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Fuzzy Logic Approaches for Pedestrian Collision Avoidance in Intelligent Vehicles

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Abstract:- An automated braking decision or steering decision and control framework is proposed in this paper to avoid pedestrian collisions. Collision avoidance is an importantprerequisite for safe and automated driving in modern traffic systems. This paper explores intelligent and safe obstacle avoidance in complex traffic scenarios with main focus on pedestrian collision avoidance. The driver's purpose is important in collision avoidance, when the driver intends to avoid a collision by relying only on braking a safe stopping distance is 0.5 meters. But, when a driver intends to avoid collision by relying only on steering, for the most part, it is necessary to ensure that automated braking intervention will not occur.

Keywords:- *Obstacle Avoidance, Fuzzy Logic, Pedestrian Protection, Steering Control, Automated Braking, Kalman Filter, ANFIS, Complex Traffic Scenarios.*

I. INTRODUCTION

Automobiles with active safety systems may substantially make up for intrinsic driver shortcomings in busy traffic settings, hence lowering the number of incidents that could have been avoided. While some contend that automatic steering may be the most effective way to avoid crashes in thefuture, others assert that when the speed of a vehicle strikinga pedestrian drops from 50 to 25 km/h, the likelihood of a pedestrian dying drops by 85%. From this vantage point, an autonomous braking system is crucial to lowering the probability of fatalities in scenarios involving vehicles and pedestrians. Additionally, it has been found that in emergencycircumstances, human drivers are more likely to brake than tosteer. Drivers' reluctance to steer may be a result of a propensity to keep their own lanes of traffic open at all costs. Autonomous collision avoidance for some requires deferringto the driver, while for others, the intention of the driver is crucial.

The choice of a car's behavior in a dynamic traffic situation depends on a number of variables that may be predictableor unpredictable, such as the volume of traffic in the adjacent lanes, the vehicle's speed, the distance to the obstacle, and the speed of an object in back, all of which are extremely desirable for safety and the avoidance of gridlock. In order to avoid obstacles, a collision avoidance system often incorporates numerous driving behaviors such as obstacle recognition, lane change behavior, and lane holding behavior.

It must make the best judgement possible in order to avoid a barrier by selecting the appropriate driving behavior.

II. METHODOLGY

Table 1. Comparison for paper 1

Criteria	Automated Braking Decision and Control for PedestrianCollision Avoidance Based on Risk Assessment
Sensors	The motivations of this article is to detect pedestrian motionwith a camera, which can obtain more information than radar and is much cheaper than lidar.
Collision avoidance type	In the proposed paper, collision is avoided using hysteresisbraking system response model.
Equipment	The proposed control scheme is verified through a multivehicle driving simulator platform and an autonomous vehicle platform. The autonomous vehicle platform is equipped with a 128-linelidar, two 32-line lidars, a front long-range milli-meter-waveradar, a rear long-range milli-meter-wave radar, four corner radars, a front-view camera, a rear-view camera, two side- view cameras, and a GPS. In addition, the controller has an Intel Core- i7-7700T processor at 2.9 GHz, four cores, and 8 GB of Double Data Rate 4 random-access memory.
Data recorded	Pedestrian's relative positions, velocities, and accelerations& Vehicle's wheel speed and acceleration.
Estimation algorithm	Kalman filter

Assumptions	Speed, acceleration, and yaw rate are accurately obtained from onboard sensors. During verification pf algorithm road adhesion value of 1 andvehicle speed of 120 km/h is assumed. To address the strong nonlinearity of pedestrian motion in real traffic and simplify the calculation process, it is assumedthat pedestrian trajectories are linear. Car rotates counter clockwise and that a pedestrian walks forward from the left. When the driver intends to avoid a collision by relying only on braking, a safe stopping distance *D*safe = 0.5 m To simplify the calculation, the fuzzy decision module is triggered only when amount of time a vehicle has to stop to avoid a collision <= earliest time of automated braking.
Constrains	road adhesion, vehicle lateral stability, driver intentionconstraints
FuzzyLogic input	collision time difference
FuzzyLogic output	desired deceleration rate
Futurework	Future work will investigate driver personalization, with multiple risk indicators to achieve more human-like andflexible automated braking decisions and control

Table 2. Comparison for paper 2

Criteria	A Fuzzy Logic based control system for obstacleavoidance while driving light motor vehicles.
Collision Avoidance type	In the proposed paper, collision is avoided usingdeceleration and braking.
Sensors	Three ultrasonic sensors, an Arduino micro-controller and a Raspberry pi II microprocessor.
Data recorded	Distances to obstacles around the vehicle and stateof the vehicle (rest or motion)
Estimationalgorithm	Fuzzy logic controller is a set of fuzzy rules thatreplace mathematical models/algorithms.
Assumptions	Vehicle will have a linear acceleration (as the accelerator is pressed speed increases and when accelerator is not pressed the vehicle will start deaccelerating)
Constrains	Driver intention, Intentions of pedestrians on theroad.
Fuzzy Logic input	X_input: Linear acceleration along the axis XY_input: Linear acceleration along the axis Y LD: The distance between the left sensor and obstacles RED: The distance between the rear sensor and obstaclesFD: The distance between the front sensor and obstacles RD: The distance between the right sensor and obstacles
Fuzzy Logic output	X_out: The linear acceleration along the axis X after regulation in such a way the risk of hitting objects is limited. Y_out: The linear acceleration along the axis Y after regulation.

