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Intelligent Vehicle System in Undefined Environment

(Recommended by Prof. H. Rao)

This paper discusses the issue of detection of collision of a four-wheel vehicle on road in an undefined environment that is road traffic in small towns and cities. Initially the system is implemented to avoid the border hits of the vehicles during night time because of the inability of driver's visual capacity. This system is extended to find the collision point in an undefined that is unknown environment where the approach of the vehicle is unrestricted. This system directs the driver, based on collision point information. The advisory information helps the driver to avoid collision. This system need not be installed in all the vehicles in the environment. It needs to be installed in the vehicle that requires advisory information to the driver.

Рассмотрена задача распознавания ситуации с четырехколесным транспортным средством на дороге в условиях неопределенности окружающей обстановки, например при прохождении трафика в поселке и городе. Первоначально система использовалась для предотвращения выхода транспортного средства за границы дороги в ночное время вследствие ограниченности визуального обзора для водителя. Система предлагается в качестве источника консультативной информации для водителя транспортного средства.

Keywords: The keywords are: undefined path, collision detection, automatic dipper, collision warning, collision avoidance.

1. Introduction. Intelligent techniques as a part of decision-making can be very effective. Fay [1] has developed a dispatching support system for use in railway operation control systems, which requires expert knowledge in fuzzy rules of the IF-THEN type. The concept «intelligence» seems to be very popular among the transport management systems. In these cases the intelligence usually means systems capability to adapt when surrounding conditions change or its capability to learn from data. Continuously increasing amount of vehicles in road, air and marine transport areas has put the pressure on the research of these problem areas. More economical, more efficient and thus more intelligent methods have to be developed to deal with these challenging problems.

This paper presents a novel technique, which is utilized to identify the mobile vehicle characteristics and used to define the path of the vehicles with the help of system processed collision detection point. The threat severity is also discussed. The basic system is designed and implemented with discrete electronic components with minimal functionality of avoiding the border hits or collisions of the opposite coming vehicles due to the inability of light perception by the driver. This product is tested and verified with good number of autonomous vehicles traveling in non-defined paths.

The concept used in the above basic system is to work with the on-off devices based on the light intensity, which eliminates the manual operation. This method is meant for the non-specific path travel of the four-wheelers during nighttime. The threat probability of different orientations is discussed. The discrete components used are optical sensors, solid-state relays. This product is designed for Indian environment of four wheelers travel to avoid the accidents because of considerable reasons.

The discrete system explains the implementation using discrete components such as transistors. The alternative is the micro controller based system for the same purpose, which is extensively used, in data acquisition and processing, to control the signals acquired from different vehicles in the unknown environment. The data acquisition and processing describes how to collect the data required for calculating the collision point. The data acquisition and processing uses the concept of multiplexing while processing the acquired data and takes the decisions to communicate to the advisory system. The fourth part describes the mathematical model for simulating the environment and finds the parameters of the collision point. In this part three cases are categorized and formulae in respect of each case are derived.

The first and more important, reason for automating the driving process is safety. In 2001, there were approximately 6,393,000 automotive accidents, leading to over 41,000 deaths and more than 3,000,000 injured [2] in US as per department of transportation. The causes of these accidents come from a wide array of backgrounds, but all lead to being error on the part of the driver. If this error has been removed, even in the highway setting, the number of accidents each year would surely decrease. In 1945, Teetor, inspired by the poor driving habits of his lawyer friend, invented cruise control [3]. With the invention of cruise control, the burden of driving was decreased. With a charge as ambiguous as this, the focus in automation has been spread in many different directions. There are those who focus on control strategies in adaptive cruise control [4], whose focus is to slow a vehicle as it approaches a slower-moving vehicle ahead.

Why automate the driving task? One of the major reasons is safety. In 2000, there were approximately 6,394,000 police reported motor vehicle traffic crashes, resulting in 3,189,000 people being injured and 41,821 lives lost [5] in US as per department of transportation. Accidents on our roadways not only cause injuries and fatalities, but they also have a huge economic impact [6]. According to [7], driver distraction was a factor in 11% of fatal crashes and 25—30% of injury and property damage- only crashes in 1999.

Traditionally two basic approaches are being used for path generation of an autonomous mobile vehicle, fixing the total path in a known environment, and instantaneous fixing of path directions depending on situations in an unknown environment [8]. An intelligent vehicle may be defined as a vehicle that senses the environment and produces some automatic action or driver advisory. Vehicle recognition plays an important role in the field of road traffic monitoring and the collision avoidance purpose. The problems are of different types such as vehicle location identification, vehicle behavior identification. Conventional loop detectors and video based systems are found to be quiet inefficient in solving these problems.

