

Strategy and Mechanical Design

Maslab IAP 2010

Ellen Yi Chen
Sam Powers
Kimberlee Collins
Chris Celio

Agenda

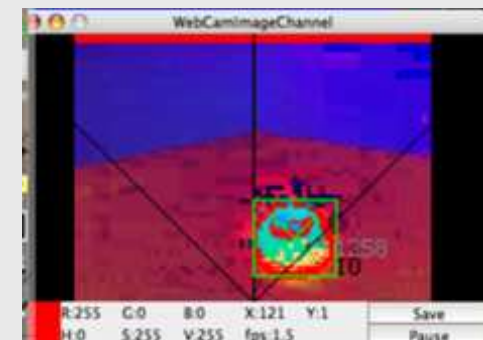
- Strategy
 - Schedule
 - Systematic Strategy Selection
 - Case Studies

Build Schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
3	4 Assignment 1	5 Assignment 2	6	7 Assignment 3	8 Assignment 4	9
<div style="background-color: #e0e0ff; padding: 10px; border-radius: 15px; display: inline-block;"> Design / Feasibility Tests / Prototype </div>						
10	11 Mock #1	12 Sponsor Dinner	13	14 Assignment 5	15 Mock #2	16
<div style="background-color: #e0e0ff; padding: 10px; border-radius: 15px; display: inline-block;"> Build </div>						
17	18 MLK	19	20 Mock #3	21 Assignment 6	22	23
<div style="background-color: #ffcc66; padding: 10px; border-radius: 15px; display: inline-block;"> Debug </div>						
24	25 Mock #4	26 Assignment 7	27	28 Impounding	29 Final Competition	30 Cleanup Day
<div style="background-color: #ff6666; padding: 10px; border-radius: 15px; display: inline-block;"> Fail Week! </div>						

Build Schedule

- Mock #1
 - Drive, maybe navigate
 - Test your color recognition / vision algorithm
 - Take lots of pictures of the field (lighting in 26-100)
 - Find field features your robot might have trouble with
- Mock #2
 - Navigate the field
 - Find balls and goals
 - Maybe pick up balls
- Mock #3
 - Pick up balls
 - Score Points
 - Mechanical feature freeze
- Mock #4
 - Dress Rehearsal
 - No big changes

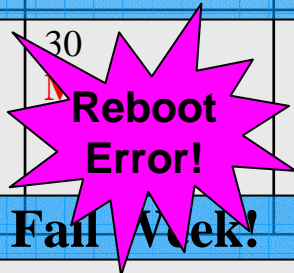
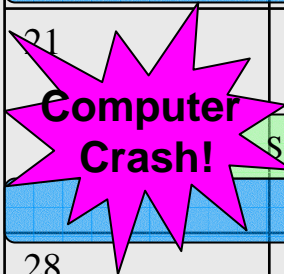


Detailed Schedule

(Based on Team 12AW12 in 2007)

Design Stage
MechE and Sensors
Software

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
7	8 CAD Modeling Design	9	10	11	12 SW Architecture	13 Driving Roomba
← Strategy Decisions			Machining Chassis at Edgerton			Complete Chassis "Roomba"
Design / Feasibility Tests / Prototype						
14	15 Driving Roomba	16	17 Scoring Code	18	19 Sensor Suite Programming	20
			Machining Ball Collection Mechanism		Complete Basic Sensors	
Build						
21	22	23 Locktite Con	24	25 Mock #2	26	27
Sensor Suite, Debugging Lights and So			MechE & Sensor Feature Freeze			
Debug						
28	29	30 Reboot Error!	31	1 Impounding	2 Final Competition	3 Cleanup Day
Wire Management		Fail Week!				



Scheduling Summary

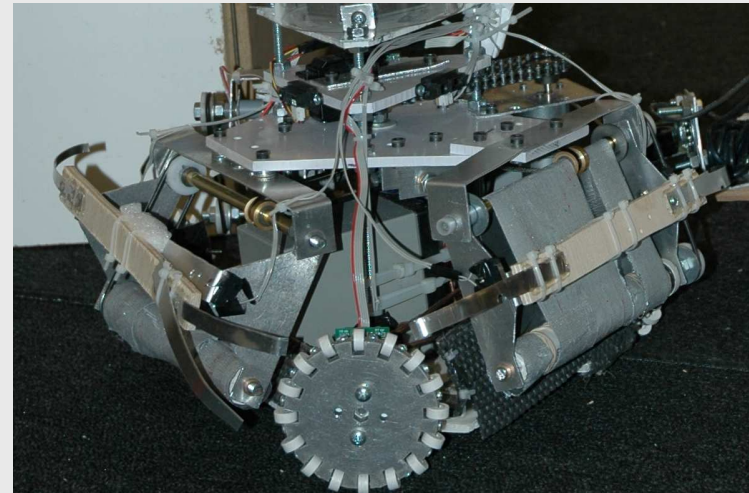
- Two weeks to build
- Keep your programmers happy!
 - Stagger work schedules:
 - Build by day (machine shops open)
 - Code by night
 - Get them food
 - Give them a working robot at all times!
- Expect failures so leave room in the schedule

