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# Introductory Chapter: Roles of Path Planning in Providing Reliable Navigation and Control for Autonomous Vehicles and Robots

*Umar Zakir Abdul Hamid, Volkan Sezer, Bin Li,  
Yanjun Huang and Muhammad Aizzat Zakaria*

## 1. Introduction

Shared, connected, and driverless vehicles have been the discussion of many researchers, and autonomous vehicle (AV) itself is considered as a highly disruptive emerging technology. One of the examples of its disrupting feature is when 11 major automotive companies which include BMW, Daimler and Volkswagen have collaborated and published a white paper entitled “Safety First for Automated Driving” in 2019 to address the topic [1]. With the predicted market value of US\$7 Trillion by 2050 for the automated driving segments, it is hard to ignore the highly disruptive effects that the AV will deliver [2, 3]. In addition to the ongoing development of the autonomous vehicles’ platforms, to complement for its expanding advancement, the discussion is also now reaching other topics such as the mobility-as-a-service (MaaS), city infrastructures as well as policy-making [4–6].

## 2. How does autonomous vehicle work?

Generally, in addition to the hardware requirements, a high-level autonomous vehicle software module comprises of the perception and vision, localization and mapping as well as the guidance, navigation and control modules (**Figure 1**). The combination of these modules yields an ability to compensate for the driver’s absence during the navigation. AV, in any case, should possess the ability to measure the risk surrounding its environment as well as guiding the vehicle motion. In addition, a driverless vehicle is also expected to compensate for the absence of a human driver by possessing the required intelligence to mimic the human driving behavior of the vehicle.

The smooth and comfortable automated driving experience requires the expertise of interdisciplinary fields, which includes the development of required hardware and software integration. In the case of road navigation of an autonomous vehicle, the vehicle is typically expected to navigate independently during the entire

driving process. This implies that the vehicle is fully responsible for preventing any unwanted incidents.

In a controlled environment, the use of predefined information of the environment is usually sufficient. However, in the risky scenario that demands the AV to react to its environment, the usage of dependable path planning strategies to replan its current reference or trajectory is demanded.

3. Path planning

Path planning (PP) is the computation of a maneuverable path from an initial point to a terminal point, which the host vehicle or robots tracks and follows [8, 9]. Despite much of the works done in the PP fields for autonomous robots and vehicles, real-time implementation still possesses some challenges. This is due to the dynamic nature of the environment of the real world. For example, a road that is usually traversable can abruptly be having a continuous change in a construction site. This requires dependable PP for AV to provide reliable reference path for the vehicle. In addition, for the discussion of autonomous mobile robots, the maneuver in the narrow scattered environment is also a challenge. Thus, PP does not only revolve on the topics of moving from point A to B, but instead, the challenges are of large scales.

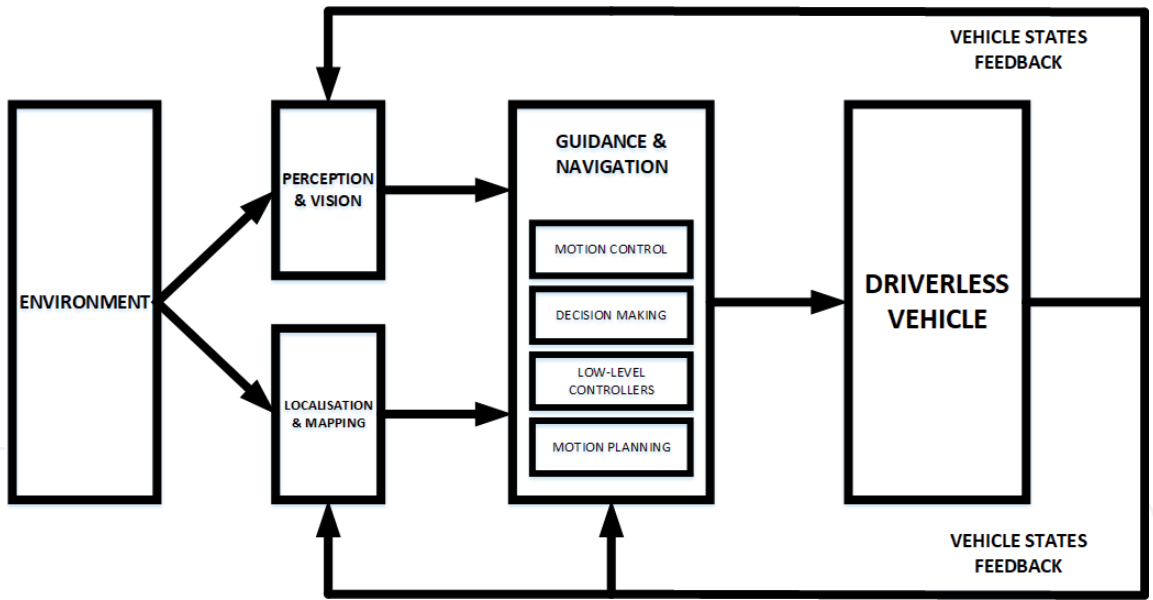


Figure 1. Modules of driverless vehicles [7].

