2010 Off-Season Robotics

Students

Mentors

Presentation Introduction

2010 Four Wheel Steering Robot

- Steerable Wheel
- Steering Module
- Steering Control

2010 Subsystems

- Mechanical
- Electrical/Computer

Shooter Robot Redux

Past-Year Subsystems

Steerable Wheel

Steerable Wheel

Purpose of project:

- To design a wheel for a non-skid steer based robot
  - This will provide greater turning power
  - Full drive is applied in desired direction

Requirements/Constraints

- Steer 360 degrees
- Must drive and steer wheel
- Minimize height from ground
  - Especially height from wheel axle

Drive Train

Drive gear A:

- Connected to Drive gear B and moves with drive chain A

Drive chain A:

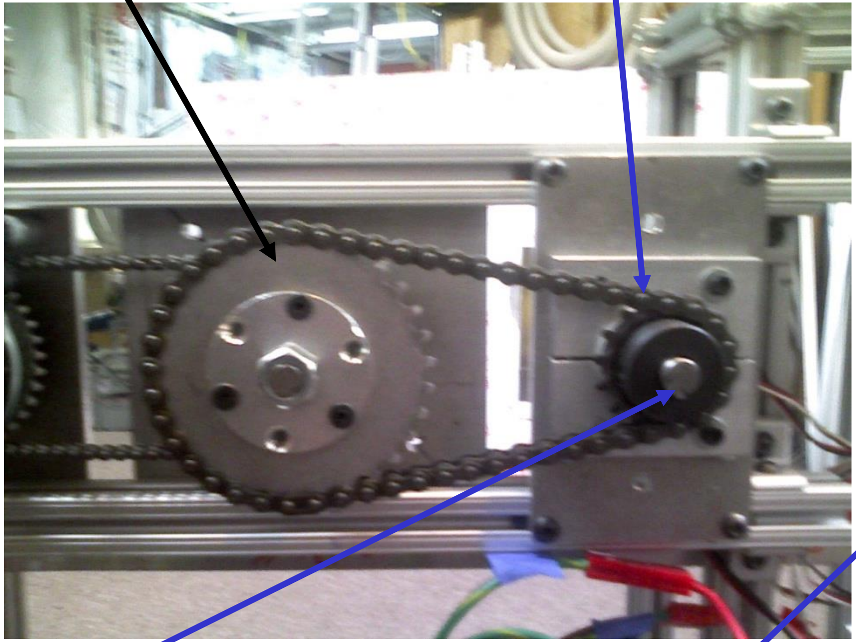
- Moves with motor gear and turns Drive gear in desired direction

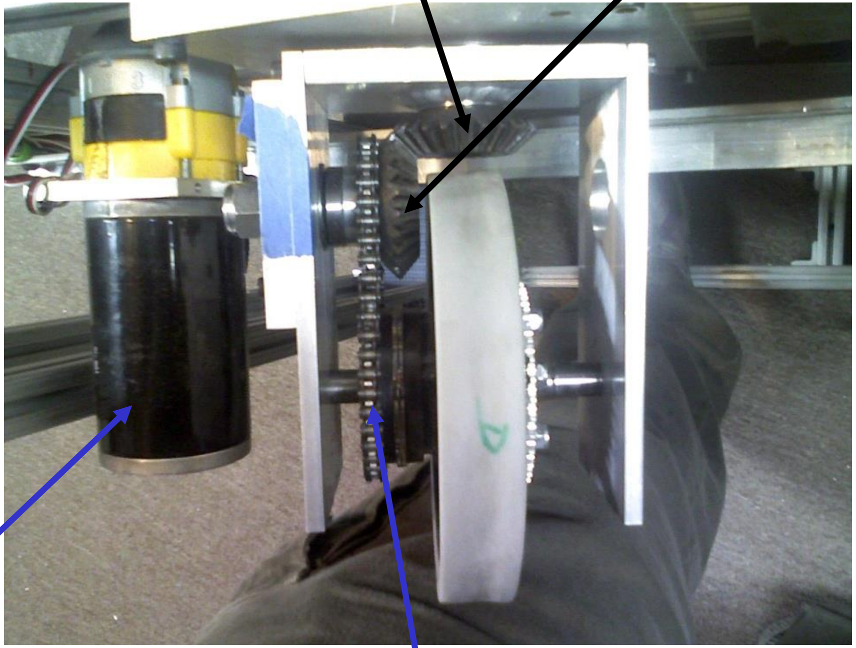
Drive gear B:

- Connected to Drive gear A and Drive gear C

Drive gear C:

- Connected to drive gear and chain B





Motor shaft and gear:

- Moves Drive chain A in desired direction

Motor:

- Moves motor shaft in desired direction

Drive chain B:

- Connects drive gear C and wheel. Turning wheel in desired direction

Steerable Wheel

Steering Train

Steer chain:

- Connects motor gear and steering gear

Steering gear:

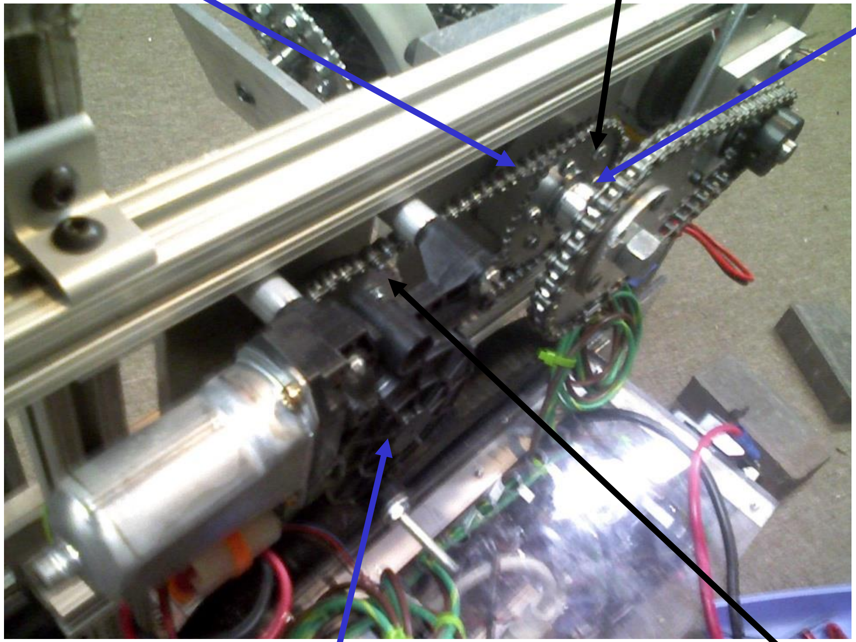
- Connected to steer chain, moves fork shaft

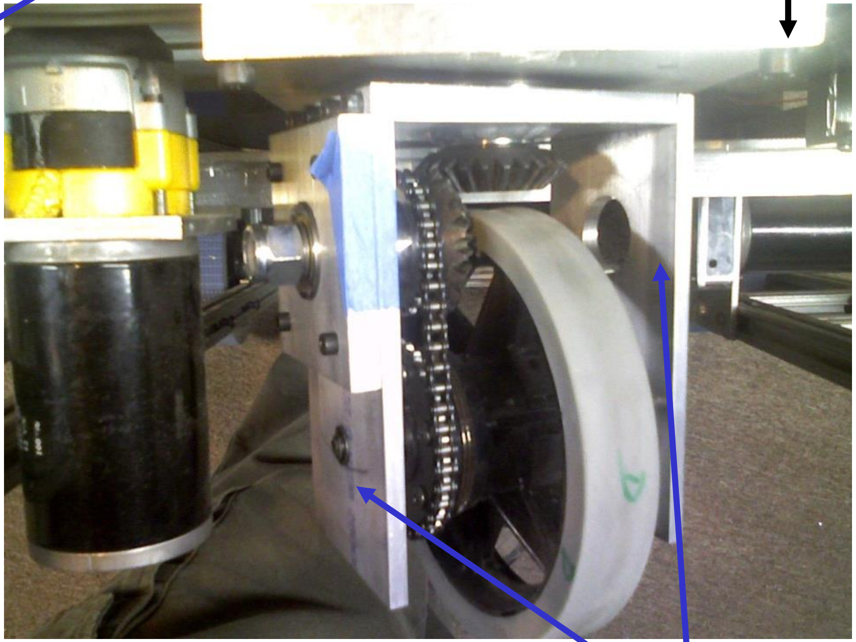
Fork Shaft:

- Attached to steering gear and moves fork in desired angle

Sensor:

- Gives absolute angle of wheel to controller for turning





Motor:

- Moves motor gear in desired direction

Motor Gear:

- Attaches to steer chain and rotates in desired direction

Fork:

- Holds wheel and turns with fork shaft

Steering Module

Steering Module

Purpose of project:

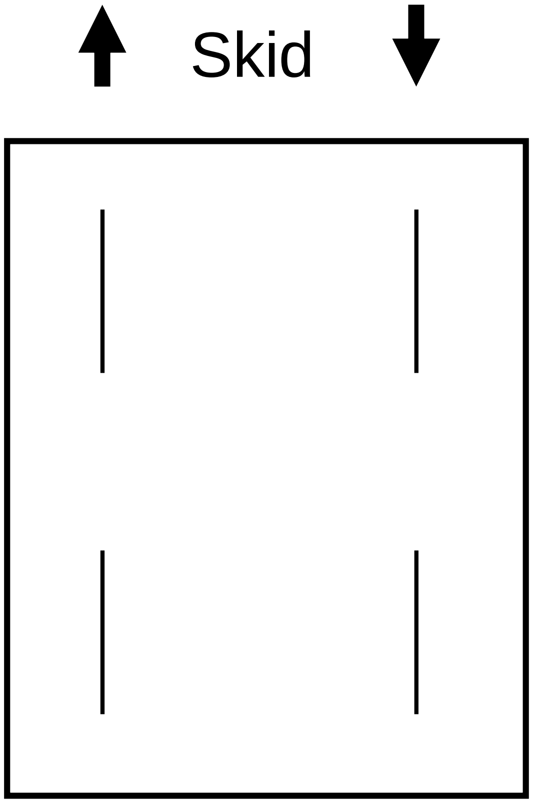
- To design a steering module to provide steering similar to skid steer without skid steering loss

