ME462 Literature Review

Group MAMBA

1. Abstract

In the present world, electrical vehicles have gained high attention due to their cost-efficient and environmentally friendly capabilities. As the number of EVs is increasing, their charging features become completely significant. There are, also, autonomous driving features included in some EVs. A large range size of autonomous drive systems is getting more popular in today's world. Our mission, in this paper, is to first analyze the past academic studies conducted on state-of-the-art autonomous EVs. Then, we will develop a new conceptual design of a digital-twin autonomous EV by considering both virtual/real world interaction and wireless charging mechanisms after demonstrating some of the sample robots already available on the internet.

2. Introduction

Electrical vehicles have been becoming part of our daily lives. There are EVs seen both as large public vehicles and sport cars. Given that it is getting more interesting to encounter different types of EVSs in urban life. Recently, the academicians have become more interested in EV concept due to its unique nature of electricity utilization. Indeed, the opportunity of numerous developing ideas make the area competitive. To illustrate, the batteries and their charging systems gained the main attention since it is a challenging objective to develop new methods. Moreover, digital twin creating is considered as the number one method to test the control system of up-to-date autonomous EVs. These two features require more challenging design steps since the it is needed to analyze the precise positioning for effective wireless charging while the safety necessities must be fully satisfied to avoid the risk of pedestrians in urban life. In this literature review, we analyze past studies on EV charging and X-In-the-Loop. After that, we will demonstrate the sample available robots on the internet. Then, our unique design will be discussed based on the hardware, simulation platform selection and the sample work-flow diagram design.

3. Literature Review

3.1. Pololu 3pi

The Pololu 3pi is a small, low-cost robot platform that uses two motors and a pair of wheels to move around. It measures just 9.5 cm in diameter and includes a suite of sensors, such as an array of line sensors and an accelerometer. The robot is designed to be easy to program and can be controlled using a variety of methods, including remote control and autonomous navigation.

3.1.1. Advantages:

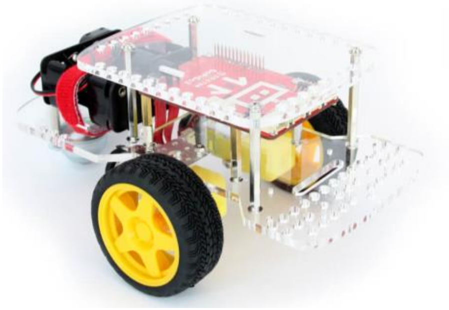
- **Low cost:** The Pololu 3pi is a relatively inexpensive robot platform, making it accessible to a wide range of users, including hobbyists and students.
- Compact size: The robot's small size makes it easy to transport and use in a variety of environments.
- **Suite of sensors:** The 3pi includes a variety of sensors, such as an array of line sensors and an accelerometer, which allow it to perform a range of tasks, including line following and obstacle avoidance.
- **Easy to program:** The robot is designed to be easy to program, with support for a variety of programming languages, including C++ and Python.
- **Versatile:** The 3pi can be controlled using a variety of methods, including remote control and autonomous navigation, making it useful for a wide range of applications.

3.1.2. Disadvantages:

- **Limited sensor range:** While the 3pi includes a variety of sensors, its range is limited compared to more advanced robot platforms.
- **Limited computing power:** The robot's computing power is limited, which can make it difficult to perform more advanced tasks.
- **Limited battery life:** The robot's battery life is relatively short, which can limit its use in extended projects or applications.

Overall, the Pololu 3pi is a useful and versatile robot platform that is well-suited to a wide range of applications. Its low cost and small size make it accessible to a wide range of users, while its suite of sensors and ease of programming make it useful for a variety of tasks. However, its limited computing power and sensor range may limit its use in more advanced applications.

3.2. GoPiGo



The GoPiGo is a Raspberry Pi-powered robot kit that uses two motors and wheels to move around. It includes a variety of sensors, such as a camera, distance sensor, and line follower sensor. The robot is designed to be easy to assemble and program and can be controlled using Python programming language.

