Vehicle Rollover Prevention by Countersteering

ABSTRACT
Percentage of accidents are caused due to rollover. Therefore this brings a need to prevent accidents caused by roll-over of vehicles. So this system prevents the eventual roll-over of the vehicle by a method of counter steering which turns or moves the vehicle in the direction where an eventual roll-over is occurring by applying a physical principle of neutral equilibrium which is displacing an object while not changing the position of its center of gravity. Counter steering brings the vehicle into a neutral equilibrium state thus avoiding the rollover. The rollover is sensed by the MPU-6050 accelerometer cum gyroscope sensor which detects the roll angle, roll acceleration of the vehicle. The programming is done for the ATMEGA controller using Arduino IDE software for continuous monitoring of roll angle and roll acceleration of the vehicle. When the roll acceleration or the roll angle exceeds the rollover threshold value calculated by mathematical modeling the controller sends the control signal through the H-bridge which changes the direction of the motor to turn the vehicle on the same side of the occurring rollover which drives the ring gear on the steering column to create an effect of counter steer thus maintaining a neutral equilibrium and bringing the vehicle back to the ground and avoiding the rollover.

Keywords
Rollover, Counter Steering, Neutral Equilibrium, Roll Angle and Acceleration.

1. INTRODUCTION
A summarization of rollovers, accidents due to rollovers, components used in this project and their types, the variable features of the components are discussed below. Rollovers are dangerous incidents and have a higher fatality rate than other kinds of crashes. Of the nearly 9.1 million passenger car, SUV, pickup and van crashes in 2010, only 2.1% involved a rollover. However, rollovers accounted for nearly 35% of all deaths from passenger vehicle crashes. Any additional structural strengthening in the body like roll cage would eventually increase the weight of the whole vehicle. Vehicle rollovers are divided into two categories: tripped and untripped. Few other factors also contribute to the rollover.
2. LITERATURE SURVEY

Ansour Ataei et al [1] “Model predictive rollover prevention for steer-by-wire vehicles with a new rollover index” presents a Model Predictive Control (MPC) strategy for rollover prevention through active front steering. A new Rollover Index (RI) and a specified vehicle model are proposed to realize an effective rollover prevention approach. The new RI is represented by vehicle parameters and state variables so that it can be readily incorporated into the MPC objective function. Using a barrier cost function, the proposed MPC controller limits vehicle maneuvers within a safe region of rollover without sacrificing vehicle maneuverability under normal conditions. The roll dynamics, the tire nonlinearity, the lateral load transfer, and the road bank are considered for vehicle modeling to provide appropriate actions at the threshold of a rollover. October 2018

Wanzhong Zhao et al [2] “Control of integrated rollover prevention system based on improved lateral load transfer rate” states a rollover dynamic model that merges the active front steering model and differential braking model is established in this paper. After analyzing and improving the existing rollover evaluation method, a new evaluation method that takes both sprung mass and under-sprung mass into consideration is proposed. The reliability of the improved LTR (lateral load transfer rate) is confirmed by simulation results obtained from MATLAB and CARSIM where, all of three evaluation methods are taken under the same condition. The accuracy of the rollover evaluation index depends on the centroid height of under-sprung mass and the ratio of under-sprung mass and under-sprung mass. June 2018

Mohammad Ghazali et al [3] “Vehicle trajectory challenge in predictive active steering rollover prevention” states the conflicts between rollover prevention and trajectory tracking is investigated. Model predictive control (MPC) is adopted to predict and avoid rollover while tracking desired trajectory. For this regard a model based future error estimation is introduced. The control framework predicts both rollover and trajectory error simultaneously. It avoids rollover while tries to track the trajectory. Simulation results for two controllers with and without trajectory tracking are presented. The results indicate that the controllers effectively limit rollover as a hard constraint while the trajectory tracking controller also minimizes and recovers the path error. April 2017 Duanfeng Chu et al [4] “Smooth Sliding Mode Control for Vehicle Rollover Prevention using Active Antiroll Suspension” studies, a lateral load transfer ratio which reflects the load distribution of left and right tires is used to indicate the rollover criticality. An antiroll controller is designed with smooth sliding mode control technique for vehicles, in which an active antiroll suspension is installed. A simplified second order roll dynamic model with additive sector bounded uncertainties is used for control design, followed by robust stability analysis. Combined with the vehicle dynamics simulation package Trucks, MATLAB/Simulink is used for simulating. It show that the applied controller can improve the roll stability under some typical steering maneuvers, such as Fishhook and J-turn. This direct antiroll control method could be more effective for untripped rollover prevention when driver deceleration or steering is too late. It could also be extended to handle tripped rollovers, May 2015

M.K. Arripina et al [5] “A Review on Integrated Active Steering and Braking Control for Vehicle Yaw Stability System” presents The main objective of this paper is to provide an overview and comprehensive understanding of the main elements in yaw stability control system and its control strategies in
improving vehicle handling and stability performances.