Harlow et al [9] have proved that cameras based upon range sensors are not sensitive to lightning and other environmental conditions. Goerick et al [10] have applied neural networks for vehicle detection called car track system in which monocular visual sensor system used, to identify rear frontal views of automobiles and image sequences taken from the viewpoints of a following car. A method for vehicle classification using models and neural networks is based on 3D structured model [11]. Acoustic signature of traveling vehicles can be used for vehicle classification [12]. Pasquerillo et al [13] have proposed the automatic target recognition system for naval traffic control using neural networks. A comprehensive study of road safety (Treat et al 1977) found that human errors were the sole cause in 57% of all accidents. Only 2.4% were due to mechanical fault and 4.7% were caused by environmental factors.

The accidents are occurring due to the following reasons during nighttime. They are identifying the border of the opposite coming vehicle, sleeping of the driver, high intensity of the headlights, which are not operating properly. The discrete system of this paper gives the solution for the first and third reasons. The driver is not interested to use one hand for switch on and off the headlights during the vehicle coming in opposite direction. Because of this reason the driver can’t estimate the border of the vehicle coming in opposite direction and thus collision may occur at their edges in most of the cases. This type of collision can be avoided by using the system, which is presented in this paper explained as discrete system.

2. Discrete system. The discrete form of the collision avoidance system is designed to avoid accidents during night time. This system includes a light-detecting resistor whose resistance varies with light intensity. It will operate for all

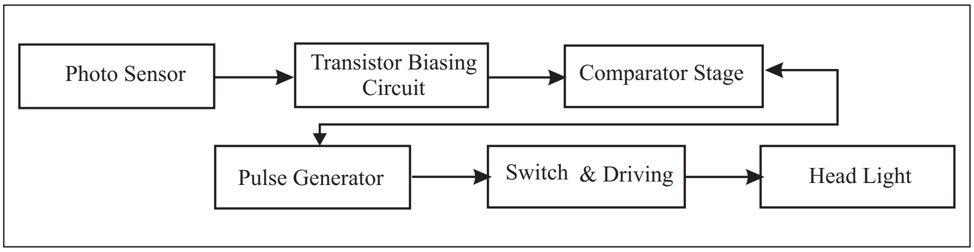

Fig. 1. Automatic head light control system

types of head light intensities. The Light sensor is connected in a bias circuit so that, based on the light the transistor is driven into ON and OFF state, which will drive the headlights. The relay is used between the system and the headlight. Initially mechanical relays are used which require more response time. Later solid state relays are used for better response as well as better rise time. The system is designed for a cycle time of 1 minute.

This system is fabricated and tested on many number of vehicles, which travel on the road during night time for a considerable length of time. The motor vehicle inspector and the owners of the vehicles are satisfied with this experiment. They felt that it is advantage because driver need not put the efforts for on and off the light manually and the synchronization may not be achieved with manual system.

The block diagram of the system described in this part is shown in Fig. 1. The Light sensor converts the physical quantity that is Light into its electrical quantity like resistance. The transistor biasing circuit converts the small variations of the Light sensor output to the desired level by acting as an amplifier in active region. The transistor stage is used for on and off purpose with saturation and cutoff regions. The comparator stage contains two input signals. One signal is obtained from the sensor biasing stage. The second signal is the reference signal, which can be varied with the help of potentiometer adjustment such that the driver will adjust the reference based on his vision capability.

The output of the comparator is thus dependent on the adjustment to the input made by the driver. This stage uses IC741.We design pulse generator stage to our time period and level of signal. The best-suited generator for this stage is A-stable multivibrator. This stage uses IC555. In the normal case the pulse generator is off and the headlights are continuously on. Only when the light intensity of the on coming vehicle is sensed the system starts blinking the head lights. The pulses generated from the pulse generator stage must directly drive the switch to operate the headlight, if not we introduce the driving circuit to drive the switch. The switches are either electromechanical or solid state relays. The later one is preferred in this paper.

