International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Vehicle Dynamic Maneuverability through Data-Driven Six Sigma Analysis for Enhanced Driver Assistance

Shyam Raman[1], Brijesh Jha[2], Prasad PV[3], Deepak Misra[4]

[1]Senior Engineer, Research & Advanced Engineering, Renault Nissan Technology and Business Center India Pvt Ltd
[2]Deputy General Manager, Research & Advanced Engineering, Renault Nissan Technology and Business Center India Pvt Ltd
[3]Deputy Manager, Research & Advanced Engineering, Renault Nissan Technology and Business Center India Pvt Ltd
[4]Assistant Manager, Research & Advanced Engineering, Renault Nissan Technology and Business Center India Pvt Ltd

Abstract

This paper presents the concept of a vision-based system to provide intelligent driving assistance for steering, braking, and acceleration maneuvers. The system utilizes vision systems to detect the vehicle's surroundings, including the road, other vehicles, pedestrians, and obstacles. Based on this environmental awareness, the system can intervene to assist the driver to enhance the safety and efficiency of the driving experience by maneuverability access or alert to driver in steering, brake, and acceleration. The steering assist function analyzes the road geometry and trajectory and provides subtle steering adjustments alerts to keep the vehicle centered in the lane thereby smoothly navigate curves. The braking assist function detects potential collision threats and can assist driver on application status of brakes to avoid or mitigate impacts. Similarly, the acceleration assist function monitors the driving conditions and traffic flow to optimize throttle input for improved fuel economy, traffic flow thereby reducing the impact to dynamic parts of vehicles. A detailed six sigma analysis is done by DMAIC method to prove the proposed methodology significance compared to existing techniques.

Keywords: Vision system, Maneuverability alerts, DMAIC, Six sigma analysis

1. Introduction

- The contemporary automotive consumer is exigent in the advancement of vehicular operation through the leveraging of safety attributes inherent to the system itself. This prevailing trend aims to fortify the driving assistance modality during critical vehicle dynamic and ergonomic spheres of influence.
- These problems are majorly due to road accidents and bad road conditions which leads to people death as well as early dynamic parts wear resulting in claim cost and breakdowns. Below are global figures of the bad road accidents and breakdowns:

Figure 1: Global Accidents, Breakdowns, Cost statistics

- Advanced driver-assistance systems (ADAS) have become increasingly common in modern vehicles, providing a range of features to enhance safety and convenience. However, many current ADAS technologies rely on sensors like radar and lidar, which can be expensive, complex, and have limited environmental perception capabilities & also are not economical for consumers or users
- To overcome the challenge of reducing the above-mentioned issues economically and effectively is by alerting the customer of the bad road conditions and guidance of necessary timely action. This paper illustrates about the existing and the new proposed way of maneuverability which can be assisted to customer to enhance safety driving experience.

2. Existing Vehicle Scenario's

Figure 2: Existing vision condition inside vehicle

- There are 5 levels of ADAS in which level 0 is no adas system, level 1 is either lateral or longitudinal control & level 2 is both. In India Level 2 ADAS vehicles are evolving and is also very costly due to radar and other components packaging.
- High level featured radar package costs nearly Rs.80,000. These consists of traditional features like Adaptive Cruise Control (ACC), Forward Collision Warning (FCW), Automatic Emergency Braking (AEB)... etc. But there is no direct assistance to drivers in critical scenarios and guidance of dynamic maneuver unavailability is a major drawback.
- Our concept is to enhance the Vehicle Dynamic Maneuverability, and which will be kind of alerting and assisting drivers for Acceleration, Brake and Steering operations.

