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Self-Mobile - Solar Powered Unmanned Ground Vehicle (UGV) - Jordanian Trial Case

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ABSTRACT

A four-wheel-driven mobile robot vehicle that can move in the environment is a driverless ground vehicle. It is typically a sub-field of automation and information technology. This research discusses mobile vehicle robots and how they will pass into the external reality to achieve their goals without interacting with human beings. To understand the basics, it is essential to remember that many technical aspects and fields for the proper function of the robot must be observed and combined with a mobile robot: a control unit must integrate all of the following systems: conception and perception system by (sensors), the locomotion and kinematics systems, the navigation system and the localization system All of these systems to perform the mobile robot's task or job in a logical manner. This manuscript aims primarily to develop and manufacture an uncrewed or driverless ground vehicle, which can navigate fully autonomous to user-defined Global Positioning System (GPS) points of reference. Having a Planned project is the most challenging task in creating a robot that could be saved by the automatic phase of a conventional RC vehicle, which includes: construction of a frame, installing engines on the chassis, and mounting wheels on the vehicle. It's not just a robot that builds without planning. In addition, write the framework procedure so that the encrypted readings of the encoder control the journeyed distance. The robot movement is tested in a clear way, and the motor movement is controlled as a whole. Also, to design and build a mobile-wheeled robot that can continuously monitor and check predetermined points in the X-Y horizon plane using only the motion variables of the robot wheels and no other functional guide such as GPS. In pursuit of control of the Wheeled Mobile Robot car, the radar sensors, cameras, and other sensors needed were installed. MATLAB modeling Simultaneous simulation of UGV kinematics and dynamics. A specific program to monitor stop and go, velocity, the safety of the vehicle while the movement has been introduced. To compile UGV models and validate them. To collect and simulate dimensional data utilizing the selfsame MATLAB model from a manufactured UGV. In addition to this, the second aim of the study to charge mobile-wheeled robot systems with photovoltaic solar energy and estimate and submit the quantity of photovoltaic solar cells needed to charge self-powered solar UMV.

KEYWORDS

Unmanned Ground Vehicle, self-electric solar power car, Global Positioning System, Geographic Information System (GIS), four Wheeled Mobile Robot, mobile

INTRODUCTION

Vehicles or trucks with self-driving system applications in which human operators never have to drive and run the motor in a controlled manner. They integrate software and sensors to control the automobile, navigate it and operate it, also known as autonomous, driverless vehicles. UGVs are like UAVs and remotely operating systems for crewless aircraft. Driverless robots are being aggressively designed to conduct unattainable, filthy, and dangerous tasks both for civilian and military use [1-9]. There are additionally important hypothetical dangers and benefits associated with self-driving automobiles. More analysis is needed to comprehensively analyze the factors, the environmental and global health, equity, and economy. Unmanned ground vehicles (UGVs) are supposed to do a significant function in the objective of the Army Force structural system. Using (UGVs) systems would minimize losses while greatly increasing the military warfare efficacy. Unmanned land and air technologies are also used in early designs for the Army's Future Combat Systems (FCS) program. These UGVs are intended to be utilized for various purposes, including weapons systems, surveillance, logistical supply vehicles, target detection, and reconnaissance. The military UGV program has introduced remotely controlled combat robots, robotic-follower demos, and basic semiautonomous movement depending on updated research activities. The project is currently in its early stages of testing.