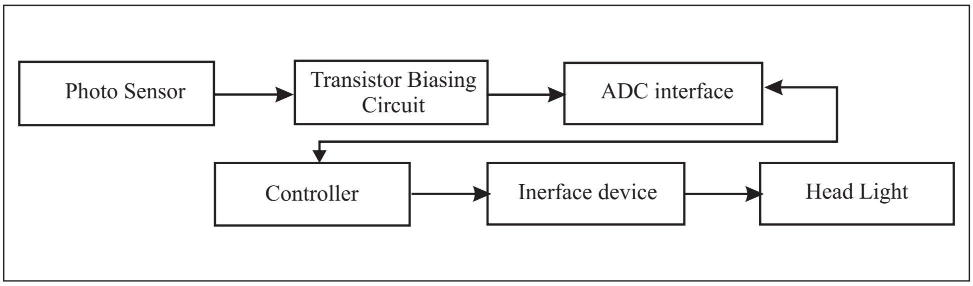

Fig. 2. Automatic head light controller system

3. Micro controller based system. The inventions of the integrated circuit (IC) and later, the microcomputer, have been the major factors in the development of electronic control in automobiles. The system described in discrete system consists of solid-state discrete devices with which it is difficult to process and handle large data. Hence we have developed a technique using the principle of data acquisition to acquire data and process it using a micro controller. In this technique the first two stages of the part1 that is in Fig.1 are same and the later stages are different.

The next stage in this technique is the analog to digital converter (ADC), which converts the analog input into digital output. This output is given to the micro controller with the help of interfacing devices. The driver sets the reference value related to vision capability. The driver or user enters this reference input through programming the micro controller.

The micro controller generates the square wave if the light intensity of the opposite coming vehicle falls on the sensor. The headlights are operating on and off synchronously with the opposite vehicle headlights. At any time only one-vehicle headlights are on if two vehicles travel in opposite direction. This technique is advantageous than the first one. Although the micro controller as used here is not really necessary, it is introduced as an evolutionary step for the third stage. This technique is applied in the data acquisition and processing of the paper, which describes the methodology of collision avoidance for vehicles traveling in undefined path. The block diagram of the second technique described in part 2, is shown in Fig.2. The data acquisition and processing of this paper explains how the vehicle or object is identified, its position, velocity and the expected collision point and collision time.

4. Data acquisition and processing. This part is meant for identifying the moving objects surrounding the moving vehicle on the road. The collision point and time are calculated by the micro controller and communicated properly to the driver by advisory system. As a further step of safety due to non-attention of the driver this system can control the vehicle, which will be doing as a later stage.

The existing systems available in cars are adaptive cruise control, in which the car slows if it detects a slower moving vehicle in front of it, is starting to become available on higher-end models. In addition, some cars come equipped with sensors to determine if an obstacle is near and sounds an audible warning to the driver when it is too close [14]. The availability of this feature costs high. With lateral control technique, the driver would be able to remove his hands from the steering wheel and let the car steer itself. Here, the idea is that the car has some desired path to follow. Sensors on the car must be able to detect the location of the desired path. The error between the desired path and the car is calculated and the microcomputer acting as the controller determines how to turn the steering wheels to follow the correct path. The lateral controller's purpose is to follow the desired path. It does not determine what the desired path is. A higher-level planner is responsible for that task. It only needs to know the car's location with respect to the desired path [14].

This paper describes a common system, which can track the vehicles in unknown environment.

The schematic diagram of this technique is shown in Fig 3. In the first stage the sensors are placed in the four corners of the vehicle in all directions. Those sensors are rotated between +45 and –45 degrees with the help of stepper motor at an appropriate speed. The rotation of four sensors covers all the area surrounding the vehicle. The stepper motors are driven by using a micro controller, which knows the angle of rotation at any instant thus the angle of the moving object, is known surrounding the vehicle in any direction. Based on the delay between emission and collection of rays, the micro controller calculates the distance of the moving object surrounding the vehicle in any direction. Hence with the above two principles we are calculating the distance and angle of the object. By knowing this data the collision point and time are also calculated.

The outputs of the sensors are connected to individual analog to digital converters. The digital outputs are multiplexed and given to the micro controller through interface device. The output of the micro controller is given to the advisory system, which is guiding the driver to avoid collision.

