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REMOTE CONTROL OF ARM ROBOTIC GUIDED BY GPS SYSTEM

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Abstract- In this paper, we present the platform and system architecture of an autonomous arm robot guided by GPS allocations over an outdoor wide open area. The platform mainly made of a toy car equipped with ultrasonic sensors and GPS system, arm robotic with griper, and the development of two Arduino microcontroller boards using basic of C programing language. Its practical implementation keeps taking and monitor the updated readings of the current location while moving plus using an ultrasonic sensor in order to detect obstacles that face the moving car. Using the GPS and compass data plus the bearing and distance calculations which are based on the observed GPS readings, must be sufficient to direct the car with high accuracy toward any given point on the map. A typical explorer GPS location based robot is described as a compact of autonomous remote controlled wireless object such as car, drone or rover, with the ability of auto guiding itself toward any given on map coordinates.

Keywords: GPS Guided Robot, Gripper Arm, Arduino, Arm Robot.

I. INTRODUCTION

In recent years, mobile machines have an important role in industry, in the robotics systems that are used for service in office or house, to reach unsafe and difficult areas, wars and also for amusements [1] .Robotic system employed in exploration, observation and helping to grip objects at given location that a human can't reach or too dangerous and life threat to go by using the GPS location. There are so many benefits of utilizing a robot guided by GPS and not assign people because it will help to improve the ability to serve the main purpose in a better way, explore GPS locations of a given longitude, latitude taken from the global map in which people are not able to reach and dangerous their lives.

A self-ruling (Autonomous) machine is a self-steered robot that does not require an administrator to explore and achieve its jobs. Mobile robots are self-ruling machines that designed and equipped for performing their duties under variable conditions and their properties attract the attention of engineers [2]. Independent vehicles are recent created subset of mechanical autonomy and can be presented in three general structures: ground, air and submarine [3].

There are many outdoor locations of mountains and unreachable places un-discovered, such invention could be used to provide a conventional discovery on such locations. In addition to the exploring feature, another task is provided by this robot which is tracking system that this system provides while moving around and updating its positioning coordinates dependent on the GPS in a specified interval of time. Moreover, another skill of this robot will be the preciseness of its guiding mechanism as using specific algorithms it will be able to guide to the set destination point within a range of no more than 2-meter error around the point. The coordinates of the destination point will be occupied from the map online, Google's Map in specific.

One more additional feature of this car is the ability to guide itself to the destination point and use its gripper on the robotic arm to grip objects. A GPS guided robot is a great deal to have in a place where many locations with landmines, in which a robotic car with an expletory ability of a given location can be used to explore them instead of a human being and save so many innocent lives [4]. The robot is built up within the most economical and suitable available devices, as the low cost is one of the main points and advantages of this project. Therefore, to achieve accurate guiding with low cost, the car is equipped with only essential parts that are vital to drive accurately using an economical platform toy car with direct current (DC) motors for the purpose of cheapness of the DC motors over servo motors.

II. SYSTEM DESCRIPTION AND METHOD

This project aims for a product of a robot rover capable of autonomously guiding itself to a specific given coordinates GPS location on the map in an open area. To satisfy this project, the robot should be autonomously guided only by giving a GPS allocation and the rover should reach the destination without any interaction by human.

A. Guided Car

Generally, in order to guide the car to a specific location, a GPS location of longitude and latitude is occupied from the map (ex. Google Map) and given to the car, according to robot's current location depending on the distance from it and heading of the car the robot makes its calculations toward the aimed point and starts moving based on them.

In general, there are so many other approaches and attempts used from achieving such project as mention in the previous section. Mainly this project methodology consists of combination and contribution of several electronic devices to provide the needed data in order to guide the rover precisely to the destination. The electronic devices used in this project consists of a microcontroller which is the brain of the robot, an electronic GPS shield for receiving the coordinates, plus an ultrasonic sensor to find obstacles. The steps of achieving this project could be summed into a flow chart as shown below in Figure 1.

