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Can Your Phone Detect a Dangerous Corner?

Self-Supervised Harsh Cornering Detection at Scale via Smartphone Telematics

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IVORY

This research has been conducted within the IVORY project. The project has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement No 101119590.

What We'll Cover

From the problem to the pipeline — and the numbers that matter

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Motivation & Background

- Harsh cornering is linked to vehicle instability and elevated rollover risk
- Rollovers = ~3% of crashes but ~⅓ of passenger fatalities (Padmanaban & Husher, 2005)
- Smartphones with accelerometers, gyroscopes & GPS enable large-scale driving behaviour monitoring
- Prior work has focused on longitudinal events (hard braking/acceleration); cornering remains under-explored
- Key challenges: arbitrary phone orientation, no ground-truth labels, sensor noise
- **Goal:** self-supervised, scalable detection of harsh cornering without manual annotation

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Data Collection & Preprocessing

4,017
trips

1.76M
data points

1,900
validated turns

1 Hz
sampling rate

Source & Sensors

- OSeven Telematics — anonymised naturalistic driving data
- GPS: lat/lon, speed, heading
- Accelerometer: 3-axis
- Gyroscope: 3-axis
- Diverse road environments

Yaw Rate Estimation

- GPS heading changes normalised over 1–4 second horizons
- Sensor-fusion-free proxy for cornering behaviour
- Robust across vehicle types and sensor placements

Validation & Invariance

- OpenStreetMap intersection check within 15 m
- 1,900 turn events validated against map data
- 3-axis Euclidean magnitudes for orientation invariance

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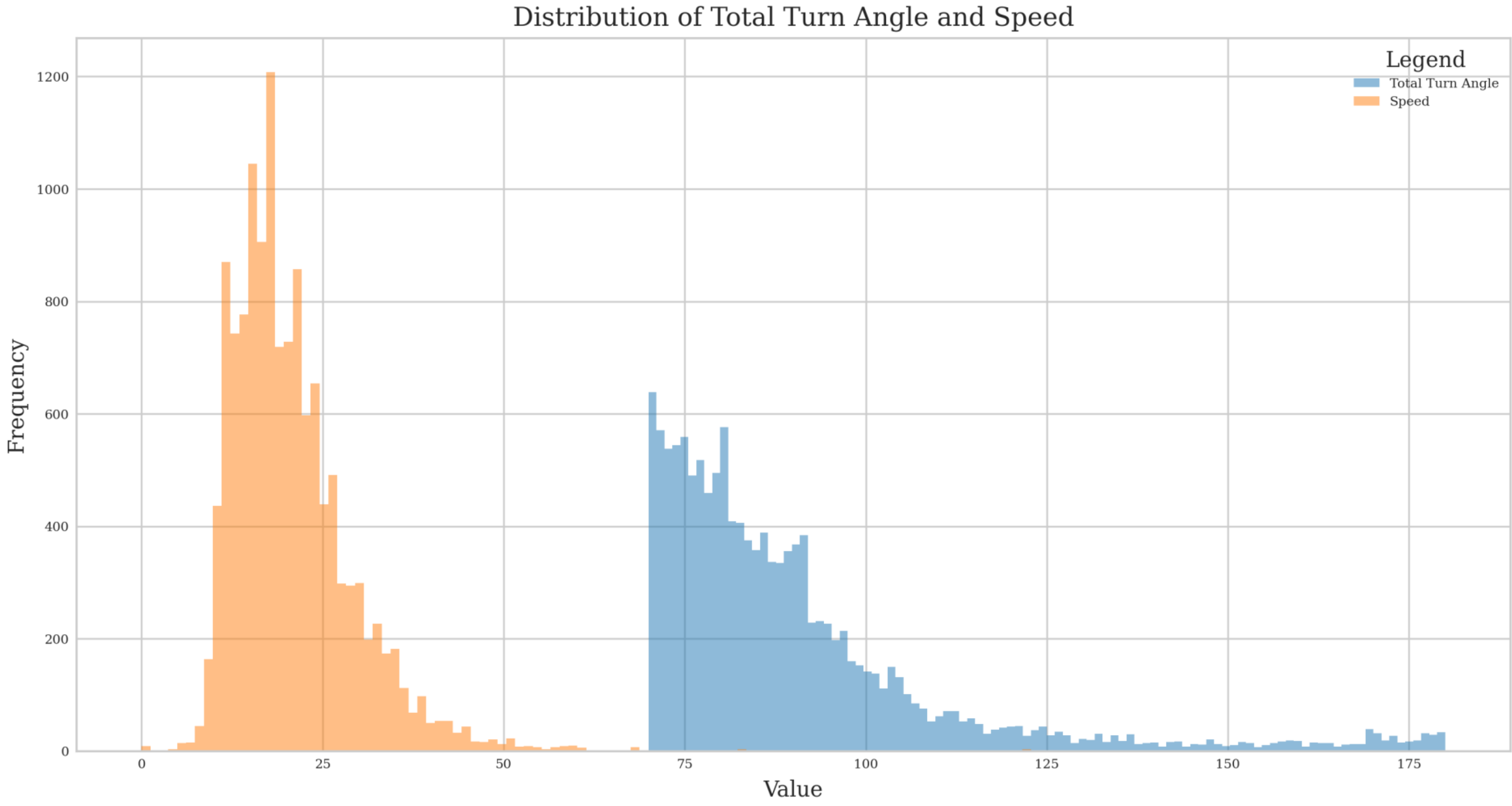
Distribution of Turn Events