Agenda

- Strategy
 - Schedule
 - **Systematic Strategy Selection**
 - Case Studies

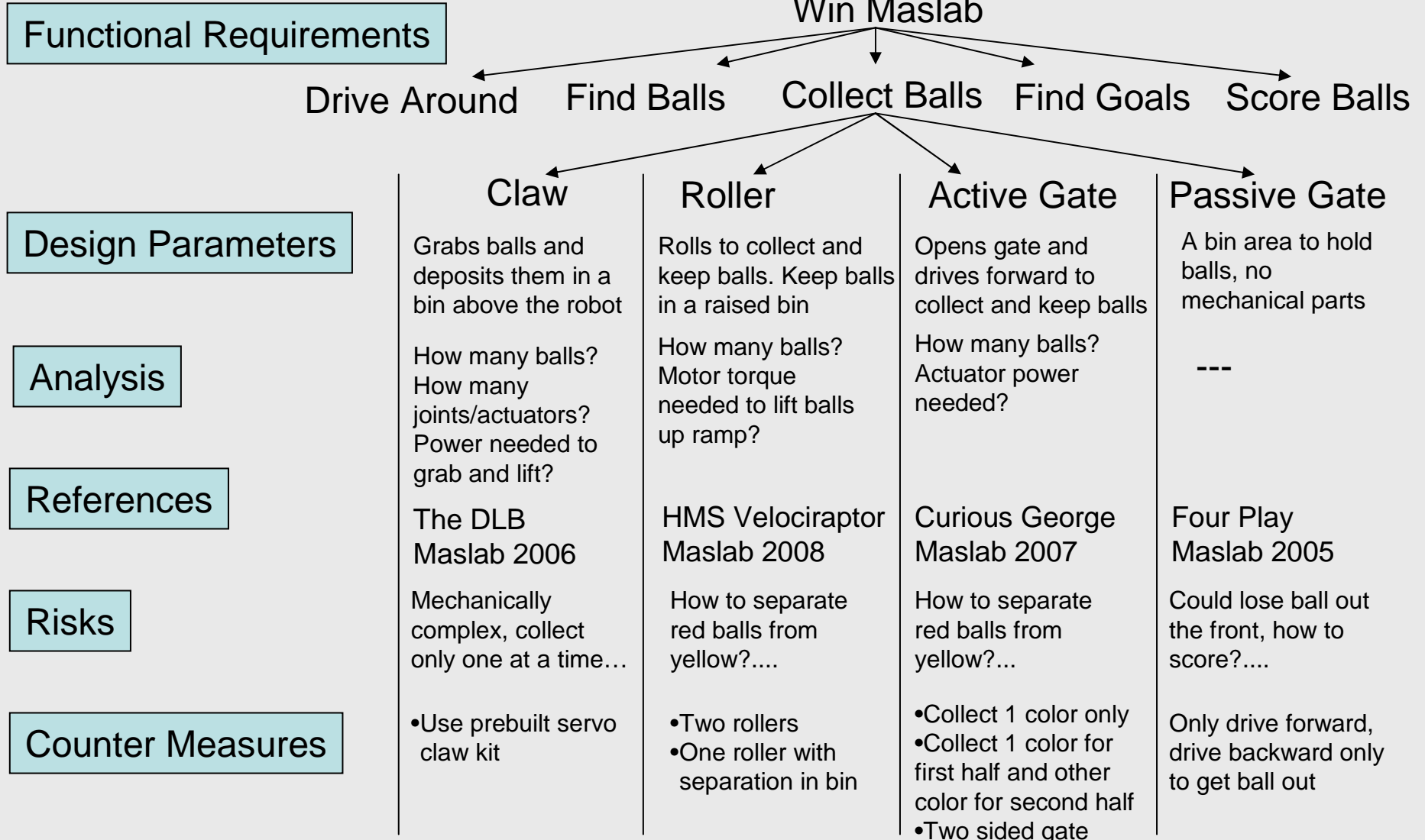
Strategy

- What do we mean by strategy?
 - Design (mechanical, software) chosen based on available resources to achieve a goal (hopefully to win Maslab)
- Systematic strategy selection*
 - Functional Requirements
 - Design Parameters
 - Analysis
 - References
 - Risks
 - Countermeasures
- Why spend time teaching this?
 - 52% of you have never built a robot
 - Don't just build something because its cool! This goes for the MechEs especially!
 - A plan will keep you focused.



*Also known as FRDPARRC by Professor Alex Slocum

Strategy



Pros/Cons to decide? Further Analysis Needed? More Brainstorming?

Strategy: Pugh Chart

- Used to select a strategy
- Choose a datum (simplest) strategy
- Choose criteria (time, difficulty, accuracy)
- Weight your most important criteria
- Score your strategies
 - “+” if its better
 - “-” if its worse
 - “0” if it is as good as your datum
- Add up the totals

Drive Strategies	Datum: Standard Two wheels and caster	Option2: Bigger wheels	Option3: Omniwheels
Coding difficulty	0	0	-
Building difficulty	0	-	--
Field Time (2x)	0	+	-
Navigating (2x)	0	-	++
Odometry	0	-	--
Total	0	-2	-3

System Strategy

- Design a system not parts!
 - Top Down
 - Bottom Up
- Resources
 - Time/People
 - Shop Access
 - Experience
- Areas
 - Navigation
 - Driving Around
 - Vision
 - Ball Capture/Deposit

Mechanical Strategy

People: 1 coder, 3 mechEs

Access: Maslab shop, Edgerton, CSAIL, Papallardo

Experience: Built and coded robots before

Strategies

Navigation: Bump sensors and wall following

Driving: omniwheels

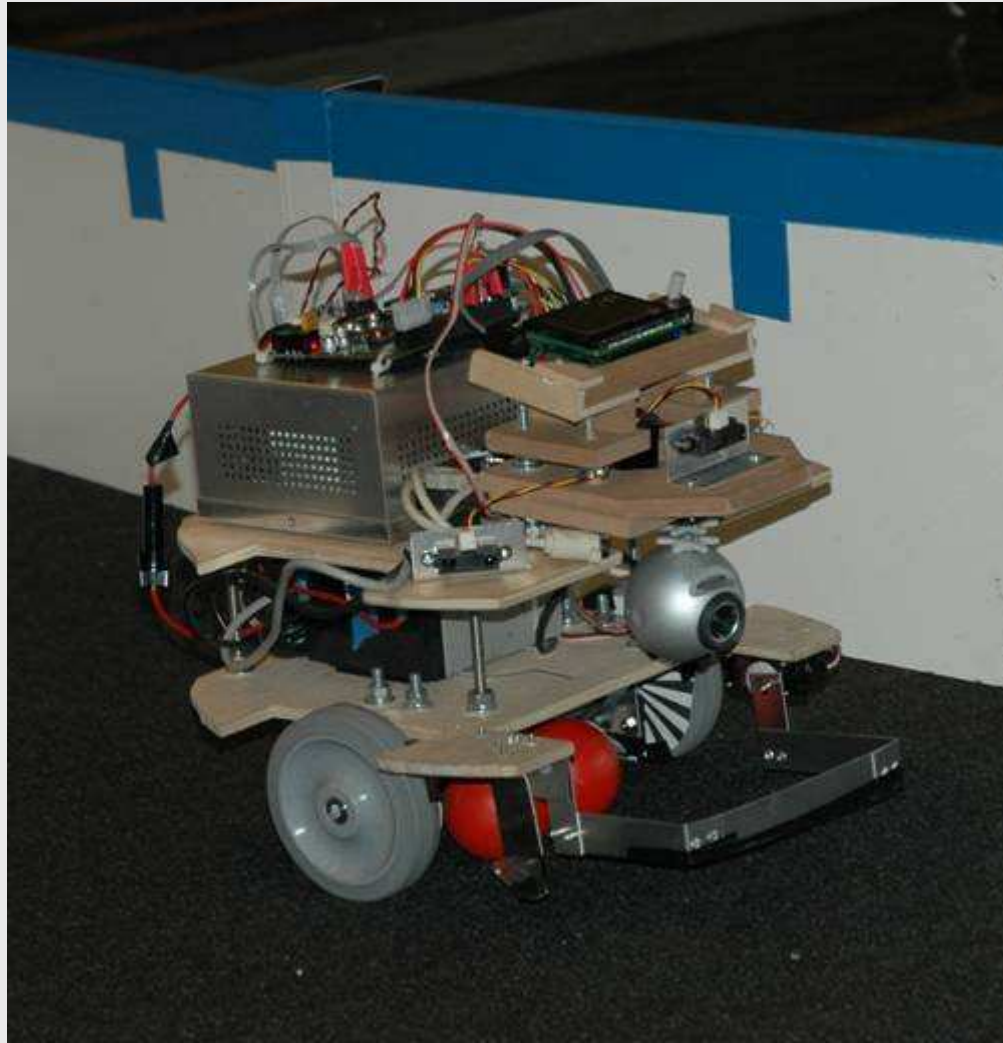
Vision: Rotating camera, Color detection only

