Intelligent Motion Control for Safe Driving of Automobiles

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ABSTRACT
Presently there has been an exponential rise in the number of fast moving automobiles on the roads. There are therefore, justifying reasons for developing cost-effective, reliable intelligent control systems for the assistance of drivers to ensure safety of the drivers of the automobiles as well as the pedestrians and other vehicles moving on the roads. This paper presents a fuzzy logic based control system, which adequately takes into consideration various uncertainties associated with the road traffic. This control system is extremely easy to implement on microcomputers because it is linguistic and carries out all such operations which are normally done by human beings using robust common sense.

Keywords
Motion Control, Automobiles, Microcomputers

1. INTRODUCTION
Almost every activity of present day world carries a tag "Prosperity with speed". It is therefore not surprising to see rapidly growing number of fast moving vehicles on the roads. This has unfortunately resulted in an embarrassingly large number of accidents on the roads, especially in countries having large population but inadequately planned roads. It stands to reason that our motto should now change to "Prosperity with speed as well as safety". Hence a large number of scholars, especially in countries like China and India are actively engaged in developing cost-effective, reliable intelligent control systems for ensuring safety of the vehicle drivers as well as the pedestrians and other vehicles moving on the roads [1-5].

It may be pointed that the task of developing intelligent motion control is interdisciplinary which demands team efforts of experts from mechanical engineering, control systems, computer science and sensor technology. An attempt has been made to present in this paper microcomputer based fuzzy logic controller for achieving this aim.

2. INTELLIGENT MOTION CONTROL SYSTEM
Fig.1 shows a block diagram representation of an intelligent motion control system for a vehicle. The mode selector provides options for driving the vehicle in either manual mode or alternatively in auto mode. Normally the vehicle is driven in auto mode. In case of an emergency or fault in the microcontroller based controller, the vehicle is driven in manual mode.

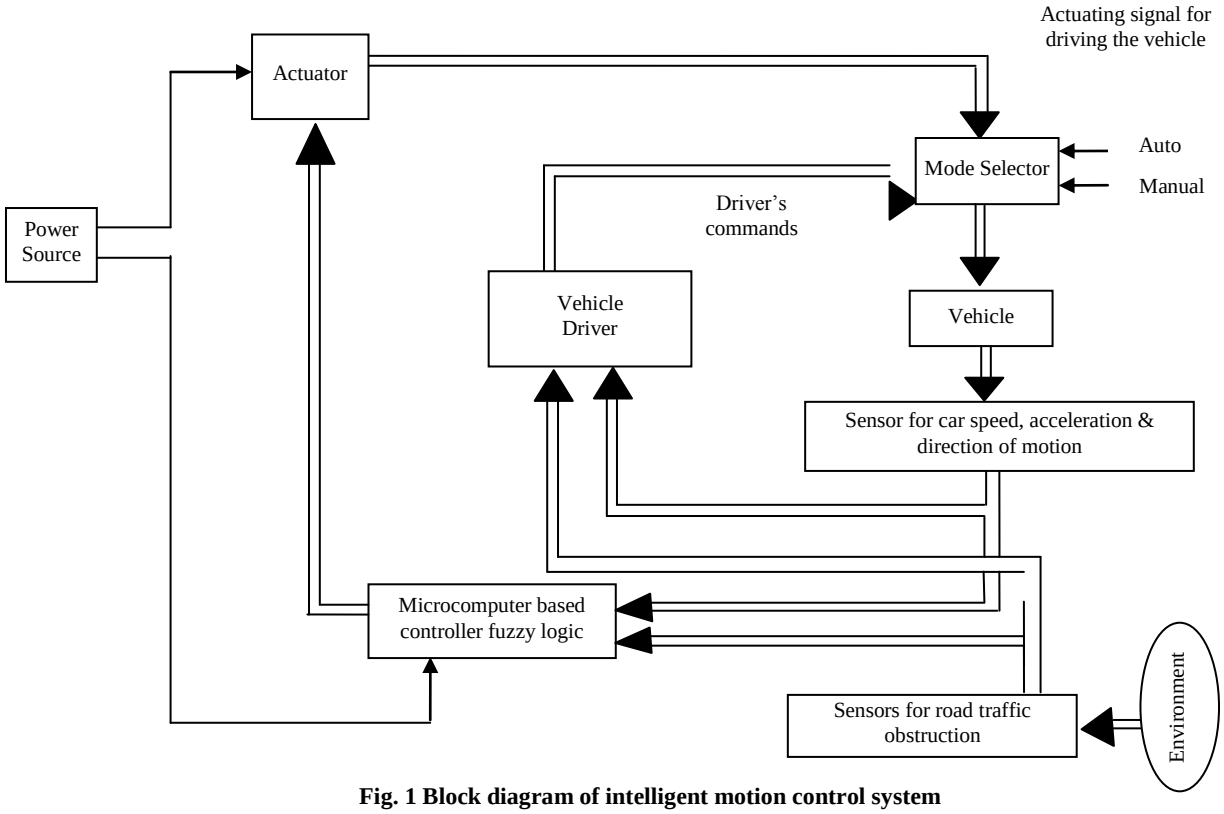
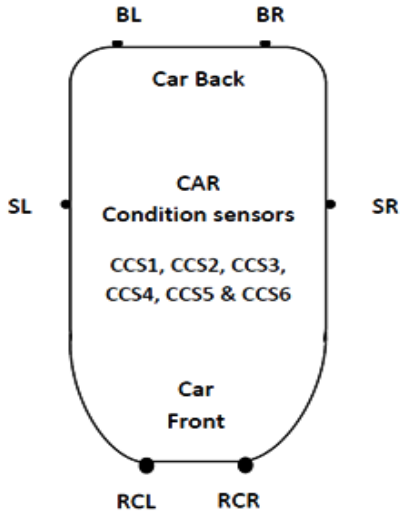


Fig. 1 Block diagram of intelligent motion control system

The vehicle is normally fitted with a set of sensors for indicating the following dynamic states of the vehicle:-

1. Speed of the vehicle
2. Direction of motion
3. Acceleration of the vehicle

Another set of sensors are used for monitoring the environmental conditions viz. pedestrians coming dangerously closer to the vehicle, other vehicles moving erratically for an imminent collision; poor visibility during fog and dust storms and rains, etc. Fig 2 shows positioning of various car condition and environment sensors.