Requirements/Constraints

- Minimize height from ground
  - Especially height from wheel axle
- Retain steering around robot center
- Limit to two drive plus two steering motors
- Embed motors in module
- Maintain 6x6 frontal cross section
- Provide for chain tensioning

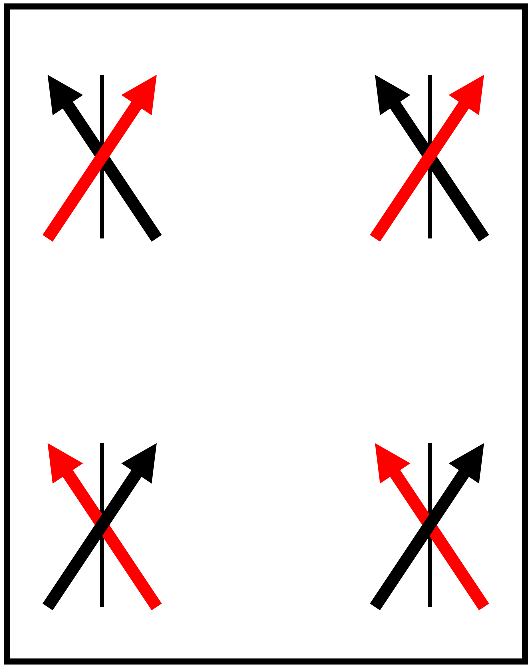
Turning: Skidsteer wheels vs Steerable wheel

Skid



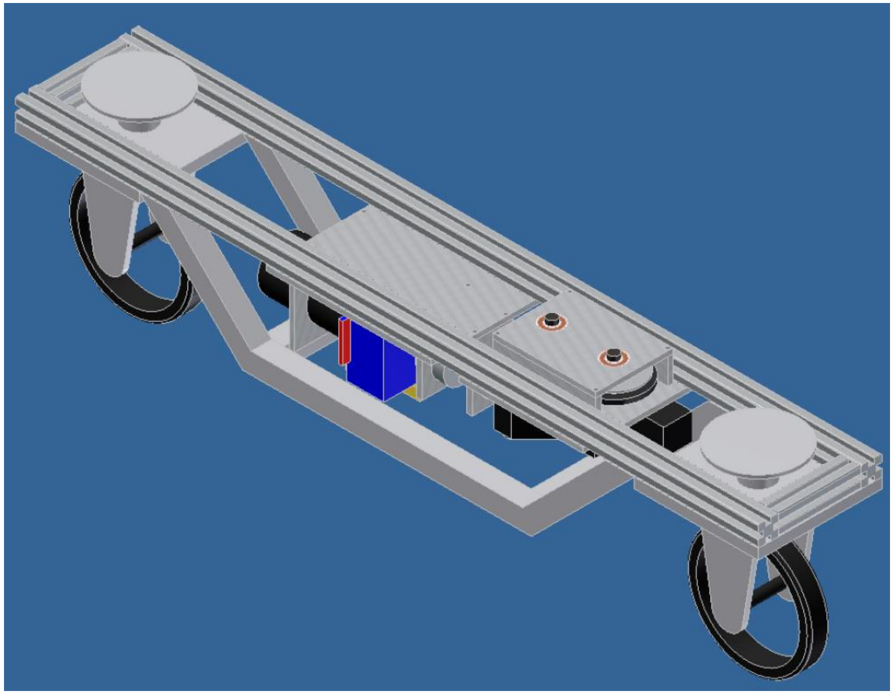
Left set of wheel move forwards as right set moves backwards

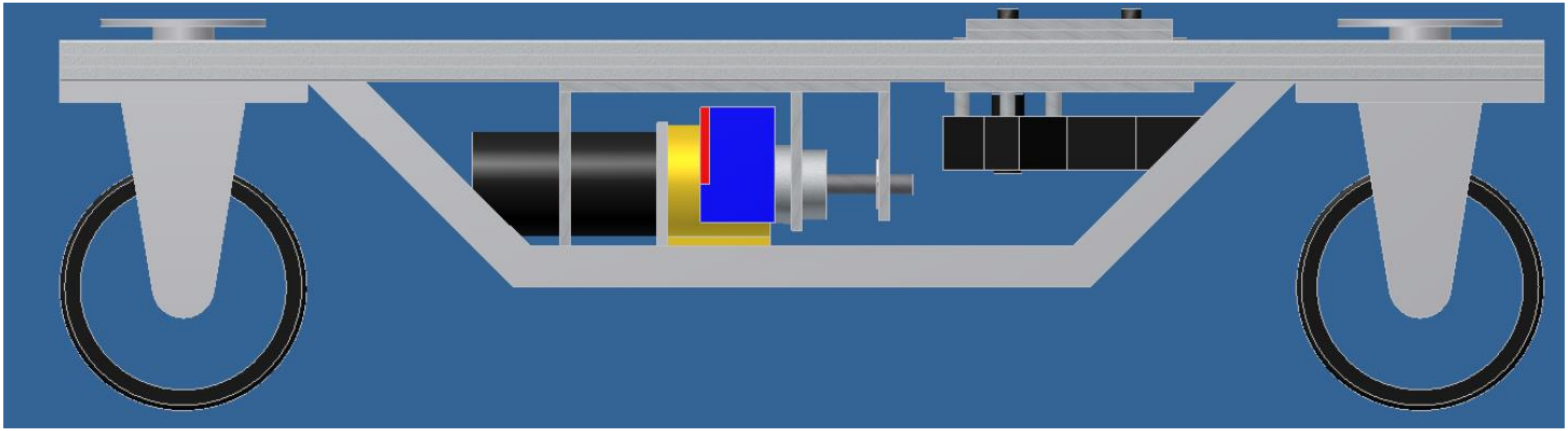
Steerable Wheel



Left set of wheels can rotate in either direction simultaneously with right set

Steering Module





Steering Control

Steering Control

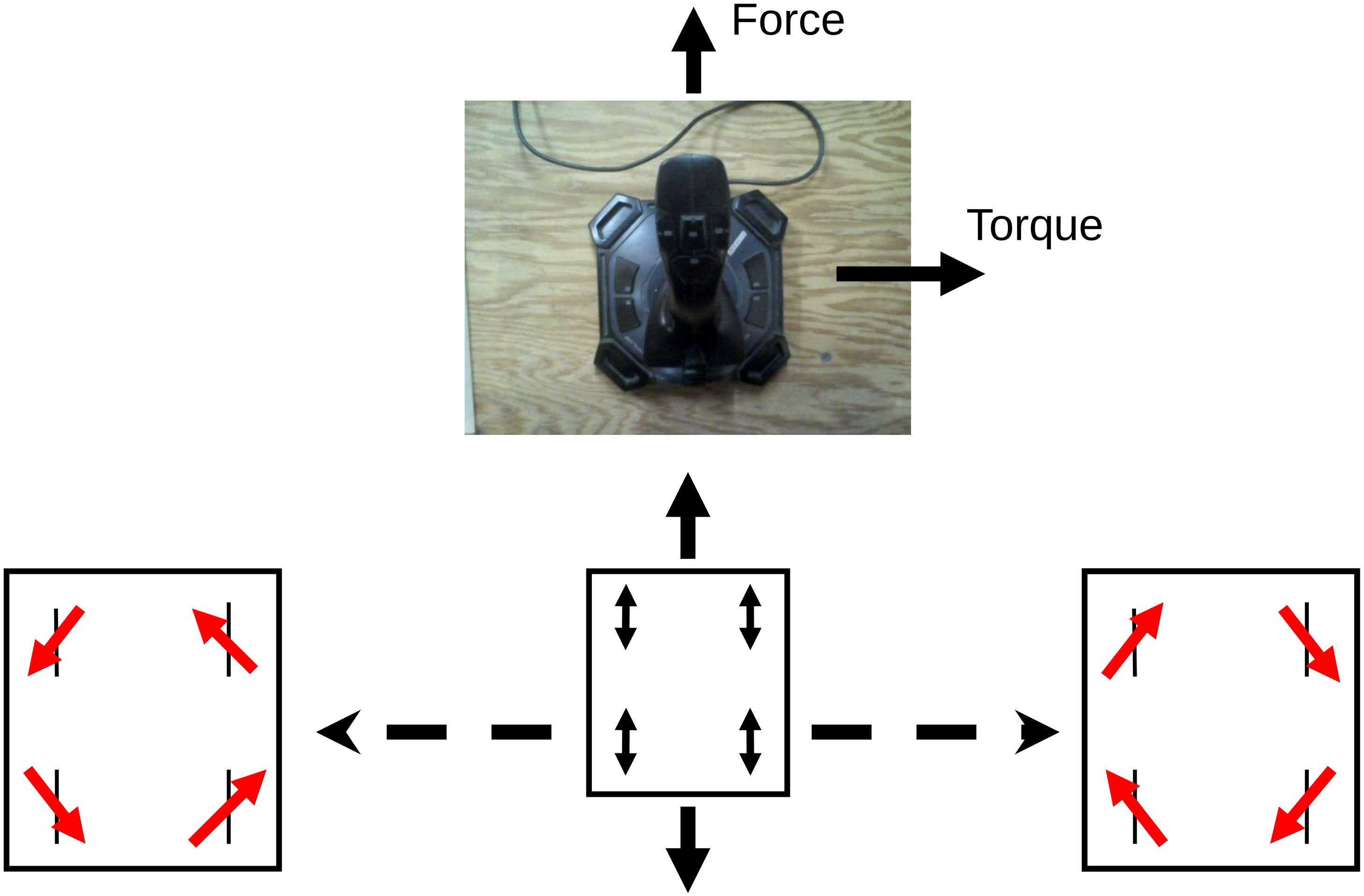
Purpose of project:

- Design a steering control to operate the robot with a feel identical to the skid steer robots but without the turning power loss

