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Shared Steering Control between a Driver and an Automation: Stability in the Presence of Driver Behavior Uncertainty

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Abstract: **Now-a-days the Automatic control has been increasingly implemented for vehicle control system. Especially the steering control is essential for preventing accidents. In the existing systems there is no fully automatic steering control and it has serious problems. When it is made automatic, the system complexity is more. So, the shared steering concept is used in the proposed system to avoid accidents. In this, the position of the road is found using the web camera installed in front of the vehicle which is connected to the PC installed with MATLAB. Using MATLAB the image is processed to check the road characteristics. This paper presents an advanced driver assistance system (ADAS) for lane keeping, together with an analysis of its performance and stability with respect to variations in driver behavior. The automotive ADAS proposed is designed to share control of the steering wheel with the driver in the best possible way. Its development was derived from an H2-Preview optimization control problem, which is based on a global driver–vehicle–road (DVR) system. The DVR model makes use of a cybernetic driver model to take into account any driver–vehicle interactions. Such a formulation allows 1) Considering driver assistance cooperation criteria in the control synthesis, 2) improving the performance of the assistance as a cooperative copilot, and 3) analyzing the stability of the whole system in the presence of driver model uncertainty. The developed assistance system improved lane-keeping performance and reduced the risk of a lane departure accident. Good results were obtained using several criteria for human–machine cooperation. Poor stability situations were successfully avoided due to the robustness of the whole system, in spite of a large range of driver model uncertainty.**

Keywords: **Driver model, H2-Preview, lane keeping, shared steering control, vehicle lateral control.**

I. INTRODUCTION

Driving is a dangerous activity that can have serious human and economic consequences. According to the statistics, unintended lane departure is the second most frequent type of single light-vehicle accidents . In many cases, the accidents can be attributed to degradation in driver performance, which is caused by such factors as fatigue, drowsiness, or inattention. This fact has motivated major research effort aimed at helping drivers and improving safety, particularly through the use of active systems that have the potential to prevent vehicle accidents. Several advanced assistance systems have been proposed over the last decade to improve vehicle lateral control . Some of them are based on the principle of mutual control between the driver and the automation system. The challenge in designing such human–machine interaction is how to combine the adaptability of humans with the precision of machines because manual control tasks are prone to human error, and fully automated tasks are subject to wide-ranging limitations. Recently, an alternative solution, known as haptic shared control or haptic guidance, has received increased attention. In the shared control paradigm, the machine's manual control Interface is motorized to allow both a human and a controller to be able to exert control simultaneously. In such a setup, the haptic interface can sense the action of the operator and feed the forces back to him. Shared control has been investigated for a wide range of applications, e.g., in the control of automobiles And aircraft, or

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during tele-operated control to support object manipulation, surgery, micro assembly or the steering of unmanned aerial vehicles. Haptic feedback on the steering wheel is reported in the literature as a promising way to support drivers during a steering task. One successful realization is the lane-keeping assistance system (LKS), which continuously produces torque on the steering wheel to match predicted lateral lane deviations. Thus, both the driver and the support system contribute to the steering task. The benefit is that the driver is aware of the system's actions and can choose to overrule them. Such LKS systems are often designed based on a vehicle–road (VR) model and consider driver action as a disturbing signal. Therefore, these systems do not guarantee the global stability of driving and cannot provide a robustness analysis in the presence of variations in driver's behavior. A performance analysis of LKS systems has highlighted the fact that the vehicle and the driver form a human–machine system. Such a system should be considered as a whole to develop a cooperative co-pilot that monitors the driver's control actions, and understands and corrects them if necessary.

II. LITREATURE SURVEY

Jose I. Hernandez and Chen-Yuan Kuo, in 2003 proposed a **Steering Control of Automated Vehicles Using Absolute Positioning GPS and Magnetic Markers (**IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 52, NO. 1, JANUARY 2003**)** Steering control for passenger cars on automated highways is analyzed. Feasibility of an automatic steering system based on absolute positioning global positioning system (GPS) and a magnetic marker guidance system has been evaluated using computer simulations. State estimation and control algorithm issues are examined for such control system. By use of GPS and a magnetic marker sensor, an accurate and real-time estimation of the vehicle's lateral displacements with respect to the road can be accomplished. A steering control algorithm based on road curvature preview for achieving good road tracking and providing ride comfort is also presented.

