*International Journal of Engineering & Technology*, 7(4.16) (2018) 169-173

International Journal of Engineering & Technology

*Website: www.sciencepubco.com/index.php/IJET*

***Research paper***

# GPS-Guided Smart Go-Kart with Obstacle Avoidance

**Alexander C. Abad[1]*, Dino Dominic F. Ligutan[2], Carl Vinson B. Matulac[3], Marc Serzo[4], Raven A. Soliguen[5]**

*[1]De La Salle University - Manila*
*[2]De La Salle University - Manila*
*[3]De La Salle University – Laguna Campus*
*[4] De La Salle University – Laguna Campus*
*[5] De La Salle University – Laguna Campus*
**Corresponding author E-mail:*

**Abstract**

This study presents a Smart Go-Kart capable of moving automatically from one waypoint to another. The system uses hoverboard as its main engine. GPS is used for setting the beginning and destination through an android application. The graphical user interface contains buttons to select the destination with an option of manual or automatic drive, and the inputs will be sent to the Arduino microcontroller through Bluetooth module. The Kart starts moving after all the inputs are set and will navigate automatically by the help of the algorithm created by the researchers which integrates the compass sensor from the android application and the wiper motor. A certain radius is placed on the google maps that will actively check if the kart's marker enters that circle; if the marker is detected inside that circle's area, the android application sends a command to the Arduino to stop the process that means destination is reached.

***Keywords**: GPS, Go-Kart, Hoverboard, Arduino, Bluetooth*

## 1. Introduction

The fast and continuous growth in technology has led researchers, especially engineers to improve anything and everything that human uses in everyday life, to help tasks become easier and more convenient. Cars are continuously being improved that has even led to inventions of self-driving cars, or what is better known as smart-cars; where even the driver can relax as much as the passengers. Related to this is the invention of Smart Go-Kart. Go-Karts are famously known to be used in mini car racing. It is a four-wheeled small vehicle which are primarily single seated and powered by a 2 or 4-stroke internal combustion engines [1]. This Smart Go-Kart will rely with the use of Global Positioning System for navigation which has the most fully functional navigation constellations [2]. With the use of smartphones, GPS navigation can be done easily because of its almost accurate location prediction, recording the device's trajectory as a sequence of time-stamped locations and uses its record pattern of movements through trilateration with a normal accuracy of 10 meters [3]. To ensure the safety of the vehicle, collision-avoidance system is installed using Sonar sensor. Sonar sensors are used around the world, indoors and outdoors in the harshest conditions for a variety of application. The sensor calculates the distance of the object by getting the time elapsed between the sound wave that the sensor sends and the sound wave that bounces back that the initial signal hits, which promotes the obstacle detection system [4][5]. This project can be used in small areas like schools for delivering items from point to point and can later be developed to larger cars and be used in express deliveries without any human contact.

## 2. System Overview

The Smart Go-Kart shown in Figure 1. uses two hoverboards, one as its main engine at the rear end while another hoverboard at the frontend as freewheeling support. The project is called Smart Go-Kart for it is guided using GPS with the help of an android application made by the researchers, which is connected using Bluetooth module.

**Fig. 1.** Smart Go-Kart

An obstacle avoidance system was designed using ultra sonic sensor for the safety of the Kart if the user chooses automatic drive. The android application contains the controls of the Kart that enables the user to choose between manual and automatic drive. If automatic-drive is selected, the user needs to choose the destination on the application with the GPS, which will enable the Kart to automatically move towards the end avoiding any obstacle. If the user wants to drive manually, the controls will also be on the application containing the left, right, forward and backward mo-

tions controls. The Smart Go-Kart's measures 85.09cm in length, 65.02cm in height, and 57.15cm in width.
Smart Go-Kart system architecture is shown in Figure 2. The project is divided in two major category: a) Hardware Design and Development, b) Software Design.

