ABSTRACT

In this paper, we introduce a vision system for the navigation of a ground vehicle. The major tasks in the project are low level motor control and image processing. The mobile robot was mechanically designed and simulated in the CAD Solidworks software and its operation and controls conceptually demonstrated in the ROS ecosystem. Its electric components were designed and simulated using Proteus electrical software.

Low level motor control for the mecanum configuration is achieved by the use of motor drivers, here, the speed and direction of the motor is handled. Image processing is implemented by the use of raspberry pi camera and a raspberry pi 3b+ controller.

Intelligence, for navigation, is enabled by fusion of ultrasonic sensors, an inertial measurement unit and the camera sensors.

INTRODUCTION

Mobile robots are robots that can move from one place to another autonomously, that is, without assistance from external human operators. Unlike the majority of industrial robots that can move only in a specific workspace, mobile robots have the special feature of moving around freely within a predefined workspace to achieve their desired goals. This mobility capability makes them suitable for a large repertory of applications in structured and unstructured environments. Ground mobile robots are distinguished in wheeled mobile robots (WMRs) and legged mobile robots (LMRs). WMRs are very popular because they are appropriate for typical applications with relatively low mechanical complexity and energy consumption.

Intelligent mobile robot design employs the methodologies and technologies of intelligent, cognitive, and behavior-based control.

PROBLEM STATEMENT

The localization and ultimately the movement of a mobile robot within an environment is one that can be achieved in different ways. Railed robots, in warehouses, or line tracking robots, in industry have become increasingly dominant, however, the need to accurately perceive and map the environment has fueled the need of incorporating addition sensors, like, cameras, radars an lidars, all this, for increased autonomy.

The project aims at improving the idea of intelligent navigation by incorporating a camera into the robots perception stack.

JUSTIFICATION

The use of cameras in vehicle and robot mobility is one that elevates the perception abilities significantly. The ability of a robot to distinguish objects, people, colors and even read signs is a great measure of intelligence.

Using behavior-based control, we seek to leverage the use of artificial intelligence methods, that is deep learning for computer vision, and the camera's vision capabilities to train the robot to understand and clearly distinguish elements in its immediate environment.

PROJECT SCOPE

The project is to be completed in two steps:

Software implementation: this entailed the design and modeling of the electrical, mechanical and demonstration of its controls system using the appropriate software and virtual environments. The electrical circuit was designed and simulated using Proteus software while the mechanical design was also modeled and simulated using Solid works software whereas the control aspect was demonstrated using the ROS ecosystem.

Hardware implementation is characterized by loads of iteration. Testing of the robots electrical components, connection between them and their control. Model training and searching for the most optimized methods to solve the handle the vision capabilities of our robot using the available hardware stack.

LITERATURE REVIEW

This paper deals with the design of the optimal navigation of an mobile robot. The project at hand entails the design, simulation, fabrication and control of the mobile robot for it to optimally keep within a lane, follow an object and avoid obstacle collision with the aid of the raspberry pi camera incorporated into the assembly. The camera is held in place; fixed to its position (in between the 2 ultrasonic sensors) which are the essential components of the project. This leaves the control aspect of the project an essential tool in the project as the performance of the project depends upon the accuracy of the control implemented.

The three sensory components aid the ground vehicle to perceive its immediate environment and pass the information to the control aspect and that is the most challenging point since the control incorporates; image detection and tracking, controlling the motors using PWM signals, making sure that there is a coordination between lane keeping and object following in case the two scenarios contradict. The solid woks CAD design was a guide to the parameters to fabricate it using a 3D printer and also to understand the arrangements of the required components adequately with sufficient space. The electrical deign and simulation was to understand the electrical connection between the components, power distribution, sources of power and ensure that every component is up and running. The control aspect was to understand the control of the ground vehicle, how the control program is to be structured while coming up with flow chart program flow.

The fabrication bit of electrical works include power distribution, design and physical implementation of the puff board customized to the project; physical wire connection between the components according to the electrical flow chart.

The orientation and velocity of the ground vehicle is determined with help of an IMU 6050 and this acts as a feedback that aid in the optimal functionality of the camera and the two ultrasonic sensors thus sensor fusion is of great essence.

The mecanum wheels used are Omni wheels that help navigate more intensively as compared to the differential wheels. This wheels are controlled by DC motors which are in turn controlled using LM298N motor drivers since it is unprofessional to power DC motors.

A microcomputer is used to control the functionality and operation of the ground vehicle. It collects the data obtained from the sensors, fusses it and sends control signals to the actuators eg the motor driver which is a controller on its own (this thus uses the signal it receives and sends another signal to the motors).

METHODOLGY

A computer program is developed for control the robot's manipulators, image processing and over the air communication with the mobile robot therefore allowing for tele-operation also known as remote-operation.

Remote operation allows the user perform the control required for behavior-based training of the robot.

The data required to effectively train the model is collected by mimicking the mobile robot in action. This implies that, the robot is supposed to be driven around, severally to gather enough data while patterning its motor control states; speed and direction of rotation as part of the data to be collected.

The frameworks and API required to, collect data, structure it, label it and later on to train the model, low level device control, image acquisition, and the libraries required for the computer vision processes and task, are all based on the python language.

Settling for a single language to implement the project is solemnly based on maintaining the authenticity of the data being passed exchanged between the devices and the program processes.

SOFTWARE REQUIREMENTS

Deep learning for computer vision necessitates the use of Python as the main programming language, TensorFlow, an open-source software library for machine learning and artificial intelligence leveraging its training and inference of deep neural networks capabilities, Open-CV for image processing and Keras, an interface for TensorFlow library that enables fast experimentation with deep neural networks.

The entire framework for the mobile robot is run from a raspberry pi, that in-turn runs a native operating system, the Raspbian OS. This operating system offers an advantage over others due to its plug and play nature. Most of the libraries required to interact with our programs have their libraries pre-installed. Therefore, preparation of the controller to suit our project is lightened.

DISCUSSION

In order to calculate the sensory input of the neural network, the captured color image is converted to a binary image. The input of the visual processing module is the image frame captured from the robot's camera.

The image first is converted to a gray scale and then to a binary image. In our implementation the size of captured image is to be 240 by 320 pixels. The reduction in picture element for the input image to be used with our model is on the basis of getting maximum efficiency -speed and computing power - from the limited graphical processing power of the controller.

The images are captured in a stream – video – where the objective upon each frame is to:

- Detect an obstacle and allow for tele-operation for its avoidance.
- Position the mobile robot at the lane center.
- Recognize signs on the environment for autonomous navigation.

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