

Lane management system

Primary requirement:

1. The system shall turn on when the vehicle is in forward gear and the LMS is enabled by the driver.
2. The system shall be enabled once the lanes are detected for 2 seconds using the camera sensing and image processing subsystems.
3. System will provide audible and visual warning to the driver when it detects the vehicle moving out of its lane
 - a. If the speed of the vehicle is above 50 mph, the system will provide visual and audio warning
4. The system shall use the camera sensing and image processing subsystems to measure the distance between the vehicle and the line markings on each side.
 - a. If the absolute value of the difference of the distance between the vehicle and the line markings on each side is greater than .5 feet, then adjust the steering wheel to 1 degree inside of the lane marking by using the vehicle state estimation system.
 - i. Once the vehicle reaches a difference of less than .1 feet, then match the angle of the wheel to the lane markings.
 - b. If the vehicle gets within 1 foot of the lane markings on either side, then the system shall adjust the steering wheel to 2 degrees inside of the lane markings
 - c. This assist in steering should be able to be overwritten by the driver at any time by applying more force to the steering wheel
5. The system shall turn off if the lane markings become inconsistent or undetectable.
 - a. If the system is turned off, the system shall alert the driver by a vibration of the steering wheel, as well as an audible beep with a notification on the dashboard that the LMS has been deactivated.
6. The system will use the supervisory control systems to report to the driver if any subsystem is not working in which case the system will terminate.
7. The system should be able to detect a number of different lane markings
 - a. Solid Yellow
 - b. Solid Double Yellow
 - c. Dashed Yellow
 - d. Solid Yellow & Dashed Yellow
 - e. Solid White
 - f. Dashed White
8. The system shall ignore all boundaries on the same side as an active blinker.
 - a. Once the blinker is deactivated, the system will reevaluate the lane markings before turning back on if they are detected.
9. The system shall still give alerts even when driver is purposely crossing a lane marking without a blinker.
10. Turning the steering wheel to move the vehicle outside of the inner boundary of .5 feet on either side will lightly vibrate the steering wheel and will temporarily disable the inner boundary until the steering wheel is no longer being turned.
11. The system shall use Vehicle State Estimation system to monitor:

- a. Speed of Car
 - b. Steering Angle of Vehicle
 - c. Road Curvature
12. The system will monitor the drivers engagement with the steering wheel, and will provide alerts when they are off (detection is 2 seconds)

Secondary requirement:

- 13. The system won't alert the driver when using the turn signal.
- 14. Do not annoy the driver with too many vibrations
- 15. Have a clear indication of the LMS being active on the dashboard
- 16. Display proximity to boundaries on dashboard visually
- 17. The system needs to alert the driver of a deactivation for failures
- 18. Do not send false signals
- 19. System sensitivity should be able to be customizable at the user's discretion
 - a. The user can decide how much torque they wish the system to apply when lane keeping
 - b. The user can decide how they wish to be alerted when the warning system detects the vehicle leaving its lane

Invariant and primary requirement:

- 20. The system shall not be active at or above 85 miles per hour
- 21. The system shall enable only when driving 25+ miles per hour.
- 22. The system will not activate, if a double yellow lane marking is detected to be on the right side of the vehicle. (Regional setting)
- 23. Turning the steering wheel without a blinker on to break the 1-foot boundary will disable the LMS until it is manually reactivated.
- 24. The system shall not work if it is turned off
- 25. The vehicle must be stable and within the boundaries of the lane.
- 26. The system should always be prepared to relinquish control to the driver
 - a. The system should stop applying steering torque on the steering wheel when the driver is applying more force in order to turn or change lane
- 27. The vehicle must have functionally working blinkers.

Questions:

Should there be a speed minimum and or maximum for system to be active at?

If yes, what should they be?

How close to the line should the driver receive a warning? How close until torque is applied by the system?

When driving the vehicle, how should the system alert the driver when they veer from the center of the lane?

- Should the driver be able to disable the system?
 - o If so, what should enabling and disabling look like visually and functionally/

How much torque should be applied to the wheel in keeping the vehicle within the markings?

What should the alerts look like when these adjustments occur?

If the lane markings disappear on the road, or they are faded and not detected, what should the system do to ensure safety of the passengers?

- If the system sits on standby, as opposed to being turned off, how do we let the user know that the system is still on so that they aren't unexpectedly alerted when lane markings return?

If the driver's hands are off the wheel on the highway, should there be more than just giving them a visual and audio warning?

Are there any specific legal requirements that need to be followed for this system to be compliant?

Bibliography

Khattak, Z. H., Smith, B. L., Fontaine, M. D., Ma, J., & Khattak, A. J. (2022). Active lane management and control using connected and automated vehicles in a mixed traffic environment. In *Transportation Research Part C: Emerging Technologies* (Vol. 139, p. 103648). Elsevier BV.

<https://doi.org/10.1016/j.trc.2022.103648>

Maserati. "Lane Keeping Assist System." *Maserati.com*, 2021, www.maserati.com/us/en/ownership/maserati-manuals/safety/lane-keeping-assist. Accessed 30 Sept. 2024.

National Safety Council. "Lane Keeping Assist: MyCarDoesWhat.org." *My Car Does What*, mycardoeswhat.org/safety-features/lane-keeping-assist/.

Ford. "Lane-Keeping System | Ford Co-Pilot 360™ Technology." *Ford Motor Company*, www.ford.com/technology/driver-assist-technology/lane-keeping-system/.

Mopar, "Active Lane Management | How To | 2023 Jeep Vehicles," *YouTube*, Jan. 26, 2023. <https://www.youtube.com/watch?v=gBuJ6gD-nuA> (accessed Sep. 30, 2024).

"Lane Keep Assist Safety Feature | Vehicle Support," *GMC*. <https://www.gmc.com/support/vehicle/driving-safety/driver-assistance/lane-keep-assist-departure-warning>

"Lane Management System Customer: Ayush Agrawal, formerly with AI/ML GMIT (now with Amazon)." Accessed: Sep. 30, 2024. [Online]. Available: <http://www.cse.msu.edu/~cse435/Projects/F2024/ProjectDescriptions/2024-LMS-GM-Amazon-Agrawal.pdf>

<https://www.youtube.com/watch?v=aFgMODWrIyY> 2.

https://www.youtube.com/watch?v=Qmvq3wJ_zrg

<https://www.nhtsa.gov/vehicle-safety/driver-assistance-technologies>

<https://www.kbb.com/car-advice/lane-keeping-assist/>