Requirements/Constraints

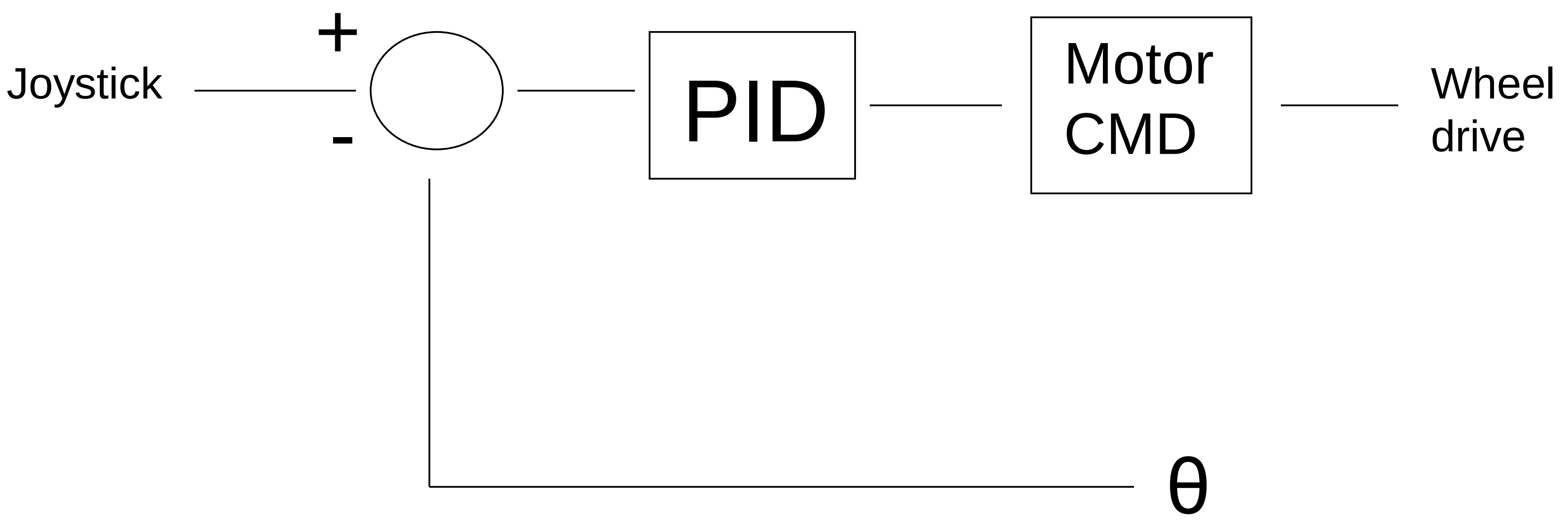
- Full power turning (fighting)
- Limited turning rate (control while driving)
- Wheels turning in the direction of rotation
- Wheels turning at rate consistent with radius of turn
- Turn on center
- No wild wheel movements for small wheel adjustments

Steering Control



Infinity radius

Steering Control



- An absolute positioning sensor measures the angle of the wheel
- Sensor feeds back to controller determines how much to adjust the angle the wheel is pointing

Steering Control

DEMO

Shooter Robot

Shooter Robot

Purpose of project:

- Design a robot capable of outdoor driving with the ability to rapidly shoot tennis balls at will

Requirements/Constraints

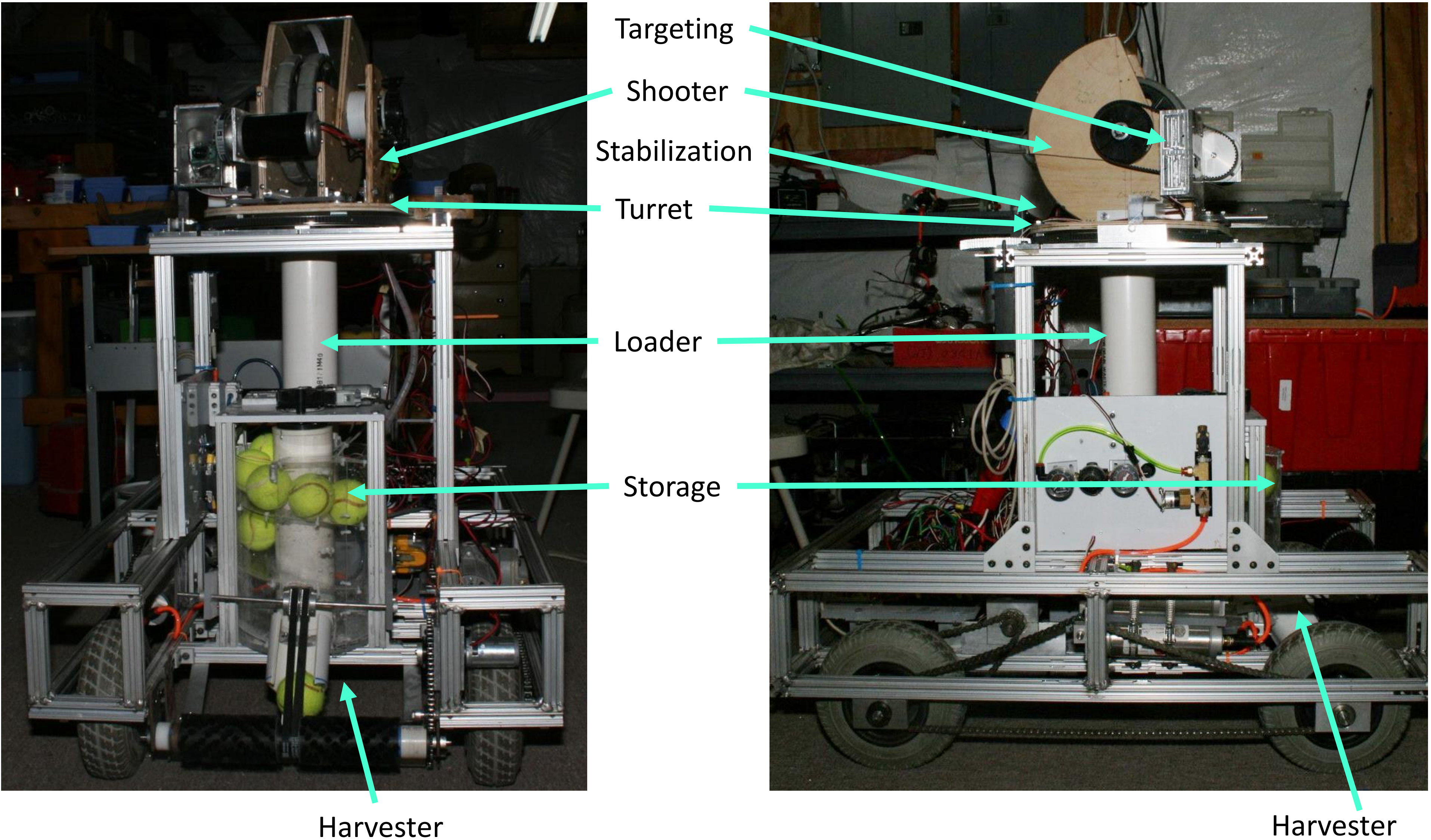
- Pick up tennis balls across the full front open area of robot
- Pick up while moving at 8 ft/sec
- Store 12+ balls
- Load a shooter
- Shoot balls 50+ feet
- Shoot at any angle +/-270 degrees azimuth and up to 45 degrees elevation
- Stabilize shooter independent of robot heading
- Track a brightly colored object

Shooter Robot

6 Subsystem Design

- Harvester: Intakes the tennis balls into the system
- Storage: Stores the tennis balls in preparation for Shooting
- Loader: Places tennis balls into the shooter
- Shooter: Fires the tennis balls
- Turret: Allows shooter to rotate +/-270 degrees on it's Y-axis
- Targeting: Finds targets for the shooter
- Stabilization: Locks onto the target and keeps the shooter pointed at the target no matter where it drives

Shooter Robot



Shooter Robot

DEMO

Subsystems Introduction

Subsystems Introduction

Mechanical/Electro-Mechanical

- Dewalt Drive
- Dual Motor Drive
- Gripper
- Half-Track
- Wide Wheels

Electrical/Computer

Digital Architecture

- Competition Architecture
- Processor
- CRIO Interface
- Peripheral Interface
- ZigBee

Sensors

- Current/Velocity/Voltage/Encoder
- IMU
- H-Bridge
- Optical Mouse

Mechanical/Electro-Mechanical

DeWalt Drive

DeWalt

Shifting motors: 3 gears (3:1,4:1,12:1)

- Lower gear means more torque which equates to pushing power
- Higher gears more speed for pursuit, escape, or getting to goal

Based on Team 647's "Nothing but DeWalts" design

- CIM motor
- DeWalt Drill Transmission
- Servo
- custom parts

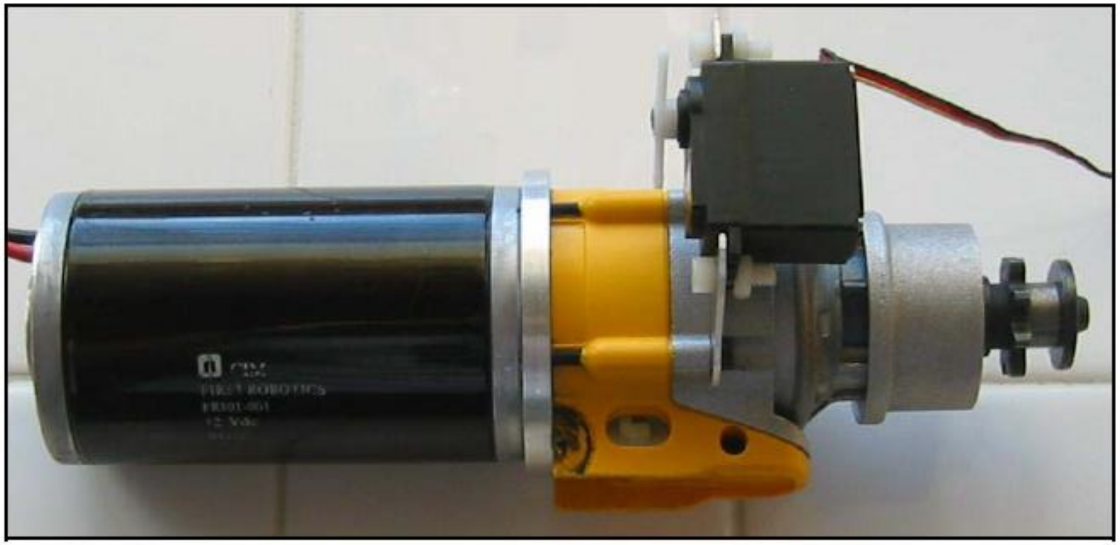


Figure 12 - Chiaphua/Dewalt Assembly with Servo

Dual Motor Drive

Past problems

One motor was powerful but not always enough - obviously, two motors were even more powerful

