Car Crash Prevention Expert System in Urban Traffic Based on Ultrasounds

L. Alonso*, J.P. Oria **,M. Fernández*, C. Rodríguez******

**Universidad de Cantabria, Cantabria, 39005*
ESPAÑA (Tel: +34 942 20 18 64; e-mail: alonso@ teisa.unican.es).
***Universidad de Cantabria, Cantabria, 39005*
ESPAÑA (Tel: +34 942 20 15 41; e-mail: oria@ teisa.unican.es).
****Universidad de Cantabria, Cantabria, 39005*
ESPAÑA (Tel: +34 942 20 18 64; e-mail: monica@ teisa.unican.es).
*****Universidad de Cantabria, Cantabria, 39005*
ESPAÑA (Tel: +34 942 20 18 64; e-mail: cristina@ teisa.unican.es).

Abstract: The system presented is an expert system capable of taking decisions to avoid collisions in urban traffic or to minimize the damages, due to a lack of attention or some other unexpected situation. It is based on the use of simple and inexpensive ultrasonic transducers as sensing elements for the driver support. The rule-based expert system is able to detect a potentially dangerous situation and act accordingly on the brake. Simulations demonstrates the validity of the system to improve the active safety of vehicles.

Keywords: expert system, car dynamics, ultrasound, safety distance, driving-aid systems, artificial intelligence.

1. INTRODUCTION

The use of new technologies to make vehicles safer, cleaner and energetically efficient, helping to reduce the number of traffic accidents and congestion, is an initiative of the European Commission. The commission established in the communication COM (2006) 59 final in the Intelligent Car Initiative: "*The present Communication is an answer to the need of the citizen, the industry and the Member States to solve transport related societal problems and improve Information and Communication Technologies (ICT) take up. The Communication presents the Intelligent Car Initiative as a policy framework for actions in this area*".

In this work a system based on ultrasonic sensors is used to develop a new intelligent expert system capable of preventing collisions or minimizing the damage caused in urban traffic. The overall system is formed by three subsystems. The first one corresponds to the ultrasonic transducer, used to obtain information about the distance and relative velocity of the vehicle in front. The second subsystem is the intelligent system, in this case an expert one has been chosen, which decides the braking necessary to avoid collision. Finally, the third subsystem controls the brake action and consists of a pump that transmits controlled pressure to the hydraulic circuit of the vehicle.

The legal maximum speed in urban traffic conditions, is 50 Km/h, which is the maximum velocity considered in this work. The Highway Code rules cannot be used, when driving in urban traffic to maintain the safety distance among vehicles, because circulation would become unviable. Shorter distances based on experience, are more logical and habitual on the city traffic.

In the case of sudden braking, the safety distance d is given by the expression shown in (1).

$$d = vt_r + \frac{v^2}{2}\left(\frac{1}{a_r} - \frac{1}{a_f}\right) \qquad (1)$$

where the safety distance d is the separation which must be maintained from the vehicle in front to avoid collision, v is the velocity at which the two cars are driving, a_r and a_f are the braking decelerations of the vehicle behind and the vehicle in front, and t_r is the reaction time, which is the time the driver takes to apply the brakes. For instance, for vehicles driving at 50 Km/h, with the same braking capacity and estimating a typical reaction time of 1.5 seconds, the safety distance would be 20 m., which would be unacceptable in urban traffic. If the vehicle in front were stopped ($a_f = \infty$), the safety distance would depend as the square of the velocity.

