An Advanced Priori Algorithm for Collision Avoidance by Adaptive Path Determination using RFID

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ABSTRACT
This paper proposes an advanced priori algorithm by which a collision detection and avoidance scheme can be implemented such that a probable collision between two vehicles can be pre-empted and a proper collision avoidance strategy can be enforced early to avoid a possible mishap. In spite of technological advancement in the recent past collisions and accidents occur frequently resulting in economic and human loss. This algorithm depicts an effective method of detecting and avoiding collision in real life scenarios implementing advanced RFID systems involving TAGs and READERs.

General Terms
Algorithm, Collision Avoidance.

Keywords
Priori Algorithm, Collision Avoidance, RFID, Adaptive Path Determination.

1. INTRODUCTION
A major issue plaguing modern transport systems is Collision, which in most cases, occurs due to operational errors. Thus the need for a collision avoidance system arises [1-3]. These systems aid the operator to learn in advance about any possibility of collision with an adjacent vehicle utilizing advanced data acquisition technique by using RFID tags fitted to the vehicles. RFID stands for Radio Frequency Identification [4-7], is a system of identification wherein an electronic device that uses radio frequency or magnetic field variations to communicate is attached to an item. In this system RFID tag generates a signal containing tagged data which is read by the RFID reader which then may pass this information to the processor for processing information for a particular application.

In the present work an advanced priori algorithm for collision avoidance is developed in which the received data is processed to determine any possible point of collision between the pair of interacting vehicles. If a collision is apprehended a proper avoidance measure is selected early to avoid a possible mishap.

2. ANTI-COLLISION SCHEME
The proposed algorithm puts forward a probabilistic approach where the instants of collision can be calculated with high precision. Priori is used as the instants of collision are determined before the directional configurations of the physical bodies are updated. For this a physical workspace is constructed, consisting of cars fitted with active RFID tags and RFID readers that transmit the information about the velocity vectors as shown in Fig. 1. Each vehicle sends its velocity of propagation (v) and angle of propagation (ϴ) which is received by another vehicle using a RFID reader. The User vehicle is denoted as car 1 and the other vehicle is denoted by car 2.

A collision free environment is to be established for a highly congested area of cars. In the present work, the test vehicles are fitted with Devantech CMPS03 Electronic Magnetic Compass [8] for determination of the direction, hence angle of propagation (ϴ) with the angle of earth's central axis. The Cars are also fitted with Optical Tachometers which measure the rpm of the driving motors from the revolution of the wheels. From the optical reflector attached to the wheels of the car. The velocity of propagation (v) can be calculated from the device. Use of active tags results in instantaneous transfer of velocity and direction parameters of the test vehicles to the neighboring ones.

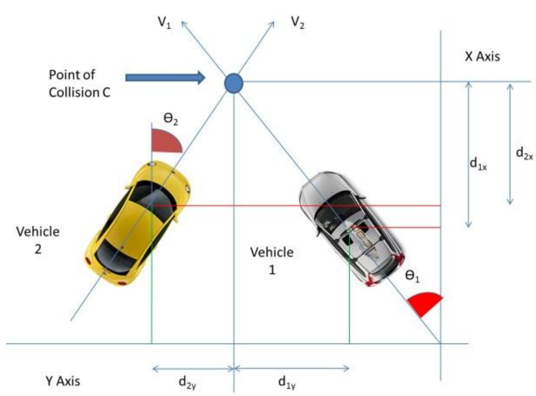

Fig 1: Graphical diagram of the proposed algorithmic scheme.

2.1 COLLISION DETECTION ALGORITHM
The present scheme calculates the velocity and directions of the interacting vehicles and determines the motion paths of the vehicles as represented in the diagram. The vehicles would collide only if the motion paths intersect at a specific point at a particular instant of time. Resolution of velocity vectors along X and Y axes and subsequent solving of the equations for different distances, determines the possibility of collision as depicted in Fig. 2.

