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Improvement of the break and steering system for the golf-cart

Rami Raed Mustafa

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Abstract

This project aims to gain knowledge and test theories related to autonomous vehicles using an electric golf cart as a test platform. There are several goals set, including obtaining electrical and controls experience related to autonomous driving and expanding their electrical engineering skills. The project has the potential to benefit the general population, as the electric golf cart shares similar attributes to a motor vehicle. Through diligent work and research, three key objectives have been achieved: transforming the previous single Arduino system into two mega Arduinos, reconfiguring the placement of the steering motor, and implementing an emergency braking system. Improving the golf cart's steering, voltage regulator "throttle," and braking system using sensors to address existing complications. The primary goal is to use remote control to test applications instead of LiDAR, supporting future plans to make the project autonomous.

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IMPROVEMENT OF THE BRAKE AND STEERING SYSTEM FOR THE GOLF-CART

By

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ABSTRACT

This project aims to gain knowledge and test theories related to autonomous vehicles using an electric golf cart as a test platform. There are several goals set, including obtaining electrical and controls experience related to autonomous driving and expanding their electrical engineering skills. The project has the potential to benefit the general population, as the electric golf cart shares similar attributes to a motor vehicle. Through diligent work and research, three key objectives have been achieved: transforming the previous single Arduino system into two mega Arduinos, reconfiguring the placement of the steering motor, and implementing an emergency braking system. Improving the golf cart's steering, voltage regulator "throttle," and braking system using sensors to address existing complications. The primary goal is to use remote control to test applications instead of LiDAR, supporting future plans to make the project autonomous.

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INTRODUCTION

Autonomous vehicles have been a hot topic in recent years, as they have the potential to revolutionize transportation by increasing safety, efficiency, and reducing emissions. In this project, you aim to explore this technology by utilizing an electric golf cart as a test platform. This vehicle is small and eco-friendly, making it a suitable choice for testing theories related to autonomous vehicles. Furthermore, this project intends to modify the golf cart's steering and braking systems to allow for autonomous operation. This modification will necessitate a thorough understanding of the vehicle's mechanical and electrical systems, as well as the development of software to control the vehicle's movement. With these changes in place, you can put various theories about autonomous vehicle technology to the test and gain valuable insights into this exciting field.

This project aims to gain technical expertise in the field of autonomous driving while also testing theories on a practical platform. The team intends to use their prior knowledge in electrical and controls engineering to broaden their skill set, while also benefiting the larger community through the possibility of safer, more efficient transportation. The project's main goals include converting the previous single Arduino system into two mega Arduinos for improved control and accuracy of the golf cart's movements, relocating the steering motor for improved efficiency, and implementing an emergency braking system to ensure passenger and bystander safety.

This project also aims to improve the golf cart's steering, voltage regulator "throttle," and braking system by utilizing sensors to address existing complications. The team intends to test applications using remote control rather than LiDAR, which will help them achieve their long-term goal of making the project self-sufficient. This project has helped to gain hands-on

experience and knowledge in the field of autonomous driving while testing practical applications. This project's findings could help to advance autonomous vehicle technology and the transportation industry as a whole.

SPECIFICATIONS

2.1 Customer Needs

The primary objective of this project is to develop a remote-controlled golf cart that emulates the experience of autonomous driving. The main aim is to create a golf cart that can navigate to predetermined destinations without requiring manual input from the driver. While a human operator will be necessary to steer the vehicle, the addition of sensors and software will create an environment that replicates autonomous driving conditions.

The potential benefits of autonomous driving have been widely documented, with studies showing a reduction in risky and dangerous driver behavior when control is relinquished to an automated system. While the golf cart will not be fully autonomous, it will provide an opportunity to test theories related to this technology and develop a practical platform for future research. Through the development of this remote-controlled golf cart, the goal is to contribute to the advancement of autonomous vehicle technology and pave the way for safer, more efficient transportation. The insights gained from this project could inform future developments in the field and contribute to the realization of a fully autonomous driving future.