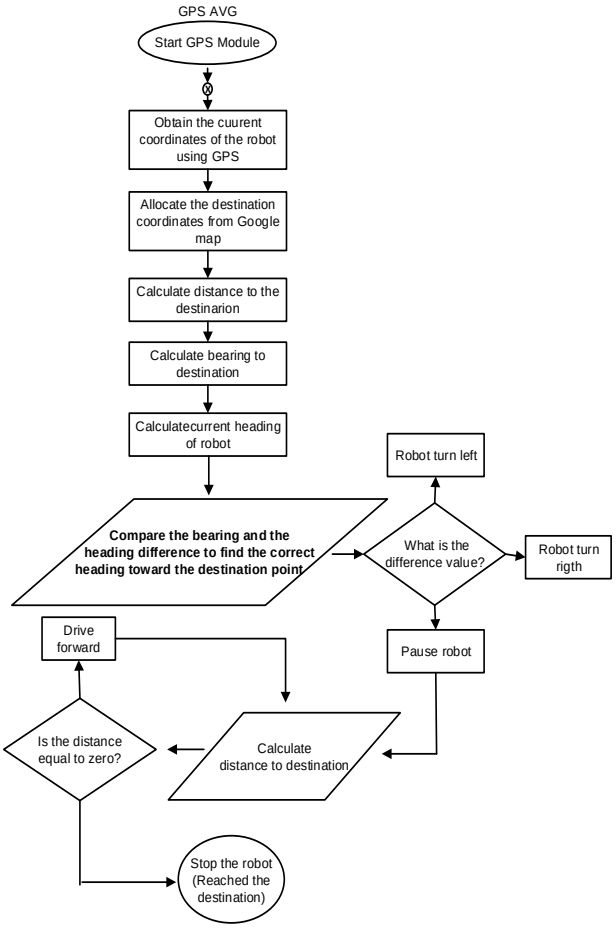

Figure 1. Flow chart of car guided by GPS system

This above chart of steps will be repeated over and over again for each waypoint until reaching out to the final destination point. Furthermore, according to this chart each part will be explained in the upcoming parts to have a clear vision of how to achieve this project, the whole project process is divided into three main parts where in combining them all we obtain the big picture of how the robot functions.

B. Arm Robotic

The robot has been designed to treat like a human arm. In this section, the description of mechanical and electrical part of robot design will be presented. The mechanical and electrical part constitutes the hardware of robot design.

In the mechanical part, the robot has a round sole that has 11 cm semi-diameter and 15 cm height. The servo motors directly power the degree of freedom of robot mechanism. Acrylic is used for robot sole because it can be formed easily and can bear the motor weight and movements, besides, it is cheap and robust. The robotic arm is designed by using servo brackets that are made of aluminums due to its lightweight but it is hard to behave like the bone structure of a human arm [5], the robot gripper is also made of aluminum because of the same reason as the main robot arm structure.

The power source that is used for robot because of its properties and benefits is an acid batter which 12 V / 1.2 Ah. The power source output voltage is regulated to 5 V by means of voltage regulator LM78XX. Servo motor is a DC motor that has feedback is used in many applications for controlling the system in direction of up-down. Servo motors are commonly used in robotics and they are useful and beneficial [6]. Reaching low RPM with high torque by servo motors is very important in this project. Therefore, servo motor that is controlled by mobile on internet by means of Arduino (Figure 2) is preferred in this project.

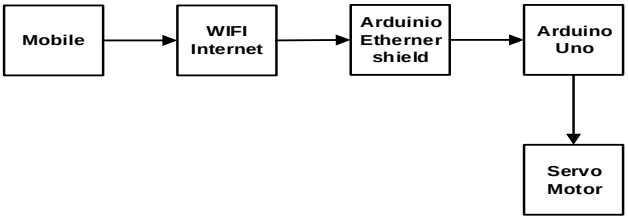

Figure 2. The control block diagram of servo motor on robotic arm

III. SYSTEM DESIGN

The remote control of arm robotic guided by GPS system is performed in two stages: The first stage involves the robot arm design. The arm has 6 doff and also a gripper as shown in Figure 3.

