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Joint Deep Neural Network Modelling and Statistical Analysis on Characterizing Driving Behaviors

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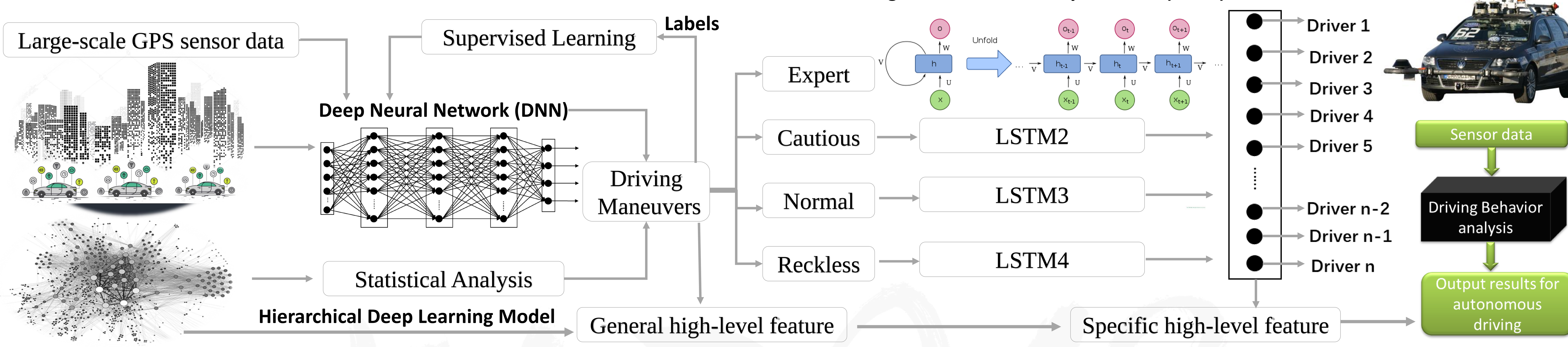
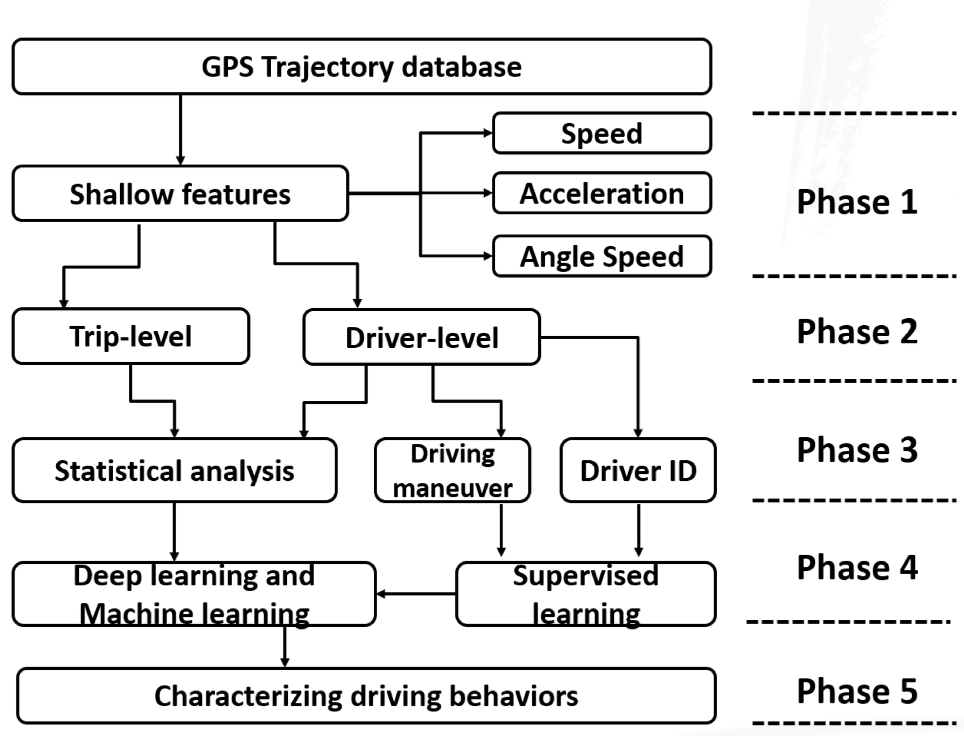
Introduction



