
Date: 4/17/09
Student Name: Bo Liu
Robot Name: Dachong
TA : Mike Pridgen
Thomas Vermeer
Instructors: Dr. A. Antonio Arroyo
Dr. Eric M. Schwartz

Project "Dachong"

Bo Liu

University of Florida
Department of Electrical and Computer Engineering
EEL 5666
Intelligent Machines Design Laboratory
Final Report

Table of Contents

Abstract

The project to build the six-legged walking robot "Dachong", which means "big bug" in Chinese, was finally finished. In this report I'll give an overview of the concept of the robot, and then I'll talk about the mechanical structure of the robot. I'll show all the electronic parts of the robot, including micro-controller, sensors and feedbacks. Finally I'll explain the behavior of the robot.

Introduction

The robot, named "Dachong", is a six legged robot that uses ATmega128 micro-controller as control unit and 6 servos for movement. The main mechanical components of the robot are 3 identical assemblies of legs. For each leg assembly there are 2 servos, one is in charge of the vertical movement of the robot, the other is in charge of the horizontal movement of the robot. All the electronics are mounted on a platform on top of the mechanical part supported by 4 rods. The sensors used on the robot including 3 IR sensors for obstacle avoidance, 3 CdS cells for light intensity measurement, a bump switch for calibration and interaction with people, and a 3-axis accelerometer for acceleration detection. The behaviors of the robot including doing obstacle avoidance while walking and turning, detect light intensity and move to the brightest part of a region, and level itself on a uneven surface by detecting the gravity.

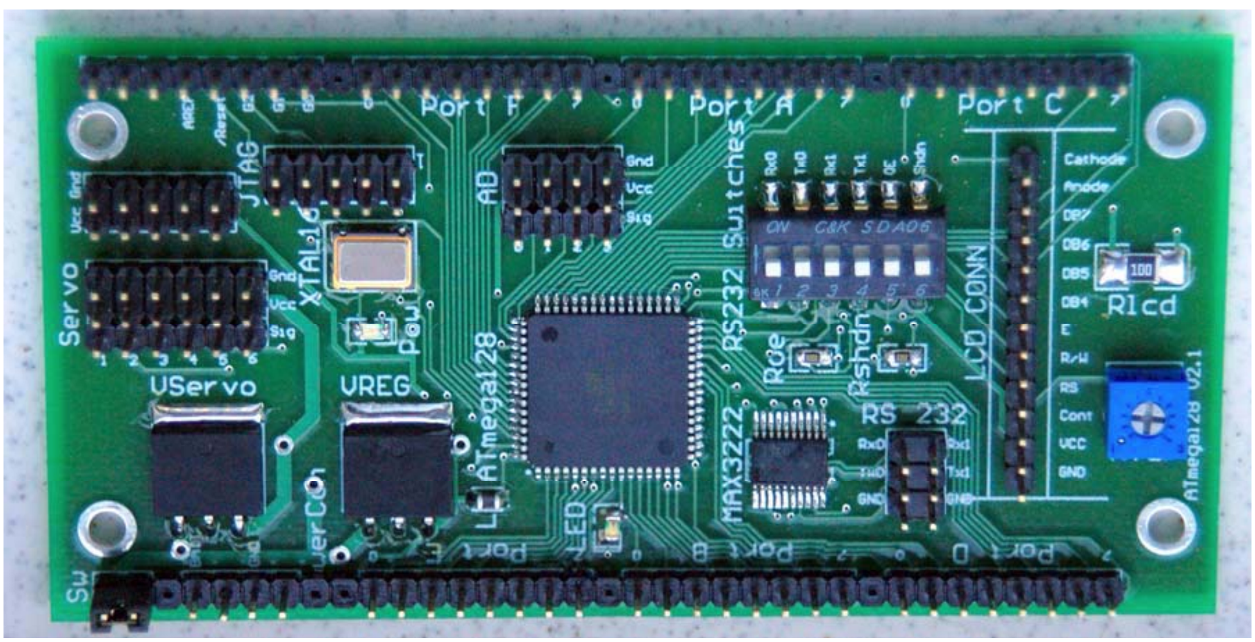
MAIN BODY

Integrated System

The robot is controlled by a PVR control board developed by Mike Pridgen and Tom Vermeer based on an ATmega128 chip. The specs of the board are as follows:

