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Efficient normalization for quantitative evaluation of the driving behavior using a gated auto-encoder

Key words: Driving behavior; Normalization; Gated auto-encoder; Quantitative evaluation

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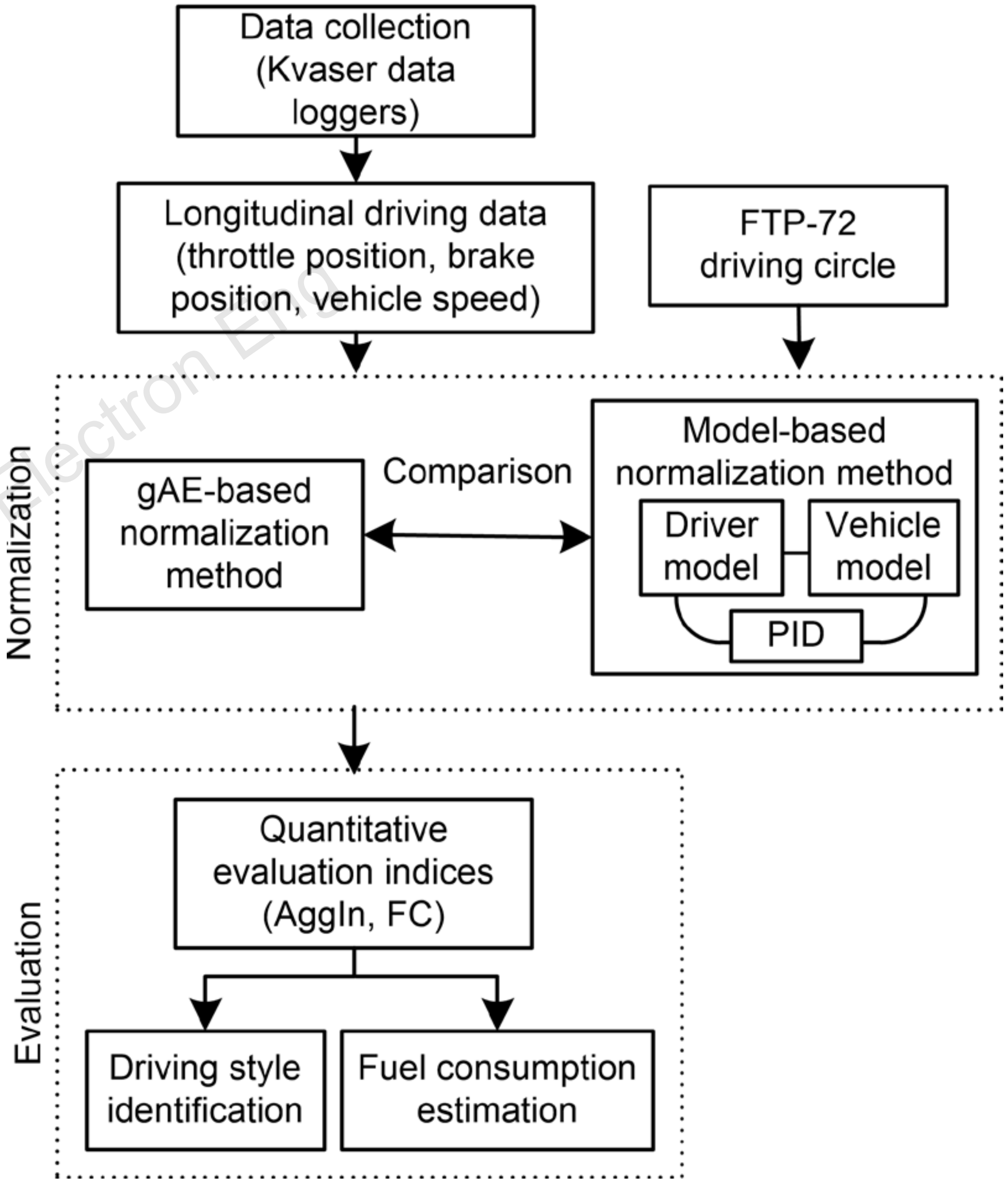
Global progress

