The Decision Algorithm for Driving Intension Using Moduled Neural Network

Joon-Young Kang[1], Seong-Joo Kim[1], Jae-Yong Seo[2], and Hong-Tae Jeon[1]
[1] School of Electrical and Electronics Engineering, College of Engineering Chung-Ang Univ.
221 Heuk-Suk Dong, Dong-Jak Gu, Seoul, 156-756, Korea
Tel.: +82-2-820-5297, Fax.: +82-2-817-5508
[2] School of Information and Technology Engineering, Korea university of Technology and Education.
307 Ga-Jun Ri, Byung-Chun Myun, Cheon-An, Chung-Nam, 330-708, Korea
Tel.: +82-41-560-1318
e-mail : bodysoul@orgio.net

Abstract: Automatic Transmission System(ATS) was designed to replace the human's manual operation of the gear box. So far, this system operates with the fixed shift pattern information. In this paper, new algorithm considering driver's operation tendency is proposed. Also, to get rid of the uselessly frequent shift of the ATS, the conditions and the status of the vehicle would be included for the evaluation in making a decision of shifting. A field test is done in a car equipped with the computer set connected to Transmission Control Units(TCU) to check the status of the test car, and it shows the excellency of the proposed algorithm.

1. Introduction

Vehicles became part of our life. Automatic shift change system has been used to lessen the manual operations of the driver. This system uses the expert's shift pattern for the automatic shift. However, this fixed shift pattern does not always match with other drivers' driving tendency and the frequent shifting in down-hill driving is useless (or causes complaints of the drivers). This paper proposes an algorithm considering the tendency of the driver and the conditions of the vehicle. This algorithm will be compared with the ATS with fixed shift pattern by the simulation and show the proposed algorithm has an excellency over fixed shift pattern method.

2. The Basic Theory of Neural Network

After the research of probability such that the principle from the neuron model can be connected with each others was proposed in the early 1940 by McCulloch and Pitts [1], there are various researchs ;*on the adaptation theory of neuron system in 1949 by Hebb* [1], *perceptron, various nonlinear dynamic system based on biological, psychological evidence, parallel processing and so on.* Nowadays, neural networks become the powerful tool in dealing with the following;

(1) Nonlinearity
(2) Parallel distributed processing
(3) Learning and Adaptivity
(4) Multi-variable system
(5) Fault tolerance

2.1 The Feed-forward Network

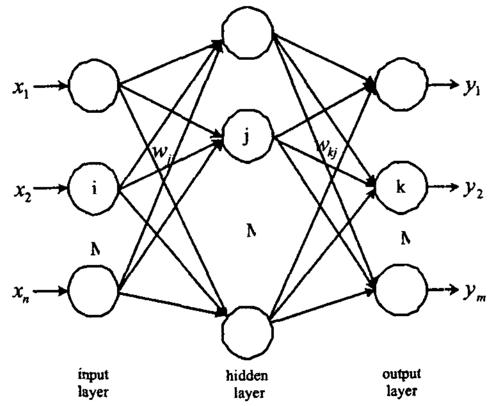


Figure 1. The Structure of Multi-layer Neural Network

$$v_k(n) = \sum_{j=0} w_{kj}(n) y_j(n) \tag{1}$$

$$y_k(n) = f(v_k(n)) \tag{2}$$

where $f(\cdot)$ is activation function, $v_k(n)$ is an input of activation function, and $y_k(n)$ is the output of k-th neuron.

2.2 The Back-propagation Algorithm

This algorithm is based on the error-correction learning rule. The actual response of the network is subtracted from a desired response to produce an error signal. The error signal is then propagated backward through the network, against the direction of synaptic connections. The synaptic weights are adjusted to make the actual response of the network move closer to the desired response in a statistical sense.

$$E = \frac{1}{2}\sum_k (d_k - y_k)^2 \tag{3}$$

where d_k, y_k are the desired output and an actual output respectively.
The weight are updated by steepest descent method.

$$\Delta w_{kj} = -\eta \cdot \frac{\partial E}{\partial w_{kj}} = -\eta \cdot \frac{\partial E}{\partial v_{kj}} \cdot y_j$$

$$= \eta \cdot \delta_k \cdot y_j \quad (4)$$

$$\delta_k = (d_k - y_k) f'(v_k) \quad (5)$$

where

$$f'(v_k) = \frac{\partial f(v_k)}{\partial v_k} \quad (6)$$

where η is learning rate, δ_k is an error that passes to backwards. The weight update equation for hidden layer is as follows.

$$\Delta w_{ji} = -\eta \cdot \frac{\partial E}{\partial w_{ji}} = \eta \cdot \delta_j \cdot y_i \quad (7)$$

$$\delta_k = f'(v_k) \cdot \sum_k (\delta_k w_{kj}) \quad (8)$$

Lastly, weights are updated as follow.

$$w_{kj}(t+1) = w_{kj}(t) + \Delta w_{kj} \quad (9)$$

$$w_{ji}(t+1) = w_{ji}(t) + \Delta w_{ji} \quad (10)$$

If the update algorithm is repeated, connection weights are changed so that each neuron's output error could be decreased. This update is repeated until the response is within the desired boundary.