The selection ADC is based on the application and the accuracy required. The micro controller processes these data. The future extension of this project deals with the vehicle control, which includes the technology of mechanical parts and is described in literature [15—19]. The central idea on the decision-making is that the moving objects are recognized as harmful or as harmless. Harmful objects are those, which approach towards vehicle and harmless ones move away from the vehicle. The loci of harmful objects are evaluated in Fig 4. The micro controller uses the level of threat also while finalizing the decision to the advisory system. The threat level the cellular logic rule for fixation of path to

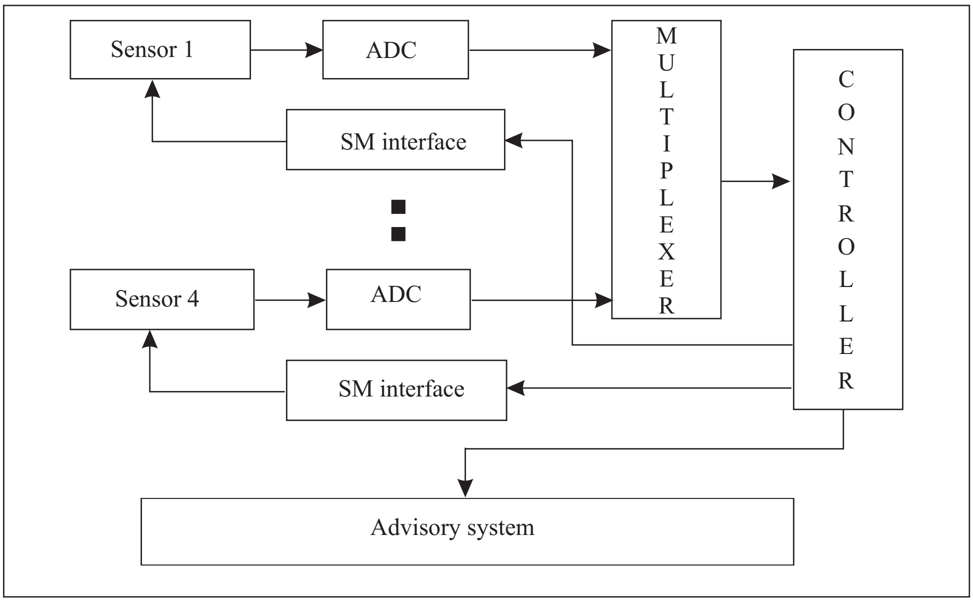

Fig. 3. Block diagram of collision avoidance system in undefined path

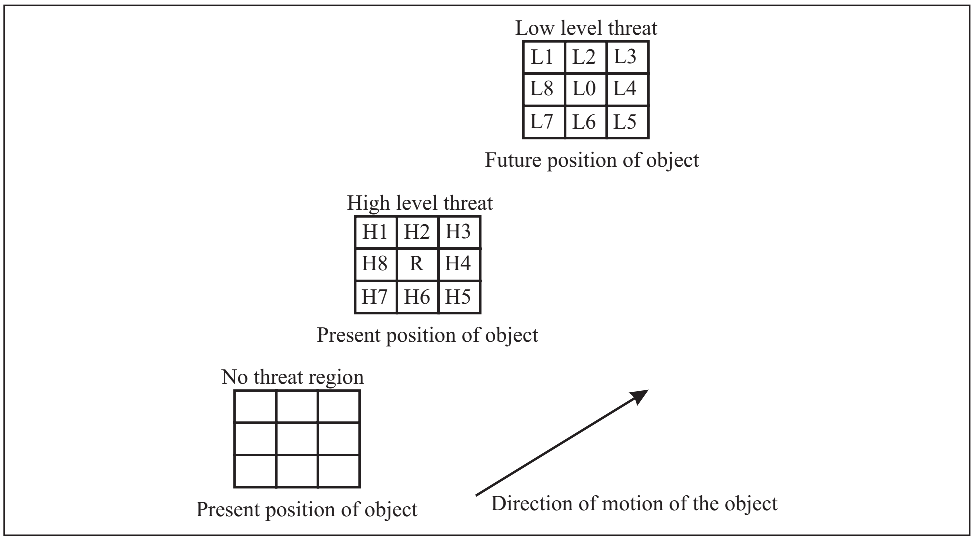

Fig. 4. Threat calculation

avoid the collision is shown in Fig. 3. and explained the rules of threat in next section. In Fig. 3 the position of the object in future and present is shown with reducing the threat rate, that is object is moving from high threat region to low threat region. The intended path of the object is given by $R \rightarrow L0$. Normal speed

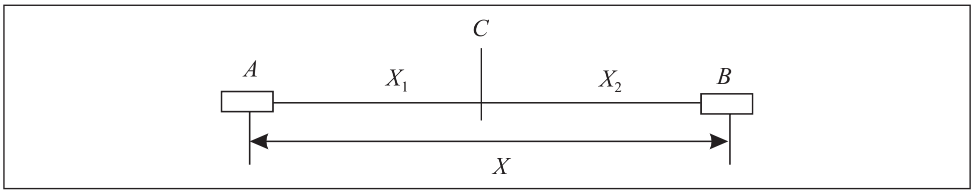

Fig. 5. Vehicles travelling in opposite direction

of object is denoted as S. A path is fixed by the object depending on the positions and speeds of obstacles. At a time instant the object dynamics is determined by the ordered. pair $< S, R \to Lj>$.