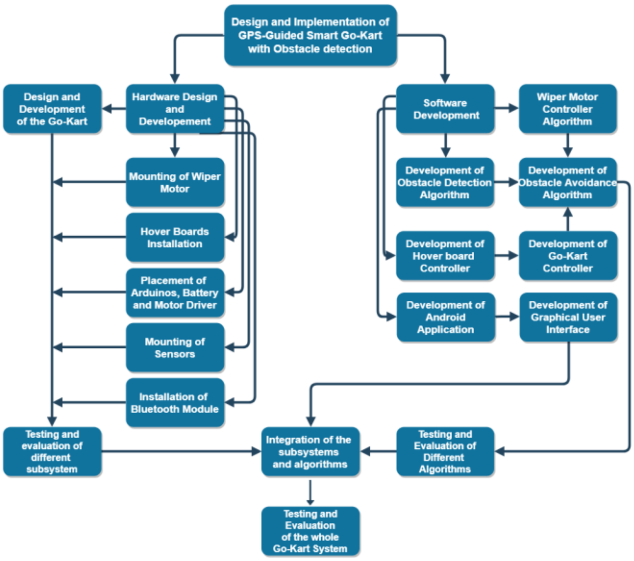


**Fig.2.** Smart Go-Kart System Architecture

# 3. System Design

## 3.1. Components of the System

This section discusses the different parts used in making the Smart Go-Kart.

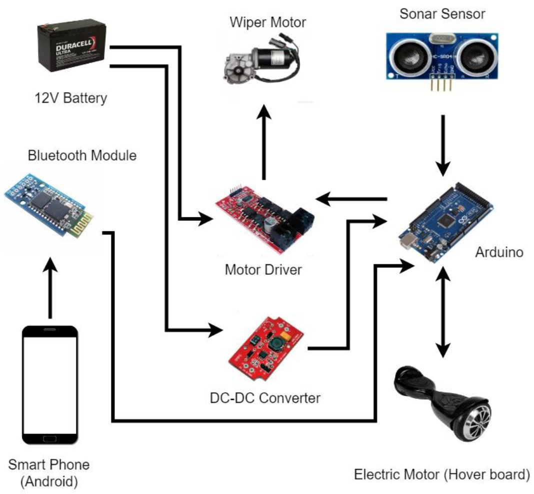


**Fig. 3.** Smart Go-Kart Hardware Components

### 3.1.1. Motor Driver

The motor driver is used to amplify the small currents into large currents, because the Arduino is only capable of driving small amount of currents, while the wiper motor uses large currents. Therefore, the motor driver is needed to convert the current into the desired amount to control the wiper motor.

### 3.1.2. Bluetooth Module

The Bluetooth module serves as the communication interface between the Arduino mega and the smartphone device. The module used is HC-05 which allows for master and slave operation to provide seamless data transfer. The baud rate is set to 115200, and another Bluetooth module is set up to communicate with an auxiliary phone that serves as a sensor to measure the steering angle.

### 3.1.3. DC-DC Converter

The purpose of DC-DC converter is used to down convert the 12v battery supply to 5v necessary for the operation of Arduino.

### 3.1.4. Wiper Motor

The wiper motor is used for steering the hover board used to turn the Go-Kart to left and right. To sense its angle, an auxiliary smart phone is attached to measure the angle relative to the body of the kart.

### 3.1.5. Ultrasonic Sensor

Ultrasonic sensor is used to measure the distance of an object or obstacle by sound waves with frequencies beyond the range of human hearing. By recording the elapsed time between the sound sent and sound wave bouncing back, the distance between the sonar and the object is calculated.

### 3.1.6. Battery

A 12V rechargeable battery is used to power the whole project to cover all the power needed by the components used without having problems on power source.

### 3.1.7. Hover *Board*

The hover board is mounted in the back of the Go-Kart and serves as the main engine that drives the whole Kart. The board is controlled by means of UART protocol. The process involves decoding the wave forms produced by the sensors and developing a program using Arduino to reproduce the waveforms of the sensor. A series of test and experiment were made to completely characterize the waveform and to successfully control the hover board [6]. Another hover board is installed that serves as the front wheel.

