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PEDESTRIAN COLLISION AVOIDANCE USING DEEP REINFORCEMENT LEARNING

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ABSTRACT–The use of intelligent systems to prevent accidents and safety enhancement in vehicles is becoming a requirement. Besides, the development of autonomous cars is progressing every day. One of the main challenges in transportation is the high mortality rate of vehicles colliding with pedestrians. This issue becomes severe due to various and abnormal situations. This paper proposes a new intelligent algorithm for pedestrian collision avoidance based on deep reinforcement learning. A deep Q-network (DQN) is designed to discover an optimal driving policy for pedestrian collision avoidance in diverse environments and conditions. The algorithm interacts with the vehicle and the pedestrian agents and uses a specific reward function to train the model. We have used Car Learning to Act (CARLA), an open-source autonomous driving simulator, for training and verifying the model in various conditions. Applying the proposed algorithm to a simulated environment reduces vehicles and pedestrians' collision by about 64 %, depending on the environment. Our findings offer an early-warning solution to mitigate the risk of a crash of vehicles and pedestrians in the real world.

KEY WORDS : Pedestrian collision avoidance, Autonomous driving, Deep reinforcement learning, Car Learning to Act (CARLA), Deep Q- Network (DQN)

NOMENCLATURE

S	: state space
A	: action space
P	: probability function
R	: reward function
θ	: network weights
α	: learning rate, dimensionless
γ	: discount factor, dimensionless
L_S	: safe distance, m
V	: velocity, m/s
X, Y	: position coordinate, m
θ_{ped}	: pedestrian crossing angle, degree
O	: overall risk, dimensionless
K	: risk degree, dimensionless

1. INTRODUCTION

Nowadays, there is a severe threat of pedestrians' collision by increasing traffic and the number of vehicles. Hence, the focus of research has shifted to pedestrian protection methods versus vehicles, such as fatigue driving detection (McDonald *et al*., 2018), driver emotion detection (Kanarachos *et al*., 2018), energy-absorbing bumper (Li *et al*., 2017b), and composite engine hood (Yin *et al*., 2018). Another motivation is the increasing interest in developing and using self-driving cars. One of the main challenges in self-driving vehicles is to provide safety and security for pedestrians (Wang *et al*., 2019a). Safety has a high priority in fully autonomous driving vehicles. For safe autonomous driving, vehicles should perceive the environment using the sensors and travel to the destination without any accidents (Badue *et al*., 2020). Since it is inevitable for an autonomous vehicle to encounter unexpected and high-risk situations, it is crucial to developing reliable, independent control systems that can cope well with such uncertainties.

Human-centric detection is an essential field in robotics and computer vision, including applications such as face recognition, the automotive industry, and surveillance (Lin *et al*., 2020). Many efforts have been made to improve human safety and reduce collisions and injuries in automobile transportation. One of the most dangerous accidents is pedestrians' collisions since they do not have facilities to minimize damages. Unfortunately, pedestrians' crash has a significant percentage of accident casualties. Studies indicate that 34 % of accident deaths are related to pedestrians hit (Anowar *et al*., 2008). In 2016, a survey showed that among 25,000 deaths in traffic-related accidents in Europe, 21 % of fatalities were pedestrians (Lucidi *et al*., 2019).

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