Estimation of Motorcar Engine Fuel Consumption Rate using Adaptive Neural Fuzzy Influence System (ANFIS)

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ABSTRACT
Correct estimation of the engine output torque as a basic principle for control and optimization of efficiency of other components in the power transmission of passenger cars are concerned. The purpose of this paper is to provide an Adaptive neural fuzzy model to estimate fuel consumption rate of motorcar engine. Because of the effects of different parameters it is a complex process to analyze engine performance by mathematical equations. So, by designing an intelligent model, verbal fuzzy function based on empirical data obtained by neural system have been used. Then accuracy of presented neural fuzzy model have been compared with obtained results of experimental engine SI95 that their comparison confirms correct performance of neural fuzzy model.

KEYWORD
Engine modeling, adaptive neural fuzzy influence system, fuel consumption, passenger car.

INTRODUCTION
Today many researchers have been performed to provide models for investigating motorcar engine performance but since engine behavior is depended on many parameters, to achieve a precise and perfect mathematical model has been always impossible [2-4]. If we could achieve an optimal combination of these parameters, indeed an appropriate engine model would be provided. so that, purpose of this paper is to provide a model that could estimate effect of different parameters exactly [3]. As for lack of achievement to precise and comprehensive mathematical models, new effects have been performed for modeling in form of neural network and fuzzy systems [5]. By these methods because of high capability of intelligent systems, a proper estimation of engine behavior quality has been provided [6]. In this paper, by designing an adaptive neural fuzzy system (ANFIS), verbal fuzzy functions that based on empirical data obtained by neural network have been used. Because of neural system introduction capability and deduction of fuzzy systems, this model is able to estimate nonlinear complex systems behavior appropriately, more exactly and in less time than existing intelligent systems and therefore it provides a precise trustable model in defined interval [1].

1. POWER GENERATION SYSTEM MODELING
A) mathematical model

First, power generation system is modeled based on vehicle performance and empirical data inform of mathematical equations.

Generation torque model:
\[ T_e = (\text{throttle}).T_{\text{max}} \cdot \omega_e + (1 - \text{throttle}).T_{\text{min}} \cdot \omega_e \] (1)

There \( T_e \) is torque engine value, \( \text{throttle} \) is gas throttle opening amount. \( \omega_e \) is revolution, \( T_{\text{min}} \) and \( T_{\text{max}} \) are also engine torque values in no-gas condition and gas throttle maximum opening respectively.

Fuel consumption model (Dsf coefficient):

Fuel consumption model is expressed in form of \( D_{\text{sf}} \) criterion that is appropriate for investigating fuel consumption rate condition.

\[ D_{\text{sf}} = \frac{B_{\text{sf}}(T_e \omega_e)}{3600v} \] (2)

Where \( D_{\text{sf}} \) is consumed fuel amount to cover a distance equal to 1km and \( B_{\text{sf}} \) criterion is required fuel for supplying 1kw of energy for 1 hour (gr/kw.hr)
B) neural fuzzy model

Empirical results of an experimental engine (SI95) have been used to design neural fuzzy models. Provided model has two inputs and one output. Revolution and engine output torque are its inputs and fuel consumption rate is as model output. The network designed to instruct model has two hidden layers and its structure has been shown in figure 1, also a part of experimental engine (SI95) empirical data which has been used in neural fuzzy system is provided in table 1.

In this model Gaussian membership functions have been applied and 20 series of data have been used for it’s instruction (120 inputs totally) and 12 series of data for network test. For instruction this system requires many rules, so fuzzy rules have been clustered by using sub clustering method and optimum number of rules have been applied for instruction.

Engine revolution and output torque are inputs of this model and engine fuel consumption value is its output. Some parts of empirical data presented in table 1.

CONCLUSION

As you can see in table 2, for examining engine fuel consumption estimation capability of designed model, a set of experimental data has been used to investigate conditions of neural fuzzy system performance quite randomly.

Moreover, as for figure 2, very low error rate of estimated values comparing with empirical data confirms appropriate performance accuracy of suggested model.

Obtained results show that because of having capabilities of both neural and fuzzy systems and also adjustability, adaptive neural fuzzy model is able to provide a much more precise model rather than existing intelligent systems. So it is not only a quite proper alternative for mathematical complex models, but also is more exact and simpler than other models. It is note that neural fuzzy model provides suitable estimation of engine generated torque even in the area out of empirical data and it shows high capability of this model designed by ANFTS.
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**REFERENCES**