LITERATURE REVIEW

Nowadays, autonomous robot systems are being built in about each industry to handle various complex problems, in many aspects such as manufacturing, warehouse management, farming, army defense, mining, science, law enforcement, et cetera. A controller, cameras, actuators, and a power supply are the parts of an autonomous wheel vehicle. In most cases, the controller is a microcontroller board, integrated microprocessor, or a personal computer (PC). The utilized sensors depend on the robot's needs. Dead reckoning, physical and nearness sensing, place location, collision prevention, triangulation ranging, and other particular requirements may be needed. Actuators are the engines that operate the robot, which can be wheeled or legged. To run a mobile system, we typically use a DC power source (a battery) rather than an AC power supply. [10] Yu Tian et al. designs (WMR) unit to enhance its ability to maneuver in an actual situation, and wheel dynamics, which can breach no-slipping and pure rolling restrictions, must be investigated. [11]. Tall et al. examined whether the one's gaze (point of regard) might control a robot moving on a racetrack. Five various input items (on-screen controls, a mouse-pointing low-cost webcam eye sensor, and two commercial eye monitoring systems) monitor the heading and speed of the running robot's scenario view. Controlling one's gaze was discovered to be identical to controlling one's cursor. This indicates that robotics and wheelchairs may be operated without using one's hands. Outputs were hampered by poor sensitivity gaze detection and image transfer delays. [12]. In the last decade, there has been a significant increase in studies into two-wheeled systems for robotics that actively equalize themselves. To describe and monitor the dynamics of two-wheeled automated systems, various designs and controls were utilized. We study the approaches examined, the controllers used, first for balance and motion of two-wheeled robots on flat ground, then for two-wheeled robotics in other cases, where the road may not be balanced, secondary targets may exist, and the robots might include further actuators. Almost all of the designs are depending on linear control systems. [13-14]. Arxiv proposed simulation and control mechanisms for an autonomous three-wheeled mobile robotic vehicle with front-wheel steering. The research also includes a summary of the pathway control system, which is a difficult challenge for a three-wheeled robot. The collected experimental outcomes for the robotic vehicle configuration were used to validate the developed system concept. Controller functioning and durability problems have even been briefly explained. [15]. This study investigates the dynamics simulation of a four-wheeled autonomous robotic vehicle. All of the robot's wheels are uncontrolled, and the robot is driven by servomotors. Three robotic control mechanism scenarios are described. In the first scenario, two of the robot's four wheels are driven separately, i.e., a pair of the frontal or rear wheels. The robot's wheels are operated in the second scenario, but the drive is also conveyed to the other wheels through serrated belts on either side of the robot. Finally, in the third scenario, all four wheels are driven independently [16].

MATERIAL AND METHOD

The current research has the following aims:

- Design and create a mobile-wheeled robotic vehicle whose location is directed by a Geographic Information System (GIS). In addition, write the backbone procedure so that the moved distance is controlled depending on encoder reading, measure the robot moves along a clear path, and examine the complete control of motor movement [17-29]. Also, to design and build a mobile-wheeled robot that can continuously monitor and check predetermined points in the X-Y horizon plane using only the motion variables of the robot wheels and no other functional guide such as GPS.

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- In pursuit of control of the car, the radar sensors, cameras, and other sensors needed were installed. MATLAB modeling Simultaneous simulation of UGV kinematics and dynamics. A specific program to monitor stop and go, velocity, vehicle safety while movements have been introduced. To compile UGV models and validate them. To collect and simulate dimensional data using the same MATLAB model from a manufactured UGV.

- Inventory analysis to compute the number of solar cells PV available to charge any Self-electric solar-generated UMV.

The four-wheeled Mobile Robotic Vehicle's Tracker

The primary purpose of our project is to create a Ground Vehicle (UGV) which not need a crew with the ability to completely autonomous navigating to user-specified Global Positioning System (GPS) directions.

- The UGV's autonomous navigation performance was evaluated to identify UGV model strengths and weaknesses using a digital compass for guidance and GPS for position detection. It was noticed that UGV location navigation is compatible in smooth types of terrain, while uneven terrains presented a problem for UGV navigation because the underlying land introduced noise and error into the compass, rendering UGV guidance measurements inaccurate.
- Also, to design a mobile-wheeled vehicle that can continuously monitor and check predetermined points in the X-Y horizon plane using only the motion variables of robotic motor wheels and no other functional guide such as GPS.
- In pursuit of control of the car, the radar sensors, cameras, and other sensors needed were installed. MATLAB modeling Simultaneous simulation of UGV kinematics and dynamics. A specific program to monitor stop and go, velocity, the safety of the vehicle while movements have been introduced. To compile UGV models and validate them. To collect and simulate dimensional data using the equal MATLAB model from a manufactured UGV.
- A circuit board incorporating a single axis rate gyro and a microcontroller were installed to communicate with a hosting computer. The micro-controller collects commands from the hosting computer link to execute a set of maneuvers also track the UGV's status. The hardware model, combined with estimation methods, streamlined not just the digital hardware and increased device stability but also reduced the UGV design costs.
- To maneuver and completely autonomous navigate, an Unmanned Ground Vehicle (UGV) must provide sensors to measure the surface, software to interpret the data, route navigating to determine a safe route of action, and control to monitor the path.
- The robot comprises twin rear motors (for skid steering and driving) and a singular front wheel with an idle roller with free rotating axes.
- A dual quadrature shaft encoder is attached directly to the wheel’s shafts on the left and right sides, which are driven by engaging gears at a constant ratio to feel the rear wheels' angular direction robot position (rotation and transcription) selection as persistent feedback of predetermined checkpoints tracing.
- To locate the navigating GIS, a program with a GUI will be developed and activated on a computer to pass these checkpoints to the robotic control system through a serial communications system, and the automated vehicle will start routing the required positions from home point.
- The autonomous robot's major control unit collects and saves the routing points before instructing the electrical motor driver to track/visit these positions due to the input control system's reaction.