3.2.1. Advantages:

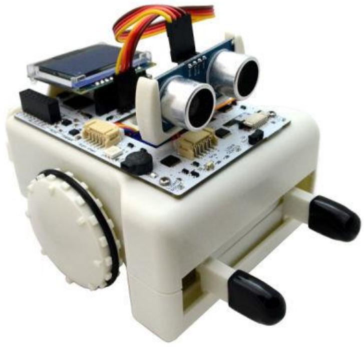
- **Easy to use:** The GoPiGo is designed to be easy to assemble and program, making it a great choice for beginners and students.
- **Versatile:** The robot includes a variety of sensors, such as a camera, distance sensor, and line follower sensor, which allow it to perform a range of tasks, from line following to object detection and even vision-based tasks.
- **Compatible with Raspberry Pi:** The robot is powered by a Raspberry Pi, which makes it easy to program and extend using the Raspberry Pi ecosystem.
- **Large community:** GoPiGo has a large and active community, which means there is a wealth of resources and support available for users.
- **Open source:** The robot is open source, which means users can modify and customize it to fit their specific needs.

3.2.2. Disadvantages:

- **Cost:** The GoPiGo is relatively expensive compared to other small robot platforms, which can be a barrier for some users.
- **Limited battery life:** The robot's battery life is relatively short, which can limit its use in extended projects or applications.
- **Limited computing power:** While the Raspberry Pi is a powerful computer, the GoPiGo's computing power is limited compared to more advanced robot platforms.
- **Requires some technical knowledge:** While the robot is designed to be easy to use, it still requires some technical knowledge to set up and program.

Overall, GoPiGo is a versatile and powerful robot platform that is well-suited to a range of applications. Its compatibility with Raspberry Pi and large community of users makes it a popular choice for hobbyists and students. However, its cost and limited computing power may be a barrier for some users, and its short battery life may limit its use in extended projects or applications.

3.3. Sparki



The Sparki is a small, Arduino-compatible robot platform that uses two motors and wheels to move around. It includes a variety of sensors, such as a line follower sensor, ultrasonic range finder, and light sensor. The robot is designed to be easy to program and can be controlled using a variety of methods, including remote control and autonomous navigation.

3.3.1. Advantages:

- **Arduino-compatible:** The Sparki is compatible with the popular Arduino platform, which means it can be programmed using a wide range of programming languages, including C++ and Python.
- **Versatile:** The robot includes a variety of sensors, such as a line follower sensor, ultrasonic range finder, and light sensor, which allow it to perform a range of tasks, from line following to obstacle avoidance.
- **Easy to use:** The Sparki is designed to be easy to assemble and program, making it a great choice for beginners and students.
- **Affordable:** The Sparki is relatively inexpensive compared to other small robot platforms, which makes it accessible to a wide range of users.
- **Large community:** The Sparki has a large and active community, which means there is a wealth of resources and support available for users.

3.3.2. Disadvantages:

- **Limited computing power:** The robot's computing power is limited compared to more advanced robot platforms, which can make it difficult to perform more advanced tasks.
- **Limited sensor range:** While the Sparki includes a variety of sensors, its range is limited compared to more advanced robot platforms.
- **Limited battery life:** The robot's battery life is relatively short, which can limit its use in extended projects or applications.

Overall, the Sparki is a versatile and affordable robot platform that is well-suited to a range of applications. Its compatibility with Arduino, large community of users, and ease of use make it a popular choice for hobbyists and students. However, its limited computing power and sensor range may limit its use in more advanced applications, and its short battery life may limit its use in extended projects or applications.

3.4. Romi

The Romi is a small robot platform developed by Pololu that uses two motors and wheels to move around. It includes a variety of sensors, such as a line follower sensor, reflectance sensor array, and gyro and accelerometer. The robot is designed to be easy to program and can be controlled using a variety of methods, including remote control and autonomous navigation.