- 1,900 validated turn events
- The histogram shows the distribution of total turn angles and vehicle speeds across all turning events in the dataset
- Predominantly involving 70°–180° turns at speeds below 30 km/h



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Feature Engineering

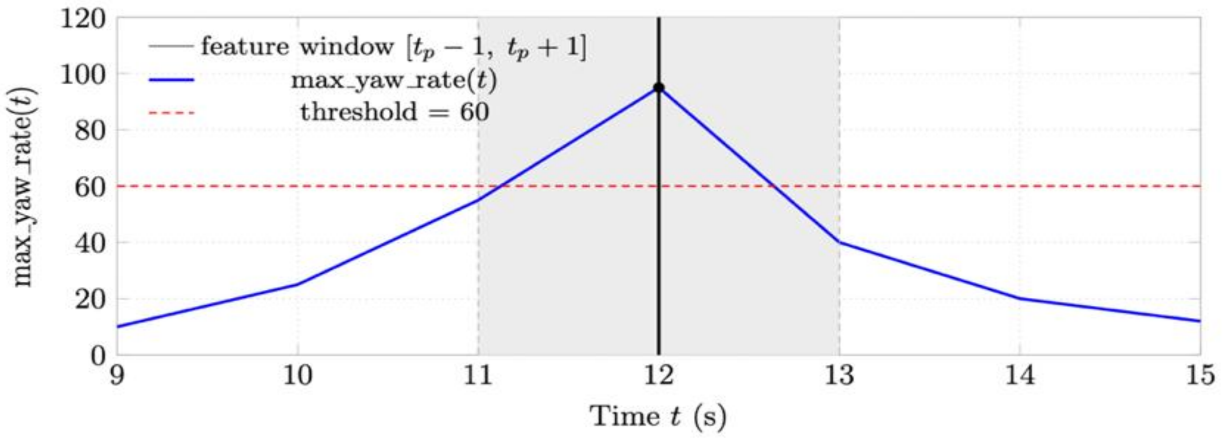
- Each turn event is isolated by a heading change threshold (Δ > 60° over 4 s)
- A 3-second peak window captures the most dynamic phase of the manoeuvre
- Per-corner statistics are compiled into a fixed-length vector ready for model input

1 → 2 → 3

Turn Detection
heading Δ > 60° / 4 s

Peak Window
3 s → max yaw rate

Per-Corner Features
speed, yaw, accel, jerk



Features
- Mean & peak speed
- Max yaw rate & angle
- Accel & gyro magnitude
- Jerk & corner duration

→ fixed-length vector

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Self-Supervised Detection Pipeline

① **Seed the Labels**
Ensemble anomaly detectors find the outliers

② **Train the Classifiers**
Supervised models learn from pseudo-labels

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Step 1: Pseudo-Label Generation

No ground-truth labels → ensemble anomaly detection as seeding strategy

- **Isolation Forest** — ease of isolation via random partitioning
- **Local Outlier Factor (LOF)** — density-based local comparison
- **One-Class SVM** — boundary of the majority class

→ Scores rank-normalised [0,1] and averaged across all three detectors

→ **Top 5% = positive seeds (harsh);** equal random sample = normal seeds

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Step 2: Supervised Classification

Four classifiers trained on pseudo-labelled data (80/20 stratified split):

- **Logistic Regression**
  - **linear baseline**
- **SVM**
  - **non-linear kernel, highest PR-AUC**
- **Random Forest**
  - **balanced ensemble of decision trees**
- **MLP**
  - **2-layer (64 units → 16-dim latent), AdamW + early stopping**

→ **MLP latent embeddings** used for k-means clustering (k=2) and interpretability

