I. Requirements Purpose, Objectives, and Goals

a.) Goal
Goal: Analyze, develop, and maintain a Lane Management System (LMS). This system will act as a security mechanism for preventing an automobile’s departure from its intended lane.

b.) Objectives & Purpose
- LMS will turn on every time the automobile starts up and will be configured to the driver’s input settings.
- LMS must be able to recognize when the automobile is starting to drift outside of its current lane.
- LMS must be able to distinguish the difference between intentional lane changing and an accidental departure.
- LDWS must alert the driver when the automobile is unintentionally departing from its lane.
● LCS must take control of the automobile and perform a readjustment of the tires to guide the automobile back onto its intended lane.
● The sensitivity of the LMS must be taken into account and the system should respond to change in a way maximizes the driver’s safety (E.g. Adjusting the degree of rotation on the wheels of a automobile over a period of time as opposed to forcefully adjusting them as quickly as possible.)
● The LMS must continue working even if other parts of the automobile are damaged or have failed.
● The LMS must be configured to receive any software updates that need to be installed.
● The LMS system software must be designed to detect unintentional lane departure quickly. A software design that processes visual inputs and produces responses slowly represents a hindrance to driver and automobile safety.
● The LMS should be designed to cooperate with all features of an automobile. The LMS should be synchronized with the tires, the speed, the turn angle, the weight, and the dashboard of the automobile, at the very least.

II.) References Related to Other Systems

Lane Keeping System
The Lane Keeping System (LKS) will connect to multiple systems in the car to provide the user with alerts or to aid them with staying in their lane. The system will use a camera that is mounted behind the windshield’s rear view mirror. This provides the camera with a height high enough to monitor the road lane markings and detect unintentional drifting toward the outside of a lane. The system, once an unintentional drift occurs, will access the steering system as well as the instrument cluster display to alert and/or aid the driver to stay in their lane. The system also utilizes the digital monitors, which are located to the left and right of the spedomediator. This is where the driver can view if the system is functioning properly and have the possibility to change some system settings. Finally, the system will access the controls behind the steering wheel. More specifically, the switch to toggle the system on and off will be on the same lever as the turning signal.

Lane Departure Warning System
The Lane Departure Warning System (LDWS) is very similar to the LKS as they both alert the driver when unintentional movement out of a lane is detected. Also, the LDWS using many of them same system integrations as the LKS. For example, the LDWS uses the multi purpose camera that is installed behind the windshield near the interior rear-view mirror. This camera will read the lane markings and detect the position of the car in the lane. So, if any unintentional movement is to occur it will warn the driver by means of a visual, audible
and/or haptic signal, such as steering wheel vibration. In addition to these systems, the LDWS takes advantage of a [1] stereo video camera that provides three-dimensional surround sensing. Taking advantage of the stereo video camera will give the LDWS a better indication of the environment around the car, such as is there about to be a collision.

**Lane Centering System**

The Lane Centering System (LCS) is the most complex of the three Lane Management Systems because the accurate readings it needs to correctly center the car in various road conditions. The LCS system will, like the LDWS and LKS, utilize a camera that will be behind the windshield and mounted on the interior rear view mirror. This will give the camera an acceptable view to read the lane markings and run algorithms to determine how to center the car. Once the car passes [4] some predefined threshold to the right or left, the system will respond by countering either direction by turning the steering wheel to try to center the car back in the lane. The LCS system is different than the LDWS or LKS because it will not notify the driver to turn back in the lane. Instead, the [4] LCS will automatically nudge the car back in the other direction to auto-correct the position. Therefore, the main systems the LCS will use in the car is the steering wheel as well as the cameras installed.

**III.) Terminology**

**a.) Abbreviation Definitions**

**LMS**: Lane Management System - A security mechanism designed to be placed within an automobile and used to prevent unintentional lane changing/drifting.

**LDWS**: Lane Departure Warning System: In road-transport terminology, a lane departure warning system is a mechanism designed to warn the driver when the vehicle begins to move out of its lane (unless a turn signal is on in that direction) on freeways and arterial roads. These systems are designed to minimize accidents by addressing the main causes of collisions: driver error, distractions and drowsiness.

**LCS**: Lane Centering System: In road-transport terminology, lane centering, also known as auto steer, is a mechanism designed to keep a car centered in the lane, relieving the driver of the task of steering. Lane centering is similar to lane departure warning, but rather than warn the driver, or bouncing the car away from the lane edge, it keeps the car centered in the lane.

**LKS**: Lane Keeping System: The lane keeping support system actively helps drivers to keep their vehicle within the lane.
b.) Terminology Definitions

**Camera Sensing Subsystem**: captures images on the sides of vehicle and sends over to the image processing unit for lane marker detection

**Image Processing Subsystem**: Processes the raw images coming from the camera and identifies the lane marker

**Vehicle State Estimation system**: A set of sensors that would periodically determine the speed, steering angle and road curvature

**Path prediction Subsystem**: A software subsystem receives information from 2 and 3 and try to predict the path of the vehicle in order to detect, warn and possibly correct any potential lane violations.