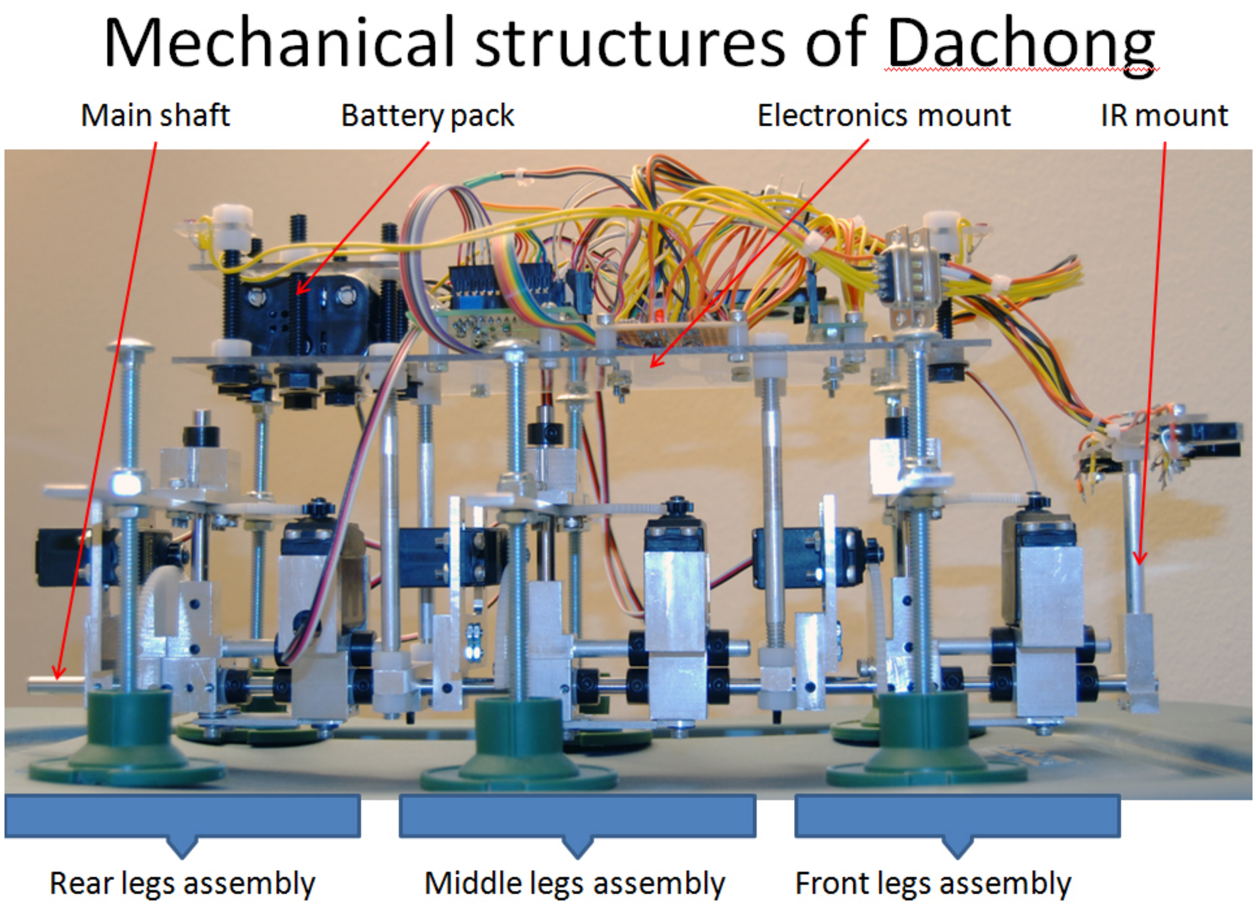
6x 8-bit I/O Ports
4x A/D Inputs
6x PWM Headers
2x RS 232 Terminals
Power Bus
LCD Header (4-bit mode)
Smart Power Connecter
Power Switch Header
Power LED
Debug LED