- Human driving behavior is a hot topic in the research field of intelligent transportation system worldwide

Date	Event
2022.2	A project titled “Telematics and Improvement of Driving Behavior” was started.
2021.1	NHTSA studied behaviors and attitudes in highway safety, focusing on drivers, passengers, pedestrians, and motorcyclists.
2019	The Transportation Research Board (TRB) launched the “Behavioral Traffic Safety Cooperative Research Program.”
2011.10	The Federal Highway Administration researched the agent-based modeling of driver behavior based on naturalistic data through an integrated framework for safety and operation analysis.

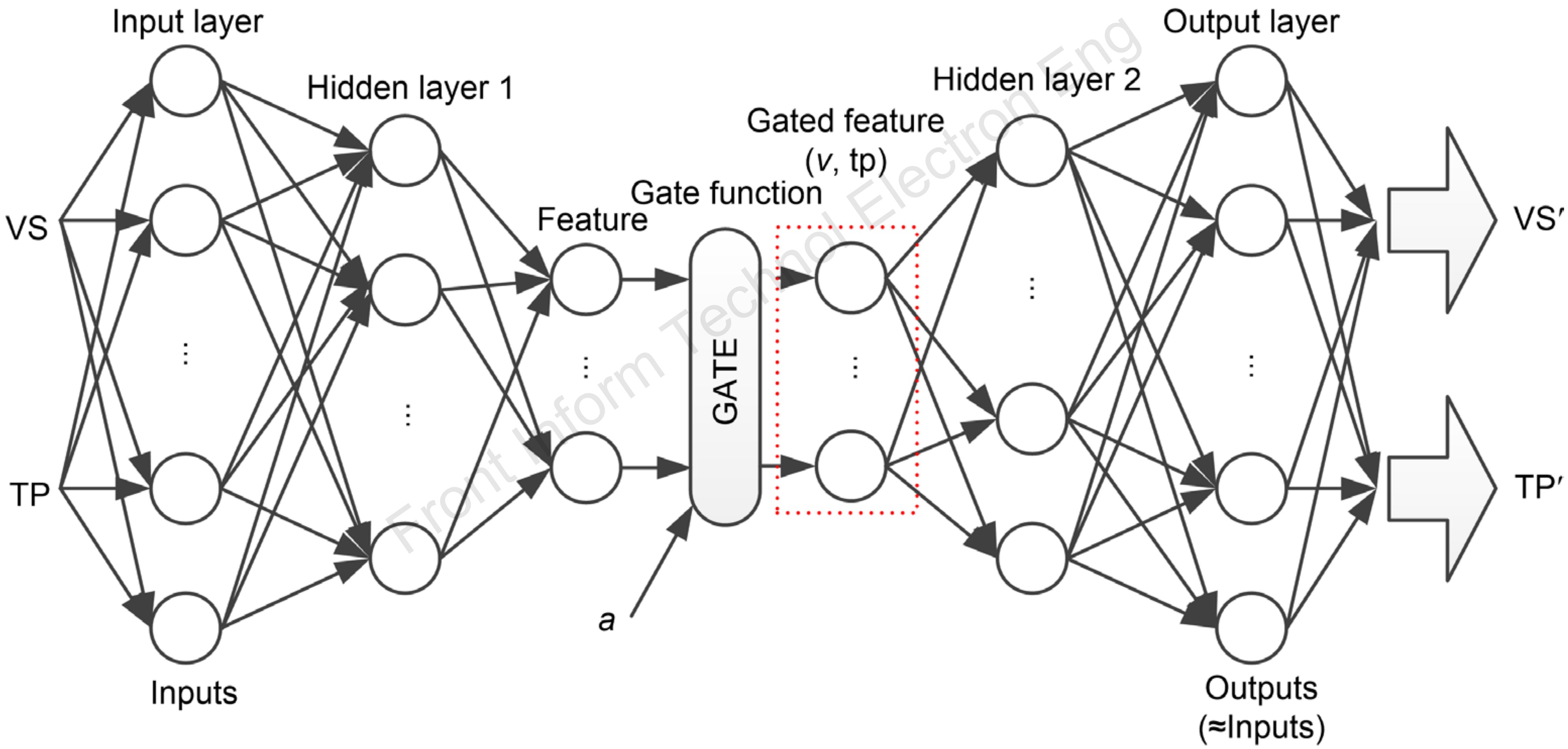
Motivation

- Quantitative evaluation of the human driving behavior is an important research topic in both the automobile industry and intelligent transportation.
- The normalization of the driving behavior is vital, since vehicle data is usually collected under different road conditions, providing an unequal basis for comparison.
- The model-based normalization method is complicated and time-consuming because of the need to establish the driver/vehicle model and to conduct the virtual driving cycle test.



Method

- Basic structure of the gated auto-encoder (gAE)



Method

- The gate function is defined as

$$\begin{cases} \text{gate}(x) = \begin{cases} x, & x = \text{VS}, \\ \text{ReLU}(a) \otimes \text{ReLU}(x), & x = \text{TP}, \end{cases} \\ \text{ReLU}(y) = \begin{cases} 0, & y < 0, \\ y, & y \geq 0, \end{cases} \end{cases}$$

