Team 3 Report

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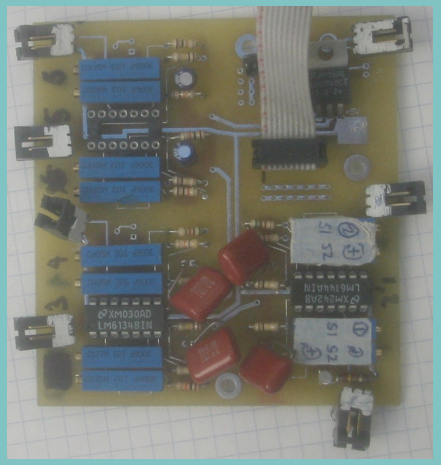
Hardware—Sensors

- Standard induction setup, 2 sensors, expanded to 4
- Velocity detection using all-in-one Hamamatsu
  - Reduced part count
- 6x 2-stage non-inverting amplifier
  - Tunable low-pass filtering, gain; ability to expand sensor model



Hardware—Actuators

- Upgraded servo
  - KO Propo 2343 Digital
  - Slew rate 0.08ms/60deg
  - High Speed Response mode
- H-bridge motor driver
  - Faster braking
- Velocity encoder painted directly on motor gear
  - Reduced part count

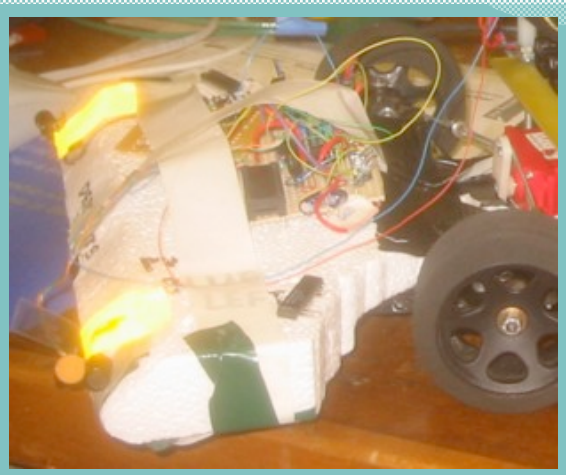
Hardware—User Interface

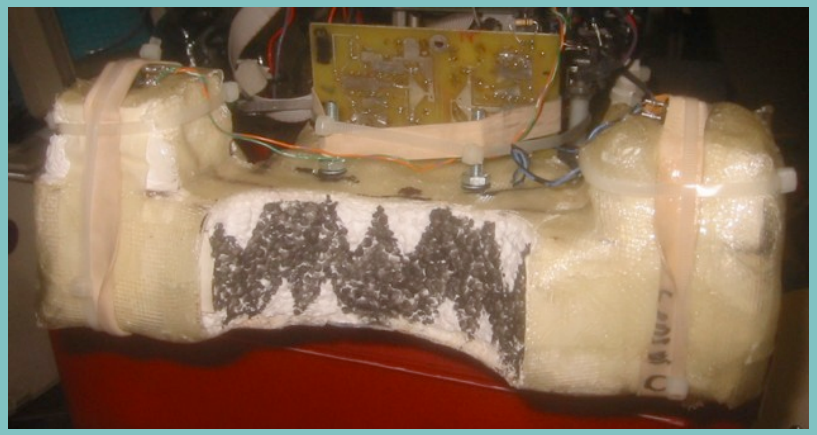
- LCD panel/keypad
  - Long initial time investment
  - Fast debugging, parameter setting
  - On-track calibration
- Piezo Speaker
  - Useful for initial debugging, easy to implement (PWM)
  - Not as much information density as LEDs

