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Measuring Driver's Relative Performance Over Time

Using DEA and Window Analysis

Presenter: Sedi Seddigheh.babaee@uhasselt.be

universiteit hasselt | imob

Co-authors

Dr. Yongjun Shen

Prof. Dr. Elke Hermans

Prof. Dr. Tom Brijs

Prof. Dr. Geert Wets

Introduction

- Among different road user types, drivers represent the largest share of road fatalities. As a result, more attention should be paid to the behavior of drivers.
- Driving performance of a driver should be evaluated not only at a specific point of time but also over a time period.
- Horizontal curves, particularly on two-lane rural roads, have been recognized as a significant safety issue for many years

Data collection on a curve taking scenario

Driving simulator Fixed-base STISIM, M400 with 180°parabollic screen

Width of 2.8m & posted speed limit of 70 km/h

Participants

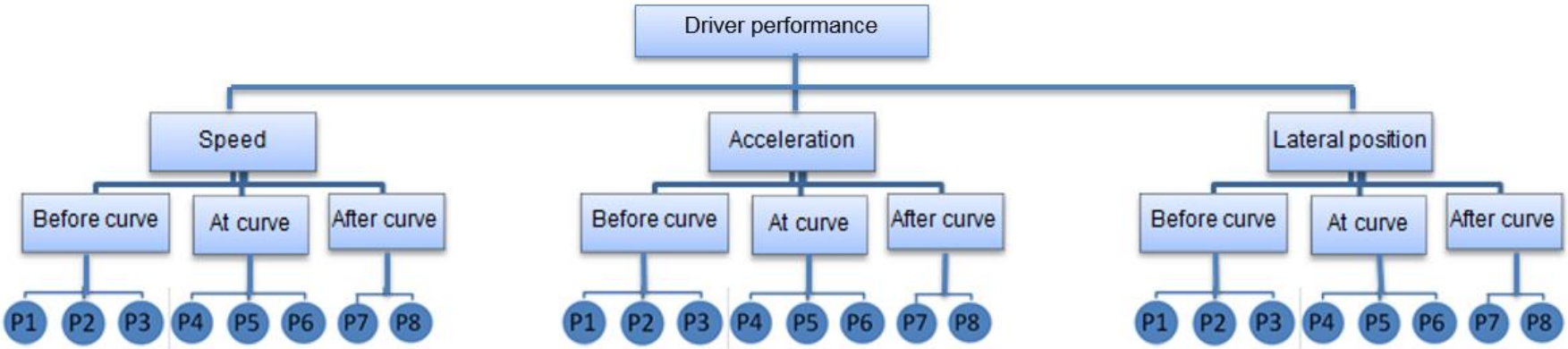
- 20 Volunteers
- 6 Excluded: 2 simulator sickness, 4 missing data
- 14 Participants in dataset; 8 men Age: 18-54; mean age 26.32; SD 10.47

Data collection on a curve taking scenario- cont.

All participants completed five same trips of 16.2 km for five different days

Indicators

- **Speed** The resultant of longitudinal and lateral speed is used
- **Acceleration** The resultant of longitudinal and lateral acceleration is used
- **Lateral position** The distance between the center of the road and the vehicle's longitudinal axis



Model Preparation

Before analysing, the raw data needed to be processed for each point separately.

- In each of the eight points, **ordinal grades** were assigned for **speed, acceleration and lateral position** illustrating the degree of each driver's performance on that parameter at that particular measurement point.
- The higher the grade, the better the performance.
- Moreover, weight restrictions were added in order to guarantee the consistency with prior knowledge and the obtainment of acceptable layer-specific weights

Time window analysis

Time window method uses a fixed window size and moves this window along the whole time series data at the speed of one time step for each moving

Time period	Window length
Odd	$(T+1)/2$
Even	$(T+1)/2 \pm 1/2$

Window 1: Day 1 Day 2 Day 3

Window 2: Day 2 Day 3 Day 4

Window 3: Day 3 Day 4 Day 5

Window analysis

Aim: to detect the trend in driving performance of each driver over time

How: The performance of a driver is assessed by treating it as a different driver in each time period

Result the performance of a driver in a particular period is contrasted with its own performance in other periods in addition to the performance of other drivers

Window analysis of alternative n, with a 3-days window

First, in each window, the MLDEA-CI model should be applied to evaluate the relative performance of all the drivers under study

Driver	Period	Day1	Day 2	Day 3	Day 4	Day 5	Mean Index Score (M)	Variance (V)	Column Range (CR)	Total range (TR)
n	W_1	$I^n_{1,1}$	$I^n_{1,2}$	$I^n_{1,3}$						
	W_2		$I^n_{2,2}$	$I^n_{2,3}$	$I^n_{2,4}$					
	W_3			$I^n_{3,3}$	$I^n_{3,4}$	$I^n_{3,5}$				
	$CR_{n,t}$	x	$CR_{n,2}$	$CR_{n,3}$	$CR_{n,4}$	x	M_n	V_n	CR_n	TR_n

X: Omitted

MLDEA-CI method

$$CI_0 = \max \sum_{f_1=1}^{s} \hat{u}_{f_1} y_{f_1 0}$$

The driver under evaluation

$$s.t. \quad \sum_{f_1=1}^{s} \hat{u}_{f_1} y_{f_1 j} \le 1, \quad j = 1, \cdots, n$$

All driver

$$\sum_{f_1 \in A_{f_k}^{(k)}} \hat{u}_{f_1} \Big/ \sum_{f_1 \in A_{f_{k+1}}^{(k+1)}} \hat{u}_{f_1} = w_{f_k}^{(k)} \in \Theta, \quad f_k = 1, \cdots, s^{(k)}, \quad k = 1, \cdots, K-1$$

$$\hat{u}_{f_1} \ge 0, \quad f_1 = 1, \cdots, s$$

Multiple Layer Data Envelopment Analysis- MLDEA model

- The focus of DEA is on individual
- By solving the model, the best possible indicator weights are determined
- An index score between zero and one is obtained for each driver, with a higher value indicating a better performance
- Take into account the layered hierarchy of indicators that often exist in reality

Result

Measuring driver's relative performance over time

Index scores of drivers using window analysis with a 3-days window

	Day1	Day 2	Day 3	Day 4	Day 5	Mean Index Score (M)	Variance (V)	Column Range (CR)	Total range (TR)
Driver 3									
W_1	0.9820	1	1			0.9926	0.0001	0.0084	0.0218
W_2		1	1	0.9782					
W_3			1	0.9867	0.9864				
$CR_{3,t}$	x	0	0	0.0084	x				
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Driver 7									
W_1	0.7794	0.7520	0.7645			0.7654	0.0003	0.0234	0.0491
W_2		0.7520	0.7643	0.7394					
W_3			0.7860	0.7627	0.7885				
$CR_{7,t}$	x	0	0.0217	0.0234	x				

Column views show the stability of results at the same days

Row views show the trend of drivers' performance at different days

(X: Omitted)

Conclusion

Conclusion

- DEA window analysis is a promising approach for driver performance evaluation
- It takes into account not only the multi-dimention of driving performance but also the variation in performance over time

What to do next?

Investigate the validation of the results

Test other parameters/indicators such as the standard deviation of the lateral position instead of the absolute lateral position

Study the relationship between driving performance and other criteria such as workload

Thank you for your attention

Suggestions

Remarks

Questions?