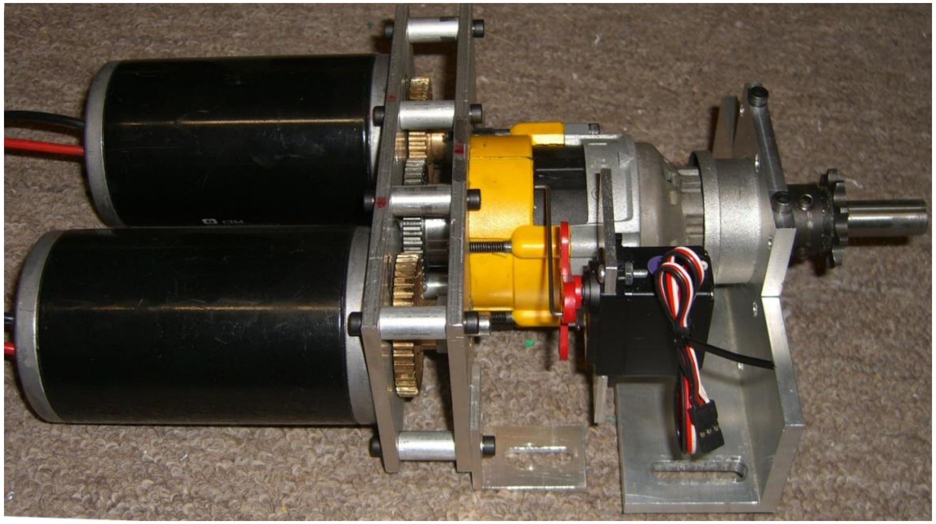
Developed dual motor

Connects power of two motor to Dewalt

- Required new transmission

Achieved power needs but

- Warped 80/20 more
  - New motor mount was made with reinforcements
- Became very long



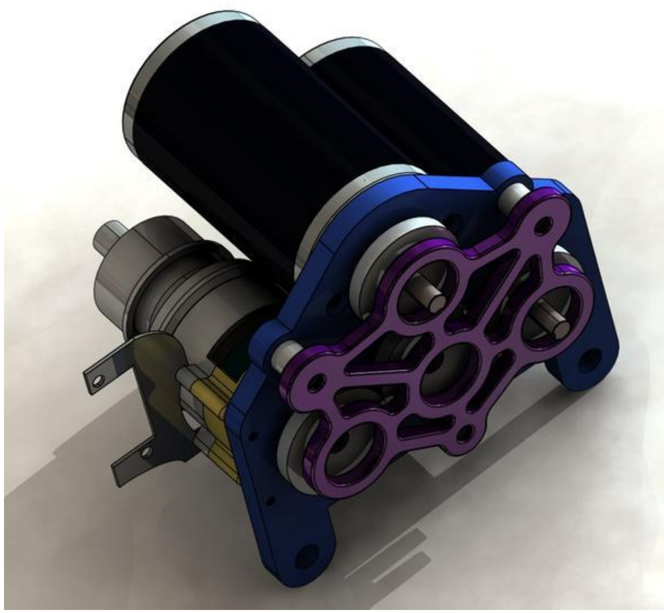
Dual Motor Drive

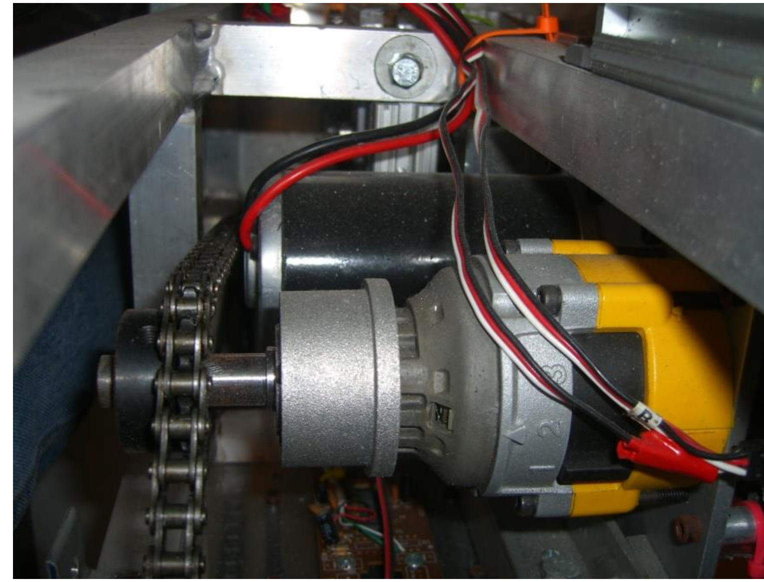
Designed a folded dual motor assembly

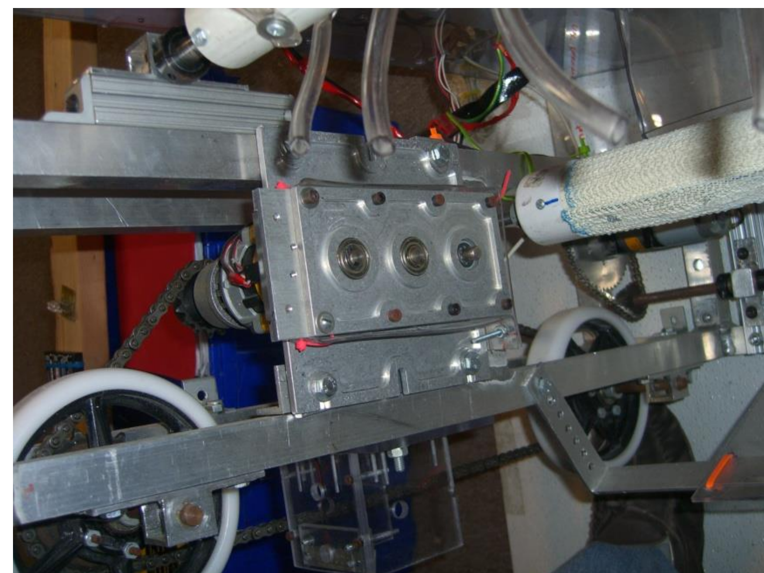
- We plan to fold the motor assembly into itself
- This will make it shorter - so that it fits in the wheel area of the robot

Used a variation of this transmission on the 2009 Robot with a single motor

- Increased available opening in front of robot







Gripper

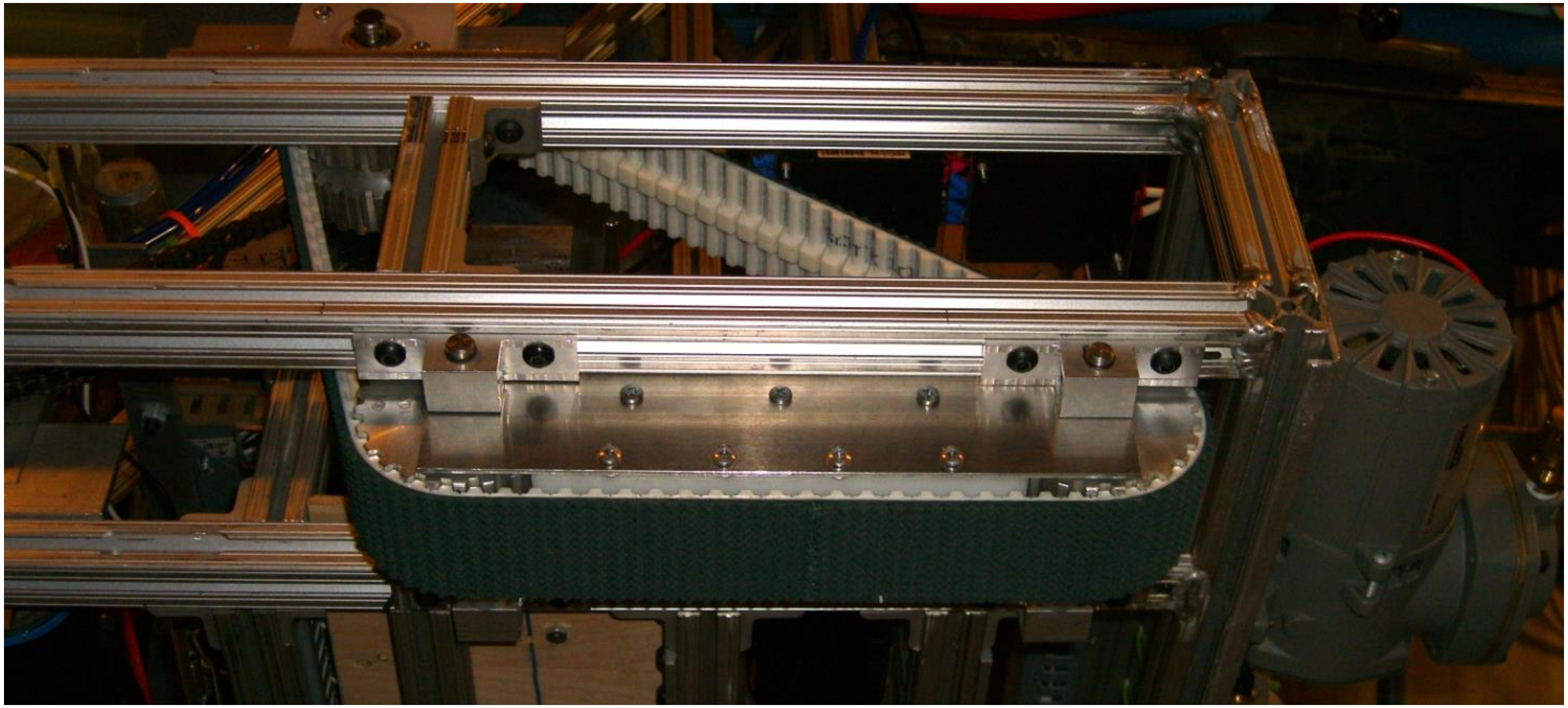
2007 Robot Gripper

- Designed for gripping pool tubes
- Applicable to gripping small balls/parts
- Simple and yet very rugged

Half-Track

Developed for the 2008 robot

- 2007 competition consisted of a lot of pushing
- 2007 robot got pushed around – we had the power but not the traction