Table 1: Customer Needs

Number	Customer Need	Description
1	Emergency Stop/Manual Override	The vehicle must have the ability to be manually controlled and stopped by the operator in case of any potential accidents or errors.
2	Easy-to-Use Design	The system must be simple and efficient, allowing for ease of use by all customers.
3	Stable Steering/ Braking System	The vehicle's steering and braking systems must be stable, reliable, and safe to ensure proper control of the vehicle.
4	Reliable Sensors and Equipment	The sensors and equipment used in the vehicle must be reliable and easily accessible to customers in case of any maintenance or repair needs.

2.2 Importance of Needs

The project proposal has identified various customer needs that will be addressed by improving the steering, acceleration, and braking of the golf cart through remote control. Additionally, an emergency stop function will be created to ensure safe driving. The design will be robust and simple, making it user-friendly. The project will leave room for future improvements and research. To meet the group's objectives, the team will focus on improving the steering and braking systems to provide a stable and reliable solution for customers. The sensors used will be highly reliable and easily available for purchase. Table 1 shows the relative importance of customer needs, where 3 is the highest priority.

In addition to improving the steering, acceleration, and braking through remote control, the group also aims to create a seamless emergency stop function for both the remote driver and any passengers. Safety is a top priority for the group, and they understand that the ability for the manual operator to take control of the vehicle and stop or correct it in case of an emergency is crucial.

The group also plans to ensure that the remote-control system is user-friendly and easy to operate for anyone who purchases the product. Furthermore, the group recognizes that there is always room for improvement and plans to leave space for future projects and research to build upon their work.

Table 1: Customer Needs Prioritization

Number	Customer Need	Description	Importance
1	Emergency Stop/ Manual Override	The vehicle must have the ability to be manually controlled and stopped by the operator in case of any potential accidents or errors.	2
2	Easy-to-Use Design	The system must be simple and efficient, allowing for ease of use by all customers.	1
3	Stable Steering/Braking System	The vehicle's steering and braking systems must be stable, reliable, and safe to ensure proper control of the vehicle.	3
4	Reliable Sensors and Equipment	The sensors and equipment used in the vehicle must be reliable and easily accessible to customers in case of any maintenance or repair needs.	3

2.3 Solution Specifications

In addition to the mechanical modifications needed to the golf cart, there are also several issues related to the electrical systems that need to be addressed. The current motion of the cart is controlled by a remote controller that sends signals to the control board. However, there are some problems with the current setup. One issue is the presence of backlash in the drive chain, which can lead to wear and tear on the system. Additionally, there is no way for the cart to know when it is in the neutral position without human feedback. The braking system is also problematic, with fluctuations in the pedal due to low frequency modulation. The group aims to create a closed loop system that provides more accurate feedback and control for these

systems. Overall, the group is committed to making necessary improvements to the golf cart's mechanical and electrical systems to achieve their goal of creating a successful autonomous driving experience.

DESIGN CONCEPTS

The aim of the proposed design approach is to create an interactive and user-friendly vehicle that meets both customer needs and engineering specifications. The approach focuses on utilizing the most efficient and readily available components, while taking into consideration the requirements for future integration of autonomous capabilities. The design incorporates established best practices and develops two concept designs that are equipped with the necessary technology and systems to facilitate the transition towards autonomous driving.

The project will be using two Arduino Mega boards as the main microcontrollers of the system, each equipped with a motor shield for improved communication with the DC motors. One board will control the steering while the other will handle the braking system and the electric throttle. Additionally, a third Arduino Uno will be responsible for emergency braking. When the emergency button is pressed, the signal is redirected to the Arduino Uno, which activates the safety braking system, gradually slowing the vehicle down until it comes to a complete stop. The first microcontroller will be connected to the steering DC motor, and a sensor will form a feedback loop for precise control of the vehicle's direction. The second microcontroller will be connected to the braking DC motor and the MCOR4, forming a feedback loop with the encoder to accurately measure position, count, speed, and distance. Finally, the RC signal receiver will be connected separately to provide additional control options for the vehicle.