Jóse E. Naranjo, Carlos González, Ricardo García, Teresa de Pedro, and Rodolfo E. Haber, in 2005 proposed a **Power-Steering Control Architecture for Automatic Driving (**IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, VOL. 6, NO. 4, DECEMBER 2005**)** The unmanned control of the steering wheel is, at present, one of the most important challenges facing researchers in autonomous vehicles within the field of intelligent transportation systems (ITSs). In this paper, we present a two-layer control architecture for automatically moving the steering wheel of a mass-produced vehicle. The first layer is designed to calculate the target position of the steering wheel at any time and is based on fuzzy logic. The second is a classic control layer that moves the steering bar by means of an actuator to achieve the position targeted by the first layer. Real-time kinematic differential global positioning system (RTK-DGPS) equipment is the main sensor input for positioning. It is accurate to about 1 cm and can finely locate the vehicle trajectory. The developed systems are installed on Citroën Berlingo van, which is used as a testbed vehicle. Once this control architecture has been implemented, installed, and tuned, the resulting steering maneuvering is very similar to human driving, and the trajectory errors from the reference route are reduced to a minimum. The experimental results show that the combination of GPS and artificial-intelligence-based techniques behaves outstandingly. We can also draw other important conclusions regarding the design of a control system derived from human driving experience, providing an alternative mathematical formalism for computation, human reasoning, and integration of qualitative and quantitative information.

A. Emre Cetin, Mehmet Arif Adli, Duygun Erol Barkana and Haluk Kucuk, in 2010 proposed a **Implementation and Development of an Adaptive Steering-Control System (**IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 59, NO. 1, JANUARY 2010**)** An adaptive steering-control system for a steer-by-wire system, which consists of a vehicle directional control unit and a driver-interaction unit, is developed. The adaptive online estimation method is used to identify the dynamic parameters of the vehicle directional-control and driver interaction units. A nonlinear 4-degree-of-freedom (DOF) vehicle model, including the longitudinal, lateral, yaw, and quasi-static roll motions, is derived using Newtonian mechanics to simulate and test the adaptive steering-control system. Experimental results are performed to demonstrate the efficacy of the proposed adaptive steering-control system.

Xiang Chen, Tiebao Yang, Xiaoqun Chen, and Kemin Zhobw, in 2008 proposed a **Generic Model-Based Advanced Control of Electric Power-Assisted Steering Systems (**IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY, VOL. 16, NO. 6, NOVEMBER 2008**)** Electric power-assisted steering (EPS) systems have been used to replace traditional hydraulic power steering systems in vehicles. In an EPS system, the assisting steering torque is from an electric motor. In principle, the control of an EPS system involves two aspects: 1) motor torque control to satisfy the

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torque requirement and 2) steering motion control to yield a satisfied feeling of the driver during the steering process in a disturbed environment. In this paper, a column-mounted steering system is taken as a generic target system to illustrate a model-based approach for advanced steering control design. In particular, we present a two-controller structure proposal for the generic EPS system, addressing motor torque and steering motion, by applying 2 and design methods, respectively. Controller model reduction is also discussed and compared to show that, actually, a reduced-order controller could be applied. This is important for industrial applications because a reduced-order control law costs less in computing resources. Finally, simulation for the EPS control system is discussed and a software-in-loop approach is presented using offs-the shelf Software. It is interesting to see that, based on the simulation results, the advanced two-controller design yields superior performance to the one-controller structure for the steering control.