Design requirement

The initial model of the robot was evaluated for success outdoors by having it execute different movements. The robot was found to drive at very low speeds and to be ineffective in making turns. To improve the mechanical effectiveness of the robot, the original design's motors must be replaced with other engines.

The UGV's design specifications are as follows: [25]

- If the UGV must be worked with outdoor conditions, the mechanical unit of the UGV should get the required torque power.
- The UGV is kitted with a GPS receiver to determine its precise position.

- When the UGV is static, it is fitted with a digital compass to determine its heading. Furthermore, it could be utilized to give reference to aircraft devices like cameras to rotate and inclination in the direction efficiently.
- The UGV configuration supports a basic networking interface similar to a serial connection to connect with the hosting computer.
- A group of commands protocol is applied by the UGV to collect instructions from the hosting computer.
- The UGV program design receives two kinds of hosting device commands: data demand commands and maneuver commands.
- A mobile controller is included in the UGV specification for manual service, mobile power control during emergencies, and override automated mode.

Set up procedure

Our research focuses on designing a smart UGV by converting an already produced RC car to a robotic platform, as shown in figure 1. This vehicle works with a joystick, which obviously requires someone to go forward, reverse, turn left and right, or generally running to follow a correct course.

Figure 1. Off-the- shelf RC car

Manufacturing procedures

Rather than designing a robot from the ground up, it is feasible to turn a typical RC car to a robotic model that can avoid some of the most challenging duties in robot production, such as:

- Create a chassis.
- Mount the engines on chassis.
- Connect wheels with the motors.

Beginning with an RC vehicle is much less expensive than beginning from the ground up, particularly if you start at nearby thrift stores. RC vehicles could be purchased for a bit of money [29-38]. Inspect that the gear trains operate properly. You may not care whether this succeeds or not because you'll be taking care of the electronics. Remove the RC car's plastic shell first. That will reveal the guts, as shown in Figure 2. Then, the wireless receiver device must be excluded from your RC car in accordance with Figure 3.

Figure 2. Vehicle after remove the plastic shell

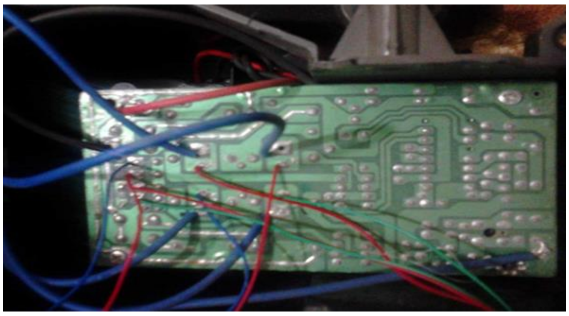

Figure 3. Vehicle board

As shown in Figure 4, you must then develop an encoder for feedback control, which is acquired from mouse internals used in robotic axles.

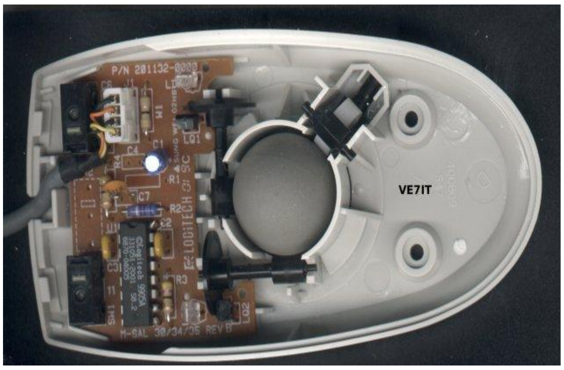

Figure 4. Encoder from mouse

Every optical quaternion encoder consists of a slotted wheel, a light source, and a pair of photo scanners. [35] figure 5 depicts the form of each encoder that can then be dispensed, shrined, and assembled in place of encoders.