Additionally, the use of two mega Arduinos allows for easier communication and control of the DC motors responsible for steering and braking, which enhances the vehicle's overall performance. The third Arduino Uno, responsible for the emergency braking system, is a crucial

component of the design as it ensures the safety of the driver and passengers in case of an emergency. The sensor connected to the first microcontroller enables precise control of the vehicle's direction, forming a feedback loop with the steering DC motor. This feature ensures that the golf cart stays on course and provides a smooth driving experience for the user. The second microcontroller, connected to the braking DC motor and the MCOR4 (Electric Throttle), accurately measures position, count, speed, and distance, forming a feedback loop with the encoder and braking DC motor. This level of control ensures that the golf cart can stop safely and reliably in all conditions, which is critical for the safety of passengers and other drivers on the road. Overall, the design incorporates a range of features that ensure the safety and reliability of the golf cart while providing a smooth and enjoyable driving experience for users.

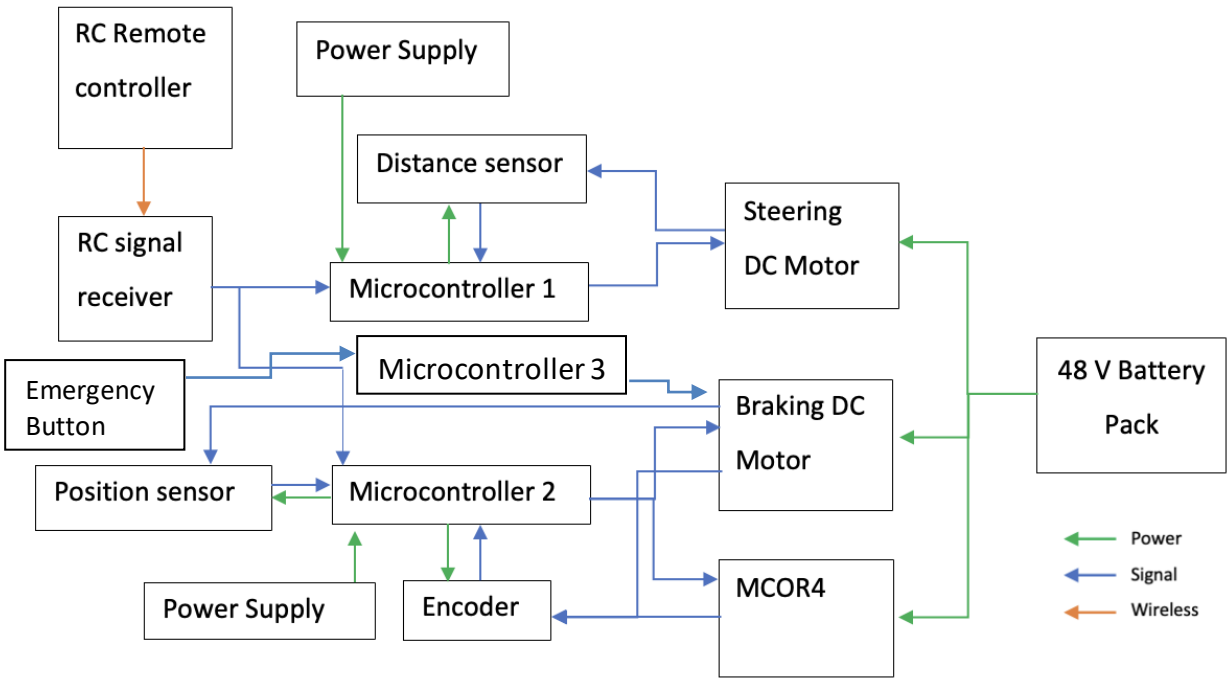

Figure 1: Concept Design of the Integrated Control System Using Two Main Microcontrollers

DESIGN CONSTRAINTS

4.1 Engineering Standards

All projects must adhere to specific standards, and engineering standards are a top priority for this project. In particular, there are IEEE standards that emphasize control and improvement, which are directly relevant to the enhancements being made in this project. Following these IEEE engineering standards will help guide the design and development of the project.