Yoshiyuki Tanaka, Naoki Yamada, Toshio Tsuji, and Takamasa Suetomi, in 2014 proposed a **Vehicle Active Steering Control System Based on Human Mechanical Impedance Properties of the Arms** (IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, VOL. 15, NO. 4, AUGUST 2014) It presents the experimental data of human mechanical impedance properties (HMIPs) of the arms measured in steering operations according to the angle of a steering wheel (limbs posture) and the steering torque (muscle cocontraction). The HMIP data show that human stiffness/viscosity has the Minimum/maximum value at the neutral angle of the steering wheel in relax (standard condition) and increases/decreases for the amplitude of the steering angle and the torque, and that the stability of the arms' motion in handling the steering wheel becomes high around the standard condition. Next, a novel methodology for designing an adaptive steering control system based on the HMIPs of the arms is proposed, and the effectiveness was then demonstrated via a set of double-lane-change tests, with several subjects using the originally developed stationary driving simulator and the 4-DOF driving simulator with a movable cockpit.

III. PROPOSED SYSTEM

Before to introduction of electronic modules in automotive the vehicle is fully controlled by human and after that the vehicle is partially controlled by embedded control system and now the automated systems were developed to control the vehicle without any human interaction. But there is a problem in human-machine interaction system because manual control vehicle tasks are prone to driver error, and fully machine controlled tasks are subjected to wide–ranging of limitations. Finally, in this work a solution is given by providing a switching operation between the embedded control system and the driver by providing sharing of steering between the ECS or driver.

Many advanced assistance systems have been developed over the last decade to improve vehicle lateral control. Some of them (man-machine systems) developed based on the principle of mutual control between driver and automation system. In man-machine systems, the mechanical response of the Control interface (e.g., knob, mouse, joystick, steering wheel) to the action of a human is not typically considered as a feedback signal to the human operator. Rather, a visual or auditory sensory input closes the loop in the traditional manual control analyses. In many cases, the response from the control interface does not carry information pertinent to the execution of manual control.

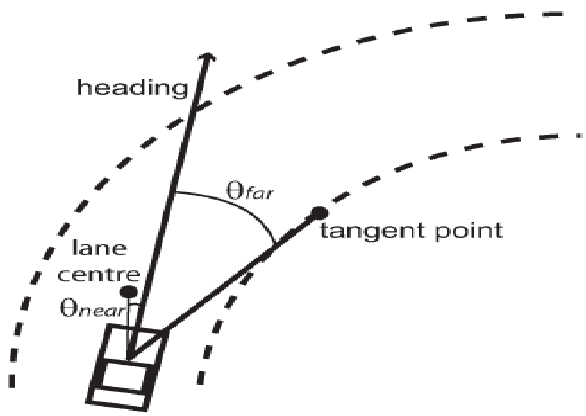

Fig .1 Road pattern

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IV. IMPLEMENTATION

A steering control concept is implemented. The figure 1 shows the general road pattern and the position of the car. Based on the road pattern and the obstacle present on the road the vehicle need to adjust its position. The position of the object is given as input using the push buttons and based on this position, the steering is adjusted. Using PSIM, code was build and with the help of PROTEUS the simulation is done.

WORKING:

The system consists of two push buttons, DC motor (act as an engine), a stepper motor (act as a steering wheel) and a LCD display to display the status of the movement of the car. The push button is used to show the obstacle position.

Initially when the supply is given the motor starts rotate. After some time, the position of the obstacle is given using the push buttons. If the obstacle is found in the right direction then the speed of the vehicle gets reduced and the steering (stepper motor) starts rotate in the left direction. After the steering gets adjusted to some position the motor starts to run in its original speed. If the obstacle is found in the left position then the speed of the vehicle gets reduced and the steering starts rotate in the right direction. After the steering gets adjusted to some position the motor starts to run in its original speed. This method also help us to overcome the over steering and under steering problem.

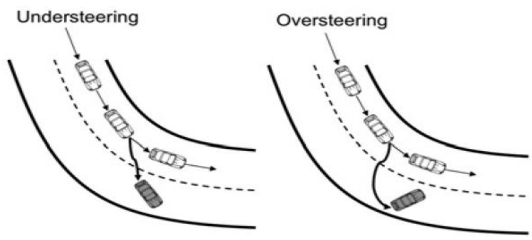

Fig 2 Understeering and Oversteering

Depending on the situation to enhance vehicle controllability by preventing skidding in cases of under steering or over steering. If the car understeers (i.e. the front wheels begin to skid), ESC decelerates the rear inner bend wheel (Figure 2 (left)). As a result, the car's heading is corrected, and the vehicle can safely continue to take the bend. If the car oversteers (i.e. the rear wheels begin to skid), ESC decelerates the front outer bend wheel (Figure 2 (Right)), which has the same benefits.