3.4.1. Advantages:

- **Versatile:** The robot includes a variety of sensors, such as a line follower sensor, reflectance sensor array, and gyro and accelerometer, which allow it to perform a range of tasks, from line following to maze solving.
- **Compatible with Arduino:** The Romi is compatible with the popular Arduino platform, which means it can be programmed using a wide range of programming languages, including C++ and Python.
- **Easy to use:** The Romi is designed to be easy to assemble and program, making it a great choice for beginners and students.
- **Large community:** The Romi has a large and active community, which means there is a wealth of resources and support available for users.
- **Expansion options:** The Romi includes a variety of expansion options, including additional sensors and modules, which allow users to customize the robot for specific tasks.

3.4.2. Disadvantages:

- **Limited battery life:** The robot's battery life is relatively short, which can limit its use in extended projects or applications.
- **Limited computing power:** The robot's computing power is limited compared to more advanced robot platforms, which can make it difficult to perform more advanced tasks.
- **Limited sensor range:** While the Romi includes a variety of sensors, its range is limited compared to more advanced robot platforms.

Overall, Romi is a versatile and affordable robot platform that is well-suited to a range of applications. Its compatibility with Arduino, large community of users, and ease of use make it a popular choice for hobbyists and students. However, its limited computing power and sensor range may limit its use in more advanced applications, and its short battery life may limit its use in extended projects or applications.

3.5. Zumo Robot

The Zumo robot is a small differential drive robot developed by Pololu. It measures only 98mm by 98mm and is designed for line-following and maze-solving applications. The Zumo includes a variety of sensors, including proximity sensors, an accelerometer, and a gyro, making it a versatile platform for experimentation and learning.

3.5.1. Advantages:

- **Small size:** The compact size of the Zumo makes it ideal for small spaces and for use in classrooms or educational environments where space may be limited.
- **Versatile sensors:** The Zumo includes a variety of sensors, including proximity sensors, an accelerometer, and a gyro, making it a great platform for learning about sensor integration and control.
- **Affordable:** The Zumo is an affordable robot, making it accessible to hobbyists, students, and educators who may not have large budgets.

3.5.2. Disadvantages:

- **Limited power:** The Zumo is powered by two micro metal gearmotors, which may not provide enough power for more advanced applications or for carrying heavier payloads.
- **Limited expandability:** While the Zumo includes a variety of sensors, its small size may limit the ability to add additional sensors or hardware to the robot.
- **Limited application:** Zumo is primarily designed for line-following and maze-solving applications, which may not be suitable for all robotics projects.

Overall, the Zumo robot is a great platform for experimentation and learning about robotics, particularly for line-following and maze-solving applications. While it may have some limitations in terms of power and expandability, its small size, versatility of sensors, and affordability make it a great choice for hobbyists, students, and educators.

4. State-of-the-Art Technologies

There are several autonomous drive simulation analyses available on the internet. The simulation platforms vary from Webot platform to Siemens PLM software. While the critical analyses can be simulated on SYS1 to SYS8, Unity Engine 3.0 is becoming also a very useful software for autonomous drive tests. (Szalay, 2020) Virtual simulations can create a realistic and case-sensitive approach. Especially, when we take the careless pedestrian scenario into account, sensor and brake control system must be executed immediately. Although computational time can consist of error compared to the real-life vehicle, sufficiently similar results are achieved by Hardware-In-the-Loop utilization. (Baruffa and Pereira, 2020) Despite that, Zofka et.al. (2018) proved that unexpected environmental actions can be accurately simulated with multi-Lidar set up.

Autonomous driving systems bring human safety into consideration. While following the front vehicle from a safe distance is a hard task, sudden encounter with a pedestrian is totally a crucial subject of study. Indeed, Baruffa and Pereira (2020) used aruco markers to provide virtual duties to robots as bus and ordinary vehicle and, he analyzed whether the rear autonomous driven vehicle protect the safety distance with the front bus. Robot operating system, here, was used to arrange all the sensor actuation and the communication between the virtual and real world. Safety became a significant concern. To satisfy the standards in this area, there are a large number softwares on the market such as Siemens PLM, Webot, Unity Engine and SYS1-8. (Szalay, 2020)

The batteries and their charging are another important issue. Charging approaches have become diverse in EV field. To illustrate, while the drivers used cables to charge their cars initially, the present aspect has become wireless charging set up. (Khudwar and Gaur, 2016) Although cable usage used to be an applicaple way to deal with charging, it has become an impractical approach. Wireless charging, therefore, has gained attention.