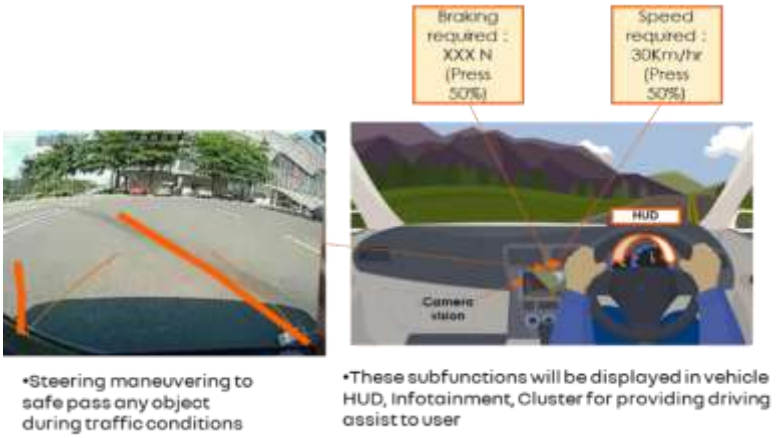
3. Proposed Vehicle Dynamic Maneuverability system

- The evolution of the ideology is to benefit the customer with the ongoing vehicle dynamics behavior

This is done technically with using the vision system (Stereo camera or mono camera) in the vehicle thereby connecting it to Body control ECU to O/P devices (HUD/Infotainment/Cluster)

- Further the proposed technique will result in knowing below parameters and use cases

Figure 3: Proposed Maneuverability system

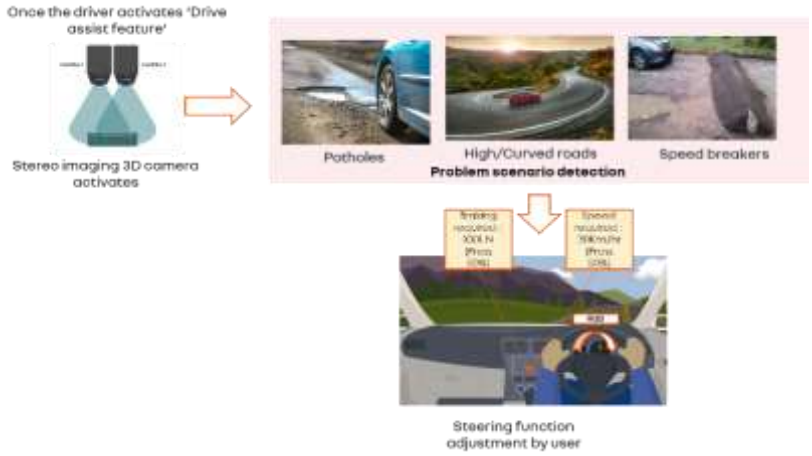


- Many people get confused on judging the necessary steering during traffic conditions which result in car collision at lower speed also. Steering maneuvering will be provided to the customer and user for ease safe passing of objects in traffic scenarios. The system is integrated to steering & angle sensor thereby leveraging the wheel dynamics to alert the user to steer to defined angle as shown in the detailing.

Figure 4: Working scenario of Lateral maneuverability

- Similarly Brake function works during object detection scenario or in bad road conditions and traffic sign recognition to help the user on the application of brake the above image shown can also be represented in UI form.
- Accelerator function works during high tilt conditions like during mountain driving or during highway driving this alerts driver to slow down or increase the speed during different conditions as shown in the below details:

Figure 5: Working of Brake and Accelerator maneuverability



4. Existing Technologies vs Proposed Technology comparison

- Here we have considered two relevant features from ADAS level for technological comparison with proposed maneuverability technology. Here are below parameters to conditions & technological mapping below:

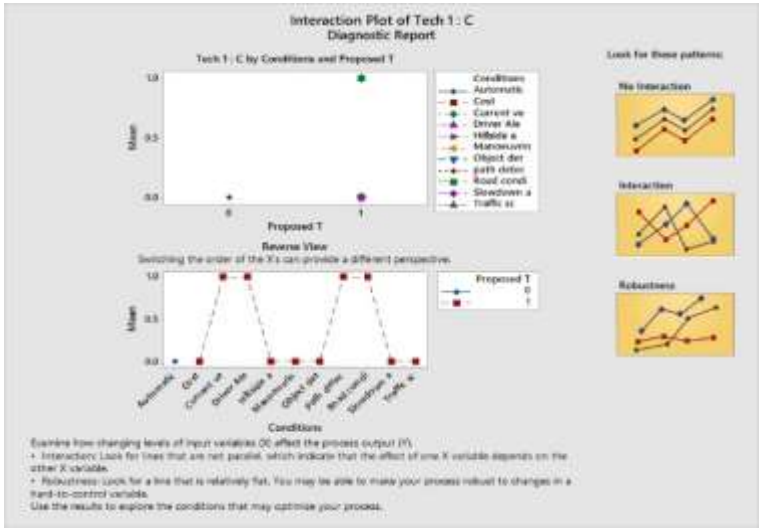
Figure 6: Tabulation of Existing vs Proposed technology