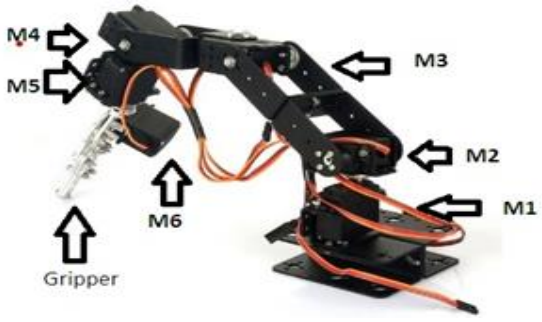

Figure 3. The robot arm used in this study

The working limits of the robot arm are given as. In the base, the first joint of the arm can rotate 180º about the vertical z-axis (M1). In the shoulder, the second joint can rotate 180º about a horizontal axis (M2). In the elbow, the third joint can rotate 180º about the axis which is parallel to that of M3. In the wrist, the firth joint can rotate 180º about the axis parallel to that of M4 the firth joint can rotate 180º about the axis parallel to that of M5.

The gripper can move in the range of 0-40 mm to keep the objects. To actuate the robot arm [7], Figure 4 show to as the simulation by Proteus program of arm robotic with 6 servo motor.

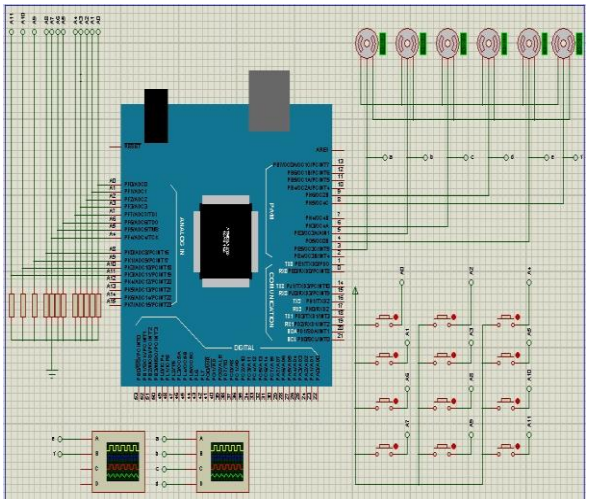

Figure 4. Proteus simulation of arm robotic

We can also the see output of our arm project by digital oscilloscope as shown in Figure 5.

Figure 5. Output signals

Each square wave in the figure above represent the output of each servo motor. Second stage GPS guided car, according to the toy car which we used as explained and demonstrated in the prior chapter a car could be used for purposes of projects developing, as it could be considered as a functional and ready platform for projects in need of rovers controlled over by microcontrollers like Arduino one of the essential property or main build is the motor that the car uses. For the purpose of this project a toy car with two DC motors was used Figure 6 is the block diagram of motor driver which we use in our project.

This car used in the project is one of the easiest, simplest and functional vehicle in which it doesn't require complex wiring and programing as it will be shown later. We start disassembling the car by taking off the top cover and remove the wirings between the motors and the driver, as shown below we are left with the motor driver of the car Figure 7.