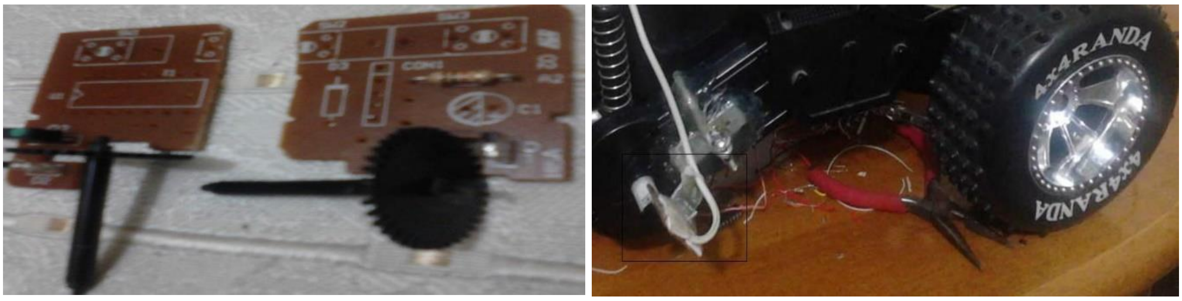

Figure 5: The shape of each encoder

Following that, you must create your microprocessor and vehicle control unit. As shown in the figure 6.

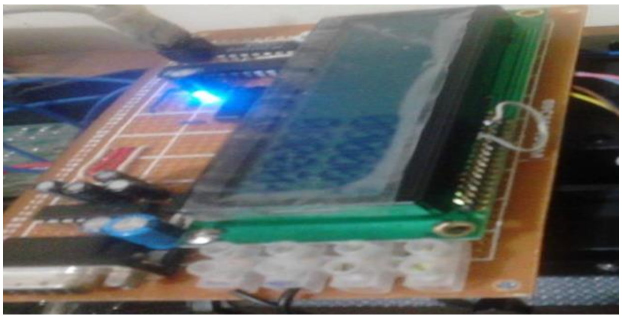

Figure 6. Board

The board must then be fixed in the RC Chassis. The board was attached with double-sided foam tape. Each engine was connected to the outcomes of the H Bridge chips. The RC Car was put to the test by giving it a basic series of commands to follow:

- Run motors ongoing in forward.
- Turn front wheels to the left.
- Turn front wheels to the right.
- Reverse the vehicle, and then repeat the process.

And at last, the updated board was linked to the RC vehicle, which is now able to move around the backyard. Also, you may be transformed into a line follower by utilizing one sensor of the many sensors that have been debated here. Several sensors could be installed to allow this to function as a completely autonomous vehicle.

The final mobile UGV robotic is shown in the figure 7

Figure 7. Final mobile UGV robotic

Software and tracking

The aim of the control program software is to help the consumer to monitor (command) the required movement profile of the robot easily and simply, so long as the user has high technical capabilities and proficiency. The control program software was implemented using the MATLAB SIMULINK program, which employs basic blocks and integrated codes to execute a mission, mathematical, and logical functions

Program description

The control program software will perform the necessary tasks, as presented in the steps below:

1) The type of movement per function is selected by the user; there are two categories of tasks: translation and rotation. The software assignments were reduced to just five to simplify things.

2) The consumer enters the value for each task; for translation, the unit of centimeters, and for the rotation, the unit of degrees used.

3) Since the PC must be attached sequentially to the autonomous car to pass the wheel counting value to step on, the hold switch on the robot must be set to ‘0' to prevent the robot from beginning motion when it is in the process of being coded.

4) The service provider then instructs the control program system to begin.

5) control program will begin to calculate the relative movement of the wheels, depending on the external envelope movement profile, and then translate this movement from degrees and centimeters to pulses with count values (based upon the wheels encoder counters).

6) The software creates a serial interface packet for sequential communication to be sent to the robot. The software ends immediately after two seconds after submitting the interface packet.

For the utilization of the preceding procedures to get the robot to the following:

The upper limit of wheel diameter is 14 centimeters, so the circumference is 44 centimeters per revolution, the effective circumference is 43.3 centimeters per revolution, and the encoder outcomes 36 pulses per revolution.

43.3/36 = 1.2 centimeter/pulse

The length between two wheels is 21cm, the distance required is: 2*21*3.14 = 132cm => 132 / 1,2= 110 pulses on the single wheel while the other one is at stopping to spin the complete rotation on the single wheel.