Adhering to engineering standards is crucial in ensuring the safety and reliability of any project. In this golf cart project, it is specifically focused on IEEE standards for controls and improvement. By following these standards, the control systems are functioning as intended and any improvements made are made in a safe and effective manner. The IEEE standards provide guidelines for various aspects of the project, including the design, testing, and documentation of the system. Any applicable legal and regulatory requirements to ensure that the project is compliant with any relevant laws and regulations are taken into consideration. By following these standards, a high-quality and safe product for the end-users can be provided.

IEEE Std 45-2002, for example, is a recommended practice for electrical installation. It emphasizes that tests should be performed prior to delivery to ensure that the machine complies with the recommendations and operates at the specified rating. A test for compliance with clause 13 of this standard, which defines the specifications for DC motors, has also been done.

IEEE Std 1666-2011, which establishes the standard for the SystemC language, is another IEEE standard that has been adhered to. This standard, which is based on C++, is perfect for

architects and designers that work with intricate systems that include both software and hardware. The SystemC class library is precisely described by this standard, enabling programmers to construct a SystemC implementation that adheres to the specification.

Moreover, IEEE Std 999-1992 is crucial for this project since it outlines the ideal methods for communicating master/remote supervisory control and data collecting. This standard is essential because the project calls for the usage of a remote control and steering wheel. The receiver and transmitter are the two devices that communicate most frequently and do so using radio frequency signals. The supplied command signal is converted by the receiver into a specific action for the RC or motor. The project's receiver and transmitter are correctly bound, enabling wireless communication.

Lastly, IEEE Std C37.21-2005 mainly focuses on the rating, construction, and testing of dead-front control switchboards. It includes devices such as switches, control devices, instrumentation, metering, monitoring, alarms, and regulating devices and accessories, which are related to the control system used in this project.

4.2 Economic

Economic limitations are a major factor in the development of an autonomous golf cart. First off, the combined costs of the prior group and this group can reach roughly $7,000 in total. The desired level of functionality and reliability must be balanced with the cost of the necessary sensors and hardware. In addition, the project's economic design must consider costs associated with production, energy efficiency, and maintenance. Having said that, this project is only a prototype, and no actual production is planned in the near future.

4.3 Environmental

Minimizing the influence on the ecosystem is one of the environmental design limitations for an autonomous golf cart project. The golf cart should be made using low-pollution materials and sustainable energy sources in mind. Moreover, ecologically sustainable solutions should be prioritized in the selection of materials and manufacturing techniques. But right now, the golf cart's batteries are the problem. Nowadays, wet sealed lead-acid batteries with led plates that may contain hazardous substances are used to power golf carts.

4.4 Sustainability

An autonomous golf cart project's sustainability design restrictions include taking into account the vehicle's whole lifecycle, from production to disposal. The golf cart should be made with durability, repairability, and recycling in mind. Furthermore, ethical and ecological practices should be prioritized when acquiring materials and energy. The golf cart is currently made of recyclable or separatable parts for simple dismantling.

4.5 Manufacturability

For an autonomous golf cart project, manufacturability design constraints entail making sure that the design can be readily produced within the desired timeline and budget. The current design components can be easily produced, and the primary emphasis is on design for manufacturing

(DFM). There have been thorough notes taken and research reports made while the group has been working on this endeavor. For future manufacturers, every step of testing and construction has been recorded.