There are 8 analog input from different sensors on the robot (2 channels for the accelerometer, 3 for the IR sensors, and 3 for CdS sensors), which makes the 4 ADC channels onboard inadequate. To solve this problem, a 16-Channel Analog Multiplexer/Demultiplexer (model CD74HC4067, Texas Instruments) was used to increase the ADC input channels.



Mobile Platform

The robot has three pair of legs. Each pair of legs are driven by a horizontal servo and a vertical servo. Horizontal servos drive the legs forward and backward, and vertical servos drive the legs up and down. When the middle legs are moving out of phase for 180 degrees relatively to the front and rear legs, the robot will walk straight. By moving all legs to the same horizontal directions the robot can make turns. The legs have to return to their initial position to keep turning, which is realized by turning legs one by one while having other legs supporting the robot.



Actuation

Six Futaba servos are used to actuate the robot. On each pair of legs, there are one servo actuates vertical movement, and another servo actuates horizontal movement.

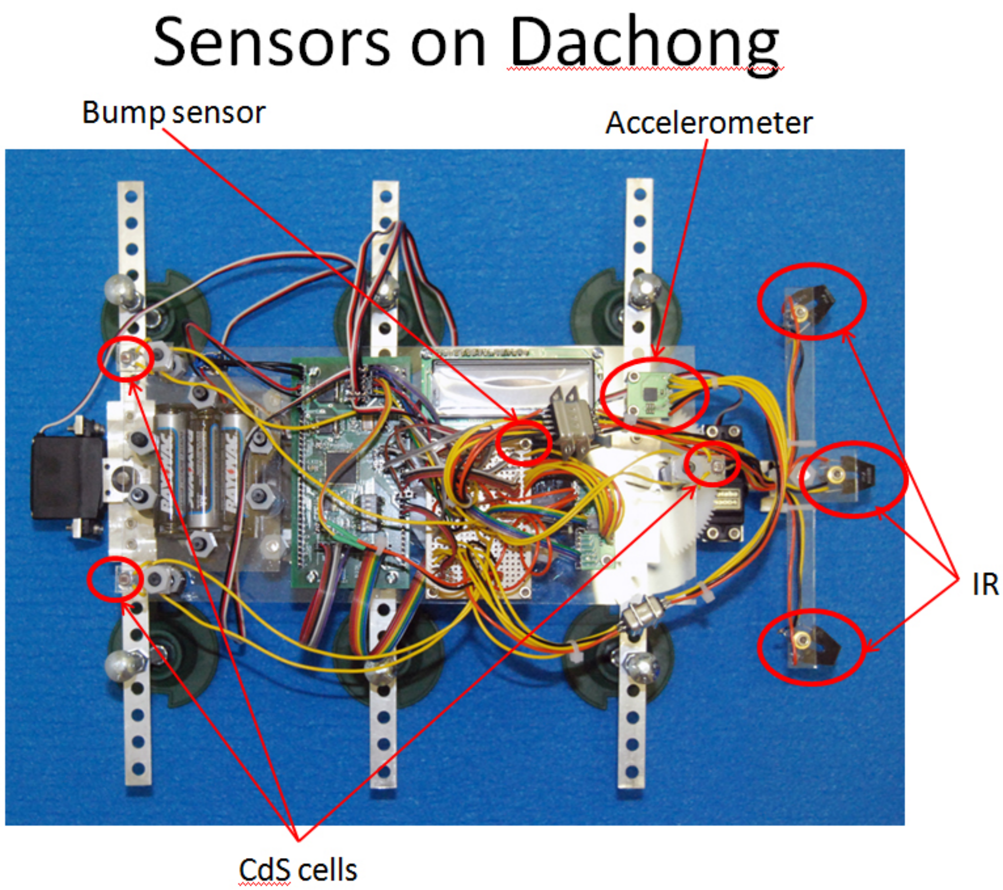
Sensors

First of all, a switch is used to turn the robot on and off instead of the jumper.

