

ITEP4SDC at the SBFT 2026 Tool Competition: Self-Driving Car Testing Track

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Abstract

In regression testing, prioritizing fail-revealing test cases within a test suite is crucial for reducing failure detection time. In the context of the Self-Driving Car Testing Tool Competition held at the 19th Search-Based Fuzz and Testing Workshop, we developed a tool named ITEP4SDC. ITEP4SDC prioritizes test cases based on the predicted failure probability of a given road, which is determined by its curvature, angle, and length profiles. By ranking test cases according to their likelihood of failure, ITEP4SDC aims to improve early failure detection in simulation-based testing of self-driving cars.

CCS Concepts

• **Computing methodologies** → **Modeling methodologies**.

Keywords

Self-driving Cars, Simulation-based Testing, Test Prioritization.

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1 Introduction

Self-driving cars (SDCs) must undergo extensive simulation-based testing before deployment in the real world to mitigate safety risks and financial losses. Within the scope of the 19th International Workshop on Search-Based and Fuzz Testing (SBFT), a Self-Driving Car Testing Tool Competition is organized to evaluate automated testing approaches for SDCs [1]. The competition focuses on test case prioritization.

Test case prioritization is a regression testing technique that aims to sort test cases such that those with a higher likelihood of revealing failures are executed earlier. This approach enables faster failure detection and more efficient use of testing resources. In the competition, multiple performance metrics are used to assess the effectiveness of the submitted tools. The primary evaluation metrics are as follows:

- **APFD**: Measures how early failure-revealing test cases appear in the prioritized test suite. Higher values indicate earlier failure detection.
- **APFDC**: A cost-aware extension of APFD that incorporates test execution time. Lower cumulative execution time yields higher scores.

Our entry to the competition is a tool named **Intelligent Test Prioritizer for Self-Driving Cars (ITEP4SDC)**, which prioritizes simulation-based test cases by predicting their likelihood of failure based on road profile characteristics [4]. **ITEP4SDC** is based on the award-winning tool **ITS4SDC** [5, 6].

2 ITEP4SDC Tool Description

In the simulation environment, an SDC receives a road represented as a sequence of $2D$ (x, y) points as a test case and aims to follow the road on an asphalt surface generated by the simulator. The competition platform relies on the BeamNG simulator, which provides a high-fidelity simulation environment.

A test case is terminated and labeled as “FAIL” when the SDC leaves the lane. Otherwise, it is labeled as “PASS”. Our observations indicate that the SDC speed is the primary factor contributing to lane departure.

We analyze road profiles segment-by-segment and consider curvature, angle, and length as informative features. A segment is defined as the connection between two consecutive road points [2]. After segment identification, three features are extracted for each segment. An example road and its segment-based representation are illustrated in Figure 1.

- (1) **Curvature**: The Menger curvature computed using three consecutive points (in $\frac{1}{m}$).
- (2) **Length**: The Euclidean distance between the two points forming a segment (in meters).
- (3) **Angle**: The change in orientation between the current segment and the previous segment with respect to the x-axis (in degrees).

Given three consecutive points P_1, P_2 and P_3 , the curvature value κ is calculated using the Menger curvature formula as follows:

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad (1)$$

$$s = \frac{d_{12} + d_{23} + d_{13}}{2} \quad (2)$$

$$A = \sqrt{s(s - d_{12})(s - d_{23})(s - d_{13})} \quad (3)$$

$$\kappa = \frac{4 \cdot A}{d_{12} \cdot d_{23} \cdot d_{13}} \quad (4)$$



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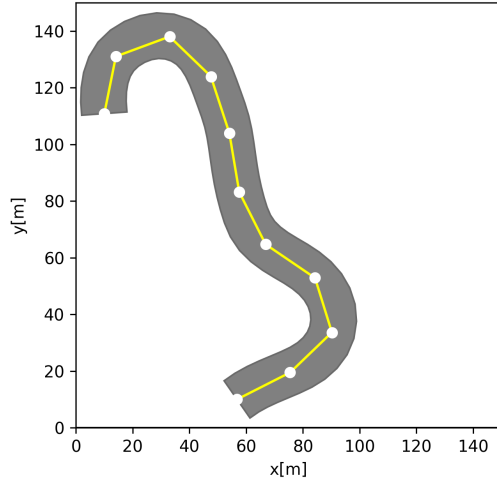


Figure 1: Example road

For the segment S_2 , formed by points P_2 and P_3 in the road section illustrated in Figure 2, where a circle of radius r centered at P_C is defined using three consecutive road points, the extracted features are defined as:

- Curvature: $\kappa = \frac{1}{r}$
- Angle: $\theta = \theta_{S_2} - \theta_{S_1}$
- Length: $\|P_2 - P_3\|$

After constructing the feature vector for each test case, we employ a Long Short-Term Memory (LSTM) model to estimate a failure likelihood score, where lower values indicate a higher probability of failure. We adopt a single-layer LSTM architecture with 220 cells, followed by a fully connected dense layer with a sigmoid activation function to produce predictions in the range $[0, 1]$.

For training the model, we use the SensoDat dataset, which has previously been employed for simulation-based testing of self-driving cars [3]. Prior to training, all feature vectors are normalized using standard scaling. After training, the Keras model is converted to an ONNX Runtime model to enable fast loading and high-speed inference on the competition platform.

Test cases are ranked in ascending order of the model's failure likelihood score, prioritizing fail-prone test cases for earlier execution.

3 Conclusions and Future Work

In this paper, we present ITEP4SDC, a test prioritization tool developed for the Self-Driving Car Testing Tool Competition. ITEP4SDC analyzes each test case, represented as a 2D road, by extracting segment-based features including curvature, length, and angle profiles. Using these features, the tool employs an LSTM-based model to predict the likelihood of test case outcomes and prioritizes fail-prone test cases earlier in the execution order, thereby improving the APFD metric.

While the current prioritization strategy primarily targets APFD, future work will focus on improving the APFDc metric. In particular, for test cases with similar failure probabilities, additional factors

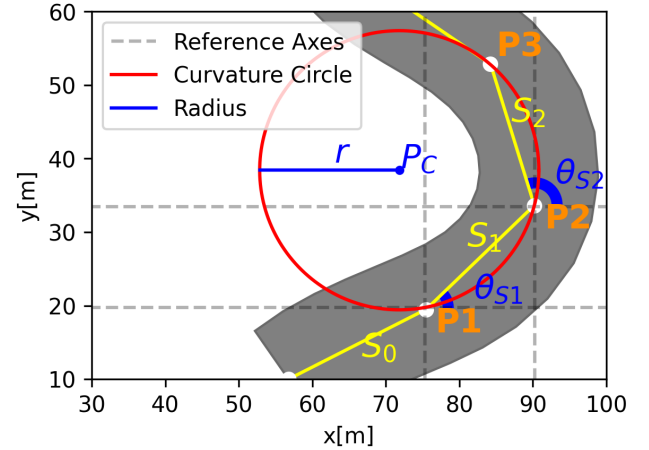


Figure 2: Example road section

such as overall road length and the estimated distance from the road start to a potential failure location will be incorporated into the prioritization process. By considering both failure likelihood and execution cost, we aim to further improve test prioritization effectiveness.

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