The Future of Automobiles: Cognitive Cars

S. A. Gadsden [1], *S. R. Habibi* [2]

[1] McMaster University, gadsdesa@mcmaster.ca
[2] McMaster University, habibi@mcmaster.ca

1. Introduction

The cognitive car can be regarded as the future form of urban vehicles. Cognitive car implies intelligence not in an isolated form that involves just internal functionality, but also in the context of group that would include neighbouring vehicles and an intelligent transportation system (ITS). The cognitive car would adjust itself for optimum operation (in terms of safety, fuel, traffic, and emissions) by monitoring itself as well as other cars in its vicinity and traffic conditions. Central to the cognitive car are communication, intelligence, information, and sensing.

2. About Cognition

In the engineering sense, a system may be termed cognitive if it has memory, has the ability to sense and learn from the environment, can communicate with its environment, can benefit from the collective intelligence in its environment, is able to adapt over a period of time, and has feedback. The human brain (and body) is one of the best examples of a cognitive system. It has the capability to store information at a high rate of speed, is able to sense (via eyes, ears, and nerves), can learn and predict outcomes from situations found within the environment, can operate in a social environment benefiting from collective intelligence, is able to adapt over a period of time (different neural synapses can be formed, or chemical balances can change based on a required output), and it is constantly performing closed-loop feedback and data processing of information obtained from the environment.

3. Cognitive Cars

The article entitled *The "Cognitive Car": A roadmap for research issues in the automotive sector* [1] discusses some future developments of autonomous cars within the next 15 years. Since the numbers of cars on the road are continuously increasing, the risk of accidents also increases [1]. To reduce this risk, it is proposed to add more intelligence into vehicles, ultimately making them cognitive vehicles.

Three main research areas mentioned in [1] include: cognitive process of vehicle guidance, complete system traffic, cognitive driving assistance. The first research focus involves the "identification of the drivers' cognitive process (necessary cognitive tasks and competencies) that can be transferred to technological system components" [1]. The second focus includes the creation and implantation of intelligent interfaces for the interaction between the driver, vehicle, and environment. The final research area looks at enabling the car to provide 'suggestions' to the driver based on the identification and diagnosis of the driving situation [1]. Ultimately, the goal would be to create an autonomous driving network that enables society to have accident-free roads.

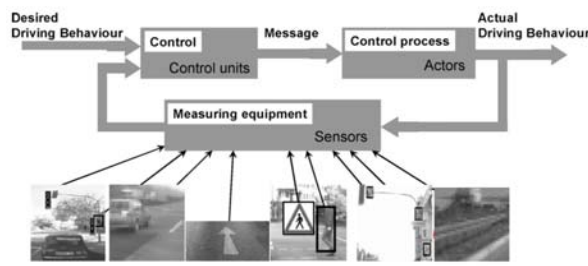

Fig. 1: Control circuit for driving assistant systems [1].

An interesting example of a cognitive car system involves the control circuit for driver assistance systems. Figure 1 illustrates this example quite well. The input to the system would be the desired driving behaviour (from the driver), and feedback from the sensors studying the environment (traffic signals, other vehicles, pedestrians, signs, and road lines/conditions). These values are fed into the control units which would send a message to the control process. At this point, a specific action would be generated based on the driving situation and environment. This is a classic example of a cognitive system for vehicles.

Another good use of cognitive systems is in the management of energy in hybrid vehicles. The need for cognitive systems is increasingly felt in the automotive sector due to the recent market entry of hybrid cars that are considered to be more complex in terms of power management. The history of hybrid vehicles is surprisingly long, and delves into topics covering politics, the environment, business, and technology. In short, a hybrid vehicle is commonly referred to as a vehicle that uses a combination of an internal combustion engine (ICE) and an electric motor and generator powered by gasoline, rechargeable batteries, and a regenerative braking system [2].

It is important to note that there are two basic types of hybrid electric vehicles: series (SHEV) and parallel (PHEV). In the series hybrid, "the electric motor provides all the propulsion power, while the [internal combustion engine] serves only to increase the energy, power, or both available to the motor" [3]. The parallel hybrid design uses both the internal combustion engine and the electric motor to deliver propulsion power to the wheels [3]. Modeling a hybrid system can be a challenging task. Most hybrid vehicles are inherently cognitive and intelligent, since they contain: memory, decision-making processes, feedback, control, robustness, and their fuel efficiency may be governed by driving patterns.

The paper entitled *Energy-Management System for a Hybrid Electric Vehicle* [4] discusses a new system for balancing the energy load and minimizing the energy requirements in hybrid vehicles using ultracapacitors and neural networks. The proposed control system measures and stores a variety of parameters: primary-source voltage, car speed, instantaneous currents in both terminals, and actual voltage of the ultracapacitor. It is interesting to note that with their new design they increased the vehicle range around 5.3% [4]. However, with the addition of neural networks for optimal control, the range was increased to 8.9% [4]. Other methods have been used to optimize the power and energy requirements of hybrid vehicles. These include: fuzzy logic [5], genetic algorithms [6], and intelligent mechanism designs [7].

An interesting use of cognitive systems involves regenerative braking and also assistance braking. The paper entitled *Human Behaviour Based Predictive Brake Assistance* presents a "predictive braking assistance system that identifies not only the need for braking action, but also whether or not a braking action is being planned by the driver" [8]. The system identified in the paper uses a Bayesian framework to identify the criticality of each situation [8]. This is accomplished by assessing two probabilities: whether braking should be made given observations of the vehicle and environment, and whether the driver will apply brakes in this situation [8]. Four types of data are observed from the environment: wheel speed, acceleration, brake pressure, and accelerator position [8]. These measurements are used, in conjunction with a driver point-of-view camera, to predict driver behaviour and ultimately provide a novel method of braking assistance.

3. Conclusions

The motivation for hybrid vehicles is quite simple. Rising energy costs, contributed mainly due to peak oil, and the recent green movement are the main motivators for this research. Peak oil, which is also known as Hubbert's peak, refers to "the maximum rate of the production of oil in any area under consideration, recognizing that it is a finite natural resource, subject to depletion" [9]. The green movement refers to the reawakening of environmental issues, such as global warming, which has shown to be caused by a dramatic increase in CO2 emissions [10]. Currently, the main resources that are used by hybrid vehicles include: an ICE, gasoline, electric motor (or generator), batteries, and a braking system. It appears that car companies are working towards all electric or hydrogen vehicles, in which case cognition should be applied to properly allocate its corresponding resources.

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