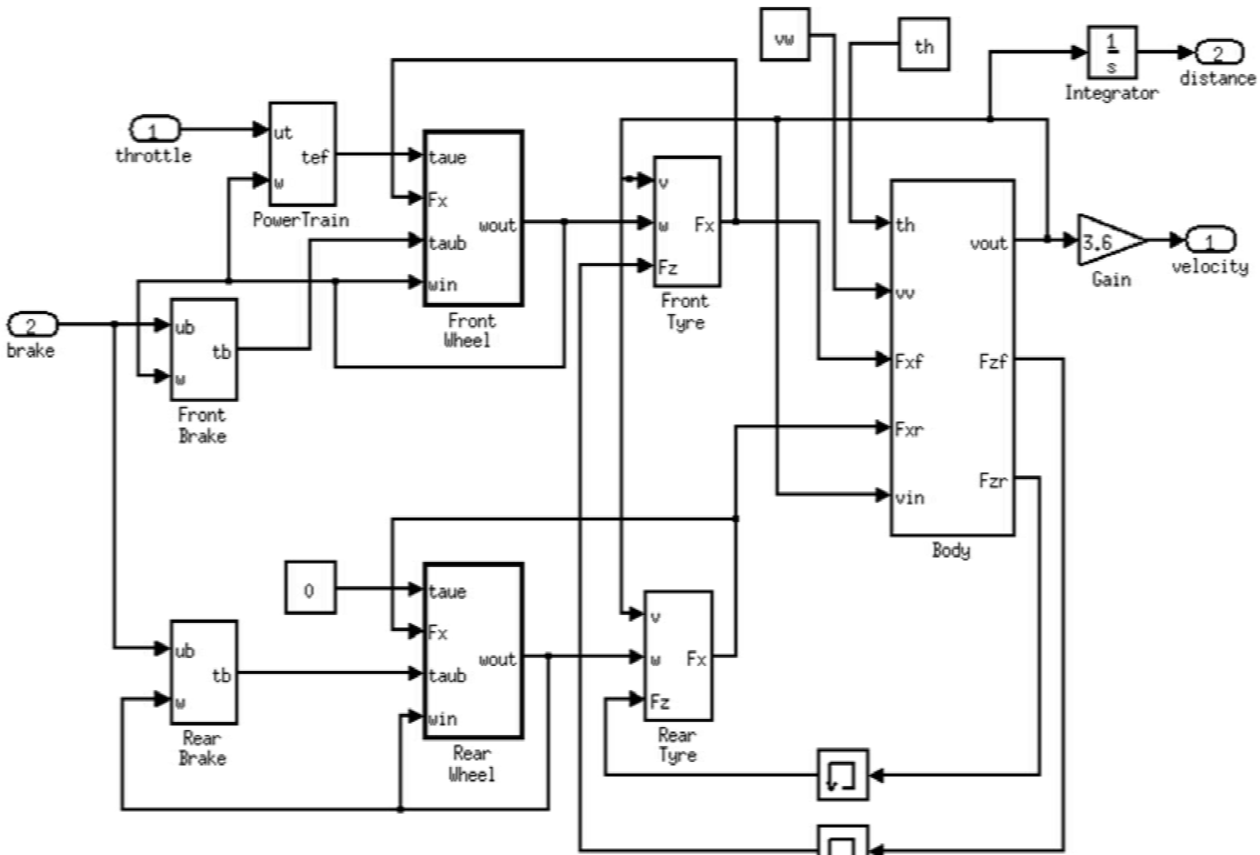

Fig.1. Block Diagram of the vehicle model used

The system developed considerably reduces the safety distance between vehicles when driving in conditions of normal urban traffic. The dependence on road conditions has not been taken into account in this work

2. DYNAMIC MODEL

Under conditions of low velocity, corresponding to urban traffic, it was necessary to develop a vehicle model to study its dynamic behaviour. A description of the model used can be seen in [4], considering only the longitudinal dynamics. A model considering all transversal and longitudinal forces can be found at [1]. Figure 1 shows the block diagram used for simulation of the model.

The input and output signals in the model car are:

- *throttle*: position of the accelerator pedal (between 0% and 100%)
- *brake*: position of the brake pedal (between 0% and 100%)
- *vw*: velocity of the wind. In the case of urban traffic, this parameter has been considered zero because with low velocities it has a very little influence.
- *th*: inclination of the road. In our case, this parameter is also considered zero to simplify the model. It is important to notice that the braking distances depend on the street slope.
- *velocity*: linear velocity of the automobile (in Km/h)
- *distance*: distance covered by the automobile (in m)

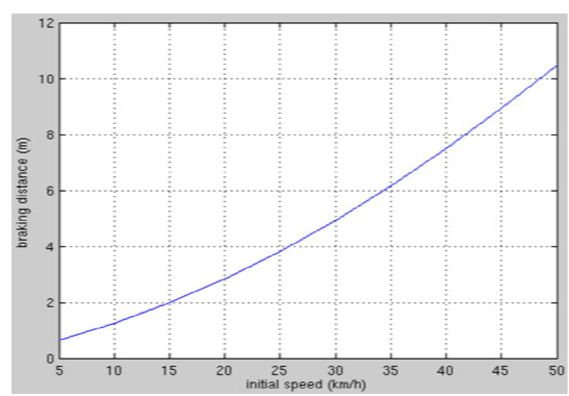

Fig.2. Braking distance depending on the velocity of the vehicle

The blocks making up the model are:

- *Powertrain*: providing the traction torque applied to the front wheels obtained from the position of the accelerator pedal and the rotational velocity of the wheels. It includes the behaviour of the 5-speed