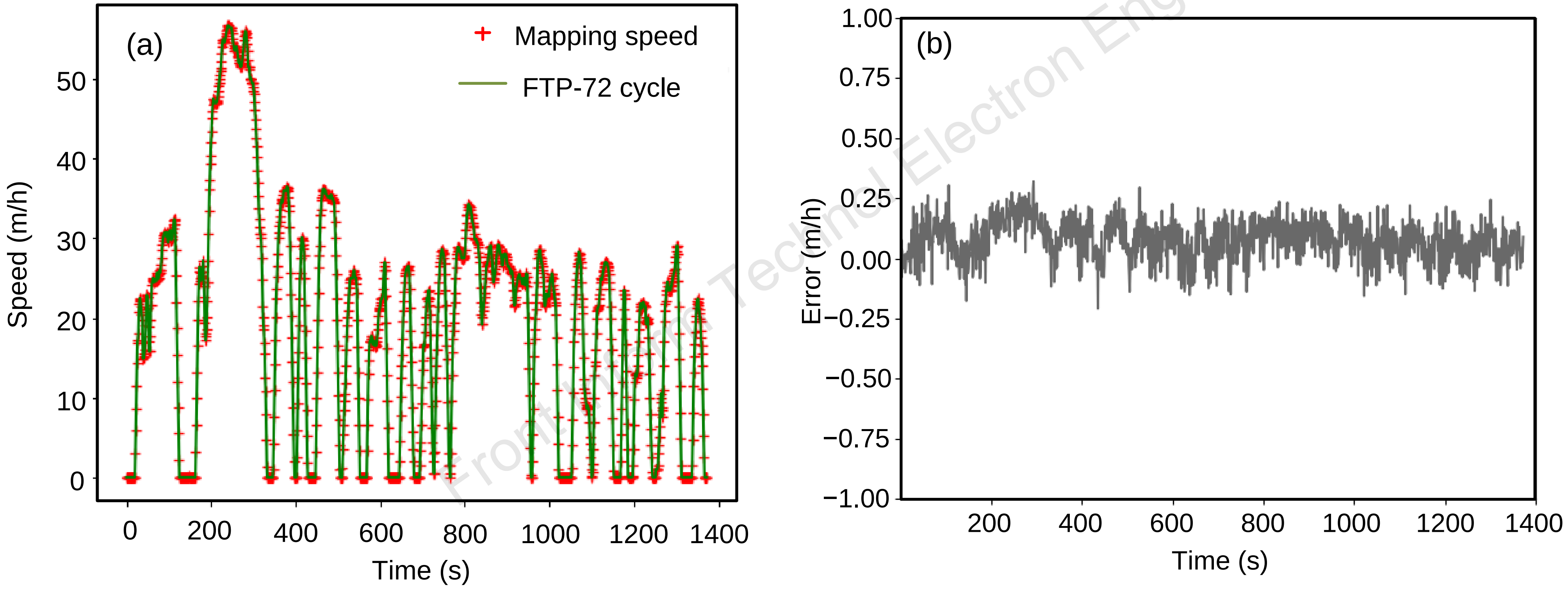
- The loss function is defined as

$$\text{Loss} = \alpha \frac{1}{N} \sum_{n=1}^{n} (\text{VS}_n - \text{VS}'_n)^2 + \beta \frac{1}{N} \sum_{n=1}^{n} (\text{TP}_n - \text{TP}'_n)^2 + \gamma \frac{1}{N} \sum_{n=1}^{n} (v - V_\text{F})^2,$$