Parameters	Conditions	Tech 1 : Curve speed warning	Tech 2 : Cruise/evasive assist	Proposed Technology
Surrounding function	Road condition detection (Curved Road, Pothole)	Yes	Yes	Yes
	Current Vehicle position (Steering angle, Accelerator)	Yes	Yes	Yes
	Traffic scenario's	No	Yes	Yes
	Object detection	No	Yes	Yes
	Path detection	Yes	Yes	Yes
Vehicle function	Automatic Action (Braking, Acceleration ... etc)	No	Yes	No
	Manoeuvring alert assist	No	No	Yes
	Hillside assistance (Acceleration)	No	No	Yes
	Slowdown alert (Brake)	No	No	Yes
Cost		High	High	Comparatively Low (Than ADAS Lvl 2 feature)
Requirements		GPS action used	Radar & Other components	Only Vision system + Algorithm dev
Driver Alerts		Yes	No	Yes

5. 6σ Technology Interaction Analysis (Using Minitab)

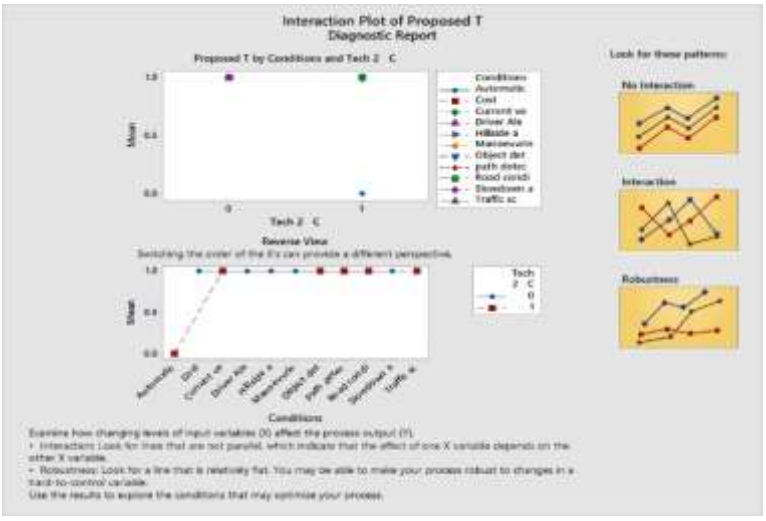
- The analysis of Technology Interaction shows the similarity of conditions & differentiation for all three technologies. In 1st Interaction analysis we will compare the Tech 1 vs Proposed condition (As in above subject). For doing the analysis we take the function 'Yes & Low as 1.0' & 'No & High as 0'

Figure 7: Interaction plot for Technology 1 vs Proposed Technology



- Tech 1 (Curve speed warning) vs Proposed technology interaction plot describes the significance of similarity conditions. In Functional conditions only driver alerts is a common condition but without maneuverability assist in Tech 1. Only 4 conditions are common in above graph plot (Mentioned as 1.0 for 4 points) as mentioned in Figure 6

Figure 8: Interaction plot for Technology 2 vs Proposed Technology



6. 6σ Model Based Analysis (Using Minitab)

- We have three group of technologies to compare statistically on the safety & economical aspects. We use one-way anova method to determine the effective technology and which will be user friendly.
- Here in below anova comparison report states there are some significant differences between all three technologies technically differs as 3, 1 are vehicle functions ((Maneuvering assist, Hillside assist, Slowdown alert), Automatic action) as shown. The data taken for the below comparison comes from tabulation figure 6 conditions.

