# REINFORCEMENT LEARNING BASED DECISION-MAKING MODEL IN AUTONOMOUS VEHICLE CONTROL FOR COOPERATION AND MITIGATION OF COLLISION AMONG MULTIPLE VEHICLES

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We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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**STUDENTS'S DECLARATION**

I hereby declare that the work in this thesis/project is my own for quotations and summaries which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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# Reinforcement Learning Based Decision-Making Model in Autonomous Vehicle Control for Cooperation and Mitigation of Collision Among Multiple Vehicles

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The work for this thesis has been conducted at the Robotics and AI Lab at Universiti Malaysia Pahang (UMP). Since I have been able to investigate a wide range of machine learning and robotics research areas:

- *Sensing and Prediction:* The Unity 3D game engine offers synthesis images captured by its fleet of self-driving cars.For each timestep, a set of five images provides visual information from different angles, and image stitching methods provide a complete panorama image of the car's surroundings. This was my work for the first phase of this experiment.
- *Reinforcement Learning for Decision-Making:* A novel learning-based strategy for the collision avoidance problem among multiple vehicles is presented, which is based on a trial-and-error approach. It is this work that is the subject of this thesis. For this project a new traffic simulator was created, which was the open sourced at [Github][17].

My studies at UMP have proved to be essential to tackle the challenges that raised during the project. To be more precise, my extensive study of learning-based methods for sequential decision-making strategies, system dynamics, automatic control, and machine mechanisms has provided me with a lot of expertise. Consequently, the theory and informative courses in the degree of computing were incredible insights into statistics, probability, algorithms, and implementations in computer science.

# ABSTRAK

Kereta pandu sendiri telah menjadi topik penyelidikan yang popular sejak beberapa tahun kebelakangan ini. Pemanduan autonomi ialah bidang pengajian yang rumit yang melibatkan pelbagai disiplin, seperti elektronik, penglihatan komputer, geo-lokasi, membuat keputusan atau kawalan. Kenderaan autonomi ialah contoh teknologi bukan linear yang digunakan dalam dunia sebenar. Mengawal peranti jenis ini dalam situasi tertentu dalam konteks sistem trafik berbilang ejen adalah sukar kerana ketidakstabilan. Peralatan jenis ini memerlukan kepakaran, dan lebih sukar untuk mewujudkan pemahaman bakat ini sebagai sistem kawalan bebas. Oleh kerana setiap ejen mempunyai pengurusan keputusan protokol yang ditentukan sendiri, adalah sukar untuk menyelaraskan beberapa peranti autonomi pada satu kerja. Sepanjang dekad yang lalu, terdapat banyak perhatian terhadap pembuatan keputusan berurutan di bawah kekaburan dan ketidakpastian, yang merupakan pelbagai cabaran yang berbeza yang memerlukan ejen berinteraksi dengan persekitaran yang tidak menentu untuk mencapai sasaran. Kaedah pembelajaran pengukuhan yang digunakan untuk cabaran ini telah menghasilkan pencapaian AI baru-baru ini dalam robotik, permainan permainan dan bidang lain. Sebagai tindak balas kepada testimoni empirikal ini, projek ini menghadapi masalah keputusan kawalan kenderaan berbilang dan melaksanakan strategi kawalan untuk mengelakkan perlanggaran kenderaan berbilang teruk dalam kenderaan autonomi. Teknik kawalan ini bergantung pada model pembelajaran pengukuhan dan menggunakan dua senario trafik yang berbeza untuk memajukan aliran penyelidikan. Taksonomi yang meluas menyampaikan protokol dan penyelesaian sedia ada, dan model konsep untuk MVCCA telah dirumuskan terlebih dahulu. Kemudian, menggunakan model PReinforcement Learning-based Decision-Making (RLDM), sistem dibangunkan dan dilaksanakan. Simulasi yang meluas memberikan kita hasil terbaik untuk pembangunan strategi pemanduan optimum dalam persekitaran trafik berbilang ejen. Kami menilai secara meluas prestasi latihan, prestasi pemanduan dan keupayaan mengelak perlanggaran juga. Kami menyiasat prestasi latihan kedua-dua kenderaan tunggal dan pelbagai persekitaran kenderaan.

## ABSTRACT

Self-driving cars have become a popular research topic in recent years. Autonomous driving is a complicated field of study that involves a variety of disciplines, such as electronics, computer vision, geo-location, decision-making, or control. Autonomous vehicles are an example of non-linear technologies being used in the real world. Controlling this kind of device in particular situations in the context of multi-agent traffic systems is difficult because of instability. This type of equipment demands expertise, and it is even more difficult to create this understanding of talent as an independent control system. Because each agent has its own self-determined protocol decision management, it is hard to coordinate several autonomous devices on a single job. Over the last decade, there has been a lot of attention on sequential decision-making under ambiguity and uncertainty, which is a distinct range of challenges requiring an agent to interact with an uncertain environment to achieve a target. Reinforcement learning methods applied to these challenges have resulted in recent AI achievements in robotics, game playing, and other areas. In response to these empirical testimonies, this project confronts the problem of multiple vehicle control decisions and performs control strategies for the avoidance of severe multiple vehicle collisions in autonomous vehicles. These control techniques rely on the reinforcement learning model and deploy two distinct traffic scenarios for progressing research flow. An extensive taxonomy conveyed the existing protocols and solutions, and a conceptual model for MVCCA was formulated first. Then, using the Reinforcement Learning-based Decision-Making (RLDM) model, the system is developed and implemented. An extensive simulation gives us the best outcomes for the development of optimum driving strategies in a multi-agent traffic environment. We extensively evaluate the training performance, driving performance, and the ability of collision avoidance as well. We investigated the training performance of both the single vehicle and multiple vehicle environments. Validation of the decision-making scheme would create new opportunities for autonomous driving, as well as new concepts and applications.

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