where VS and TP are the original driving behaviors, VS′ and TP′ are the reconstructed driving behaviors, and V_F denotes FTP-72.

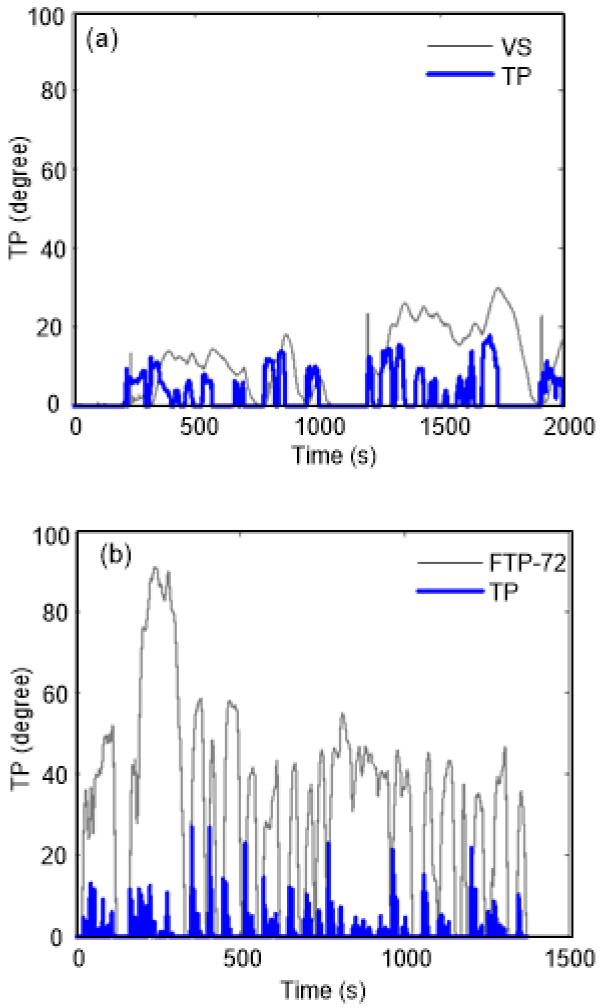
Major results

- Quantitative evaluation of the human driving behavior is an important in both the automobile industry and intelligent transportation