There are 8 loci corresponding to less harmful objects approaching the object in directions: $Lj \to R, 1 \le j \le 8$. So $R \to Lj$ is a function of $Lj \to R$, and S is a function of $Hk \to R, 1 \le k \le 8$. Now the cellular logic rule that fixes the instantaneous path is:

$$< S, R \to Lj >= \Phi\,(R \to Lj, 1 \le j \le 8, Hk \to R, 1 \le k \le 8).$$

5. Simulation. This part gives the mathematical model of the system which takes the distance of the vehicle, angle of arrival and the velocity as input and derives the following outputs which are representing the collision point. They are the distances from all vehicles in an unknown environment to the collision point, the angle of collision and the velocities of those vehicles leads to find the first collision span time. In this paper three different cases are considered. The first case is the vehicles are approaching approximately with 0 degrees that is range of –2 to +2 degrees. The second case is the vehicles are approaching approximately with 180 degrees that is range of 178 to 182 degrees. The third case is that vehicles are approaching with other range of values. These cases are described in detail later.

Case 1. This is the case in which the vehicles travelling in opposite direction. Diagrammatic representation is given below. The input values provided by sensors such as

distance of other vehicle from our vehicle (X);

velocity of our vehicle V_1;

angle with which the other vehicle is approaching that is 0 degrees in this case.

The assumption is that vehicle collides at some point which is at a distance X_1, X_2 from two vehicles A and B respectively.

Suppose vehicles collide at point C. And distances from A, B are X_1, X_2 respectively. From above assumptions A and collides after certain time t, with their respective distances. (Fig. 5). For vehicle A ,

$$t = X_1 / V_1 \tag{1}$$

For vehicle *B*,

$$t = X_2 / V_2. \tag{2}$$

From Fig. 5 we have

$$X_2 = X - X_1. \tag{3}$$

Substitute 3 in 2 and by equaling 1 and 2 we get,

$$\frac{X_1}{V_1} = \frac{X - X_1}{V_2},\ X_1 = \frac{X V_1}{V_1 + V_2}. \tag{4}$$

By substituting 4 in 3 we get,

$$X_2 = \frac{X V_2}{V_1 + V_2}. \tag{5}$$

From equations (4) and (5) we have X_1 and X_2 respective distances from vehicles A and B. We have angle as 0°.

Case 2. This is the case when vehicles coming from back side of our vehicle. Diagrammatic representation is given below. The input values provided by sensors such as

distance of other vehicle from our vehicle(X);

velocity of our vehicle V_1;

angle by which other vehicle is approaching, in this case that is 180°.

The assumption is that vehicle collides at some point which is at a distance X_1, X_2 from *A* and *B* respectively. Suppose vehicles collide at point *C*. And distances from *A*, *B* are X_1, X_2 respectively. From above assumptions *A* and *B* collides after certain time *t*, with there respective distances (Fig. 6). For vehicle *A*,

$$t = X_1 / V_1 \tag{6}$$

For vehicle *B* ,

$$t = X_2 / V_2. \tag{7}$$

From Fig. 6 we have

$$X_2 = X + X_1. \tag{8}$$

Substitute (8) in (7) and by equaling (6) and (7) we get,

$$\frac{X_1}{V_1} = \frac{X + X_1}{V_2},\ X_1 = X\left(\frac{V_1}{V_2 - V_1}\right). \tag{9}$$