→**latent space silhouette = 0.759**

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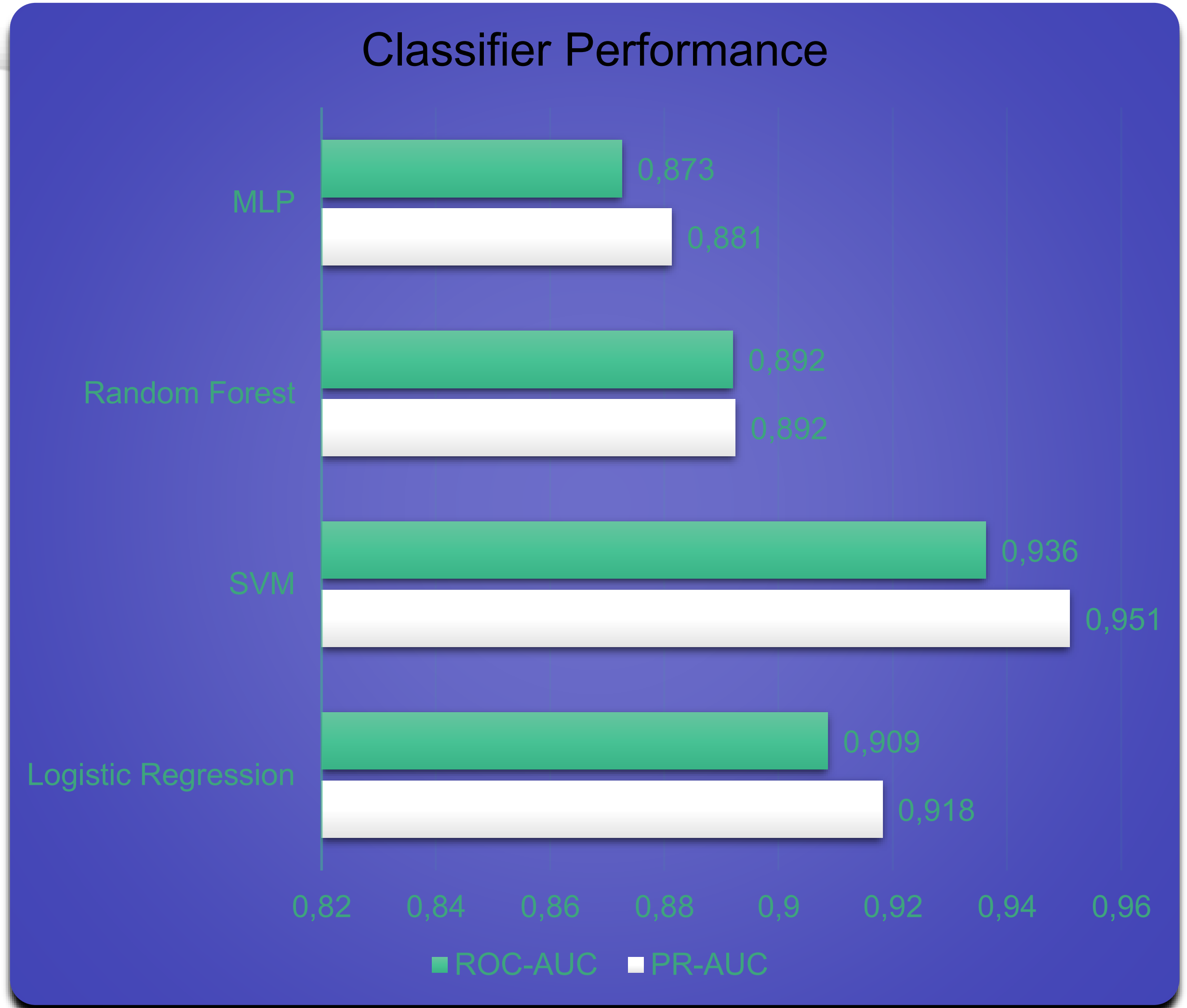
Results & Discussion

- Logistic Regression: 0.918 / 0.909
- **SVM: 0.951 / 0.936**
- Random Forest: 0.892 / 0.892
- MLP: 0.881 / 0.873

→Key features: yaw rate, accel jerk, gyro magnitude



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Conclusions & Future Work

- Self-supervised framework detects harsh cornering without manual annotation
- Orientation-invariant features and OSM validation
- All classifiers AUC >0.87
- MLP latent space silhouette = 0.759 (clear separation)
- Applications: insurance telematics, fleet management, urban safety planning

Future work:

→ Validate across diverse regions and OBD data as validator

→ Temporal patterns of risky driving; integrate video / CAN-bus data

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