Ball Handling: Two roller systems

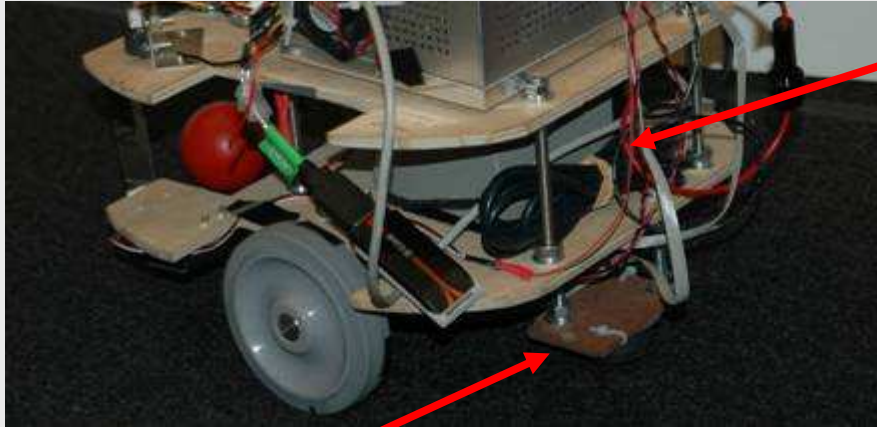
Agenda

- Strategy
 - Schedule
 - Systematic Strategy Selection
 - **Case Studies**

Case Studies: Team Yellow Hat



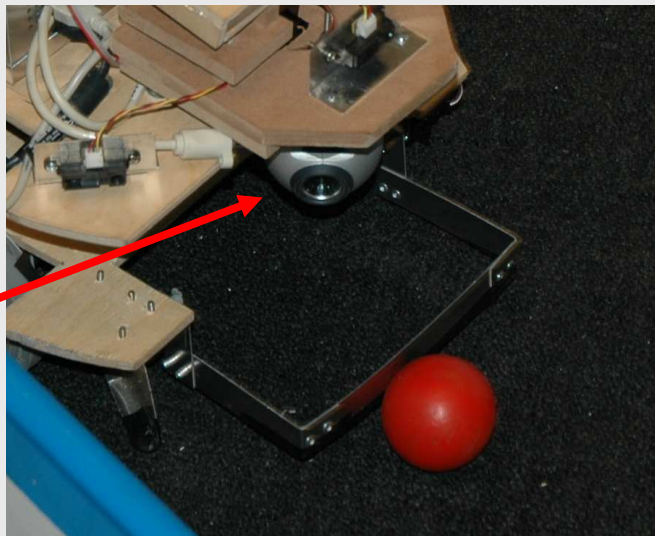
Team Yellow Hat - Features



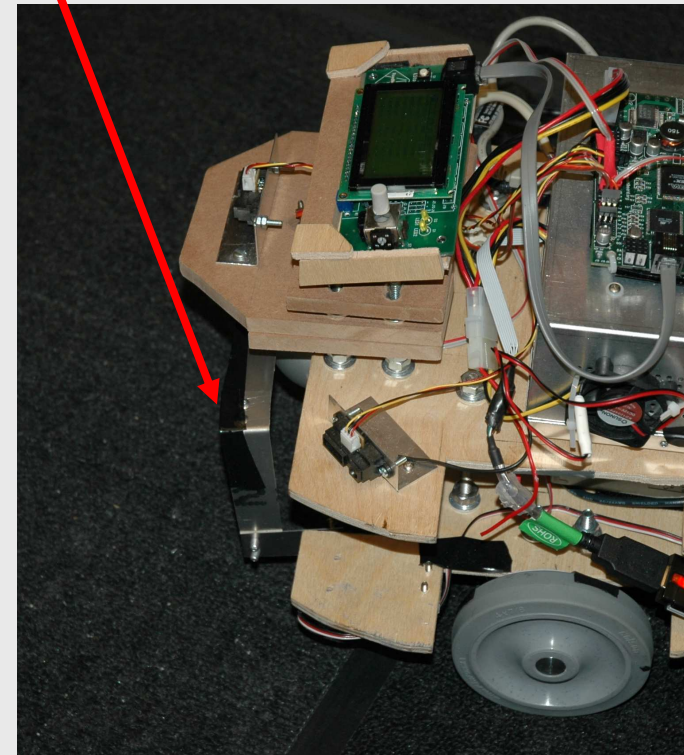
Battery – Center of Mass issues

Back Caster

Ball Gate



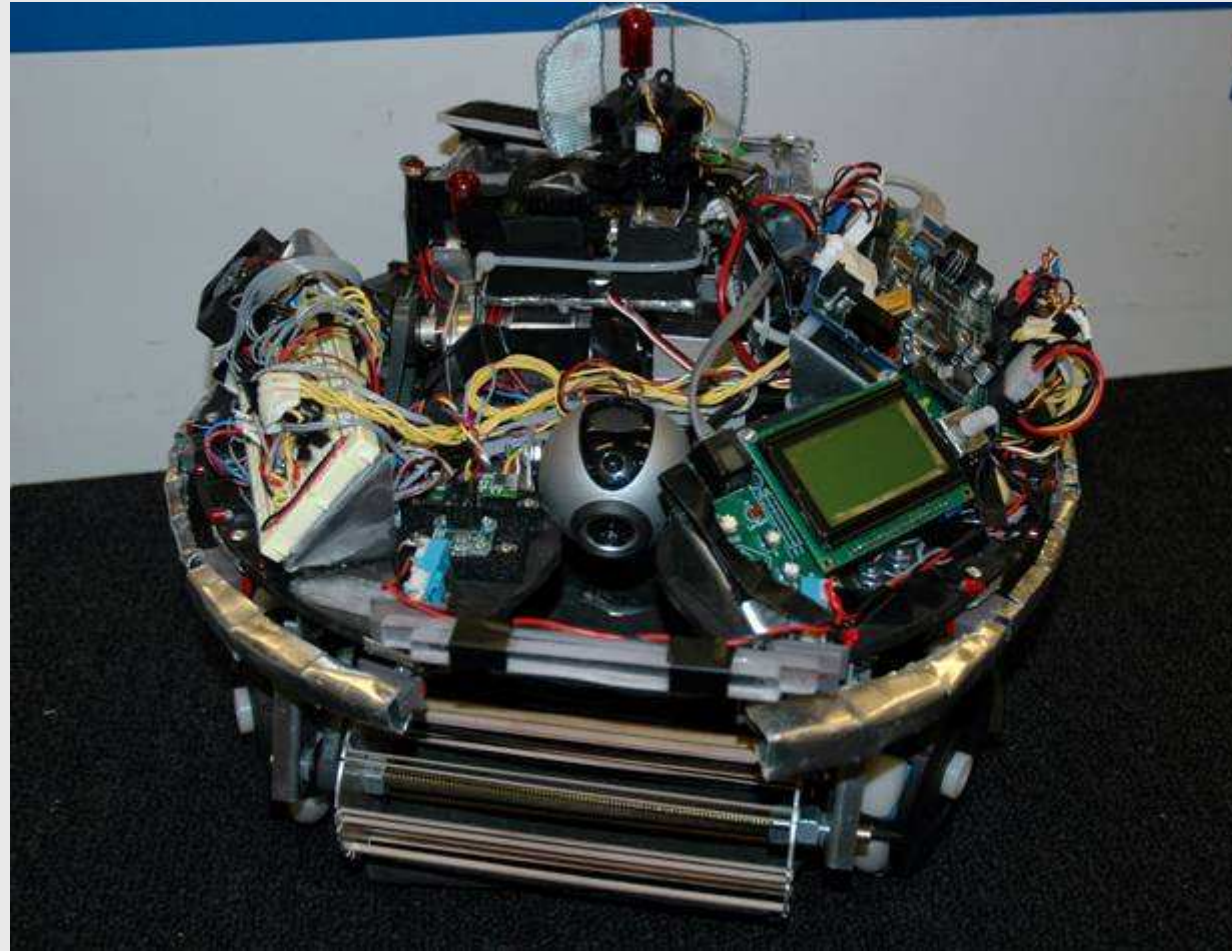
Rotating Camera



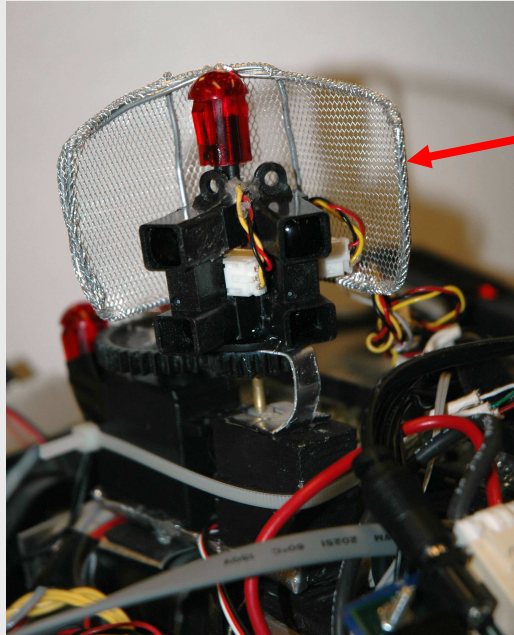
Team Yellow Hat's Advice

- Curious George was designed on the premise that simple behaviors are more reliable than complex ones. As such, any complex behavior, like mapping, must be backed up by simple behaviors, like wall following. **Our plan was to build a robot that could reliably wander, collect balls, and deposit in goals. Once this was complete, we would attempt to add mapping capabilities to provide more intelligence while wandering.