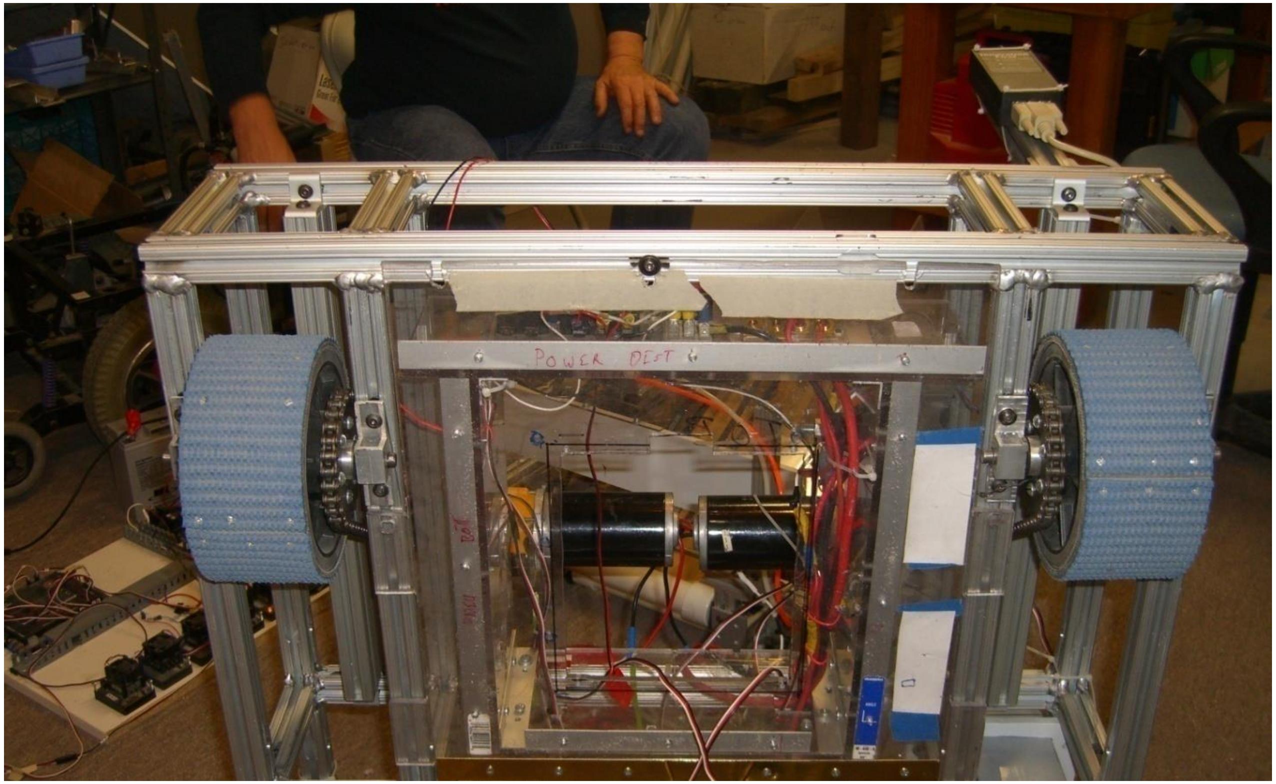


Not used in FIRST competition – unit requires too much power.

Wide Wheels

Increased traction used in high speed competition

- Half track design had too much power loss and the game rules that year (2008) precluded pushing



Electrical/Computer

History

FIRST competitions designed for beginner programmers

Some of our projects are hard

- New sensors
- New architectures

We must:

- Provide challenges to “hardcore” programmers
- Remain accessible to beginners
- Continue to innovate with new projects

The solution is to partition the system

The Plan

Partition development by software experience required

Advanced Experience Levels – focused on support

- Sensors are developed individually
- Enable easy plug-and-play abstraction
- Program FPGA to perform all tasks unique to the sensor and provide a simple interface to the user

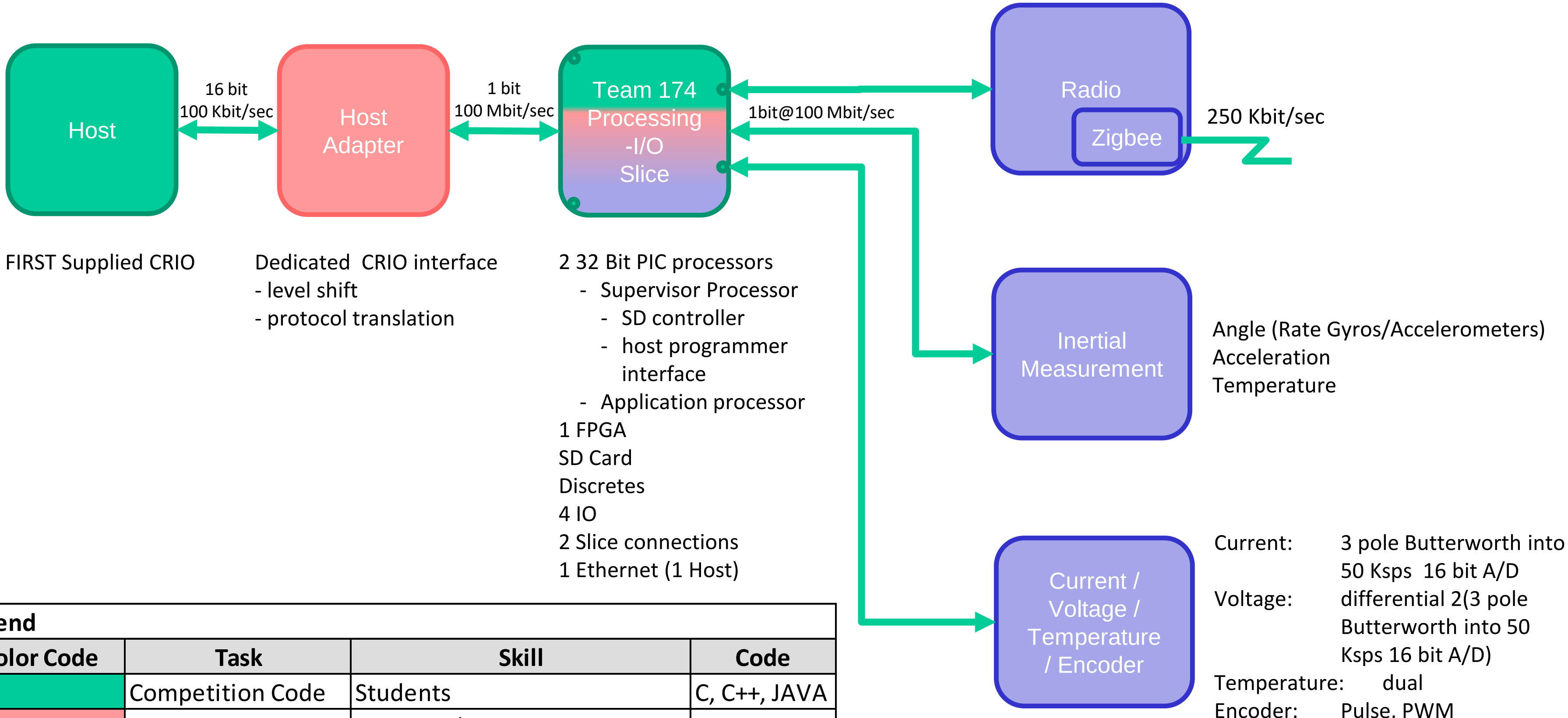
Beginner Experience Levels – focused on the year's challenge

- Sensors are processed and their outputs merged
- Algorithms for navigation, visual detection, robot control, robot manipulator control