RESULTS AND DISCUSSION

A tracked vehicle moves on rollers rather than wheels. They are sometimes referred to as track-laying vehicles, or Caterpillars, on consideration of the producer of one of the bulldozers. The essential model benefits of tracked vehicles over wheeled vehicles are that they possess a wider surface area in touch with the ground than wheeled vehicles generally, thus consuming a much lower power per unit area on the ground being moved than a typical vehicle which has wheels with the same weight. As an outcome, they are appropriate for a drive on soft and bumpy terrain. The only drawback is that tracks have a much more complicated mechanism than wheeled models and are more vulnerable to failure modes like snapped or derailed tracks. .[41]. Generally, the outcome of transforming an RC vehicle to a smart UGV seemed beneficial. To date, an appropriate RC car platform has been chosen and improved. Two nodes in a UGV system have been effectively used to collaboratively map out challenges in a search field while avoiding them jointly, paving the groundwork for broader and more advanced collectives. Although when the trial was working, the main defects in the system were discovered. Even after modifying the RC car's drive train, the vehicle had difficulty traversing outdoor ground. The UGV, in specific, found it challenging to turn in location. That occurred due to the platform's inadequacy directed in favoring torque over velocity. This lack in the drive train caused the pack of batteries to be quickly removed and slow performance. .[42]

UGV Power Supply Circuit

The robot's power supply is regulated. The robot was powered manually by turning on the remote recipient and the mobile-controlled (ON-OFF) relay, which controls the robot's power source. To preserve the robot's circuitry, the whole circuit is secured by a 10 Amper fuse. The mobile controlled relay, in turn, activates the relays with numbers one, two, three, and four, which are wired to switches with numbers SW1, SW2, SW3, and SW4, respectively, to provide engines with power, computers, GPS, and other devices. Two 12 Volt batteries are linked in parallel to power the motors, and two 12 Volt batteries are linked in parallel to power the remaining of the robot's electronics [43-44].

Steering wheel

The ability of tracked vehicles to maneuver has long been studied. Steeds explained the skid steering system by accounting for longitudinal slip on the tracked vehicle's path [17]. Even so, a constant pressure of the ground was expected, and a time-consuming trial and error technique of solution was proposed. Weiss, in his analysis, utilized a more realistic model based on Steeds' research on turning efficiency. He stated that it will be more appropriate to handle a proper track path of wheels described by loads on point instead of a load evenly spread in a straight path for running on rough terrain. As an outcome, motor equations have been formulated to calculate the variables $\alpha 0$, β, and αi; those coordinates are non-dimensional of the instant center points of rotation. Even so, these solutions are graphically achieved in the shape of nomograms. Nowadays, the advancement of modern computing allows for simple calculations with high precision and rapidly. Previously, experiments on tracked vehicles were only performed in the case of circular movements at constant revolution speed. Since stationary motions are irregular and nearly all of the moves on a tracked motor are called non-stationary, it is vital to analyze the non-stationary movement of a tracked automobile.

The hardware that was utilized

Microcontrollers

Microcontrollers are the brains of robots. They enable the designer to connect sensors and advanced control electronics, besides provide the robot's general logic [45]. Beginner and intermediate developers alike could program the robot logic in a variety of coding languages. A quadrature encrypter measures the speed and trajectory of a revolving shaft. It may use various sensors such as optical and Hall Impact sensors, which are also widely utilized. The image below depicts the interior of a Rover 5 gearbox [32]. On the PCB, two infrared sensors examine the black and white sequence on one gear. Doubled Square frequencies wave is created by feeding the results into an XOR gate independently of the direction in which both encoders inputs are controlled.

Optical Encoders

The Baldwin Piano Company evolved optical encoders for the first time in the mid-1940s to be employed as "tonewheels" that enabled electric organs to imitate other musical instruments [46]. The break-beam proximity sensor has been a miniature version nowadays matching application. A shaft of attention is described as a focused-interrupted pattern of opaque/transparent coding on a moderate rotational disk linked to a light beam intended at a corresponding photodetector. The revolving disk could be produced of chrome on glass, polished metal, or photo plast like Mylar. In comparison to more sophisticated alternating current resolvers, the optical encoder's clear encoding structure and inherently digital performance will result in a low-cost, efficient set with strong noise insulation. Two essential optical encoders are useable: incremental and absolute. The cumulative system calculates rotational speed while the absolute systems calculate the specifically angular direction and accurately assess the velocity.