Figure 9: Anova comparison chart

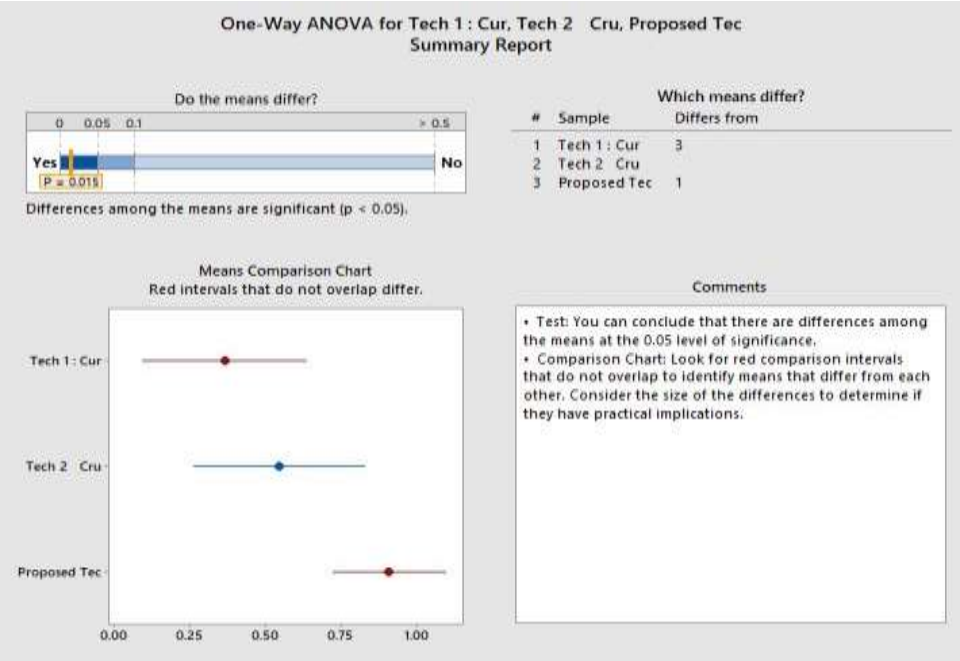
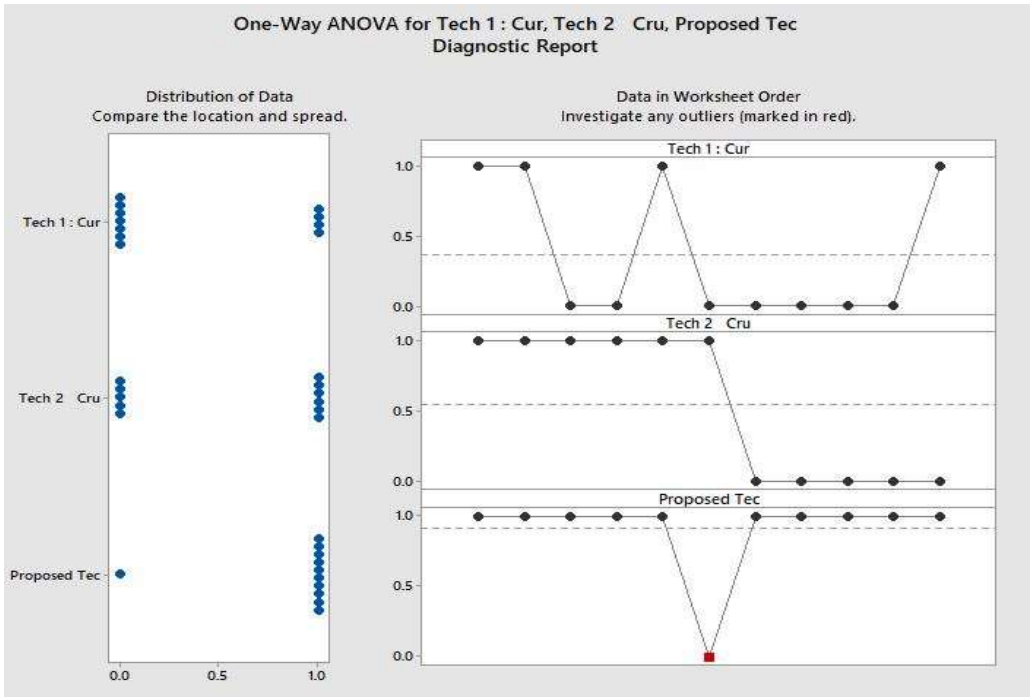
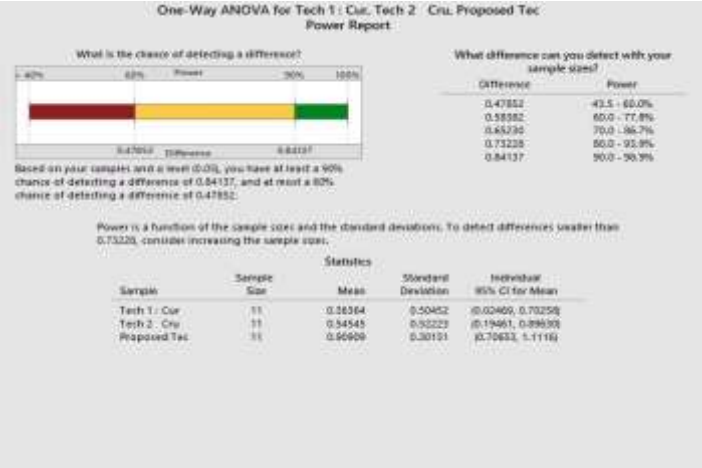