System Architecture

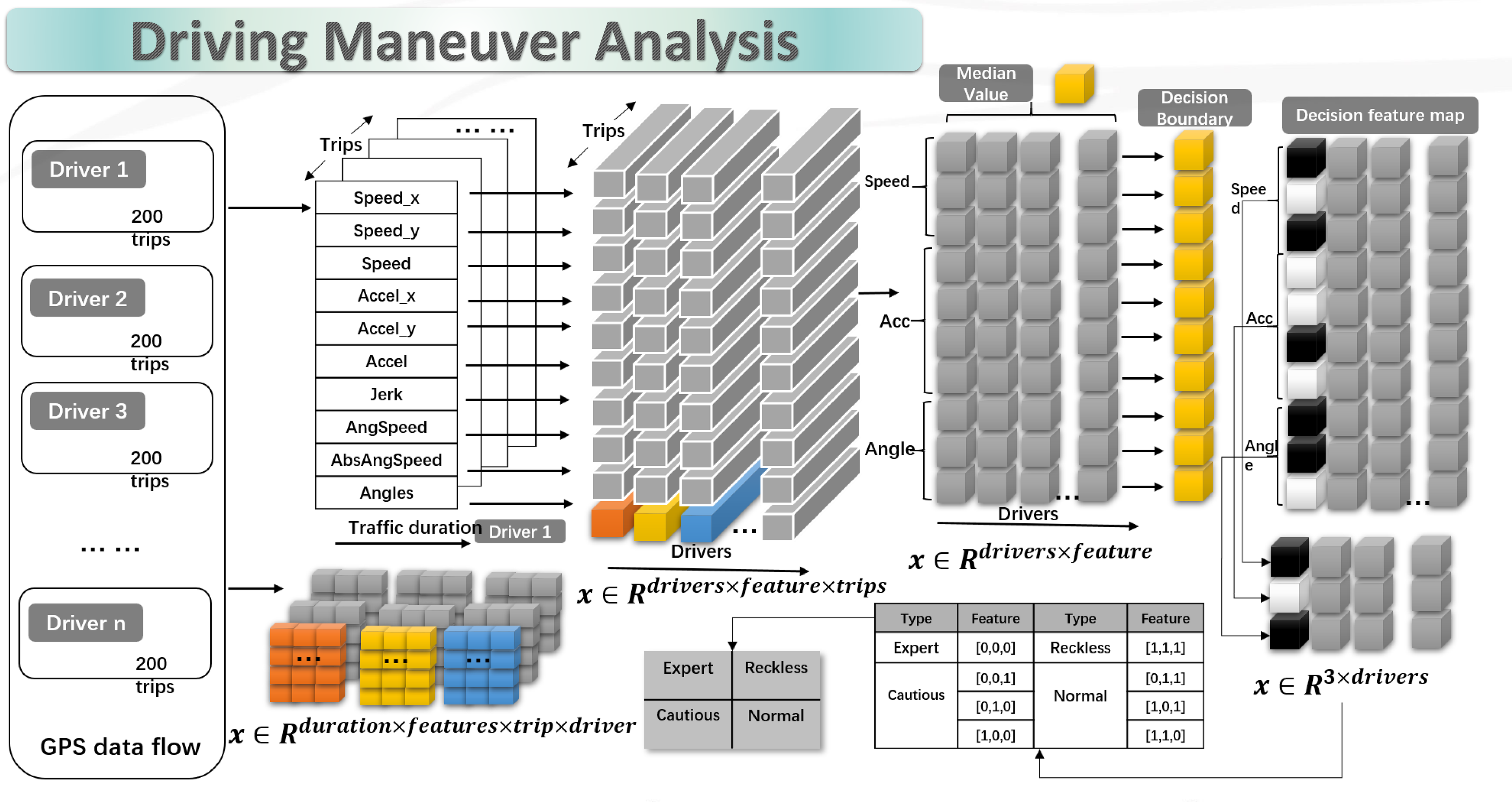


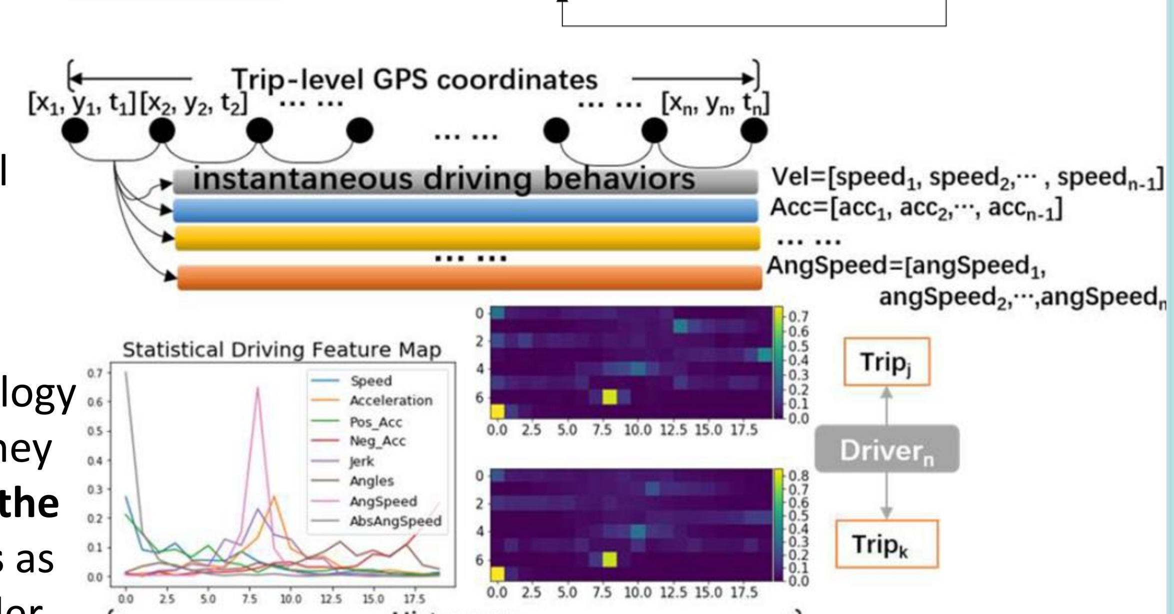
The major contributions:

The **general architecture:**

- The shallow driving features can be calculated from a large GPS trajectory database;
- The statistical analysis of driving maneuvers and the driver identity will be treated as the sematic-level driving features;
- We then introduce a joint histogram feature map as the input to characterize the driving features with the assistance of the artificial neural network;
- And a hierarchical deep learning model for the large-scale driver identification task.

