MIL Rover: An Autonomous All-Terrain Robot

Shu Jiang
Machine Intelligent Laboratory
University of Florida

Abstract

MIL Rover was designed for the Machine Intelligence Laboratory (MIL) at the University of Florida. The mechanical platform of Rover is modeled after the Mars Sojourner, and it is capable of navigating in rough terrain environments. This paper presents the recent development of Rover's control system. The control system is designed to enable the Rover to perform two basic robotic tasks: obstacle avoidance and color tracking. Three ultrasonic sensors (sonar) are used for obstacle avoidance, and color tracking is achieved by CMUcam, a vision sensor. Data produced by all sensors are processed by an AVR 8-bit microcontroller, ATmega128.

Introduction

The design of a robot's mechanical platform is usually based on the environment it is going to operate in. MIL Rover was designed to be an all-terrain robot. May the traversing surface be uneven and full of unfriendly rocks (i.e. Martian surface), or simply a flat-tiled floor, Rover will always be able to navigate at ease. Rover's size renders itself suitable for indoor navigation as well.

Besides a robust mechanical platform, a robot also needs a perception of the world it is in and a set of behaviors associate with certain perceptions in order to be intelligent. Obstacle avoidance is a basic behavior of autonomous mobile robots. It is usually the first step in the development of autonomous mobile robots. Without obstacle avoidance, a robot would destroy itself before any other more intelligent behaviors can be implemented. There are many low cost implementations exist for obstacle avoidance (i.e. bump switches). For this paper, ultrasonic sensors are used to implement obstacle avoidance.

With the ability to navigate both indoor and outdoor, Rover is an excellent platform for vision-based navigation research. A simple color tracking behavior is implemented for Rover with a vision sensor (CMUcam).

Lastly, Rover has an 8-bit microcontroller as brain. It translates the data sampled by sensors into Rover's perception of the world it is in, which results in execution of the behavior associated with the perception.

Mechanical Platform

MIL Rover's mechanical platform adapted the six-wheeled rocker-bogie suspension design, which is originally developed by the Jet Propulsion Laboratory (JPL) for the Mars Sojourner [1], Figure-1. Each of the six wheels is actuated by a low current 12VDC motor. All six wheels are machined out of aluminum, and are hollow in the center, where motors are mounted internally, Figure-2. Rover's steering is achieved with 4 servos, 2 for front wheels and 2 for back wheels. Figure-1 shows where the servo is mounted for one of the front wheels. To ensure stable navigation over rocky surfaces, two pivot axels are used to allow each individual wheel to shift up/down, which enables all six wheels of Rover to maintain making contact with ground during traversal, Figure-1. Figure-3 demonstrates the robustness of Rover's mechanical platform and its ability to traverse hostile surfaces.