Figure 10: Anova data distribution chart



- The above data distribution chart tells us in Tech 1 : Score 1 are 4 factors, Tech 2 : Score 1 are 6 factors, In proposed technology : Score 1 are 10 factors that means that the proposed technology can adapt to more number of features and can provide economical solution as we have mapped the scores to technology as mentioned in above clause section V.
- Score : 0 meaning no function features available in the technology and also one part is the high cost and adaptability.

Figure 10: Anova statistical analysis



- As per statistical analysis proposed technology proves to be more reliable and has minimum deviation of 0.3 & mean of 0.9 which is greater other two technologies as per the mentioned conditions in Figure 6.

7. Six Sigma Analysis

- **DMAIC** stands for Define, Measure, Analyze, Improve, Control. This is the methodology from which we are going to validate our proposed technology superiority compared to the existing ones. In our case of maneuvering assist the following is the line items with respect to each word:
- **Define:** Driver's non alerting by vehicle and assisting driver to overcome different scenario's is the problem statement.
- **Measure:** Factors affecting the problem to help the drivers are classified into two functions: surrounding function, vehicle function & driver alerts, other assistance maneuverability.
- **Analyze:** Each measure condition has been compared with the relevant technologies and features to see the most favorable conditions for user.
- **Improve:** Interaction and anova analysis comparison have been made to see the critical factors impact.
- **Control:** By using the Statistical anova chart we have tried to prove that the proposed technology is user friendly, provides alerts and cost effective.

8. Conclusion

- Vehicles maneuverability alert is one of the key features and safety related warning to the user under different conditions. Detailed feature comparison is done above to prove that the proposed feature gives an improvised action- to user in terms of feature advancement and cost effectiveness. Proposed technology of maneuverability can be in position above the level of ADAS level 1 without using costly hardware to the vehicles.

9. References

1. Analysis of Vehicle Maneuverability and Driving Characteristics on a Curved Road Condition DOI:10.1007/s12205-018-1803-y.
2. Geometric analysis of maneuverability performance for vehicles with two steering axles DOI:10.20858/tp.2017.12.2.5.

3. Advanced Curve Speed Warning System using Standard GPS Technology and Road-level Mapping Information DOI: 10.5220/0009396800002550
4. Path Planning and Motion Control in Evasive Steering Assist SAE 2022-01-0088, 2022-03-29, 2022-01-0088 https://doi.org/10.4271/2022-01-0088