trends in number of Accidents, Fatalities and Persons Injured: 2018 to 2022

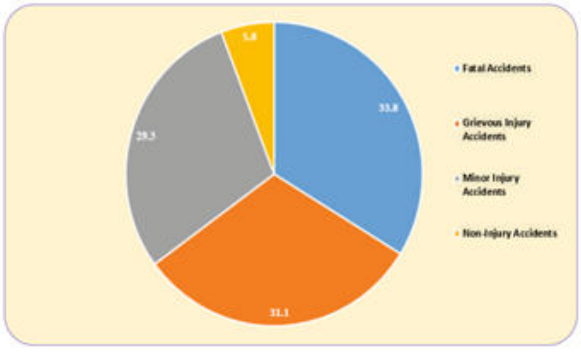

Figure 2: Type of Road Accidents in 2022 (in percent)

Sharp curves on roads are more likely to lead to accidents as they demand additional skill, caution, and attentiveness to navigate safely. During 2022 in India, there was a slight rise in the number of accidents, deaths, and injuries on curved roads compared to 2021 (Figure 3). As per below chart, out of 461k accidents reported in 2022, 11.8% are in the sharp curve or curved roads, which is 2nd highest (Figure 4).

Road feature	Number of accidents			Persons killed			Persons injured		
	2021	2022	%age change	2021	2022	%age change	2021	2022	%age change
Straight road	2,78,218	3,09,247	11.2	1,02,623	1,11,815	9.0	2,59,402	2,97,694	14.8
Curved road	49,581	54,593	10.0	19,120	20,573	8.0	48,888	55,866	14.0
Bridge	12,709	14,111	11.0	5,337	6,258	17.3	11,546	13,062	13.1
Culvert	6,663	7,384	11.0	2,960	3,473	17.0	6,029	6,309	5.0
Potholes	3,625	4,446	22.6	1,481	1,856	25.3	3,103	3,734	20.3
Steep grade	3,967	4,475	13.0	1,635	2,056	26.0	3,398	4,089	20.0
Ongoing road works/ Under construction	9,075	9,211	1.5	4,014	4,054	1.0	7,539	7,955	5.5
Others	48,594	57,845	19.0	16,802	18,406	10.0	44,543	54,657	23.0
Total	**4,12,432**	**4,61,312**	**11.9**	**1,53,972**	**1,68,491**	**9.4**	**3,84,448**	**4,43,366**	**15.3**

Figure 3: Accidents, Persons killed and Injuries by Road Feature

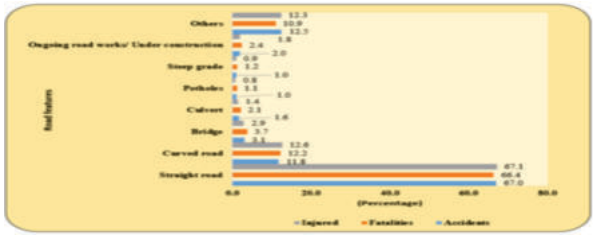

Figure 4: Accidents, Persons killed and Injuries by Road Feature in 2022

Current System:

Currently, many curved and winding roads on national highways, state highways, and mountainous areas lack proper safety measures to prevent accidents. Many techniques demand human focus and entail high levels of exertion, making it challenging to accomplish. There are not many curved roads with blind turns that have convex mirrors, however, these mirrors are not highly effective in warning drivers. The lighting systems in current vehicles are not very convincing. Consequently, numerous occurrences take place at night, particularly in ghats. Typically, regular headlights are turned on while rounding corners or fully illuminating the road, potentially creating hazardous situations. Cars nowadays come with safety features, which only lessen the effects of accidents rather than preventing them. What if we enhanced the intelligence of roads to avoid accidents instead?

Figure 5: Current Situation At Blind Turns With Convex Mirrors

Proposed system:

The positive development is that robotics and automation technology can aid in addressing these problems by lessening the burden on human drivers, thereby decreasing the chances of accidents. Place the anti-collision vehicle management system on sharp bends, curved roads, and blind corners. Main components include IR sensors, Control unit, alert system.

A pole equipped with a built-in vehicle alert system will be mounted at a hairpin turn. IR sensors are going to be employed for detecting the existence of approaching vehicles on curved routes. The IR sensors will be placed at specific locations along the road and will transmit data to a central control unit. The control unit will gather information from IR sensors and interpret it by running programs and algorithms. The system will sense vehicle motion along this winding road and activate a warning. The warning system will alert drivers with flashing lights and horn sounds. Humans naturally respond to light and sound signals, which are utilized in smart poles to monitor vehicle speed. The radar on the poles communicates with each other to warn drivers on both sides with flashing red lights and honking to slow down and ensure safe crossing. This warning system will be strategically placed along the road to sufficiently alert drivers.