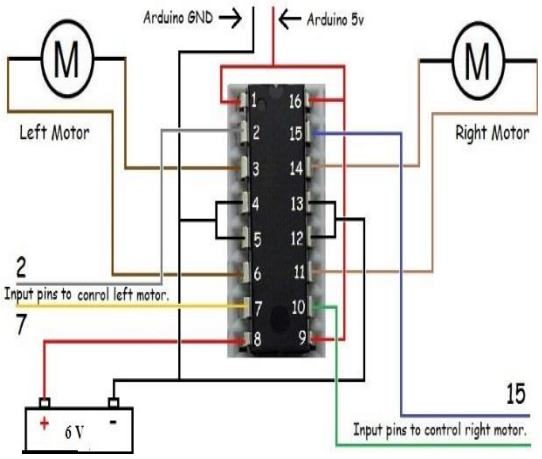

Figure 6. Block diagram of motor driver

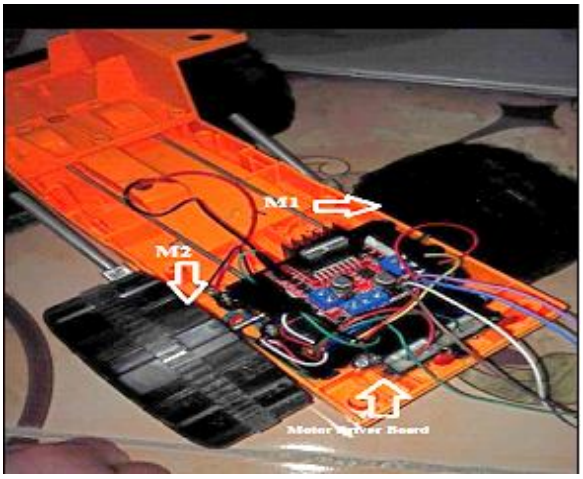

Figure 7. Motor driver

One more thing the GPS system with toy car, the GPS shield is placed on Arduino Uno then we will establish the connection of the motor controller pins and Arduino the connection instruction already declared in the previous chapter. After connecting the motor shield, another important device to be connected also to Arduino is the digital compass which its connection description with Arduino is declared in the prior chapter assembling the compass is placed on a high stable stick away from the other devices, and the reason for this fitting is so that the compass won't get effected by the magnetics and electrical signal field caused by the other devices which will cause noise and error in the signal of the compass producing false directions. Moreover, in order to supply all these devices by power throughout the process of driving toward the destination a 5 V chargeable portable battery is attached to the vehicle and connected to Arduino Uno power volt in pin, then there's another set connected in parallel which are also chargeable and portable that are used for supplying power to the car motors as shown below in the Figure 8.

Figure 8. Toy car with GPS system

Figure 9. General view of arm robotic guided by GPS system

In the end, we putted the arm robotic on the top place of the toy car due to not face any obstacle during the movement of the arm robotic as shown in Figure 9.

IV. EXPERIMENTAL RESULTS

After designing, some experiments have been done and results have been observed. To give instructions and control the arm robotic and car its needs a brain and as a controller of this robot Arduino is used. The reason why Arduino was chosen over other kinds of microcontrollers goes back to its efficiency and it could be connected to various types of devices in which it provides libraries for supporting all the devices used in this project and its easiness for programming them

A. GPS System Guided Car, Calculating Bearing

First of all, it's important to what does bearing mean on the map and to know why we need bearing plus in what way it will help up directing the vehicle. Initially, when the car is demanded to drive toward a certain point, the car must be steered so it's facing toward the point and this cannot be done only using the compass it also demands the bearing that is fundamentally an angle is made by two lines begin from the point (X) where the measurement is done. While one line stretches from X point towards North, the other one stretches from X point to different side. The point where the measurement is done may be a known or an unknown location. The idea of bearing calculation can be demonstrated in a figure via a simple way as shown in Figure 10.

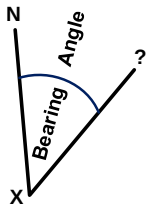

Figure 10. Bearing angle

where "?" is the destination point and "X" is the initial point of the car in this project and "N" is the magnetic north taken as reference. So using this theory of taking north as a reference to find the angle for steering the car toward the destination point is the reason why we need bearing. To calculate bearing we use the formula below:

$$\theta = a\tan\begin{pmatrix}\sin(\Delta\lambda).\cos(\varphi_2),\cos(\varphi_1).\cos(\varphi_2)-\\-\sin(\varphi_1).\cos(\varphi_2).\cos(\Delta\lambda)\end{pmatrix} \quad (1)$$

where λ is longitude, and φ is latitude plus θ which is the bearing bet ween both coordination's. When calculating bearing it needs to be compared with the value of the compass reading of the heading of the car to determine the steering angle and direction.