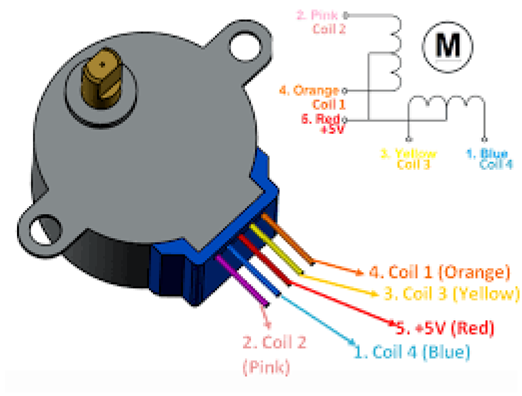
There are multiple wireless EV charging methods developed during the last decade. Inductive power transfer (IPT) is one of the most common ways to build a wireless EV charging set up. It is fundamentally based on Faraday's Inductive Law where the energy is transferred by the magnetic waves. Inductive coupling is made of use of in this approach. (Khudwar and Gaur, 2016) There were even some futuristic inventions having both sides charging multiple vehicles simultaneously. (Swain et. al., 2012)

Although the cables could be completely avoided in this way, time was taken into account as another important parameter. In other words, IPT requires a considerable amount of time for drivers. In order to avoid this time-waste, Santhosh and Vasanthaseelan (2019) conducted a study on developing a road charging system. Their objective was to eliminate the time waste of IPT way. To achieve that, they built a model consisting of Aluminum Road which was the conductive element of the model. While a mini-car was moving, it was charged below 45% of battery charge. Therefore, they developed a unique method to charge the cars in motion by using mutual induction principle.

5. Concept Design

5.1. Differential Drive

28byj-48 stepper motor might be used as the differential drive. The motor specifications are as follows:



- Step angle: 5.625 degrees/64 steps
- Rated voltage: 5V DC
- Number of phases: 4
- Coil resistance: 50 ohms per phase
- Gear ratio: 1/64
- Holding torque: 300 gf-cm (0.03 N-m)
- Maximum pull-in rate: 1200 pps
- Maximum pull-out rate: 1600 pps
- Dimensions: 28mm diameter, 19.5mm body length, 9mm shaft length

5.2. Battery

Different types of batteries might be implemented to the system such as LiPo, LiFePO4. LiFePO4 and LiPo batteries are both common types of lithium-ion batteries used in robotics and other electronic devices. While LiPo batteries have a higher energy density and are lighter in weight, LiFePO4 batteries are considered safer, have a longer cycle life, and are less prone to thermal runaway. LiFePO4 batteries also have a lower nominal voltage, which can make them slightly larger and heavier than LiPo batteries for the same capacity. Additionally, LiFePO4 batteries are generally more expensive than LiPo batteries due to their higher safety and longer lifespan.

5.3. Charger

While charging the system, wireless charging modules might be used. Wireless charging modules for LiPo and LiFePO4 batteries are available in the market, and some examples include the TP4056 Wireless Charger Module, Qi Wireless Charging Module, PowerCast Wireless Charging Module, and Adafruit Universal Qi Wireless Receiver Module. These modules can be used with wireless charging transmitters to charge the batteries wirelessly, and they support different input voltages and charging standards.

Also, magnetic connection might be used while charging the system. In this application, the detachment might be challenging due to the torque requirement for the detachment.

5.4. PCB Design

There will be two PCBs in the design. The first one is the battery and charger PCB, and the other one is the main PCB which holds the controller, motor driver, LEDs, and other required electrical components.

5.5. Add-on Components

5.5.1. OLED Screen

In the system OLED screen might be implemented in case of the user desires. This component should not be mandatory for the working of robot. The user should be able to use it if he/she wants.

5.5.2. Additional Sensors

Some sensors such as IMU might be implemented to the system if the user wants to use it.