4.6 Ethics

The potential effects of technology on society and the person are taken into account when designing an autonomous golf cart. The golf cart should be built with safety features to

guarantee the welfare of its occupants and passersby while also upholding confidentiality and data security. The company places a high value on complete transparency, ensuring that users of the road, including passengers, are aware of how the golf cart functions. Additionally, this endeavor adheres to the code of ethics in many ways. The convenience of its passengers is not given more importance in this endeavor than other people's safety. The emergency braking system and the motor are just two examples of the ethical components that have been added to or assembled on the project. Both are effectively moral materials that adhere to rules and norms.

4.7 Health and Safety

Assuring the protection of users, pedestrians, and operators are health and safety design constraints for an autonomous golf cart project. Designing a golf cart with security features like emergency stops and collision prevention systems is a good idea. In light of this, the organization has installed an emergency braking device for users. To guarantee safety, numerous testing procedures are carried out.

PROJECT RISK ANALYSIS

A table to define the risks has been created after much discussion regarding the risk factor in this endeavor. In this instance, Table 5 will display risks on a scale from 1 to 10, with the higher the number indicating a larger risk's severity. Currently, there are three major risks associated with the project. The first is the potential for mechanical problems. It can take some time to learn how to use and comprehend brand-new tools. This said, technical problems can also happen. There can also be programming problems. Because the project is being worked on under a deadline, programming this will require a lot of thought and effort.

After creating the risk table, A risk mitigation plan to minimize the impact of these potential risks has been established. For example, to prevent mechanical problems, extensive tests of the

hardware and ensure all tools are properly functioning before proceeding with the project has been done. In terms of programming, the team has allocated additional time for debugging and testing to reduce the likelihood of errors. Additionally, the team has identified the need for effective communication and collaboration to ensure everyone is on the same page and can work together to tackle any challenges that arise. By proactively addressing these risks and having a plan in place, the team is well-prepared to handle any unexpected issues and deliver a successful project.

Table 5: Risk Severity Calculation

Risk Number	Risk Explained	Likelihood (1-10)	Impact (1-10)	Severity (1-100)
1	Equipment Issues	6	8	48
2	Programming Issues	7	8	56
3	Injury Risk	3	10	30

DETAILED DESIGN

Project Overview

As for completed work this project is an implementation of precision and safety measures in a project. This project utilizes two DC motors, steering, braking, and MCOR4 systems for the golf cart. The goal of this project is to enhance the performance of a golf cart's control system for a particular application, while also implementing necessary safety measures. By using advanced control systems and sensors, the project will ensure that the golf cart operates efficiently and reliably, even under demanding conditions.

Hardware Components

The project utilizes the following hardware components:

- A golf cart chassis
- Two DC motors
- Two Mega-Arduinos
- One Arduino Uno
- MCOR4 system
- Steering system
- Braking system
- Emergency Stop Switch

Software Components

The project utilizes the following software components:

- Arduino IDE
- SystemC language
- ClearPath-MC and -SD Series Motor Setup Program (MSP)
- IEEE Standards (IEEE Std 45-2002, IEEE Std 1666-2011, IEEE Std 999-1992, and IEEE Std C37.21-2005)

System Design

The golf cart chassis is the foundation of the system, upon which all other components are installed. The two DC motors provide propulsion for the cart. The MCOR4 system controls the speed of the cart by adjusting the voltage to the motors. The steering system is responsible for steering the cart, while the braking system is responsible for slowing down and stopping the cart. The two Mega-Arduinos are used to split the steering and braking systems with their own code, enabling enhanced

response time and limited interference between the systems. The Emergency Stop Switch provides a safety measure to stop the cart in case of any problems. The steering motor is removed from the bottom of the cart and placed directly to the steering wheel to prevent the play in the steering system.

(a) (b)

Figure 2: (a) Old steering motor placement; (b) New steering motor placement

Technical Details

Before making any modifications or changes, the code provided by previous groups has been studied to understand its functionality. Two Mega-Arduinos are used to split the steering system and the braking system with their own code. This splitting of the systems allowed for enhanced response time and limited interference between the systems. Configuring the two DC motors to optimize their performance for the specific application. This involves adjusting the motors' operational parameters, such as torque, acceleration, velocity, and load. An Emergency Stop Switch has been implemented to stop the cart if the system experiences any problems or if something is in the cart's path.