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Car condition Sensors

CCS1 - Car fuel level indicator
CCS2 - Car engine coolant level indicator
CCS3- Battery condition indicator
CCS4 - Tyres pressure indicator
CCS5 - Car doors status indicator
CCS6 - Use of safety belts indicator

Environmental Sensors

CBL- Clearance on the back left side of the car
CBR- Clearance on the back right side of the car
CLS - Clearance on lateral left side of car
CRS- Clearance on lateral right side of car
RCL- Road clearance on the front left side of car
RCR- Road clearance on the front right side of car

Fig. 2 Positions and Functions of car condition and environmental sensors

Before putting the car into use, it is necessary to check various conditions of the car as discussed below.

When all the CCS_i, i= 1, 2, …6, indicate satisfactory results, then and then only shift the gear to neutral position and press the car engine switch CSW to ON position. Since all CCSi switches are connected in series, any fault in the car conditions will not allow the car engine switch to start the car. And if the car happens to be in motion when the fault takes place, it will immediately stop the car engine. This is an important safety measure.

3. DEVELOPMENT OF FUZZY LOGIC BASED CONTROLLER

Now a fuzzy logic based control is described for the following operations:

A: Backward motion of the car
B: Driving the car in forward direction
C: Prognostic actions for avoiding possible accidents

The reasons for the choice of using fuzzy logic based controller are:

- Fuzzy logic is linguistic [6-8]
- It easily takes into consideration the various types of uncertainties associated with road traffic environment such as absence of rigorous precision, incompleteness and partial truth of sensed data with the help of approximate reasoning used for decision making.
- It is easy to implement the fuzzy logic control because it emulates what the people frequently do using robust common sense in their day to day practice.

The format of fuzzy logic rules is:
If (Antecedent)
Then (Consequent)
The antecedents for motion control are:

- CBL
- CBR
- CLS
- CRS
- RCL
- RCR
- Car speed CS (low, medium, high)
  (For details, see fig. 2)

The consequents for the above listed antecedents are:

- Gear setting GS (Neutral, Forward, Reverse)
- Acceleration setting AS (Off, Min, Medium)
- Car engine switch CSW(Off and On)
- Car brakes CB (Normal soft braking, Emergency hard braking)
- Blowing of horn BH(Off and On)
- Blowing of hooter HR (Off and On)

The data required for developing fuzzy logic based rules is:

- Min(CBL)
- Min (CBR)
- Min(CLS)
- Min(CRS)
- Min (RCL),Medium(RCL) and High(RCL)
- Min(RCR),Medium(RCR) and High(RCR)
- Low(CS), Medium(CS) and High(CS)

The above data is decided by taking into consideration the size of car, road traffic conditions and the convenience of the car driver.

A: Backward motion of car
After starting the car

(i)	IF	CBL > Min(CBL), CBR > Min(CBR)
		CLS > Min(CLS)
	and	CRS > Min(CRS)
	THEN	GS is Reverse
		AS is Min
(ii)	IF	CBL ≤ Min(CBL) or CBR ≤ Min (CBR)
	THEN	stop the car

(See C(i) for details)

B: Driving the car in forward direction
After starting the car,

(i) IF RCL > Min(RCL)
RCR > Min(RCR)
THEN GS is Forward
AS is Min

(ii) IF RCL > Medium(RCL)
RCR > Medium(RCR)
CS < Medium(CS)
THEN AS is Medium

(iii) IF CS > High(CS)
THEN AS is Low
CB is Normal soft braking

C: Prognostic actions for avoiding possible accidents

(i) IF RCL < Min(RCL)
RCR < Min(RCR)
THEN AS is Off
CB is Normal Soft Braking
BH is On

(ii) In case, a fast moving vehicle is coming from the opposite direction, then it is necessary to initiate measures, well in time, to avoid a possible head-on collision. The information about the erratic fast moving vehicle can be obtained using ultrasonic proximity sensors.

IF (Erratic vehicle is approaching as detected by ultrasonic proximity sensor)

THEN CSW is Off
CB is Emergency hard braking
HR is On

As soon as the hooter starts making shrieking noise, the driver of the erratic vehicle will feel alarmed and he will be prompted to take measures well in time for avoiding the imminent head-on collision.

4. CONCLUSION

It has been shown in this paper that fuzzy logic based intelligent motion control of vehicles is easy to develop since the use of approximate reasoning obviates the need of high quality precision sensors. While it is true that intelligent vehicles embedded with microcomputer controller will be more costly in comparison to the present day commercially available cars, yet it will prove to be a blessing in disguise. The high cost of intelligent vehicles will put a salutary check on the mushroom growth of accident prone vehicles. The world wide reporting of ever increasing road accidents by multimedia makes an extremely painful reading since all these accidents involve loss of many precious lives together with the destruction of large amount of valuable property.

The intelligent cars will not only be a helpful assistance for physically handicapped drivers, but also make road travel more comfortable and safe for people at large. The world of intelligent vehicles will be a happier place to live and enjoy the fruits of prosperity.

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