V. SIMULATION RESULTS

If Lane is normal and there is no obstacle in front of vehicle, then the vehicle is move in a particular direction without interference of the control signal from the steering.

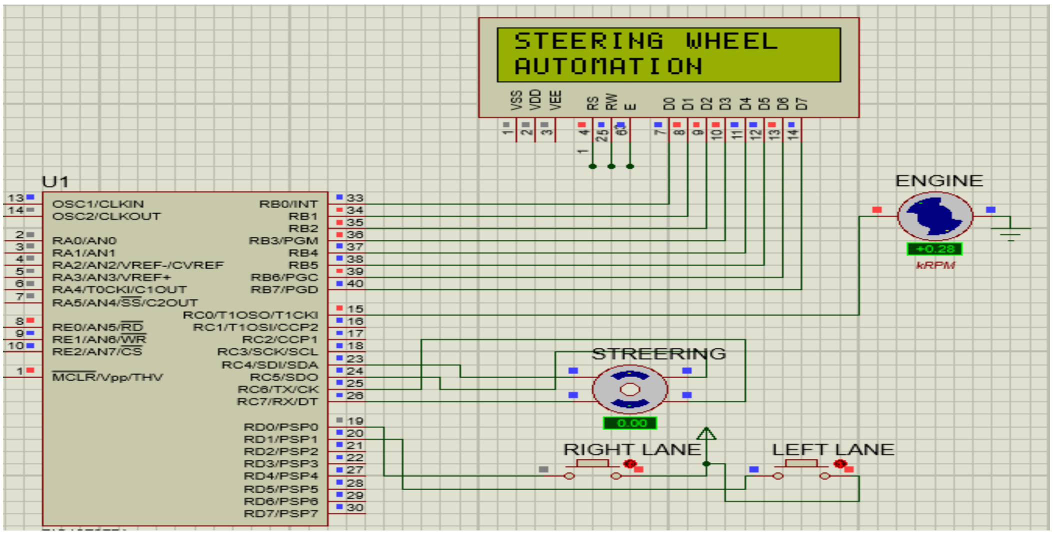

Fig 3. Initial Condition

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If any object is found on the lane, then the corresponding signal is given to the controller and based on that, the position of the steering gets adjusted. If the vehicle detects the obstacle in the right side border of the lane then the vehicle become automatically slow and taking the left side of the lane. Fig 7.2 shows the left rotation of the steering wheel.