** Alas, we never accomplished the latter, but our focus on reliability paid off with 19 points and a win at the final competition.

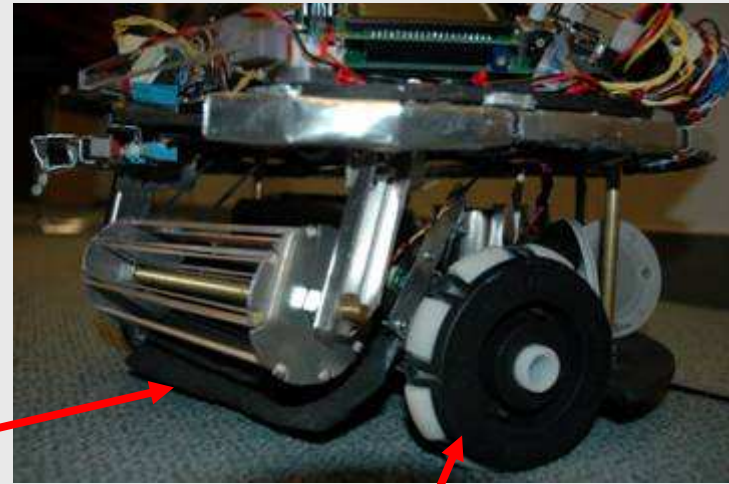
Case Studies: Team 12AW12



Team 12AW12 - Features

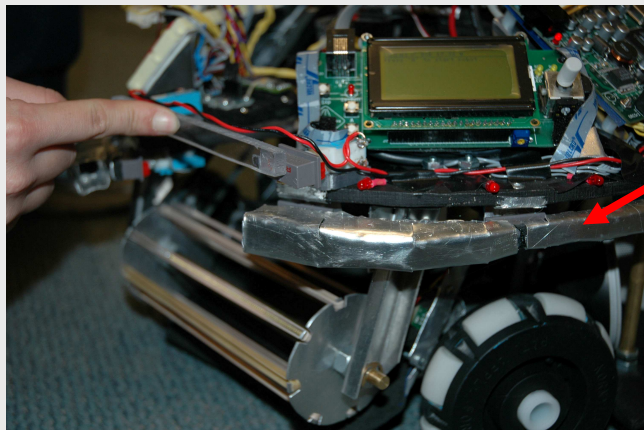


SSS
(Swiveling
Sensor
Suite)

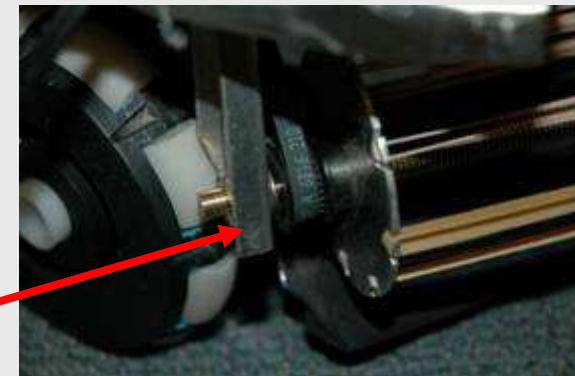


12 Ball
Capacity Bin

Omni-Wheels

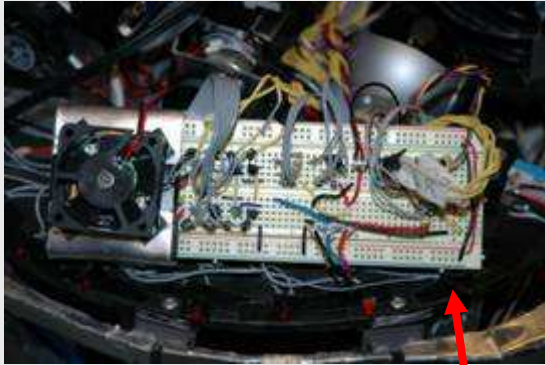


360° Bump
Sensor
Coverage

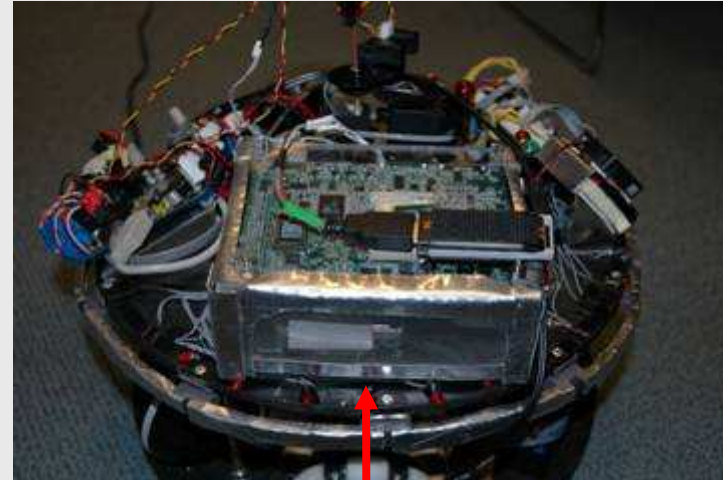


Roller and
Belt Drive

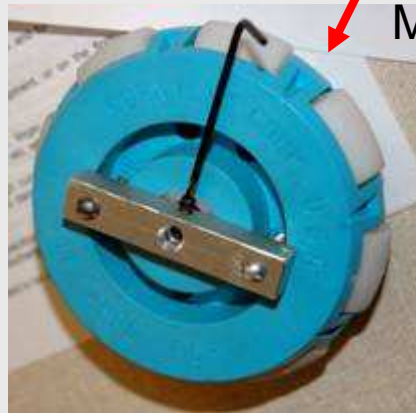
Team 12AW12 – Features



Breadboard Driving
LEDs and Fans

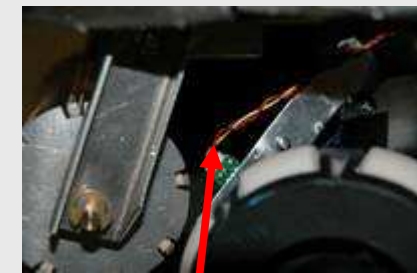


Small, Custom
Computer Box (the
stock box blocked the SSS)