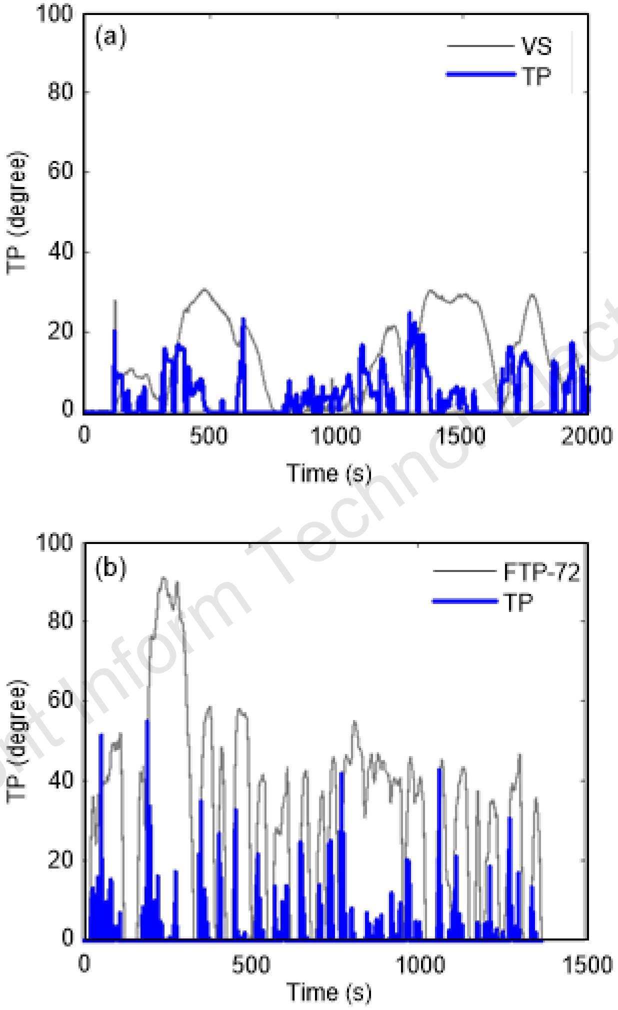


Normalization of Aggr1: (a) mapping speed and FTP-72; (b) error between the mapping speed and FTP-72

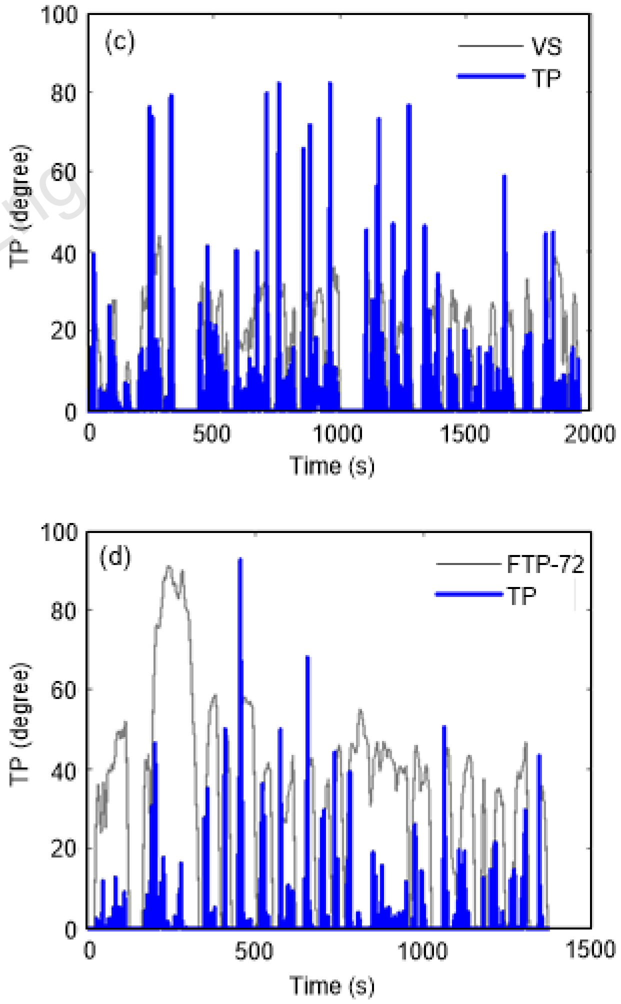
Major results



(a) Mild style



(b) Moderate style



(c) Aggressive style

Conclusions

- Normalized driving behavior was applied to quantitative evaluation tasks, i.e., driving style classification using an aggressiveness index and fuel consumption comparison using a fuel consumption index.
- Results showed that the proposed scheme is consistent with the model-based approach and easier and more efficient for driving behavior normalization.
- In the driving style classification task, the normalized driving behavior based on the proposed method obtained at least 95% accuracy and outperformed the other methods.
- The proposed approach is valuable for driving behavior analysis.