Table 3. Comparison for paper 3

Criteria	Fuzzy Control of AutonomousVehicle at Non signalizedIntersection in Mixed Traffic Flow
Collision Avoidance type	In the proposed paper, collision is avoided using acceleration,deceleration and braking.
Sensors	MPC and PID controllers to simulatepath tracking and evaluated both speed and position/location
Data recorded	Information about the speed andlocation of the human-driven car
Estimation algorithm	Fuzzy logic controller is a set offuzzy rules that replacemathematical models/algorithms.
Assumptions	There is no cooperation between an autonomous vehicle and the human-driven vehicle for passing the intersection. The autonomous vehicle isresponsible for speed adaptation to prevent potential collisions using the fuzzy controller to guarantee a safe intersection crossing maneuver according to the human-driven vehicle position.
Constrains	Intentions of the person driving thevehicle
Fuzzy Logic input	Sm:- This fuzzy input determines thehuman-driven vehicle's speed; the speed range is defined 0-100 km/h. Sa:- This fuzzy input determines theAV's speed as afuzzy variable with two Gaussian membership functions; the speed range is definedas 0-50 km/h. Dm:- This fuzzy input determinesthe distance of the human driven vehicle to the crossing point. Da:- This fuzzy input determines thedistance of the AV vehicle to the crossing point.
Fuzzy Logic output	Defined as integer numbers in the range of (0-50) km/h; as 'stop' represents 0 km/h, 'slow' shows 20 km/h, 'middle' represents 38 km/h and 'fast' is a symbol for 50 km/h.

Table 4. Comparison for paper 4

Criteria	**Autonomous Mobile Robot Navigation using Adaptive Neuro Fuzzy Inference System**
Sensors	Front, center and right distance sensor
Collision avoidance type	In the proposed paper, collision is avoided using ANFIS steering model.
Equipment	The performance of the proposed method is analyzed using MATLAB202la and CoppeliaSim Edu 4.2.0. A three- wheeled mobile robot 'Pioneer 3dx' with two front wheels having independent motor control and a roller wheel at the rear is used to perform simulations. All the training and testing of FIS are executed in MATLAB. An API connection is necessary for both platforms to communicate while performing simulations. MATLAB is responsible for mobile control, while obstacles prone environment is designed in CoppeliaSim.
Data recorded	To calculate the separation between the robot and obstacles in simulations, the robot's left, right, and front sensors are used.
Estimation algorithm	16 fuzzyset rules
Assumptions	To create a path planning algorithm, it is important to have knowledge of the robot's goal position as well as sensor data to determine direction and distances.
Constrains	Fuzzy logic Matlab toolbox, membership function, epoch numbers
FuzzyLogic input	Heading angle
FuzzyLogic output	ANFIS steering output
Future Work	According to simulation results, the suggested ANFIS controller outperforms a number of state-of-the-art techniques. To prevent concave barriers in subsequent research, this work will be improved.

6. Future work will investigate driver personalization, with multiple risk indicators to achieve more human- like and flexible automated braking decisions and control.

Table 5. Comparison for paper 5

Criteria	**Fuzzy-based Collision Avoidance System for Autonomous Driving in Complicated Traffic Scenarios**
Sensors	Front ultrasonic sensor
Collision avoidance type	In the proposed paper, collision is avoided in complex traffic using lane change and deceleration.
Equipment	The scenarios where developed in Matlab/Simulink environment.
Data recorded	front obstacle distance, rear object velocity, current lane of car, x-coordinate of the center of the rear axle of the car, left obstacle distance, right obstacle distance
Estimation algorithm	Adaptive Cruise Control Fuzzy-based Lane Change Control
Assumptions	Effective collision avoidance is made possible by the fuzzy controller's combination of the lane change controller and the adaptive cruise controller with a set of ideal rules.
Constrains	Car distance, lane change and deceleration time
FuzzyLogic input	front obstacle distance, rear object velocity, current lane of car, x-coordinate of the center of the rear axle of the car, left obstacle distance, right obstacle distance
FuzzyLogic output	Car speed, car direction, and the car mode.
Safe distance	Multiple scenarios, varying.

III. RESULTS

This article presented an automated braking algorithm frame-work for pedestrian collision avoidance.

- First, accurate motion estimation and trajectory prediction for host vehicles and pedestrians were achieved based on the vehicle CTRV model and a KF.
- The collision area and corresponding geometric parameters were precisely defined considering a straight/curved vehicle motion path, the sizes of the host vehicle and a pedestrian, and the road geometry configuration. On that basis, flexible and accurate collision verification was achieved.
- The most dangerous pedestrian was identified according to the minimum TTC.
- Then, multiple constraints related to road adhesion conditions, vehicle lateral stability conditions, and driver intentions were considered, and an automated braking decision strategy was proposed based on fuzzy theory to achieve smooth deceleration outputs.
- Finally, a first-order, inertial pure hysteresis braking system response model was built based on real vehicle braking data from experiments.

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IV. CONCLUSION

Using a camera is more cost-effective since it can collect more data than radar and costs a lot less than lidar. Some people utilize MATLAB, while others use the driving simulator platform. Instead of steering, the braking system may be a superior option for collision avoidance. The tendency of drivers to maintain their own lanes of traffic clear at all costs may be the cause of their unwillingness to steer. Additionally, it was discovered that the driver's intentions affect automated braking decisions.

Distinctive braking may make it more difficult for a driverto feel comfortable. As a result, a brake choice approach based on fuzzy theory is suggested while taking the automatic braking restrictions into account. This method removes the need for a difficult dynamic modelling procedure, establishes the mapping connection between the error and output based on data on actual driving behavior and human experience, and generates a continually changing deceleration rate that aids in driver adaptation while braking.

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