## 3.2. Controllers

### 3.2.1. Arduino

The Arduino Mega [7] is used to control the whole system by using the program created by the researchers. At the start of the program, the android application made by the researchers will ask the user to choose between manual and automatic modes of driving. If manual drive mode is chosen, the user will manually control the Go-Kart until it reaches the desired destination. On the other hand, if automatic drive mode is chosen, the user will select the desired destination and the Go-Kart will gather the location through GPS. The android application will send the inputs to the Arduino to calculate the distance of the Kart to its desired location selected by the user. Along the way, if any obstacle is encountered by the Kart, the sensor will send the data to the Arduino, and it will determine if the obstacle can be avoided or not; If not, the Kart will completely stop; If yes, the Arduino will signal the Kart to go around the obstacle and will continue the same process until the destination is reached.

**Fig. 4.** Arduino Mega

### 3.2.2. Android Application

The android app was made to use the smart phones' sensor capabilities for accurate gathering of data like GPS auto lock-in protocol, compass data protocol and tilt motion protocol [8]. The application makes all the data gathered as 12byte (start code, identifier, 4byte float data, 4byte filler data, and enter code). The application will then connect to Arduino via Bluetooth module and it is ready to decode all the 12byte data with a readily made protocol in 112500 baud rates for faster transmission. Everything that the android app is sending to the Arduino will be converted into a 12byte synchronized data to avoid congestion and lagging. It is also better to avoid putting extensive code structures in order to minimize the use of clock cycle preventing it to exhaust, in order to do it, the android app will use serial write (in big endian), and the Arduino will decode it (in little endian) and will read the data one by one to analyze the whole data, so the Arduino will know what readily made functions it will use depending on what data was received from the android application.

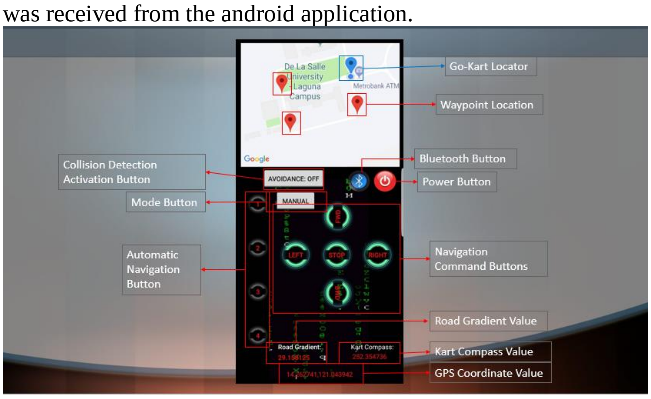


**Fig. 5.** Android Application

Choosing a mode for the Go-Kart will give the user additional choices on what to do. Choosing manual mode will let the user use the cart like a RC toy. Choosing the Automatic, you need to press the location on where you want to go to and the Kart will go there automatically without the need of intervention of the user.

## 3.3. System Process

### 3.3.1. Communication Protocol

To facilitate data transfer between the Arduino microcontroller and the Android phone, a communication protocol was developed on top of the UART protocol. Each frame consists of 12 bytes and the arrangement is shown in Figure 6. The first byte (byte 0) denotes the start of transmission that signals the UART the upcoming frame. The byte value of 0x02 was arbitrarily chosen. The next byte (byte 1) specifies the packet type which shall be used to interpret the subsequent bytes. Possible packet types may include, but not limited to GPS data, sensor data and are assigned a sepcific identifier. Bytes 2 to 9 contains the actual payload and the structure differs for each packet type. The last two bytes (byte 10 and 11) are trailer bytes to signal the end of frame transmission. Byte values 0x0D and 0x0A were chosen for these byte respectively.

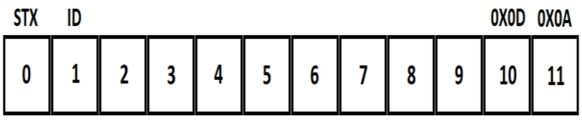


Fig. 6. Data Frame

### 3.3.2. Steering Mechanism

The steering mechanism shown in Figure 7 consists of angle sensor and a DC wiper motor coupled to a freewheeling hoverboard at the front end of the Smart Go-Kart. The wiper motor serves as the steering drive of Smart Go-Kart. On the other hand, the angle sensor is a potentiometer whose axis coincides with the shaft of the wiper motor to serve as a feedback signal element. The proportional-derivative (PD) controller was developed to accurately control the movement of the steering drive. Thus, the angle of steering is controlled whilst improving the response time without overshooting.