A click momentary switch (bump sensor) is used to give signals for the robot to do self calibration, and is also used to switch between different operations modes.

3 IR sensors (QRB1113, Fairchild Semiconductor Corporation) are mounted on the front, front right and front left of the robot for obstacle avoidance.

3 CdS cells are mounted on the front top, left rear top and right rear top of the robot to provide light sense ability to the robot.



A three axis low-g micromachined accelerometer (MMA7260Q, Freescale Semiconductor) is used for the robot to maintain balance on an unleveled surface. Because the accelerometer operates at 3.3V, a 3.3V voltage regulator (REG1117, Texas Instruments) is used to regulate 5V board voltage to 3.3V.

The MMA7260Q is a surface-micromachined integrated-circuit accelerometer. The operation principle is as follows*. The device consists of two surface micromachined capacitive sensing cells (g-cell) and a signal conditioning ASIC contained in a single integrated circuit package. The sensing elements are sealed hermetically at the wafer level using a bulk micromachined cap wafer. The g-cell is a mechanical structure formed from semiconductor materials (polysilicon) using semiconductor processes (masking and etching). It can be modeled as a set of beams attached to a movable central mass that move between fixed beams. The movable beams can be deflected from their rest position by subjecting the system to an acceleration. As the beams attached to the central mass move, the distance from them to the fixed beams on one side will increase by the same amount that the distance to the fixed beams on the other side decreases. The

*From the MMA7260Q technical data sheet

change in distance is a measure of acceleration. The g-cell beams form two back-to-back capacitors. As the center beam moves with acceleration, the distance between the beams changes and each capacitor's value will change, ($C = A\varepsilon/D$). Where A is the area of the beam, ε is the dielectric constant, and D is the distance between the beams.

The ASIC uses switched capacitor techniques to measure the g-cell capacitors and extract the acceleration data from the difference between the two capacitors. The ASIC also signal conditions and filters (switched capacitor) the signal, providing a high level output voltage that is ratiometric and proportional to acceleration.

The accelerometer output an analog signal proportional to the acceleration it feels on each axis. Only 2 channels (x axis and y axis) are used on the robot "Dachong". Because the acceleration caused by tilt the robot to a small angle is small, the ADC channel are configured to output a 10 bit number instead of 8 bit as normally used.