By substituting (9) in (8) we get,

$$X_2 = X\left(\frac{V_2}{V_2 - V_1}\right). \tag{10}$$

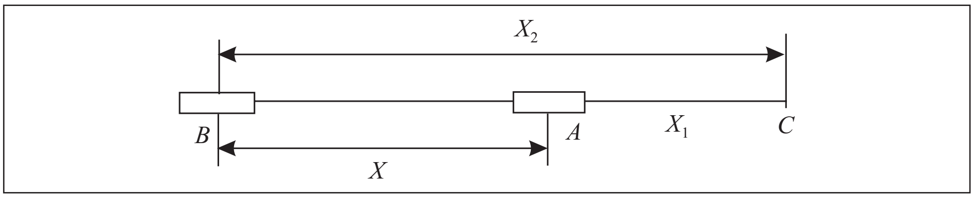

Fig. 6. Vehicles following in the same direction

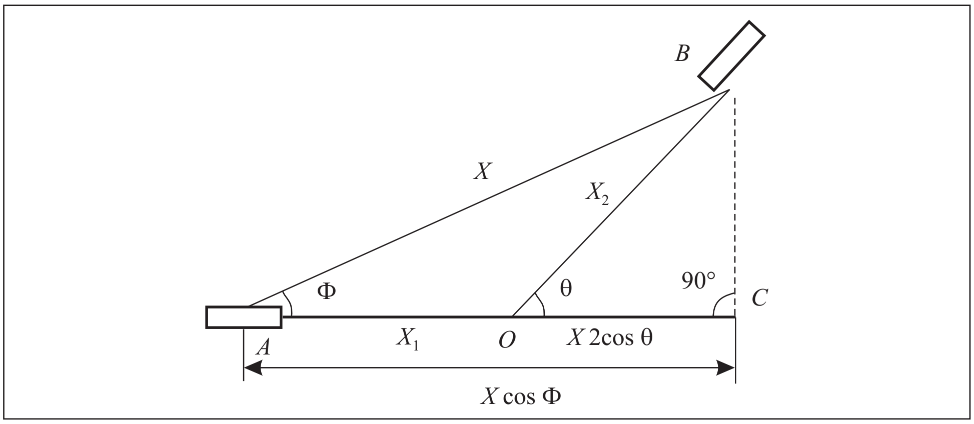

Fig. 7. Vehicles approaching with an angle

Case 3. This is the case that the vehicle coming towards our vehicle, such that it makes some angle with our vehicle. The input values provided by sensors such as

distance of other vehicle from our vehicle (X);
angle made by that vehicle with our vehicle (φ);
velocity of our vehicle V_1.

The assumption is that vehicle collides at some point with an angle at collision point is θ. We derive from below diagram. X_2 is the distance of collision point from the approaching vehicle, X_1 is the distance of collision point from our vehicle that is where system is installed (Fig. 7). For vehicle A, $t = X_1 / V_1$. For vehicle B, $t = X_2 / V_2$. By equalizing both equations of vehicle A and B we have,

$$\frac{X_1}{V_1} = \frac{X_2}{V_2}, \quad X_1 = \frac{V_1}{V_2} X_2 . \tag{11}$$

From base of triangle AOC we have

$$x\cos\varphi = x_1 + x_2 \cos\theta; \; x_2 = \frac{x\cos\varphi - x_1}{\cos\theta}. \tag{12}$$

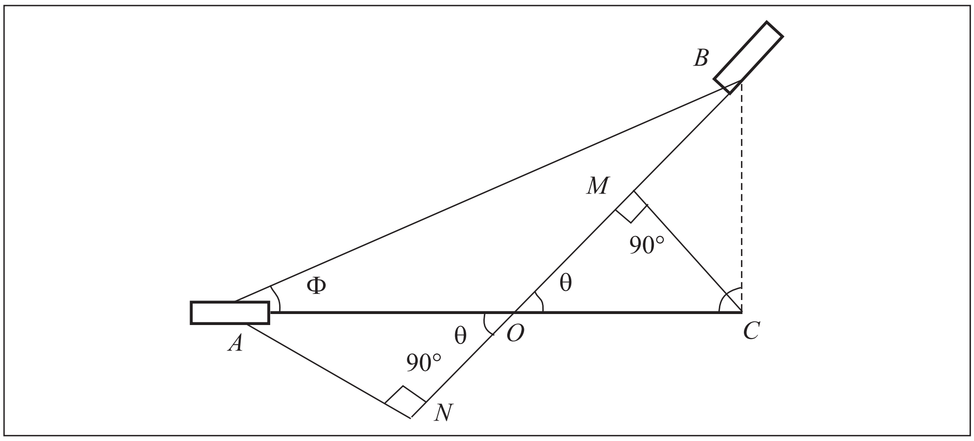

Fig. 8. Calculation of angle of collision

From the triangle *AOB* (Fig. 8). The side x_1 and angle Φ are known, and hence other side x_2 is,