Wheel
Mounts

Speakers (played R2D2
sounds. Useful for
debugging state changes).

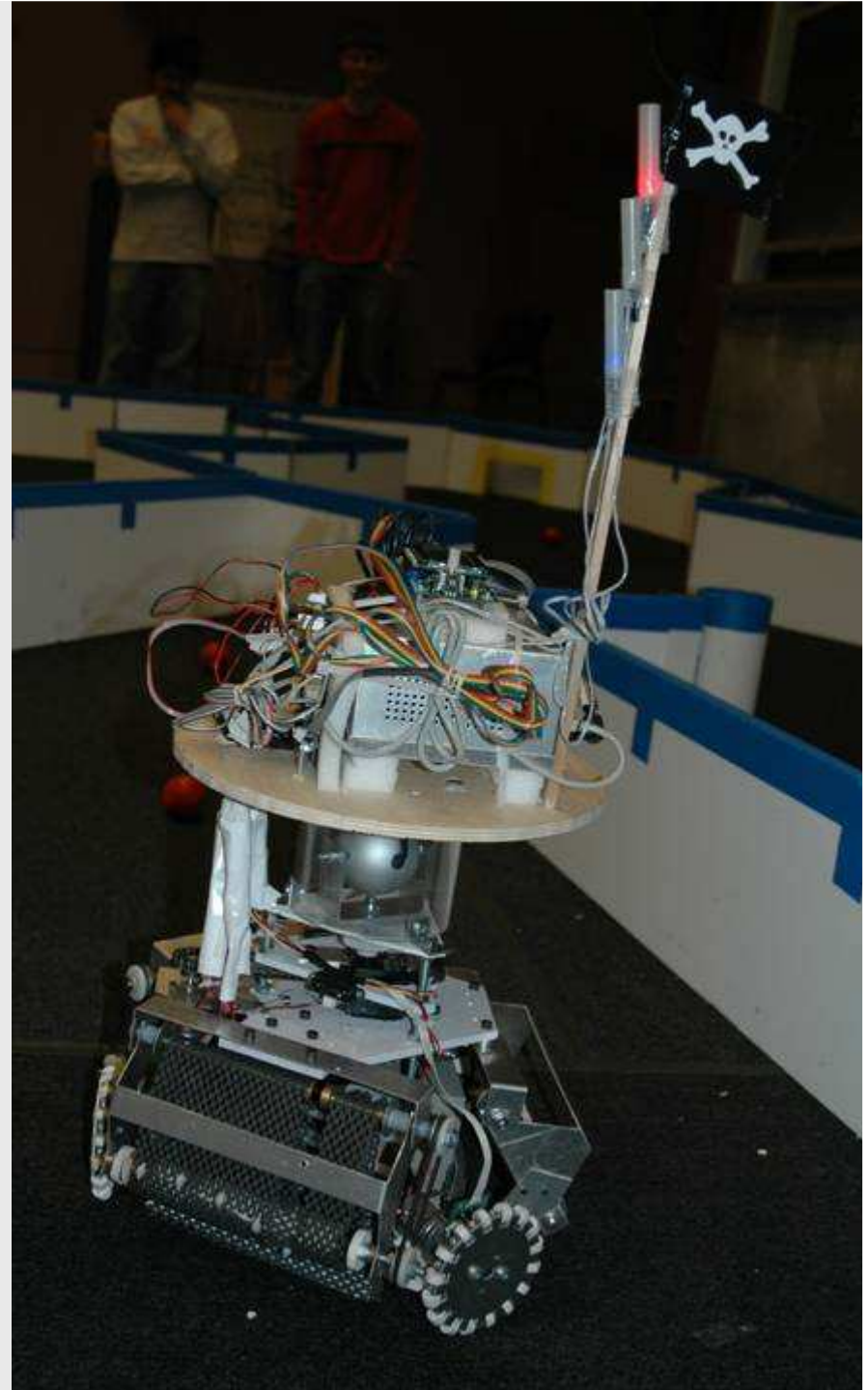


Break Beam

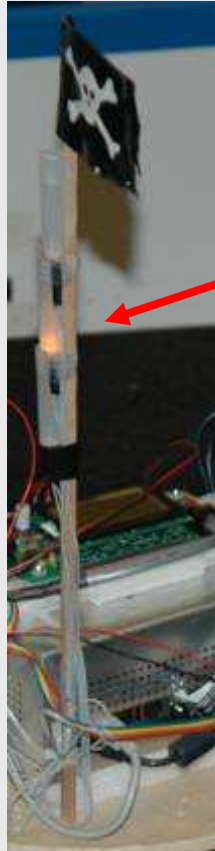
Team 12AW12's Advice

- **Modularity** is key! Design it to be easy to take apart and easy to take on new functionality.
- Invest some time (and man-power) into the mechanical side. Make a strong push to finish the robot ASAP (try to mostly finish it in the first week). **It is hard to program when you do not have a robot, so make some of the programmers build too.** Do not be afraid to make something a little more complicated mechanically if it will make things easier to code!

