Vehicle Behavior Analysis and Safety Evaluation for Roundabouts in Japan

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Current Situation in JAPAN

- Revised road traffic law was enacted (Sep.2014)
  → Roundabouts have been gradually getting implemented and planned as one of intersection type
- The first roundabout design guideline in Japan was published (Apr.2016)
  → Surveys and discussions for the safety performance check methodology are still insufficient

Objectives

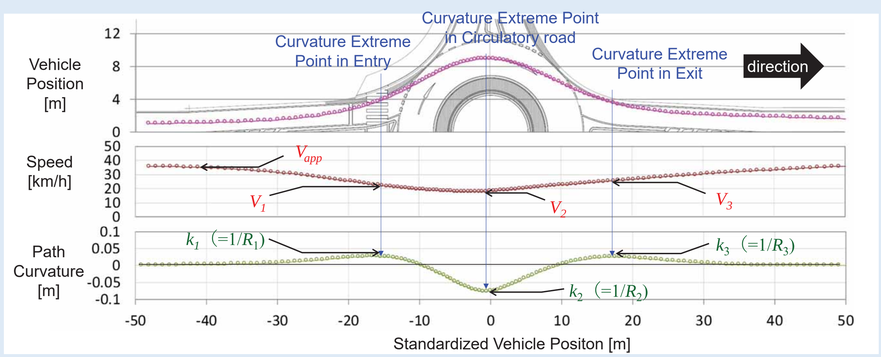
To verify the speed prediction model for the safety performance check
→ 2 different models (trajectory based or regression) are compared

UAV Survey and Data Collection

- UAV SPEC
  - Equipment: Zion QC730
  - Camera: GoPRO HERO4 (4K Vision)
  - Flight Height: 80m around

- Procedure of Data Collection
  - Remove lens distortion and slight motion of video by software
  - Acquire the vehicle position data per 0.2 sec by plotting manually
  - Convert into a plane rectangular coordinate system from video coordinate system by projective transformation
  - Apply a smoothing and interpolation process by using Kalman filtering

- Data Sample and Definition of Behavioral Parameter



Survey Sites and Geometries

4 Sites and 13 Movements(directions) are selected

<YAMANOTE>

D=27m

<NUMAME>

D=27m

<AZUMINO>

D=31m

<NOBE>

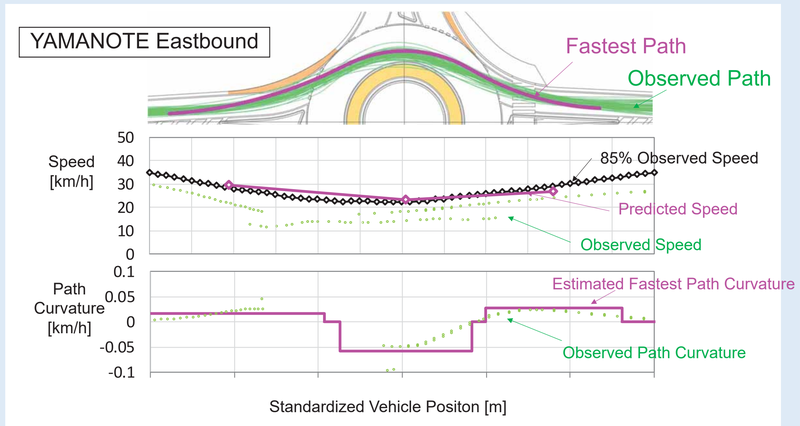
D=32m

Geometric Elements	Ranges
Number of Legs	4 to 5
Turning Angle	130° to 230°
Inscribed Diameter	27m to 32m
Circulatory Roadway Width	5.0m only
Apron Width	2.0m to 3.5m
Entry Angle	46° to 63°
Entry Roadway Width	3.6m to 5.3m
Entry Curb Radius	6m to 25m
Splitter Island Length	11m to 30m
Splitter Island Width	0.75m to 3.5m
Exit Angle	53° to 61°
Exit Width	3.8m to 5.5m
Exit Curb Radius	6m to 35m
Deflection Width	-2.3m to 13.9m

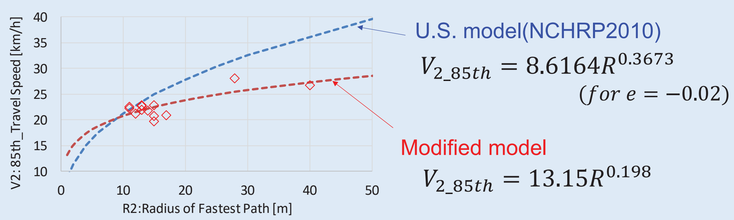
Speed Prediction Model with Fastest Path

- Fastest path reproduces the actual vehicle path accurately
- Speed-radius relationship model in Japan estimates lower speed than the U.S. model
  → may be influenced by speed reduction measures (e.g. colored pavement) or driver's experience

<Observed vs Estimated Behavior by Fastest Path>



<Modified Speed–Radius Relationship Model (V_2-R_2) >



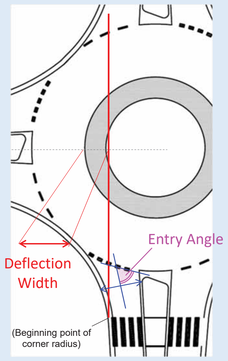
Multiple Regression Model

- Approach speed, Entry angle and Deflection width are statically significant

$$V_{2\_85th} = 0.355 \cdot V_{app\_85th} + 0.153 \cdot \theta_{in} - 0.340 \cdot DW$$

Where

V_{2_85th} : 85percentile speed of V_2 [km/h]
V_{app_85th} : 85percentile speed of V_{app} [km/h]
θ_{in} : Entry Angle [degrees]
DW : Deflection Width [m]

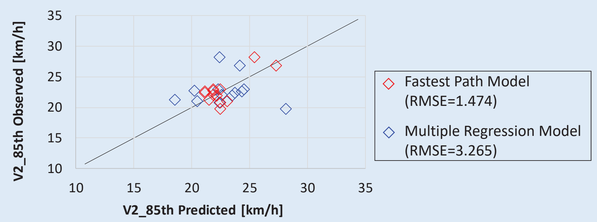


<Multiple Regression Analysis Result>

	T-value	P-Value
V_{app_85th}	4.61	$6.0*10^{-4}$
θ_{in}	2.22	$4.6*10^{-2}$
DW	-2.21	$4.7*10^{-2}$
Adjusted R^2	0.90	
Standard Error	2.52	
F-value	$1.3*10^{-11}$	

Fastest Path Model vs Regression Model

- The fastest path model have better accuracy than the regression model



Conclusions and Future Work

- A speed prediction model based on "Fastest Path" has good accuracy also in Japan
- Continuous investigation and improvement of speed prediction model are required in the future.