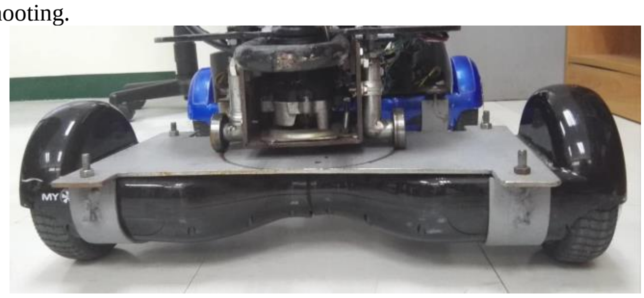

**Fig. 7.** Steering Mechanism

### 3.3.3. Obstacle avoidance system

The obstacle avoidance uses an active sonar which uses the obstacle detection algorithm. The algorithm contains 3 states. The moving state that allows the Kart to continuously move forward when no obstacle is detected. If an obstacle is detected and within 70cm distance, the sonar will send a 1 to the main Arduino to activate the second state named, The move backward state, which sets all the GPS automation flag off, and focuses on commanding the hoverboard to go backwards while turning the front wheel to the right away from the obstacle, until the obstacle is not within range of 70cm. We chose to set the steering angle to the right while moving backward to produce an overtaking algorithm to the left side of the obstacle, this is based to the country's driving standards of having a left-hand drive. If the obstacle is out of range, the timer state will activate, allowing the Kart to move forward for 5 seconds. It was set to 5 seconds because the sizes or dimension of the obstacles used are already known initially. The Kart will go back to the moving state and align the steering making the Kart go back to the initial path based on the compass data from point A to point B.

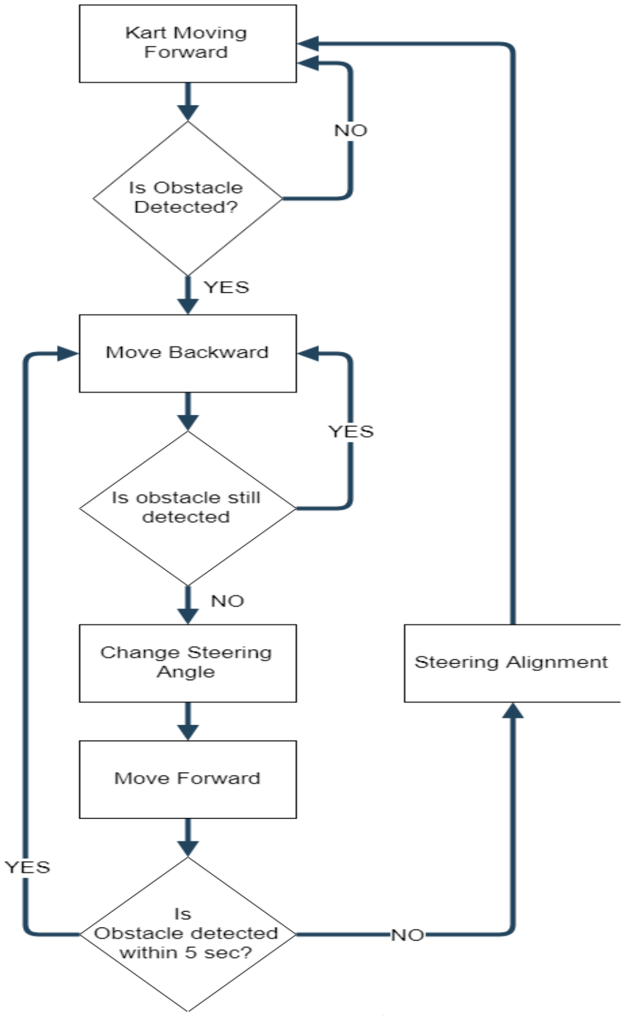


**Fig. 8.** Obstacle avoidance flowchart

# 4. Results and Discussion

## 4.1. Path of Smart Go-Kart

Each section of the road was divided into 4 segments to better characterize the needed data. The following graphs are only 1 section of the road with the corresponding data:

