Soft Computing Technologies in Intelligent Vehicle Control & Information Systems

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Outline

This presentation discusses some of the research aspects and trends in designing driver aware intelligent automotive vehicle systems. The focus is on the progress of soft computing technologies and applications as a major enabler for introducing intelligent features and behaviors in vehicle control systems, improving the interaction between the driver and the vehicle, and vehicle personalization. The paper summarizes the long term theoretical research and practical experience of the speaker in the area of soft computing technologies and some of the major contributions of the group "Modern Control Methods & Computational Intelligence" he leads at Ford Research.

Traditional mass produced vehicles target a hypothetical nominal driver that represents a significant group of customers. Generally, vehicle systems are designed to be robust with respect to any major deviations in the behavior of that hypothetical driver. Vehicle systems are not generally considered to adapt to the driver style and preferences; the driver is expected to accept and adjust to the features, functions, attributes, and assumed performance characteristics that are offered by the OEMs. It is the responsibility of the driver to learn the vehicle and to try to maximize its utility. The increased level of electronics, software, computational and communication power of current vehicles enables a different approach in which the vehicle transforms from a hardware appliance to a flexible system that can better tune and adapt to the driver's wants. Therefore, we can observe the first signs of a possible trend in the opposite direction, towards creating vehicles that are capable to sense and estimate driver's style, desires and intentions and adjust accordingly.

In the following we review some of the research directions and original results related to designing intelligent vehicle systems.

Real Time Evolving Modeling. The evolving paradigm is based on the concept of evolving (expanding or shrinking) model structure which is capable of adjusting to the changes in the objects that cannot solely be represented by parameter adaptation. An evolving system continuously collects new data and attempts to update with this data the existing models. The evolving model develops its structure and parameters continuously adapting it to the data and creating an open multiple model representation. The concept of evolving systems is applied when a complex activity, e.g. driver's, are to be decomposed, learned, and analytically described by a set of simpler prototypical behaviors. These behaviors are further used for prediction of driver's actions and intentions, and decision making between different alternatives. Another area of application relates to the problem of real time learning of nonlinear mappings characterizing complex relationships between measures variables, e.g. sideslip angle, road friction coefficient, fuel consumption prediction under variable conditions, etc., by their decomposition, and simpler model approximation around the current operating point.

Generalized Markov Models for On-Board Prediction & Optimization . The generalized Markov chain – a probabilistic model that synergistically combines the idea of transition probabilities with the information granulation paradigm – is introduced as tool for on-board stochastic modeling. We consider generalized Markov chains based on two different types of information granules – intervals and fuzzy subsets – and the algorithms for their learning from data. This approach is motivated by and intended for in-vehicle modeling traffic and road, long term and short term characterization of driver's preferences, recursive estimation of frequent stop locations and destinations, etc.

Real Time Intelligent Control Algorithms for Automotive Applications. Several algorithms from the family of intelligent control techniques (combination of adaptive control, real-time time possibilistic / probabilistic decision making, and reinforcement learning) addressing the problem of fuel economy, performance, and active safety in modern vehicles are reviewed.