Roxi

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Abstract

abstract lorem ipsum

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3.1 Structure Overview

This years drive base was guided by the following main goals: After our move last year to a four wheeled drive base, our team sought to further improve on this platform. Some deficiencies with last years were noted. This years drive base was guided by the following main goals:

roofing performance

educed overall mass

oad accommodation

o hold a new laptop

l ride characteristics

1. Increased waterproofing performance
2. Reduced overall mass
3. Improved payload accommodation
4. Ability to hold a new laptop
5. Enhanced ride characteristics

3.2 Drive System

Layout & Suspension

Motors & Encoder Modification

3.3 Waterproofing

3.4 Electronics Accommodation

Laptop

Camera

LIDAR

Interface Panel

Power Electronics

4 Electronics Design

The electronics for Roxi can be broken into three major categories: Senors, Power, and computers.

4.1 Sensors

Roxi uses vision and LIDAR as its primary sensors used for the navigation challenge and also has GPS and wheel encoders to allow for waypoint navigation.

4.1.1 Vision

The vision system consists of a AVT Guppy F-036C camera connected via an IEEE 1394a link to the main computer. This camera is capable of 752 x 480 resolution at 64 fps. This camera is polled at approximately 10 Hz to send a new frame to the vision algorithm. The camera is placed at the top of the mast, facing forwards and down to allow the lines and obstacle in front of the robot to be sensed.

4.1.2 Wheel Encoder

Each wheel is connected to a quadrature wheel encoder, allowing wheel rate to be measured. This allows the velocity of the robot to be measured. The encoder is a US Digital E3-200-375-I-H-M-B, with 200 counts per revolution and an index channel. This allows for wheel rates up to XX speed to be sensed. The quadrature lines drive interrupts on a microcontroller, which then feeds the state of the lines to a state machine which increments or decrements a wheel counter. Wheel angular velocity is measured by differencing the number of counts over a 5 ms period, allowing a bandwidth of XX Hz and XX m / s. The microcontrollers are capable of sending both rate and count information to the laptop, allowing for speed control and odometry operations.

4.1.3 LIDAR

Two front and rear mounted Sick NAV300 LIDAR are used as object and ramp detectors. The LIDAR have a 270° FOV and a 10 meter range. The front facing LIDAR is used as an object finder, while the back facing LIDAR is used as a safety feature allowing the robot to sense if an object / person is moved behind it after the robot has moved through an area.

4.1.4 GPS

A GPS is used to provide world position to the robot, allowing obstacles to be placed in world space and allowing waypoints to be followed. A Garmin ”GPS 18-5Hz” gps is mounted to the mast to allow a clear view of the sky. This GPS is accurate to ¡15 m / ¡3 m (GPS / WAAS) and has a time to first fix of 45 seconds. The GPS updates 5 times per second.

4.2 Power

4.2.1 Main Power

Main power for the robot comes from two sealed lead acid gell-cell batteries. These batteries are connected in series to produce a nominal 24 VDC supply for the motors and other systems. This provides approximately XX $W \cdot hr$ of energy, XX hours of runtime of the motors, and XX hours of runtime of the electronics and motors.

The batteries are connected to a power distribution board, which allows the connection to each motor to be fused with XX Amps, allowing power to be cut in the event of a motor stall to prevent damage to the H-bridge. Power is also provided to several DC-DC boost converters, which output 5 VDC, 9 VDC, and 19.5 VDC for other electronics on the robot.

4.2.2 H Bridge

Each motor is connected to an OSMC H-bridge. This board is used to allow a low power signal from the microcontrollers to generate a high power PWM input to the motors. Each OSMC is capible of switching up to 50 VDC at 160A cont / 300A peak, allowing significant margin above our standard operating power of around 24 VDC / 20 A.

4.2.3 Component Power

Other systems are provided power through the use of DC-DC converters to produce voltages at 5 V, 9 V, and 19.5 V. This allows for the usb tethered microcontrollers, the sensors, and the main computer to be powered off of the main lead acid batteries. This greatly simplifies charging the robot, as only one battery system needs to be maintained.

4.3 Computers

4.3.1 Main Computer

Nearly all computation is performed on a single laptop containing a quadcore Intel Core i7 cpu, cuda enabled NVIDIA 285M gpu, and 6 GB of RAM. This computer is responsible for all vision, LIDAR, and GPS data processing and all path planning and control algorithms. It also forms the core of the sensor interconnects, providing the firewire and USB bus the camera, GPS, and microcontrollers use. This laptop replaces the main computer used in previous years, and was replaced with support from Northrup Grumman.

4.3.2 MCU

Microcontrollers are used on Roxi as data acquisition boards to collect data from the wheel encoders, and as motor control boards to generate PWM signals to drive the H-bridges. There are 6 ATmega328p based Arduino Duemilanove boards on the robot, 4 interfacing with the wheel encoders, and 2 to drive the motors.

5 Software Design

5.1 Architecture

5.2 Algorithms

5.2.1 vision

The robot uses vision as the primary method of detecting obstacles and lines. The vision algorithm has been developed and modified over several years of competition and is considered reasonably robust. After passing the input video through several different algorithms, a short-term map of the world is created, which the robot is driven off of.

The input video, above-left, is first passed through an inverse perspective transform, as seen above-right. This transform makes both near and far off objects a normalized size, and makes the image appear to be taken from directly overhead. This flattened image assumes the course is a plane, which does cause distortion of the barrels, but this is accounted for in the mapping algorithm. The transformed image is much easier to process into a map than a normal, perspective image would be.

The images is then color segmented and thresholded based on the color that is centered directly in front of the robot, as seen above. Safe colors are marked white, the rest are black. The color is averaged in time between frames to allow for some variation in color, for example, if there is dead pach in the grass. This allows the robot to operate on many different surfaces with the same software. For testing we have operated on asphalt parking lots, navigating between the lines marking parking spaces.

After converting the transformed image to grayscale, feature tracking is preformed between subsequent frames. The tracked features are denoted by the black lines in the above grayscale image. The algorithm looks for features that have been translated and rotated between frames. This allows us to build a set of likely homographic transform between the images, which can be backed out into likely robot motion between frames. The possible homographic transforms often include several incorrectly matched points, so RANSAC, a nonlinear filter good at outlier handling, is used to reject the outliers and select the best transform.

Using motion data, camera frames are drawn into the world map, shown to the right above. The map is a grayscale image, representing a probabilty function of traversablility, where black (0) represents non-traversable, gray (127) represents unknown areas and white(0) represents traversable ares. The map is built up as the robot moves, and slowly decays back to gray to prevent loop closure errors from building up. This map allows the robot to remember that it just passed an obstacle and needs to not turn sharply in order to avoid a collision. The robot is driven from the map, by a path planning algorithm.

5.2.2 Path Planning

6 Performance

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