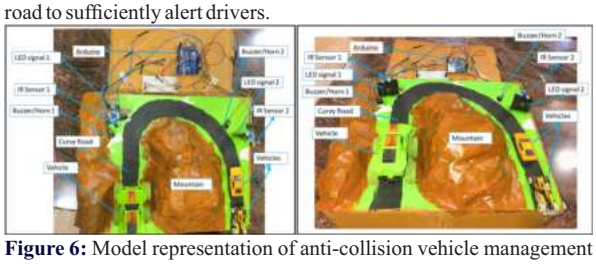

Figure 6: Model representation of anti-collision vehicle management system

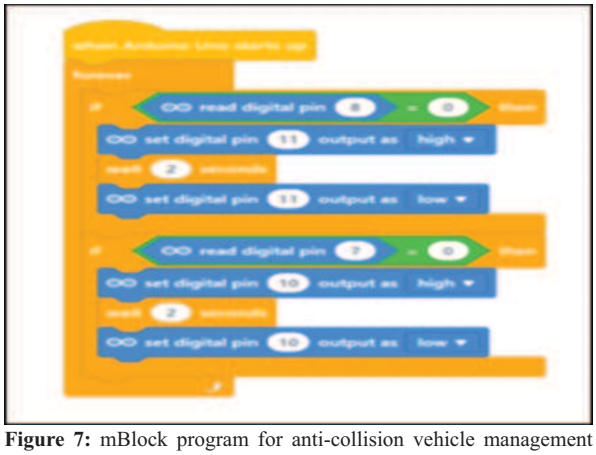

Figure 7: mBlock program for anti-collision vehicle management system

A model shown in Figure 6 with simulation was prepared to demonstrate the working principle of the concept and the mBlock program for anti-collision vehicle management system is shown in Figure 7. When Ardiuno starts up, then the whole circuit is activated. The project includes two Infrared sensors (IR Sensors), two light emitting diodes (LED), jumper wires and an Ardiuno. If a car approaches near the IR sensor 1, [**digital pin 8**], it shows value 0 (indicating that it detected vehicle approaching) and the LED [**digital pin 11**] glows [**high**] waits for 2 seconds and gets switched off [**low**]; gives a sign to the driver on the other side that the car is approaching. Similarly, if a car approaches near the IR sensor 2, [**digital pin 7**], it shows value 0 (indicating that it detected vehicle approaching) and the LED [**digital pin 10**] glows [**high**] waits for 2 seconds and gets switched off [**low**]; gives a sign to the driver on the other side that the car is approaching.

Similar concept, on a larger scale was co-developed by HP Lubricants and Leo Burnett and further has been conceptualized, designed and executed by Leo Burnett India was launched on National Highway 1 in North India, along the Jammu-Srinagar Highway as shown in Figure 8.

Figure 8: anti-collision vehicle management system **sensing vehicle at Blind turns**

Future Advacements:

These days, more and more autonomous cars are being introduced, using cutting-edge systems and technology to travel without the need for human assistance. By removing the chance of human mistake, this technology may reduce the number of accidents. To improve road safety, a number of manufacturers are investing in the creation of next-generation Advanced Driver Assistance Systems (ADAS). By helping drivers with additional features like adaptive cruise controls, automated emergency braking, and lane shifting assistance, ADAS is increasing road safety. Future developments like vehicle-to-everything (V2X) connectivity might revolutionize road safety. Vehicle-to-vehicle (V2X) communication is a wireless technology that allows cars to communicate with other cars and road infrastructure, including traffic signals. By sharing the position, speed, and trajectory, this information transmission will make it possible to prevent mishaps. Additionally, heavy traffic zones, high traffic times, and congestion may be tracked by artificial intelligence, which can then adjust traffic signal timings to relieve the congestion.

CONCLUSION:

Intelligent road signs can adjust to varying weather conditions or alert drivers about potential dangers ahead, giving them ample time to respond and prevent accidents. In summary, advanced robotics and automation technologies could greatly decrease car crashes and rescue lives on the road. By lowering human error and enhancing traffic and vehicle management systems, these advances are paving the way for a safer and more effective transportation future. However, widespread use of these technologies will need collaboration between consumers, businesses, and governments. Effective public education and awareness initiatives, along with regulatory structures that promote innovation while prioritizing safety, will be essential in fully harnessing the benefits of robotics and automation for enhancing road safety for everyone.

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