Driving Maneuver Analysis



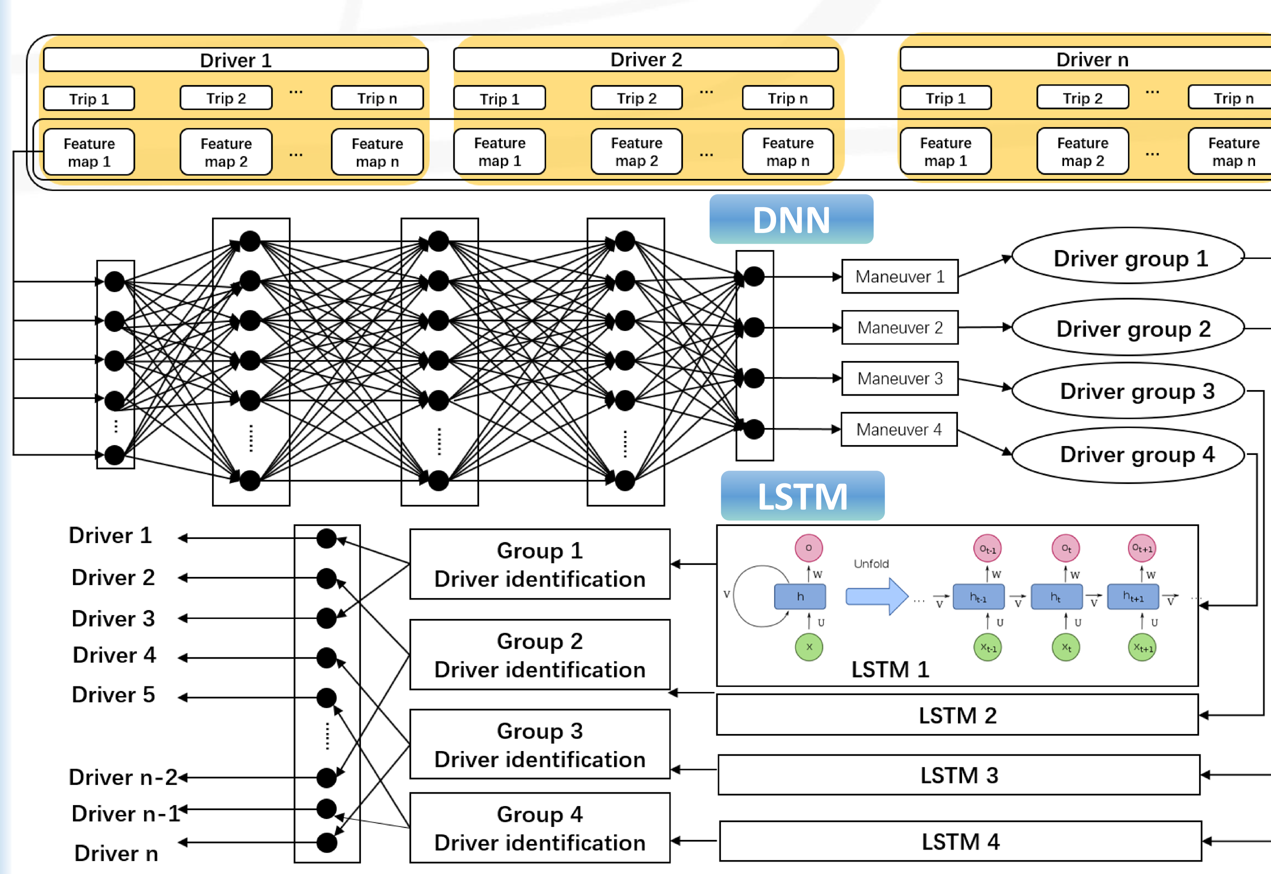


- For **real-time** application, the statistical analysis from both a **huge amount of dataset** and **numerous drivers** is not available;
- we aim to propose a working methodology to train autonomous vehicles so that they can **have stronger ability to recognize the statistical-analyzed driving maneuvers** as well as **to identify a specific driver** under different driving conditions with a **robust performance.**

Simulation Results and Discussion

Simulation results

	Model types	Driver Identification			Driving maneuver
		Trip Accuracy	Top5 Accuracy	Driver Accuracy	Classification accuracy
Joint-histogram feature maps	PCA+SVM	3.13%	---	2%	20%
	T-SNE+SVM	6.13%	---	10%	44.24%
	Random Forest	17.73%	---	18%	39.80%
	DNN	12.35%	35.10%	14%	94.66%
	RNN	28.62%	58.98%	66%	68.01%
	LSTM	36.54%	67.91%	92%	72.38%



Hierarchical Learning Model

- **DNN:** Talented at the general high-level feature classification;
- **RNN:** Talented at the specific high-level feature classification;
- **Hierarchical deep learning model:** Classify source dataset into the general feature with DNN, and identify the specific feature with multiple RNNs.

Accuracy	LSTM	
	Trip-level	Driver-level
50 Drivers	36.54%	67.91%
200 Drivers	17.04%	36.64%
	Hierarchy deep learning	
50 Drivers	42.08%	78.55%
200 Drivers	41.52%	73.38%

Conclusion and Feature Work

This study is **detecting the sematic-level driving behaviours** from **GPS sensor data:**

- We classified different driving maneuvers through a **statistical analysis method;**
- The identified maneuver information with the corresponding driver ID is useful for the **supervised learning** of high-level feature abstraction with neural network;
- We propose **a joint histogram feature map** to analyze the sensory data with **deep learning** in a consumable form;
- **DNN** is suitable for the driving maneuver classification task, while **LSTM** performs well in identifying a specific driver.
- We proposed **a hierarchical deep learning model** which can well maintain the prediction accuracy even when the scale of the recognition task is four times larger.

For future work, we intend to characterize the driving features under a more sophisticated condition.

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