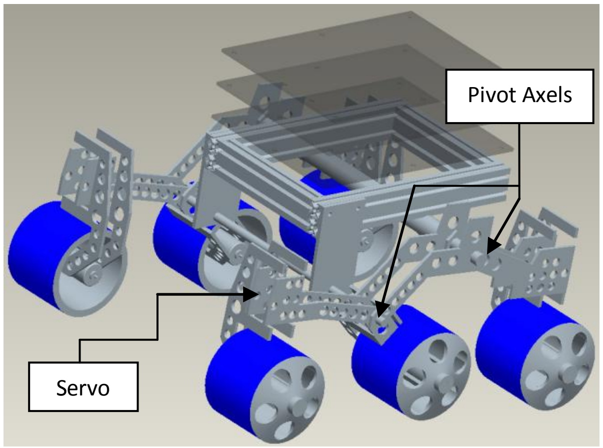

Figure-1: MIL Rover ProE model

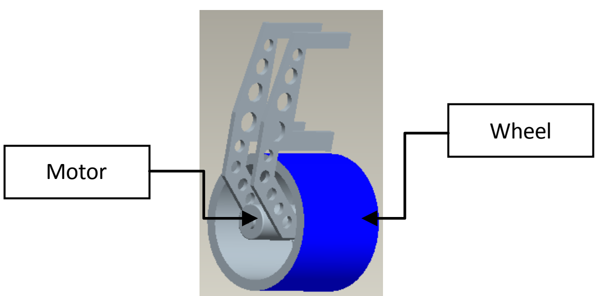

Figure-2: MIL Rover leg

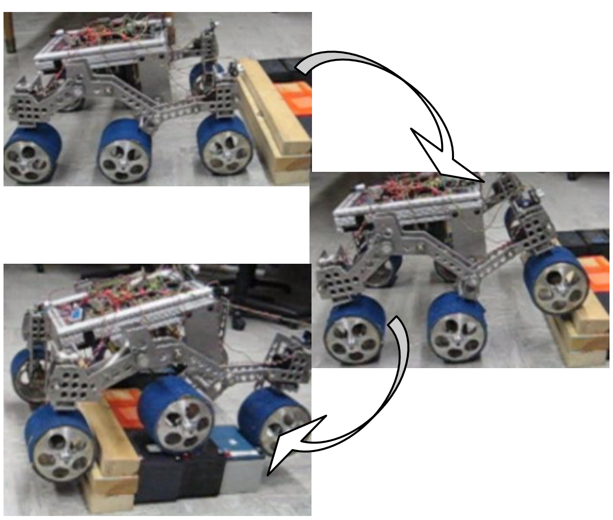
Figure-3: MIL Rover climbing video still shots

Control System

Rover's control system uses an AVR 8-bit microcontroller (uC), ATmega128, to interface with sensors, process data from sensors, and execute motor functions based on processed sensor data. An overview of the system is shown in Figure-4.

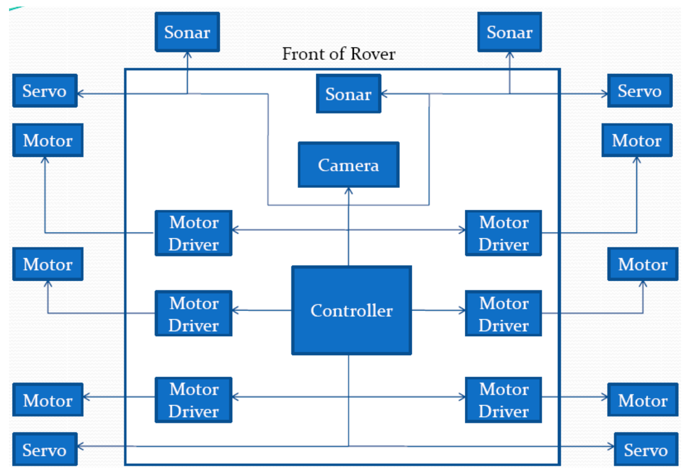

Figure-4: Rover System Overview

Obstacle Avoidance

Obstacle avoidance for Rover is implemented with three ultrasonic range finders, Devantech SRF04, Figure-4. SRF04 detects obstacle by sending out 40kHz pulses and listening for any pulse being reflected back. If there is any obstacle within the range of the sensor, then the time between sending out pulse and receiving reflected pulse can be used to calculate the distance between the obstacle and the sensor.


Figure-4: SRF04

The three ultrasonic sensors are mounted in the front of Rover; the center senor points directly forward, while the other two are mounted at an angle approximately 30° to the left and right respectively, Figure-5.

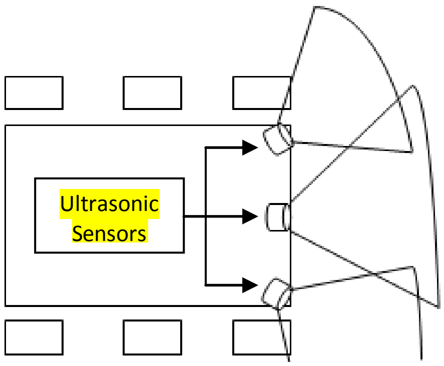

Figure-5: Ultrasonic sensors for obstacle avoidance (exaggerated beam)

SRF04 communicates with the uC through its Trigger and Echo pins. To detect an obstacle, uC first puts a short pulse (~10ns) on SRF04's Trigger pin to tell it to ping, and then uC reads data on SRF04's Echo pin. The length of time the Echo pin stays high (5V) is used to determine whether there is any obstacle in front of the sensor.

Color Tracking

Color tracking for Rover is implemented with a vision sensor, CMUcam. CMUcam has a resolution of 80x143 and is capable of tracking a user defined color blob at 17 Frames per second [3], Figure-6. It is mounted in front of Rover and right above the center ultrasonic sensor (Figure-5).

