Chapter 5
Artificial Intelligence in Navigation Systems

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ABSTRACT

The computer-based navigation system computes the object's position, speed, and direction in real-time. In the last decades, many researchers, companies, and industries have been working on improving the existing navigation system due to its vast application in military and civilian activities. Typically, navigation systems are based on integrating inertial navigation systems and global positioning systems using a Bayesian filter, like the Kalman filter. The limitations of the Kalman filter have inspired researchers to consider alternatives based on artificial intelligence. Recently, many types of research have been developed to validate the possibility of using artificial intelligence methods in navigation systems. This chapter aims to review the integration of artificial intelligence techniques in navigation systems.

INTRODUCTION

A navigation system is a computing system that assists in navigation. Usually, these systems can be implemented entirely on vehicles or other transportation machines. In addition, they can be located elsewhere and control the machine by utilizing radio or other transmission signals. In certain circumstances, a fusion of these methods can be used (Duffany, 2010).

Nowadays, navigation systems use Global Positioning Satellites (GPS) to point the machine or vehicle's location. They compare the associated location with the desired destination and guide along the right road (Hasan, Samsudin, Ramli, Azmir, & Ismaeel, 2009). GPS navigation systems are usually combined with stored map information to choose the optimal road based on the shortest path algorithm.

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This technique successfully gets to the destination in a reasonable time. It is also faulted tolerant because it can spontaneously relocate the destination in case of error (Huang, Tsai, & Huang, 2012). The major inconvenience of using GPS in navigation systems is satellite signal blockage in urban areas where position errors may range from 100 to 300 m (Grewal, Andrews, & Bartone, 2020). GPS is usually integrated with an inertial measurement unit of three accelerometers and three gyroscopes to overcome this problem. These inertial sensors are inside the vehicle to provide its position, velocity, and heading angle. This overall system is inertial navigation (INS) (Britting, 2010). In addition, the Kalman filter (KF) is used to extract the location from GPS, INS, and map information. Recently, the limitations of KF have inspired researchers to consider alternative methods by combining artificial intelligence (AI), INS, and GPS (Al Bitar, Gavrilov, & Khalaf, 2020).

Artificial intelligence (AI) represents the ability of digital systems or robots to act like humans and perform tasks related to intelligent beings. According to John McCarthy (2019), the father of AI, artificial intelligence is defined as *the science and engineering of making intelligent machines and brilliant computer programs*. Additionally, the word artificial in AI stands for human-created; the word intelligence represents the power of thinking. Therefore, AI is a machine with thinking power (Jokanoviж, 2022).

Recently, AI techniques such as neural networks (NN) and multilayer perceptron (MLP) have been used in INS (Haid, et al., 2019). In (Zhang & Xu, 2012), the authors have proved that position and velocity update architecture based on two MLP networks can manipulate INS data and provide the location for east and north directions.

This chapter is composed of four sections. The different techniques used in navigation systems are presented in the following section. Later, the different AI systems are described, followed by exciting research on AI techniques in the navigation sector afterward. Finally, a conclusion about the importance of using AI in navigation systems is represented.

NAVIGATION SYSTEMS

The navigation system is a computer-based system embedded in a vehicle or any mobile device that delivers a real-time value of its current location. Recently, many researchers have focused on developing navigation systems due to their importance in civilian and military applications. Modern navigation systems using different electronic sensing devices (sensors) have been developed since the 1960s. These systems combine independent navigation sensors such as inertial measurement units, Doppler radar, and radio position fixed devices to collect the available information to produce a continuous position of the navigated object. Nowadays, microprocessors are integrated with current navigation systems to produce more accurate results (Hasan, Samsudin, Ramli, Azmir, & Ismaeel, 2009). Figure 1 shows the basic structure of navigation systems. The information collected by inertial navigation system (INS) sensors is combined with the position given by the global positioning system (GPS) receiver using a Kalman filter (KF) to give an accurate estimation of the object's position. Usually, a digital map and estimation position are combined to give the object's current position using a map matching technique.