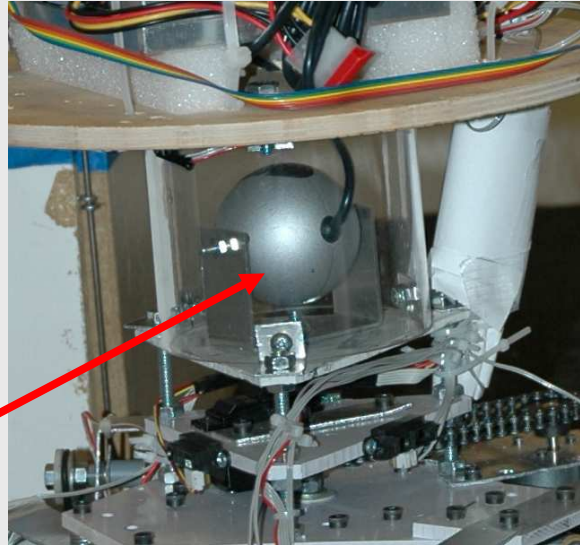
Case Studies: Team “Pieces of” Eight



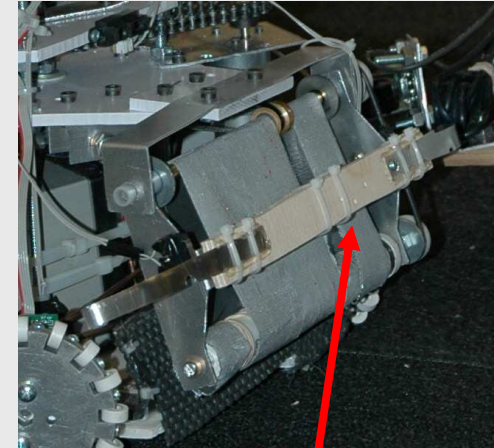
Team "Pieces of" Eight - Features



LED Lights for Debugging

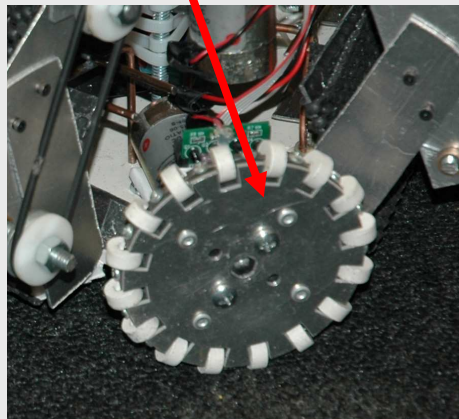


Rotating Camera

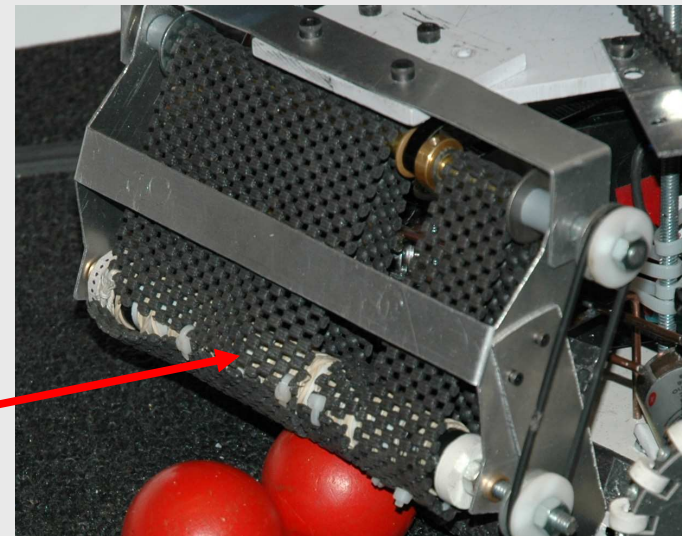


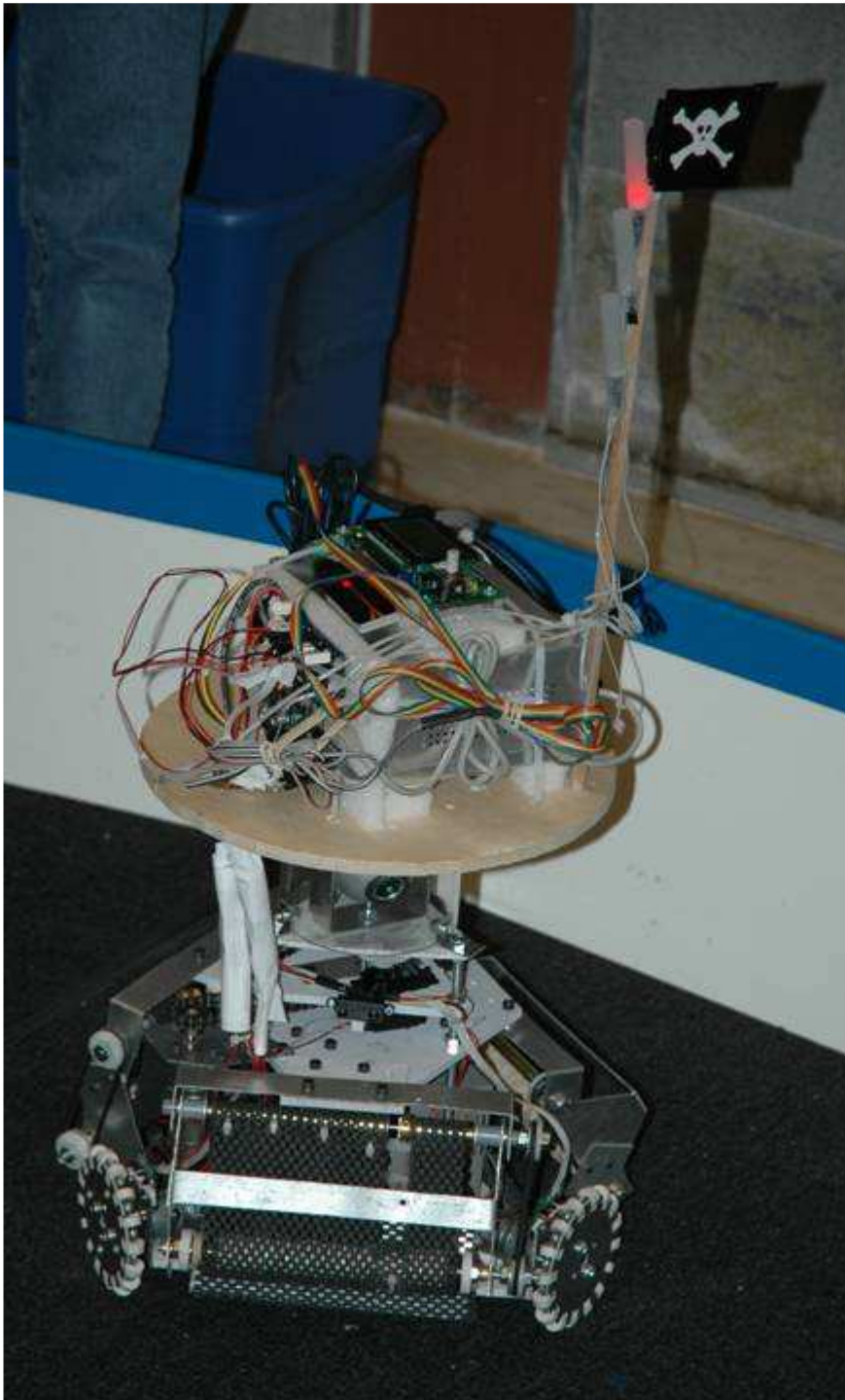
Bump Sensors

Omni Wheels



3 Rollers Powered by a Single Motor





Team “Pieces of” Eight’s Advice

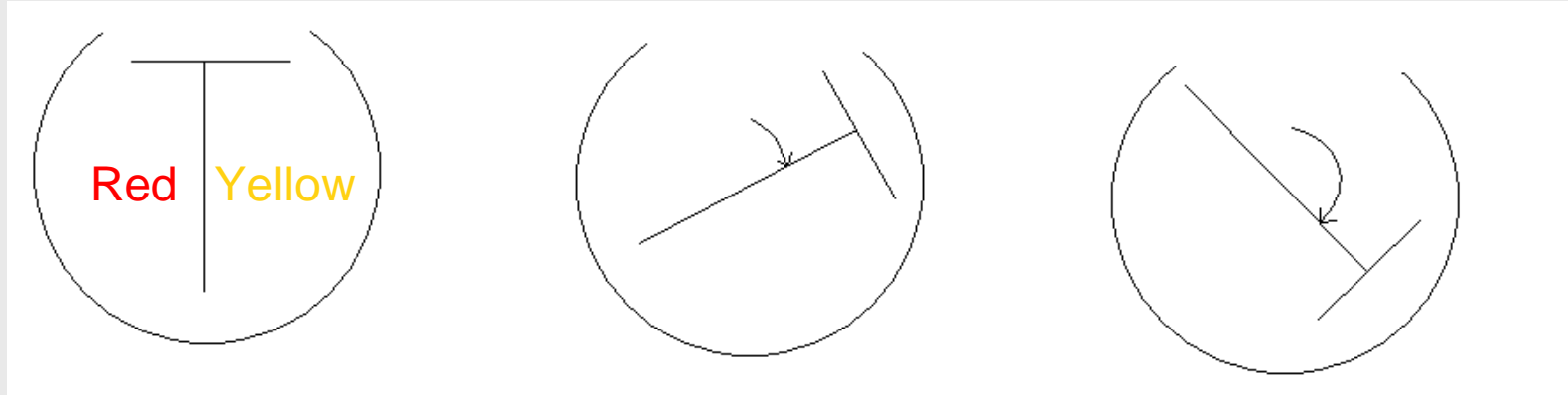
- “When we tested the robot on the field, I feel like we were mostly testing individual pieces of the robot. It wasn't until the very end that we combined everything, and **we found that they didn't come together as seamlessly as we'd hoped.** It would have probably been better to throw everything together at the beginning and fine-tune each thing later on.”

-Email from Daniel Torres, Jr., answering questions for a Maslab magazine article