Hardware—Construction

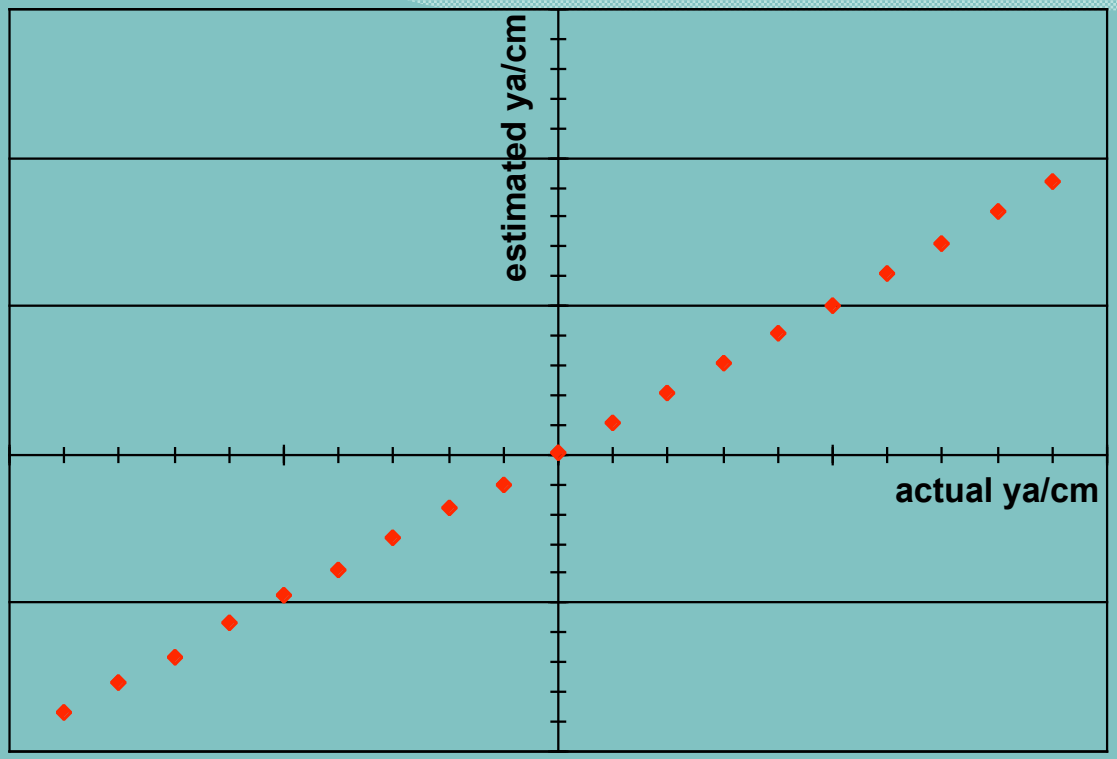
- Styrofoam structure
  - Rapid prototyping
  - Cut with hot wire
- Fiberglass coating
  - Make styrofoam permanent
- Carbon fiber rods
  - Lightweight, cheap
- Rubber bands/zip-ties
  - Quickly change structure
  - No large investment in a bad structure

Hardware—Iterations





Sensors



- Startup calibration over [-10,+10] cm range
- Linear interpolation between calibration values in mm
- Source of error: parallax when calibrating

