Autonomous Navigating Robot

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Mission Statement

Based on the robot hardware built by Team 6 Cents from last year, this year we are designing an intelligent agent that can autonomously navigate around confined areas within Rice campus. The robot should take destination commands from users, determine its own postion, plan for the appropriate routes to reach the goal, while avoiding unexpected obstacles and following lanes at the same time.

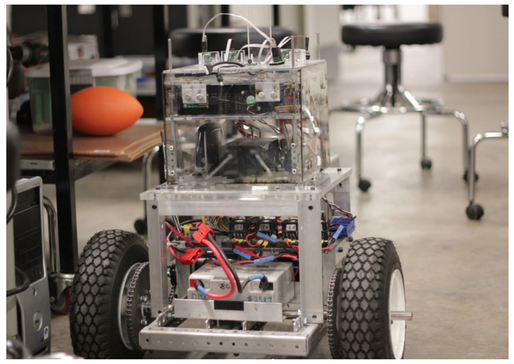
Design Criteria

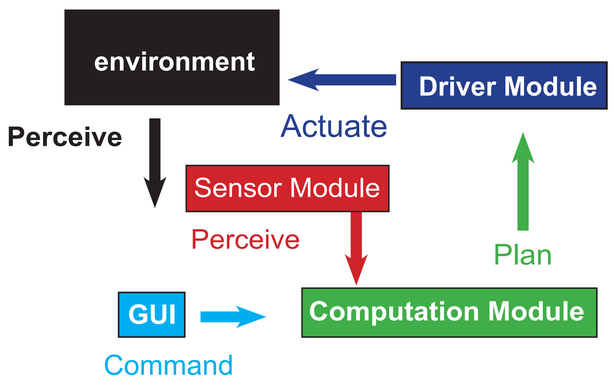
1. GPS waypoint navigation
2. lane detection and following
3. obstacle avoidance
4. stable speed control
5. emergency stop mechanism
6. intuitive user interface
7. shortest path search

Applications

- unmanned vehicles and carriers
- persistent surveilence, search and rescue
- intelligent delivery service
- robotics education tool kit

System Overview





Computer Intel Core 2 Due E7500 2.93 GHz, running Ubuntu 9.10, 8GB flash memory

OrcBoard 8 PWM output ports, 2 encoder input ports, Ethernet interface, Java-based API

Motor 2.5” output shaft, one on each wheel, attached to a gearbox with ratio 12.75:1

Encoder one on each gearbox to measure rotational velocity and control feedback

GPS OEMStar, carrier phase differential GPS, accuracy 0.5m

Antenna used to communicate with the base station

Compass tri-axial digital compass, gyroscopes and accelerometer

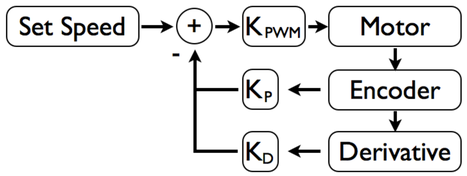
Camera Logitech Pro 9000, 2 megapixel video resolution, 30 fps, used for lane detection

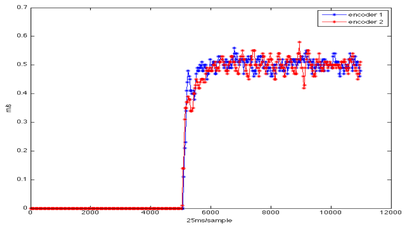
Laser Hokuyo URG-04LX, 240 scan range, 10 samples/sec, used to detec obstacles

GUI used to display and interpret current robot position and gather destination command from the user, written in Javascript with Google Maps API

Key Features

Speed Controller





step response for speed controller

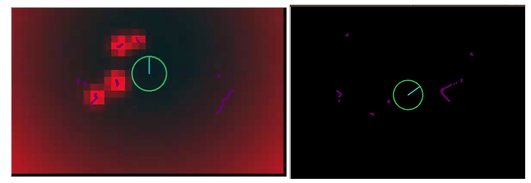
Potential Field Path Planning

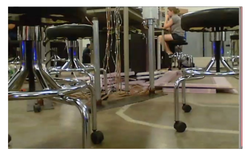
$$U_{rep}(q) = \begin{cases} \frac{1}{2}\, k_{rep}\, (\frac{1}{\rho(q)} - \frac{1}{\rho_0})^2 & \text{if } \rho(q) \le \rho_0 \\ 0 & \text{otherwise} \end{cases}$$

$$U_{att}(q) = \frac{1}{2}\, k_{att}\, \rho^2(q) \qquad \rho(q) = ||q - q_{goal}||$$

$$U(q) = U_{att}(q) + U_{rep}(q)$$

$$F(q) = -\nabla U(q) = -\nabla U(q) = -(\frac{\partial U}{\partial x}, \frac{\partial U}{\partial y})$$





laser rangefinder data, potential field diagram, and camera image

Lane Detection

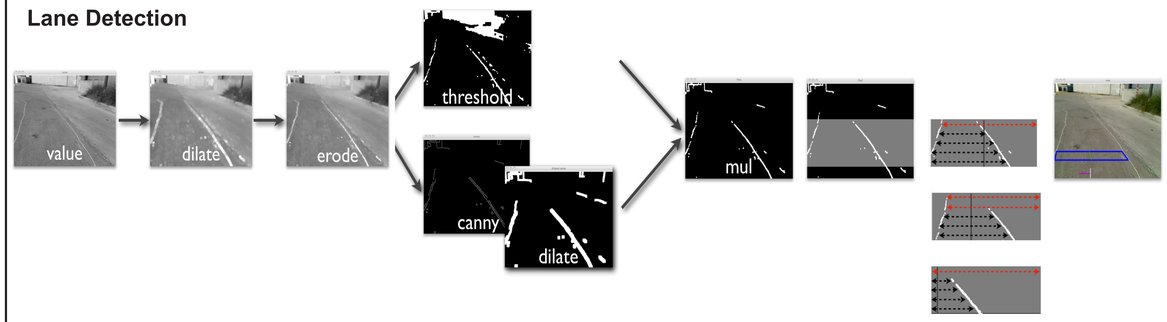


image processing | line extraction | lane detection

Accomplishments

- lane detection and following
- stable speed control within 5~10%
- web-based GUI and wireless access
- obtain current position using GPS and encoder odometry

Advisors

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