

INTISARI

METODE CURRICULUM LEARNING DAN DEEP REINFORCEMENT LEARNING UNTUK SKENARIO BERKENDARA DI KAWASAN PERKOTAAN YANG PADAT DAN KOMPLEKS MENGGUNAKAN UNITY

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Kecelakaan lalu lintas di Indonesia menjadi masalah serius dengan meningkatnya jumlah kejadian, terutama yang melibatkan pesepeda, pengendara sepeda motor, dan pejalan kaki. Salah satu solusi potensial untuk mengurangi kecelakaan ini adalah penggunaan kendaraan otonom, yang dapat meminimalisir kesalahan manusia. Namun, pengembangan kendaraan otonom yang efektif di Indonesia menghadapi tantangan besar karena terdapat rintangan seperti kendaraan terparkir di tepi jalan serta pejalan kaki yang sering menyebrang sembarangan.

Penelitian ini bertujuan untuk mengembangkan sistem kendaraan otonom menggunakan metode *reinforcement learning* yang diperkuat dengan pendekatan *curriculum learning* serta algoritma Proximal Policy Optimization (PPO), dengan simulasi berbasis *Unity Engine* dan *toolkit ML-Agents*. Sistem ini dirancang untuk mengatasi tantangan spesifik seperti kendaraan terparkir di tepi jalan dan pejalan kaki yang menyebrang sembarangan dengan membagi proses pelatihan ke dalam beberapa tahap bertahap berdasarkan kompleksitas lingkungan. Simulasi berbasis *Unity Game Engine* dan *toolkit ML-Agents* ini memungkinkan kendaraan belajar menavigasi secara aman dan efisien dalam kondisi jalan pemukiman di Indonesia yang dinamis.

Penelitian ini menunjukkan bahwa penerapan *curriculum learning* dalam pelatihan kendaraan otonom dapat meningkatkan performa dan stabilitas sistem, dengan rata-rata *completion rate* sebesar 95,3%, *success rate* sebesar 80%, dan hasil *permutation test* yang mengindikasikan perbedaan *completion rate* antara metode dengan kurikulum dan tanpa kurikulum adalah signifikan. Selain itu, penggunaan kurikulum juga terbukti mengurangi frekuensi terminasi akibat tabrakan, terutama dengan rintangan dinamis seperti pejalan kaki dan kendaraan bergerak.

Kata-kata kunci: Kendaraan Otonom, Curriculum Learning, Deep Reinforcement Learning, Proximal Policy Optimization, Unity Engine.

ABSTRACT

A CURRICULUM LEARNING WITH DEEP REINFORCEMENT LEARNING APPROACH FOR CROWDED AND COMPLEX URBAN DRIVING SCENARIOS IN UNITY

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Traffic accidents in Indonesia are becoming a serious problem with an increasing number of incidents, especially those involving cyclists, motorcyclists, and pedestrians. One potential solution to reduce these accidents is the use of autonomous vehicles, which can minimize human error. However, the development of effective autonomous vehicles in Indonesia faces great challenges due to narrow road conditions and obstacles such as parked vehicles on the roadside as well as pedestrians who often cross carelessly.

This research aims to develop an autonomous vehicle system using reinforcement learning enhanced with curriculum learning methods and the Proximal Policy Optimization (PPO) algorithm. The system addresses specific challenges such as parked vehicles on the roadside and pedestrians crossing unpredictably by implementing a staged training process that incrementally introduces environmental complexities. The Unity Engine-based simulation with the ML-Agents toolkit enables the vehicle to learn safe and efficient navigation in dynamic and narrow residential roads typical of Indonesia.

This research shows that the application of curriculum learning in autonomous vehicle training can improve system performance and stability, with an average completion rate of 95,3%, a success rate of 80%, and permutation test

results that indicate the difference in completion rate between methods with and without curriculum is significant. In addition, the use of curriculum was also shown to reduce the frequency of termination due to collisions, especially with dynamic obstacles such as pedestrians and moving vehicles.

Keyword: Autonomous Vehicle, Curriculum Learning, Deep Reinforcement Learning, Proximal Policy Optimization, Unity Engine.