December 2014

Leonardo De Novellis et al [6] “Direct yaw moment control actuated through electric drivetrains and friction brakes” states the Theoretical design and experimental significant challenge in electric vehicles with multiple motors is how to control the individual drivetrains in order to achieve measurable benefits in terms of vehicle cornering response, compared to conventional stability control systems actuating the friction brakes. This paper presents a direct yaw moment controller based on the combination of feedforward and feedback contributions for continuous yaw rate control. When the estimated sideslip exceeds a pre-defined threshold, a sideslip-based yaw moment contribution is activated. December 2014

Markus Lemmen et al [7] “Roll stability control and rollover mitigation by steering” relates to a method for reducing a risk of or avoiding a roll-over event of a vehicle, having means of an electronic controllable steering system and an electronic control unit.

3. PROPOSED WORK

To prevent the accidents caused due to roll-over of vehicles by applying a physical principle of neutral equilibrium by counter steering the vehicle in the direction where an eventual roll-over is taking place.

To collect and study concepts

Mathematical modeling

program

Implement

Testing

Fig 1: Methodology

The steps which was followed for the execution of the project is given below as methodology. Collection and study of literature/patent of similar projects and identification of problem is done after which the Mathematical modelling for rollover to occur and steering torque calculation is derived, then the development of working model layout and selection of microcontroller and sensor as per the requirement is completed. The study of patents gives a broad view of the concepts related to the rollover prevention system and the similar methodologies adapted in order to prevent the rollover of the vehicles. From the patent study a clear view on the problem is obtained which results in identification of single specific problem, after which the procedures need to be followed is sorted out.

Mathematical modelling is done assuming the vehicle is in beginning of its rollover and taking moments and reaction forces with one wheel lifted off gives the clear condition for the rollover, the arrived equations are the threshold lateral acceleration and threshold roll angle.

Coding is done using Arduino IDE software in which the deciding equations are coded and burned to the microcontroller in order to actuate the servomotor in a
particular direction in accordance with the direction of the occurring rollover. Selection of servo motor is done based on the steering torque calculation.

Prototype is made of sheet metal and toy car wheels and the components are assembled on board. Finally

4. DESIGN LAYOUT

A prototype for rollover prevention system using counter steering mechanism was developed. The System successfully detects the roll angle when the vehicle is maneuvered aggressively during cornering or during a collision with an obstacle on the road and actuates the steering electronically when the roll angle reaches the threshold value and avoids the eventual rollover of the vehicle. Thus the Prototype was tested successfully and the following objectives are accomplished. The roll angle was monitored by the 3-axis accelerometer. The angle was read and processed successfully by the controller. The roll angle was displayed by the LCD display. The signal for stepper motor was sent corresponding to the direction of eventual rollover. The stepper motor was actuated to steer the vehicle in the direction of rollover. Associating this project with selective braking of individual wheels to create an external yaw moment similar to electronic stability program would make the rollover prevention system more effective.

5. PROTOTYPE

A prototype is made with sheet metal and toy car wheels. The servomotor, sensor and the Arduino are fixed onboard of the prototype.

6. CONCLUSION

The connections are given to interface the sensor, LCD display and the servomotor to the Arduino by using jumper wires and components are fixed on board to the prototype. The steering system is made with simple four bar linkage made out of sheet metal and steel rod. The linkage is then connected to the servomotor.

Generation of the program and the prototype testing is done

7. REFERENCES


[7] Markus Lemmen, Krefeld (DE); Dirk-Uwe Eidam, Bergisch-Gladbach Refrath (DE); Edwin Vliem, Eersel (NL); Torsten Wey, Moers (DE); Bengt Johan Henrik Jacobson, Mohnlycke (SE); Johan Hulten, Göteborg ” Roll stability control and rollover mitigation by steering” AUG 2013.


[9] S,g hassan naqvi “the rollover prediction and prevention of bullet proof vehicles for improved stability” Life Science Journal 10(4s):209-214 · April 2013