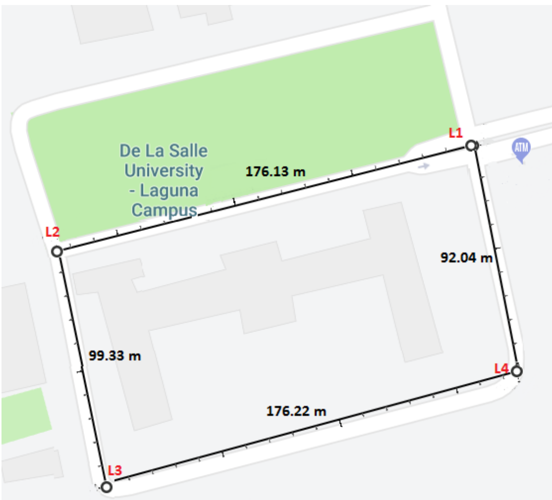


**Fig.9.** Path of the Smart-Go-Kart

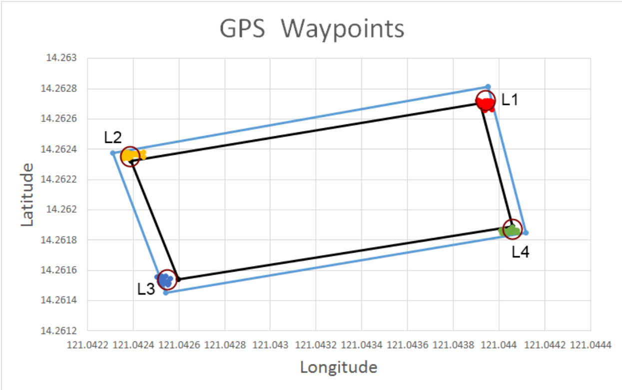


**Fig.10.** GPS Waypoints

As the data shows, the Power Max and Min for each section of the road are almost the same meaning that there is a small difference between them. Each section of the road are on different road gradients. L1-L2 and L3-L4 being on almost flat road segment therefore needing less power to move it forward. The road sections also have a zero acceleration therefore having a constant speed all throughout. L2-L3 being on a inclined plane, needing more power for the Kart to traverse the uphill road than the rest of the road. L4-L1 being on a declined plane, it will require less power than the rest of the road, as it often moves only in free-wheel adjusting its directions once it has detected it has strayed off its path.

Each corner of the road has a certain coordinate. Then a 6m radius was inputted in the system to know whether the kart has reached its destination. The kart was able to traverse the road with at least 80%. Meaning it has reached the 6m radius from the assigned waypoint for each segment of the road.

## 4.2. Obstacle Avoidance

The obstacle avoidance uses an active sonar which uses the obstacle detection algorithm. The algorithm contains three states: moving, . The "moving" state that allows the Kart to continuously move forward when no obstacle is detected. If an obstacle is detected and within 70-cm distance, the sonar will send a 1 to the main Arduino to activate the second state named, "move backward" state, which sets all the GPS automation flag off, and focuses on commanding the hoverboard to go backwards while turning the front wheel to the right away from the obstacle, until the obstacle is not within range of 70cm. We chose to set the steering angle to the right while moving backward in order to produce an overtaking algorithm to the left side of the obstacle, this is based to the country's driving standards of having a left hand drive. If the obstacle is out of range, the timer state will activate, allowing the Kart to move forward for 5 seconds. It was set to 5 seconds because the sizes or dimension of the obstacles used are already known initially. The Kart will go back to The moving state and align the steering making the Kart go back to the initial path based on the compass data from point A to point B.