Both Experience Levels - Simplify

- Eliminate interrupts – overly complex, to prone to error

Architecture Functional Block Diagram

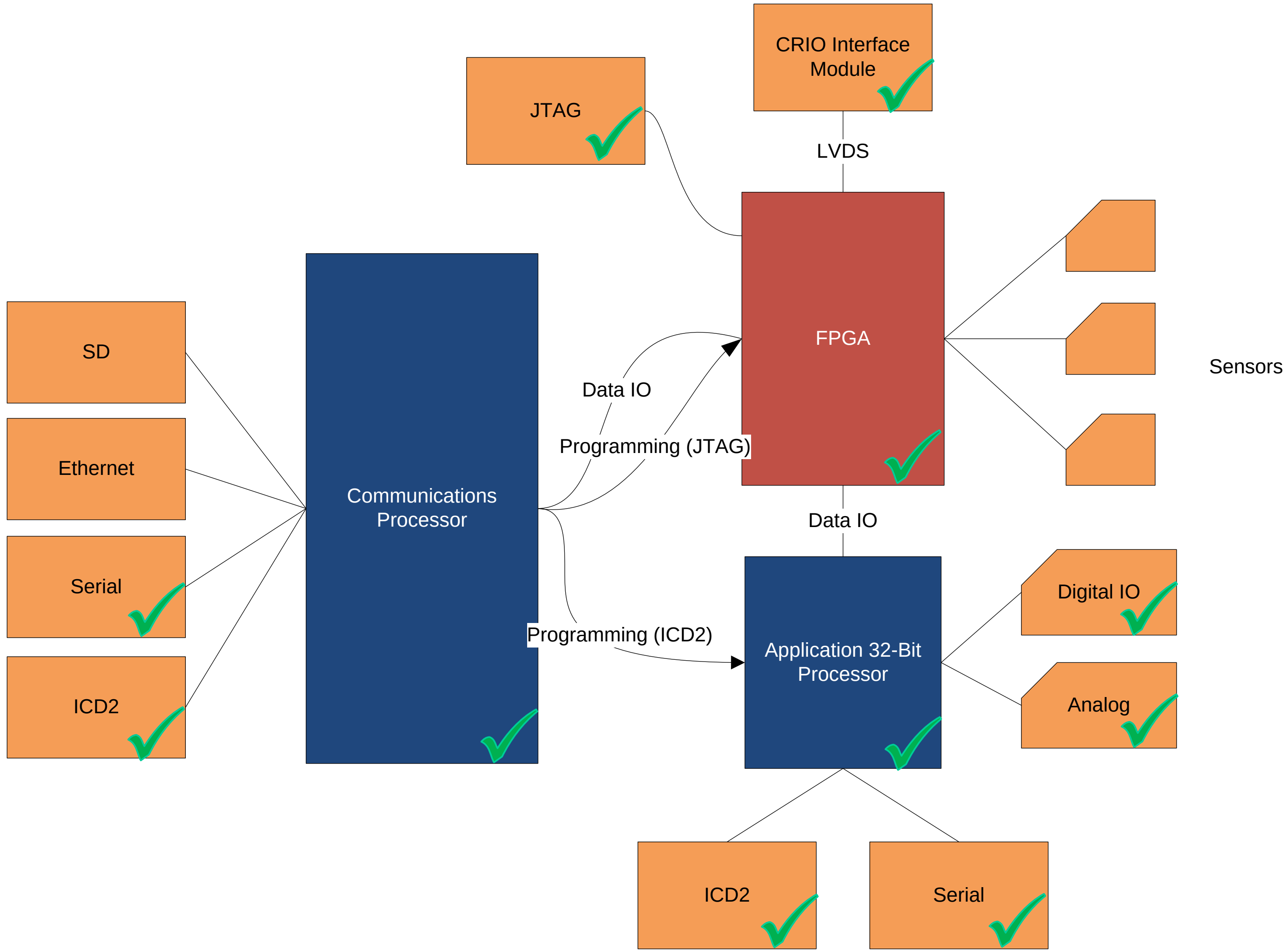


Legend

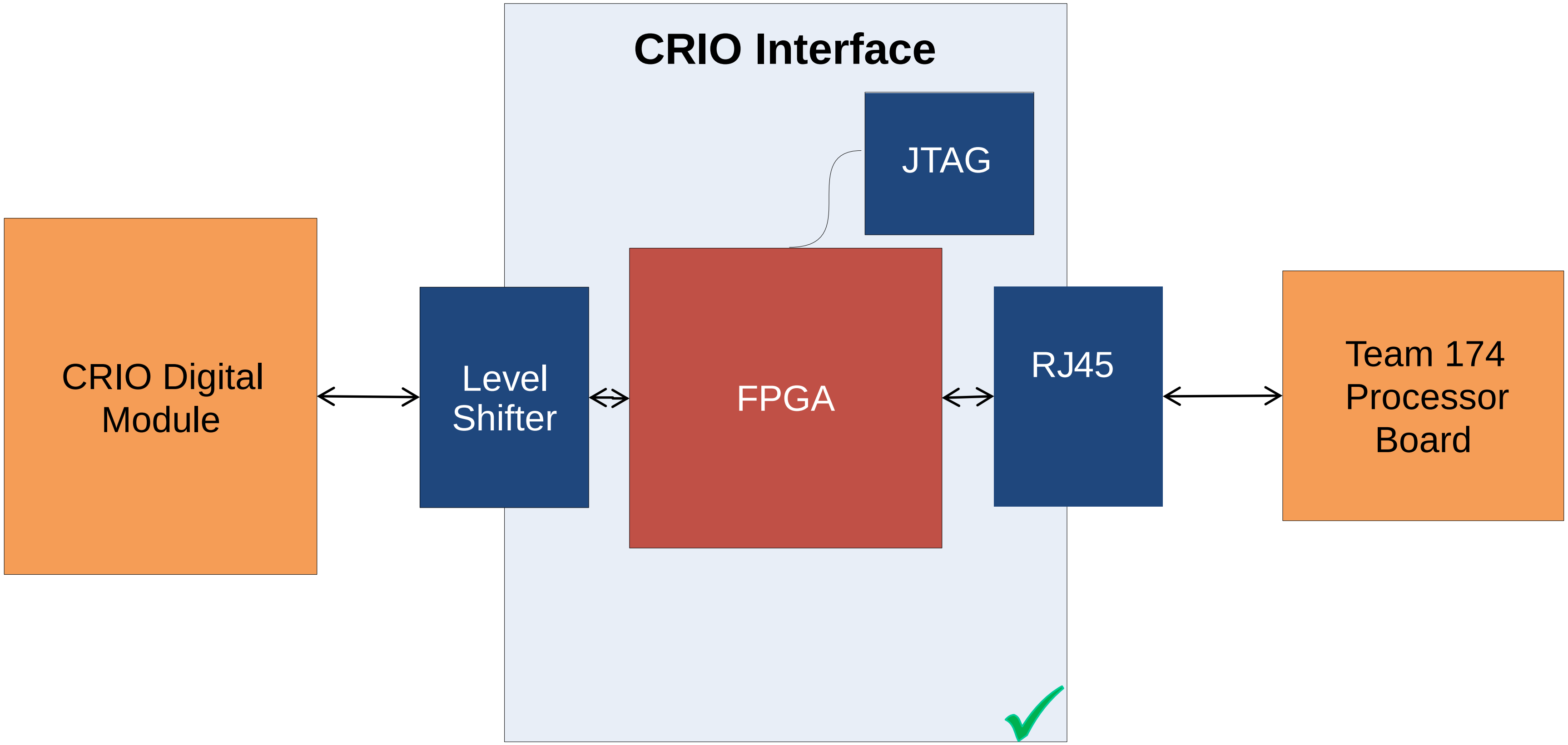
Color Code	Task	Skill	Code
(green)	Competition Code	Students	C, C++, JAVA
(red)	Infrastructure Code	Mentors / Advanced Students	C++, VHDL
(purple)	Sensor Code	Mentors / Advanced Students	C++, VHDL

Focus the students on the competition

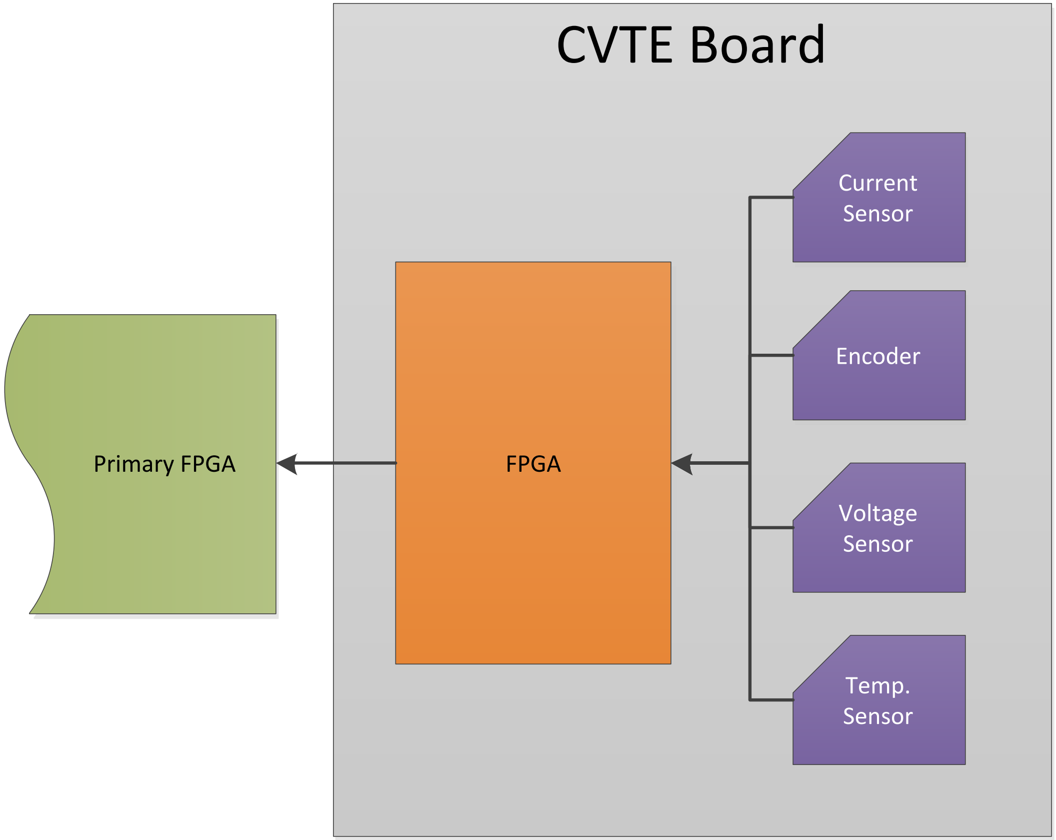
Processor Architecture



CRIO Interface , Architecture



CVTE , Architecture



Current to 100A (40A continuous)

1 encoder channels (quadrature)

Voltage on both motor leads ±24V

2 temperature channels

On-board FPGA for preliminary data processing and buffering

Sensor Systems:

Hall Effect Sensor, Optical Encoder, Optical Mouse, Inertial Measurement Unit, Absolute Encoder

Hall Effect Sensor

Hall Effect Gear Tooth Sensor

- Used from 2006 to 2009
- Generates a pulse per tooth
- Different pulse width for tooth depending on the direction of rotation

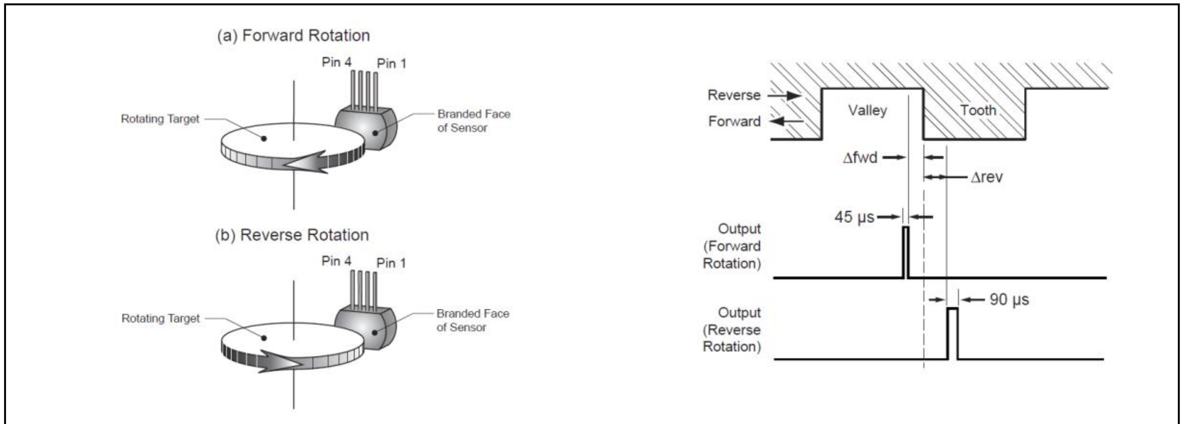
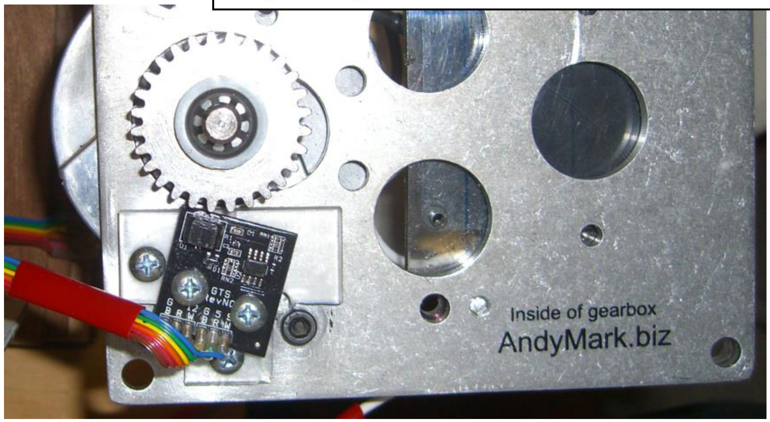
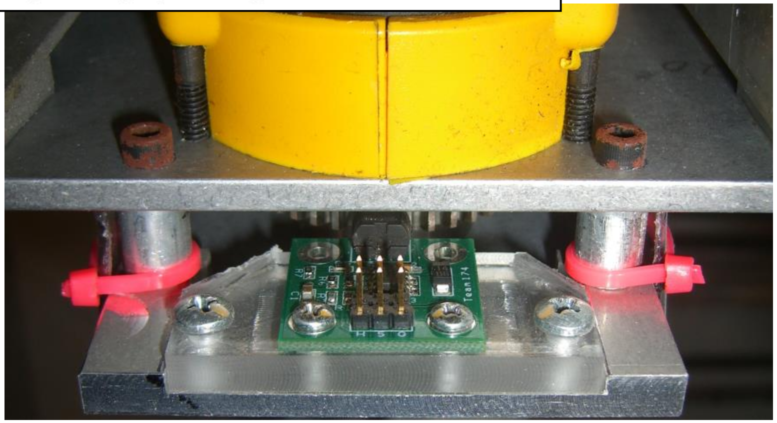