Case Studies: Team 2 from 2009 and “DHL Plus”



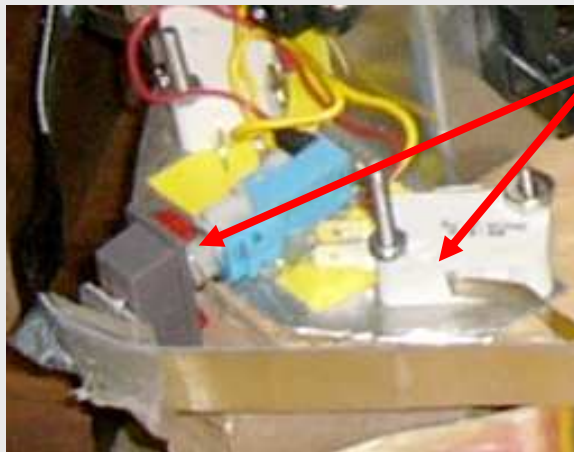
DHL Plus - Features



Gate Closed

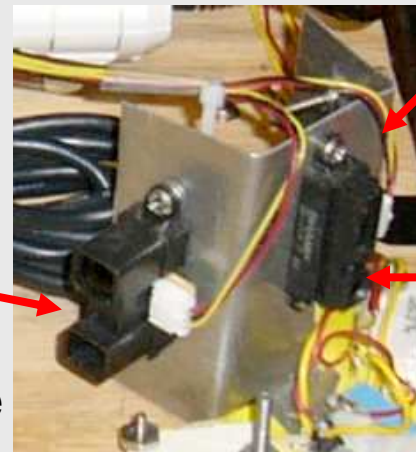
Gate Open for
Collection

Ball Deposit



Simple 360
bump sensors

Crossed IR
sensors for
front coverage



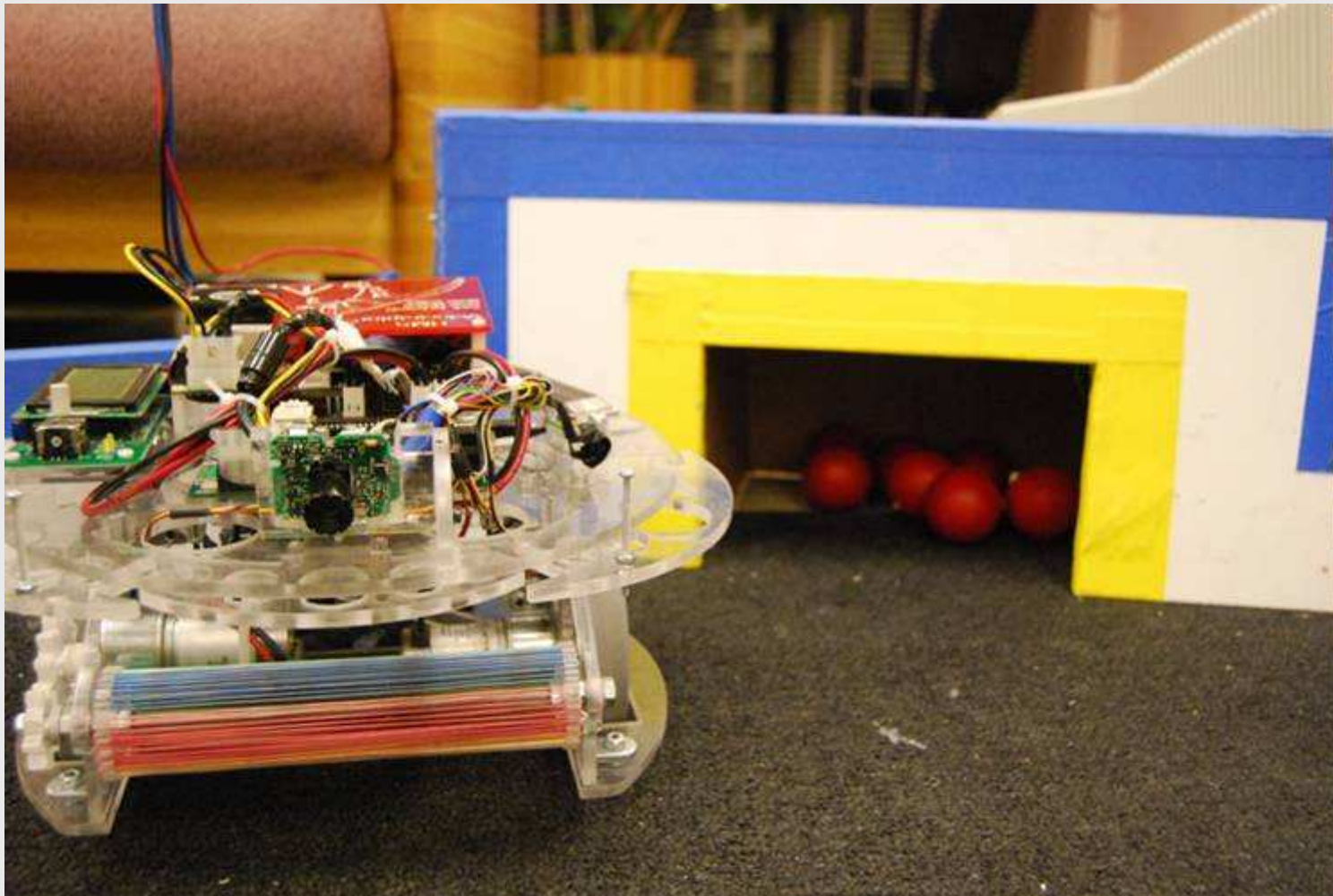
IR Mount

IR Sensor
coverage for
corners

DHL Plus - Advice

- As none of our four teammates had mechanical experience before, we designed our robot, DHL Plus, to be mechanically simple yet effective. **Finalize your mechanical design as early as possible.**
- It's good to work on each behavior individually, but just **give yourself enough time to test the entire program.** Unfortunately, we did not do that until a few hours before the impounding and submitted our robot with lots of scripts that could have been easily improved.
- Build reliable infrastructure before trying any fancy stuff.