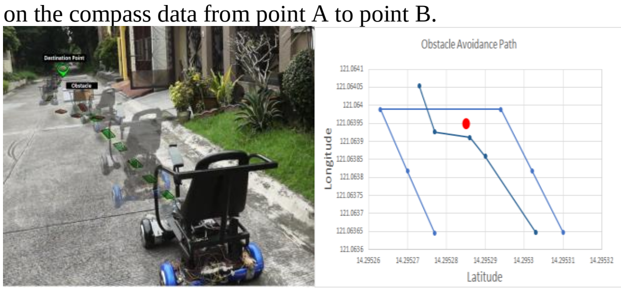


**Fig.10.** Obstacle Avoidance

As shown above, an obstacle was placed in a fixed coordinate while the Kart varies its starting position by no more than 1 meter from each data. Both instance, the Go-Kart has dodged the obstacle and has reached its final destination.

### 4.3. Loading Test

Smart Go-Kart was successfully tested to carry loads of 72.8kg and 121kg as shown in Fig. .The data gathering was made more than 30 times per segment from L1-L2, L2-L3, L3-L4 and L4-L1. This loading test shows that the Smart Go-Kart is robust and can be used to carry heavy load of 121 kg.

**Fig.12.** Loading test

## 5. Conclusion

The location picked for the research is the road around the Milagros Bldg. in De La Salle Laguna Campus, Binan Laguna. Through the tests and trials, the researchers were able to identify the road gradient, how much power was needed for the motor to move in a straight and inclined plane, distance between vehicle and obstacle before it starts avoiding, response time for avoidance collision. A few of the main factors that affected the data gathering was the distance of the object to the kart and the clearness of the sky. The clearness of the sky determines how accurate the GPS can be. Satellites will be able to pinpoint the location of the user and the kart. The maximum distance of the obstacle to the vehicle was also a big factor as it needs to be in a certain distance before it can be read as an obstacle. The smoothness of the surface is also another factor. This study was able to integrate or combine 5 systems to build a Smart Go-Kart. The control of the system is from the Android GUI then the Arduino will process the request of the user and will implement certain protocols to reach its destination.

## Acknowledgment

The authors would like to thank Almighty God for making everything possible according to His divine will and providence, especially in giving them strength, knowledge, and wisdom towards the completion of this document. They would also like to thank their family and friends, De La Salle University – Manila (DLSU), De La Salle University – Laguna Campus, and Department of Science and Technology – Engineering Research and Development for Technology (DOST-ERDT) for funding and helping them to finish this study.

## References

[1] T. Machado et al., "Design and development of a go kart," 2015 International Conference on Technologies for Sustainable Development (ICTSD), Mumbai, 2015, pp. 1-5. doi: 10.1109/ICTSD.2015.7095881

[2] M. Bagci and C. Hajiyev, “Integrated NRM/EKF for LEO satellite GPS based orbit determination,” 2016 IEEE Metrology for Aerospace (MetroAeroSpace), 2016

[3] Giremus and V. Pereira, “A Bayesian non parametric time-switching autoregressive model for multipath errors in GPS navigation,” 2016 IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM), 2016.

[4] Instructables, “Ultrasonic Range Detector Using Arduino and the SR04 Ultrasonic Sensor,” Instructables.com, 22-Oct-2017. [Online]. Available: http://www.instructables.com/id/Ultrasonic-Range-detector-using-Arduino-and-the-SR/step2/Parts-List. [Accessed: 13-May-2018].

[5] S. S. S. Ramesh, T. Keshri, S. Singh, and A. Sharma, “Solar Powered Obstacle Avoiding Robot,” Int. J. Emerg. Technol. Eng. Res. (IJERET), vol. 6, no. 4, pp. 62–66, 2018.

[6] J. List, “Reverse Engineering Hoverboard Motor Drive,” Hackaday, 10-Jun-2016. [Online]. Available: https://hackaday.com/2016/06/10/reverse-engineering-hoverboard-motor-drive/. [Accessed: 28-Aug-2018].

[7] Arduino.cc, "Arduino - Getting Started", 2016. [Online]. [Accessed: 28-Aug- 2018].

[8] “API reference | Android Developers,” Android Developers. [Online]. Available: https://developer.android.com/reference/. [Accessed: 28-Aug-2018].