Figure 1. Target rotation

Figure 2. Output pulse timing



2006

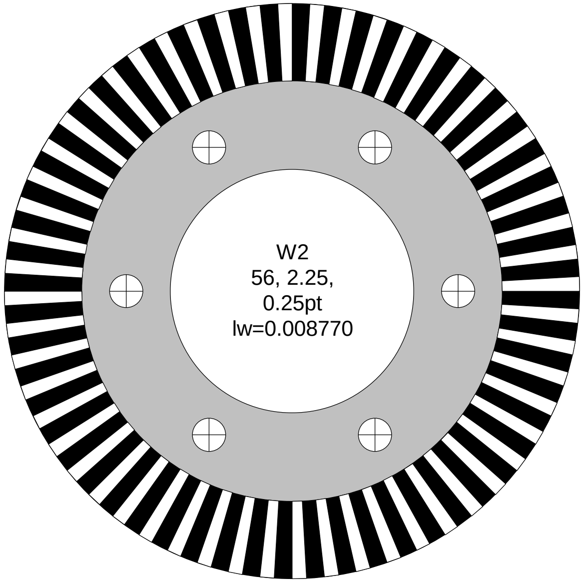


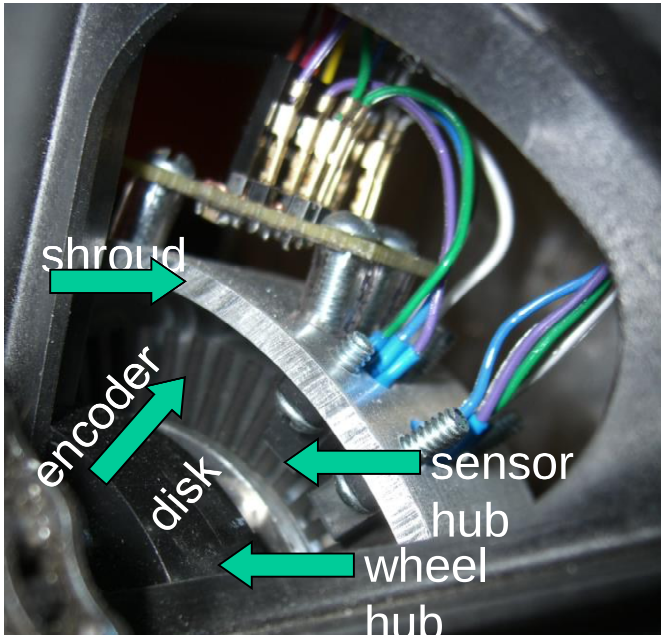
2009

Optical Encoder Sensor

This technology was installed on the 2006 robot, however was used only in practice

- The optical sensors detect forward and backward motion like the Hall effect
- Required precise machining of parts including FIRST supplied wheels – limited the ultimate performance of this sensor
- It detects changes from black to clear, similar to how the hull effect detects changes from tooth valleys and peaks

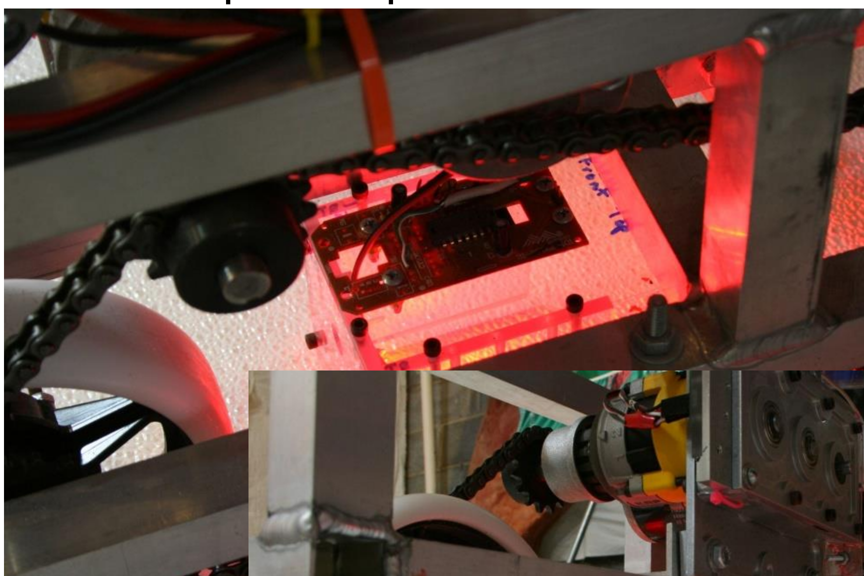




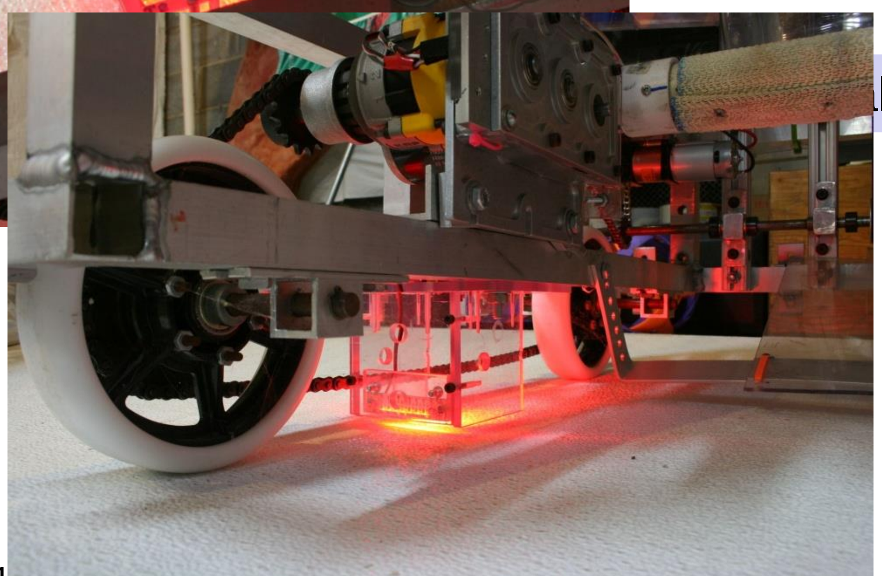
Optical Mouse Subsystem

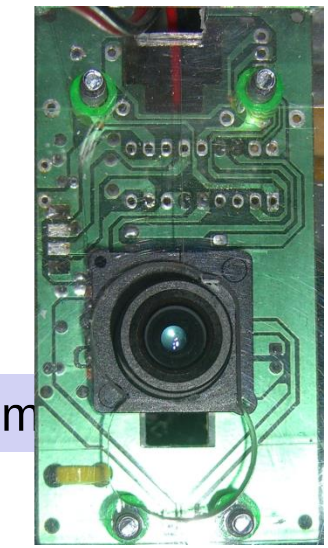
Optical Mouse

- Working optical mouse system
- Accurate distance detection and traction control on multiple surfaces
- Slip-free speed data



2009
Robot
Mounted
Mouse





2009
Mouse
Optics

2010
Mouse
Optics

4x the light gathering capability

IMU

Purpose

- Devise a control system that can accurately compensate for friction and keep the robot on course during the autonomous part of competition even if the robot is bumped aside

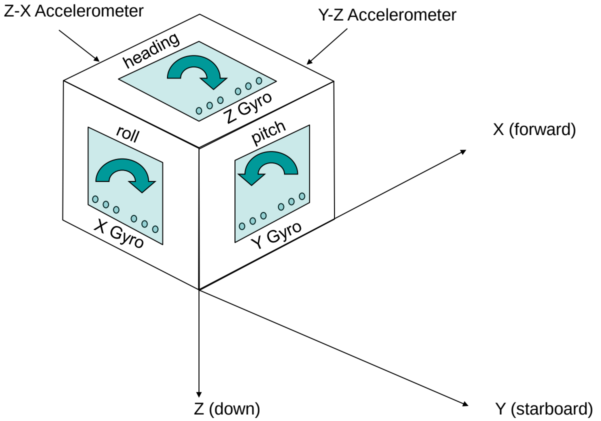
Previous systems

- measured motion in discrete steps, could not see motion until the next discrete step was crossed
- control system initially overdrive the system because it could not see that the applied torque had had any effect.
  - control system observed the overdrive and began to reduce the torque applied, causing the robot to jerk when turning. The only correction for this was to detune the control system, causing the robot to be unresponsive.