$$x_2^2 = x_1^2 + x^2 - 2x\,x_1 \cos\varphi. \tag{13}$$

From the triangle *ABN* we have

$$AB^2 = BN^2 + AN^2;$$

$$x^2 = (x_2 + x_1 \cos\theta)^2 + (x_1^2 + x_1^2 \cos^2\theta). \tag{14}$$

Thus we are having four equations and four unknowns, by solving these equations we get

$$x_1 = \frac{x\cos\varphi}{2}(3 - \cos\varphi \pm \sqrt{\cos^2\varphi - 6\cos\varphi + 5}). \tag{15}$$

We consider the value of X_1 as Z. By substituting Z value in X_2 we get:

$$x_2 = \sqrt{z^2 + x^2 - 2xz\cos\varphi}. \tag{16}$$

We consider value of X_2 as p. By substituting values of X_1, X_2 in V_2, cos θ we get:

$$V_2 = \frac{V_1}{z}p \tag{17}$$

$$\cos\theta = \frac{x\cos\varphi - z}{p}. \tag{18}$$

From equations (5)—(8) we get x_1, x_2, v_2, cos θ.

6. Algorithms. The algorithms show the procedure how to acquire the data from sensor and processed it. A_1 and A_2 are the minimum and maximum angle with which sensor is rotating. A_1 and A_2 depend on the number of sensors used.

Algorithm 1. To get the distance of vehicles with respect the referenced vehicle and the angle of existence.

```
Start
While( angle=A1 to A2 degrees)
while(Vehicle[I]) // vehicle exists
//angle[I][] is the angles of objects or vehicles found in the
//environment obtained from controller.
//distance[I][] is the distances of objects from the reference
//object in the environment measured in meters.
{
Then angle[I][]=A; //A is the angle at which sensor
identifies
// the vehicle that is stepper motor angle
distance[I][]=x;
}
// vehicle(I) is the condition that vehicle exists in
//environment
swap(A1,A2)
goto start
```

Algorithm 2. To find the elapsed collision time

```
Start
Begin
Number of sensors =n
//I is the sensor number
Begin
while(I<n)
{
If (angle[I][]= -2 to 2degrees)
Then case1
Else if (angle[I][]= 178 to 182) case2
Else case3
}
Multiple x the data of different sensors
Find the collision point and time elapse to collision
End
Find the minimum time of collision among the vehicles
Warn the driver with the time span of collision and direction
Goto start
```

7. Results. The discrete system is monitored with nine vehicles that is college buses for a period of 2 months time and is appreciated by the motor vehicle inspector of local town. The system succeeds to identify the vehicle approaching with 92% rate and the headlights are on and off. The system fails whenever the vehicle approaching with dim light that is low intensity or when the head lights are not functioning properly. Such cases are recognized by the system when they approach nearer. The micro controller based system is tested with 5 vehicles for a period of one month (Tables 1—10). This system succeeds with 96% of the samples taken. This system is not succeeding when in the power supply fluctuations are observed.

The data acquisition and processing of this paper is implemented. The data of distance and the angle of approaching vehicle is collected from one to five vehicles simultaneously during the period of 15 days with the system installed in two college buses. The system succeeds with 78% rate. This system advised the driver regarding hit with voice information of time of collision and angle of collision. The failure is due to the processing speed of data acquisition because of using only two sensors.

Table 1. **Input sample 1**

$X\,(m)$	$V_1(m/s)$	Angle of arrival(rad)
250.5	21.2	1.45
226.3	20.8	1.45
208.6	21.1	1.45
185.3	19.6	1.43
162.8	18.4	1.42
142.7	17.5	1.41
110.5	16.8	1.41
85.2	15.4	1.41

Table 2. **Output sample for input sample 1**

$X_1\,(m)$	$X_2\,(m)$	t (sec)
73.646114	42.532341	3
66.531400	116.305632	3
61.327663	146.099281	2
63.184064	174.625313	3
59.304756	164.681511	3
55.288271	144.544111	3
42.812571	111.928549	2
33.010236	86.301796	2

Table 3. **Input sample 2**

$X\,(m)$	$V_1(m/s)$	Angle of arrival(rad)
240.5	21.2	1.83
216.3	20.8	1.82
208.6	21.1	1.82
185.3	19.6	1.82
162.8	18.4	1.81
142.7	17.5	1.81
110.5	16.8	1.81
85.2	15.4	1.81
50.3	13.2	1.79