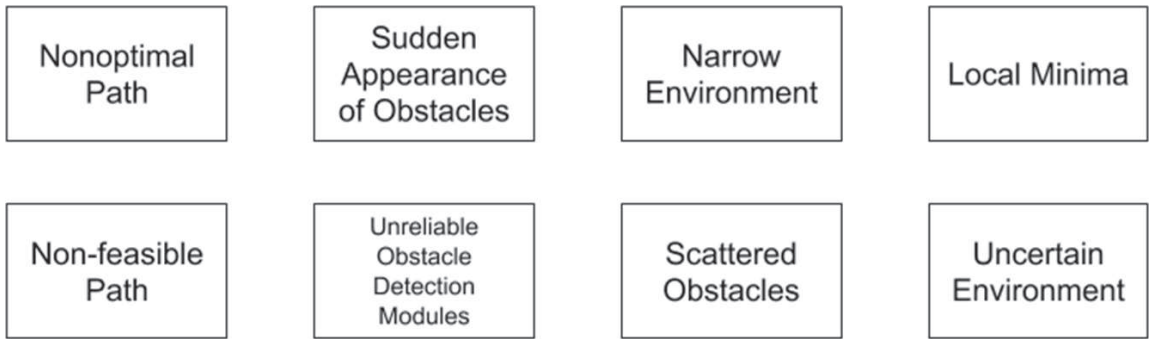


Figure 2. Challenges and issues for path planning of autonomous vehicles [12–14].

### **3.1 Challenges of path planning**

Due to the rapid progress of works done in recent years, the implementation and validation of AV development have been performed in varied environments, which include harsh-weather conditions and city environment, among many others [10, 11]. These studies have led to the identification of previously known and new issues in the path planning topics, with some of them being highlighted in **Figure 2**. For brevity, details of the listed issues can be found in the following references [12–14]. Thus, to ensure reliable and safe navigation by AV and autonomous robots, it is evident the necessity to understand the topics of PP.

### **4. Aim of the book and its organization**

Realizing the importance of the path planning topic for autonomous vehicles and robots, this book is written. With the open-access publication concept, the book is hoped to give the introductory ideas to the researchers and the general audience about the topics. It is co-edited by researchers who have worked extensively in the field of autonomous vehicles and robots from Finland, Turkey, USA, Canada as well as Malaysia.

It is important to be mentioned that this book does not aim to solve and highlight each of the available PP issues. But instead, it tries to present as many topics and issues as possible to give the wide idea of path planning. As automation of the vehicles does not only cover the road vehicles, the book will also cover the autonomous vehicle for the off-road, military, and unmanned aerial vehicles (UAV). Despite the different type of vehicle and robot, the ethos of the discussions can still be adapted to the varied platforms.

### **5. Conclusion and expectations**

We hope this introductory chapter and the book will be able to indicate and give ideas on the issues related to PP topics, where the authors explore the topics of PP in the context of road vehicles, robots, off-road scenario, multi-robot motion, and UAVs.

For further reading following the discussions in this book (which serve as the introductory ideas for new researchers), we are recommending the topics of path planning as an active safety feature of AV, which includes the collision avoidance theme, among many others. We believe the knowledge of path planning will help researchers in developing safer collision avoidance system for AV.

Concluding, for a wide implementation of AV to be seen, the questions are not limited to “Can it be done?” but instead, the real question is “How do we do it safely?”. And the discussion of PP is one of the prerequisites of a safe AV. With the open access nature of the book, it is hoped that the discussion reaches as much as possible audience.

### **Acknowledgements**

The editors would like to thank all the reviewers and authors involved in the works.

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## Author details

Umar Zakir Abdul Hamid<sup>1\*</sup>, Volkan Sezer<sup>2</sup>, Bin Li<sup>3</sup>, Yanjun Huang<sup>4</sup>  
and Muhammad Aizzat Zakaria<sup>5</sup>

1 Sensible 4 Oy, Finland

2 Istanbul Technical University, Turkey

3 Aptiv PLC, United States of America

4 University of Waterloo, Canada

5 Universiti Malaysia Pahang, Malaysia

\*Address all correspondence to: umar.hamid@sensible4.fi

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