LCD

The brightness intensity in LCD panels is regulated by pulse-width modulation (PWM). The frequency of the PWM switch should be even faster than the frequency charge of 200 Hertz would be affected. The concept operation cycle refers to the proportional duration of time when The switch has been turned on for a while. Since the light is switched off the majority of the time, a short service period leads to low power (low lighting in this case). The working cycle is represented in (100%), which means that it's turned on (max. backlight brightness).

Voltage controller

The voltage regulator can make sure that the components receive the proper amount of voltage [36].

Vehicle control

PID controller is used to guide the steering wheel for vehicle control [46-50]. The sensor pot gives comments from the three-axis accelerometer to determine collision direction and magnitude, calculate vehicle angle, and the useless calculation of navigation. Furthermore, the ATX type computer and the cRIO controller are utilized. The system's roles are split to permit concurrent task invention and implementation, which improves development and system efficiency.

The cRIO's software is split into two categories the FPGA setup and CPU program. Applications were efficiently developed in Lab View with all of these goals to do the follows: [36]

1. GPS data is received and converted.
2. Decrypt quadrature encoders.
3. Activate PID mechanism control.
4. Follow a predetermined moving direction.
5. Change between autonomous vehicles and manual ones.

UGV Algorithm of Navigation

The UGV is gotten the commands to guide to a particular target. As a result, it moves towards the target and comes to a stop, gradually resuming acceleration and navigating towards the waypoint [46-50].

The UGV algorithm of navigation can be separated into many proceedings as follows:

1) The UGV collects the GPS checkpoint for the destination from the hosting device.

2) The UGV's current location and navigating are obtained from the GPS and digital compass consecutively.

3) The UGV's goal set direction is determined with the current and destination GPS positions. Utilizing the optical compass measures, the UGV turns towards the aim GPS waypoint and comes to a stop hence.

4) The overall length between two GPS points is separated into a predetermined length of shorter distance goals known as milestones. The UGV gradually accelerates to get the speed of the target.

5) The UGV tries to move in a straight path while checking to see if either it has completed the milestone or met the targeted mark.

6) Once the UGV has hit the target, the navigation is considered successful, and the deceleration technique is used to bring the UGV to a safe and smooth stop.

7) Once the milestone has been met, it analyzes the angular distance between the actual heading and the recently determined goal heading.

8) In the case where the angular deviation exceeds the tolerance, the UGV is proportionally calibrated to the target value, and Step 5 is carried out in order to reach the upcoming milestone. This enables UGV to redirect its path to control the slipping issue.

UGV Navigation Software for Mini PC

On account of the following advantages, the "Matlab" coding language was selected to develop navigation applications for the robot.

Control Flow

The major thread is notified of a new instruction. Suppose that command is a request command for information that asks for data like GPS location points, UGV headings, etc [46-50]. In this case, it can respond to the order with the needed data without any impacting the carrying out of current instructions. If the next instruction is a new maneuver, it disables the executing of current commands, interrupts the UGV, and creates a new thread to execute the new task. The flowchart below depicts the flow of control on the primary line.

UMV powered by self-electric solar

A solar vehicle is a solar-powered electric car generated on the top of the vehicle using solar cells. It consists of four-wheeled vehicles operated by an electric motor and operated by a solar panel [51-53]. Power is transferred from the engine to the wheels via gears. Figures (8-12) show all required step to calculated the number of solar panel array of UMV powered by self-electric solar. Sample computer program was used to compute all values required in the design procedure.