IMU

Theory

- IMU is a 3-axis gyro and 3-axis accelerometer cluster of sensors with added temperature sensors
- Acceleration and rotation can be calculated on the X, Y, and Z axis.
- If the robot is pushed aside, it should be able to compensate for the change of position and get back on track
- The control system can observe the interaction between the applied torque and the actual acceleration of the wheel driving the torque
- Acceleration is instantly available for measurement upon application of torque. In turns the knowledge of wheel acceleration allows the control system to quickly react to friction changing in real time.



Magnetic Absolute Encoder

Specifications

- 4096 positions, less than 1/10th of a degree between each
- Updates at 250 times/second

Issues

- If the heat shrink tubing on the input shaft slips, the encoder will need to be recalibrated
- Some mounting difficulties
- Using multiple would send information faster than one processor would be able to handle
  - Some of the boards we have developed will be able to handle this, but not the FIRST-supplied C-Rio

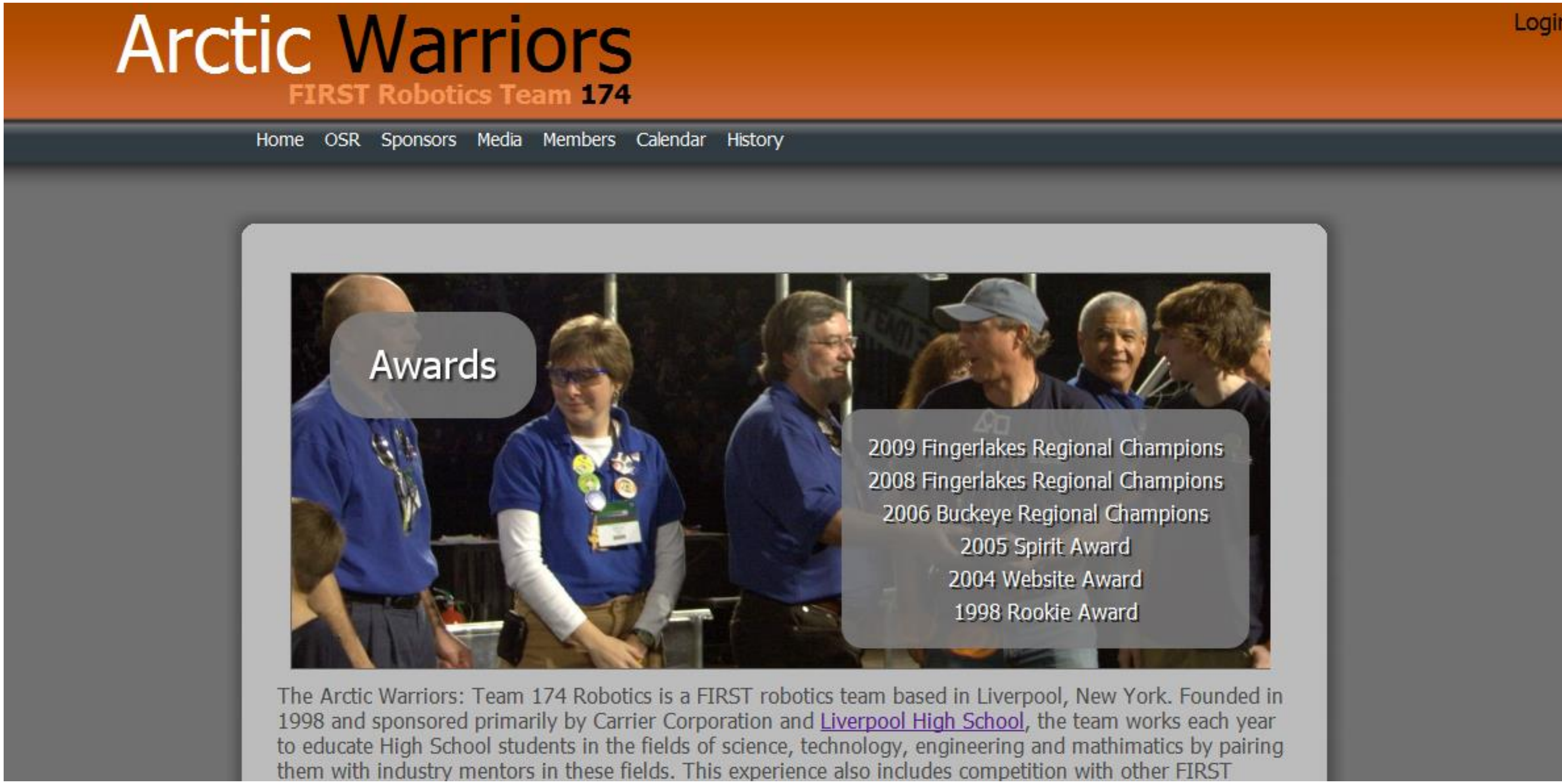
Applications

- Currently in use on the steerable-wheel concept robot to make it more user-friendly
- Will be used on the robot next year to coordinate the wheels

Website

www.snobot.org

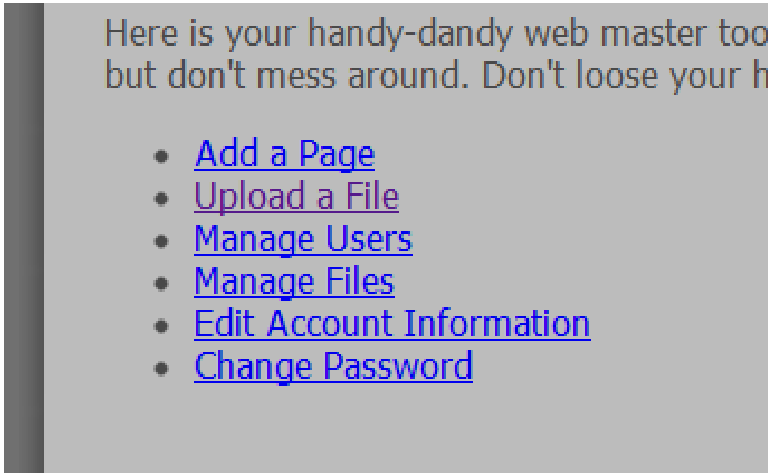
Website


Arctic Warriors
FIRST Robotics Team 174
Login
Home OSR Sponsors Media Members Calendar History
Awards
2009 Fingerlakes Regional Champions
2008 Fingerlakes Regional Champions
2006 Buckeye Regional Champions
2005 Spirit Award
2004 Website Award
1998 Rookie Award
The Arctic Warriors: Team 174 Robotics is a FIRST robotics team based in Liverpool, New York. Founded in 1998 and sponsored primarily by Carrier Corporation and Liverpool High School, the team works each year to educate High School students in the fields of science, technology, engineering and mathimatics by pairing them with industry mentors in these fields. This experience also includes competition with other FIRST

Website

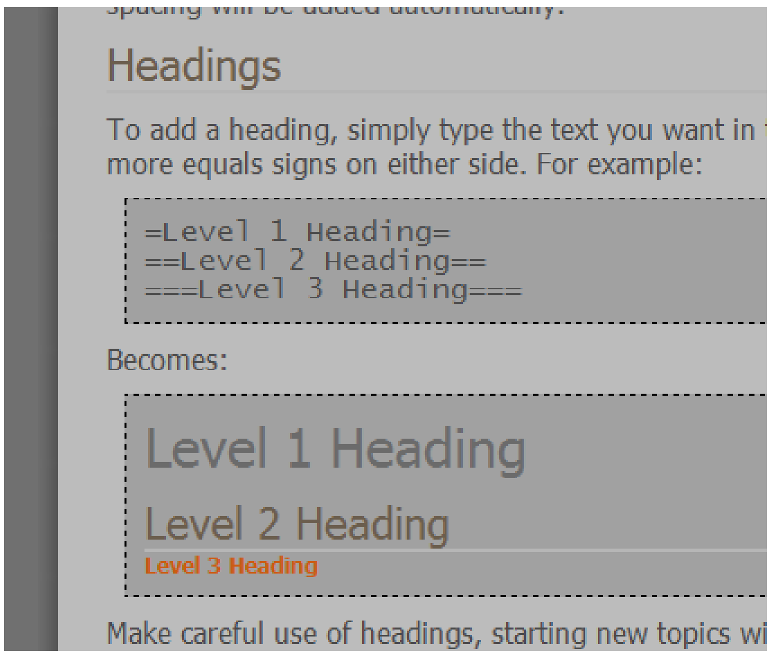
Menu System

Admin Console

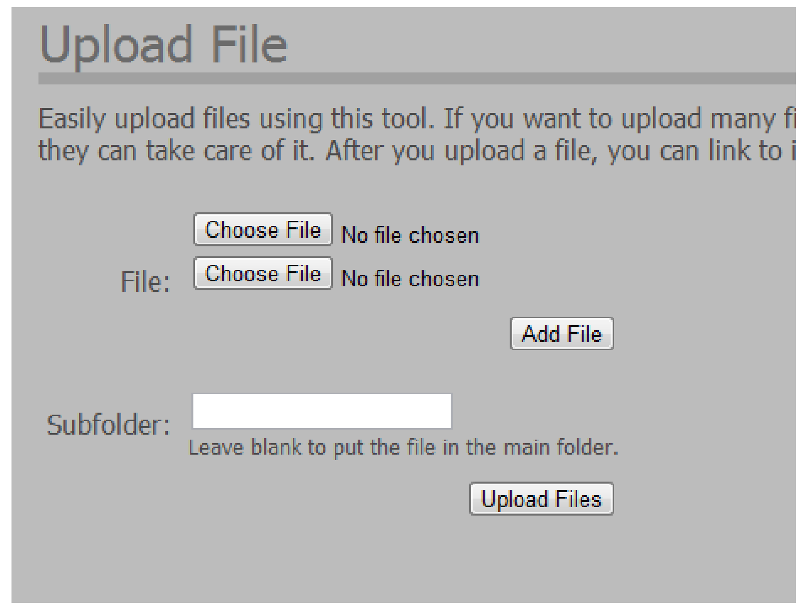


Website

Simple Wiki Markup



File System



Java Programming Course

- Languages
  - 2008: C
  - 2009: C++
  - 2011: Java
- Need for coders
  - Freshmen and sophomores
  - Start early
  - Valuable and effective
  - OSR
- Goal
  - December: Humans
  - January: Programmers
- Investment
  - Mathematics and logic
  - College
  - Employment