**User Interface system**: The driver and LMS exchange control and data information through this system 1.

**Supervisory Control Systems**: Controls all the other subsystems, decides when to enable and disable other subsystems and possibly provide diagnostic information.

**Botts’ dots**: are used, along with reflective raised pavement markers, to mark lanes on highways and arterial roads.

**Multi purpose camera**: Monocular camera platform for video-based driver assistance systems. Usually, mounted behind the windshield near the interior rear-view mirror. This camera can also be combined with other sensors, such as radar.

**Stereo video camera**: This video camera is used for three-dimensional surround sensing. The control unit for image processing and function control is integrated in the housing of the stereo video camera.

IV.) Rationale for Proposed System

The rationale behind creating an LMS is to enhance the driving experience for the driver. The result of this is two-fold, as it creates a more desirable experience for the driver leading to more vehicle sales and it helps to enhance the safety of the driver and surrounding drivers. As hardware and software technology advance, it seems that the slowest to accept the trend is auto
manufacturers. The cars, SUVs and trucks that manufacturers have been making for decades are relatively slow to adapt and incorporate new technological advances compared to many other sectors. Most of the time this is not by choice, but rather by the complexity of incorporation coupled with the severe repercussions that follow defective vehicles that lead to accidents. Now that manufacturers have the means to incorporate newly advanced technology into new vehicles without too much cost and safety testing that is advanced enough to foresee undesirable risk, manufacturers are starting to develop features that make the task of driving easier for the driver. Each advance taking one step closer to self-driving vehicles.

There are many manufacturers who have been working tirelessly to perfect systems like lane-departure warning, lane-keeping assistance, and road-departure mitigation. General Motors currently has technology available on vehicles such as Lane Departure Warning and Lane Keep Assist. The LDW alerts the driver if the vehicle is too close to one side of the lane. The LKS assists the driver by gently applying torque to the steering wheel if the driver does not respond to the initial warning.

These methods are currently unsatisfactory because they are currently underperforming when measured against reliability and consistency. Consumer Reports mentions that drivers are making complaints about inconsistent operation, “The LKA will work for a few minutes and then it is as if it forgets what it is supposed to be doing and lets your car drift out of the lane, mostly toward the shoulder.” Inconsistent operation can lead to the driver becoming over-reliant on the LMS. This may result in an otherwise avoidably accident that could lead to injury or death. The LMS, while active, should be at or near one-hundred percent reliable. Another problem that consumers have reported is false alerts, “But even the brands rated best for these systems—BMW, Lexus, and Cadillac—can be improved, with owners reporting close to 30 percent of vehicles with LDW having at least one false alert. Giving a false alert can also pose potential danger to drivers who aren’t expecting alerts. It could potentially lead to over-correcting the vehicle when it isn’t necessary.

V.) Essential Characteristics of Solution

- Software which can process visual inputs and generate appropriate responses, to the environment around the automobile, quickly and accurately.
- High definition motion capture cameras placed around the automobile to identify lane markings, other automobiles, and surrounding scenery.
- Powerful motion detection sensors placed around the automobile to detect objects within its range.
- A visual interface within view of the driver used to configure and manage the Lane Management System.
- Speakers within the car are synchronized to alert the driver when accidental lane departure occurs.
• A failsafe mechanism to disable the LMS if it fails or does not perform as intended. This failsafe mechanism should be within reach of the driver, yet placed in such a way to prevent accidental deactivation of the LMS.
• Software integration with all mechanical features of an automobile. These mechanical features will provide the LMS with current metrics about the vehicle such as: automobile weight, speed, turn radius, etc.
• Well defined values for determining the parameters of the LMS, LDWS, and LCS.
• Consistent and reliable updates/maintenance for all components of the LMS, LDWS, and LCS.

VI.) Description of System Environment

• Under conditions such as when the automobile is on a side street, residential street, or main street the LMS will remain active and fully responsive to the driver’s configuration. This includes the LMS taking complete advantage of its cameras and motion detection sensors.
• When the automobile is on a highway/expressway or moving at a high rate of speed, the LMS is designed to respond appropriately towards increased rates of speed. Thus, the LCS will guide the vehicle towards its proper lane without jutting or jerking the wheels.
• In the event that the failsafe deactivation mechanism for the LMS is triggered, the Lane Management System will immediately stop all of its functionality, thus giving full control to the driver.
• In the event that the automobile is in a parking lot or a driveway the LMS will continue to remain active, though only through its motion detection sensors. It will resume its full functionality when a lane marking is within the LMS camera detection range.
• If the driver decides to take the automobile offroad (Ex: Jeep/SUV) the LMS will continue to remain active, though idle. The LMS will be configured to respond to an offroad environment and will adjust its detection/sensing mechanisms to activate when a automobile is within a finite collision distance. This is to prevent false activations of the LMS if a automobile is purposefully driving through a path with a lot of obstructing objects (Ex: trees, hills, boulders).
References