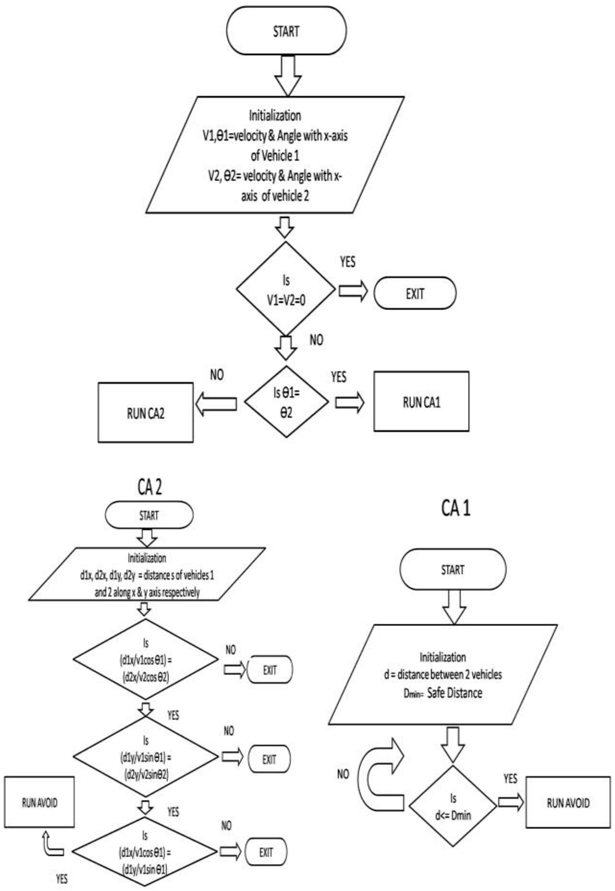

Fig 2: Collision Detection scheme.

The time of collision is compared and the resulting distances from the point of collision is calculated for each vehicle. Since RFID readers can calculate the distance of a tag from itself by using the Friis free space propagation equation as

Preader = EIRP x Greader ($\lambda/4\pi r2$).

Then 'd' is the distance between reader and tag, hence the distance between 2 vehicles. The scheme assumes that the vehicles move with uniform velocities in constant direction.

2.2 COLLISION AVOIDANCE ALGORITHM

Once the possibility of collision is apprehended then collision avoidance measures need to be implemented. Each vehicle has a given critical braking distance (dc). This distance is considered as a safe distance. Beyond this distance it is possible to brake and stop to avoid collision. Based on the possible scenarios the required modifications in motion paths are implemented as depicted in Fig. 3.

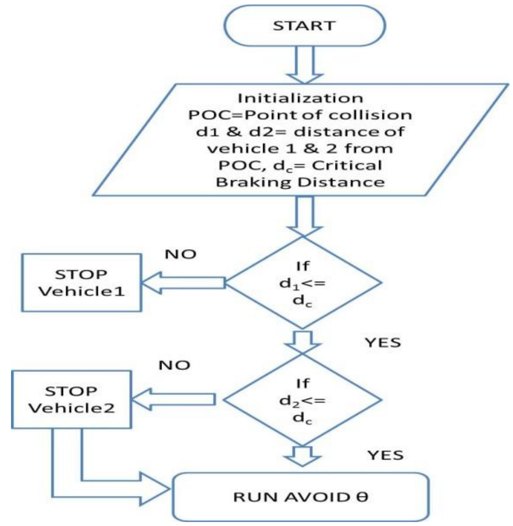

Fig 3: Collision avoid scheme.

If a collision is detected and both the vehicles are at distances greater than the critical safe distance then simple "Brake and Stop" Method is implemented. Stop 1 means the User Vehicle 1 is stopped, if no other vehicle is in vicinity or in collision course with it apart from vehicle 2. Otherwise a "Brake and Slow Down" technique is used. If any of the colliding vehicles comes within the critical braking distance then its direction is changed and consequently stopped or slowed down and again after a while it reverts back to its original course. Stop 2 is used to issue an alarm to the other vehicle and subsequently stop both the vehicles or change their course. Avoid Ɵ actually changes the direction of one of the colliding vehicles so that the other vehicle can pass by and after a specific time the car moving in the new direction reverts back to its original course. During avoidance of collision and modification of motion path, at each step, the presence of any other vehicle is calculated to avoid any sort of collision due to the avoidance measures. A simple looping of the collision detection program helps the cause.

3. RESULT DISCUSSION

The proposed algorithm can be implemented in real life scenario. Since the calculation of the values of sine and cosine of the given Ɵ is unfeasible in HDL Digital Logic as it is a floating point variable, a Look-up-Table scheme is implemented in this regard which contains the absolute mod values of the sines and cosines of the various angles ranging from 0˚ to 359˚. Since negative values cannot be implemented in distance measurement hence the mod values are taken into account. The functionality of the proposed algorithm is evaluated using MATLAB software where the velocities of the vehicles and the directions were initialized as constants. Incrementing the distances at each step, over a given range, the possible collision instants were calculated.