B. Distance Calculation

As soon as we have the car headed directly to the destination point, we need to drive the vehicle forward toward the distention depending on the distance until it becomes or it's approximate to 0. Essentially, for calculating distance between two sets of geographical coordinates basically there's two methods could be performed either Pythagorean or Haversian (Great-Circle) formula. Since we are not going to send the rover over short distance area of a distance no more than 1 mile using Haversian formula is more recommended by Bob Chamberlain for it calculates the shortest distance between two points on earth which makes it adequate for short distance calculation between two sets of coordinates. Basically, Haversian theory is so basic and uses the formula below for calculating distance:

$$a = \sin^2\left(\frac{\Delta\varphi}{2}\right)+\cos(\varphi_1).\cos(\varphi_2).\sin^2\left(\frac{\Delta\lambda}{2}\right) \quad (2)$$

where $\Delta\varphi$ is the delta of latitude of both coordinates, and $\Delta\lambda$ is the delta of longitude of both coordinates. The formula for finding distance is as below:

$$c = 2a\tan 2\left(\sqrt{a},\sqrt{(1-a)}\right) \quad (3)$$

$$d = R.c \quad (4)$$

where R is the radius of the earth, and d for distance. Again, after finding distance via the GPS and Arduino the validity of the results could be compared with a site where it calculates accurately the distance between two given coordinates which will be demonstrated with an example later in the test and results chapter.

C. The Control System of Arm Robot

This system contains main two parts, one of them is the robotic arm and the other one is Blynk application that control the robotic arm remotely. In this project, for control of the system Arduino is used as a controller. Arduino connects to the internet by means of an Arduino Ethernet shield. Arduino Ethernet shield enables the Arduino to interconnect to the internet by using WIFI. Then, any smart phone that can connect the internet uses the Blynk application to access the robotic arm for control.

V. CONCLUSION

To sum up and wrap this paper, only the thought of having a robot that is able to guide itself autonomously in an outdoor open area relying on GPS coordinates without any human intervention is a massive innovation for a region in specific. It's not just a regular car driving, it's a smart self-guiding car that can calculate its current location and its current heading degree then only by serving the robot a coordinate from the map it will do all the calculations needed to self-drive precisely to the pointed coordinates on the map. Coming to one major advantage of this robot it's in its accuracy, although DC motors were used but following certain algorithm for steering the vehicle will reach out around any given point with the minimum error possible. It's vital to keep in mind this car with robotic arm prototype was made on the base of being a low cost project and affordable for anybody to build, simplicity in programing and minimum use of hardware to accomplish this project was highly taking into consideration.

VI. RECOMMENDATIONS

As noticed in the project prototype minimum devices were used to make it low costing and simple to build, but for more complexity and with high budget many features could be added within the robot. One major feature could be added to the robot is the ability to display data by using LCD (Liquid Crystal Display). This LCD can be used to show the position and the pathway of the car. Another impressing capability can be added to arm robotic system is the robot program runs smoothly as planned. For the future recommendation, this robot arm can be equipped with a camera to view and display at the monitor screen.

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BIOGRAPHIES

Naci Genc received his B.Sc., M.Sc., and Ph.D. degrees from Gazi University (Ankara, Turkey), Yuzuncu Yil University (Van, Turkey) and Gazi University in 1999, 2002, and 2010, respectively. Currently, he is an Associate Professor in the Electrical and Electronics Engineering Department of Yuzuncu Yil University. His interests include energy conversion systems, power electronics and electrical machines.

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