3. The decision Algorithm for driving intension

Figure 2 shows the basic block diagram of the proposed algorithm.

Each modules consist of several sub-neural networks. Each network was learned offline to make a decision in a given environment.

The moduled network has merits in specializing its modules to each function of the shift system and in considering other types of vehicle. Each module can be learned separately and makes new control system when it is put together.

In this paper, 3 modules for dynamic operation, safety operation and decision of driver's tendency of acceleration are set to consider safety as well as the improvement of the system.

In the first block of the figure 2, the tendency of a driver, whether he prefer dynamic driving(Ma1) or safety(Ma2) is evaluated. The second block which has output Mm make a evaluation about the driver's tendency of acceleration. And the vehecle's load as well as Ma1, Ma2 and Mm are all considered to make a decision about the shifting.

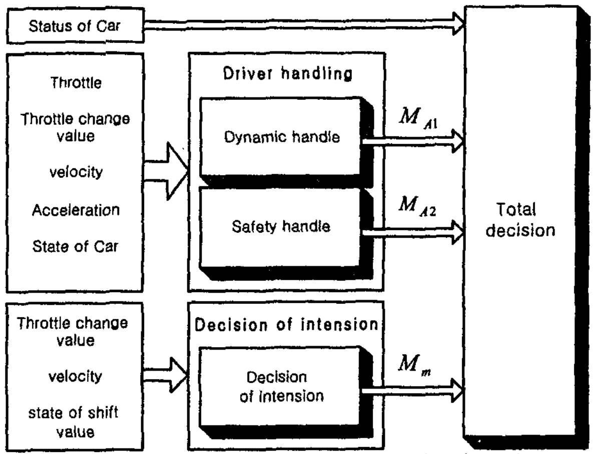


Figure 2. Decision Block Diagram use driver intension

3.1 Driver Manufacturing State Decision

To evaluate the driver's tendency, the acceleration and deceleration are considered. This block consists of 2 modules. The one is to evaluate the dynamic tendency of a driver and it has 4 inputs : throttle, variation of the throttle, velocity and acceleration of the mobile. If a large amount of deceleration is followed by a large amount of acceleration, this block evaluate the driver has dynamic tendency. The other is for safety module. This module evaluate the degree of safety of a driver with the same inputs as the first module.

3.2 Acceleration Intension Decision Module

While driving, if the driver wants to accel fastly he operates the accel pedal and the TMS changes the shift according to the shift map. In this case, the driver wants to speed up but the shift goes to upper range, so the vehicle couldn't provide the enough driving power to speed up because of the fixed shift map. It means the change of the shift with fixed shift map may cause a complain of driver.

To overcome this problem, we design a sub-neural network to learn the driver's intensity and decide the suitable shift range to the driver. Namely, this sub-neural network can learn the driver's intensity and decide a suitable driving power to the driver who wants to speed up fastly.

This sub-neural network uses the variables of throttle, ingear state and velocity of vehicle as inputs, and finally outputs the level of intension for acceleration.

3.3 Driver Manufacturing Will Composition Decision Module

In this paper, we calculate the load of vehicle (Lve) with equation 11. The Lve means the ratio of acceleration torque and maximum torque.

Lve is determined as follows:

$$Lve = \frac{TE_{ACC}}{TE_{MAX} - TE + TE_{ACC}} \quad (11)$$

where, TE_{ACC} is acceleration torque , TE is engine torque and TE_{MAX} is maximum engine torque.

More specific, the equation 11 means that Lve is the ratio of current torque being used for current acceleration to the maximum torque being able to used for current acceleration. The change rate of shift map is determined by the prior outputs of sub-neural networks, Ma1, Ma2, Mm and rate of change in the Lve.

The figure 3 shows the standard fixed shift map and enable maximum shift map in the range of 2nd and 3rd shift.

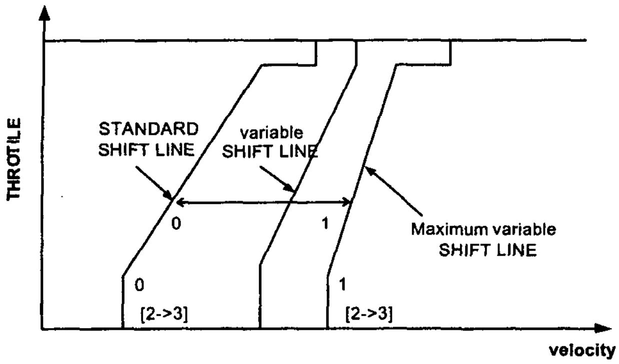
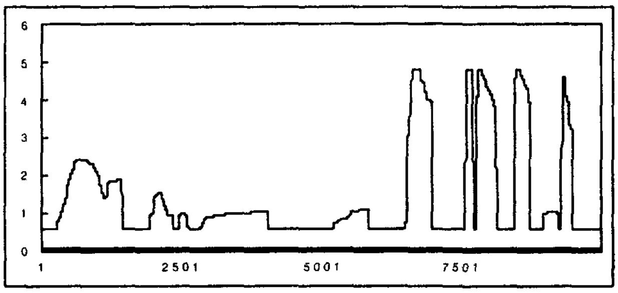