Figure-6: CMUcam

CMUcan communicates with the uC via TTL serial port. With CMUcam, to track a color is easy, since it has a built-in function for color tracking, TC. To track a certain color, the uC first sends the TC (track color) command with the RGB information of desired color to CMUcam, then it receives data return by TC and stores the data in a buffer. The data return by the TC command has the format, M Type Packet [3], shown in Figure-7. The data packet starts with 'M' and follows by *mx* and *my*, which constitute the location of the center of the color blob in the image. When tracking a color, *mx* is used to determine the direction and *my* is used to determine the distance from the color object. Figure-8 shows still shots of Rover tracking the red color.

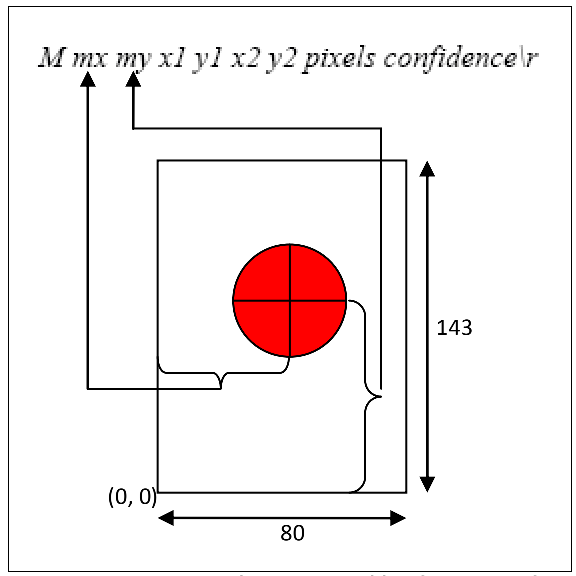

Figure-7: Data packet returned by CMUcam TC command

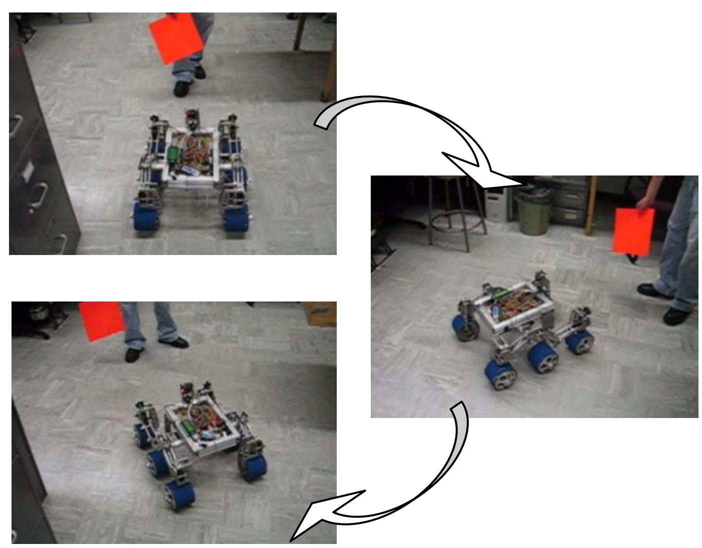

Figure-8: MIL Rover color tracking video still shots

Conclusion

MIL Rover is an all-terrain autonomous robot. With its robust mechanical platform, Rover is an ideal platform for both indoor and outdoor vision-based navigation researches. A simple control system has been developed for Rover to achieve basic intelligent behaviors: obstacle avoidance and color tracking. Obstacle avoidance is achieved with three ultrasonic sensors, while color tracking is implemented with a vision sensor. Lastly, a microcontroller is used to interface sensors with Rover's actuators (motors and servos).

References

[1] Robert Pitzer, "Gross Hund: All-terrain Autonomous Robot", Intelligent Machine Design Laboratory, University of Florida, 1997.
[2] S. Kanowitz and A. Arroyo, "Development of an Autonomous All-Terrain Vision Research Platform", Machine Intelligence Laboratory, University of Florida, 2000.
[3] Anthony Rowe, "CMUcam Vision Board User Manual", Carnegie Mellon University, 2003.