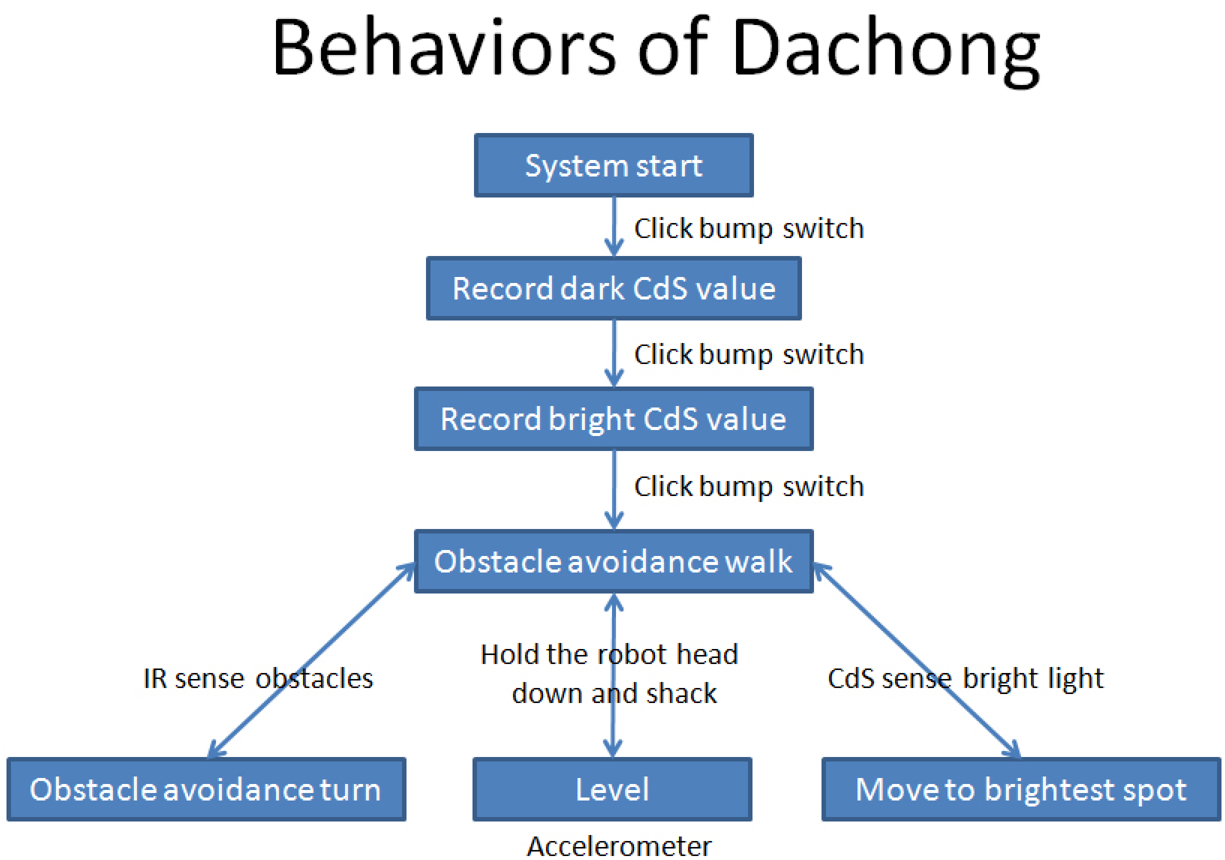
To demonstrate the functioning of the accelerometer, I wrote a function to let the robot balance itself when it is tilted. In the function, a PI control routine was used to set new servo setpoints based on the signal received from the accelerometer. Upon proper settings of proportional gain and integral gain, the function works well and the robot "Dachong" can balance itself when it is tilted.

Feedback displays

There are several feedback display devices on the robot to show the status of the robot while the robot is operating, and also help debugging. First of all, a 16X2 character LCD display is used on the robot to show the majority of information. There are 2 LEDs on the PVR board, one of which is indicating the power status of the robot, the other is programmerable. On the auxiliary board there are 3 more LEDs, one is red, one is yellow, the other is green. All of these 3 LEDs help to indicate the status of the robot.

Behaviors

The robot will do obstacle avoidance walking. It will turn to the position where it doesn't see obstacles. The degree it turns will be generated by a random number. It will also sense the circumstance light, and if the bright level is above a threshold (generated automatically during self calibration routine), it will enter light searching mode and trying to go to the brightest spot. If the brightness level is dropped below the threshold, it will enter the obstacle avoidance walking mode again. It will enter self leveling mode if the bump switch is pressed during either obstacle avoidance mode or the final state of the light searching mode. This can also be done by holding the robot head down, and shake the robot, to activate the accelerometer. When placed on an unleveled surface, it'll able to level itself. If shacked more during leveling mode, it'll enter the obstacle avoidance walking mode again. The following chart described the operating orders of the robot and different mode it can enter.



Conclusion

The project "Dachong" is done with pretty satisfying results. Different sensors are incorporated on the robot and reasonable behaviors are demonstrated. However, there are some lessons learned from the project. The greatest limitations of the robot is the platform; driving a six legged robot by only six servos puts great restrictions on the movement of the robot; also, because of the constant changing of the center of gravity, the robot consumes power rapidly. If another six legged robot are built, more servos will be the choice.