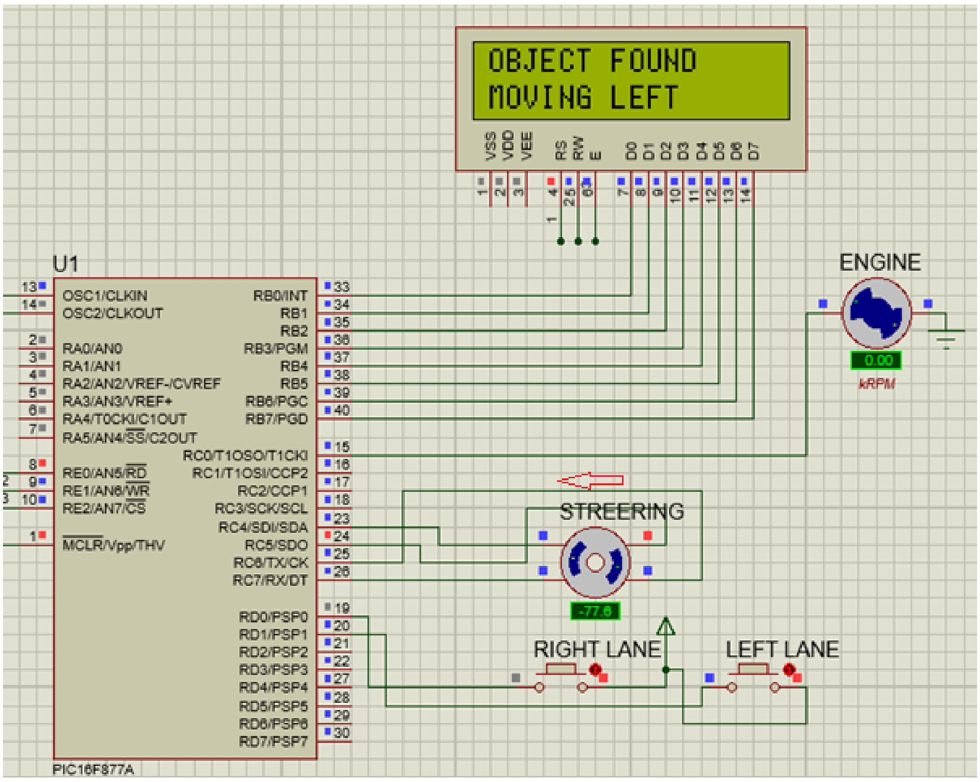

Fig 4. Left Direction

Similarly, if the vehicle detects the obstacle in the left side border of the lane then the vehicle become automatically slow and taking the right side of the lane. Fig 7.3 shows the direction of the vehicle after it detects the object in the left side. Fig 7.3 shows the left rotation of the steering wheel.

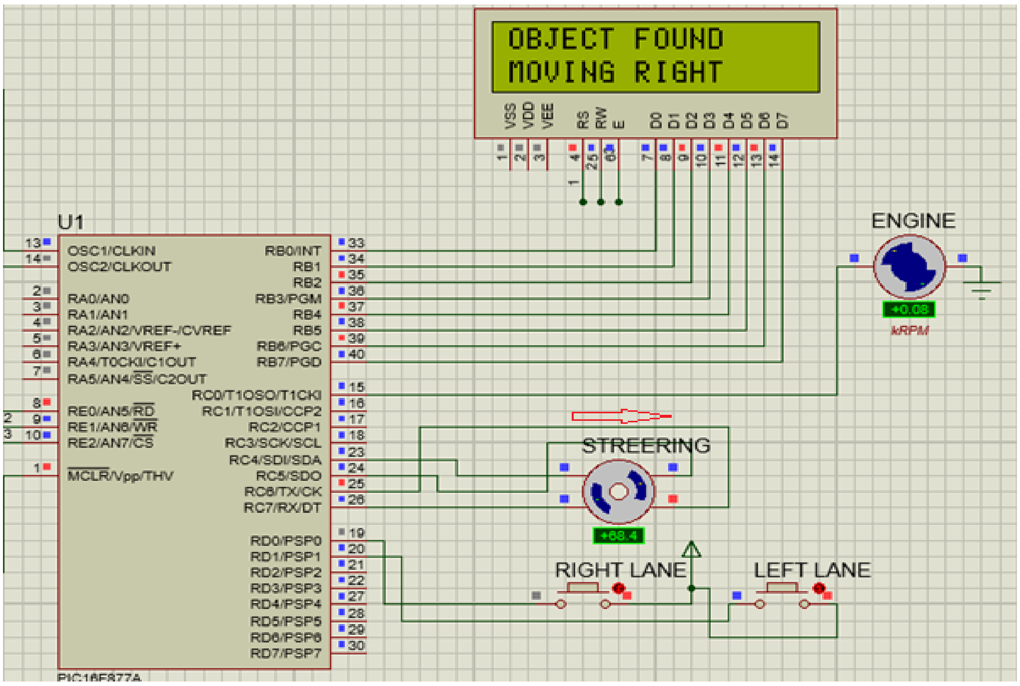

Fig 5. Right Direction

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V. CONCLUSION

This model is best suitable for electric cars; with some modifications this can be applicable to the cars which contain engines. In the operation there are various cases as follows; if Lane is normal and there is no obstacle in front of vehicle. If the vehicle crossing the right side border of the lane then the vehicle become automatically slow and taking the left side of the lane. If the vehicle crossing the left side border of the lane then the vehicle become automatically slow and taking the right side of the lane.

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