Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 01-2023
DOI 10.17605/OSF.IO/S3AGF

DESIGN AND IMPLEMENTATION OF AUTONOMOUS ROVER USING COMPUTER VISION ALGORITHM

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Abstract

Robot navigation is the difficulty of guiding a robot to its intended destination. Autonomous navigation is contingent upon motion planning, i.e., the interdependence between activities such as environment sensing, path planning, and path tracking, among others. This research paper proposes and develops a four-wheel differential drive for the autonomous rover. The rover used computer vision techniques to avoid a collision with obstacles and walls and predict the Rover's direction of motion, a Global Positioning System (GPS) and magnetometer sensor were used to reach its target location. Transfer learning was used to retrain the ResNet-18 model to our dataset. A camera was mounted in front of the rover to capture the images, and a powerful low-cost embedded computer Nvidia Jetson Nano was used to process those images and predict the Rovers direction of motion. A GPS sensor was used to get the rover's current location, and a magnetometer was used to get the rover's current heading from which the distance from the target location and required heading were calculated. PID controller was used to calculate the speed of motors at which the rover will steer and move towards the target location. A functional autonomous Rover was successfully developed with computer vision techniques to avoid obstacles. Many possibilities exist to improve the model proposed in this paper. LIDAR can enable a 360 obstacle detection functionality, which could allow it to avoid obstacles from all directions.

Index Terms: Autonomous, Rover, Computer Vision, Artificial Intelligence, GPS, Robotics

1) INTRODUCTION

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Autonomous robots' ability to perform something independently is a fundamental feature. They are a valuable resource because they can complete any task without using humans. In the subject of robotics, this is an exciting section. Technology in the present day is steadily moving away from manual labour and towards automation. Having fewer human interactions and achieving simple functionality. Autonomous Rovers are exploration robots dwelling on the ground in the absence of humans with different autonomous capabilities. There are continuous advances in the field of autonomous vehicles. Modern neural networks and vision-based systems now provide improved performance and results for on-road conditions. However, in off-road situations, GPS is preferable. Adding an image processing layer to it makes the whole thing better. The system can be improved further. But in the case of long path planning, only the image processing-based system cannot reach the destination and generate the desired path. In this circumstance, the GPS-based global positioning system is mandatory.

2) LITERATURE REVIEW

In [1], R. Miyata used Jetson Nano, a single-board computer designed by NVIDIA. Jetson Nano is an embedded hardware platform that may be used for robot and IoT research and development. It is widely utilized in both the academic and industrial worlds. Jetson Nano is now equipped with a CUDA-compatible 128-core GPU that can do AI processing faster than other processing boards of comparable size. M.M. Abrar [2] discussed an effective way to track the independent mobile robot, vehicle that navigates without the assistance of a human operator [3]. Before the operation, the motions and trajectory are predetermined, and the robot navigates appropriately. We employed the GPS data for the robot's self-governing navigation. The destination is preset as latitude and longitude coordinates in the robot's software, among other navigation strategies. The primary benefit of utilizing GPS for navigation is that the data obtained from past readings makes it simple to reduce errors [4]. A digital compass calculates the robot's leading angle and assists it in determining the trajectory's direction. A. Krishnan [5] suggests a concept for an autonomous robot that can navigate in a static environment utilizing low-cost 3D cameras like the Kinect. The built robot uses particle filters to locate itself in a 2D map. It employs the A* algorithm for global path planning once localized. A PID controller uses data from odometry to provide motion control once a route is available. In his experiment, C.N. To do obstacle avoidance, Viet [6] claimed that a robot needs know the distances between things. Stereovision is the most common method for extracting depth information from visual images. Frequently, stereo vision creates precise depth maps. Using motion parallax, depth information may be extracted from a series of photographs taken with a single camera [7].

3) HARDWARE SCHEMATICS

The project aims to develop an Autonomous Rover which can navigate from one location to another while avoiding obstacles. The hardware components selected entirely depend on efficiency and the cost of the component. The rover is a differential

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drive mobile robot. The main processing unit used in this course was NVIDIA Jetson NANO, which is a compact computer with high computational power, specially designed for embedded applications and Artificial Intelligence. The rover is also equipped with an Arduino Mega as its flight controller to control its movement, Ublox 6M GPS Module, QMC5883L Magnetometer, 12 Ah Dry Cell Battery, Logitech C270 Camera and DC Geared Motors with 680 rpm.

