線形予測分析と自己想起型ニューラルネットワークによるドライバ個性のモデリング

Driver-dependent model by linear prediction analysis and auto-associative neural network

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Abstract: This paper presents a new method for modeling driver operation behavior. The proposed method is based on using the predictor coefficients as feature vectors extracted from driving operation signal by linear prediction analysis (LPA). The distribution of the feature vectors is captured by employing auto associative neural networks (AANN) model. The performance of the model was evaluated through driver identification process and the results obtained demonstrate that the model can grasp the individual characteristics of the driver.

Introduction

Objective:
To provide primary solution for traffic accidents by detection of abnormal behavior from ordinary driving signal
- literature study reported that abnormal driving is one of the major factor causing accident [1]
- abnormal behavior mean that the behavior of the driver has deviated from the expected standard of performance

Research strategies:
Driver-dependent model (using driver behavior signal)
Future behavior prediction
Analysis of driving behavior

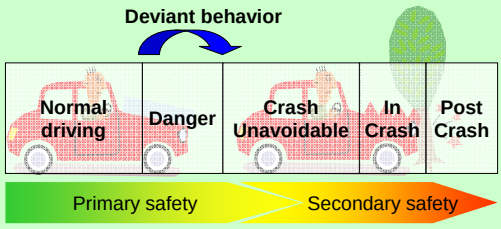


Fig.1 Five phases in driving for vehicle safety analysis

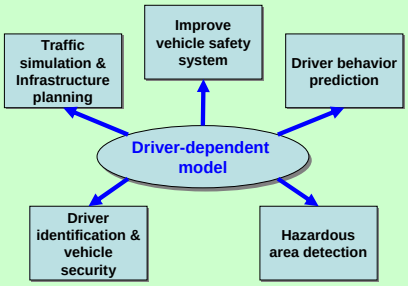


Fig.2 Driver model can serve for many driver-vehicle related application.

Methods

LPA of driver operation behavior

- Output of driver operation signal is modeled and predicted from linear combination of its past values as show in (1):

$$\hat{g}(n) = \sum_{k=1}^{p} a_k g[n-k] \qquad ...(1)$$

- Predictor coefficients, a_k are obtained by minimizing total square error, E by setting:

$$\frac{\partial E}{\partial a_i} = 0, \qquad 1 \le i \le p \qquad ...(2)$$

$$where: E = \sum_n e_n^{\,2} = \sum_n \left(g[n] - \sum_{k=1}^{p} a_k g[n-k] \right)^2 \qquad ...(3)$$

Levinson-Durbin recursion method [2]

- Optimal model order, p is determined based on Final Prediction Error (FPE) value as in (4):

$$FPE = \frac{N+(p+1)}{N-(p+1)} \hat{\sigma}^2 \qquad ...(4)$$

Autoassociative neural network model

- *Associative properties* among feature vectors are captured by employing AANN model.
- number of input and output layers are same.

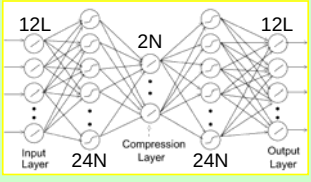


Fig. 3 The structure of AANN

Results

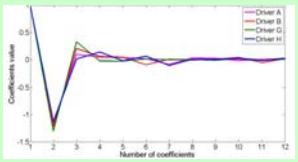


Fig. 4 Predictor coefficients of 4 different drivers

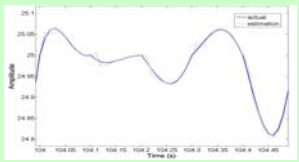
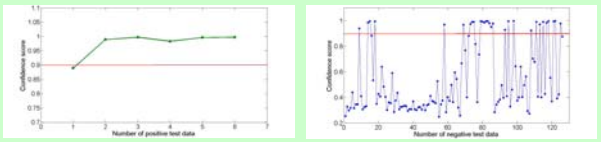


Fig. 5 Actual and estimated gas pedal signal



(a) (b)

Fig. 6 Confidence score of driver A for (a) positive test data and (b) negative test data

Table 1 Summary of driver model performance

	Positive test data		Negative test data		Accuracy (%)
Drv	True Positive (TP)	False Negative (FN)	False Positive (FP)	True Negative (TN)	(TP+TN) (P+N)
A	5	1	29	97	77.27
B	5	1	19	107	84.85
C	6	0	20	106	84.85
D	3	1	36	92	71.97
E	5	1	22	106	82.84
F	6	0	12	114	90.91
G	5	1	23	105	82.09
H	5	1	15	113	88.06
I	4	2	23	105	81.34
J	4	2	36	92	71.64
K	5	1	22	106	82.84
Average Identification Rate					81.70

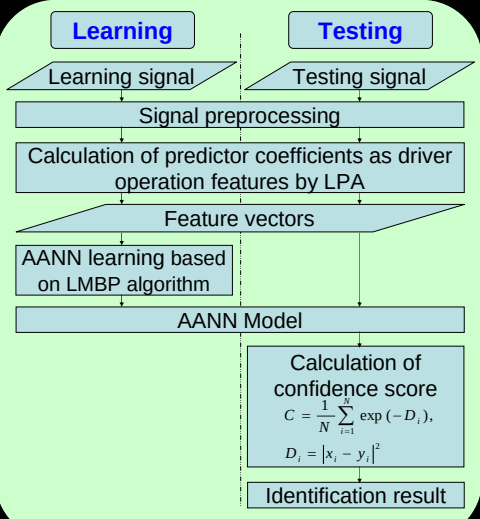


Fig. 7 Flow chart of driver identification system

Conclusions

- LPA provides a good approximation of driver operation signal and reduce a number of raw data into p order features vector.
- AANN can capture and learn well the distribution of features vector of the driver.
- This is prove by having high confidence score for data from same driver and low confidence score for different drivers.
- The average performance of driver model using the proposed method is 81.70%.

References

[1] Aronsson B., "ACEA primary safety model", Prepared by ACEA's Task Force on Active Safety, Brussel, 2003. [2] Makhoul, J., "Linear Pred iction: A tutorial Review", Proceedings of IEEE, 63(4), pp.561-580, 1975.

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For further information

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