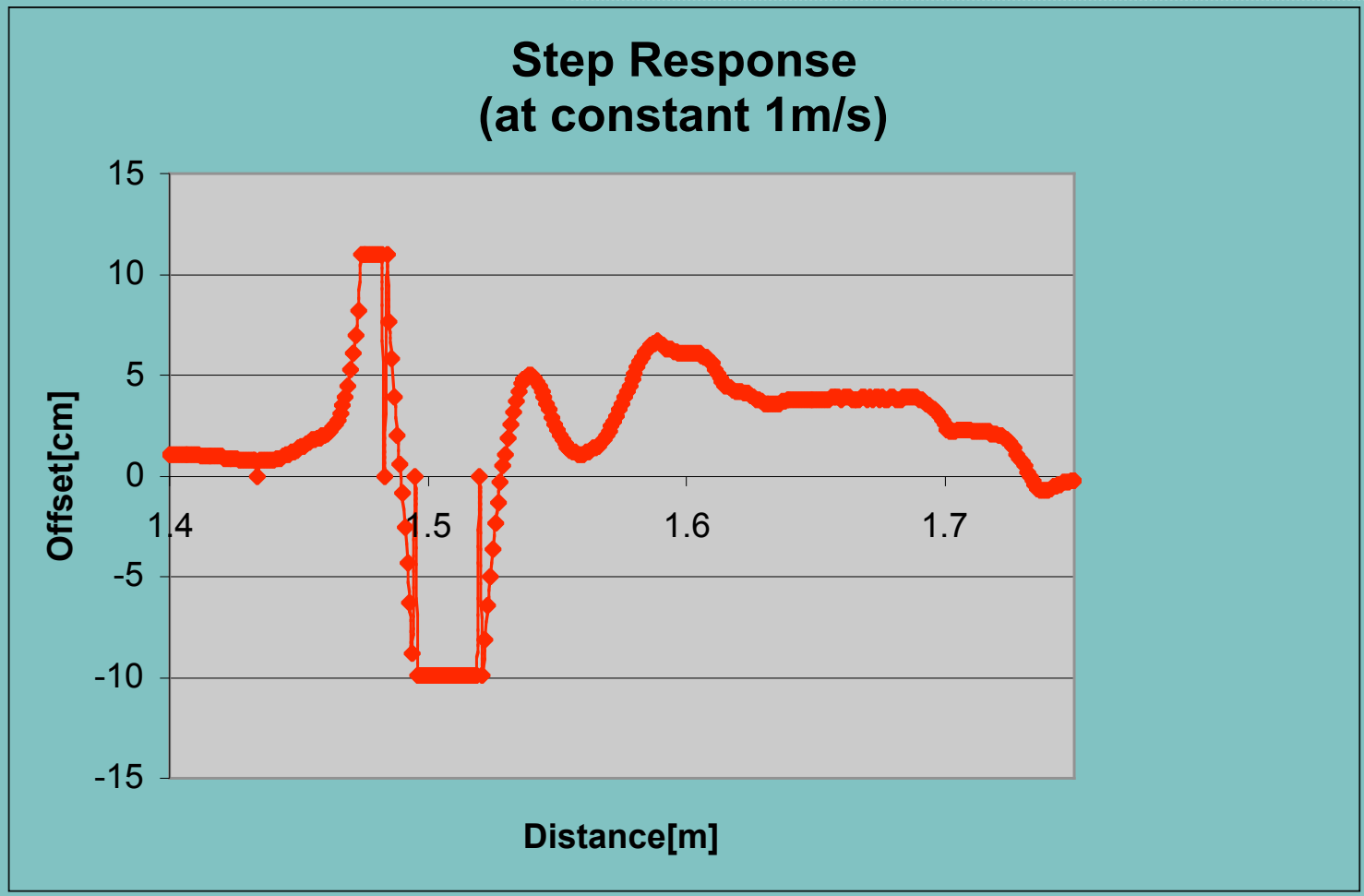
Software

- Initial calibration over [-10,+10] cm, linear interpolation between data points
- User Interface
  - State-machine based
  - Turns off Interrupts while in UI handling
  - All gains, parameters tunable using UI
  - Sensor readings, y_a interpretations available
- Servo control PI parameters stored as float, conversion to integer values; all other values operated as 16-bit integers
- PD control—no track memorization

Control

- Velocity Control (P)
  - Kp =63.6 duty% / (m/s)
- Servo Control (PD)
  - Kp = 69.8 rad/m
  - Kd = 0.00291 rad/(m/s)
- Steering state machine
  - On loss of track, use last known state to steer
  - Reduce speed if off track
- Straightaway detection
  - Use front sensors (“hardware lookahead”)
  - If $\{|y_a|, |y_a\_dot|, |y_a\_front|\}$ < error, increase speed
  - Separate servo Kp, Kd parameters at high speed

Performance



Modifications for NATCAR

- Smoother controller
  - Change velocity smoothly depending on tracking quality
  - Digital filtering of control to reduce oscillations
- 4WD, full suspension chassis (TC3)
- Decrease resolution dropoff after ±8 cm
- Broader frequency response of sensors
- Track memorization
  - Step 1: Feedforward velocity
  - Step 2: Feedforward orientation
  - Memory: 2ms sample interval over 40 seconds, ~40 kbytes storage
- “Lasers” to destroy DeVry, Davis cars

Credits

- H-Bridge, Power Sch - JS
- H-bridge/Pwr PCB - FC
- Construction - DL
- Sensor Hardware - DL
- Sensor Software - JS
- UI - FC
- Control - ALL
- Debugging & Tuning - ALL