Case I:

Considering the 1st case, let the vehicles 1 and 2 have velocities 40m/s and 50m/s and moving in direction specified by angles Ɵ1 = 30˚ and Ɵ2=60˚, then by incrementing the values of 'd' over a range of 1000m, and solving the given equations, it was found that there is a possible point of collision (POC) such that the distances of the vehicles 1 and 2 from the POC along 'X' and 'Y' axis are as given in Table 1.

Table 1. Distances of Vehicles from POC

Vehicle-1	Vehicle-2
d_1x = 433m	d_2x = 313m
d_1y = 250m	d_2y = 542m

Thus after 12.5s there is a possibility of collision between the two vehicles in the present course and a collision avoidance strategy needs to be implemented to avoid the imminent disaster.

After a possible collision is pre-empted from the calculation, the avoidance algorithm is used to avoid the collision. The vehicles are stopped using "Avoid ϴ" and "Brake & Stop" avoidance steps as discussed earlier.

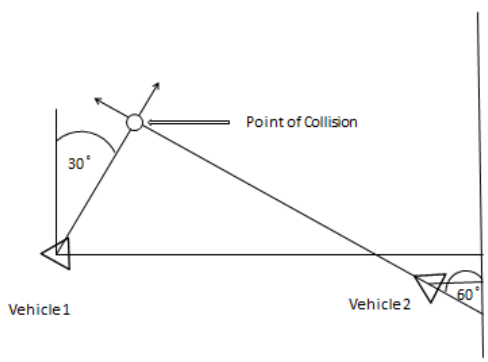

Fig 4: Initial configuration.

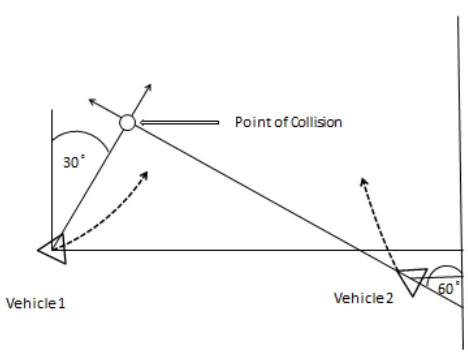

Fig 5: Final configuration after path modification.

Thus using the proposed algorithmic scheme, collision between two test vehicles was successfully pre-empted.

Case II:

In the 2nd case, the vehicles 1 and 2 have velocities 40m/s and 50m/s and moving in direction specified by angles ϴ1 = 15˚ and ϴ2=75˚, then by incrementing the values of d over a range of 1000m, and solving the given equations, it was found that there is NO possible point of collision (POC) in the given range.

Hence, the proposed algorithm effectively calculated collision possibilities

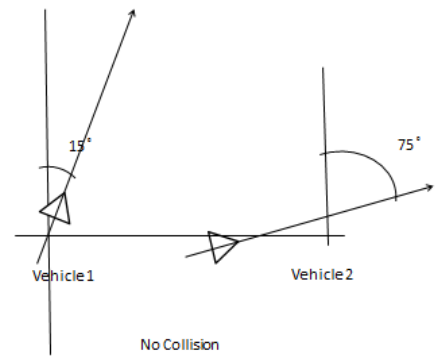

Fig 6: No Collision

4. PERFORMANCE EVALUATION

The proposed algorithm uses simple circuits to calculate the velocity and direction of the cars. The use of complex Doppler Shift Detector algorithm circuits is avoided here for determination of velocity. As the vehicles are continuously transmitting the velocity and direction parameters hence on reception of the information, calculations are done immediately to analyze collision possibilities. Unlike a binary tagging algorithm for collision detection, this is a direct approach towards determining a chance of a collision since at any instance the total no. of tags that are in the workspace are not considered but only with those which are interacting. Moreover in multiple vehicle- multiple tag scenarios, binary tagging algorithm is concerned with all the no of tags involved but the proposed algorithm is not. The no. of major operations required varies from step-8 (worst case) to step-1(best case). The calculation of point of collision is carried out over a range of distance values limited by the range of the RFID reader. Hence it is not necessary to calculate those tags that are possibly out of range. This increases efficiency of the algorithm as well as decreases the run time operation from the other algorithm.

5. CONCLUSION

In the present work an advanced priori algorithm for collision avoidance is developed to avoid collision between the pair of interacting vehicles. RFID technology is used here as it is flexible and convenient to use for automatic operation. It overcomes the complexities posed by other detection schemes. It is sure that the proposed algorithm is more efficient and faster compared to other algorithm and is effective in a multiple tag-multiple vehicle environment where a large no of vehicles are involved.

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