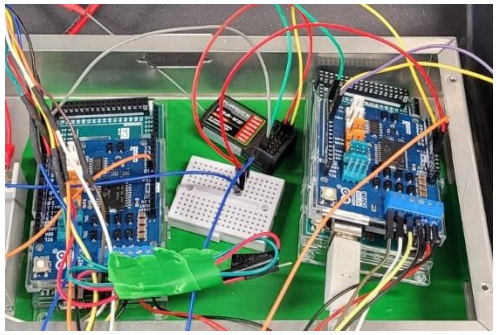

Figure 3: Two Mega-Arduinos are used to split the steering system and the braking system.

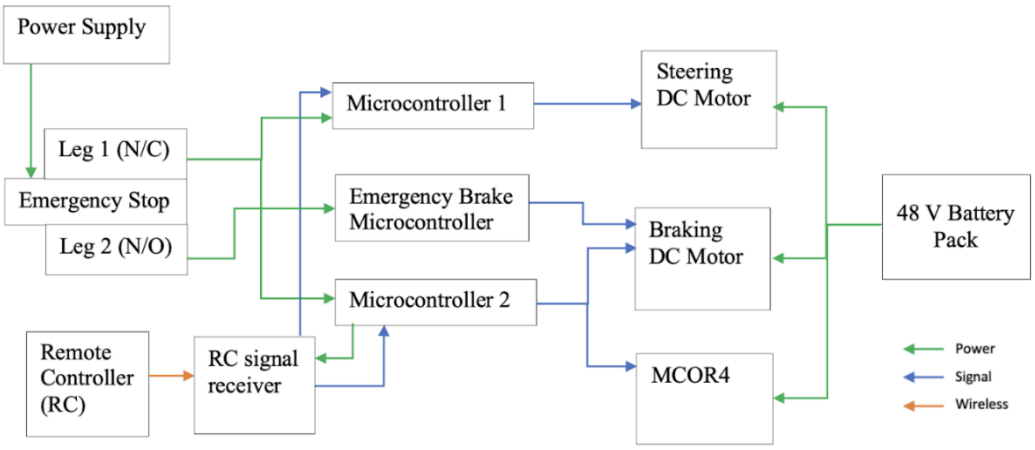

Figure 4: Concept Design of the Integrated Control System Using Two Microcontroller with Emergency Brake

FUTURE MILESTONES

The creation of a closed loop system is one of the primary objectives because there is currently no feedback signal other than reports from humans. The addition of a stepper motor to this undertaking may now be advantageous, following much discussion. The idea might benefit from a stepper motor, which can be used in a variety of Arduino-controlled applications and moves in precise, small increments. This project will recreate the throttle control mechanism and put it back in working order. Next, the team will proceed to modify the steering motor's current location on the steering shaft on the mechanical side of the project. And finally, there is ongoing backlash in the present drive chain.

CONCLUSION

In conclusion, the growing interest in this field has been sparked by the increasing curiosity surrounding autonomous vehicles, and this project seeks to advance this technology. The team has diligently worked toward its primary goals, which include enhancing the braking

and steering systems, moving the steering engine, and putting in an emergency braking system. In general, this initiative offers autonomous driving experience and will advance going forward. As a result, this project seeks to balance putting safety precautions in place with optimizing a golf cart's performance for a particular application. To accomplish this, the endeavor makes use of two DC motors, steering, braking, and MCOR4 systems. The project makes use of a variety of hardware and software parts, such as two Mega-Arduinos, the SystemC programming language, and IEEE standards. The team divided the steering and stopping systems using their own code, enhanced the performance of the DC motors, and added an emergency stop switch as a safeguard.

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