ABSTRACT

The course of the entire research work investigates the Advanced Vehicle Control System (AVCS) features of Intelligent Transportation System (ITS). The work in the thesis focuses on the design and development of auto-piloted vehicles and its control algorithms, which is an AVCS feature in ITS. The major features of AVCS include lane sensing, lateral control, longitudinal control, vehicle communication and vehicle platooning. Two types of prototype vehicles are designed for the real time implementation of the proposed algorithms. Two test bed tracks are used to test the performance of the proposed algorithms.

Two types of sensors, one with IR based sensing and the other one with 128 x 1 Linear Sensor Array based sensing technique is used for lane sensing. IR based sensing is used in prototype vehicle-1 and Linear Sensor Array based sensing is used in prototype vehicle-2. Five different algorithms for IR based sensing and adaptive sensor calibration algorithm is proposed for linear sensor array based sensing. The performances of the algorithms in these sensors are analyzed. The adaptive sensor calibration technique, used in 128x1 linear sensor array adapts to the various light intensity conditions. This algorithm facilitates the identification of black line from the white background at any intensity level (10 lux – 1000 lux). Thus the proposed algorithm makes the vehicle to track the lane independent of light intensity variations. Threshold setting technique is being discussed for three different position of the vehicle and the error values are calculated and tabulated which helps in vehicle position identification. The procedure to overcome the
slanting ray problem in the sensor output is incorporated. Hence the sensing performance of the sensors is improved by incorporating these sensing algorithms.

The error value from the threshold setting techniques is used in preprocessing algorithm which helps to identify the position and orientation of the vehicle in the track. Kalman filter is an adaptive filter widely used for tracking. Kalman filter helps to reduce the environmental noise in the sensor output. Oscillations are more while using Kalman filter in the prototype vehicle when the speed of the vehicle is more. To reduce the oscillations in the vehicle at high speed PID controller is used. PID controller reduces the oscillations and makes the vehicle stable even at high speed and also tracks smoothly. Tracking accuracy of proposed algorithm in IR sensor array based sensing and linear sensor array based sensing is compared with existing PID and Kalman filter based approach in this thesis. The proposed model needs very minimum hardware requirements when compared with the hardware requirements of Ismail’s method. There is no overshoot and undershoot in the proposed algorithm and hence the number of oscillations is very minimum when compared with Gengyun’s and Ismail’s method. The estimated state of the proposed method is more reliable than Oscar’s method. Better speed and more sampling rate are achieved in the proposed method when compared with Julio E. Normey method. The proposed method maintains constant turning duration for a wide range of turn angle. This is not the case in Jose E. Naranjo method.

Longitudinal control of the vehicle includes speed control of vehicle, vehicle communication and vehicle platooning. Prototype vehicles-1 and 2 are used for testing the proposed longitudinal control algorithms in real time. The adaptive speed control algorithm used in prototype-1 uses encoder
and prototype-2 uses current feedback to measure the speed of the vehicle. In the proposed algorithm current speed of the vehicle is compared with the reference speed and based on the difference in speed the speed correction is achieved smoothly. Adaptive acceleration control algorithm uses steer error based speed control. The delta difference between the present and past deviation is used for acceleration/deceleration. This difference makes the vehicle to travel in the maximum speed in straight line as well as when the error is minimum, thus makes the vehicle to complete the desired lap is short duration of time. Thus the adaptive acceleration control algorithm optimizes the vehicle speed in straight line and in the curves appropriately.

Obstacle detection and collision avoidance algorithms are incorporated in the longitudinal control and its performance is analyzed. The torque required to propel a vehicle is directly proportional to the steering angle of the wheel and inversely proportional to the speed of the vehicle. This condition is achieved by providing steer error based speed control techniques. Steer error based speed control and critical speed estimation algorithms improves the performance and provides safety for the vehicle in motion. The lap completion time is considered as a metric for the performance analysis of the longitudinal control algorithms. The proposed algorithms make the vehicle to complete the lap in short duration of time where the other algorithms fail to complete the lap at that speed which proves the better speed accuracy.

Vehicle communication is established for implementing intersection collision avoidance between vehicles which forms cooperative vehicle systems. Implementation of infrastructure controlled system helps the roadside infrastructure unit to predict and control the traffic flow by communicating with the vehicles within the zone which prevents traffic
congestion and provides smooth traffic flow. Vehicle platooning concepts are analyzed with four vehicles in platoon. The vehicle communication systems and vehicle platooning improves the performance of the autonomous vehicles in the track.

The combination of proposed sensor calibration algorithm, pre-processing algorithm, cascaded Kalman and PID steer control algorithm, adaptive speed and acceleration control algorithm, obstacle detection and collision avoidance algorithm together makes the test bed vehicle to complete the test bed track in a shortest time smoothly without much oscillations at desired speed. Test result shows that the proposed algorithm has better stability in real time environment in multiple vehicles which justifies the proposed algorithms are vehicle independent.

These findings suggest that the research into autonomous vehicles within the ITS field is a short term reality and a promising research area and these results constitute the starting point for future developments. Some of the suggestions towards extension and/or future related works are identified and are summarized below: New sensory systems and sensory fusion is to be explored to plug additional information to the control system. This work can be further extended to include different maneuvers to make the driving system capable of dealing with all driving environments. Future issues may also include an algorithm for autonomous formation of the cooperative driving. Thus, with the current and growing awareness of the importance of security, trustworthy vehicle autonomous systems can be deployed in few years. As technology improves, a vehicle will become just a computer with tires. Driving on roads will be just like surfing the web., there will be traffic congestion but no injuries or fatalities.