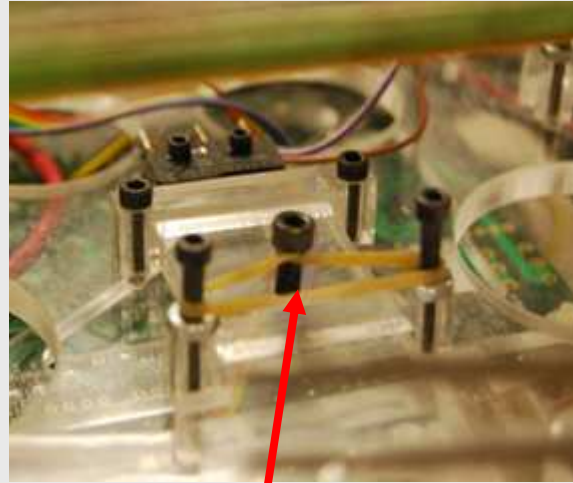
Case Studies: Team HMS Velociraptor



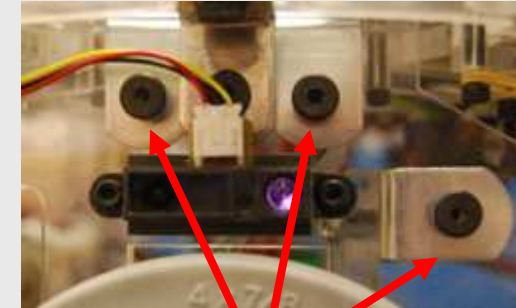
Team HMS Velociraptor - Features



Computer Cover –
Prevent Short
Circuits!

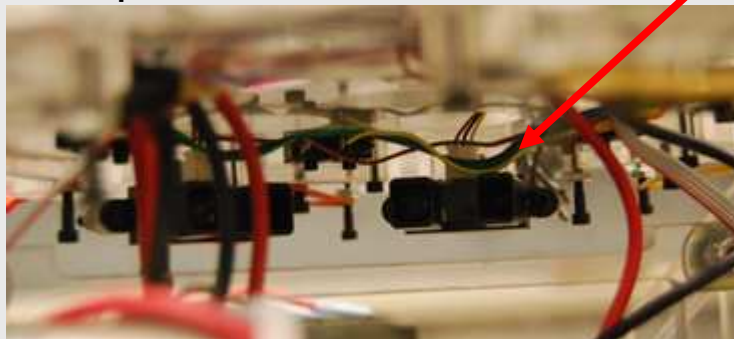


Bump sensor “return spring”



Simple standardized
brackets

Compact sensor placement – also
compensates for IR deadzone

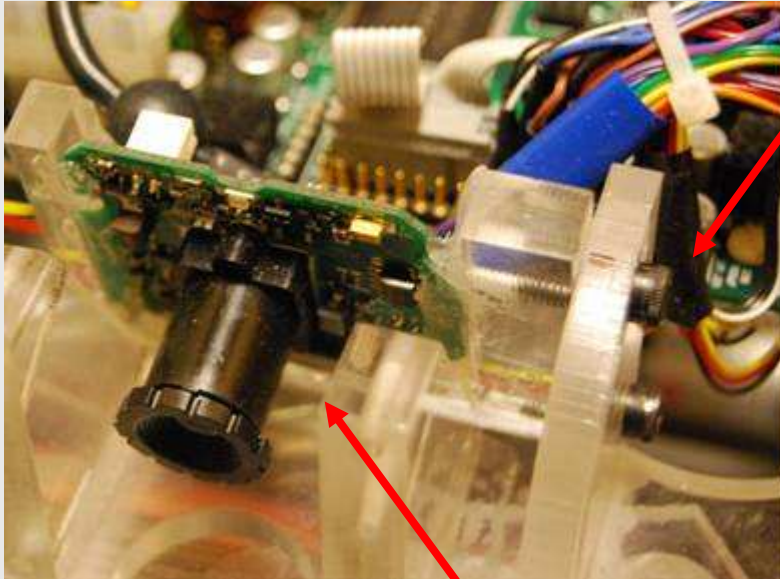


Geared drive – Note the
wide gear, bearing length,
and tolerance

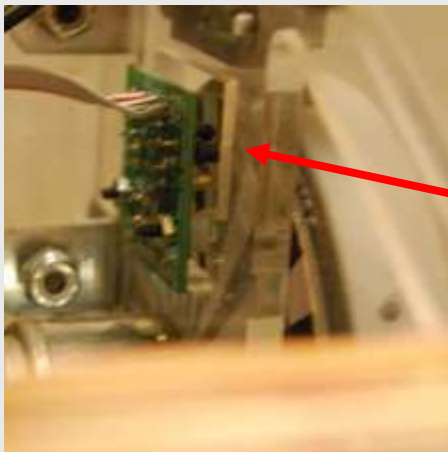


Compliant
Roller

Team HMS Velociraptor - Features



Adjustable
Camera
Angle



Camera

Quadrature
Encoder –
Note the
simple
mounting



Staggered
Bump
Sensor
Design

Team HMS Velociraptor - Advice

- Prioritize your development! If a feature is taking too much time, is it necessary? The goal is to win MASLAB, but that's impossible without a robot that can move around the table looking for balls and goals. **Don't lose sight of the goal for unnecessary pet features.**
- Get a robot up and running immediately. You can't debug your software without running hardware. We had the first version of our final competition bot built by the end of the first week.
- Use robust mechanical design principles. **Do as much as you can to abstract away the hardware, good software design is impossible without this.**

Strategy Summary

- Finish building as early as possible
- Plan for unexpected downtime
- Make design choices systematically
- Design a system, not parts.

References

- Chris Celio, “Mechanical Engineering: Design, Strategy, and Building,” 2008
- 2006 Maslab Wiki, <http://maslab.mit.edu/2006/Wiki>
- 2007 Maslab Wiki, <http://maslab.mit.edu/2007/Wiki>
- 2008 Maslab Wiki, <http://maslab.mit.edu/2008/Wiki>
- Batteries:
<http://www.batteryspace.com/index.asp?PageAction=VIEWPROD&ProdID=2145>
- Battery Charger:
<http://www.batteryspace.com/index.asp?PageAction=VIEWPROD&ProdID=2518>
- 2.009 Battery Primer:
<http://web.mit.edu/2.009/www/resources/mediaAndArticles/batteriesPrimer.pdf>
- Motors: http://www.solutions-cubed.com/solutions%20cubed/Products%20Page/Downloads/ER_DS_8.pdf
- 2.009 Design Resources:
<http://web.mit.edu/2.009/www/resources/resourceIndex.html>