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Development of reinforcement learning system for urban autonomous driving

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The decision making for safe driving in urban scenes needs to perceive multiple factors, such as pedestrian, bicycle, intersection, and traffic signals, and respond to them respectively. Besides the common traffic scenes following the traffic light or traffic sign, the safe driving behavior should be adaptive to traffic conditions and the states of detected road objects. For instance, when the emergency vehicle approaches, the vehicle shall not block the passage of the emergency vehicle and pull over even it's at green traffic light. The complexity of traffic conditions and the necessity of adapting to its surroundings make it challenging for autonomous driving in urban scene. Considering the ability to learning complex conditions, we aim to acquire the driving behavior model for complex urban driving scenarios using reinforcement learning.

Among the urban driving scenarios, we chose an intersection as the task scenario. We intend to obtain the driving behavior model which not only follows the basic traffic rules but also is able to respond to the emergency vehicle in an intersection scenario. The proper driving behaviors for crossing an intersection should meet the conditions described below: 1) The ego vehicle needs to follow the basic traffic rules and move without collision. 2) The ego vehicle should stop according to the traffic light or stop line. 3)While the emergency vehicle is approaching, the ego vehicle should give priority to the emergency vehicle and stop until the emergency vehicle passes. Meanwhile, if the ego vehicle is in an intersection, it should keep moving until pass through the intersection even the emergency vehicle is approaching.

In order to simulate the traffic environment, a logic simulator was developed to express ego vehicle's surroundings (Fig1 and Table1). Moreover, aiming to train the model effectively, we proposed a layered state expression as the input for reinforcement learning system. The proposed layered state expression is composed of ASCII code character layers. Each layer contains one type of ASCII code character, for example, the ego layer only consists of the ego vehicle(E), the other car layer consists of all other vehicles(C), and lane information is presented in the lane layer.

With the above conditions, the driving behavior model is obtained by the reinforcement learning algorithm proximal policy optimization (PPO) with convolutional neural network as feature extractor. We presented that the obtained driving behavior model can control the vehicle in 3d autonomous driving simulator and complete the task scenario with proper driving behavior. In addition, the proposed layered state expression has been shown is able to improve the learning efficiency and have better performance than using one layer expressing surroundings of ego vehicle.

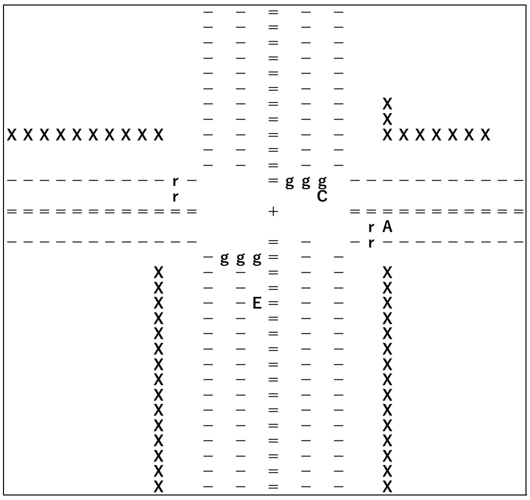

Fig. 1 Proposed state expression

character	
E	EGO Vehicle
A	Emergency Vehicle (ex. ambulance)
C	General Vehicle
s	Stop Line
g	Traffic signal - green light
y	Traffic signal - yellow light
r	Traffic signal - red light
-, =	lane
X	other objects

Table 1 Legend of state expression

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