Fig 1: Final Design of the Rover

4) APPROACH

(1) Robot Navigation

The software of the robot begins by initialising the GPS and compass sensors. The GPS-based module searches for satellites and calculates the latitude and longitude of the current position. To accurately calculate latitude and longitude, the GPS module must be locked with a minimum of three satellites. The robot then computes the goal angle using the latitude and longitude data. The angles must be calculated using radians. The compass module supplies the current heading angle; the error angle is determined by subtracting the current angle from the desired angle. Based on the error angle, we can determine if the robot has to turn to the left or right. The rover uses PID (proportional integral derivative) controllers, which are reliable controllers that employ a control loop feedback mechanism to regulate process variables. It maintains the actual direction of the destination point as near as it is practical to the goal or set point output. The flight controller, Arduino Mega, sends PWM signals to motor drivers based on the error angle. The BTS7960 motor driver controls the robot's motors to align them with the required angle. Using an efficient method, the distance to the target location is estimated. The robot ascertains whether or not it has reached the destination's threshold value (in our program, we set the threshold value to 1 meter). The robot recalculates the goal angle, current heading angle, and distance to the destination if this is not the case. The cycle will continue till the robot reaches its destination. When the robot reaches its destination, it determines if this is the final waypoint. If not, it loads the subsequent waypoint and repeats the cycle; if it is the final waypoint, it stops.

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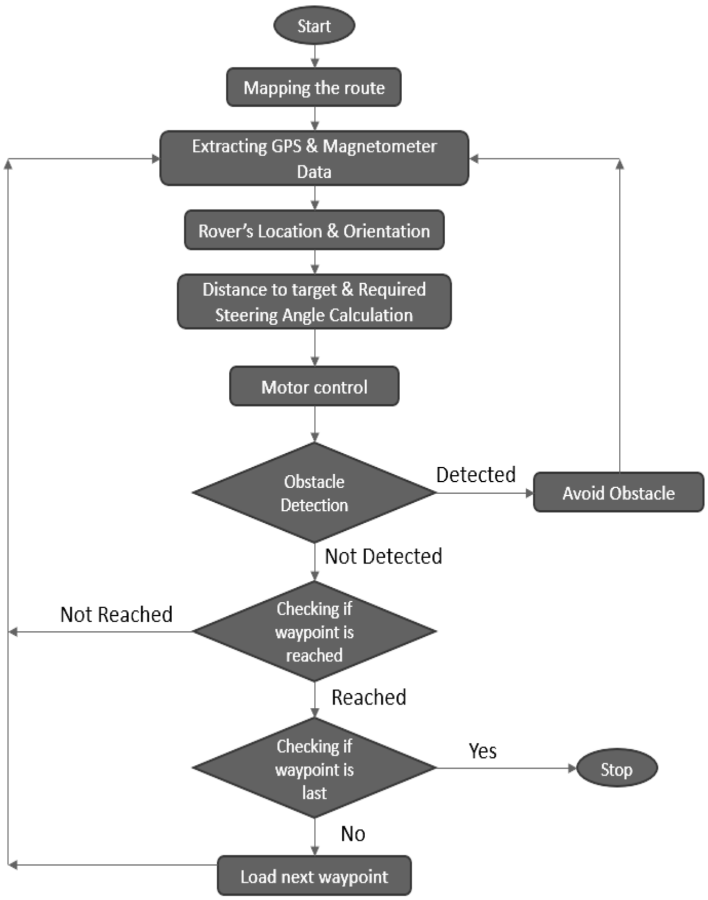

Fig 2: Navigation Flowchart

(2) Obstacles Avoiding

The resnet-18 model was used in this study for transfer learning. The trained Resnet-18 model was fine-tuned on our own data set to avoid the obstacles.

A Ligi Tech Camera, a C270 720p 30fps camera, is used in this experiment. We put the camera on the workstation to capture the needed data set. The data set is divided into three categories: center, which means there are no impediments and the rover can move forward, left, which means the rover must avoid obstructions which are at right and should turn left, and right, which means the rover must avoid obstructions which are at left and should turn right. To obtain high accuracy, we employ the transfer learning approach and the weights of the pre-trained models that have been learned, followed by a modest number of data sets. The model was trained with over 3500 images for each class and tested with over 250 images for each category. For transfer learning, this article used the ResNet-18 network. These data sets are then loaded into the model for training, and the model is then utilized to forecast obstacles.

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Fig 3: Image Classification

The input image is anticipated with the camera's real-time image, and the threshold value for encountering obstacles is established. The autonomous vehicle is programmed to avoid obstacles and rotate if the chance of detecting the impediments reaches the threshold value. After that, the rover can avoid obstacles on its own.

The Jetson Nano is mounted on the back side of the Rover chassis. Its main function is to run our Model in real-time and detect objects and provide the appropriate command to the flight controller (Arduino Mega) to avoid an obstacle or a pedestrian in its way. The Jetson Nano communicates with the flight controller via the serial port.

5) RESULTS

Our fine-tuned Resnet18 can successfully detect obstacles and provide the rover's appropriate commands to avoid obstacles. The rover was tested in an open street to navigate to waypoints while avoiding obstacles.

Fig 4: Set waypoints

Fig 5: Class center successfully classified

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6) CONCLUSION

A functional autonomous Rover was successfully developed with computer vision techniques to avoid obstacles. GPS and Magnetometer sensors were used to reach the target location. Many possibilities exist to improve the model proposed in this paper. LIDAR can enable a 360 obstacle detection functionality, which could allow it to avoid obstacles from all directions.

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