Figure 3. An Example of Changed Shift Line

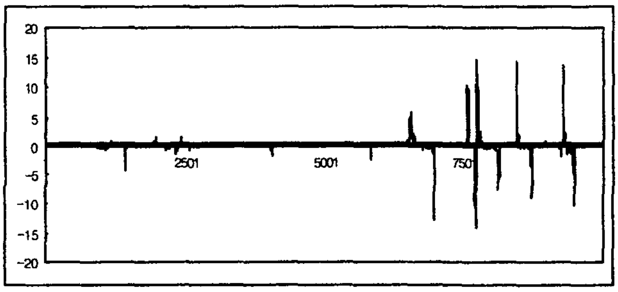
The change rate of shift map could be set from 0 to 1. In this case, the position of standard shift map is set to 0 and maximum changeable shift map is set to 1. In the proposed ATS, the value for change of the shift map is learned to determine 0.3 for 2nd-3rd shift map and 0.5 for 3rd-4th shift map, respectively.

4. Simulation Result

Figure 4 shows result that use modular neural network and apply driver's intension.



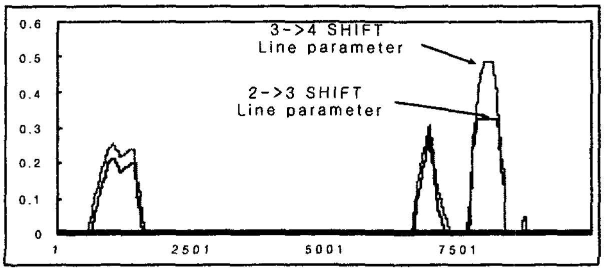
(a) Throttle



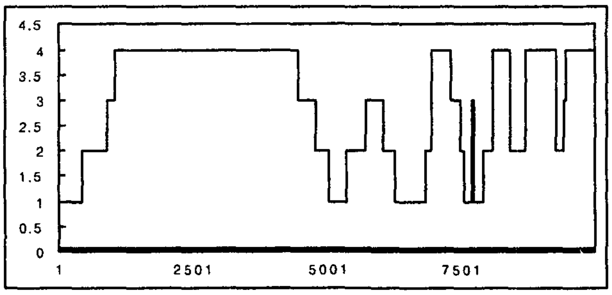
(b) Change amount of throttle

(c) Velocity

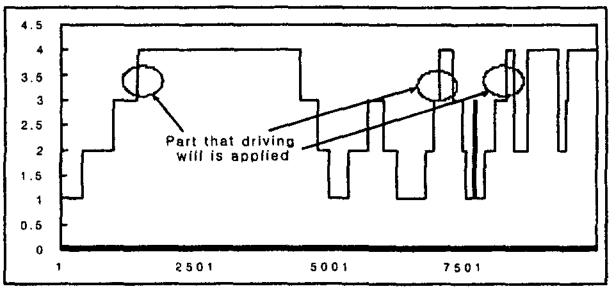
(d) Acceleration



(e) Shift line parameter



(f) The result with regular ATS



(g) The result with proposed ATS

Figure4. Test result and priority data

If see this data, throttle manufacturing can analyze that happened often. Figure 4. (e) shows the result for regular transmission system, and (f) shows the result for proposed transmission system.
There is part that secure drive force as sbwing down change of shift timing. When change amount of throttle is frequent and surprise, Shift-line moved, and engine force was defined by the result.

5. Conclusions and Future Work

In this paper, new ATS system considering driver's operation tendency is proposed. To simplify and reduce the size of the neural network, moduled neural network was used. Each module was optimized for the special purpose of evaluating the driver's operat ion tendency and the status of the test car. Considering the operation tendency and the conditions of the car, the proposed ATS determines the coefficient which change the shift-line of the shift map. In this method, arbitrary shifting pattern generated by the ATS enhances the efficiency of the shifting system.
The moduled network, because of its module property, can be adjusted partly and applied to the variety of system.
A field test was done in a car equipped with the computer set which is connected to Transmission Control Unit(TCU) to check the status of the test car. The result of the test shows that the proposed ATS acquire sufficient engine force in case sudden throttle operation and the sudden increasement of the velocity was given.
For the further work, a field test with much more information of the human behavior should be done to apply this system to vehicles.

Acknowledgements : This research was supported by Korea Ministry of Science and Technology under the Brain Science Research Program.

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