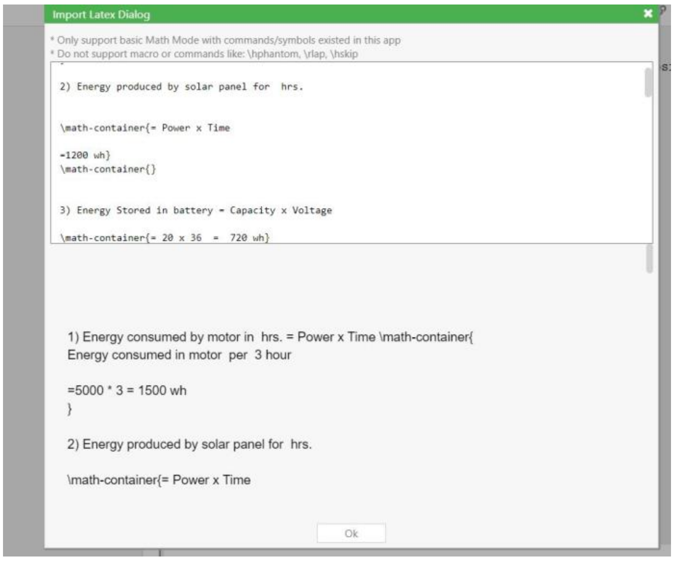

Figure 8. Step number 2

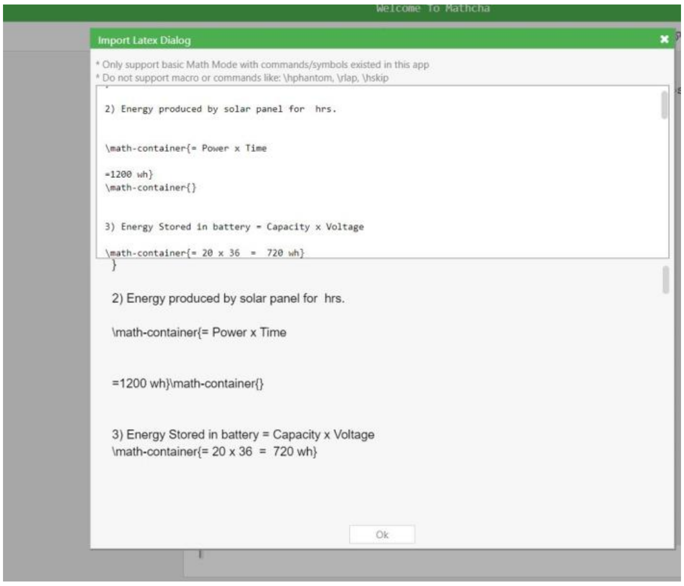

Figure 9. Step number 3

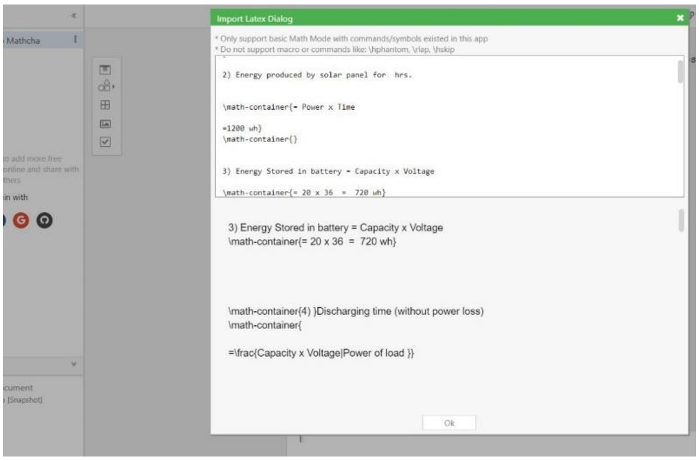

Figure 10. Step number4

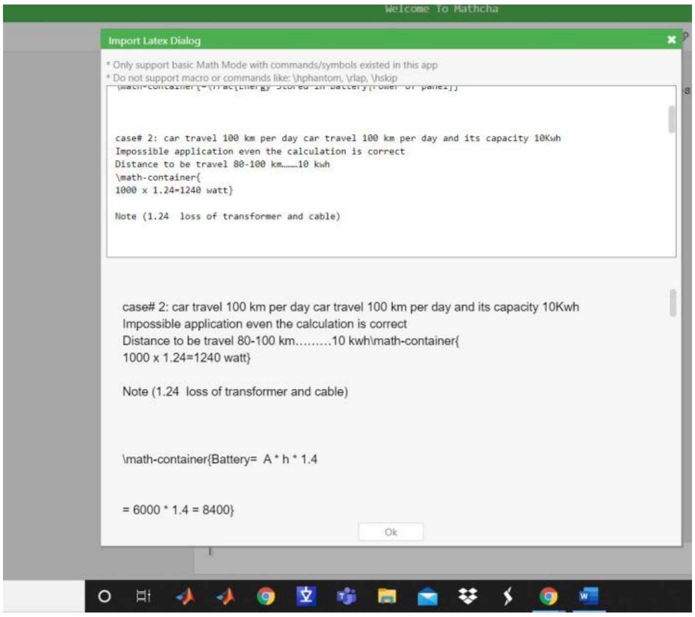

Figure 11. Step number 5

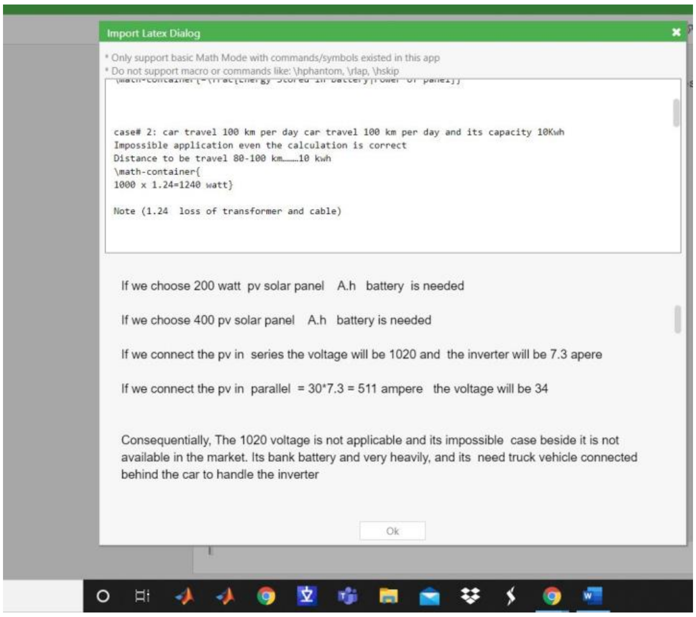

Figure 12. Step number 6

Our calculation leads the following finding- :

- the number of solar cell pv required to charging EV depend on size vehicle's battery. And the amount of energy produce .
- 200 W solar panel can generate 30-40 kWh of AC power .
- most cars needed 6-12 solar cell pv panel.
- In past, researcher used pv and inverter together to convert the DC current to AC current , recently no longer need of inverter since The new manufacturing PV which located over the solar electric toy are produced AC current directly.
- 6pv solar cell will be placed over the roof of solar electric toy
- The solar electric product required a whole day [4.5 hours] to charge because the first and last picks were not involved in the charging period besides the overheated duration.
- The solar electric robot has an ampere-hour of (600/16 = 16.16. A.h) and a voltage of 36 volts.

On the marketplace, there are many solar cell PV choices:

1) Thin-film that's the best choice.
2) Mono class.
3) Poly class.

A vehicle traveling 100 kilometers per day requires a 30 solar cells PV with a capacity of 400 amperes and a voltage of 24 volts.

There are four classes of batteries:

1) The acidic sort that is incompatible with photovoltaic solar cells.
2) Gell batteries.
3) Sodium batteries.
4) Lithium batteries are the best choice.

There is no necessity for charging control since the current inverter can position itself and do its duty.

There are two kinds of inverters:

1) PWM with a low cost.