Table 4. **Output sample for input sample 2**

$X_1\,(m)$	$X_2\,(m)$	t (sec)
151.934283	108.981650	7
146.525619	125.019998	6
130.159143	161.728167	6
109.668412	173.407036	5
96.128271	151.996710	5
74.437098	117.698768	4
57.394034	90.746901	3
30.992101	53.028294	2
14.081168	26.305893	1

Table 5. **Input sample 3**

$X\,(m)$	$V_1(m/s)$	Angle of arrival(rad)
240.5	21.2	0.12
216.3	20.8	0.12
208.6	21.1	0.12
185.3	19.6	0.12
162.8	18.4	0.12
142.7	17.5	0.12
110.5	16.8	0.12
95.2	15.4	0.12
50.3	13.2	0.12
25.5	10.2	0.12

Table 6. **Output sample for input sample 3**

$X_1\,(m)$	$X_2\,(m)$	t (sec)
239.629020	28.792360	11
215.516661	25.903668	10
207.844547	24.979992	9
184.628929	22.181073	9
162.210413	19.493589	8
142.183206	17.088007	8
110.099820	13.228757	6
94.855229	11.357817	6
50.117837	6.000000	3
25.108737	3.000000	2

Table 7. **Input sample 4**

$X\,(m)$	$V_1(m/s)$	Angle of arrival(rad)
226.3	20.8	1.25
208.6	21.1	1.25
185.3	19.6	1.23
162.8	18.4	1.22
142.7	17.5	1.21
110.5	16.8	1.21
85.2	15.4	1.21
50.3	13.2	1.18
25.2	10.2	1.17

Table 8. **Output sample for input sample 4**

$X_1\,(m)$	$X_2\,(m)$	t (sec)
157.583241	109.462322	7
145.257906	141.534448	6
136.187629	171.822583	6
122.755818	166.844239	6
110.298755	146.342065	6
85.410038	113.318136	5
65.854618	87.372765	4
38.639952	50.418251	2
19.781931	25.238859	1

Table 9. **Input sample 5**

$X\,(m)$	$V_1(m/s)$	Angle of arrival(rad)
240.5	21.2	4.69
216.3	20.8	4.68
208.6	21.1	4.67
185.3	19.6	4.57
162.8	18.4	4.56
95.2	15.4	4.52
50.3	13.2	4.50

Table 10. **Output sample for input sample 5**

$X_1\,(m)$	$X_2\,(m)$	t (sec)
70.708589	172.971096	3
66.575235	166.267856	3
62.266207	146.174553	3
56.428147	114.594939	3
51.337800	99.141313	3
30.008085	52.858301	2
15.757415	26.608269	1

The results of the data acquisition and processing are verified with the results of the mathematical model explained in simulation part. The results are satisfactory that most of the values are matched with success rate of 72%. Three samples are shown below. The number of samples of data acquired is 55 related to different vehicles approaching in different directions. This data involves different angles, distances and the velocities.

7. Conclusions. The results of three samples are given. In an environment the number of samples depends on the number of vehicles. The number of sensors may increase to get better accuracy and decrease the failure rate. The resolution of sensors may be increased if required for an application. The samples of all sensors of one rotation are multiplexed to find the minimum of those elapse collision times with different vehicles in the environment. This system may be developed as rugged system. This will be used as a black box for information gathering if we maintain backup with protection. This facility may be used in other continents also for legal purpose that which vehicle has violate the rule of traffic, where the roads are well developed and the collision rate is low.

The future expansion of this paper may be controlling the vehicle based on the advisory system output. The Control of vehicle involves the mechanical operations like applying break and steering actions with the help of data supplied electronically by the controller. This is required particularly for Indian system to avoid the collisions on the roads because accidents are occurring even though the speed of vehicles is low. The data of this paper will be helpful for guiding the intelligent vehicle on the road in undefined environment. This system need not be installed in other vehicle, which exists in the unknown environment. This is the advantage of this methodology. Those who require safety measures they may use it.

Розглянуто задачу розпізнавання ситуації з чотириколісним транспортним засобом на дорозі в умовах невизначеності навколишнього стану, наприклад при проходженні трафіка у селищі та місті. Спочатку систему використовували для запобігання виходу транспортного засобу за межи дороги вночі внаслідок обмеженості візуального огляду для водія. Систему запропоновано як джерело консультативної інформації для водія транспортного засобу.

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