# Research Report Summary

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## *Multitask Learning and Prediction of Baseline Driving Performance Measures*

Driving performance measures (DPMs) are important indices for driving and personal safety in vehicle operation. The modeling and prediction of the DPMs under unobserved driving conditions are critical, and many methods have been developed. However, existing methods suffer a common limitation: The interactions among different DPMs are not fully considered (each DPM is modeled individually), although the existence of such interactions is widely reported. This project developed a novel DPM modeling and prediction method, i.e., multi-output convolutional Gaussian process (MCGP), that incorporates the interactions among different DPMs. The method features the modeling flexibility for different DPMs and the interpretable modeling structure for integrating the DPM interactions. The method is compared with three benchmark methods on the DPM data set under four different settings, and the results demonstrate the superiorities of the method. The proposed method provides flexible and accurate predictions for DPMs at unobserved driving conditions, which can significantly reduce simulation costs and time.

**Table 1. Independent variables.**

| Variable | Range |
|---|---|
| Speed Limit | 10 to 70 mph |
| Presence of Traffic | Yes or No |
| Number of Lanes | 1 or 2 |
| Driver Age | 16 to 89 years |
| Simulator Platform | NADS-1 or miniSim |

**Table 2. Dependent variables.**

| Variable | Units |
|---|---|
| Standard Deviation of lateral Lane Position (SDLP) | Centimeters |
| Standard Deviation of driving Speed (SDS) | Meter per second |

**Table 3 Data settings for model evaluations**

| | Number of Lanes | Presence of Traffic | Simulator Platform | Inputs Variables | Outputs Variables |
|---|---|---|---|---|---|
| Subset 1 | 1 | Yes | NADS-1 | Age, Speed limit | SDLP, SDS |
| Subset 2 | 1 | Yes | miniSim | Age, Speed limit | SDLP, SDS |
| Subset 3 | 2 | Yes | NADS-1 | Age, Speed limit | SDLP, SDS |
| Subset 4 | 1 | No | NADS-1 | Age, Speed limit | SDLP, SDS |

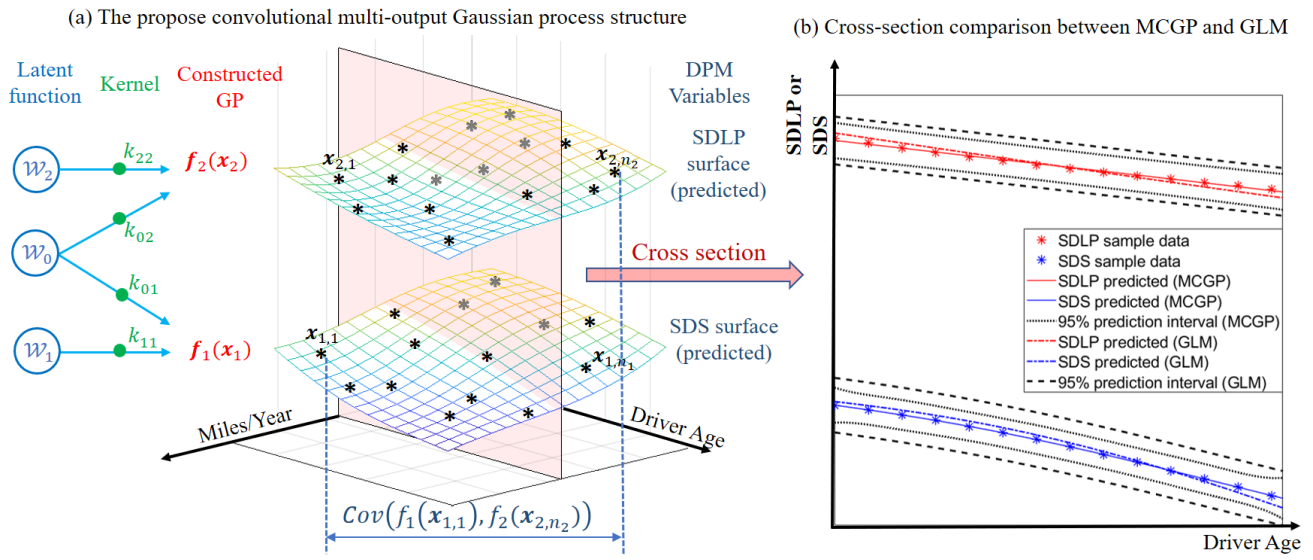


Figure 1. Illustration of the proposed MCGP framework.

*In this report, the relationship between driving conditions and DPMs are studied. The uniqueness and contribution of the proposed model are that it facilitates the interactions among different DPMs. Comparing with state-of-art methods, the proposed model achieves 15%-20% improvement of DPM prediction accuracy in various driving conditions.*

**Outcomes**

- *A novel method was proposed to capture the interactions among different DPMs so that the prediction performance is improved.*
- *The method was validated in NADS-1 and mini-SIM under various driving conditions, and the results demonstrated that 15%-20% improvement of DPM prediction accuracy can be achieved.*
- *Two journal papers have been published under the support of the project*
- *One Master student was supported and graduated from the Department of Industrial and Systems Engineering at the University of Iowa.*

**Impacts**

***Impacts*** *– The direct impact of the project is to provide an accurate prediction of the DPMs under unobserved driving conditions, which can reduce simulation costs and time. The long-term impact of the project is to reveal the interaction mechanism among different DPMs, which can provide guidance for the DPM design and collection process.*

*Impact Performance Measures*

- *A 30%-40% deduction of simulation costs and time can be expected by using the proposed DPM prediction method.*
- *The thorough understanding of the DPM interactions can contribute to accurate control and feedback of autonomous driving.*

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