2) MPRT which is the favorable choice.

CONCLUSION

An amusement RC car that transforms into a driverless Ground Vehicle can be patrolling in a straight path fully autonomous. A simple four-wheeled robot model self-guided electric vehicle with remote control was investigated; the final model would be a self-guided vehicle. The radar sensors, cameras, and all other sensors used to drive the vehicle on the path were mounted.

- A four-wheeled robot model driven by a Geographic Information System (GIS) in its environment was designed and built to be functional and multitask. Furthermore, create the spine routine so that the traveled distance is tracked and guided based upon the encoder-reading, test the robot moves along a basic track, and test complete control of engine motion.
- The wheeled robot model was utilized to create a functional and multitask wheeled robot that can follow/visit prespecified targets in the X-Y skyline plane, based upon the moving boundaries of the robot wheels and no other dynamic reference such as GPS.
- A unique application was utilized to take control of the vehicle's stopping and moving, speed, and safety when in motion.
- The software was developed to control all vehicle movement, and it will make use of the navigation system to drive the motor from the point of departure to the point of arrival.
- The wheeled robot design was operated by a photovoltaic (PV) solar system.
- In addition, when required, manual remote control via a controlled camera can transcend the autonomous system.
- Finally, our basic experimental configuration can help as an easy, stable, and cost-effective test platform for future gaze-controlled functionality design, perhaps enhanced with other techniques.

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